

AO 120 (Rev. 08/10)

TO: Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK
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In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court _____ for the Eastern District of Texas, Marshall Division _____ on the following

☐ Trademarks or ☒ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO. 2:23-cv-00261	DATE FILED 5/31/2023	U.S. DISTRICT COURT for the Eastern District of Texas, Marshall Division
PLAINTIFF ACTIVE WIRELESS TECHNOLOGIES LLC		DEFENDANT T-MOBILE USA, INC. and T-MOBILE US, INC.
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 10,531,443	1/7/2020	Active Wireless Technologies LLC
2 11,019,557	3/25/2021	Active Wireless Technologies LLC
3 10,785,764	9/22/2020	Active Wireless Technologies LLC
4 10,601,566	3/24/2020	Active Wireless Technologies LLC
5		

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1		
2		
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE
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Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

AO 120 (Rev. 08/10)

TO: Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK
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PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
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Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
 Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/059,926	03/24/2020	10601566	SLA3704.3	7857

50735 7590 03/04/2020
AUSTIN RAPP
170 SOUTH MAIN STREET
SUITE 735
SALT LAKE CITY, UT 84101

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b) (application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (<http://pair.uspto.gov>).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site <http://pair.uspto.gov> for additional applicants):

Zhanping Yin, Vancouver, WA;
Sharp Kabushiki Kaisha, Sakai City, JAPAN;
Toshizo Nogami, Chiba, JAPAN;
FG Innovation Company Limited, New Territories, CHINA;

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit SelectUSA.gov.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

50735 7590 12/18/2019
AUSTIN RAPP
170 SOUTH MAIN STREET
SUITE 735
SALT LAKE CITY, UT 84101

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/059,926	08/09/2018	Zhanping Yin	SLA3704.3	7857

TITLE OF INVENTION: MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5TH GENERATION (5G) NEW RADIO (NR)

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	\$1000	\$0.00	\$0.00	\$1000	03/18/2020

EXAMINER	ART UNIT	CLASS-SUBCLASS
TOWFIGHL, AFSAWN M	2469	370-329000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-09 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,

(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 Austin Rapp

2

3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

Sharp Kabushiki Kaisha
FG Innovation Company Limited

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Osaka, Japan
Hong Kong, China

Please check the appropriate assignee category or categories (will not be printed on the patent): ☐ Individual ☒ Corporation or other private group entity ☐ Government4a. Fees submitted: ☒ Issue Fee ☐ Publication Fee (if required) ☐ Advance Order - # of Copies

4b. Method of Payment: (Please first reapply any previously paid fee shown above)

☒ Electronic Payment via EFS-Web ☐ Enclosed check ☐ Non-electronic payment by credit card (Attach form PTO-2038)☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. 60-1987

5. Change in Entity Status (from status indicated above)

☐ Applicant certifying micro entity status. See 37 CFR 1.29☐ Applicant asserting small entity status. See 37 CFR 1.27☐ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature /Wesley L. Austin/

Date February 10, 2020

Typed or printed name Wesley L. Austin

Registration No. 42273

Electronic Patent Application Fee Transmittal				
Application Number:		16059926		
Filing Date:		09-Aug-2018		
Title of Invention:		MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5TH GENERATION (5G) NEW RADIO (NR)		
First Named Inventor/Applicant Name:		Zhanping Yin		
Filer:		Wesley L. Austin/Jessamy Newton		
Attorney Docket Number:		SLA3704.3		
Filed as Large Entity				
Filing Fees for Utility under 35 USC 111(a)				
Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
UTILITY APPL ISSUE FEE	1501	1	1000	1000

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Extension-of-Time:				
Miscellaneous:				
Total in USD (\$)				1000

Electronic Acknowledgement Receipt	
EFS ID:	38539602
Application Number:	16059926
International Application Number:	
Confirmation Number:	7857
Title of Invention:	MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5TH GENERATION (5G) NEW RADIO (NR)
First Named Inventor/Applicant Name:	Zhanping Yin
Customer Number:	50735
Filer:	Wesley L. Austin/Jessamy Newton
Filer Authorized By:	Wesley L. Austin
Attorney Docket Number:	SLA3704.3
Receipt Date:	10-FEB-2020
Filing Date:	09-AUG-2018
Time Stamp:	15:53:51
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	\$1000
RAM confirmation Number	E202020F54439521
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:					
Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Issue Fee Payment (PTO-85B)	171157US_IssueFeeTransmittal_3292-2-309-3.pdf	201056	no	1
			c5f6c082edf2b1a45398f28393427e5fde548646		
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	30816	no	2
			e9bc5f1853ca9a5b63e10e0c6c5274692707fa1b		
Warnings:					
Information:					
Total Files Size (in bytes):			231872		
This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503. <u>New Applications Under 35 U.S.C. 111</u> If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application. <u>National Stage of an International Application under 35 U.S.C. 371</u> If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course. <u>New International Application Filed with the USPTO as a Receiving Office</u> If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.					



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

50735 7590 12/18/2019
AUSTIN RAPP
170 SOUTH MAIN STREET
SUITE 735
SALT LAKE CITY, UT 84101

EXAMINER

TOWFIGHI, AFSHAWN M

ART UNIT

PAPER NUMBER

2469

DATE MAILED: 12/18/2019

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/059,926	08/09/2018	Zhanping Yin	SLA3704.3	7857

TITLE OF INVENTION: MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5TH GENERATION (5G) NEW RADIO (NR)

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	\$1000	\$0.00	\$0.00	\$1000	03/18/2020

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at www.uspto.gov/PatentMaintenanceFees.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

50735 7590 12/18/2019
AUSTIN RAPP
170 SOUTH MAIN STREET
SUITE 735
SALT LAKE CITY, UT 84101

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/059,926	08/09/2018	Zhanping Yin	SLA3704.3	7857

TITLE OF INVENTION: MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5TH GENERATION (5G) NEW RADIO (NR)

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	\$1000	\$0.00	\$0.00	\$1000	03/18/2020

EXAMINER	ART UNIT	CLASS-SUBCLASS
TOWFIGHL, AFSHAWN M	2469	370-329000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-09 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,

(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 _____

2 _____

3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent): ☐ Individual ☐ Corporation or other private group entity ☐ Government

4a. Fees submitted: ☐ Issue Fee ☐ Publication Fee (if required) ☐ Advance Order - # of Copies _____

4b. Method of Payment: (Please first reapply any previously paid fee shown above)

☐ Electronic Payment via EFS-Web ☐ Enclosed check ☐ Non-electronic payment by credit card (Attach form PTO-2038)

☐ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. _____

5. Change in Entity Status (from status indicated above)

☐ Applicant certifying micro entity status. See 37 CFR 1.29

☐ Applicant asserting small entity status. See 37 CFR 1.27

☐ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____

Date _____

Typed or printed name _____

Registration No. _____



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/059,926	08/09/2018	Zhanping Yin	SLA3704.3	7857
50735	7590	12/18/2019	EXAMINER	
AUSTIN RAPP 170 SOUTH MAIN STREET SUITE 735 SALT LAKE CITY, UT 84101			TOWFIGHI, AFSHAWN M	
			ART UNIT	PAPER NUMBER
			2469	

DATE MAILED: 12/18/2019

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b) (Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. **DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.** Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No. 16/059,926	Applicant(s) Yin et al.	
	Examiner AFSHAWN M TOWFIGHI	Art Unit 2469	AIA (FITF) Status Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to remarks filed 11/25/19.
☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☒ The allowed claim(s) is/are 1-16 . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a) ☐ All b) ☐ Some *c) ☐ None of the:

1. ☐ Certified copies of the priority documents have been received.

2. ☐ Certified copies of the priority documents have been received in Application No. _____.

3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

* Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)	5. ☐ Examiner's Amendment/Comment
2. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____.	6. ☒ Examiner's Statement of Reasons for Allowance
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.	7. ☐ Other _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____.	

/AFSHAWN M TOWFIGHI/ Primary Examiner, Art Unit 2469	
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DETAILED ACTION

Notice of Pre-AIA or AIA Status

1. The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

Response to Arguments

2. Applicant's arguments, see pages 7-10, filed 11/25/19, with respect to claims 1-16 have been fully considered and are persuasive. The rejection of claims 1-16 has been withdrawn.

Allowable Subject Matter

3. Claims 1-16 are allowed.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Conclusion

1. Any inquiry concerning this communication or earlier communications from the examiner should be directed to AFSHAWN M TOWFIGHI whose telephone number is (571)270-7296. The examiner can normally be reached on M-F 8:00 AM -5:00 PM.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at <http://www.uspto.gov/interviewpractice>.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Ian N Moore can be reached on 571-272-3085. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/AFSHAWN M TOWFIGHI/
Primary Examiner, Art Unit 2469

<i>Search Notes</i> 	Application/Control No. 16/059,926	Applicant(s)/Patent Under Reexamination Yin et al.
	Examiner AFSHAWN M TOWFIGHI	Art Unit 2469

CPC - Searched*		
Symbol	Date	Examiner
H04L5/005 or H04L5/0091 or H04L5/0053 or H04W76/27 or H04L5/0055 or H04L1/1812 or H04B1/713 or H04W72/0413 or H04L5/0012 or H04L5/0048	08/22/2019	AT

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
H04L5/005 or H04L5/0091 or H04L5/0053 or H04W76/27 or H04L5/0055 or H04L1/1812 or H04B1/713 or H04W72/0413 or H04L5/0012 or H04L5/0048 (Text Search Only) - see search history printout	08/22/2019	AT
EAST(USPAT, USPGPUB, EPO, JPO) - see search history printout	08/22/2019	AT
Inventor and Assignee Search in EAST - see search history printout	08/22/2019	AT
Updated EAST Search - see search history printout	12/05/2019	AT

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
	Interference Search - see search history printout	12/05/2019	AT

/AFSHAWN M TOWFIGHI/ Primary Examiner, Art Unit 2469	
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<i>Search Notes</i> 	Application/Control No. 16/059,926	Applicant(s)/Patent Under Reexamination Yin et al.
	Examiner AFSHAWN M TOWFIGHI	Art Unit 2469

/AFSHAWN M TOWFIGHI/ Primary Examiner, Art Unit 2469	
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Issue Classification 	Application/Control No. 16/059,926	Applicant(s)/Patent Under Reexamination Yin et al.
	Examiner AFSHAWN M TOWFIGHI	Art Unit 2469

CPC						
Symbol					Type	Version
H04L	/	5	/	005	F	2013-01-01
H04L	/	5	/	0053	I	2013-01-01
H04L	/	5	/	0091	I	2013-01-01
H04W	/	76	/	27	I	2018-02-01
H04B	/	1	/	713	I	2013-01-01
H04L	/	1	/	1812	I	2013-01-01
H04L	/	5	/	0055	I	2013-01-01
H04W	/	72	/	0413	I	2013-01-01
H04L	/	5	/	0012	A	2013-01-01
H04L	/	5	/	0048	A	2013-01-01

CPC Combination Sets					
Symbol				Type	Set

NONE	Total Claims Allowed:	
(Assistant Examiner)	(Date)	16
/AFSHAWN M TOWFIGHI/ Primary Examiner, Art Unit 2469	05 December 2019	O.G. Print Claim(s)
(Primary Examiner)	(Date)	1

Issue Classification 	Application/Control No. 16/059,926	Applicant(s)/Patent Under Reexamination Yin et al.
	Examiner AFSHAWN M TOWFIGHI	Art Unit 2469

INTERNATIONAL CLASSIFICATION			
CLAIMED			
H04L		5	00
NON-CLAIMED			

US ORIGINAL CLASSIFICATION	
CLASS	SUBCLASS

CROSS REFERENCES(S)						
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)					

NONE	Total Claims Allowed:	
(Assistant Examiner)	(Date)	16
/AFSHAWN M TOWFIGHI/ Primary Examiner, Art Unit 2469	05 December 2019	O.G. Print Claim(s)
(Primary Examiner)	(Date)	1
		O.G. Print Figure
		1

Issue Classification 	Application/Control No. 16/059,926	Applicant(s)/Patent Under Reexamination Yin et al.
	Examiner AFSHAWN M TOWFIGHI	Art Unit 2469

☒ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47															
CLAIMS															
Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
	1		10												
	2		11												
	3		12												
	4		13												
	5		14												
	6		15												
	7		16												
	8														
	9														

NONE	Total Claims Allowed:	
(Assistant Examiner)	(Date)	16
/AFSHAWN M TOWFIGHI/	05 December 2019	O.G. Print Claim(s)
Primary Examiner, Art Unit 2469	(Date)	O.G. Print Figure
(Primary Examiner)		1
		1

Bibliographic Data

Application No: 16/059,926

Foreign Priority claimed: ☐ Yes ☒ No

35 USC 119 (a-d) conditions met: ☐ Yes ☒ No ☐ Met After Allowance

Verified and Acknowledged: /AFSHAWN M TOWFIGHI/

Examiner's Signature

Initials

Title:

MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5th GENERATION (5G) NEW RADIO (NR)

FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
08/09/2018	370	2469	SLA3704.3
RULE			

APPLICANTS

Sharp Kabushiki Kaisha, Sakai City, JAPAN

FG Innovation Company Limited, New Territories, CHINA

INVENTORS

Zhanping Yin Vancouver, WA, UNITED STATES

Toshizo Nogami Chiba, JAPAN

CONTINUING DATA

This application is a CON of PCT/US2018/045836 08/08/2018

This application has PRO of 62543795 08/10/2017

FOREIGN APPLICATIONS

IF REQUIRED, FOREIGN LICENSE GRANTED**

08/29/2018

STATE OR COUNTRY

UNITED STATES

ADDRESS

AUSTIN RAPP

170 SOUTH MAIN STREET

SUITE 735

SALT LAKE CITY, UT 84101

UNITED STATES

FILING FEE RECEIVED

\$2,340

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	21374	((("SHARP" near3 ("KABUSHIKI") near3 ("KAISHA")) OR (("FG" near3 ("INNOVATION") near3 ("COMPANY") near3 ("LIMITED")))).AS,AANM.	USPAT	OR	OFF	2019/08/22 03:32
S2	21374	((("SHARP" near3 ("KABUSHIKI") near3 ("KAISHA")) OR (("FG" near3 ("INNOVATION") near3 ("COMPANY") near3 ("LIMITED")))).AS,AANM.	USPAT	OR	OFF	2019/08/22 03:32
S3	685	((("YIN" near3 ("Zhanping")) OR (("NOGAMI" near3 ("Toshizo")))).INV.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	OFF	2019/08/22 03:32
S4	21828	S1 S3	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/08/22 03:34
S5	0	S4 and (frequency and hopping and gnb and UCI and lot and PUCCH and DMRS).clm.	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/08/22 03:36
S6	55048	(H04L5/005 or H04L5/0091 or H04L5/0053 or H04W76/27 or H04L5/0055 or H04L1/1812 or H04B1/713 or H04W72/0413 or H04L5/0012 or H04L5/0048).opc.	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/08/22 03:37
S7	3	S6 and (long adj pucch with dmrs with hopping with determin\$3)	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/08/22 03:43
S8	3	S6 and (long adj pucch with dmrs with hopping with slot with determin\$3)	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/08/22 03:43
S9	3	(long adj pucch with dmrs with hopping with slot with determin\$3)	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/08/22 03:57
S10	21	S6 and (long adj pucch with slot with determin\$3)	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/08/22 04:28
S11	3	S6 and (long adj pucch with slot with determin\$3 with UCI)	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/08/22 04:29
S12	21589	((("SHARP" near3 ("KABUSHIKI") near3 ("KAISHA")) OR (("FG" near3 ("INNOVATION") near3 ("COMPANY") near3 ("LIMITED")))).AS,AANM.	USPAT	OR	OFF	2019/11/26 11:26
S13	21589	((("SHARP" near3 ("KABUSHIKI") near3 ("KAISHA")) OR (("FG" near3 ("INNOVATION") near3 ("COMPANY") near3 ("LIMITED")))).AS,AANM.	USPAT	OR	OFF	2019/11/26 11:26
S14	702	((("YIN" near3 ("Zhanping")) OR	US-PGPUB;	OR	OFF	2019/11/26

		((("NOGAMI") near3 ("Toshizo"))).INV.	USPAT; USOCR; EPO; JPO; DERWENT			11:26
S15	22049	S12 S14	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/11/26 11:26
S16	0	S15 and (frequency and hopping and gnb and UCI and lot and PUCCH and DMRS).clm.	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/11/26 11:26
S17	58090	(H04L5/005 or H04L5/0091 or H04L5/0053 or H04W76/27 or H04L5/0055 or H04L1/1812 or H04B1/713 or H04W72/0413 or H04L5/0012 or H04L5/0048).cpc.	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/11/26 11:26
S18	3	S17 and (long adj pucch with dmrs with hopping with determin\$3)	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/11/26 11:26
S19	3	S17 and (long adj pucch with dmrs with hopping with slot with determin\$3)	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/11/26 11:26
S20	3	(long adj pucch with dmrs with hopping with slot with determin\$3)	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/11/26 11:26
S21	22	S17 and (long adj pucch with slot with determin\$3)	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/11/26 11:26
S22	3	S17 and (long adj pucch with slot with determin\$3 with UCI)	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/11/26 11:26
S24	21614	((("SHARP") near3 ("KABUSHIKI") near3 ("KAISHA")) OR ((("FG") near3 ("INNOVATION") near3 ("COMPANY") near3 ("LIMITED"))).AS,AANM.	USPAT	OR	OFF	2019/12/05 11:51
S25	21614	((("SHARP") near3 ("KABUSHIKI") near3 ("KAISHA")) OR ((("FG") near3 ("INNOVATION") near3 ("COMPANY") near3 ("LIMITED"))).AS,AANM.	USPAT	OR	OFF	2019/12/05 11:51
S26	705	((("YIN") near3 ("Zhanping")) OR ((("NOGAMI") near3 ("Toshizo"))).INV.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	OFF	2019/12/05 11:51
S27	22074	S24 S26	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/12/05 11:51
S28	0	S27 and (frequency and hopping and gnb and UCI and lot and PUCCH and DMRS).clm.	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/12/05 11:51
S29	58377	(H04L5/005 or H04L5/0091 or H04L5/0053 or H04W76/27 or H04L5/0055 or H04L1/1812 or H04B1/713 or H04W72/0413 or H04L5/0012 or H04L5/0048).cpc.	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/12/05 11:51
S30	3	S29 and (long adj pucch with dmrs with hopping with determin\$3)	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/12/05 11:51
S31	3	S29 and (long adj pucch with dmrs with	US-PGPUB;	OR	OFF	2019/12/05

		hopping with slot with determin\$3)	USPAT; EPO; JPO			11:51
S32	3	(long adj pucch with dmrs with hopping with slot with determin\$3)	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/12/05 11:51
S33	22	S29 and (long adj pucch with slot with determin\$3)	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/12/05 11:51
S34	3	S29 and (long adj pucch with slot with determin\$3 with UCI)	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/12/05 11:51
S35	21614	((("SHARP") near3 ("KABUSHIKI") near3 ("KAISHA")) OR (("FG") near3 ("INNOVATION") near3 ("COMPANY") near3 ("LIMITED"))).AS,AANM.	USPAT	OR	OFF	2019/12/05 11:51
S36	21614	((("SHARP") near3 ("KABUSHIKI") near3 ("KAISHA")) OR (("FG") near3 ("INNOVATION") near3 ("COMPANY") near3 ("LIMITED"))).AS,AANM.	USPAT	OR	OFF	2019/12/05 11:51
S37	705	((("YIN") near3 ("Zhanping")) OR (("NOGAMI") near3 ("Toshizo"))).INV.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	OFF	2019/12/05 11:51
S38	22074	S35 S37	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/12/05 11:51
S39	0	S38 and (frequency and hopping and gnb and UCI and lot and PUCCH and DMRS).clm.	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/12/05 11:51
S40	58377	(H04L5/005 or H04L5/0091 or H04L5/0053 or H04W76/27 or H04L5/0055 or H04L1/1812 or H04B1/713 or H04W72/0413 or H04L5/0012 or H04L5/0048).cpc.	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/12/05 11:51
S41	3	S40 and (long adj pucch with dmrs with hopping with determin\$3)	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/12/05 11:51
S42	3	S40 and (long adj pucch with dmrs with hopping with slot with determin\$3)	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/12/05 11:51
S43	3	(long adj pucch with dmrs with hopping with slot with determin\$3)	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/12/05 11:51
S44	22	S40 and (long adj pucch with slot with determin\$3)	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/12/05 11:51
S45	3	S40 and (long adj pucch with slot with determin\$3 with UCI)	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/12/05 11:51

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	2	(PUCCH and slot and multiple and symbol and frequency and hop\$4).clm.	USPAT	OR	OFF	2019/12/05 16:50
L2	0	(PUCCH and slot and multiple and symbol and	USPAT	OR	OFF	2019/12/05

EAST Search History

		frequency and hop\$4 and gnb).clm.				16:50
L3	0	(PUCCH and slot and multiple and symbol and frequency and hop\$4 and uci).clm.	USPAT	OR	OFF	2019/12/05 16:50
S23	0	((UCI "uplink control information") and PUCCH and sequence and orthogonal and gNB and slot).clm.	USPAT	OR	OFF	2019/11/26 11:33
S46	0	((UCI "uplink control information") and PUCCH and sequence and orthogonal and gNB and slot).clm.	USPAT	OR	OFF	2019/12/05 11:51

12/ 5/ 2019 4:50:49 PM
C:\ Users\ atowfighi\ Documents\ EAST\ Workspaces\ yin_Zhanping.wsp

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875				Application or Docket Number 16/059,926		Filing Date 08/09/2018		☐ To be Mailed		
ENTITY: ☒ LARGE ☐ SMALL ☐ MICRO										
APPLICATION AS FILED - PART I										
		(Column 1)	(Column 2)							
FOR		NUMBER FILED	NUMBER EXTRA	RATE (\$)		FEE (\$)				
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))		N/A	N/A	N/A						
☐ SEARCH FEE (37 CFR 1.16(k), (l), or (m))		N/A	N/A	N/A						
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))		N/A	N/A	N/A						
TOTAL CLAIMS (37 CFR 1.16(j))		minus 20 =	*	x \$100 =						
INDEPENDENT CLAIMS (37 CFR 1.16(h))		minus 3 =	*	x \$460 =						
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))		If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$310 (\$155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).								
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))										
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL						
APPLICATION AS AMENDED - PART II										
		(Column 1)	(Column 2)	(Column 3)						
AMENDMENT	11/25/2019	CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE (\$)		ADDITIONAL FEE (\$)			
	Total (37 CFR 1.16(i))	* 16	Minus	** 20	= 0	x \$ 100 =		0		
	Independent (37 CFR 1.16(h))	* 4	Minus	*** 4	= 0	x \$ 460 =		0		
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))									
						TOTAL ADD'L FEE		0		
AMENDMENT		(Column 1)	(Column 2)	(Column 3)						
		CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE (\$)		ADDITIONAL FEE (\$)			
	Total (37 CFR 1.16(i))	*	Minus	**	=	x \$ 0 =				
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x \$ 0 =				
	☐ Application Size Fee (37 CFR 1.16(s))									
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))										
						TOTAL ADD'L FEE				
* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.						LIE				
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".						/VIOLA D ROGERS/				
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".										
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.										

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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Appl. No. 16/059,926
Amdt. dated November 25, 2019
Reply to Office Action of August 27, 2019

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application No.	:	16/059,926	Confirmation No.:	7857
Applicants	:	Sharp Kabushiki Kaisha et al.		
First Named Inventor	:	Zhanping Yin		
Filed	:	August 9, 2018		
Art Unit	:	2469		
Examiner	:	Afshawn M. Towfighi		
Docket No.	:	SLA3704.3		
Customer No.	:	50735		

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

AMENDMENT

Sir:

In response to the Office Action dated August 27, 2019, please amend the above-identified application as follows:

Amendments to the Claims are reflected in the listing of claims that begins on page 2 of this paper.

Remarks/Arguments begin on page 7 of this paper.

Attorney Docket No.: SLA3704.3
Customer No.: 50735

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1. (Currently Amended) A user equipment (UE), comprising:
a processor; and
memory in electronic communication with the processor, wherein instructions stored in the memory are executable to:
determine an uplink control channel (PUCCH) spans over multiple slots based on a signaling from a base station (gNB);
~~determine a demodulation reference signals (DMRS) structure in the configured multi slot PUCCH;~~
determine ~~a frequency hopping method of~~ a method of a frequency hopping for the configured ~~multi slot~~ multiple slots PUCCH;
~~determine UCI encoding and loading methods on the configured multi slot PUCCH;~~
~~determine a resource of a control channel for UCI feedback;~~ and
transmit uplink control information (UCI) on a selected channel with the frequency hopping, wherein
the number of symbols of the PUCCH is the same in each slot of the multi slots, and
the location of the symbols for the PUCCH is the same in the each slot of the multiple slots.
2. (Currently Amended) The UE of claim 1, wherein the number of ~~PUCCH~~ PUCCH symbols of the PUCCH in each slot of ~~a multi slot the multiple slots uplink control channel (PUCCH[[]])~~ is greater than or equal to 4, and ~~[[the]]~~ a reference symbol (RS) pattern in each slot is determined

on a per slots basis by a long PUCCH format of a given the number of PUCCH symbols in the slot.

3. (Currently Amended) The UE of claim 1, wherein ~~the number of PUCCH symbols may be the same in each slot of a multi slot uplink control channel (PUCCH), and the same PUCCH symbol location may be allocated in each slot.~~

4. (Currently Amended) The UE of claim 1, wherein UCI encoded bits are rate matched and loaded to all to PUCCH UCI carrying symbols of each slot of the long PUCCH separately[[. If]], and if the number of ~~PUCCH~~ symbols of the PUCCH in each slot is the same, the PUCCH format and encoded UCI in each slot is repeated in the multiple slots.

5. (Currently Amended) The UE of claim 1, wherein the frequency hopping is applied at slot boundaries in ~~a multi slot~~ the multiple slots PUCCH.

6. (Currently Amended) The UE of claim 1, wherein the frequency hopping is applied within each slot in ~~a multi slot~~ the multiple slots PUCCH.

7. (Currently Amended) The UE of claim 1, wherein whether the frequency hopping is inter-slot or intra-slot can be configured by higher layer signaling for ~~a multi slot~~ the multiple slots PUCCH.

8. (Currently Amended) A base station (gNB), comprising:
a processor; and
memory in electronic communication with the processor, wherein instructions stored in
the memory are executable to:
~~determine an uplink control channel (PUCCH) spans over multiple slots;~~

~~determine a demodulation reference signals (DMRS) structure in the configured multi slot PUCCH;~~

~~determine a frequency hopping method of the configured multi slot PUCCH;~~

~~determine UCI encoding and loading methods on the configured multi slot PUCCH;~~

~~determine a resource of a control channel for UCI feedback; and~~

transmit, to a user equipment (UE), a signaling, an uplink control channel

(PUCCH) spans over multiple slots being determined based on the

signaling; and

receive uplink control information (UCI) on a selected channel with the frequency

hopping for the configured multiple slots PUCCH, wherein

the number of symbols of the PUCCH is the same in each slot of the

multiple slots, and

the location of the symbols for the PUCCH is the same in the each slot of

the multiple slots.

9. (Currently Amended) The gNB of claim 8, wherein the number of ~~PUCCH~~ symbols of the PUCCH in each slot of ~~a multi slot the multiple slots uplink control channel (PUCCH[D])~~ is greater than or equal to 4, and ~~[[the]]~~ a reference symbol (RS) pattern in each slot is determined on a per slots basis by a long PUCCH format of a given the number of PUCCH symbols in the slot.

10. (Currently Amended) The ~~[[UE]]~~ gNB of claim 8, wherein ~~the number of PUCCH symbols may be the same in each slot of a multi slot uplink control channel (PUCCH), and the same PUCCH symbol location may be allocated in each slot.~~

11. (Currently Amended) The gNB of claim 8, wherein UCI encoded bits are rate matched and loaded to all to PUCCH UCI carrying symbols of each slot of the long PUCCH separately[[.

If]] , and if the number of ~~PUCCH~~ symbols of the PUCCH in each slot is the same, the PUCCH format and encoded UCI in each slot is repeated in the multiple slots.

12. (Currently Amended) The gNB of claim 8, wherein the frequency hopping is applied at slot boundaries in ~~a multi-slot~~ the multiple slots PUCCH.

13. (Currently Amended) The gNB of claim 8, wherein the frequency hopping is applied within each slot in ~~a multi-slot~~ the multiple slots PUCCH.

14. (Currently Amended) The gNB of claim 8, wherein whether the frequency hopping is inter-slot or intra-slot can be configured by higher layer signaling for ~~a multi-slot~~ the multiple slots PUCCH.

15. (Currently Amended) A method by a user equipment (UE), comprising:
determining an uplink control channel (PUCCH) spans over multiple slots based on a signaling from a base station (gNB);
~~determining a demodulation reference signals (DMRS) structure in the configured multi-slot PUCCH;~~
determining ~~a frequency hopping method of~~ a method of a frequency hopping for the configured ~~multi-slot~~ multiple slots PUCCH;
~~determining UCI encoding and loading methods on the configured multi slot PUCCH;~~
~~determining a resource of a control channel for UCI feedback; and~~
transmitting uplink control information (UCI) on a selected channel with the frequency hopping, wherein
the number of symbols of the PUCCH is the same in each slot of the multi slots,
and
the location of the symbols for the PUCCH is the same in the each slot of the multiple slots.

16. (Currently Amended) A method by a base station (gNB), comprising:
- ~~determining an uplink control channel (PUCCH) spans over multiple slots;~~
 - ~~determining a demodulation reference signals (DMRS) structure in the configured multi-slot PUCCH;~~
 - ~~determining a frequency hopping method of the configured multi slot PUCCH;~~
 - ~~determining UCI encoding and loading methods on the configured multi slot PUCCH;~~
 - ~~determining a resource of a control channel for UCI feedback; and~~
- transmit, to a user equipment (UE), a signaling, an uplink control channel (PUCCH)
spans over multiple slots being determined based on the signaling; and
receiving uplink control information (UCI) on a selected channel with the frequency
hopping for the configured multiple slots PUCCH, wherein
the number of symbols of the PUCCH is the same in each slot of the multiple slots,
and
the location of the symbols for the PUCCH is the same in the each slot of the
multiple slots.

REMARKS/ARGUMENTS

In the Office Action dated August 27, 2019 (hereinafter, “Office Action”), claims 1–16 were rejected under 35 U.S.C. § 103. By this paper, claims 1-16 are being amended.

Applicant respectfully responds to the Office Action.

I. Claims 1–16 Rejected Under 35 U.S.C. § 103

Claims 1–16 stand rejected under 35 U.S.C. § 103 based on “Long Duration PUCCH structure” to Huawei (hereinafter, “R1-1706953”) in view of “Long-PUCCH for more than one slot” to NTT DOCOMO, INC. (hereinafter, “R1-1711102”). Applicant respectfully requests reconsideration in view of the above claim amendments and the following remarks.

The factual inquiries that are relevant in the determination of obviousness are determining the scope and contents of the prior art, ascertaining the differences between the prior art and the claims in issue, resolving the level of ordinary skill in the art, and evaluating evidence of secondary considerations. *KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 406 (2007) (citing *Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966)). As the Board of Patent Appeals and Interferences has confirmed, “obviousness requires a suggestion of all limitations in a claim.” *Ex parte Wada & Murphy*, No. 2007-3733 (B.P.A.I. Jan. 14, 2008) (citing *CFMT, Inc. v. Yieldup Int’l Corp.*, 349 F.3d 1333, 1342 (Fed. Cir. 2003)).

Claim 1 has been amended to recite “transmit uplink control information (UCI) with the frequency hopping, wherein the number of symbols of the PUCCH is the same in each slot of the multi slots, and the location of the symbols for the PUCCH is the same in the each slot of the multiple slots.” This amendment is supported by at least paragraphs [0047], [0051], [0052], [0061] and [00377] of the originally-filed specification. The combination of R1-1706953 and R1-1711102 does not teach or suggest this claimed subject matter.

The cited reference R1-1706953 discusses the structures of an NR long PUCCH in multiple slots. (R1-1706953, pages 5-6.) However, it does not teach or suggest “transmit uplink control information (UCI) with the frequency hopping, wherein the number of symbols of the

PUCCH is the same in each slot of the multi slots, and the location of the symbols for the PUCCH is the same in the each slot of the multiple slots.” R1-1711102 does not make up for the deficiencies of R1-1706953.

For at least the foregoing reasons, Applicant respectfully submits that amended claim 1 is allowable. Claims 2–7 depend from claim 1, and are therefore allowable for at least the same reasons as claim 1.

Amended claim 8 recites “transmit, to a user equipment (UE), a signaling, an uplink control channel (PUCCH) spans over multiple slots being determined based on the signaling; and receive uplink control information (UCI) with the frequency hopping for the configured multiple slots PUCCH, wherein the number of symbols of the PUCCH is the same in each slot of the multiple slots, and the location of the symbols for the PUCCH is the same in the each slot of the multiple slots.” As discussed above, the combination of R1-1706953 and R1-1711102 does not teach or suggest this claimed subject matter. Accordingly, Applicant respectfully submits that amended claim 8 is allowable. Claims 9–14 depend from claim 8, and are therefore allowable for at least the same reasons as claim 8.

Amended claim 15 recites “transmitting uplink control information (UCI) with the frequency hopping, wherein the number of symbols of the PUCCH is the same in each slot of the multi slots, and the location of the symbols for the PUCCH is the same in the each slot of the multiple slots.” As discussed above, the combination of R1-1706953 and R1-1711102 does not teach or suggest this claimed subject matter. Accordingly, Applicant respectfully submits that amended claim 15 is allowable.

Amended claim 16 recites “transmit, to a user equipment (UE), a signaling, an uplink control channel (PUCCH) spans over multiple slots being determined based on the signaling; and receiving uplink control information (UCI) with the frequency hopping for the configured multiple slots PUCCH, wherein the number of symbols of the PUCCH is the same in each slot of the multiple slots, and the location of the symbols for the PUCCH is the same in the each slot of the multiple slots.” As discussed above, the combination of R1-1706953 and R1-1711102 does

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not teach or suggest this claimed subject matter. Accordingly, Applicant respectfully submits that amended claim 16 is allowable.

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CONCLUSION

In view of the foregoing, Applicant respectfully submits that all pending claims in the present application are in a condition for allowance, which is earnestly solicited. Should any issues remain unresolved, the Examiner is encouraged to telephone the undersigned at the number provided below.

Respectfully submitted,

/Wesley L. Austin/

Wesley L. Austin
Reg. No. 42,273
Attorney for Applicant

Date: November 25, 2019

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Electronic Acknowledgement Receipt	
EFS ID:	37846411
Application Number:	16059926
International Application Number:	
Confirmation Number:	7857
Title of Invention:	MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5th GENERATION (5G) NEW RADIO (NR)
First Named Inventor/Applicant Name:	Zhanping Yin
Customer Number:	50735
Filer:	Wesley L. Austin/Ashley Austin
Filer Authorized By:	Wesley L. Austin
Attorney Docket Number:	SLA3704.3
Receipt Date:	25-NOV-2019
Filing Date:	09-AUG-2018
Time Stamp:	12:55:41
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment		no			
File Listing:					
Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		171157US_ResponseTo27Aug2019OfficeAction_3292-2-309-3.pdf	60199	yes	10
			83e65f4b40e85a0ea3a2dd4a80ccaa430e6b0fce		

	Multipart Description/PDF files in .zip description		
	Document Description	Start	End
	Amendment/Req. Reconsideration-After Non-Final Reject	1	1
	Claims	2	6
	Applicant Arguments/Remarks Made in an Amendment	7	10
Warnings:			
Information:			
Total Files Size (in bytes):		60199	
This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503. <u>New Applications Under 35 U.S.C. 111</u> If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application. <u>National Stage of an International Application under 35 U.S.C. 371</u> If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course. <u>New International Application Filed with the USPTO as a Receiving Office</u> If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.			



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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/059,926	08/09/2018	Zhanping Yin	SLA3704.3	7857
50735	7590	08/27/2019	EXAMINER	
AUSTIN RAPP 170 SOUTH MAIN STREET SUITE 735 SALT LAKE CITY, UT 84101			TOWFIGHI, AFSHAWN M	
			ART UNIT	PAPER NUMBER
			2469	
			NOTIFICATION DATE	DELIVERY MODE
			08/27/2019	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

usptocorrespondence@austin-rapp.com

DETAILED ACTION

Notice of Pre-AIA or AIA Status

1. The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

Information Disclosure Statement

2. The information disclosure statement (IDS) submitted on 12/11/18 and 8/9/18 is being considered by the examiner.

Claim Rejections - 35 USC § 103

3. In the event the determination of the status of the application as subject to AIA 35 U.S.C. 102 and 103 (or as subject to pre-AIA 35 U.S.C. 102 and 103) is incorrect, any correction of the statutory basis for the rejection will not be considered a new ground of rejection if the prior art relied upon, and the rationale supporting the rejection, would be the same under either status.
4. The following is a quotation of 35 U.S.C. 103 which forms the basis for all obviousness rejections set forth in this Office action:

A patent for a claimed invention may not be obtained, notwithstanding that the claimed invention is not identically disclosed as set forth in section 102, if the differences between the claimed invention and the prior art are such that the claimed invention as a whole would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art to which the claimed invention pertains. Patentability shall not be negated by the manner in which the invention was made.

5. Claims 1-16 are rejected under 35 U.S.C. 103 as being unpatentable over (Huawei, HiSilicon, "Long Duration PUCCH structure", 3GPP TSG RAN WG1 Meeting #89, Hangzhou, China, R1-1706953, 19 May 2017), as disclosed in the IDS, and further in view of (NTT DOCOMO, INC., "Long-PUCCH for more than one slot", 3GPP TSG RAN WG1 NR Ad-Hoc#2, Qingdao, China, R1-1711102, 30 Jun 2017), as disclosed in the IDS.

As to claim 1, Huawei teaches a user equipment (UE) (Huawei, Section 1 and 2.3, a UE for transmitting on Uplink (from UE to gNB) control channel), comprising: a processor; and memory in electronic communication with the processor, wherein instructions stored in the memory are executable (Huawei, Section 1 and 2.3, a UE has a processor and memory to operate) to:

determine a demodulation reference signals (DMRS) structure in the configured multi-slot PUCCH (Huawei, 2.1, determine a DMRS position in the long PUCCH);

determine a frequency hopping method of the configured multi-slot PUCCH (Huawei, 2.1, determine a frequency hopping point on the long PUCCH);

determine UCI encoding and loading methods on the configured multi-slot PUCCH (Huawei, Section 1 Ran #88b and 2.4, determine UCI method for the PUCCH);

and transmit UCI on a selected channel (Huawei, Section 1 Ran #88b, UCI payload transmission on PUCCH).

Huawei does not explicitly teach determine an uplink control channel (PUCCH) spans over multiple slots based on a signaling from a base station (gNB); determine a resource of a control channel for UCI feedback.

However, NTT teaches determine an uplink control channel (PUCCH) spans over multiple slots based on a signaling from a base station (gNB) (NTT, Section 2, determining a duration of slots of a long PUCCH from DCI (downlink "gNB to UE" control information) signaling); determine a resource of a control channel for UCI feedback (NTT, Section 2, determine a PUCCH resource in time/frequency to use for UCI delivery).

It would have been obvious to one of ordinary skill in the art at the time of invention to combine the teachings of Huawei with NTT to determine slot duration and a resource because NTT teaches long PUCCH methods for improving reliability/coverage (NTT, Section 2).

As to claim 2, the combination of Huawei and NTT teaches wherein the number of PUCCH symbols in each slot of a multi-slot uplink control channel (PUCCH) is greater than or equal to 4 (Huawei, 2.1 & 2.2, PUCCH symbols is 4 to 14), and the reference symbol (RS) pattern in each slot is determined on a per slots basis by a long PUCCH format of a given the number of PUCCH symbols in the slot (Huawei, 2.1 & 2.2, the DMRS structure and SRS are determined based on the number of symbols).

As to claim 3, the combination of Huawei and NTT teaches wherein the number of PUCCH symbols may be the same in each slot of a multi-slot uplink control channel (PUCCH), and the same PUCCH symbol location may be allocated in each slot (Huawei, 2.4, the same UCI structure is transmitted repeatedly in every slot).

As to claim 4, the combination of Huawei and NTT teaches wherein UCI encoded bits are rate matched and loaded to all to PUCCH UCI carrying symbols of each slot of the long PUCCH separately (Huawei, 2.4, the same UCI structure is transmitted repeatedly in every slot where each slot has the same number of symbols). If the number of PUCCH symbols in each slot is the same, the PUCCH format and encoded UCI in each slot is repeated in multiple slots (Huawei, 2.4, the UCI is repeated in each slot for multiple slots when the same number of symbols exist).

As to claim 5, the combination of Huawei and NTT teaches wherein the frequency hopping is applied at slot boundaries in a multi-slot PUCCH (Huawei, 2.1, Frequency hopping is intra-slot in the multi slot long PUCCH).

As to claim 6, the combination of Huawei and NTT teaches wherein the frequency hopping is applied within each slot in a multi-slot PUCCH (Huawei, 2.1, Frequency hopping is in the middle of the long PUCCH).

As to claim 7, the combination of Huawei and NTT teaches wherein whether the frequency hopping is inter-slot or intra-slot (Huawei, 2.1, Frequency hopping is intra-slot in the multi slot long PUCCH) can be configured by higher layer signaling for a multi-slot PUCCH (NTT, Section 2, determining structure of a long PUCCH from DCI (downlink "gNB to UE" control information) signaling).

As to claim 8, Huawei teaches a base station (gNB) (Huawei, Section 1 and 2.3, a gNB for receiving on Uplink (from UE to gNB)), comprising: a processor; and memory in electronic communication with the processor, wherein instructions stored in the memory are executable (Huawei, Section 1 and 2.3, a gNB has a processor and memory to operate) to:

determine a demodulation reference signals (DMRS) structure in the configured multi-slot PUCCH (Huawei, 2.1, determine a DMRS position in the long PUCCH);

determine a frequency hopping method of the configured multi-slot PUCCH; determine UCI encoding and loading methods on the configured multi-slot PUCCH (Huawei, Section 1 Ran #88b and 2.4, determine UCI method for the PUCCH); and

receive UCI on a selected channel (Huawei, Section 1 Ran #88b, UCI payload reception on PUCCH).

Huawei does not explicitly teach determine an uplink control channel (PUCCH) spans over multiple slots based on a signaling from a base station (gNB); determine a resource of a control channel for UCI feedback.

However, NTT teaches determine an uplink control channel (PUCCH) spans over multiple slots based on a signaling from a base station (gNB) (NTT, Section 2, determining a duration of slots of a long PUCCH from DCI (downlink "gNB to UE" control information) signaling); determine a resource of a control channel for UCI feedback (NTT, Section 2, determine a PUCCH resource in time/frequency to use for UCI delivery).

It would have been obvious to one of ordinary skill in the art at the time of invention to combine the teachings of Huawei with NTT to determine slot duration and a resource because NTT teaches long PUCCH methods for improving reliability/coverage (NTT, Section 2).

As to claim 9, the combination of Huawei and NTT teaches wherein the number of PUCCH symbols in each slot of a multi-slot uplink control channel (PUCCH) is greater than or equal to 4 (Huawei, 2.1 & 2.2, PUCCH symbols is 4 to 14), and the reference symbol (RS) pattern in each slot is determined on a per slots basis by a long PUCCH format of a given the number of PUCCH symbols in the slot (Huawei, 2.1 & 2.2, the DMRS structure and SRS are determined based on the number of symbols).

As to claim 10, the combination of Huawei and NTT teaches wherein the number of PUCCH symbols may be the same in each slot of a multi-slot uplink control channel (PUCCH), and the same PUCCH symbol location may be allocated in each slot (Huawei, 2.4, the same UCI structure is transmitted repeatedly in every slot).

As to claim 11, the combination of Huawei and NTT teaches wherein UCI encoded bits are rate matched and loaded to all to PUCCH UCI carrying symbols of each slot of the long PUCCH separately (Huawei, 2.4, the same UCI structure is transmitted repeatedly in every slot where each slot has the same number of symbols). If the number of PUCCH symbols in each slot is the same, the PUCCH format and encoded UCI in each slot is repeated in multiple slots (Huawei, 2.4, the UCI is repeated in each slot for multiple slots when the same number of symbols exist)..

As to claim 12, the combination of Huawei and NTT teaches wherein the frequency hopping is applied at slot boundaries in a multi-slot PUCCH (Huawei, 2.1, Frequency hopping is intra-slot in the multi slot long PUCCH)..

As to claim 13, the combination of Huawei and NTT teaches wherein the frequency hopping is applied within each slot in a multi-slot PUCCH (Huawei, 2.1, Frequency hopping is in the middle of the long PUCCH)..

As to claim 14, the combination of Huawei and NTT teaches wherein whether the frequency hopping is inter-slot or intra- slot (Huawei, 2.1, Frequency hopping is intra-slot in the multi slot long PUCCH) can be configured by higher layer signaling for a multi-slot PUCCH (NTT, Section 2, determining structure of a long PUCCH from DCI (downlink "gNB to UE" control information) signaling).

As to claim 15, Huawei teaches a method by a user equipment (UE)) (Huawei, Section 1 and 2.3, a method for transmitting on Uplink (from UE to gNB)), comprising:

determine a demodulation reference signals (DMRS) structure in the configured multi-slot PUCCH (Huawei, 2.1, determine a DMRS position in the long PUCCH);

determine a frequency hopping method of the configured multi-slot PUCCH (Huawei, 2.1, determine a frequency hopping point on the long PUCCH);

determine UCI encoding and loading methods on the configured multi-slot PUCCH (Huawei, Section 1 Ran #88b and 2.4, determine UCI method for the PUCCH);

and transmit UCI on a selected channel (Huawei, Section 1 Ran #88b, UCI payload transmission on PUCCH).

Huawei does not explicitly teach determine an uplink control channel (PUCCH) spans over multiple slots based on a signaling from a base station (gNB); determine a resource of a control channel for UCI feedback.

However, NTT teaches determine an uplink control channel (PUCCH) spans over multiple slots based on a signaling from a base station (gNB) (NTT, Section 2, determining a duration of slots of a long PUCCH from DCI (downlink "gNB to UE" control information) signaling); determine a resource of a control channel for UCI feedback (NTT, Section 2, determine a PUCCH resource in time/frequency to use for UCI delivery).

It would have been obvious to one of ordinary skill in the art at the time of invention to combine the teachings of Huawei with NTT to determine slot duration and a resource because NTT teaches long PUCCH methods for improving reliability/coverage (NTT, Section 2).

As to claim 16, Huawei teaches a method by a base station (gNB) (Huawei, Section 1 and 2.3, a method for reception Uplink (from UE to gNB)), comprising:

determine a demodulation reference signals (DMRS) structure in the configured multi-slot PUCCH (Huawei, 2.1, determine a DMRS position in the long PUCCH);

determine a frequency hopping method of the configured multi-slot PUCCH; determine UCI encoding and loading methods on the configured multi-slot PUCCH (Huawei, Section 1 Ran #88b and 2.4, determine UCI method for the PUCCH); and receive UCI on a selected channel (Huawei, Section 1 Ran #88b, UCI payload reception on PUCCH).

Huawei does not explicitly teach determine an uplink control channel (PUCCH) spans over multiple slots based on a signaling from a base station (gNB); determine a resource of a control channel for UCI feedback.

However, NTT teaches determine an uplink control channel (PUCCH) spans over multiple slots based on a signaling from a base station (gNB) (NTT, Section 2, determining a duration of slots of a long PUCCH from DCI (downlink "gNB to UE" control information) signaling); determine a resource of a control channel for UCI feedback (NTT, Section 2, determine a PUCCH resource in time/frequency to use for UCI delivery).

It would have been obvious to one of ordinary skill in the art at the time of invention to combine the teachings of Huawei with NTT to determine slot duration and a resource because NTT teaches long PUCCH methods for improving reliability/coverage (NTT, Section 2).

Conclusion

6. Any inquiry concerning this communication or earlier communications from the examiner should be directed to AFSHAWN M TOWFIGHI whose telephone number is (571)270-7296. The examiner can normally be reached on M-F 8:00 AM -5:00 PM.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at <http://www.uspto.gov/interviewpractice>.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Ian N Moore can be reached on 571-272-3085. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/AFSHAWN M TOWFIGHI/
Primary Examiner, Art Unit 2469

<i>Notice of References Cited</i>	Application/Control No. 16/059,926		Applicant(s)/Patent Under Reexamination Yin et al.	
	Examiner AFSHAWN M TOWFIGHI		Art Unit 2469	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-20180323932-A1	11-2018	HUANG; Yi	H04L5/0012	1/1
*	B	US-20190081763-A1	03-2019	AKKARAKARAN; Sony	H04L1/0026	1/1
	C					
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FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
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<i>Search Notes</i> 	Application/Control No. 16/059,926	Applicant(s)/Patent Under Reexamination Yin et al.
	Examiner AFSHAWN M TOWFIGHI	Art Unit 2469

CPC - Searched*		
Symbol	Date	Examiner
H04L5/005 or H04L5/0091 or H04L5/0053 or H04W76/27 or H04L5/0055 or H04L1/1812 or H04B1/713 or H04W72/0413 or H04L5/0012 or H04L5/0048	08/22/2019	AT

CPC Combination Sets - Searched*		
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US Classification - Searched*			
Class	Subclass	Date	Examiner

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Search Notes		
Search Notes	Date	Examiner
H04L5/005 or H04L5/0091 or H04L5/0053 or H04W76/27 or H04L5/0055 or H04L1/1812 or H04B1/713 or H04W72/0413 or H04L5/0012 or H04L5/0048 (Text Search Only) - see search history printout	08/22/2019	AT
EAST(USPAT, USPGPUB, EPO, JPO) - see search history printout	08/22/2019	AT
Inventor and Assignee Search in EAST - see search history printout	08/22/2019	AT

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner

/AFSHAWN M TOWFIGHI/ Primary Examiner, Art Unit 2469	
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Bibliographic Data

Application No: 16/059,926

Foreign Priority claimed: ☐ Yes ☒ No

35 USC 119 (a-d) conditions met: ☐ Yes ☒ No ☐ Met After Allowance

Verified and Acknowledged: /AFSHAWN M TOWFIGHI/

Examiner's Signature

Initials

Title:

MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL
CHANNEL (PUCCH) DESIGN FOR 5th GENERATION (5G) NEW
RADIO (NR)

FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
08/09/2018	370	2469	SLA3704.3
RULE			

APPLICANTS

Sharp Kabushiki Kaisha, Sakai City, JAPAN

FG Innovation Company Limited, New Territories, CHINA

INVENTORS

Zhanping Yin Vancouver, WA, UNITED STATES

Toshizo Nogami Chiba, JAPAN

CONTINUING DATA

This application is a CON of PCT/US2018/045836 08/08/2018

This application has PRO of 62543795 08/10/2017

FOREIGN APPLICATIONS

IF REQUIRED, FOREIGN LICENSE GRANTED**

08/29/2018

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SUITE 735

SALT LAKE CITY, UT 84101

UNITED STATES

FILING FEE RECEIVED

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Doc code: IDS

PTO/SB/08a (03-15)

Doc description: Information Disclosure Statement (IDS) Filed

Approved for use through 07/31/2016. OMB 0651-0031

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number	16059926
	Filing Date	2018-08-09
	First Named Inventor	Zhanping Yin
	Art Unit	
	Examiner Name	
	Attorney Docket Number	SLA3704.3

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Examiner Name	
Attorney Docket Number	SLA3704.3

1	Sharp, "5G NR long PUCCH considerations", 3GPP TSG RAN WG1 NR Ad-Hoc Meeting, Spokane, USA, R1-1700731, 20 Jan 2017
2	ZTE, "On long-PUCCH for more than 2 bits", 3GPP TSG RAN WG1 NR Ad-Hoc#2, Qingdao, P.R. China, R1-1710115, 30 Jun 2017
3	Huawei, HiSilicon, "Long Duration PUCCH structure", 3GPP TSG RAN WG1 Meeting #89, Hangzhou, China, R1-1706953, 19 May 2017
4	International Search Report and Written Opinion issued for PCT Application No. PCT/US2018/045836 on 12 Oct 2018

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Examiner Signature	/AFSHAWN M TOWFIGHI/	Date Considered	08/21/2019
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Application Number	16059926
Filing Date	2018-08-09
First Named Inventor	Zhanping Yin
Art Unit	
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Attorney Docket Number	SLA3704.3

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Signature	/Wesley L. Austin/	Date (YYYY-MM-DD)	2018-12-11
Name/Print	Wesley L. Austin	Registration Number	42273

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EAST Search History**EAST Search History (Prior Art)**

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	21374	((("SHARP") near3 ("KABUSHIKI") near3 ("KAISHA")) OR (("FG") near3 ("INNOVATION") near3 ("COMPANY") near3 ("LIMITED"))).AS,AANM.	USPAT	OR	OFF	2019/08/22 03:32
L2	21374	((("SHARP") near3 ("KABUSHIKI") near3 ("KAISHA")) OR (("FG") near3 ("INNOVATION") near3 ("COMPANY") near3 ("LIMITED"))).AS,AANM.	USPAT	OR	OFF	2019/08/22 03:32
L3	685	((("YIN") near3 ("Zhanping")) OR (("NOGAMI") near3 ("Toshizo"))).INV.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	OFF	2019/08/22 03:32
L4	21828	l1 l3	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/08/22 03:34
L5	0	l4 and (frequency and hopping and gnb and UCI and lot and PUCCH and DMRS).clm.	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/08/22 03:36
L6	55048	(H04L5/005 or H04L5/0091 or H04L5/0053 or H04W76/27 or H04L5/0055 or H04L1/1812 or H04B1/713 or H04W72/0413 or H04L5/0012 or H04L5/0048).cpc.	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/08/22 03:37
L7	3	l6 and (long adj pucch with dmrs with hopping with determin\$3)	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/08/22 03:43
L8	3	l6 and (long adj pucch with dmrs with hopping with slot with determin\$3)	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/08/22 03:43
L9	3	(long adj pucch with dmrs with hopping with slot with determin\$3)	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/08/22 03:57

EAST Search History (Interference)

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Doc code: IDS

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Doc description: Information Disclosure Statement (IDS) Filed

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number	
	Filing Date	
	First Named Inventor	Zhanping Yin
	Art Unit	
	Examiner Name	
	Attorney Docket Number	SLA3704.3

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STATEMENT BY APPLICANT**
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Application Number	
Filing Date	
First Named Inventor	Zhanping Yin
Art Unit	
Examiner Name	
Attorney Docket Number	SLA3704.3

1	Huawei, HiSilicon, "Support of long-PUCCH over multiple slots", 3GPP TSG RAN WG1 NR Ad-Hoc Meeting, Qingdao, China, R1-1710013, 30 Jun 2017
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5	LG Electronics, "Support of long NR-PUCCH over multiple slots", 3GPP TSG RAN WG1 NR Ad-Hoc#2, Qingdao, China, R1-1710317, 30 Jun 2017
6	Intel Corporation, "Long PUCCH over multiple slots", 3GPP TSG RAN WG1 NR Ad-Hoc#2, Qingdao, China, R1-1710555, 30 Jun 2017
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8	ETRI, "Long-PUCCH over multiple slots", 3GPP TSG RAN WG1 NR Ad-Hoc#2, Qingdao, China, R1-1710620, 30 Jun 2017
9	Samsung, "Multi-Slot Long PUCCH Transmission", 3GPP TSG RAN WG1 NR Ad-Hoc#2, Qingdao, China, R1-1710707, 30 Jun 2017
10	Panasonic, "Discussion on support of long-duration NR-PUCCH over multiple slots", 3GPP TSG RAN WG1 NR Ad-Hoc#2, Qingdao, China, R1-1710935, 30 Jun 2017
11	CMCC, "NR Long PUCCH Design Requirements", 3GPP TSG RAN WG1 NR Ad-Hoc#2, Qingdao, China, R1-1710976, 30 Jun 2017

**INFORMATION DISCLOSURE
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Application Number	
Filing Date	
First Named Inventor	Zhanping Yin
Art Unit	
Examiner Name	
Attorney Docket Number	SLA3704.3

12	NTT DOCOMO, INC., "Long-PUCCH for more than one slot", 3GPP TSG RAN WG1 NR Ad-Hoc#2, Qingdao, China, R1-1711102, 30 Jun 2017
13	Qualcomm Incorporated, "Long PUCCH over multiple slots", 3GPP TSG RAN WG1 NR AH Meeting#2, Qingdao, China, R1-1711192, 30 Jun 2017
14	Sharp, "Structure of NR long PUCCH over multiple slots", 3GPP TSG RAN WG1 NR Ad-Hoc#2, Qingdao, China, R1-1711241, 30 Jun 2017
15	Cohere Technologies, "Support of Long-PUCCH over Multiple Slots", 3GPP TSG RAN WG1 NR Ad-Hoc Meeting #2, Qingdao, China, R1-1711252, 30 Jun 2017
16	Ericsson, "On support of Long PUCCH over multiple slots", 3GPP TSG-RAN WG1 NR Ad Hoc#2, Qingdao, China, R1-1711492, 30 Jun 2017

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EXAMINER SIGNATURE

Examiner Signature	/AFSHAWN M TOWFIGHI/	Date Considered	08/21/2019
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Signature	/Wesley L. Austin/	Date (YYYY-MM-DD)	2018-08-09
Name/Print	Wesley L. Austin	Registration Number	42273

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3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

~~ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.M.T/~~



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO	TOT CLAIMS	IND CLAIMS
16/059,926	08/09/2018	2415	2340	SLA3704.3	16	4

CONFIRMATION NO. 7857
CORRECTED FILING RECEIPT



50735
AUSTIN RAPP
170 SOUTH MAIN STREET
SUITE 735
SALT LAKE CITY, UT 84101

Date Mailed: 06/10/2019

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

Please verify the accuracy of the data presented on this receipt. If an error is noted on this Filing Receipt, please submit a written request for a corrected Filing Receipt, including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections provided that the request is grantable.

Inventor(s)

Zhanping Yin, Vancouver, WA;
Toshizo Nogami, Chiba, JAPAN;

Applicant(s)

Sharp Kabushiki Kaisha, Sakai City, JAPAN;
FG Innovation Company Limited, New Territories, CHINA;

Power of Attorney: The patent practitioners associated with Customer Number 50735

Domestic Priority data as claimed by applicant

This application is a CON of PCT/US2018/045836 08/08/2018
and claims benefit of 62/543,795 08/10/2017

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see <http://www.uspto.gov> for more information.) - None.

Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 08/29/2018

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 16/059,926**

Projected Publication Date: Not Applicable

Non-Publication Request: No

Early Publication Request: No

Title

MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5th
GENERATION (5G) NEW RADIO (NR)

Preliminary Class

370

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at <http://www.uspto.gov/web/offices/pac/doc/general/index.html>.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, <http://www.stopfakes.gov>. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific

page 2 of 4

countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER
Title 35, United States Code, Section 184
Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign Assets Control, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

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The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop

technology, manufacture products, deliver services, and grow your business, visit <http://www.SelectUSA.gov> or call +1-202-482-6800.



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
16/059,926	08/09/2018	Zhanping Yin	SLA3704.3

CONFIRMATION NO. 7857

POA ACCEPTANCE LETTER

50735
AUSTIN RAPP
170 SOUTH MAIN STREET
SUITE 735
SALT LAKE CITY, UT 84101



Date Mailed: 06/10/2019

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 06/03/2019.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at (571) 272-4000 or (571) 272-4200 or 1-888-786-0101.

/ygizaw/



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
16/059,926	08/09/2018	Zhanping Yin	SLA3704.3

50735
AUSTIN RAPP
170 SOUTH MAIN STREET
SUITE 735
SALT LAKE CITY, UT 84101

CONFIRMATION NO. 7857
IMPROPER CPOA LETTER



Date Mailed: 06/05/2019

NOTICE REGARDING POWER OF ATTORNEY

This is in response to the power of attorney filed 06/03/2019. The power of attorney in this application is not accepted for the reason(s) listed below:

The power of attorney filed 06/03/2019 has not been accepted because the power of attorney must be signed by the applicant for patent. See 37 CFR 1.32(b)(4).

- The request to change the applicant is not accepted because the Statement Under 37 CFR 3.73(c) ("3.73(c) Statement") does not account for 100% of the entire right, title, and interest of the application.

Because the request to change or update the applicant cannot be accepted, the power of attorney is not properly signed by the applicant and cannot be accepted. The change to applicant must be acceptable before the new applicant can appoint power of attorney.

/fly/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101



TRANSMITTAL FOR POWER OF ATTORNEY TO ONE OR MORE REGISTERED PRACTITIONERS

NOTE: This form is to be submitted with the Power of Attorney by Applicant form (PTO/AIA/82B) to identify the application to which the Power of Attorney is directed, in accordance with 37 CFR 1.5, unless the application number and filing date are identified in the Power of Attorney by Applicant form. If neither form PTO/AIA/82A nor form PTO/AIA/82B identifies the application to which the Power of Attorney is directed, the Power of Attorney will not be recognized in the application.

Application Number	16/059,926
Filing Date	08/09/2018
First Named Inventor	Zhanping Yin
Title	MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5th GENERATION (5G) NEW RADIO (NR)
Art Unit	2464
Examiner Name	Ricky Quoc Ngo
Attorney Docket Number	SLA3704.3

SIGNATURE of Applicant or Patent Practitioner

Signature	/Wesley L. Austin/	Date (Optional)	06/03/2019
Name	Wesley L. Austin	Registration Number	42273
Title (if Applicant is a juristic entity)			
Applicant Name (if Applicant is a juristic entity)			

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. If more than one applicant, use multiple forms.



*Total of 2 forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Doc Code: PA..

Document Description: Power of Attorney

PTO/AIA/82B (07-13)

Approved for use through 01/31/2018. OMB 0651-0035

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number

POWER OF ATTORNEY BY APPLICANT

I hereby revoke all previous powers of attorney given in the application identified in either the attached transmittal letter or the boxes below.

Application Number	Filing Date

(Note: The boxes above may be left blank if information is provided on form PTO/AIA/82A.)

☒ I hereby appoint the Patent Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above: 50735

OR

☐ I hereby appoint Practitioner(s) named in the attached list (form PTO/AIA/82C) as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the patent application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above. (Note: Complete form PTO/AIA/82C.)

Please recognize or change the correspondence address for the application identified in the attached transmittal letter or the boxes above to:

☒ The address associated with the above-mentioned Customer Number

OR

☐ The address associated with Customer Number:

OR

☐ Firm or
Individual Name

Address

City

State

Zip

Country

Telephone

Email

I am the Applicant (if the Applicant is a juristic entity, list the Applicant name in the box):

FG Innovation Company Limited

- ☐ Inventor or Joint Inventor (title not required below)
- ☐ Legal Representative of a Deceased or Legally Incapacitated Inventor (title not required below)
- ☒ Assignee or Person to Whom the Inventor is Under an Obligation to Assign (provide signer's title if applicant is a juristic entity)
- ☐ Person Who Otherwise Shows Sufficient Proprietary Interest (e.g., a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document) (provide signer's title if applicant is a juristic entity)

SIGNATURE of Applicant for Patent

The undersigned (whose title is supplied below) is authorized to act on behalf of the applicant (e.g., where the applicant is a juristic entity).

Signature Chie Ming Chou Date (Optional)

Name CHIE-MING CHOU

Title CEO

NOTE: Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. If more than one applicant, use multiple forms.

☒ Total of 3 forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 36 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

STATEMENT UNDER 37 CFR 3.73(c)

Applicant/Patent Owner: Zhanping Yin et al.
Application No./Patent No.: 16/059,926 Filed/Issue Date: 08/09/2018
Titled: MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5th GENERATION (5G) NEW RADIO (NR)
FG Innovation Company Limited, a corporation
(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that, for the patent application/patent identified above, it is (choose **one** of options 1, 2, 3 or 4 below):

1. ☐ The assignee of the entire right, title, and interest.
2. ☒ An assignee of less than the entire right, title, and interest (check applicable box):
- ☒ The extent (by percentage) of its ownership interest is 42.4%. Additional Statement(s) by the owners holding the balance of the interest must be submitted to account for 100% of the ownership interest.
- ☐ There are unspecified percentages of ownership. The other parties, including inventors, who together own the entire right, title and interest are:

Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

3. ☐ The assignee of an undivided interest in the entirety (a complete assignment from one of the joint inventors was made). The other parties, including inventors, who together own the entire right, title, and interest are:

Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

4. ☐ The recipient, via a court proceeding or the like (e.g., bankruptcy, probate), of an undivided interest in the entirety (a complete transfer of ownership interest was made). The certified document(s) showing the transfer is attached.

The interest identified in option 1, 2 or 3 above (not option 4) is evidenced by either (choose **one** of options A or B below):

- A. ☐ An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel _____, Frame _____, or for which a copy thereof is attached.
- B. ☒ A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: Zhanping Yin et al. To: Sharp Laboratories of America, Inc.

The document was recorded in the United States Patent and Trademark Office at
Reel 046852, Frame 0783, or for which a copy thereof is attached.

2. From: Sharp Laboratories of America, Inc. To: Sharp Kabushiki Kaisha

The document was recorded in the United States Patent and Trademark Office at
Reel 048386, Frame 0421, or for which a copy thereof is attached.

[Page 1 of 2]

This collection of information is required by 37 CFR 3.73(b). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

STATEMENT UNDER 37 CFR 3.73(c)

3. From: Sharp Kabushiki Kaisha To: Sharp Kabushiki Kaisha and FG Innovation Company Limited

The document was recorded in the United States Patent and Trademark Office at
Reel 049217, Frame 0940, or for which a copy thereof is attached.

4. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

5. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

6. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

☐ Additional documents in the chain of title are listed on a supplemental sheet(s).

☒ As required by 37 CFR 3.73(c)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (i.e., a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

Wesley L. Austin/

06/03/2019

Signature

Date

Wesley L. Austin

42273

Printed or Typed Name

Title or Registration Number

[Page 2 of 2]

Electronic Acknowledgement Receipt	
EFS ID:	36188865
Application Number:	16059926
International Application Number:	
Confirmation Number:	7857
Title of Invention:	MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5th GENERATION (5G) NEW RADIO (NR)
First Named Inventor/Applicant Name:	Zhanping Yin
Customer Number:	50735
Filer:	Wesley L. Austin/Jessamy Newton
Filer Authorized By:	Wesley L. Austin
Attorney Docket Number:	SLA3704.3
Receipt Date:	03-JUN-2019
Filing Date:	09-AUG-2018
Time Stamp:	20:34:09
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment		no			
File Listing:					
Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Miscellaneous Incoming Letter	SLA3704-3_RequestToChange Applicant_3292-2-309-3.pdf	21968	no	1
			e289fae5a69e88286eb1db5bc40124dcff17448		
Warnings:					

Information:					
2	Application Data Sheet	SLA3704-3_SupplementalApplicationDataSheet_3292-2-309-3.pdf	170870 014b4d0bb201378a22f545b575b803d3efed2338	no	8
Warnings:					
Information:					
This is not an USPTO supplied ADS fillable form					
3	Power of Attorney	SLA3704-3_PowerOfAttorney_SharpKabushikiKaisha_3292-2-309-3.pdf	250038 df96d642c0e9cd5ceb09c5b6e5fca8487e467e	no	3
Warnings:					
Information:					
4	Power of Attorney	SLA3704-3_PowerOfAttorney_FGIInnovation_3292-2-309-3.pdf	322461 66d11933c3efe0520495825dc0f5e1395cccb0bb	no	2
Warnings:					
Information:					
5	Assignee showing of ownership per 37 CFR 3.73	SLA3704-3_StatementUnder37CFR3-73c_FGIInnovation_3292-2-309-3.pdf	73531 03028a4c5d54aed07dbaab1e55280a9916e94ac7	no	2
Warnings:					
Information:					
Total Files Size (in bytes):			838868		
This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503. <u>New Applications Under 35 U.S.C. 111</u> If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application. <u>National Stage of an International Application under 35 U.S.C. 371</u> If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course. <u>New International Application Filed with the USPTO as a Receiving Office</u> If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.					

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application No. : 16/059,926 Confirmation No.: 7857
Applicant : Sharp Laboratories of America, Inc.
First Named Inventor : Zhanping Yin
Filed : August 9, 2018
Art Unit : 2464
Examiner : Ricky Quoc Ngo
Docket No. : SLA3704.3
Customer No. : 50735

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

REQUEST TO CHANGE APPLICANT

Sir:

Applicant hereby requests under 37 CFR 1.46(c) to change the Applicant from Sharp Laboratories of America, Inc. to Sharp Kabushiki Kaisha and FG Innovation Company Limited. A supplemental Application Data Sheet and Power of Attorney documents in support of this request are filed concurrently herewith.

Respectfully submitted,

/Wesley L. Austin/

Wesley L. Austin
Reg. No. 42,273
Attorney for Applicant

Date: June 3, 2019

AUSTIN RAPP
170 South Main Street, Suite 735
Salt Lake City, Utah 84101
Telephone: (801) 537-1700

SUPPLEMENTAL

PTO/AIA/14 (02-18)

Approved for use through 11/30/2020. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	SLA3704.3
		Application Number	16/059,926
Title of Invention	MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5th GENERATION (5G) NEW RADIO (NR)		
The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76. This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.			

Secrecy Order 37 CFR 5.2:

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1					Remove
Legal Name					
Prefix	Given Name	Middle Name	Family Name	Suffix	
	Zhanping		Yin		
Residence Information (Select One) ☒ US Residency ☐ Non US Residency ☐ Active US Military Service					
City	Vancouver	State/Province	WA	Country of Residence	US
Mailing Address of Inventor:					
Address 1		2104 SE 187th Avenue			
Address 2					
City	Vancouver	State/Province	WA		
Postal Code	98683	Country i	US		
Inventor 2					Remove
Legal Name					
Prefix	Given Name	Middle Name	Family Name	Suffix	
	Toshizo		Nogami		
Residence Information (Select One) ☐ US Residency ☒ Non US Residency ☐ Active US Military Service					
City	Chiba	Country of Residence i	JP		
Mailing Address of Inventor:					
Address 1		2-22 Utase, Unit 1-303			
Address 2		Mihama-ku, Chiba-shi			
City	Chiba	State/Province			
Postal Code	261-0013	Country i	JP		
All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the Add button.					Add

Correspondence Information:

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	SLA3704.3
		Application Number	16/059,926
Title of Invention	MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5th GENERATION (5G) NEW RADIO (NR)		
Enter either Customer Number or complete the Correspondence Information section below. For further information see 37 CFR 1.33(a).			
☐ An Address is being provided for the correspondence information of this application.			
Customer Number	50735		
Email Address	uspto@austin-rapp.com	Add Email	Remove Email

Application Information:

Title of the Invention	MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5th GENERATION (5G) NEW RADIO (NR)		
Attorney Docket Number	SLA3704.3	Small Entity Status Claimed	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	40	Suggested Figure for Publication (if any)	32

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)
☐ Request Not to Publish. I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application has not and will not be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32). Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative information during processing.			
Please Select One:	☒ Customer Number	☐ US Patent Practitioner	☐ Limited Recognition (37 CFR 11.9)
Customer Number	50735		

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	SLA3704.3
		Application Number	16/059,926
Title of Invention	MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5th GENERATION (5G) NEW RADIO (NR)		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.

When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status	Pending	Remove	
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
	Continuation of	PCTUS2018045836	2018-08-08
Prior Application Status	Pending	Remove	
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
	Claims benefit of provisional	62543795	2017-08-10

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button.

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)ⁱ the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Application Number	Country ⁱ	Filing Date (YYYY-MM-DD)	Remove
			Access Code ⁱ (if applicable)

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button.

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.

NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	SLA3704.3
		Application Number	16/059,926
Title of Invention	MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5th GENERATION (5G) NEW RADIO (NR)		

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	SLA3704.3
	Application Number	16/059,926
Title of Invention	MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5th GENERATION (5G) NEW RADIO (NR)	

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.			
Applicant 1			
If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.			
Clear			
☒ Assignee	☐ Legal Representative under 35 U.S.C. 117	☐ Joint Inventor	
☐ Person to whom the inventor is obligated to assign.		☐ Person who shows sufficient proprietary interest	
If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:			
Name of the Deceased or Legally Incapacitated Inventor:			
If the Applicant is an Organization check here. ☒			
Organization Name	Sharp Laboratories of America, Inc. Sharp Kabushiki Kaisha		
Mailing Address Information For Applicant:			
Address 1	5750 NW Pacific Rim Boulevard... 1, Takumi-cho		
Address 2			
City	Gamss Sakai-ku, Sakai City, Osaka	State/Province	WA
Country	US JP	Postal Code	98607-590-8522
Phone Number		Fax Number	
Email Address			
Additional Applicant Data may be generated within this form by selecting the Add button.			

SUPPLEMENTAL

PTO/AIA/14 (02-18)

Approved for use through 11/30/2020. OMB 0651-0032

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	SLA3704.3
	Application Number	16/059,926
Title of Invention	MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5th GENERATION (5G) NEW RADIO (NR)	

Applicant 2

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

- ☒ Assignee ☐ Legal Representative under 35 U.S.C. 117 ☐ Joint Inventor
- ☐ Person to whom the inventor is obligated to assign. ☐ Person who shows sufficient proprietary interest

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor:

If the Applicant is an Organization check here. ☒

Organization Name

Mailing Address Information For Applicant:

Address 1	Flat 2623, 26/F Tuen Mun Central Square		
Address 2	22 Hoi Wing Road, Tuen Mun		
City	New Territories, Hong Kong	State/Province	
Country	CN	Postal Code	
Phone Number		Fax Number	
Email Address			

Additional Applicant Data may be generated within this form by selecting the Add button.

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

If the Assignee or Non-Applicant Assignee is an Organization check here. ☐

SUPPLEMENTAL

PTO/AIA/14 (02-18)

Approved for use through 11/30/2020. OMB 0651-0032

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	SLA3704.3
		Application Number	16/059,926
Title of Invention	MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5th GENERATION (5G) NEW RADIO (NR)		

Prefix	Given Name	Middle Name	Family Name	Suffix

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1					
Address 2					
City		State/Province			
Country		Postal Code			
Phone Number		Fax Number			
Email Address					
Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button.					

Signature:

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). However, if this Application Data Sheet is submitted with the **INITIAL** filing of the application and either box A or B is **not** checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/Wesley L. Austin/		Date (YYYY-MM-DD)	2019-06-03	
First Name	Wesley L.	Last Name	Austin	Registration Number	42273
Additional Signature may be generated within this form by selecting the Add button.					

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. **DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the international Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

POWER OF ATTORNEY TO PROSECUTE APPLICATIONS BEFORE THE USPTO

I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(c).

I hereby appoint:



Practitioners associated with Customer Number:

50735

OR



Practitioner(s) named below (If more than ten patent practitioners are to be named, then a customer number must be used):

Name	Registration Number

Name	Registration Number

As attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned according to the USPTO assignment records or assignments documents attached to this form in accordance with 37 CFR 3.73(c).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(c) to:



The address associated with Customer Number:

50735

OR

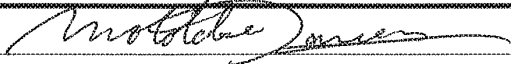
☐	Firm or Individual Name			
	Address			
	City	State	Zip	
	Country			
	Telephone	Email		

Assignee Name and Address: Sharp Kabushiki Kaisha
1 Takumi-cho, Sakai-ku
Sakai City, Osaka 590-8522, Japan

A copy of this form, together with a statement under 37 CFR 3.73(c) (Form PTO/AIA/96 or equivalent) is required to be filed in each application in which this form is used. The statement under 37 CFR 3.73(c) may be completed by one of The practitioners appointed in this form, and must identify the application in which this Power of Attorney is to be filed.

SIGNATURE of Assignee of Record

The individual whose signature and title is supplied below is authorized to act on behalf of the assignee

Signature		Date	27, Dec. 2017
Name	Mototaka Taneya	Telephone	360 834-8754
Title	Managing Officer, BU President, Corporate Research & Development BU		

This collection of information is required by 37 CFR 1.31, 1.32 and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

STATEMENT UNDER 37 CFR 3.73(c)

Applicant/Patent Owner: Zhanping Yin et al.
Application No./Patent No.: 16/059,926 Filed/Issue Date: 08/09/2018
Titled: MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5th GENERATION (5G) NEW RADIO (NR)
Sharp Kabushiki Kaisha, a corporation
(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that, for the patent application/patent identified above, it is (choose **one** of options 1, 2, 3 or 4 below):

1. ☐ The assignee of the entire right, title, and interest.
2. ☒ An assignee of less than the entire right, title, and interest (check applicable box):
- ☒ The extent (by percentage) of its ownership interest is 57.6%. Additional Statement(s) by the owners holding the balance of the interest must be submitted to account for 100% of the ownership interest.
- ☐ There are unspecified percentages of ownership. The other parties, including inventors, who together own the entire right, title and interest are:

Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

3. ☐ The assignee of an undivided interest in the entirety (a complete assignment from one of the joint inventors was made). The other parties, including inventors, who together own the entire right, title, and interest are:

Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

4. ☐ The recipient, via a court proceeding or the like (e.g., bankruptcy, probate), of an undivided interest in the entirety (a complete transfer of ownership interest was made). The certified document(s) showing the transfer is attached.

The interest identified in option 1, 2 or 3 above (not option 4) is evidenced by either (choose **one** of options A or B below):

- A. ☐ An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel _____, Frame _____, or for which a copy thereof is attached.
- B. ☒ A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: Zhanping Yin et al. To: Sharp Laboratories of America, Inc.

The document was recorded in the United States Patent and Trademark Office at
Reel 046852, Frame 0783, or for which a copy thereof is attached.

2. From: Sharp Laboratories of America, Inc. To: Sharp Kabushiki Kaisha

The document was recorded in the United States Patent and Trademark Office at
Reel 048386, Frame 0421, or for which a copy thereof is attached.

[Page 1 of 2]

This collection of information is required by 37 CFR 3.73(b). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

STATEMENT UNDER 37 CFR 3.73(c)

3. From: Sharp Kabushiki Kaisha To: Sharp Kabushiki Kaisha and FG Innovation Company Limited

The document was recorded in the United States Patent and Trademark Office at
Reel 049217, Frame 0940, or for which a copy thereof is attached.

4. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

5. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

6. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

☐ Additional documents in the chain of title are listed on a supplemental sheet(s).

☒ As required by 37 CFR 3.73(c)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (i.e., a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

Wesley L. Austin/

06/03/2019

Signature

Date

Wesley L. Austin

42273

Printed or Typed Name

Title or Registration Number



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
16/059,926	08/09/2018	Zhanping Yin	SLA3704.3

CONFIRMATION NO. 7857

50735

AUSTIN RAPP

170 SOUTH MAIN STREET

SUITE 735

SALT LAKE CITY, UT 84101

PUBLICATION NOTICE



OC000000105914568

Title:MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5th GENERATION (5G) NEW RADIO (NR)

Publication No.US-2019-0052421-A1

Publication Date:02/14/2019

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publicly available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently <http://www.uspto.gov/patft/>.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Public Records Division. The Public Records Division can be reached by telephone at (571) 272-3150 or (800) 972-6382, by facsimile at (571) 273-3250, by mail addressed to the United States Patent and Trademark Office, Public Records Division, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently <https://portal.uspto.gov/pair/PublicPair>. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

Doc code: IDS

Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (03-15)

Approved for use through 07/31/2016. OMB 0651-0031

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number	16059926
	Filing Date	2018-08-09
	First Named Inventor	Zhanping Yin
	Art Unit	
	Examiner Name	
	Attorney Docket Number	SLA3704.3

U.S. PATENTS							Remove	
Examiner Initial*	Cite No	Patent Number	Kind Code ¹	Issue Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines where Relevant Passages or Relevant Figures Appear		
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number		16059926
	Filing Date		2018-08-09
	First Named Inventor	Zhanping Yin	
	Art Unit		
	Examiner Name		
	Attorney Docket Number		SLA3704.3

1	Sharp, "5G NR long PUCCH considerations", 3GPP TSG RAN WG1 NR Ad-Hoc Meeting, Spokane, USA, R1-1700731, 20 Jan 2017
2	ZTE, "On long-PUCCH for more than 2 bits", 3GPP TSG RAN WG1 NR Ad-Hoc#2, Qingdao, P.R. China, R1-1710115, 30 Jun 2017
3	Huawei, HiSilicon, "Long Duration PUCCH structure", 3GPP TSG RAN WG1 Meeting #89, Hangzhou, China, R1-1706953, 19 May 2017
4	International Search Report and Written Opinion issued for PCT Application No. PCT/US2018/045836 on 12 Oct 2018

If you wish to add additional non-patent literature document citation information please click the Add button

EXAMINER SIGNATURE

Examiner Signature		Date Considered	
--------------------	--	-----------------	--

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

¹ See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. ² Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). ³ For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. ⁴ Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. ⁵ Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number		16059926
	Filing Date		2018-08-09
	First Named Inventor	Zhanping Yin	
	Art Unit		
	Examiner Name		
	Attorney Docket Number		SLA3704.3

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☒ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Wesley L. Austin/	Date (YYYY-MM-DD)	2018-12-11
Name/Print	Wesley L. Austin	Registration Number	42273

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. **DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

PCT

To:
Austin, Wesley L.
Austin Rapp
170 South Main Street, Suite 735
Salt Lake City, UT 84101
ETATS-UNIS D'AMERIQUE

NOTIFICATION OF TRANSMITTAL OF
THE INTERNATIONAL SEARCH REPORT AND
THE WRITTEN OPINION OF THE INTERNATIONAL
SEARCHING AUTHORITY, OR THE DECLARATION

(PCT Rule 44.1)

Date of mailing (day/month/year)		12 October 2018 (12-10-2018)
Applicant's or agent's file reference SLA3704-3PCT	FOR FURTHER ACTION See paragraphs 1 and 4 below	
International application No. PCT/US2018/045836	International filing date (day/month/year) 8 August 2018 (08-08-2018)	
Applicant SHARP LABORATORIES OF AMERICA, INC.		

- ☒ The applicant is hereby notified that the international search report and the written opinion of the International Searching Authority have been established and are transmitted herewith.
Filing of amendments and statement under Article 19:
The applicant is entitled, if he so wishes, to amend the claims of the International Application (see Rule 46):
When? The time limit for filing such amendments is normally two months from the date of transmittal of the International Search Report.
How? Directly to the International Bureau of WIPO, 34 chemin des Colombettes
1211 Geneva 20, Switzerland, Facsimile No.: (41-22) 338.82.70
For more detailed instructions, see PCT Applicant's Guide, International Phase, paragraphs 9.004 - 9.011.
- ☐ The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect and the written opinion of the International Searching Authority are transmitted herewith.
- ☐ **With regard to any protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:
 - ☐ the protest together with the decision thereon has been transmitted to the International Bureau together with any applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.
 - ☐ no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.
- Reminders**
The applicant may **submit comments on an informal basis on the written opinion of the International Searching Authority** to the International Bureau. These comments will be made available to the public after international publication. The International Bureau will send a copy of such comments to all designated Offices unless an international preliminary examination report has been or is to be established.
Shortly after the expiration of **18 months from the priority date, the international application will be published** by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau before the completion of the technical preparations for international publication (Rules 90*bis*.1 and 90*bis*.3).
Within **19 months** from the priority date, but only in respect of some designated Offices, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase **until 30 months** from the priority date (in some Offices even later); otherwise, the applicant must, **within 20 months** from the priority date, perform the prescribed acts for **entry into the national phase** before those designated Offices. In respect of other designated Offices, the time limit of **30 months** (or later) will apply even if no demand is filed within 19 months. For details about the applicable time limits, Office by Office, see www.wipo.int/pct/en/texts/time_limits.html and the *PCT Applicant's Guide, National Chapters*.
Within **22 months from the priority date, the applicant may request that a supplementary international search be carried out** by a different International Searching Authority that offers this service (Rule 45*bis*.1). The procedure for requesting supplementary international search is described in the *PCT Applicant's Guide, International Phase, paragraphs 8.006-8.032*.

Name and mailing address of the International Searching Authority  European Patent Office, P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel. (+31-70) 340-2040 Fax: (+31-70) 340-3016	Authorized officer KILIAN, Maren Tel: +31 (0)70 340-2458
--	--

Form PCT/ISA/220 (July 2017)

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference SLA3704-3PCT	FOR FURTHER ACTION see Form PCT/ISA/220 as well as, where applicable, item 5 below.	
International application No. PCT/US2018/045836	International filing date (<i>day/month/year</i>) 8 August 2018 (08-08-2018)	(Earliest) Priority Date (<i>day/month/year</i>) 10 August 2017 (10-08-2017)
Applicant SHARP LABORATORIES OF AMERICA, INC.		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 3 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

a. With regard to the **language**, the international search was carried out on the basis of:

- ☒ the international application in the language in which it was filed
☐ a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))

b. ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6**bis**(a)).

c. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. ☐ **Certain claims were found unsearchable** (See Box No. II)

3. ☐ **Unity of invention is lacking** (see Box No III)

4. With regard to the **title**,

- ☒ the text is approved as submitted by the applicant
☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

- ☒ the text is approved as submitted by the applicant
☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority

6. With regard to the **drawings**,

- a. the figure of the **drawings** to be published with the abstract is Figure No. 32
☒ as suggested by the applicant
☐ as selected by this Authority, because the applicant failed to suggest a figure
☐ as selected by this Authority, because this figure better characterizes the invention
 b. ☐ none of the figures is to be published with the abstract

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2018/045836

A. CLASSIFICATION OF SUBJECT MATTER

INV. H04L5/00

ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data, INSPEC, COMPENDEX

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	NTT DOCOMO ET AL: "Long-PUCCH for more than one slot", 3GPP DRAFT; R1-1711102, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE vol. RAN WG1, no. Qingdao, P.R. China; 20170627 - 20170630 26 June 2017 (2017-06-26), XP051300302, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN1/Docs/ [retrieved on 2017-06-26] sections 1-3 ----- -/--	1-16



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

3 October 2018

Date of mailing of the international search report

12/10/2018

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Barrientos Lezcano

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2018/045836

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	SHARP: "5G NR long PUCCH considerations", 3GPP DRAFT; R1-1700731, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. Spokane, USA; 20170116 - 20170120 16 January 2017 (2017-01-16), XP051208255, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_ SYNC/RAN1/Docs/ [retrieved on 2017-01-16] sections 1-5 -----	1,5,6,8, 12,13, 15,16
X	ZTE: "On long-PUCCH for more than 2 bits", 3GPP DRAFT; R1-1710115 ON LONG-PUCCH FOR MORE THAN 2 BITS, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. Qingdao, P.R. China; 20170627 - 20170630 26 June 2017 (2017-06-26), XP051299339, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_ SYNC/RAN1/Docs/ [retrieved on 2017-06-26] sections 1-3 -----	1,6,8, 13,15,16
A	HUAWEI ET AL: "Long duration PUCCH structure", 3GPP DRAFT; R1-1706953, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. Hangzhou, China; 20170515 - 20170519 14 May 2017 (2017-05-14), XP051272183, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_ SYNC/RAN1/Docs/ [retrieved on 2017-05-14] sections 1-3 -----	1-16

TITLE: MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5TH GENERATION (5G) NEW RADIO (NR)

APPLICANT: SHARP LABORATORIES OF AMERICA, INC.

IPC CLASSIFICATION: H04L5/00

EXAMINER: Barrientos Lezcano

CONSULTED DATABASES: DOSYS, EPODOC, WPI, TXT+, NPL, INSPEC, COMPDX, XPI3E, XPIEE, XP3GPP, XP3GPP2, SEASTAR, ANSERA, INET

CLASSIFICATION SYMBOLS DEFINING EXTENT OF THE SEARCH:

IPC:

CPC: H04L5/0053, H04L5/0048, H04L5/0091, H04L5/0012

FI/F-TERMS:

KEYWORDS OR OTHER ELEMENTS FEATURING THE INVENTION:

Multiple-slot PUCCH, multi-slot PUCCH, long PUCCH over slots. Determination of intra-slot of inter-slot frequency hopping, DMRS structure and UCI loading method to use in the transmission of multi-slot PUCCH.

From the
INTERNATIONAL SEARCHING AUTHORITY

see form PCT/ISA/220

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY
(PCT Rule 43*bis*.1)

Applicant's or agent's file reference
see form PCT/ISA/220

FOR FURTHER ACTION
See paragraph 2 below

Priority date (day/month/year)
10.08.2017

International Patent Classification (IPC) or both national classification and IPC
INV. H04L5/00

Applicant
SHARP LABORATORIES OF AMERICA, INC.

- | | |
|--|--|
| ☒ Box No. I | Basis of the opinion |
| ☐ Box No. II | Priority |
| ☐ Box No. III | Non-establishment of opinion with regard to novelty, inventive step and industrial applicability |
| ☐ Box No. IV | Lack of unity of invention |
| ☒ Box No. V | Reasoned statement under Rule 43 <i>bis</i> .1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement |
| ☐ Box No. VI | Certain documents cited |
| ☒ Box No. VII | Certain defects in the international application |
| ☒ Box No. VIII | Certain observations on the international application |

If a demand for international preliminary examination is made, this opinion will usually be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1 *bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.



European Patent Office
P.B. 5818 Patentlaan 2
NL-2280 HV Rijswijk - Pays Bas
Tel. +31 70 340 - 2040
Fax: +31 70 340 - 3016

Date of completion of
this opinion

see form
PCT/ISA/210

Authorized Officer _____

Barrientos Lezcano

Telephone No. +31 70 340-0



**WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY**

International application No.
PCT/US2018/045836

Box No. I Basis of the opinion

1. With regard to the **language**, this opinion has been established on the basis of:
 - ☒ the international application in the language in which it was filed.
 - ☐ a translation of the international application into , which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1 (b)).
2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))
3. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing:
 - a. ☐ forming part of the international application as filed:
 - ☐ in the form of an Annex C/ST.25 text file.
 - ☐ on paper or in the form of an image file.
 - b. ☐ furnished together with the international application under PCT Rule 13*ter*.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.
 - c. ☐ furnished subsequent to the international filing date for the purposes of international search only:
 - ☐ in the form of an Annex C/ST.25 text file (Rule 13*ter*.1(a)).
 - ☐ on paper or in the form of an image file (Rule 13*ter*.1(b) and Administrative Instructions, Section 713).
4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.
5. Additional comments:

**WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY**

International application No.
PCT/US2018/045836

Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes: Claims	<u>2-4, 7, 9-11, 14</u>
	No: Claims	<u>1, 5, 6, 8, 12, 13, 15, 16</u>
Inventive step (IS)	Yes: Claims	
	No: Claims	<u>1-16</u>
Industrial applicability (IA)	Yes: Claims	<u>1-16</u>
	No: Claims	

2. Citations and explanations

see separate sheet

Box No. VII Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

Reference is made to the following documents:

- D1 NTT DOCOMO ET AL: "Long-PUCCH for more than one slot", 3GPP DRAFT; R1-1711102, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG1, no. Qingdao, P.R. China; 20170627 - 20170630 26 June 2017 (2017-06-26), XP051300302, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN1/Docs/ [retrieved on 2017-06-26]
- D2 SHARP: "5G NR long PUCCH considerations", 3GPP DRAFT; R1-1700731, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG1, no. Spokane, USA; 20170116 - 20170120 16 January 2017 (2017-01-16), XP051208255, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN1/Docs/ [retrieved on 2017-01-16]
- D3 ZTE: "On long-PUCCH for more than 2 bits", 3GPP DRAFT; R1-1710115 ON LONG-PUCCH FOR MORE THAN 2 BITS, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG1, no. Qingdao, P.R. China; 20170627 - 20170630 26 June 2017 (2017-06-26), XP051299339, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN1/Docs/ [retrieved on 2017-06-26]
- D4 HUAWEI ET AL: "Long duration PUCCH structure", 3GPP DRAFT; R1-1706953, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG1, no. Hangzhou, China; 20170515 - 20170519 14 May 2017 (2017-05-14), XP051272183, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN1/Docs/ [retrieved on 2017-05-14]

1 NOVELTY

The present application does not meet the criteria of **Article 33(1) PCT**, because the subject-matter of **claims 1, 5-6, 8, 12-13 and 15-16** is not new in the sense of **Article 33(2) PCT**.

1.1 The document **D1** discloses (the references in parentheses applying to this document) the subject-matter of **independent claim 1**:

"A user equipment, UE, comprising:

a processor; and memory in electronic communication with the processor, wherein instructions stored in the memory are executable to:

- determine an uplink control channel, PUCCH, spans over multiple slots based on a signaling from a base station, gNB (section 2, "the exact structure of long-PUCCH for a given slot within the aggregated slots for a long-PUCCH transmission over multiple slots should be determined per slot basis. This should be realized by higher-layer signaling or L1 signalling");*
- determine a demodulation reference signals, DMRS, structure in the configured multi-slot PUCCH (section 1, "UCI/DMRS symbols");*
- determine a frequency hopping method of the configured multi-slot PUCCH (section 2, "frequency-hopping for a long-PUCCH over multiple slots .. frequency-hopping for a long-PUCCH within a slot");*
- determine UCI encoding and loading methods on the configured multi-slot PUCCH (section 2, "slot structure or usage could be different slot-by-slot", "UE2 - One UCI over 4 slots");*
- determine a resource of a control channel for UCI feedback (section 2, "PUCCH resource in time/frequency/code can be indicated by the scheduling DCI or can be configured by higher-layer"); and*
- transmit UCI on a selected channel (implicit from previous citations")*

Document **D1** (see section 2, "frequency-hopping for a long-PUCCH over multiple slots .. frequency-hopping for a long-PUCCH within a slot") also discloses the subject-matter of **dependent claims 5-6**. As a consequence of this, the subject-matter of **claim 1 and 5-6** cannot be considered novel (**Article 33(2) PCT**).

- 1.2 Document **D2** (sections 1-5. "A long PUCCH format may span multiple symbols and slots". "LTE PUCCH structure may be reused in NR. at least on the DMRS location". "A long PUCCH should occupy an integer number of RBs in frequency domain, and an integer number of slots in time domain". "The frequency hopping may be applied at slot level or sub-slot level". "The subset of symbols may be defined based on a beam sweeping pattern, e.g. indicated by the gNB") also discloses the subject-matter of **claims 1 and 5-6**; which are also considered not new (**Article 33(2) PCT**).
- 1.3 Document **D3** (sections 1-3. "start position and the length of long PUCCH should be signalled to the UE". "long-PUCCH over one or multiple slots". "the DMRS position is preconfigured". "DMRS and UCI symbols are TDMed". "intra-slot hopping") also discloses the subject-matter of **claims 1 and 6**; which are also considered not new (**Article 33(2) PCT**).
- 1.4 The same reasoning applies, mutatis mutandis, to the subject-matter of the corresponding **claims 8, 12-13 and 15-16**, which therefore are also considered not new (**Article 33(2) PCT**).

2 INVENTIVE STEP

The present application does not meet the criteria of **Article 33(1) PCT**, because the subject-matter of **claims 2-4, 7, 9-11 and 14** does not involve an inventive step in the sense of **Article 33(3) PCT**.

- 2.1 The document **D1** is regarded as being the closest prior art to the subject-matter of **dependent claims 2-4, and 7**. The additional features claimed by said claims are regarded as normal design options that come within the customary practice of the skilled person in the art, which consist merely in the juxtaposition or association of known features functioning in their normal way and not producing any surprising technical effect. In particular, rate-matching and high layer signalling are well known in the art and the claimed additional features from **dependent claims 2-3** have been already disclosed in document **D4** in the same context (sections 1-3. "long PUCCH in multiple slots". "gNB can enable frequency hopping". "the PUCCH channel in the

second slot is a direct repetition of the first slot. An example is shown in Figure 8(a). Direct repetition means the PUCCH symbols in the second slot convey the same signals as that in the first slot". "6 symbols operating on the upper PRB(s), but only 4 symbols operate on the lower PRB(s) -so 5 symbols per slot-". "DMRS should locate at the fixed position(s)". Therefore, the subject-matter of **dependent claims 2-4 and 7** cannot be considered inventive (**Article 33(3) PCT**).

- 2.2 The same reasoning applies, mutatis mutandis, to the subject-matter of the corresponding **claims 9-11 and 14**, which therefore are also considered not inventive (**Article 33(3) PCT**).

Re Item VII

Certain defects in the international application

- 1 The features of **claims 1-16** are not provided with reference signs placed in parentheses (**Rule 6.2(b) PCT**). Acronyms are not reference signs.
- 2 Contrary to the requirements of **Rule 5.1(a)(ii) PCT**, the relevant background art disclosed in **D1-D4** is not mentioned in the description.
- 3 The independent claims are not in the two-part form in accordance with **Rule 6.3(b) PCT**.

Re Item VIII

Certain observations on the international application

The application does not meet the requirements of **Article 6 PCT**, because **claims 1-4, 8-11 and 15-16** are not clear.

- 1 **Claims 1, 8, 15 and 16** are not clear in the following:
 - 1.1 The claims merely state the determination of DMRS structure, frequency hopping method, UCI encoding and loading and resource allocation for UCI; but do not specify based on what information the determination is being made. The mere fact of transmitting/receiving UCI and DMRS and the mention of frequency hopping would already take away the novelty of this

features. The features could be also interpreted as UCI is being transmitted and the result of the determination of DMRS and frequency hopping being not to transmit DMRS and not to use frequency hopping.

- 1.2 The claims only recite the transmission/reception of UCI. It is doubtful thus, if there is actually a transmission/reception of the multi-slot PUCCH, a transmission/reception of DMRS and if frequency hopping is even used.
- 2 **Claims 2 and 9** refer to "the RS pattern". There is however no antecedent. It seems that this refers to the DMRS structure determined in the independent claims.
- 3 **Claims 3 and 10** contain the expression "may be" twice. The following feature is thus optional. The expression should be instead "is".
- 4 **Claims 4 and 11** contain incoherent language.
- 5 **Claim 8** does not transmit the signalling specified by **claim 1** in order to determine tat the PUCCH spans over multiple slots. **Claim 8** is not corresponding to **claim 1** (in that it cannot be considered interrelated apparatuses). Said step is thus missing from **claim 8**.

Possible steps after receipt of the international search report (ISR) and written opinion of the International Searching Authority (WO/ISA)

General information

For all international applications, the competent International Searching Authority (ISA) will establish an international search report (ISR) accompanied by a written opinion of the International Searching Authority (WO/ISA). The WO/ISA may be responded to by

- filing informal comments with the **International Bureau of WIPO (IB)** (where no demand for international preliminary examination (**demand**) is filed)
- filing amendments under Art. 19 PCT (this can be done whether or not a **demand** is filed)
- filing amendments under Art. 34 PCT and/or formal observations in response to objections raised in the **WO/ISA** (where a **demand** is actually filed)

This document explains these possibilities.

Filing informal comments

After receipt of the **ISR and WO/ISA**, the applicant may file informal comments on the **WO/ISA**, **directly with the IB** (see International Search and Preliminary Examination Guidelines 2.15). These will be communicated to the designated/elected Offices, together with the International Preliminary Report on Patentability (**IPRP**) at 30 months from the priority date.

Amending claims under Art. 19 PCT

The applicant may file **amended claims** under Art. 19 PCT, **directly with the IB** by the later of the following dates:

- 2 months from the date of mailing of the **ISR** and the **WO/ISA**
- 16 months from the priority date

However, any such amendment received by the **IB** after the expiration of the applicable time limit shall be **considered to have been received on time** by the **IB**, if it reaches it **before** the technical preparations for international publication have been completed (the 15th day prior to the date of publication, see PCT Applicant's Guide, International Phase, 9.013).

For further information, please see Rule 46 PCT as well as form PCT/ISA/220.

Please also note that, when filing amended claims under Art. 19 PCT, such amendments shall be **accompanied by a letter** identifying the amendments made and also the basis for the amendments in the application as originally filed (Rule 46.5(b) PCT). Where a **demand** is filed, failure to comply with this requirement may result in the amendments being ignored in the International Preliminary Examination Report (**IPER**), see Rule 70.2(c-bis) PCT.

**Filing a demand
for international
preliminary
examination**

In principle, the **WO/ISA** will be considered to be the written opinion of the International Preliminary Examining Authority (**IPEA**). Where the **WO/ISA** issued by the **EPO** as **ISA** gives a positive opinion on the international application and the invention to which it relates, filing a **demand** with the **EPO** as **IPEA** would normally be unnecessary, since a positive **IPRP** would anyway be established by the **IB** based on the **WO/ISA** (see also further below).

If the applicant wishes to file a **demand** (for example, to allow him to argue his case in international preliminary examination with regard to objections raised in a negative **WO/ISA** before the **IPEA** issues an **IPER**), this must be done before expiration of **3 months after the date of mailing of the ISR and WO/ISA** or **22 months after priority date**, whichever expires later (Rule 54*bis* PCT). Amendments under Art. 34 PCT can be filed with the **IPEA**, normally at the same time as filing the demand (Rule 66.1(b) PCT) or within the time limit set for reply to any written opinion issued during international preliminary examination by the **IPEA**.

If a **demand** is filed at the **EPO** as **IPEA** and no comments/amendments have been received by the time the **EPO** starts drawing up the **IPER** (Rule 66.4*bis* PCT), the **WO/ISA** will be transformed by the **IPEA** into an **IPER** (also called the **IPRP (Chapter II)** which would merely reflect the content of the **WO/ISA** (OJ 10/2011, 532). The **demand** can still be withdrawn (Art. 37 PCT).

Please also note that, when filing amendments under Art. 34 PCT, such amendments shall be accompanied by a letter which identifies the amendments made and also the basis for the amendments in the application as originally filed (Rule 66.8(a) PCT). Failure to comply with this requirement may result in the amendments being ignored in the **IPER (IPRP (Chapter II))**, see Rule 70.2(c-*bis*) PCT.

**Filing a request
for supplementary
international
search**

The applicant may, with the **IB**, file a request for **supplementary international search** under Rule 45*bis*.1 PCT. The present **ISR** and **WO/ISA** may also be taken into account in the execution of that supplementary international search, provided that these are available to the Authority charged with this task before it starts the supplementary search (Rule 45*bis*.5 PCT).

This kind of request **cannot be filed specifying the ISA** who did the **international search**.

More information on this topic can be found in the **PCT Applicant's Guide**, Chapter 8 (<http://www.wipo.int/pct/en/guide/ip08.html>).

**End of the
international
phase**

Where no **demand** is filed, at the end of the international phase, the **IB** will transform the **WO/ISA** into the **IPRP (PCT Chapter I)** (Rule 44*bis* PCT), which will then be transmitted together with possible informal comments to the designated Offices. Where a demand is filed, the **WO/ISA** is not transformed into an **IPRP (Chapter I)** by the **IB**, but rather the **IPEA** will establish an **IPER**, (the **IPER** is the same as the **IPRP (PCT Chapter II)**, see Rule 70.15 PCT).

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XS CPRTENFRDE

Electronic Acknowledgement Receipt	
EFS ID:	34550303
Application Number:	16059926
International Application Number:	
Confirmation Number:	7857
Title of Invention:	MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5th GENERATION (5G) NEW RADIO (NR)
First Named Inventor/Applicant Name:	Zhanping Yin
Customer Number:	50735
Filer:	Wesley L. Austin/Jessamy Newton
Filer Authorized By:	Wesley L. Austin
Attorney Docket Number:	SLA3704.3
Receipt Date:	11-DEC-2018
Filing Date:	09-AUG-2018
Time Stamp:	15:01:56
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no
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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Form (SB08)	SLA3704-3_SupplIDS_3292-2-3 09-3.pdf	1035035	no	4
			84c640ea06ed3fed569b2ca7ead424ba2af9fc9f		

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2	Non Patent Literature	R1-1700731.pdf	289786	no	3
			2d035dffcb67d1b10e63fe4a220ec4b9575840f8		
Warnings:					
Information:					
3	Non Patent Literature	R1-1710115.pdf	362906	no	5
			6c66275e582fbac7d5554dc4f03482e70db7e1666		
Warnings:					
Information:					
4	Non Patent Literature	R1-1706953.pdf	1007419	no	7
			2f25fab34e4574b138e1bf0c78b0e443e13a3ac0		
Warnings:					
Information:					
5	Non Patent Literature	PCTUS2018045836_PCTSearch Report_12Oct2018.pdf	4069211	no	16
			dd16182cc5a29a343f9962385b8c3ae5f7152dc4		
Warnings:					
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Total Files Size (in bytes):			6764357		

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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.



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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
16/059,926	08/09/2018	Zhanping Yin	SLA3704.3

CONFIRMATION NO. 7857

POA ACCEPTANCE LETTER

50735
AUSTIN RAPP
170 SOUTH MAIN STREET
SUITE 735
SALT LAKE CITY, UT 84101



Date Mailed: 09/17/2018

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 09/12/2018.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at (571) 272-4000 or (571) 272-4200 or 1-888-786-0101.

/qtran/

Electronic Acknowledgement Receipt	
EFS ID:	33700261
Application Number:	16059926
International Application Number:	
Confirmation Number:	7857
Title of Invention:	MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5th GENERATION (5G) NEW RADIO (NR)
First Named Inventor/Applicant Name:	Zhanping Yin
Customer Number:	50735
Filer:	Wesley L. Austin/Ashley Austin
Filer Authorized By:	Wesley L. Austin
Attorney Docket Number:	SLA3704.3
Receipt Date:	12-SEP-2018
Filing Date:	09-AUG-2018
Time Stamp:	15:14:40
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment		no			
File Listing:					
Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Oath or Declaration filed	SLA3704-3_Declaration_3292-2-309-3.pdf	221878	no	2
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Warnings:					

Information:					
2	Power of Attorney	SLA3704-3_PowerOfAttorney_3292-2-309-3.pdf	689513	no	5
			1389a40cb28c8a15d1923c9d26c90ecde1bf30e56		
Warnings:					
Information:					
Total Files Size (in bytes):			911391		
This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503. <u>New Applications Under 35 U.S.C. 111</u> If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application. <u>National Stage of an International Application under 35 U.S.C. 371</u> If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course. <u>New International Application Filed with the USPTO as a Receiving Office</u> If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.					

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	)	PATENT APPLICATION
Inventors: Zhanping Yin et al.	)	
Serial No.: 16/059,926	)	Attorney Docket No.
	)	SLA3704.3
Filed: August 9, 2018	)	
Title: Multiple Slot Long Physical Uplink	)	
Control Channel (PUCCH) Design for	)	
5th Generation (5G) New Radio (NR)	)	

DECLARATION FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

This declaration is directed to:

- ☐ The attached application; OR
- ☒ The United States Application or PCT International application number assigned the above-identified "Serial No."; filed on the above-identified "Filed" date.

The above-identified application was made or authorized to be made by me.

I believe I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

Full name of sole
or first inventor: Zhanping Yin

Residence: Vancouver, WA

Post Office Address: 2104 SE 187th Avenue, Vancouver, WA 98683

Inventor's Signature: 

Date: Sep 10, 2018

Full name
of second inventor: Toshizo Nogami

Residence: Chiba 261-0013, Japan

Post Office Address: 2-22 Utase, Unit 1-303, Mihama-ku, Chiba-shi,
Chiba 261-0013, Japan

Inventor's Signature: Toshizo Nogami

Date: August 15 2018

POWER OF ATTORNEY TO PROSECUTE APPLICATIONS BEFORE THE USPTO

I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(c).

I hereby appoint:

☒

Practitioners associated with Customer Number:

50,735

OR

☐

Practitioner(s) named below (if more than ten patent practitioners are to be named, then a customer number must be used):

Name	Registration Number

Name	Registration Number

As attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned according to the USPTO assignment records or assignments documents attached to this form in accordance with 37 CFR 3.73(c).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(c) to:

☒

The address associated with Customer Number:

50,735

OR

☐	Firm or Individual Name			
	Address			
	City		State	Zip
	Country			
	Telephone			Email

Assignee Name and Address: **Sharp Laboratories of America, Inc.**
5750 NW Pacific Rim Blvd.
Camas, WA 98607

A copy of this form, together with a statement under 37 CFR 3.73(c) (Form PTO/AIA/96 or equivalent) is required to be Filed in each application in which this form is used. The statement under 37 CFR 3.73(c) may be completed by one of The practitioners appointed in this form, and must identify the application in which this Power of Attorney is to be filed.

SIGNATURE of Assignee of Record

The individual whose signature and title is supplied below is authorized to act on behalf of the assignee

Signature	/David C. Ripma/	Date	September 1, 2017
Name	David C. Ripma	Telephone	360-834-8754
Title	Patent Counsel of MiiCs IP, Inc. a subsidiary of SBPJ Co., Ltd. and Sharp Corporation		

This collection of information is required by 37 CFR 1.31, 1.32 and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

STATEMENT UNDER 37 CFR 3.73(c)

Applicant/Patent Owner: Zhanping Yin and Toshizo Nogami

Application No./Patent No.: 16/059,926 Filed/Issue Date: August 9, 2018

Titled: Multiple Slot Long Physical Uplink Control Channel (PUCCH) Design for 5th Generation (5G) New Radio (NR)
Sharp Laboratories of America, Inc., a Corporation

(Name of Assignee)

(Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that, for the patent application/patent identified above, it is (choose **one** of options 1, 2, 3 or 4 below):

1. ☒ The assignee of the entire right, title, and interest.
2. ☐ An assignee of less than the entire right, title, and interest (check applicable box):
- ☐ The extent (by percentage) of its ownership interest is ____%. Additional Statement(s) by the owners holding the balance of the interest must be submitted to account for 100% of the ownership interest.
- ☐ There are unspecified percentages of ownership. The other parties, including inventors, who together own the entire right, title and interest are:

Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

3. ☐ The assignee of an undivided interest in the entirety (a complete assignment from one of the joint inventors was made). The other parties, including inventors, who together own the entire right, title, and interest are:

Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

4. ☐ The recipient, via a court proceeding or the like (e.g., bankruptcy, probate), of an undivided interest in the entirety (a complete transfer of ownership interest was made). The certified document(s) showing the transfer is attached.

The interest identified in option 1, 2 or 3 above (not option 4) is evidenced by either (choose **one** of options A or B below):

- A. ☒ An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel _____, Frame _____, or for which a copy thereof is attached.

- B. ☐ A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

2. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

[Page 1 of 2]

This collection of information is required by 37 CFR 3.73(b). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

STATEMENT UNDER 37 CFR 3.73(c)

3. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

4. From: _____ To: _____

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The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

6. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

☐ Additional documents in the chain of title are listed on a supplemental sheet(s).

☒ As required by 37 CFR 3.73(c)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (i.e., a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

/David C. Ripma/

Signature

David C. Ripma

Printed or Typed Name

September 10, 2018

Date

Reg. No. 27,672

Title or Registration Number

ASSIGNMENT

WHEREAS, the undersigned Zhanping Yin, a resident of Vancouver, WA and Toshizo Nogami, a resident of Chiba, Japan, (hereinafter termed "Inventors") have invented certain new and useful improvements in:

Multiple Slot Long Physical Uplink Control Channel (PUCCH) Design for 5th Generation (5G) New Radio (NR)

and have executed a declaration and oath for an application for a United States patent disclosing and identifying the invention:

☐ Declaration executed on _____

or

☒ Having been previously filed and assigned Serial Number 16/059,926 and filing date August 9, 2018; and

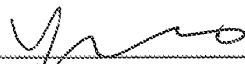
WHEREAS Sharp Laboratories of America, Inc., a corporation of the State of Washington, (hereinafter termed "Assignee"), having a place of business at 5750 NW Pacific Rim Boulevard, Camas, Washington 98607, wishes to acquire the entire right, title and interest in and to said application and the invention disclosed therein, and in and to all embodiments of the invention, heretofore conceived, made or discovered by said Inventors (all collectively hereinafter termed "said invention"), and in and to any and all patents, certificates of invention and other forms of protection thereon (hereinafter termed "patents") applied for or granted in the United States and/or other countries.

NOW THEREFORE, for good and valuable consideration acknowledged by said Inventors to have been received in full from said Assignee:

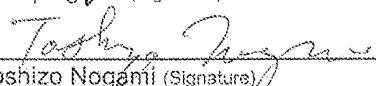
1. Said Inventors hereby sell, assign, transfer and convey unto said Assignee, the entire right, title and interest (a) in and to said application and said invention; (b) in and to all rights to apply in any and all countries of the world for patents, certificates of inventions or other government grants on said invention, including the right to apply for patents pursuant to the International Convention for the Protection of Industrial Property or pursuant to any other convention, treaty, agreement or understanding; (c) in and to any and all applications filed and any and all patents, certificates of inventions or other governmental grants granted on said invention in the United States or any other country, including each and every application filed and each and every patent granted on any application which is a division, substitution, or continuation of any of said applications; (d) in and to each and every reissue or extension of any of said patents; and (e) in and to each and every patent claim resulting from a reexamination certificate for any and all of said patents.

2. Said Inventors hereby covenant and agree to cooperate with said Assignee to enable said Assignee to enjoy to the fullest extent the right, title and interest herein conveyed in the United States and other countries. Such cooperation by said Inventors shall include prompt production of pertinent facts and documents, giving of testimony, executing of petitions, oaths, specifications, declarations or other papers, and other assistance all to the extent deemed necessary or desirable by said Assignee (a) for perfecting in said Assignee the right, title and interest herein conveyed; (b) for complying with any duty of disclosure; (c) for prosecuting any of said applications; (d) for filing and prosecuting substitute, divisional, continuing or additional applications covering said invention; (e) for filing and prosecuting applications for reissue of any of said patents; (f) for interference or other priority proceedings involving said invention; and (g) for legal proceedings involving said invention and any applications therefore and any patents granted thereon, including without limitation opposition proceedings, cancellation proceedings, priority contests, public use proceedings, reexamination proceedings, compulsory licensing proceedings, infringement actions and court actions; provided, however, that the expense incurred by said Inventors in providing such cooperation shall be paid for by said Assignee.
3. The terms and covenants of this Assignment shall inure to the benefit of said Assignee, its successors, assigns and other legal representatives, and shall be binding upon said Inventors, said Inventors' heirs, legal representatives and assigns.
4. Said Inventors hereby warrant and represent that said Inventors have not entered and will not enter into any assignment, contract, or understanding in conflict with this Assignment.

IN WITNESS WHEREOF, the said Inventors have executed this Assignment on the date given below:

(1) 
Zhanping Yin (Signature)

Sep 10, 2018
(Date)

(2) 
Toshizo Nogami (Signature)

August 15 2018
(Date)



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
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Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
16/059,926	08/09/2018	Zhanping Yin	SLA3704.3

CONFIRMATION NO. 7857

50735
AUSTIN RAPP
170 SOUTH MAIN STREET
SUITE 735
SALT LAKE CITY, UT 84101

INFORMAL NOTICE



Date Mailed: 08/31/2018

INFORMATIONAL NOTICE TO APPLICANT

Applicant is notified that the above-identified application contains the deficiencies noted below. No period for reply is set forth in this notice for correction of these deficiencies. However, if a deficiency relates to the inventor's oath or declaration, the applicant must file an oath or declaration in compliance with 37 CFR 1.63, or a substitute statement in compliance with 37 CFR 1.64, executed by or with respect to each actual inventor no later than the expiration of the time period set in the "Notice of Allowability" to avoid abandonment. See 37 CFR 1.53(f).

The item(s) indicated below are also required and should be submitted with any reply to this notice to avoid further processing delays.

- A properly executed inventor's oath or declaration has not been received for the following inventor(s):
Zhanping Yin
Toshizo Nogami

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at (571) 272-4000 or (571) 272-4200 or 1-888-786-0101.

/bcao/

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875					Application or Docket Number 16/059,926		
APPLICATION AS FILED - PART I							
(Column 1)		(Column 2)		SMALL ENTITY		OR	
FOR	NUMBER FILED	NUMBER EXTRA	RATE(\$)	FEE(\$)	OTHER THAN SMALL ENTITY		
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A		N/A	300	
SEARCH FEE (37 CFR 1.16(k), (l), or (m))	N/A	N/A	N/A		N/A	660	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A		N/A	760	
TOTAL CLAIMS (37 CFR 1.16(j))	16	minus 20 = *			OR	x 100 = 0.00	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	4	minus 3 = *	1		OR	x 460 = 460	
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$310 (\$155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).					0.00	
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))						0.00	
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL		TOTAL	2180	
APPLICATION AS AMENDED - PART II							
(Column 1)		(Column 2)		(Column 3)		SMALL ENTITY	
AMENDMENT A	CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE(\$)	ADDITIONAL FEE(\$)	OTHER THAN SMALL ENTITY	
	Total (37 CFR 1.16(i))	*	Minus	**	=	RATE(\$)	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	ADDITIONAL FEE(\$)	
	Application Size Fee (37 CFR 1.16(s))					OR	
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					OR	
TOTAL ADD'L FEE					OR	TOTAL ADD'L FEE	
(Column 1)		(Column 2)		(Column 3)		SMALL ENTITY	
AMENDMENT B	CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE(\$)	ADDITIONAL FEE(\$)	OTHER THAN SMALL ENTITY	
	Total (37 CFR 1.16(i))	*	Minus	**	=	RATE(\$)	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	ADDITIONAL FEE(\$)	
	Application Size Fee (37 CFR 1.16(s))					OR	
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					OR	
TOTAL ADD'L FEE					OR	TOTAL ADD'L FEE	
* If the entry in column 1 is less than the entry in column 2, write "0" in column 3. ** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20". *** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3". The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.							



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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO	TOT CLAIMS	IND CLAIMS
16/059,926	08/09/2018		2340	SLA3704.3	16	4

CONFIRMATION NO. 7857

FILING RECEIPT



0000000101934276

50735
AUSTIN RAPP
170 SOUTH MAIN STREET
SUITE 735
SALT LAKE CITY, UT 84101

Date Mailed: 08/31/2018

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

Zhanping Yin, Vancouver, WA;
Toshizo Nogami, Chiba, JAPAN;

Applicant(s)

Sharp Laboratories of America, Inc., Camas, WA;

Power of Attorney: None

Domestic Priority data as claimed by applicant

This application is a CON of PCT/US2018/045836 08/08/2018
and claims benefit of 62/543,795 08/10/2017

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see <http://www.uspto.gov> for more information.) - None.

Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 08/29/2018

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 16/059,926**

Projected Publication Date: 02/14/2019

Non-Publication Request: No

Early Publication Request: No
Title

MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5th GENERATION (5G) NEW RADIO (NR)

Preliminary Class

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at <http://www.uspto.gov/web/offices/pac/doc/general/index.html>.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, <http://www.stopfakes.gov>. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER
Title 35, United States Code, Section 184
Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign Assets Control, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

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The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop technology, manufacture products, deliver services, and grow your business, visit <http://www.SelectUSA.gov> or call +1-202-482-6800.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number	
	Filing Date	
	First Named Inventor	Zhanping Yin
	Art Unit	
	Examiner Name	
	Attorney Docket Number	SLA3704.3

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number		
	Filing Date		
	First Named Inventor	Zhanping Yin	
	Art Unit		
	Examiner Name		
	Attorney Docket Number	SLA3704.3	

1	Huawei, HiSilicon, "Support of long-PUCCH over multiple slots", 3GPP TSG RAN WG1 NR Ad-Hoc Meeting, Qingdao, China, R1-1710013, 30 Jun 2017
2	CATT, "Design of multi-slot PUCCH transmission", 3GPP TSG RAN WG1 NR Ad-Hoc#2, Qingdao, China, R1-1710087, 30 Jun 2017
3	ZTE, "Consideration on long-PUCCH over slots", 3GPP TSG RAN WG1 NR Ad-Hoc#2, Qingdao, China, R1-1710116, 30 Jun 2017
4	Guangdong OPPO Mobile Telecom, "Slot aggregation and configuration for NR long PUCCH", 3GPP TSG RAN WG1 NR Ad-Hoc#2, Qingdao, China, R1-1710159, 30 Jun 2017
5	LG Electronics, "Support of long NR-PUCCH over multiple slots", 3GPP TSG RAN WG1 NR Ad-Hoc#2, Qingdao, China, R1-1710317, 30 Jun 2017
6	Intel Corporation, "Long PUCCH over multiple slots", 3GPP TSG RAN WG1 NR Ad-Hoc#2, Qingdao, China, R1-1710555, 30 Jun 2017
7	Lenovo, Motorola Mobility "Long PUCCH over multiple slots", 3GPP TSG RAN WG1 NR Ad-Hoc#2, Qingdao, China, R1-1710600, 30 Jun 2017
8	ETRI, "Long-PUCCH over multiple slots", 3GPP TSG RAN WG1 NR Ad-Hoc#2, Qingdao, China, R1-1710620, 30 Jun 2017
9	Samsung, "Multi-Slot Long PUCCH Transmission", 3GPP TSG RAN WG1 NR Ad-Hoc#2, Qingdao, China, R1-1710707, 30 Jun 2017
10	Panasonic, "Discussion on support of long-duration NR-PUCCH over multiple slots", 3GPP TSG RAN WG1 NR Ad-Hoc#2, Qingdao, China, R1-1710935, 30 Jun 2017
11	CMCC, "NR Long PUCCH Design Requirements", 3GPP TSG RAN WG1 NR Ad-Hoc#2, Qingdao, China, R1-1710976, 30 Jun 2017

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number		
	Filing Date		
	First Named Inventor	Zhanping Yin	
	Art Unit		
	Examiner Name		
	Attorney Docket Number	SLA3704.3	

12	NTT DOCOMO, INC., "Long-PUCCH for more than one slot", 3GPP TSG RAN WG1 NR Ad-Hoc#2, Qingdao, China, R1-1711102, 30 Jun 2017
13	Qualcomm Incorporated, "Long PUCCH over multiple slots", 3GPP TSG RAN WG1 NR AH Meeting#2, Qingdao, China, R1-1711192, 30 Jun 2017
14	Sharp, "Structure of NR long PUCCH over multiple slots", 3GPP TSG RAN WG1 NR Ad-Hoc#2, Qingdao, China, R1-1711241, 30 Jun 2017
15	Cohere Technologies, "Support of Long-PUCCH over Multiple Slots", 3GPP TSG RAN WG1 NR Ad-Hoc Meeting #2, Qingdao, China, R1-1711252, 30 Jun 2017
16	Ericsson, "On support of Long PUCCH over multiple slots", 3GPP TSG-RAN WG1 NR Ad Hoc#2, Qingdao, China, R1-1711492, 30 Jun 2017

If you wish to add additional non-patent literature document citation information please click the Add button

EXAMINER SIGNATURE

Examiner Signature		Date Considered	
--------------------	--	-----------------	--

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

¹ See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. ² Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). ³ For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. ⁴ Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. ⁵ Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number		
	Filing Date		
	First Named Inventor	Zhanping Yin	
	Art Unit		
	Examiner Name		
	Attorney Docket Number	SLA3704.3	

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Wesley L. Austin/	Date (YYYY-MM-DD)	2018-08-09
Name/Print	Wesley L. Austin	Registration Number	42273

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. **DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Patent Application Fee Transmittal				
Application Number:				
Filing Date:				
Title of Invention:		MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5th GENERATION (5G) NEW RADIO (NR)		
First Named Inventor/Applicant Name:		Zhanping Yin		
Filer:		Wesley L. Austin/Jessamy Newton		
Attorney Docket Number:		SLA3704.3		
Filed as Large Entity				
Filing Fees for Utility under 35 USC 111(a)				
Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Basic Filing:				
UTILITY APPLICATION FILING	1011	1	300	300
UTILITY SEARCH FEE	1111	1	660	660
UTILITY EXAMINATION FEE	1311	1	760	760
Pages:				
Claims:				
INDEPENDENT CLAIMS IN EXCESS OF 3	1201	1	460	460
Miscellaneous-Filing:				
LATE FILING FEE FOR OATH OR DECLARATION	1051	1	160	160

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
Total in USD (\$)				2340

Electronic Acknowledgement Receipt	
EFS ID:	33418546
Application Number:	16059926
International Application Number:	
Confirmation Number:	7857
Title of Invention:	MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5th GENERATION (5G) NEW RADIO (NR)
First Named Inventor/Applicant Name:	Zhanping Yin
Customer Number:	50735
Filer:	Wesley L. Austin/Ashley Austin
Filer Authorized By:	Wesley L. Austin
Attorney Docket Number:	SLA3704.3
Receipt Date:	09-AUG-2018
Filing Date:	
Time Stamp:	17:52:55
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	\$2340
RAM confirmation Number	081018INTEFSW17540500
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:					
Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	SLA3704-3_ApplicationDataSheet_3292-2-309-3.pdf	1255937	no	8
			a91c6871c450b433668f17ac5a0c6968bd2f896d		
Warnings:					
Information:					
2		SLA3704-3_Application_3292-2-309-3.pdf	338635	yes	81
			c34f150b001b8a8980d120aac07eb3d61eb50620		
	Multipart Description/PDF files in .zip description				
	Document Description		Start	End	
	Specification		1	76	
	Claims		77	80	
	Abstract		81	81	
Warnings:					
Information:					
3	Drawings-only black and white line drawings	SLA3704-3_Drawings_3292-2-309-3.pdf	540091	no	40
			5afea794c0c02a67f2bb2b68240a963b40c86154		
Warnings:					
Information:					
4	Information Disclosure Statement (IDS) Form (SB08)	SLA3704-3_InformationDisclosureStatement_3292-2-309-3.pdf	1035062	no	5
			bc16d14e94377e17598c56e4561a9a1a3f6237ac		
Warnings:					
Information:					
A U.S. Patent Number Citation or a U.S. Publication Number Citation is required in the Information Disclosure Statement (IDS) form for autoloading of data into USPTO systems. You may remove the form to add the required data in order to correct the Informational Message if you are citing U.S. References. If you chose not to include U.S. References, the image of the form will be processed and be made available within the Image File Wrapper (IFW) system. However, no data will be extracted from this form. Any additional data such as Foreign Patent Documents or Non Patent Literature will be manually reviewed and keyed into USPTO systems.					

5	Non Patent Literature	R1-1710013.pdf	71129	no	4
			f7748a3ba0c8ba2a46f21aab05d6d31eeb15992b		
Warnings:					
Information:					
6	Non Patent Literature	R1-1710087.pdf	63562	no	3
			64ba35e6814f0d4b2893a2a235696935203b5dba		
Warnings:					
Information:					
7	Non Patent Literature	R1-1710116.pdf	57338	no	3
			74d12fed2dc311f922ace1588e71fcd3a78fdfa2		
Warnings:					
Information:					
8	Non Patent Literature	R1-1710159.pdf	60709	no	5
			6d6b2086371520bbf3307f8ba15e1309adabc9d03		
Warnings:					
Information:					
9	Non Patent Literature	R1-1710317.pdf	48148	no	4
			c77f03851ea0627ac85acc5ae34d78d997a9ec33		
Warnings:					
Information:					
10	Non Patent Literature	R1-1710555.pdf	64579	no	3
			3e06c6adc7a8545949a14b34b8735abad5eb3f67		
Warnings:					
Information:					
11	Non Patent Literature	R1-1710600.pdf	33228	no	2
			cc2a057c163cae6330f057987612be8ed5fd9dfe		
Warnings:					
Information:					

12	Non Patent Literature	R1-1710620.pdf	43366	no	2
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Warnings:					
Information:					
13	Non Patent Literature	R1-1710707.pdf	50657	no	3
			d62af66c452a58f5388575ba55b0fc31c9d903c9		
Warnings:					
Information:					
14	Non Patent Literature	R1-1710935.pdf	48667	no	3
			62f46ab42203e565a6ca66019dd1832a3db507e0		
Warnings:					
Information:					
15	Non Patent Literature	R1-1710976.pdf	70798	no	4
			1a0eaa1f0ea73ba9984fb08abb605a73f3a15ecb		
Warnings:					
Information:					
16	Non Patent Literature	R1-1711102.pdf	54926	no	3
			658f09f51bbcb63bb8297c4add58e0c9679a84dc		
Warnings:					
Information:					
17	Non Patent Literature	R1-1711192.pdf	61595	no	2
			e8a73f92be7b1347c56f8c6f6c6bdafef18eb17f		
Warnings:					
Information:					
18	Non Patent Literature	R1-1711241.pdf	24088	no	2
			325cd6a2ce6644ac730b5652251e376c0b28249d		
Warnings:					
Information:					

19	Non Patent Literature	R1-1711252.pdf	93339	no	4
			850ae2160ebd4ae9ad2c700940db52bef39610e7		
Warnings:					
Information:					
20	Non Patent Literature	R1-1711492.pdf	31699	no	2
			10713f01e9541cb90a1d55572a531676f00f40c3		
Warnings:					
Information:					
21	Fee Worksheet (SB06)	fee-info.pdf	38407	no	2
			4feb9963c2e9601a43d7f275fdcd9f1043dee		
Warnings:					
Information:					
Total Files Size (in bytes):			4085960		
This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503. <u>New Applications Under 35 U.S.C. 111</u> If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application. <u>National Stage of an International Application under 35 U.S.C. 371</u> If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course. <u>New International Application Filed with the USPTO as a Receiving Office</u> If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.					

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	SLA3704.3
		Application Number	
Title of Invention	MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5th GENERATION (5G) NEW RADIO (NR)		
The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76. This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.			

Secrecy Order 37 CFR 5.2:

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor	1				Remove	
Legal Name						
Prefix	Given Name	Middle Name	Family Name	Suffix		
	Zhanping		Yin			
Residence Information (Select One) ☒ US Residency ☐ Non US Residency ☐ Active US Military Service						
City	Vancouver	State/Province	WA	Country of Residence ⁱ	US	
Mailing Address of Inventor:						
Address 1	2104 SE 187th Avenue					
Address 2						
City	Vancouver	State/Province	WA			
Postal Code	98683	Country ⁱ	US			
Inventor	2				Remove	
Legal Name						
Prefix	Given Name	Middle Name	Family Name	Suffix		
	Toshizo		Nogami			
Residence Information (Select One) ☐ US Residency ☒ Non US Residency ☐ Active US Military Service						
City	Chiba	Country of Residence ⁱ	JP			
Mailing Address of Inventor:						
Address 1	2-22 Utase, Unit 1-303					
Address 2	Mihama-ku, Chiba-shi					
City	Chiba	State/Province				
Postal Code	261-0013	Country ⁱ	JP			
All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the Add button.						
Add						

Correspondence Information:

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	SLA3704.3
		Application Number	
Title of Invention	MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5th GENERATION (5G) NEW RADIO (NR)		

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ An Address is being provided for the correspondence information of this application.

Customer Number	50735		
Email Address	uspto@austin-rapp.com	Add Email	Remove Email

Application Information:

Title of the Invention	MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5th GENERATION (5G) NEW RADIO (NR)		
Attorney Docket Number	SLA3704.3	Small Entity Status Claimed	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	40	Suggested Figure for Publication (if any)	32

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not be** the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32). Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	☒ Customer Number	☐ US Patent Practitioner	☐ Limited Recognition (37 CFR 11.9)
Customer Number	50735		

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	SLA3704.3
		Application Number	
Title of Invention	MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5th GENERATION (5G) NEW RADIO (NR)		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.

When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status	Pending	Remove	
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
	Continuation of	PCTUS2018045836	2018-08-08
Prior Application Status	Pending	Remove	
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
	Claims benefit of provisional	62543795	2017-08-10
Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the Add button.			Add

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)ⁱ the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Application Number	Country ⁱ	Filing Date (YYYY-MM-DD)	Access Code ⁱ (if applicable)	Remove
Additional Foreign Priority Data may be generated within this form by selecting the Add button.				Add

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.

NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	SLA3704.3
		Application Number	
Title of Invention	MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5th GENERATION (5G) NEW RADIO (NR)		

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	SLA3704.3
		Application Number	
Title of Invention	MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5th GENERATION (5G) NEW RADIO (NR)		

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.			
Applicant	1	<button>Remove</button>	
If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.			
		<button>Clear</button>	
☐ Assignee	Legal Representative under 35 U.S.C. 117		Joint Inventor
Person to whom the inventor is obligated to assign.		Person who shows sufficient proprietary interest	
If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:			
Name of the Deceased or Legally Incapacitated Inventor:			
If the Applicant is an Organization check here. ☒			
Organization Name	Sharp Laboratories of America, Inc.		
Mailing Address Information For Applicant:			
Address 1	5750 NW Pacific Rim Boulevard		
Address 2			
City	Camas	State/Province	WA
Country	US	Postal Code	98607
Phone Number		Fax Number	
Email Address			
Additional Applicant Data may be generated within this form by selecting the Add button. <button>Add</button>			

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	SLA3704.3
		Application Number	
Title of Invention	MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5th GENERATION (5G) NEW RADIO (NR)		

Assignee 1				
Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.				
Remove				
If the Assignee or Non-Applicant Assignee is an Organization check here. ☐				
Prefix	Given Name	Middle Name	Family Name	Suffix
Mailing Address Information For Assignee including Non-Applicant Assignee:				
Address 1				
Address 2				
City		State/Province		
Country i		Postal Code		
Phone Number		Fax Number		
Email Address				
Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button. Add				

Signature:[Remove](#)

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/Wesley L. Austin/		Date (YYYY-MM-DD)	2018-08-09	
First Name	Wesley L.	Last Name	Austin	Registration Number	42273
Additional Signature may be generated within this form by selecting the Add button. Add					

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	SLA3704.3
		Application Number	
Title of Invention	MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5th GENERATION (5G) NEW RADIO (NR)		

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**MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL
CHANNEL (PUCCH) DESIGN FOR 5th GENERATION (5G) NEW
RADIO (NR)**

RELATED APPLICATIONS

[0001] This application is related to and claims priority from U.S. Provisional Patent Application No. 62/543,795, entitled “MULTIPLE SLOT LONG PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) DESIGN FOR 5th GENERATION (5G) NEW RADIO (NR),” filed on August 10, 2017, which is hereby incorporated by reference herein, in its entirety.

TECHNICAL FIELD

[0002] The present disclosure relates generally to communication systems. More specifically, the present disclosure relates to multiple slot long physical uplink control channel (PUCCH) design for 5th generation (5G) new radio (NR).

BACKGROUND

[0003] Wireless communication devices have become smaller and more powerful in order to meet consumer needs and to improve portability and convenience. Consumers have become dependent upon wireless communication devices and have come to expect reliable service, expanded areas of coverage and increased functionality. A wireless communication system may provide communication for a number of wireless communication devices, each of which may be serviced by a base station. A base station may be a device that communicates with wireless communication devices.

[0004] As wireless communication devices have advanced, improvements in communication capacity, speed, flexibility and/or efficiency have been sought. However,

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improving communication capacity, speed, flexibility and/or efficiency may present certain problems.

[0005] For example, wireless communication devices may communicate with one or more devices using a communication structure. However, the communication structure used may only offer limited flexibility and/or efficiency. As illustrated by this discussion, systems and methods that improve communication flexibility and/or efficiency may be beneficial.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Figure 1 is a block diagram illustrating one implementation of one or more base stations (gNBs) and one or more user equipments (UEs) in which systems and methods for multiple slot long physical uplink control channel (PUCCH) design for 5th generation (5G) new radio (NR) may be implemented;

[0007] Figure 2 is a diagram illustrating one example of a resource grid for the downlink;

[0008] Figure 3 is a diagram illustrating one example of a resource grid for the uplink;

[0009] Figure 4 shows examples of several numerologies;

[0010] Figure 5 shows examples of subframe structures for the numerologies that are shown in Figure 4;

[0011] Figure 6 shows examples of slots and sub-slots;

[0012] Figure 7 shows examples of scheduling timelines;

[0013] Figure 8 shows examples of downlink (DL) control channel monitoring regions;

[0014] Figure 9 shows examples of DL control channel which consists of more than one control channel elements;

[0015] Figure 10 shows examples of uplink (UL) control channel structures;

[0016] Figure 11 is a block diagram illustrating one implementation of a gNB;

[0017] Figure 12 is a block diagram illustrating one implementation of a UE;

- [0018]** Figure 13 illustrates several examples of long PUCCH duration design;
- [0019]** Figure 14 illustrates examples of two demodulation reference signals (DMRS) in every 7 symbols for normal cyclic prefix (NCP) or 6 symbols for extended cyclic prefix (ECP);
- [0020]** Figure 15 illustrates examples of the minimum number of symbols for a long PUCCH;
- [0021]** Figure 16 illustrates examples of one DMRS in every 7 symbols for NCP or 6 symbols for ECP;
- [0022]** Figure 17 illustrates fixed hopping candidates for PUCCH based on fixed DMRS patterns;
- [0023]** Figure 18 illustrates examples of PUCCH DMRS basic blocks in a hop;
- [0024]** Figures 19A and 19B illustrate examples of DMRS patterns for different durations;
- [0025]** Figure 20 illustrates examples of RS patterns with frequency division multiplexing (FDM) among UEs for two DMRS in every 7 symbols for NCP;
- [0026]** Figure 21 illustrates examples of RS patterns with FDM among UEs for two DMRS in every 6 symbols for ECP;
- [0027]** Figure 22 illustrates examples of a shifted RS pattern with FDM among UEs for two DMRS in every 7 symbols for NCP;
- [0028]** Figure 23 illustrates examples of long PUCCH with one DMRS every 7 symbols for NCP;
- [0029]** Figure 24 illustrates examples of DMRS allocation at frequency domain;
- [0030]** Figure 25 illustrates examples of UE multiplexing with different DMRS patterns;
- [0031]** Figure 26 illustrates examples of frequency hopping for long PUCCH formats;
- [0032]** Figure 27 illustrates examples of self-contained DMRS patterns in each symbol;
- [0033]** Figure 28 illustrates various components that may be utilized in a UE;
- [0034]** Figure 29 illustrates various components that may be utilized in a gNB;

[0035] Figure 30 is a block diagram illustrating one implementation of a UE in which systems and methods for long PUCCH design for 5G NR operations may be implemented;

[0036] Figure 31 is a block diagram illustrating one implementation of a gNB in which systems and methods for long PUCCH design for 5G NR operations may be implemented;

[0037] Figure 32 is a flow diagram illustrating a method for implementing a multiple slot long PUCCH design for 5G NR;

[0038] Figure 33 is a flow diagram illustrating another method for implementing a multiple slot long PUCCH design for 5G NR;

[0039] Figure 34 illustrates different cases for multiple slot long PUCCH with continuous UL symbol;

[0040] Figure 35 illustrates examples of frequency hopping methods;

[0041] Figure 36 illustrates examples of how a multi-slot long PUCCH may span over continuous or dis-continuous slots;

[0042] Figure 37 illustrates examples of how the number of PUCCH symbols in each slot may be the same or different;

[0043] Figure 38 illustrates examples of frequency hopping for multi-slot long PUCCH; and

[0044] Figure 39 is a flow diagram illustrating a method for UCI encoding and rate matching into a multi-slot long PUCCH.

DETAILED DESCRIPTION

[0045] A user equipment (UE) is described. The UE includes a processor and memory in electronic communication with the processor. Instructions stored in the memory are executable to determine an uplink control channel (PUCCH) spans over multiple slots based on a signaling from a base station (gNB). The instructions are also executable to determine a demodulation reference signals (DMRS) structure in the configured multi-slot PUCCH. The instructions are further executable to determine a

frequency hopping method of the configured multi-slot PUCCH. The instructions are additionally executable to determine uplink control information (UCI) encoding and loading methods on the configured multi-slot PUCCH. The instructions are also executable to determine a resource of a control channel for UCI feedback. The instructions are further executable to transmit UCI on a selected channel.

[0046] The number of PUCCH symbols in each slot of a multi-slot uplink control channel (PUCCH) may be greater than or equal to 4. The reference symbol (RS) pattern in each slot may be determined on a per slots basis by a long PUCCH format of a given the number of PUCCH symbols in the slot.

[0047] The number of PUCCH symbols may be the same in each slot of a multi-slot uplink control channel (PUCCH), and the same PUCCH symbol location may be allocated in each slot.

[0048] UCI encoded bits may be rate matched and loaded to all to PUCCH UCI carrying symbols of each slot of the long PUCCH separately. If the number of PUCCH symbols in each slot is the same, the PUCCH format and encoded UCI in each slot may be repeated in multiple slots.

[0049] The frequency hopping may be applied at slot boundaries in a multi-slot PUCCH. Alternatively, the frequency hopping may be applied within each slot in a multi-slot PUCCH. Whether the frequency hopping is inter-slot or intra-slot can be configured by higher layer signaling for a multi-slot PUCCH.

[0050] A base station (gNB) is also described. The gNB includes a processor and memory in electronic communication with the processor. Instructions stored in the memory are executable to determine an uplink control channel (PUCCH) spans over multiple slots. The instructions are also executable to determine a demodulation reference signals (DMRS) structure in the configured multi-slot PUCCH. The instructions are further executable to determine a frequency hopping method of the configured multi-slot PUCCH. The instructions are additionally executable to determine UCI encoding and loading methods on the configured multi-slot PUCCH. The instructions are also

executable to determine a resource of a control channel for UCI feedback. The instructions are further executable to receive UCI on a selected channel.

[0051] A method by a UE is also described. The method includes determining an uplink control channel (PUCCH) spans over multiple slots based on a signaling from a base station (gNB). The method also includes determining a demodulation reference signals (DMRS) structure in the configured multi-slot PUCCH. The method further includes determining a frequency hopping method of the configured multi-slot PUCCH. The method additionally includes determining UCI encoding and loading methods on the configured multi-slot PUCCH. The method also includes determining a resource of a control channel for UCI feedback. The method further includes transmitting UCI on a selected channel.

[0052] A method by a base station (gNB) is also described. The method includes determining an uplink control channel (PUCCH) spans over multiple slots. The method also includes determining a demodulation reference signals (DMRS) structure in the configured multi-slot PUCCH. The method further includes determining a frequency hopping method of the configured multi-slot PUCCH. The method additionally includes determining UCI encoding and loading methods on the configured multi-slot PUCCH. The method also includes determining a resource of a control channel for UCI feedback. The method further includes receiving UCI on a selected channel.

[0053] The 3rd Generation Partnership Project, also referred to as “3GPP,” is a collaboration agreement that aims to define globally applicable technical specifications and technical reports for third and fourth generation wireless communication systems. The 3GPP may define specifications for next generation mobile networks, systems and devices.

[0054] 3GPP Long Term Evolution (LTE) is the name given to a project to improve the Universal Mobile Telecommunications System (UMTS) mobile phone or device standard to cope with future requirements. In one aspect, UMTS has been modified to provide support and specification for the Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN).

[0055] At least some aspects of the systems and methods disclosed herein may be described in relation to the 3GPP LTE, LTE-Advanced (LTE-A) and other standards (e.g., 3GPP Releases 8, 9, 10, 11 and/or 12). However, the scope of the present disclosure should not be limited in this regard. At least some aspects of the systems and methods disclosed herein may be utilized in other types of wireless communication systems.

[0056] A wireless communication device may be an electronic device used to communicate voice and/or data to a base station, which in turn may communicate with a network of devices (e.g., public switched telephone network (PSTN), the Internet, etc.). In describing systems and methods herein, a wireless communication device may alternatively be referred to as a mobile station, a UE, an access terminal, a subscriber station, a mobile terminal, a remote station, a user terminal, a terminal, a subscriber unit, a mobile device, etc. Examples of wireless communication devices include cellular phones, smart phones, personal digital assistants (PDAs), laptop computers, netbooks, e-readers, wireless modems, etc. In 3GPP specifications, a wireless communication device is typically referred to as a UE. However, as the scope of the present disclosure should not be limited to the 3GPP standards, the terms “UE” and “wireless communication device” may be used interchangeably herein to mean the more general term “wireless communication device.” A UE may also be more generally referred to as a terminal device.

[0057] In 3GPP specifications, a base station is typically referred to as a Node B, an evolved Node B (eNB), a home enhanced or evolved Node B (HeNB) or some other similar terminology. As the scope of the disclosure should not be limited to 3GPP standards, the terms “base station,” “Node B,” “eNB,” and “HeNB” may be used interchangeably herein to mean the more general term “base station.” Furthermore, the term “base station” may be used to denote an access point. An access point may be an electronic device that provides access to a network (e.g., Local Area Network (LAN), the Internet, etc.) for wireless communication devices. The term “communication device” may be used to denote both a wireless communication device and/or a base station. An eNB may also be more generally referred to as a base station device.

[0058] It should be noted that as used herein, a “cell” may be any communication channel that is specified by standardization or regulatory bodies to be used for International Mobile Telecommunications-Advanced (IMT-Advanced) and all of it or a subset of it may be adopted by 3GPP as licensed bands (e.g., frequency bands) to be used for communication between an eNB and a UE. It should also be noted that in E-UTRA and E-UTRAN overall description, as used herein, a “cell” may be defined as “combination of downlink and optionally uplink resources.” The linking between the carrier frequency of the downlink resources and the carrier frequency of the uplink resources may be indicated in the system information transmitted on the downlink resources.

[0059] “Configured cells” are those cells of which the UE is aware and is allowed by an eNB to transmit or receive information. “Configured cell(s)” may be serving cell(s). The UE may receive system information and perform the required measurements on all configured cells. “Configured cell(s)” for a radio connection may consist of a primary cell and/or no, one, or more secondary cell(s). “Activated cells” are those configured cells on which the UE is transmitting and receiving. That is, activated cells are those cells for which the UE monitors the physical downlink control channel (PDCCH) and in the case of a downlink transmission, those cells for which the UE decodes a physical downlink shared channel (PDSCH). “Deactivated cells” are those configured cells that the UE is not monitoring the transmission PDCCH. It should be noted that a “cell” may be described in terms of differing dimensions. For example, a “cell” may have temporal, spatial (e.g., geographical) and frequency characteristics.

[0060] Fifth generation (5G) cellular communications (also referred to as “New Radio”, “New Radio Access Technology” or “NR” by 3GPP) envisions the use of time/frequency/space resources to allow for enhanced mobile broadband (eMBB) communication and ultra-reliable low latency communication (URLLC) services, as well as massive machine type communication (mMTC) like services. In order for the services to use the time/frequency/space medium efficiently it would be useful to be able to flexibly schedule services on the medium so that the medium may be used as effectively

as possible, given the conflicting needs of URLLC, eMBB, and mMTC. A new radio base station may be referred to as a gNB. A gNB may also be more generally referred to as a base station device.

[0061] In 5G NR, at least two different types of uplink control channel (PUCCH) formats may be specified: at least one short PUCCH format and one long PUCCH format. The PUCCH channel is designed to carry uplink control information (UCI). In NR, the long PUCCH format may span over multiple slots, and the PUCCH format of a UE may be configured by a base station. The systems and methods described herein detail formats for long PUCCH design over multiple slots. In particular, length restrictions in each slot, RS patterns in each slot, frequency hopping methods and UCI coding methods for a long PUCCH over multiple slots are described.

[0062] In NR, several PUCCH formats will be specified. For UCI, different UCI may be reported on different PUCCH channel formats. In 5G NR, both CP-OFDM and DFT-S-OFDM waveforms are supported for UL transmission. Also, different numerologies may be used on one or more carriers or serving cells.

[0063] Detailed mapping methods and signaling required for long PUCCH formats in NR are described. To minimize specification impact, a common framework may be used for both CP-OFDM and DFT-S-OFDM based long PUCCH design. Furthermore, design enhancements for some band-specific and application-specific scenarios are described.

[0064] For a long PUCCH within a slot length, the DMRS may be determined based on the length of a long PUCCH, the frequency hopping requirements, etc. In one method, the DMRSs in a long PUCCH are in fixed locations in a slot configured by higher layer signaling. In another method, the DMRSs in a long PUCCH are in fixed locations in a long PUCCH relative to the starting symbol position.

[0065] In these two methods, frequency hopping may not be supported if there is only one DMRS in the long PUCCH duration. If there are more than 2 DMRSs in the long PUCCH duration, frequency hopping can be supported. If supported, frequency hopping may be mandatory or configured by higher layer signaling. However, these methods may

not provide the best DMRS positions for a long PUCCH depending on the starting and ending symbols of a long PUCCH.

[0066] In another method, the DMRSs are determined based on the structure of each frequency hop. Frequency hopping may be mandatory for all long PUCCH durations, or it can be configured by higher layer signaling based on a long PUCCH duration.

[0067] Furthermore, to allow more flexible UE multiplexing and UCI payload sizes, the UE multiplexing capability may be supported at frequency domain instead of time domain. For a long PUCCH that spans over multiple slots, a long PUCCH may occupy continuous UL symbols only, or a long PUCCH can include discontinuous symbols in time domain. Some restrictions may be applied to the length in each slot. The DMRS pattern of a long PUCCH over multiple slots may be determined by the DMRS pattern of each slot following its own length. Frequency hopping may be applied inter-slot or intra-slot based on configurations. Different UCI encoding and rate matching methods can be applied based on the UCI payload size and the long PUCCH resources in each slot.

[0068] Various examples of the systems and methods disclosed herein are now described with reference to the Figures, where like reference numbers may indicate functionally similar elements. The systems and methods as generally described and illustrated in the Figures herein could be arranged and designed in a wide variety of different implementations. Thus, the following more detailed description of several implementations, as represented in the Figures, is not intended to limit scope, as claimed, but is merely representative of the systems and methods.

[0069] Figure 1 is a block diagram illustrating one implementation of one or more gNBs 160 and one or more UEs 102 in which systems and methods for multiple slot long physical uplink control channel (PUCCH) design for 5th generation (5G) new radio (NR) may be implemented. The one or more UEs 102 communicate with one or more gNBs 160 using one or more antennas 122a-n. For example, a UE 102 transmits electromagnetic signals to the gNB 160 and receives electromagnetic signals from the gNB 160 using the one or more antennas 122a-n. The gNB 160 communicates with the UE 102 using one or more antennas 180a-n.

[0070] The UE 102 and the gNB 160 may use one or more channels 119, 121 to communicate with each other. For example, a UE 102 may transmit information or data to the gNB 160 using one or more uplink channels 121. Examples of uplink channels 121 include a PUCCH and a PUSCH, etc. The one or more gNBs 160 may also transmit information or data to the one or more UEs 102 using one or more downlink channels 119, for instance. Examples of downlink channels 119 include a PDCCH, a PDSCH, etc. Other kinds of channels may be used.

[0071] Each of the one or more UEs 102 may include one or more transceivers 118, one or more demodulators 114, one or more decoders 108, one or more encoders 150, one or more modulators 154, a data buffer 104 and a UE operations module 124. For example, one or more reception and/or transmission paths may be implemented in the UE 102. For convenience, only a single transceiver 118, decoder 108, demodulator 114, encoder 150 and modulator 154 are illustrated in the UE 102, though multiple parallel elements (e.g., transceivers 118, decoders 108, demodulators 114, encoders 150 and modulators 154) may be implemented.

[0072] The transceiver 118 may include one or more receivers 120 and one or more transmitters 158. The one or more receivers 120 may receive signals from the gNB 160 using one or more antennas 122a-n. For example, the receiver 120 may receive and downconvert signals to produce one or more received signals 116. The one or more received signals 116 may be provided to a demodulator 114. The one or more transmitters 158 may transmit signals to the gNB 160 using one or more antennas 122a-n. For example, the one or more transmitters 158 may upconvert and transmit one or more modulated signals 156.

[0073] The demodulator 114 may demodulate the one or more received signals 116 to produce one or more demodulated signals 112. The one or more demodulated signals 112 may be provided to the decoder 108. The UE 102 may use the decoder 108 to decode signals. The decoder 108 may produce decoded signals 110, which may include a UE-decoded signal 106 (also referred to as a first UE-decoded signal 106). For example, the first UE-decoded signal 106 may comprise received payload data, which may be stored in

a data buffer 104. Another signal included in the decoded signals 110 (also referred to as a second UE-decoded signal 110) may comprise overhead data and/or control data. For example, the second UE-decoded signal 110 may provide data that may be used by the UE operations module 124 to perform one or more operations.

[0074] In general, the UE operations module 124 may enable the UE 102 to communicate with the one or more gNBs 160. The UE operations module 124 may include one or more of a UE multiple slot long PUCCH module 126.

[0075] The UE long PUCCH module 126 may implement a multiple slot long PUCCH design for 5th generation (5G) new radio (NR). Uplink control information and uplink waveform in NR are described. In LTE, the UCI carries hybrid-ARQ acknowledgements (HARQ-ACK), channel state information (CSI), and a scheduling request (SR). The CSI may include one or more of channel quality indicator (CQI), rank indication (RI), precoding matrix indicator (PMI), precoding type indicator (PTI), etc. Multiple dimensions of CSI may be reported from one or more cells to support FD-MIMO and CoMP operations.

[0076] Similarly, in NR, a scheduling request (SR), if defined, needs to be transmitted outside PUSCH, as well as HARQ-ACK for latency reasons. The CSI report in NR should be enhanced to support massive MIMO and beamforming methods. Thus, multiple sets of CSI may be reported in NR. Again, a CSI feedback may include one or more of CQI, RI, PMI, PTI, beam index, etc. At least two types of CSI reports may be supported, periodic CSI and aperiodic CSI. Periodic CSI report can be configured semi-statically. Aperiodic CSI can be trigger with a CSI request from the gNB 160. Therefore, physical uplink control signaling should be able to carry at least hybrid-ARQ acknowledgements, CSI reports (possibly including beamforming information), and scheduling requests.

[0077] The UCI information may be transmitted as L1/L2 control signaling (e.g., via a physical uplink control channel (PUCCH) or physical uplink share channel (PUSCH) or uplink data channel). Furthermore, it should be possible to dynamically indicate (at least in combination with radio resource control (RRC)) the timing between data reception and

hybrid-ARQ acknowledgement transmission as part of the downlink control information (DCI).

[0078] In NR, different numerologies are supported on the same or different carriers. For the uplink transmission supports two waveform/modulation schemes based on Orthogonal Frequency Division Multiplexing (OFDM). One waveform/modulation scheme is cyclic prefix OFDM (CP-OFDM). Another waveform/modulation scheme is discrete Fourier transform (DFT) spread OFDM (DFT-S-OFDM), also known as single carrier FDMA (SC-FDMA), or low Peak-to-Average Power Ratio (PAPR) waveform. Therefore, the uplink control and uplink data channel may be configured separately with the same or different waveforms and numerologies.

[0079] NR numerology and slot length is described herein. Multiple OFDM numerologies are supported, as given by Table 1.

μ	$\Delta f = 2^\mu \cdot 15[\text{kHz}]$	Cyclic prefix
0	15	Normal
1	30	Normal
2	60	Normal, Extended
3	120	Normal
4	240	Normal
5	480	Normal

Table 1

[0080] For subcarrier spacing configuration μ , slots are numbered $n_s^\mu \in \{0, K, N_{subframe}^{slots, \mu} - 1\}$ in increasing order within a subframe and $n_{s,f}^\mu \in \{0, K, N_{frame}^{slots, \mu} - 1\}$ in increasing order within a frame. There are N_{symb}^μ consecutive OFDM symbols in a slot where N_{symb}^μ depends on the subcarrier

spacing used and the slot configuration as given by Table 2 and Table 3. The start of slot n_s^μ in a subframe is aligned in time with the start of OFDM symbol $n_s^\mu N_{\text{symb}}^\mu$ in the same subframe.

[0081] Not all UEs 102 may be capable of simultaneous transmission and reception, implying that not all OFDM symbols in a downlink slot or an uplink slot may be used.

[0082] Table 2 shows the number of OFDM symbols per slot, N_{symb}^μ , for subcarrier spacing configuration μ and normal cyclic prefix.

μ	Slot configuration					
	0			1		
	N_{symb}^μ	$N_{\text{frame}}^{\text{slots},\mu}$	$N_{\text{subframe}}^{\text{slots},\mu}$	N_{symb}^μ	$N_{\text{frame}}^{\text{slots},\mu}$	$N_{\text{subframe}}^{\text{slots},\mu}$
0	14	10	1	7	20	2
1	14	20	2	7	40	4
2	14	40	4	7	80	8
3	14	80	8	-	-	-
4	14	160	16	-	-	-
5	14	320	32	-	-	-

Table 2

[0083] Table 3 shows the number of OFDM symbols per slot, N_{symb}^μ , for subcarrier spacing configuration μ and extended cyclic prefix.

μ	Slot configuration					
	0			1		
	N_{symb}^μ	$N_{\text{frame}}^{\text{slots},\mu}$	$N_{\text{subframe}}^{\text{slots},\mu}$	N_{symb}^μ	$N_{\text{frame}}^{\text{slots},\mu}$	$N_{\text{subframe}}^{\text{slots},\mu}$

2	12	40	4	6	80	8
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Table 3

[0084] LTE and 5G NR physical uplink control channel (PUCCH) are also discussed herein. In LTE, the PUCCH with normal TTI length occupies a full subframe and 1 resource block (RB) for format 1/2/3/5, and more than one RB is supported for Format 4. Different formats are used to carry different number of UCI payload sizes. Frequency hopping is supported for all 1ms TTI PUCCH formats by transmitting two slots in two ends of the carrier frequency. The UE multiplexing capability is performed in the frequency domain and/or time domain depending on the PUCCH format.

[0085] Format 1/1a/1b has 3 RS symbols in each slot. Zadoff–Chu (Z-C) sequence is used on frequency domain, orthogonal sequences are used for PUCCH spreading in time domain, $N_{SF}^{PUCCH} = 4$ for normal CP, $N_{SF}^{PUCCH} = 3$ for extended CP.

[0086] Format 2/2a/2b has two RS symbols in each slot. It uses Z-C sequences on frequency domain for UE multiplexing, no time domain multiplexing.

[0087] Format 3 has two RS symbols in each slot, it only uses time domain multiplexing with orthogonal sequences ($N_{SF}^{PUCCH} = 5$ for normal CP and $N_{SF}^{PUCCH} = 4$ for extended CP) and no frequency domain multiplexing.

[0088] Format 4 may occupy one or more RBs. It carries coded information bits on all data carrying symbols. Thus, it provides largest payload size, but does not support multiplexing for multiple UEs 102 in the same RB.

[0089] Format 5 uses only one RB, It has the same structure as Format 4 except that a spreading factor of 2 $N_{SF}^{PUCCH} = 2$ is supported, thus two UEs 102 can be multiplexed on the same RB resources.

[0090] Similar to different PUCCH formats in LTE, at least two transmission durations are supported for uplink control in NR. One short transmission duration around the last OFDM symbol in a slot may be supported for uplink control in NR. This short

transmission duration may be time division multiplexed (TDM) or frequency division multiplexed (FDM) with data. One long transmission duration spanning multiple symbols (e.g. filling most of a slot or slots) may be frequency division multiplexed (FDM) with data.

[0091] A short PUCCH format may consist of one or two symbols. A long PUCCH format may span multiple symbols and slots. Multiple long PUCCH formats may be defined (e.g., 4 symbols, a slot, and multiple slots, etc.). A long PUCCH format may be useful for larger payload HARQ-ACK feedback, CSI feedback, etc.

[0092] At least a low PAPR/CM design should be supported for the long PUCCH format. A UCI carried by long duration UL control channel at least with low PAPR design can be transmitted in one slot or multiple slots, and transmission across multiple slots should allow a total duration of 1 ms at least for some cases.

[0093] At least one or more of the following PUCCH formats may be supported. PUCCH format 1 may be a short PUCCH. In PUCCH format 1, transmission is over 1 symbol or 2 symbols, and the number of UCI (e.g., HARQ-ACK) bits may be 1 or 2.

[0094] PUCCH format 2 may be a short PUCCH. In PUCCH format 2, transmission is over 1 symbol or 2 symbols, and the number of UCI (e.g., HARQ-ACK) bits may be more than 2.

[0095] PUCCH format 3 may be a long PUCCH. In PUCCH format 3, transmission is over 4 or more symbols and the number of UCI (e.g., HARQ-ACK) bits may be 1 or 2.

[0096] PUCCH format 4 may be a long PUCCH. In PUCCH format 4, transmission is over 4 or more symbols, and the number of UCI (e.g., HARQ-ACK) bits may be more than 2.

[0097] A UE 102 may transmit one or more PUCCHs within a period of L_{PUCCH} symbols, referred to as PUCCH slot. Either $L_{\text{PUCCH}} = 7$ or $L_{\text{PUCCH}} = 14$ may be supported, where one value is configured by higher layers. If the UE 102 detects a DCI format in a PDCCH that configures a PDSCH reception over a number of symbols with a last symbol being within PUCCH slot n , the UE 102 may provide corresponding HARQ-

ACK information in a PUCCH transmission within PUCCH slot $n+k$, where k is indicated by the DCI format.

[0098] For PUCCH format configuration, a combination of semi-static configuration and (at least for some types of UCI information) dynamic signaling is used to determine the PUCCH formats and resources both for the long and short PUCCH formats.

[0099] The long PUCCH design for 5G NR is described more fully herein. Long PUCCH design with more than 2 bits of UCI payload (i.e., PUCCH format 4) in 5G NR is described. Hereafter, a long PUCCH refers to PUCCH format 4 (i.e., a PUCCH with a length of 4 or more symbols) and the number of UCI (e.g., HARQ-ACK) bits is more than 2. Figure 13 shows several examples of long PUCCH duration design.

[00100] In one case, a long PUCCH should occupy one or more whole slots. In Figure 13, example (a) shows a long PUCCH covers a full slot length in a UL only slot. In Figure 13, example (b) shows a long PUCCH covers multiple UL only slots. In this case, a long PUCCH should not be configured in partial UL slots (e.g., in a self-contained slot or UL centric slot). Otherwise, a different PUCCH structure may be defined for an UL centric slot with a different number of symbols. For example, the RS location, RS and UCI multiplexing methods, the orthogonal sequences used for UE multiplexing, etc.

[00101] In another case, a long PUCCH can be designed for one or more slots, but some symbols may be punctured in a UL centric slot. In this case, the design should take into account of potential puncturing of some symbols up to a given limit (e.g., 4 symbols).

[00102] In yet another case, a long PUCCH may be configured in the UL part of a slot with the number of uplink symbols greater than a threshold number X . However, different designs on the DMRS and orthogonal sequences for UE multiplexing may be used for a different number of symbols in a long PUCCH.

[00103] The X value may be 4 as agreed in 3GPP meetings. In NR, a slot may be configured as 7 symbols or 10 symbols. Therefore, for normal CP, if a slot includes 7 symbols, a long PUCCH in a slot may have durations from 4 to 7 symbols. If a slot includes 14 symbols, a long PUCCH in a slot may have durations from 4 to 14 symbols.

Similarly, for extended CP, if a slot includes 6 symbols, a long PUCCH in a slot may have durations from 4 to 6 symbols. If a slot includes 12 symbols, a long PUCCH in a slot may have durations from 4 to 12 symbols.

[00104] A long PUCCH may occupy all UL symbols in a UL centric slot, as shown in example (c) of Figure 13. Alternatively, a long PUCCH may occupy part of the UL symbols to the end of a UL centric slot or a UL only slot, as shown in example (e) of Figure 13.

[00105] A long PUCCH may occupy some symbols in a UL centric or a UL only slot, as shown in Figure (g) of Figure 13. In this case, a long PUCCH may start from the beginning of or the middle of a UL only slot or the starting UL symbol of a UL centric slot, and may end in the middle of or at the end of a UL only slot or the starting UL symbol of a UL centric slot, as long as the number of symbols is greater or equal to a threshold X.

[00106] In the case where a long PUCCH spans over multiple slots, it is possible that a long PUCCH spans over both UL centric slot and UL only slots. The UE multiplexing capability may be different for the UL centric slot and the UL only slot due to a different number of symbols available for symbol multiplexing.

[00107] In one approach, a long PUCCH should always be configured to the end of a UL centric or UL only slot, as shown in example (d) and example (f) of Figure 13. In another approach, a long PUCCH may start from a UL symbol in a UL centric or UL only slot, and ends in a symbol in the same slot or a consecutive UL slot, as shown in example (h) of Figure 13.

[00108] As a summary for long PUCCH duration, a long PUCCH may occupy part of the symbols of a UL centric or UL only slot. A long PUCCH may occupy all symbols of a UL centric or UL only slot. A long PUCCH may occupy part of the symbols of a UL centric or UL only slot followed by one or more consecutive UL only slots.

[00109] From a design perspective, options in examples (a), (b), (c) and (d) of Figure 13 may be more consistent because the long PUCCH always occupies all symbols of UL

centric or UL only slots. On the other hand, the other options may provide more flexibility for PUCCH resource assignment.

[00110] The long PUCCH may support both DFT-S-OFDM and CP-OFDM based formats. In the following sections, the long PUCCH design for different waveforms in a UL centric and a UL only slot is discussed. First, the PUCCH structure in a UL only slot will be discussed first, followed by the UL centric slot considerations.

[00111] Regarding a DFT-S-OFDM-based long PUCCH, long PUCCH formats should support at least for low PAPR waveform (i.e., DFT-S-OFDM). For DFT-S-OFDM based long PUCCH formats, the LTE PUCCH structure may be reused in NR, at least on the DMRS location and spreading sequence design. Thus, the following two DMRS patterns should be supported for NR long PUCCH with low PAPR or DFT-S-OFDM waveform.

[00112] A first DMRS pattern (Pattern 1) includes 2 RS in every 7 or 6 symbols, as shown in Figure 14. With this pattern, a long PUCCH format has 2 DMRS in every 7 symbols for normal CP (NCP), and 2 DMRS in every 6 symbols for extended CP (ECP) within a slot, as shown in Figure 14 with the DMRS positions.

[00113] The DMRS signal generation and spreading sequences for UCI data can be the same as in LTE PUCCH format 2 and PUCCH Format 3. Therefore, at least two formats can be supported for NR long PUCCH format depending on the UCI data spreading methods. In one format, within each RB, different UCI symbols are transmitted on different OFDM symbols, and spreading factor is applied at frequency domain with the Z-C sequence. This is similar to LTE PUCCH Format 2.

[00114] In another format, within each RB, different UCI symbols are transmitted on different subcarriers, and spreading factor is applied at time domain with the orthogonal sequences given in Table 4 below, where $N_{SF}^{PUCCH} = 5$ for normal CP and $N_{SF}^{PUCCH} = 4$ for extended CP. This is similar to LTE PUCCH Format 3. Table 4 provides an orthogonal sequence $w_{n_{OC}}(i)$.

Sequence index n_{OC}	Orthogonal sequence $\left[w_{n_{OC}}(0) \ \Lambda \ w_{n_{OC}}(N_{SF}^{PUCCH} - 1) \right]$	
	$N_{SF}^{PUCCH} = 5$	$N_{SF}^{PUCCH} = 4$
0	$[1 \ 1 \ 1 \ 1 \ 1]$	$[+1 \ +1 \ +1 \ +1]$
1	$\left[1 \ e^{j2\pi/5} \ e^{j4\pi/5} \ e^{j6\pi/5} \ e^{j8\pi/5} \right]$	$[+1 \ -1 \ +1 \ -1]$
2	$\left[1 \ e^{j4\pi/5} \ e^{j8\pi/5} \ e^{j2\pi/5} \ e^{j6\pi/5} \right]$	$[+1 \ +1 \ -1 \ -1]$
3	$\left[1 \ e^{j6\pi/5} \ e^{j2\pi/5} \ e^{j8\pi/5} \ e^{j4\pi/5} \right]$	$[+1 \ -1 \ -1 \ +1]$
4	$\left[1 \ e^{j8\pi/5} \ e^{j6\pi/5} \ e^{j4\pi/5} \ e^{j2\pi/5} \right]$	-

Table 4

[00115] The pattern above assumes all symbols in a UL only slot is used. In a case where some or all symbols of a UL centric slot or a part of UL symbols in a UL only slot can be used for a long PUCCH, a long PUCCH design may reuse the DMRS pattern for all symbols of a UL only slot. That is, the DMRS location in a slot may be fixed regardless of the duration of a long PUCCH. This provides better RS multiplexing capabilities and avoids interference from UCI from other PUCCH transmissions.

[00116] Therefore, if a long PUCCH always occupy the UL symbols to the end of a UL centric or a UL only slot, the minimum number of symbols X should be 3 for a long PUCCH in a UL centric slot or UL only slot to ensure a DMRS symbol included in a long PUCCH, as shown in Figure 15(a). If a long PUCCH can be allocated with any set of symbols in a slot, the minimum number of symbols X may be 4 for normal CP to ensure a DMRS symbol included in a long PUCCH, as shown in Figure 15(b).

[00117] In the following discussion, as a general example, the long PUCCH may be assumed to always occupy the UL symbols to the end of a UL centric or a UL only slot. In one format, within each RB, different UCI symbols are transmitted on different OFDM symbols, and spreading factor is applied at frequency domain with the Z-C sequence. This is similar to LTE PUCCH Format 2. The same structure can be used in a long PUCCH occupying all symbols or some symbols of a UL centric slot or some symbols of a UL only slot. This results in a reduced number of UCI carrying symbols compared with a long PUCCH occupying all symbols of a UL only slot.

[00118] Also in this format, the frequency domain multiplexing may apply a length 12 orthogonal covering code in each RB instead of a Z-C sequence. This allows multiple UCI symbols to be carried on different subcarriers. Several examples of length 12 OCC codes are as follows.

[00119] For 2 UE multiplexing, the OCC in frequency domain can be as given in Table 5. Each UE 102 may carry 6 QPSK UCI symbols in each RB of a UCI carrying symbol.

Sequence index n_{OC}	Orthogonal sequence $\left[w_{nCDM}(0) \ \Lambda \ w_{nCDM}(N_{sc}^{RB} - 1) \right]$ $N_{SF}^{PUCCH} = 2$
0	[1 1 1 1 1 1 1 1 1 1 1 1]
1	[1 -1 1 -1 1 -1 1 -1 1 -1 1 -1]

Table 5

[00120] For 3 UE multiplexing, the OCC in frequency domain can be as given in Table 6. Each UE 102 may carry 4 QPSK UCI symbols in each RB of a UCI carrying symbol.

Sequence index n_{OC}	Orthogonal sequence $\left[w_{nCDM}(0) \ \Lambda \ w_{nCDM}(N_{sc}^{RB} - 1) \right]$ $N_{SF}^{PUCCH} = 3$
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0	$[1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1]$
1	$\begin{bmatrix} 1 & e^{j2\pi/3} & e^{j4\pi/3} & 1 & e^{j2\pi/3} & e^{j4\pi/3} \\ 1 & e^{j2\pi/3} & e^{j4\pi/3} & 1 & e^{j2\pi/3} & e^{j4\pi/3} \end{bmatrix}$
2	$\begin{bmatrix} 1 & e^{j4\pi/3} & e^{j2\pi/3} & 1 & e^{j4\pi/3} & e^{j2\pi/3} \\ 1 & e^{j4\pi/3} & e^{j2\pi/3} & 1 & e^{j4\pi/3} & e^{j2\pi/3} \end{bmatrix}$

Table 6

[00121] For 4 UE multiplexing, the OCC in frequency domain can be given as given in Table 7. Each UE 102 may carry 3 QPSK UCI symbols in each RB of a UCI carrying symbol.

Sequence index n_{OC}	Orthogonal sequence $\left[w_{nCDM}^{(0)} \ \Lambda \ w_{nCDM}^{(N_{sc}^{RB} - 1)} \right]$ $N_{SF}^{PUCCH} = 4$
0	$[1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1]$
1	$[+1 \ -1 \ +1 \ -1 \ +1 \ -1 \ +1 \ -1 \ +1 \ -1 \ +1 \ -1]$
2	$[+1 \ +1 \ -1 \ -1 \ +1 \ +1 \ -1 \ -1 \ +1 \ +1 \ -1 \ -1]$
3	$[+1 \ -1 \ -1 \ +1 \ +1 \ -1 \ -1 \ +1 \ +1 \ -1 \ -1 \ +1]$

Table 7

[00122] With frequency OCC, the same OCC can be applied to all UCI carrying symbols. Thus, the total number of UCI symbols can be determined based the number of UCI carrying.

[00123] In another format, within each RB, different UCI symbols are transmitted on different subcarriers, and spreading factor is applied at time domain with the orthogonal

sequences since a long PUCCH occupying part of a slot in a UL centric slot or UL only slot may have different number of UL symbols.

[00124] If the number of symbols is 3 for the long PUCCH, one symbol is used as DMRS, only 2 symbols are used for UCI UE multiplexing, the number of orthogonal sequences can only be 2. Table 8 provides an orthogonal sequence $w_{n_{OC}}(i)$ for a 3-symbol long PUCCH.

Sequence index n_{OC}	Orthogonal sequence $\left[w_{n_{OC}}(0) \ \Lambda \ w_{n_{OC}}(N_{SF}^{PUCCH} - 1) \right]$ $N_{SF}^{PUCCH} = 2$
0	$\begin{bmatrix} +1 & +1 \end{bmatrix}$
1	$\begin{bmatrix} +1 & -1 \end{bmatrix}$

Table 8

[00125] If the number of symbols is 4 for the long PUCCH, 1 symbol is used as DMRS, only 3 symbols are used for UCI UE multiplexing, the number of orthogonal sequences can only be 3. Table 9 provides an orthogonal sequence $w_{n_{OC}}(i)$ for a 4-symbol long PUCCH.

Sequence index n_{OC}	Orthogonal sequence $\left[w_{n_{OC}}(0) \ \Lambda \ w_{n_{OC}}(N_{SF}^{PUCCH} - 1) \right]$ $N_{SF}^{PUCCH} = 3$
0	$[1 \ 1 \ 1]$
1	$\left[1 \ e^{j2\pi/3} \ e^{j4\pi/3} \right]$
2	$\left[1 \ e^{j4\pi/3} \ e^{j2\pi/3} \right]$

Table 9

[00126] If the number of symbols is 5 for the long PUCCH, for normal CP, 1 symbol is used as DMRS, and 4 symbols are used for UCI UE multiplexing, the number of orthogonal sequences can only be 4. Table 10 provides an orthogonal sequence $w_{n_{OC}}(i)$ for a 5-symbol long PUCCH with normal CP.

Sequence index n_{OC}	Orthogonal sequence $\left[w_{n_{OC}}(0) \ \Lambda \ w_{n_{OC}}(N_{SF}^{PUCCH} - 1) \right]$ $N_{SF}^{PUCCH} = 4$
0	$[+1 \ +1 \ +1 \ +1]$
1	$[+1 \ -1 \ +1 \ -1]$
2	$[+1 \ +1 \ -1 \ -1]$
3	$[+1 \ -1 \ -1 \ +1]$

Table 10

[00127] If the number of symbols is 5 for the long PUCCH, for extended CP, 2 symbols are used as DMRS, and 3 symbols are used for UCI UE multiplexing, the

number of orthogonal sequences can only be 3. The same orthogonal sequences as for 4 symbols long PUCCH can be used. Table 11 provides an orthogonal sequence $w_{n_{OC}}(i)$ for a 5-symbol long PUCCH with extended CP.

Sequence index n_{OC}	Orthogonal sequence $\left[w_{n_{OC}}(0) \ \Lambda \ w_{n_{OC}}(N_{SF}^{PUCCH} - 1) \right]$ $N_{SF}^{PUCCH} = 3$
0	$[1 \ 1 \ 1]$
1	$\left[1 \ e^{j2\pi/3} \ e^{j4\pi/3} \right]$
2	$\left[1 \ e^{j4\pi/3} \ e^{j2\pi/3} \right]$

Table 11

[00128] If the number of symbols is 6 for the long PUCCH, for normal CP, 2 symbols are used as DMRS, and 4 symbols are used for UCI UE multiplexing, the number of orthogonal sequences can only be 4. The same orthogonal sequences as for 5 symbols long PUCCH can be used. Table 12 provides an orthogonal sequence $w_{n_{OC}}(i)$ for a 5-symbol long PUCCH with normal CP.

Sequence index n_{OC}	Orthogonal sequence $\left[w_{n_{OC}}(0) \ \Lambda \ w_{n_{OC}}(N_{SF}^{PUCCH} - 1) \right]$ $N_{SF}^{PUCCH} = 4$
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0	$[+1 \ +1 \ +1 \ +1]$
1	$[+1 \ -1 \ +1 \ -1]$
2	$[+1 \ +1 \ -1 \ -1]$
3	$[+1 \ -1 \ -1 \ +1]$

Table 12

[00129] If a slot has 14 symbols, and a long PUCCH is configured with more than 7 symbols, the above mentioned constraints can be applied for every 7 symbols, and the UE multiplexing capability may be limited by the UL portion that is smaller than 7 symbols. And the UE 102 may be configured with an orthogonal sequence for the 7-symbol part and another orthogonal sequence for portion that is smaller than 7 symbols. In this case, only a subset of orthogonal sequences on a 7 symbol part can be configured for a UE 102.

[00130] Similarly, if a long PUCCH includes both UL centric and UL only slots, the UE multiplexing capability may be limited by the UL centric slot as described above. Thus, in this case, only a subset of orthogonal sequences on a UL only slot can be configured for a UE 102. And the UE 102 may be configured with an orthogonal sequence for the UL centric part and another orthogonal sequence for the UL only parts. With this method, the UCI payload is not reduced in the UL centric and UL only slot.

[00131] In another method, if a slot has 14 symbols, and a long PUCCH is configured with more than 7 symbols, the orthogonal sequences for UE multiplexing can be jointly designed across all configured symbols for the long PUCCH in the slot. Similarly, if a long PUCCH includes both UL centric and UL only slots, the orthogonal sequences for UE multiplexing can be jointly designed across the UL centric and UL only slot. For example, if a UL-centric slot has 3 UCI carrying symbols, and a UL only slot has 5 UCI carrying symbols, eight orthogonal sequences of length eight can be generated for UE multiplexing. In this case, the UE multiplexing capability is increased, but the UCI payload is reduced across all symbols, or across the UL centric and UL only slots.

[00132] A second DMRS pattern (Pattern 2) includes one RS in every 7 or 6 symbols, as shown in Figure 16. With this pattern, a long PUCCH format has 1 DMRS in every 7 symbols for normal CP (NCP), and 1 DMRS in every 6 symbols for extended CP (ECP) within a slot, as shown in Figure 16 with the DMRS positions.

[00133] The DMRS signal generation and spreading sequences for UCI data can be similar to LTE PUCCH format 4 if no UE multiplexing in the same RB is supported. If up to 2 UE multiplexing is supported in the same RB, an orthogonal sequence in Table 13 with spreading factor of 2 can be used, which is similar to PUCCH format 5.

n_{OC}	Orthogonal sequences $\left[w_{n_{CDM}}(0) \ \Lambda \ w_{n_{CDM}}(N_{sc}^{RB} - 1) \right]$
0	$[+1 \ +1 \ +1 \ +1 \ +1 \ +1 \ +1 \ +1 \ +1 \ +1 \ +1 \ +1]$
1	$[+1 \ +1 \ +1 \ +1 \ +1 \ +1 \ -1 \ -1 \ -1 \ -1 \ -1 \ -1]$

Table 13

[00134] The pattern above assumes all symbols in a UL only slot is used. In a case where some or all symbols of a UL centric slot, or a part of UL symbols in a UL only slot can be used for a long PUCCH, for a long PUCCH design should reuse the DMRS pattern for UL only slot.

[00135] Similarly, other length 12 OCC codes can be applied to allow multiple UCI symbols to be carried on different subcarriers. For example, For 3 UE multiplexing, the OCC in frequency domain can be as given in Table 14. Each UE 102 may carry 4 QPSK UCI symbols in each RB of a UCI carrying symbol.

Sequence index n_{OC}	Orthogonal sequence $\left[w_{n_{CDM}}(0) \ \Lambda \ w_{n_{CDM}}(N_{sc}^{RB} - 1) \right]$ $N_{SF}^{PUCCH} = 3$
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0	$[1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1]$
1	$\begin{bmatrix} 1 & e^{j2\pi/3} & e^{j4\pi/3} & 1 & e^{j2\pi/3} & e^{j4\pi/3} \\ 1 & e^{j2\pi/3} & e^{j4\pi/3} & 1 & e^{j2\pi/3} & e^{j4\pi/3} \end{bmatrix}$
2	$\begin{bmatrix} 1 & e^{j4\pi/3} & e^{j2\pi/3} & 1 & e^{j4\pi/3} & e^{j2\pi/3} \\ 1 & e^{j4\pi/3} & e^{j2\pi/3} & 1 & e^{j4\pi/3} & e^{j2\pi/3} \end{bmatrix}$

Table 14

[00136] For 4 UE multiplexing, the OCC in frequency domain can be given as given in Table 15. Each UE 102 may carry 3 QPSK UCI symbols in each RB of a UCI carrying symbol.

Sequence index n_{OC}	Orthogonal sequence $\left[w_{nCDM}(0) \ \Lambda \ w_{nCDM}(N_{sc}^{RB} - 1) \right]$ $N_{SF}^{PUCCH} = 4$
0	$[1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1]$
1	$[+1 \ -1 \ +1 \ -1 \ +1 \ -1 \ +1 \ -1 \ +1 \ -1 \ +1 \ -1]$
2	$[+1 \ +1 \ -1 \ -1 \ +1 \ +1 \ -1 \ -1 \ +1 \ +1 \ -1 \ -1]$
3	$[+1 \ -1 \ -1 \ +1 \ +1 \ -1 \ -1 \ +1 \ +1 \ -1 \ -1 \ +1]$

Table 15

[00137] With frequency OCC, the same OCC can be applied to all UCI carrying symbols. Thus, the total number of UCI symbols can be determined based the number of UCI carrying.

[00138] Therefore, the minimum number of symbols X should be 4 for a long PUCCH in a UL centric slot or UL only slot to ensure a DMRS symbol included in a long

PUCCH. If two UEs 102 are multiplexed in the same RB resource, the same orthogonal sequences can be applied on each UCI carrying symbol.

[00139] DMRS patterns and frequency hopping are also described herein. Frequency hopping is a key feature for PUCCH to provide frequency diversity. If configured, the PUCCH symbols can be transmitted at different PUCCH regions. For a long PUCCH duration in a slot, only 1 hop is supported. Whether frequency hopping can be supported or not may be determined by the DMRS patterns, and vice versa. The following discussion for frequency hopping and DMRS locations may be applicable to both DFT-S-OFDM based PUCCH and CP-OFDM based PUCCH.

[00140] In one method, fixed DMRS pattern in a slot as discussed above can be applied to any long PUCCH duration in a slot, regardless of the starting and ending symbol within the slot. This provides better DMRS alignment among long PUCCHs with different durations.

[00141] In another method, a fixed DMRS pattern as discussed above can be applied from the starting symbol on any long PUCCH durations. Thus, the fixed pattern is corresponding to the starting symbol of a long PUCCH instead of the beginning of a slot.

[00142] In both cases, the fixed DMRS patterns may result in non-optimal DMRS locations in a PUCCH. Furthermore, frequency hopping may not be possible in some cases if there is only one DMRS present in a given PUCCH duration. Therefore, with fixed DMRS locations in a slot, frequency hopping may not be supported for all PUCCH durations. For example, if there are 2 DMRSs in every 7 symbols with normal CP, a length 4 long PUCCH can only have one DMRS included, thus frequency hopping cannot be applied. Depending on the starting symbol location, there are cases with only one DMRS for long PUCCH durations of 5 or 6 symbols.

[00143] Therefore, with fixed DMRS patterns relative to a slot boundary or the starting symbol of a long PUCCH, frequency hopping may be disabled if there is only 1 DMRS in the long PUCCH duration. If there are 2 or more DMRSs in the long PUCCH duration within a slot, in one approach, frequency hopping may be mandatory; in another

approach, whether frequency hopping is applied may be configured by higher layer signaling.

[00144] With fixed DMRS patterns relative to a slot boundary or the starting symbol of a long PUCCH, the frequency hopping location may also be fixed based on the DMRS patterns. Figure 17 below shows an example of potential frequency hopping locations.

[00145] In yet another method, the DMRS location is determined in each hop based on basic structures of building blocks of different length. Since the long PUCCH duration in a slot may vary between 4–14 symbols, if frequency hopping is applied, each hop may have 2 to 7 symbols. The basic structures of building blocks for each hop are given in Figure 18. Figures 19A and 19B show some examples of DMRS patterns and frequency hopping locations for different long PUCCH durations

[00146] CP-OFDM based long PUCCH is also described herein. To minimize the specification impact, a common framework can be used for both DFT-S-OFDM and CP-OFDM-based long PUCCH. Thus, at least the same UCI multiplexing methods as in DFT-S-OFDM-based long PUCCH can be applied for CP-OFDM-based long PUCCH. Furthermore, the RS symbol location can also be maintained the same as in DFT-S-OFDM-based PUCCH.

[00147] In DFT-S-OFDM based transmissions, the RS is separated by different Z-C sequences. In CP-OFDM based long PUCCH, the RS should be separated by FDM for different UEs 102. Thus, different UEs 102 are assigned with different RS patterns that are not overlapping with other UEs 102. Figure 20 and Figure 21 show several examples of RS multiplexing for different UEs 102 with pattern 1 where two RS symbols are used in every 7 symbols for NCP and every 6 symbols for ECP. Different UEs 102 are assigned with different subcarriers for RS transmission in the two DMRS symbols. In the Figures, each crosshatch represents the DMRS of a different UE 102.

[00148] There is a tradeoff between the UE multiplexing capability and the number of RS symbols in each RB. In one implementation, a UE 102 may be configured with 2 subcarriers for RS transmission within each DMRS symbol. Thus, an RB can be multiplexed with 6 UEs 102.

[00149] In another implementation, a UE 102 may be configured with 3 subcarriers for RS transmission within each DMRS symbol. Thus, an RB can be multiplexed with 4 UEs 102.

[00150] In another implementation, a UE 102 may be configured with 4 subcarriers for RS transmission within each DMRS symbol. Thus, an RB can be multiplexed with 3 UEs 102.

[00151] In yet another implementation, a UE 102 may be configured with 6 subcarriers for RS transmission within each DMRS symbol. Thus, an RB can be multiplexed with 2 UEs 102.

[00152] For CP-OFDM based transmission with 2 RS symbols in each 7 symbols for NCP and every 6 symbols for ECP, the RS can also be located at the beginning. Thus, a shifted RS pattern can be applied. Figure 22 shows an example with NCP.

[00153] The pattern above assumes all symbols in a UL only slot is used. In case of some or all symbols of a UL centric slot, or a part of UL symbols in a UL only slot can be used for a long PUCCH, a long PUCCH design may reuse the DMRS pattern for UL only slot. That is, the DMRS location in a slot may be fixed regardless of the duration of a long PUCCH. This provides better RS multiplexing capabilities and avoids interference from UCI from other PUCCH transmissions.

[00154] Therefore, if a long PUCCH always occupies the UL symbols to the end of a UL centric or a UL only slot, the minimum number of symbols X should be 3 for a long PUCCH in a UL centric slot or UL only slot to ensure a DMRS symbol included in a long PUCCH. If a long PUCCH can be allocated with any set of symbols in a slot, the minimum number of symbols X should be 4 for normal CP to ensure a DMRS symbol included in a long PUCCH.

[00155] The same UE multiplexing orthogonal sequences can be applied for long PUCCH formats with different number of symbols as described above for DFT-S-OFDM based long PUCCH formats. Furthermore, in a long PUCCH, the RS multiplexing capability should be jointly designed with the UCI multiplexing capability. The actual UE

multiplexing capability is determined by the minimum of multiplexing capabilities between the RS multiplexing capability and UCI multiplexing capability.

[00156] Similarly, the same frequency division multiplexing (FDM) combinations can be used on the pattern with a single RS symbol in every 7 symbols for NCP and every 6 symbols for ECP. In this case, the RS position should be the same as in DFT-S-OFDM based transmission, and no shift of RS position is needed. Figure 23 shows several examples for a long PUCCH with a single DMRS in every 7 symbols for NCP with different UE multiplexing capabilities.

[00157] In one implementation, a UE 102 may be configured with 2 subcarriers for RS transmission. Thus, an RB can be multiplexed with 6 UEs 102.

[00158] In another implementation, a UE 102 may be configured with 3 subcarriers for RS transmission. Thus, an RB can be multiplexed with 4 UEs 102.

[00159] In another implementation, a UE 102 may be configured with 4 subcarriers for RS transmission. Thus, an RB can be multiplexed with 3 UEs 102.

[00160] In yet another implementation, a UE 102 may be configured with 6 subcarriers for RS transmission. Thus, an RB can be multiplexed with 2 UEs 102.

[00161] To achieve UE multiplexing, the same or similar orthogonal sequence can be applied on the time domain or frequency domain as in the case with 2 DMRS every 7 symbols for NCP and every 6 symbols for ECP.

[00162] The pattern above assumes all symbols in a UL only slot is used. In a case where some or all symbols of a UL centric slot, or a part of UL symbols in a UL only slot can be used for a long PUCCH, the long PUCCH should reuse the DMRS pattern of a UL only slot. Therefore, the minimum number of symbols X should be 4 for a long PUCCH in a UL centric slot or a UL only slot to ensure a DMRS symbol included in a long PUCCH. If two UEs 102 are multiplexed in the same RB resource, the same orthogonal sequences can be applied on each UCI carrying symbol.

[00163] Furthermore, in a long PUCCH, the RS multiplexing capability should be jointly designed with the UCI multiplexing capability. The actual UE multiplexing capability is determined by the minimum of multiplexing capabilities between the RS

multiplexing capability and UCI multiplexing capability. Therefore, in case of more than two UEs 102 are multiplexed on a RB using a RS pattern, the UCI multiplexing capability may be redesigned similar to the two DMRS symbol case.

[00164] In one format, within each RB, different UCI symbols are transmitted on different OFDM symbols, and spreading factor is applied at frequency domain with the Z-C sequence. This is similar to LTE PUCCH Format 2. The same structure can be used in a long PUCCH occupying all symbols or some symbols of a UL centric slot or some symbols of a UL only slot. This results in a reduced number of UCI carrying symbols compared with a long PUCCH occupying all symbols of a UL only slot.

[00165] Also in this format, the frequency domain multiplexing may apply a length 12 orthogonal covering code in each RB instead of Z-C sequence. This allows multiple UCI symbols to be carried on different subcarriers. The same length 12 OCC codes in frequency domain defined above for DFT-S-OFDM based PUCCH can be used for CP-OFDM based PUCCH as well.

[00166] In another format, within each RB, different UCI symbols are transmitted on different subcarriers, and spreading factor is applied at time domain with the orthogonal sequences since a long PUCCH occupying part of a slot in a UL centric slot or UL only slot may have different number of UL symbols.

[00167] If all symbols are used, up to 6 orthogonal sequences of length 6 can be generated (e.g., with the following sequences in Table 14). If only some symbols are used, the number of orthogonal sequences may be reduced with a reduced length, and the corresponding orthogonal sequences with length of 2, 3, 4, and 5 above can be used. Table 16 provides an orthogonal sequence $w_{n_{OC}}(i)$ for a 6 symbol spreading.

Sequence index n_{OC}	Orthogonal sequence $\left[w_{n_{OC}}(0) \ \Delta \ w_{n_{OC}}(N_{SF}^{PUCCH} - 1) \right]$ $N_{SF}^{PUCCH} = 6$
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0	$[1 \ 1 \ 1 \ 1 \ 1 \ 1]$
1	$\begin{bmatrix} 1 & e^{j2\pi/3} & e^{j4\pi/3} & 1 & e^{j2\pi/3} & e^{j4\pi/3} \end{bmatrix}$
2	$\begin{bmatrix} 1 & e^{j4\pi/3} & e^{j2\pi/3} & 1 & e^{j4\pi/3} & e^{j2\pi/3} \end{bmatrix}$
3	$[1 \ 1 \ 1 \ -1 \ -1 \ -1]$
4	$\begin{bmatrix} 1 & e^{j2\pi/3} & e^{j4\pi/3} & -1 & e^{j5\pi/3} & e^{j\pi/3} \end{bmatrix}$
5	$\begin{bmatrix} 1 & e^{j4\pi/3} & e^{j2\pi/3} & -1 & e^{j\pi/3} & e^{j5\pi/3} \end{bmatrix}$

Table 16

[00168] For frequency hopping of a long PUCCH with CP-OFDM, the same methods as in DFT-S-OFDM based long PUCCH can be used. In one method, a fixed DMRS pattern in a slot as discussed above can be applied to any long PUCCH duration in a slot, regardless of the starting and ending symbol within the slot. This may provide better DMRS alignment among long PUCCHs with different durations.

[00169] In another method, a fixed DMRS pattern as discussed above can be applied from the starting symbol on any long PUCCH durations. Thus, the fixed pattern is corresponding to the starting symbol of a long PUCCH instead of the beginning of a slot.

[00170] Therefore, with fixed DMRS patterns relative to a slot boundary or the starting symbol of a long PUCCH, frequency hopping may be disabled if there is only 1 DMRS in the long PUCCH duration. If there are 2 or more DMRSs in the long PUCCH duration within a slot, in one approach, frequency hopping may be mandatory. In another approach, whether frequency hopping is applied may be configured by higher layer signaling.

[00171] Compared with the fixed DMRS patterns for DFT-S-OFDM based long PUCCH, the DMRS pattern for CP-OFDM based long PUCCH may be shifted (e.g., front loaded DMRS in each hop).

[00172] With fixed DMRS patterns relative to a slot boundary or the starting symbol of a long PUCCH, the frequency hopping location may also be fixed based on the DMRS patterns. Depending on the starting and ending symbols of a long PUCCH in a slot, only 1 hop should be supported. The hopping location is determined based on the closest location to the middle of the long PUCCH duration of N symbols (i.e., the closest fixed hopping location relative to the end of the X th symbol where $X = \text{floor}(N/2)$ [or $\text{ceil}(N/2)$]).

[00173] In yet another method, the DMRS location is determined in each hop based on basic structures of building blocks of different length, same as DFT-S-OFDM based long PUCCH. The DMRS for CP-OFDM based PUCCH in each hop may be shifted compared with DFT-S-OFDM based PUCCH.

[00174] This method provides optimal DMRS locations for all long PUCCH durations between 4–14 symbols. With this method, the long PUCCH may be included in a single slot, or in continuous symbols cross over in multiple slots. It should be noted that the frequency hopping may be mandatory for all long PUCCH lengths in a slot.

[00175] It should also be noted that the method can be used to determine the DMRS location/pattern regardless whether frequency hopping is configured or not on a long PUCCH. Two approaches can be considered if frequency hopping is not configured. In one approach, for any long PUCCH lengths between 4-14 symbols, the same DMRS position is determined as if frequency hopping is configured. In another approach, if the long PUCCH duration is between 4–7 symbols inclusively, the DMRS position may be determined with the pattern of one hop as described in connection with in Figure 18.

[00176] As described above, for CP-OFDM-based long PUCCH, the DMRS symbol locations can be used as in DFT-S-OFDM-based long PUCCH. On the other hand, CP-OFDM-based long PUCCH can be more flexible on DMRS pattern. For example, the DMRS locations can be spread in the frequency domain other than time domain. Figure 24 shows several examples of DMRS spreads in the frequency domain on 2 subcarriers, 3 subcarriers and 4 subcarriers within each RB for NCP. For each number of RS in a RB, two potential DMRS locations are provided.

[00177] For DMRS multiplexing, different orthogonal sequences may be applied for different UEs 102. The number of available orthogonal sequence depends on the number of symbols in a slot used for the long PUCCH format. For example, in a UL only slot with length of 7 or 14 for normal CP or 6 or 12 for extended CP, the number of orthogonal sequence can be the same as the number of symbols in a slot.

[00178] On the other hand, if a long PUCCH is configured in a UL centric slot, the minimum number of symbols of a long PUCCH can be $X=3$. The number of orthogonal sequences for a long PUCCH in a UL centric slot is the same as the number of symbols of the long PUCCH in the UL centric slot.

[00179] Alternatively, for DMRS UE multiplexing, different UEs 102 can be allocated with different symbols in the time domain with a DMRS pattern. Figure 25 shows several examples where four UEs 102 are multiplexed with different DMRS patterns. In Figure 25, each crosshatch represents the DMRS pattern of a given UE 102.

[00180] For UCI data, orthogonal sequences can be applied on either a time domain or a frequency domain for UE multiplexing. If an orthogonal sequence is spread in the time domain, the sequence length can be 7 for NCP, and 6 for ECP. If an orthogonal sequence is spread in the frequency domain, the sequence length can be the number of subcarriers per RB minus the number of subcarriers for DMRS.

[00181] In a case where some or all symbols of a UL centric slot, or a part of UL symbols in a UL only slot can be used for a long PUCCH, the minimum number of symbols of a long PUCCH can be $X=3$ or $X=4$ to ensure at least two DMRS symbols present for each UE 102.

[00182] In a long PUCCH in a UL centric slot, for UCI data, orthogonal sequences can be applied on either time domain or frequency domain for UE multiplexing. If an orthogonal sequence is spread at time domain, the number of orthogonal sequences, thus the sequence length can be the same as the number of symbols for the long PUCCH in the UL centric slot. If an orthogonal sequence is spread at frequency domain, the sequence length can be the number of subcarriers per RB minus the number of subcarriers for DMRS.

[00183] Configuration of a long PUCCH is also described herein. For a long PUCCH, both continuous and distributed resource allocation should be supported. The PUCCH resource allocation may be performed in RB level. In one method, a long PUCCH resource can be configured localized in contiguous RBs in a PUCCH region/subband. In another method, a long PUCCH resource can be configured in a distributed manner with non-contiguous RBs in a PUCCH region/subband. In this case, a PUCCH resource pattern should be configured with a PUCCH region/subband for a given UE 102. If a single PUCCH region/subband is configured, the size and the position of the PUCCH region/subband can be configured.

[00184] To provide frequency diversity, frequency hopping of a long PUCCH can be configured. In this case, separate PUCCH regions or subbands should be configured for a UE 102, and the PUCCH can be transmitted with frequency hopping in different regions/subbands, as shown in Figure 26.

[00185] In one method, if a long PUCCH spans over multiple slots, frequency hopping can be applied at the slot level. Thus, adjacent slots are transmitted at different control regions/subbands.

[00186] In another method, if a long PUCCH spans over multiples of 7 symbols for NCP or multiples of 6 symbols for ECP, frequency hopping can be applied on every 7 symbols for NCP and every 6 symbols for ECP. Thus, different control regions/subbands are switched every 7 symbols for NCP and every 6 symbols for ECP. This method is slightly different from the above method. For example, a slot may have 7 or 14 symbols depending on the frequency band. Thus, this method has sub-slot frequency hopping if a slot has 14 symbols. This can be an inter-slot hopping if a slot is 7 symbols for NCP and every 6 symbols for ECP. This can be an intra-slot hopping if a slot is 14 symbols for NCP and 12 symbols for ECP.

[00187] In yet another method, if a long PUCCH occupies a single slot of 7 symbols for NCP or 6 symbols for ECP, frequency hopping can be applied at sub-slot symbol level, i.e. the first 4 symbols for NCP and first 3 symbols for ECP are transmitted in one control subband, and the remaining 3 symbols are transmitted in another control subband.

In one approach, this sub-slot frequency hopping method can be used for all lengths of a long PUCCH. This can be viewed as an intra-slot hopping. The intra-slot frequency hopping can be applied even if a long PUCCH spans over multiple slots.

[00188] The frequency hopping may not be applied in a UL centric slot if there are only 1 DMRS in the long PUCCH, or if the number of symbols is only 3 or 4 symbols.

[00189] The multiple PUCCH regions or subbands can also be viewed as a distributed resource allocation for a long PUCCH. Especially, in a transmission in unlicensed spectrum, a distributed resource mapping is important to satisfy the regulatory requirements. In a case where multiple PUCCH regions/subbands are configured, the size of each PUCCH region/subband can be configured, and the positions of PUCCH regions/subbands can be configured with a pattern within the carrier.

[00190] Similarly, a UE 102 can be configured with two PUCCH resources to provide transmit diversity. The two PUCCH resources can be configured in a single PUCCH region/subband, or different PUCCH regions/subbands. The PUCCH resources can be localized with contiguous RB allocations or distributed manner with non-contiguous RB allocations.

[00191] In LTE, multiple PUCCH formats are defined for different maximum payload sizes. Similarly in NR, multiple long PUCCH formats should be configured for different maximum payload sizes and multiplexing capabilities. Thus, the tradeoff between RS, information bits and multiplexing capabilities should be considered.

[00192] Furthermore, for a given PUCCH format, the resource allocation can be more flexible than LTE depending on the channel conditions. For UEs 102 with very good signal conditions, fewer RB resources may be allocated for a PUCCH. For UEs 102 with bad signal conditions (e.g., cell edge UEs 102), more RB resources may be allocated for a PUCCH.

[00193] Therefore, for a long PUCCH, at least the following parameters may be configured for a given UE 102: the waveform (e.g., DFT-S-OFDM or CP-OFDM); a long PUCCH may occupy multiple RBs and the number of RBs of a long PUCCH may be configured (e.g., based on the payload size); a long PUCCH may occupy one or more

slots and the length of a long PUCCH can be configurable based on the payload size and delay tolerance, etc.; a tradeoff can be considered between the number of RBs and the number of slot; the RS pattern and RS position; the spreading sequence for UCI multiplexing; frequency diversity with multiple PUCCH regions/subbands; transmit diversity with two configured PUCCH resources; the location of one or more configured PUCCH regions/subbands including size and position of each PUCCH subband/region in the carrier; and localized or distributed resource allocation for a PUCCH resource in a PUCCH region/subband.

[00194] In order to reduce the signaling overhead, a list of supported long uplink control channel formats can be specified, each with a given set of parameters, and the name or index of a supported long PUCCH format may be indicated or configured to a UE 102.

[00195] UCI encoding and rate matching on a long PUCCH with a single slot structure is also described herein. For UCI payload greater than 2 bits, a unified UCI encoding and rate matching scheme is preferred for all lengths of a long PUCCH format in a slot.

[00196] A forward error correction code (FEC) may be used to encode the UCI bits. The UCI encoded bits are then loaded to the allocated PUCCH resources. Since a long PUCCH supports different lengths, the number of encoded bits on a PUCCH may be different. Thus, rate matching methods can be applied to fit the actual PUCCH channel capacity.

[00197] The FEC may be a block code (e.g., Reed-Muller RM code or convolutional code) if the payload is smaller than a threshold (e.g., 20 or 22 bits). The FEC may use polar code if the payload is greater than the threshold.

[00198] For bit loading of the encoded UCI bits to the PUCCH RE resources, several methods may be considered. In a first method (Method 1), only frequency domain OCC is applied on all UCI carrying symbols. The encoded UCI bits may be loaded to UCI carrying symbols in a long PUCCH following rules of frequency first with multiplexing and then time domain in different UCI carrying symbols. The detailed OCC in frequency domain are provided before in this disclosure. If the same frequency domain OCC is

applied on all UCI carrying symbols, the number of encoded bit can be carried depends on the number UCI carrying symbols of a long PUCCH. The same multiplexing method can be performed for PUCCH with different lengths.

[00199] In a second method (Method 2), only time domain OCC is applied on UCI carrying symbols. The encoded UCI bits may be loaded to UCI carrying symbols in a long PUCCH following rules of frequency first without multiplexing. Then OCC is applied at time domain in different UCI carrying symbols. The detailed OCC in time domain to achieve different multiplexing capabilities are provided before in this disclosure. In this case, the number of UCI carrying symbols may be a multiple of the time domain OCC length. It may be difficult to multiplex together long PUCCH with different lengths.

[00200] In a third method (Method 3), both frequency domain and time domain OCC are applied on UCI carrying symbols. In this case, OCC may be applied in both frequency domain and time domain, this provides higher multiplexing capabilities, but may reduce the number of encoded bits that can be carried on a long PUCCH.

[00201] In an implementation, all 3 methods may be supported for a long PUCCH. The actual multiplexing method can be configured, or may be dependent on the UCI payload size. For example, OCC on both frequency and time domain may be applied if the UCI payload is small (i.e., the encoded bits with multiplexing can fit into the allocated PUCCH resources). If the UCI payload is large, only the frequency domain OCC may be applied.

[00202] A long PUCCH may span over multiple slots. This may be useful for a large payload size, flexible resource allocation and better coverage. Several aspects can be considered for a long PUCCH over multiple slots. A first aspect is long PUCCH over multiple slots with continuous UL symbols. In one method, a long PUCCH over multiple slots may occupy continuous UL symbols in multiple slots. In other words, no gap is allowed within a long PUCCH. Under this condition, there are several cases as shown in Figure 34. Examples of frequency hopping for long PUCCH over multiple slots with continuous UL symbols are described in connection with Figure 35.

[00203] A second aspect is long PUCCH over multiple slots with dis-continuous UL symbols. In this case, gaps are allowed within a long PUCCH transmission. In configured slots for a long PUCCH, some symbols are allocated for a long PUCCH in each slot. The PUCCH symbols in a slot should be continuous, but the symbols in different slots may have gap in between. Figure 36 illustrates multi-slot long PUCCH that may span over continuous or dis-continuous slots. Figure 37 illustrates examples of how the number of PUCCH symbols in each slot may be the same or different.

[00204] The DMRS pattern of a multi-slot long PUCCH should be determined on a per slot basis. The DMRS may be optimized based on the number of PUCCH symbols in each slot, as provided above for slot structure. Since each slot contains a long PUCCH format, several methods can be considered for frequency hopping. Figure 38 illustrates examples of frequency hopping for multi-slot long PUCCH.

[00205] Inter-slot or intra-slot hopping may be determined by slot length. If slot length = 7 symbols for NCP or 6 symbols for ECP, only inter-slot hopping should be applied. If slot length = 14 for NCP or 12 for ECP, intra-slot may be applied. In another approach, inter-slot or intra-slot hopping may be determined by number of PUCCH symbols in a slot length. If the number of PUCCH symbols in a slot is smaller than or equal to a threshold value (e.g., 7 symbols for NCP or 6 symbols for ECP), inter-slot hopping may be applied, otherwise, intra-slot may be applied.

[00206] Since each slot may be viewed as a long PUCCH within a slot, a multi-slot may be considered as a long PUCCH repetition over multiple slots. For UCI encoding and rate matching on multi-slot long PUCCH with gaps among slots, several methods can be considered.

[00207] A first method (Method 1) includes joint encoding and rate matching over all available UCI carrying symbols. The UCI may be encoded and the encoded bits are rate matched to all UCI carrying symbols of the multi-slot long PUCCH. Similar to a long PUCCH within a slot. The OCC may be applied in frequency domain and/or time domain over all UCI carrying symbols in the long PUCCH.

[00208] A second method (Method 2) includes joint UCI encoding with separate rate matching and bit loading to each slot. The UCI may be encoded. The encoding output is rate matched to the available UCI carrying symbols in each slot independently. With this method, each slot can be viewed as a long PUCCH, and the same UCI is encoded and repeated in consecutive long PUCCHs in different slots.

[00209] In a third method (Method 3), the UCI bits are segmented into multiple segments, each segment for each slot of a multi-slot PUCCH. Each UCI segment is separately encoded and rate matched to the PUCCH symbols in the given slot. The UCI bits may be segmented proportional to the number of UCI carrying symbols in each slot.

[00210] For multi-slot long PUCCH with gaps in between, Method 3 may simplify the UCI encoding in each slot, especially when the UCI payload is large. On the other hand, Method 3 may reduce the joint coding gain of all UCI bits compared with Method 1 and Method 2.

[00211] If all slots have the same number of PUCCH symbols, Method 2 becomes a slot long PUCCH repetition in multiple slots. Thus, Method 2 may be preferred if possible. However, if different slots have different number of PUCCH symbols, the coding rate may be different in different slots. For example, if the number of PUCCH symbols in one or more slots is too small, the encoded UCI bit may not fit into the available resources. Thus, Method 1 may be used if the encoded UCI bits cannot fit in a single slot.

[00212] Method 1 and Method 2 can be determined based on the minimum available PUCCH resource in all slots. If the encoded bits can fit in PUCCH UCI carrying symbols in all configured slots, Method 2 (joint coding with repetition in each slot) may be used. Otherwise, Method 1 (joint coding and rate matching among all slots) may be used.

[00213] The selection criteria may also be a nominal coding rate, if the available PUCCH UCI carrying symbols in all slots is lower than a nominal coding rate for UCI, Method 2 may be used. Otherwise, Method 1 may be used.

[00214] Even if the encoded bits cannot fit in PUCCH UCI carrying symbols in all configured slots, Method 2 may also be used if different redundancy versions of the

encoded bits are loaded into different slots. In this case, the gNB 160 may combine the different redundancy versions from multiple slots to decode the UCI.

[00215] Figure 39 shows a flow chart of one example of UCI encoding and rate matching methods for a multi-slot long PUCCH.

[00216] Band specific considerations of a long PUCCH are also described herein. The 5G NR supports different frequency bands with different channel characteristics. Thus, the PUCCH behavior may be different for different frequency bands. For below 6GHz frequency bands, the channel condition is more stable. Thus, it is better to use a semi-static configured PUCCH resource, or a dynamic indicated PUCCH resource.

[00217] Besides reusing the same DMRS positions as in a long PUCCH spans over all symbols in a slot, for a long PUCCH in a partial slot (e.g., in a UL centric or UL only slot), the DMRS positions can also configured by RRC signaling or indicated by physical layer signaling. In this case, the DMRS locations may be different from a long PUCCH spans over all symbols in a slot. However, the same orthogonal sequences and/or RS patterns described before can be applied on the RS REs, and the same orthogonal sequences described before for UCI carrying REs can also reused.

[00218] For frequency band above 6GHz, beamforming technology is critical for operation. Considering beam sweeping, a UE 102 may use different beams in different symbols, the DMRS from different symbols may not be appropriate for decoding of a different symbol. Thus, several methods can be considered for long PUCCH format at higher frequency bands above 6GHz.

[00219] In a first method (Method 1), a long PUCCH can be configured with less number of symbols with the same beam in time domain and more RBs in frequency domain. For example, the long PUCCH can be limited to 7 symbols for NCP and 6 symbols for ECP, or limited to a single slot length.

[00220] In a second method (Method 2), a long PUCCH can be configured with a beam pattern (i.e., a pattern for the symbols with the same beam). The symbols of a long PUCCH may be spread over the beam pattern.

[00221] In a third method (Method 3), a long PUCCH can use self-contained DMRS in each symbol. The UE multiplexing within a RB can be reduced or eliminated. Furthermore, DMRS of 1 symbol short PUCCH can be used in each symbol. Figure 27 shows the reference signal pattern designs. For each RS setting, at least two patterns can be defined, denoted as pattern 1 and pattern 2 without loss of generality. Staggered DMRS pattern or different DMRS patterns can be applied on different symbols. The UE 102 may use contiguous symbols or non-contiguous symbols defined by a symbol pattern. The symbol pattern may be configured by the gNB 160. The same beam can be applied on the symbols in the symbol pattern. Or different beams can be applied on the symbols in the symbol pattern if self-contained DMRS is used in each symbol.

[00222] For a long PUCCH above 6GHz frequency band, in one method, the gNB 160 may indicate which symbols and/or beams should be used for long PUCCH transmission by semi-static higher layer signaling or dynamic signaling via DCI. To determine the long PUCCH resource, 5G NR requires more configurations. At least one of the following aspects may be supported in NR. A long PUCCH format and/or resource for a UE 102 can be semi-statically configured by higher layer signaling. A long PUCCH format and/or resource for a UE 102 can be dynamically indicated by physical layer signaling (e.g., a DCI). Different long PUCCH formats may be configured or utilized for different types of UCI feedback and payload sizes.

[00223] The PUCCH resource configuration has a tradeoff between semi-static RRC signaling and dynamic DCI indication. In general, the PUCCH format/structure should be configured by RRC signaling, and the actual PUCCH resource to be used for UCI reporting should be determined by explicit DCI indication.

[00224] Therefore, a UE 102 can be configured with a set of long PUCCH resources with detailed parameters. The parameters include the PUCCH formats, the resource allocation, etc. And the DCI indicates the long PUCCH index within the RRC configured set of resources. In another method, the PUCCH resources may be indexed based on a RRC configured long PUCCH structure. A UE 102 may be configured with a set of

PUCCH resources based on the PUCCH indexes. The DCI indicates the index of a PUCCH resource in a set of PUCCH resources configured for a UE 102.

[00225] PUCCH considerations for URLLC are also described herein. For ultra-reliable low latency communications (URLLC) traffic, several aspects need to be considered for PUCCH transmissions. URLLC traffic requires ultra-reliability and low latency, and may collide with a PUCCH or PUSCH transmission of the same UE 102. As a general rule, the URLLC traffic should have higher priority than any other UL transmissions.

[00226] In the case where a PUCCH transmission collides with a URLLC traffic in the same symbol, the URLLC should have higher priority. Several methods can be considered.

[00227] In a first method (Method 1), URLLC traffic is transmitted and the PUCCH in the overlapping symbol is dropped. This is a simple solution and can be applicable in all cases regardless of PUCCH waveforms and/or numerologies. The whole short PUCCH should be dropped for a 1-symbol PUCCH. For a 2-symbol PUCCH, if the URLLC collides with the first symbol of a short PUCCH, all short PUCCH symbols should be dropped. If a 2-symbol short PUCCH transmission already starts, and the URLLC collides with the 2nd symbol in a 2-symbol short PUCCH, the second symbol of the short PUCCH is dropped.

[00228] For a long PUCCH transmission, the overlapping symbols should be dropped to give higher priority to a URLLC transmission. A long PUCCH transmission may resume after the URLLC transmission. The UE 102 may drop the remaining long PUCCH transmission if the number of PUCCH symbols punctured by the URLLC is above a threshold because the PUCCH is not likely to be decoded correctly. The threshold value may be semi-statically configured for a given long PUCCH format.

[00229] In a second method (Method 2), simultaneous transmission of URLLC and PUCCH may be performed, with power scaling on PUCCH if necessary. If simultaneous transmission of URLLC and PUCCH is supported on the same symbol, UL transmit power should be allocated to the URLLC traffic first. The remaining power can be power

scaled on the PUCCH REs in the same UL symbol. This can be applied if the PUCCH REs does not overlap with URLLC transmission REs.

[00230] In case of overlapping REs between URLLC and PUCCH, the URLLC signals are transmitted and PUCCH symbols on corresponding REs may be dropped. In another alternative, in case of overlapping REs between URLLC and PUCCH, the URLLC signals are transmitted and entire PUCCH symbol should be dropped as in method 1.

[00231] It should be noted that if URLLC traffic and PUCCH uses different waveforms, simultaneous transmission of URLLC and PUCCH may not be possible. Also, if URLLC traffic and PUCCH uses different numerologies, some guard interval may be required between different numerologies, and simultaneous transmission of URLLC and PUCCH may not be supported in some cases.

[00232] The UE operations module 124 may provide information 148 to the one or more receivers 120. For example, the UE operations module 124 may inform the receiver(s) 120 when to receive retransmissions.

[00233] The UE operations module 124 may provide information 138 to the demodulator 114. For example, the UE operations module 124 may inform the demodulator 114 of a modulation pattern anticipated for transmissions from the gNB 160.

[00234] The UE operations module 124 may provide information 136 to the decoder 108. For example, the UE operations module 124 may inform the decoder 108 of an anticipated encoding for transmissions from the gNB 160.

[00235] The UE operations module 124 may provide information 142 to the encoder 150. The information 142 may include data to be encoded and/or instructions for encoding. For example, the UE operations module 124 may instruct the encoder 150 to encode transmission data 146 and/or other information 142. The other information 142 may include PDSCH HARQ-ACK information.

[00236] The encoder 150 may encode transmission data 146 and/or other information 142 provided by the UE operations module 124. For example, encoding the data 146 and/or other information 142 may involve error detection and/or correction coding,

mapping data to space, time and/or frequency resources for transmission, multiplexing, etc. The encoder 150 may provide encoded data 152 to the modulator 154.

[00237] The UE operations module 124 may provide information 144 to the modulator 154. For example, the UE operations module 124 may inform the modulator 154 of a modulation type (e.g., constellation mapping) to be used for transmissions to the gNB 160. The modulator 154 may modulate the encoded data 152 to provide one or more modulated signals 156 to the one or more transmitters 158.

[00238] The UE operations module 124 may provide information 140 to the one or more transmitters 158. This information 140 may include instructions for the one or more transmitters 158. For example, the UE operations module 124 may instruct the one or more transmitters 158 when to transmit a signal to the gNB 160. For instance, the one or more transmitters 158 may transmit during a UL subframe. The one or more transmitters 158 may upconvert and transmit the modulated signal(s) 156 to one or more gNBs 160.

[00239] Each of the one or more gNBs 160 may include one or more transceivers 176, one or more demodulators 172, one or more decoders 166, one or more encoders 109, one or more modulators 113, a data buffer 162 and a gNB operations module 182. For example, one or more reception and/or transmission paths may be implemented in a gNB 160. For convenience, only a single transceiver 176, decoder 166, demodulator 172, encoder 109 and modulator 113 are illustrated in the gNB 160, though multiple parallel elements (e.g., transceivers 176, decoders 166, demodulators 172, encoders 109 and modulators 113) may be implemented.

[00240] The transceiver 176 may include one or more receivers 178 and one or more transmitters 117. The one or more receivers 178 may receive signals from the UE 102 using one or more antennas 180a-n. For example, the receiver 178 may receive and downconvert signals to produce one or more received signals 174. The one or more received signals 174 may be provided to a demodulator 172. The one or more transmitters 117 may transmit signals to the UE 102 using one or more antennas 180a-n. For example, the one or more transmitters 117 may upconvert and transmit one or more modulated signals 115.

[00241] The demodulator 172 may demodulate the one or more received signals 174 to produce one or more demodulated signals 170. The one or more demodulated signals 170 may be provided to the decoder 166. The gNB 160 may use the decoder 166 to decode signals. The decoder 166 may produce one or more decoded signals 164, 168. For example, a first eNB-decoded signal 164 may comprise received payload data, which may be stored in a data buffer 162. A second eNB-decoded signal 168 may comprise overhead data and/or control data. For example, the second eNB-decoded signal 168 may provide data (e.g., PDSCH HARQ-ACK information) that may be used by the gNB operations module 182 to perform one or more operations.

[00242] In general, the gNB operations module 182 may enable the gNB 160 to communicate with the one or more UEs 102. The gNB operations module 182 may include one or more of a gNB multiple slot long PUCCH module 194. The gNB long PUCCH module 194 may implement a multiple slot long PUCCH design for 5G NR as described herein.

[00243] The gNB operations module 182 may provide information 188 to the demodulator 172. For example, the gNB operations module 182 may inform the demodulator 172 of a modulation pattern anticipated for transmissions from the UE(s) 102.

[00244] The gNB operations module 182 may provide information 186 to the decoder 166. For example, the gNB operations module 182 may inform the decoder 166 of an anticipated encoding for transmissions from the UE(s) 102.

[00245] The gNB operations module 182 may provide information 101 to the encoder 109. The information 101 may include data to be encoded and/or instructions for encoding. For example, the gNB operations module 182 may instruct the encoder 109 to encode information 101, including transmission data 105.

[00246] The encoder 109 may encode transmission data 105 and/or other information included in the information 101 provided by the gNB operations module 182. For example, encoding the data 105 and/or other information included in the information 101 may involve error detection and/or correction coding, mapping data to space, time and/or

frequency resources for transmission, multiplexing, etc. The encoder 109 may provide encoded data 111 to the modulator 113. The transmission data 105 may include network data to be relayed to the UE 102.

[00247] The gNB operations module 182 may provide information 103 to the modulator 113. This information 103 may include instructions for the modulator 113. For example, the gNB operations module 182 may inform the modulator 113 of a modulation type (e.g., constellation mapping) to be used for transmissions to the UE(s) 102. The modulator 113 may modulate the encoded data 111 to provide one or more modulated signals 115 to the one or more transmitters 117.

[00248] The gNB operations module 182 may provide information 192 to the one or more transmitters 117. This information 192 may include instructions for the one or more transmitters 117. For example, the gNB operations module 182 may instruct the one or more transmitters 117 when to (or when not to) transmit a signal to the UE(s) 102. The one or more transmitters 117 may upconvert and transmit the modulated signal(s) 115 to one or more UEs 102.

[00249] It should be noted that a DL subframe may be transmitted from the gNB 160 to one or more UEs 102 and that a UL subframe may be transmitted from one or more UEs 102 to the gNB 160. Furthermore, both the gNB 160 and the one or more UEs 102 may transmit data in a standard special subframe.

[00250] It should also be noted that one or more of the elements or parts thereof included in the eNB(s) 160 and UE(s) 102 may be implemented in hardware. For example, one or more of these elements or parts thereof may be implemented as a chip, circuitry or hardware components, etc. It should also be noted that one or more of the functions or methods described herein may be implemented in and/or performed using hardware. For example, one or more of the methods described herein may be implemented in and/or realized using a chipset, an application-specific integrated circuit (ASIC), a large-scale integrated circuit (LSI) or integrated circuit, etc.

[00251] Figure 2 is a diagram illustrating one example of a resource grid for the downlink. The resource grid illustrated in Figure 2 may be utilized in some

implementations of the systems and methods disclosed herein. More detail regarding the resource grid is given in connection with Figure 1.

[00252] In Figure 2, one downlink subframe 269 may include two downlink slots 283. N_{RB}^{DL} is downlink bandwidth configuration of the serving cell, expressed in multiples of N_{sc}^{RB} , where N_{sc}^{RB} is a resource block 289 size in the frequency domain expressed as a number of subcarriers, and N_{symb}^{DL} is the number of OFDM symbols 287 in a downlink slot 283. A resource block 289 may include a number of resource elements (RE) 291.

[00253] For a PCell, N_{RB}^{DL} is broadcast as a part of system information. For an SCell (including a licensed assisted access (LAA) SCell), N_{RB}^{DL} is configured by a RRC message dedicated to a UE 102. For PDSCH mapping, the available RE 291 may be the RE 291 whose index l fulfils $l \geq l_{data,start}$ and/or $l_{data,end} \geq l$ in a subframe.

[00254] In the downlink, the OFDM access scheme with cyclic prefix (CP) may be employed, which may be also referred to as CP-OFDM. In the downlink, PDCCH, enhanced PDCCH (EPDCCH), PDSCH and the like may be transmitted. A downlink radio frame may consist of multiple pairs of downlink resource blocks (RBs) which is also referred to as physical resource blocks (PRBs). The downlink RB pair is a unit for assigning downlink radio resources, defined by a predetermined bandwidth (RB bandwidth) and a time slot. The downlink RB pair consists of two downlink RBs that are continuous in the time domain.

[00255] The downlink RB consists of twelve sub-carriers in frequency domain and seven (for normal CP) or six (for extended CP) OFDM symbols in time domain. A region defined by one sub-carrier in frequency domain and one OFDM symbol in time domain is referred to as a resource element (RE) and is uniquely identified by the index pair (k,l) in a slot, where k and l are indices in the frequency and time domains, respectively. While downlink subframes in one component carrier (CC) are discussed herein, downlink

subframes are defined for each CC and downlink subframes are substantially in synchronization with each other among CCs.

[00256] Figure 3 is a diagram illustrating one example of a resource grid for the uplink. The resource grid illustrated in Figure 3 may be utilized in some implementations of the systems and methods disclosed herein. More detail regarding the resource grid is given in connection with Figure 1.

[00257] In Figure 3, one uplink subframe 369 may include two uplink slots 383. N_{RB}^{UL} is uplink bandwidth configuration of the serving cell, expressed in multiples of N_{sc}^{RB} , where N_{sc}^{RB} is a resource block 389 size in the frequency domain expressed as a number of subcarriers, and N_{symb}^{UL} is the number of SC-FDMA symbols 393 in an uplink slot 383. A resource block 389 may include a number of resource elements (RE) 391.

[00258] For a PCell, N_{RB}^{UL} is broadcast as a part of system information. For an SCell (including an LAA SCell), N_{RB}^{UL} is configured by a RRC message dedicated to a UE 102.

[00259] In the uplink, in addition to CP-OFDM, a Single-Carrier Frequency Division Multiple Access (SC-FDMA) access scheme may be employed, which is also referred to as Discrete Fourier Transform-Spreading OFDM (DFT-S-OFDM). In the uplink, PUCCH, PDSCH, PRACH and the like may be transmitted. An uplink radio frame may consist of multiple pairs of uplink resource blocks. The uplink RB pair is a unit for assigning uplink radio resources, defined by a predetermined bandwidth (RB bandwidth) and a time slot. The uplink RB pair consists of two uplink RBs that are continuous in the time domain.

[00260] The uplink RB may consist of twelve sub-carriers in frequency domain and seven (for normal CP) or six (for extended CP) OFDM/DFT-S-OFDM symbols in time domain. A region defined by one sub-carrier in the frequency domain and one OFDM/DFT-S-OFDM symbol in the time domain is referred to as a RE and is uniquely

identified by the index pair (k, l) in a slot, where k and l are indices in the frequency and time domains respectively. While uplink subframes in one component carrier (CC) are discussed herein, uplink subframes are defined for each CC.

[00261] Figure 4 shows examples of several numerologies 401. The numerology #1 401a may be a basic numerology (e.g., a reference numerology). For example, a RE 495a of the basic numerology 401a may be defined with subcarrier spacing 405a of 15 kHz in frequency domain and $2048T_s + \text{CP length}$ (e.g., $160T_s$ or $144T_s$) in time domain (i.e., symbol length #1 403a), where T_s denotes a baseband sampling time unit defined as $1/(15000 \cdot 2048)$ seconds. For the i -th numerology, the subcarrier spacing 405 may be equal to $15 \cdot 2^i$ and the effective OFDM symbol length $2048 \cdot 2^{-i} \cdot T_s$. It may cause the symbol length is $2048 \cdot 2^{-i} \cdot T_s + \text{CP length}$ (e.g., $160 \cdot 2^{-i} \cdot T_s$ or $144 \cdot 2^{-i} \cdot T_s$). In other words, the subcarrier spacing of the $i+1$ -th numerology is a double of the one for the i -th numerology, and the symbol length of the $i+1$ -th numerology is a half of the one for the i -th numerology. Figure 4 shows four numerologies, but the system may support another number of numerologies. Furthermore, the system does not have to support all of the 0-th to the I -th numerologies, $i=0, 1, \dots, I$.

[00262] Figure 5 shows examples of subframe structures for the numerologies 501 that are shown in Figure 4. Given that a slot 283 includes $N_{\text{symb}}^{\text{DL}}$ (or $N_{\text{symb}}^{\text{UL}}$) = 7 symbols, the slot length of the $i+1$ -th numerology 501 is a half of the one for the i -th numerology 501, and eventually the number of slots 283 in a subframe (i.e., 1 ms) becomes double. It may be noted that a radio frame may include 10 subframes, and the radio frame length may be equal to 10 ms.

[00263] Figure 6 shows examples of slots 683 and sub-slots 607. If a sub-slot 607 is not configured by higher layer, the UE 102 and the eNB/gNB 160 may only use a slot 683 as a scheduling unit. More specifically, a given transport block may be allocated to a slot 683. If the sub-slot 607 is configured by higher layer, the UE 102 and the eNB/gNB 160 may use the sub-slot 607 as well as the slot 683. The sub-slot 607 may include one or

more OFDM symbols. The maximum number of OFDM symbols that constitute the sub-slot 607 may be $N_{\text{symb}}^{\text{DL}}-1$ (or $N_{\text{symb}}^{\text{UL}}-1$).

[00264] The sub-slot length may be configured by higher layer signaling. Alternatively, the sub-slot length may be indicated by a physical layer control channel (e.g., by DCI format).

[00265] The sub-slot 607 may start at any symbol within a slot 683 unless it collides with a control channel. There could be restrictions of mini-slot length based on restrictions on starting position. For example, the sub-slot 607 with the length of $N_{\text{symb}}^{\text{DL}}-1$ (or $N_{\text{symb}}^{\text{UL}}-1$) may start at the second symbol in a slot 683. The starting position of a sub-slot 607 may be indicated by a physical layer control channel (e.g., by DCI format). Alternatively, the starting position of a sub-slot 607 may be derived from information (e.g., search space index, blind decoding candidate index, frequency and/or time resource indices, PRB index, a control channel element index, control channel element aggregation level, an antenna port index, etc.) of the physical layer control channel which schedules the data in the concerned sub-slot 607.

[00266] In cases when the sub-slot 607 is configured, a given transport block may be allocated to either a slot 683, a sub-slot 607, aggregated sub-slots 607 or aggregated sub-slot(s) 607 and slot 683. This unit may also be a unit for HARQ-ACK bit generation.

[00267] Figure 7 shows examples of scheduling timelines 709. For a normal DL scheduling timeline 709a, DL control channels are mapped the initial part of a slot 783a. The DL control channels 711 schedule DL shared channels 713a in the same slot 783a. HARQ-ACKs for the DL shared channels 713a (i.e., HARQ-ACKs each of which indicates whether or not transport block in each DL shared channel 713a is detected successfully) are reported via UL control channels 715a in a later slot 783b. In this instance, a given slot 783 may contain either one of DL transmission and UL transmission.

[00268] For a normal UL scheduling timeline 709b, DL control channels 711b are mapped the initial part of a slot 783c. The DL control channels 711b schedule UL shared channels 717a in a later slot 783d. For these cases, the association timing (time shift)

between the DL slot 783c and the UL slot 783d may be fixed or configured by higher layer signaling. Alternatively, it may be indicated by a physical layer control channel (e.g., the DL assignment DCI format, the UL grant DCI format, or another DCI format such as UE-common signaling DCI format which may be monitored in common search space).

[00269] For a self-contained base DL scheduling timeline 709c, DL control channels 711c are mapped to the initial part of a slot 783e. The DL control channels 711c schedule DL shared channels 713b in the same slot 783e. HARQ-ACKs for the DL shared channels 713b are reported in UL control channels 715b, which are mapped at the ending part of the slot 783e.

[00270] For a self-contained base UL scheduling timeline 709d, DL control channels 711d are mapped to the initial part of a slot 783f. The DL control channels 711d schedule UL shared channels 717b in the same slot 783f. For these cases, the slot 783f may contain DL and UL portions, and there may be a guard period between the DL and UL transmissions.

[00271] The use of a self-contained slot may be upon a configuration of self-contained slot. Alternatively, the use of a self-contained slot may be upon a configuration of the sub-slot. Yet alternatively, the use of a self-contained slot may be upon a configuration of shortened physical channel (e.g., PDSCH, PUSCH, PUCCH, etc.).

[00272] The use of a self-contained slot may be upon a configuration of self-contained slot. Alternatively, the use of a self-contained slot may be upon a configuration of the sub-slot. Yet alternatively, the use of a self-contained slot may be upon a configuration of shortened physical channel (e.g. PDSCH, PUSCH, PUCCH, etc.).

[00273] Figure 8 shows examples of DL control channel monitoring regions. One or more sets of PRB(s) may be configured for DL control channel monitoring. In other words, a control resource set is, in the frequency domain, a set of PRBs within which the UE 102 attempts to blindly decode downlink control information, where the PRBs may or may not be frequency contiguous, a UE 102 may have one or more control resource sets, and one DCI message may be located within one control resource set. In the frequency-

domain, a PRB is the resource unit size (which may or may not include DM-RS) for a control channel. A DL shared channel may start at a later OFDM symbol than the one(s) which carries the detected DL control channel. Alternatively, the DL shared channel may start at (or earlier than) an OFDM symbol than the last OFDM symbol which carries the detected DL control channel. In other words, dynamic reuse of at least part of resources in the control resource sets for data for the same or a different UE 102, at least in the frequency domain may be supported.

[00274] Figure 9 shows examples of DL control channel which consists of more than one control channel elements. When the control resource set spans multiple OFDM symbols, a control channel candidate may be mapped to multiple OFDM symbols or may be mapped to a single OFDM symbol. One DL control channel element may be mapped on REs defined by a single PRB and a single OFDM symbol. If more than one DL control channel elements are used for a single DL control channel transmission, DL control channel element aggregation may be performed.

[00275] The number of aggregated DL control channel elements is referred to as DL control channel element aggregation level. The DL control channel element aggregation level may be 1 or 2 to the power of an integer. The gNB 160 may inform a UE 102 of which control channel candidates are mapped to each subset of OFDM symbols in the control resource set. If one DL control channel is mapped to a single OFDM symbol and does not span multiple OFDM symbols, the DL control channel element aggregation is performed within an OFDM symbol, namely multiple DL control channel elements within an OFDM symbol are aggregated. Otherwise, DL control channel elements in different OFDM symbols can be aggregated.

[00276] Figure 10 shows examples of UL control channel structures. UL control channel may be mapped on REs which are defined a PRB and a slot in frequency and time domains, respectively. This UL control channel may be referred to as a long format (or just the 1st format). UL control channels may be mapped on REs on a limited OFDM symbols in time domain. This may be referred to as a short format (or just the 2nd format). The UL control channels with a short format may be mapped on REs within a

single PRB. Alternatively, the UL control channels with a short format may be mapped on REs within multiple PRBs. For example, interlaced mapping may be applied, namely the UL control channel may be mapped to every N PRBs (e.g. 5 or 10) within a system bandwidth.

[00277] Figure 11 is a block diagram illustrating one implementation of a gNB 1160. The gNB 1160 may include a higher layer processor 1123, a DL transmitter 1125, a UL receiver 1133, and one or more antenna 1131. The DL transmitter 1125 may include a PDCCH transmitter 1127 and a PDSCH transmitter 1129. The UL receiver 1133 may include a PUCCH receiver 1135 and a PUSCH receiver 1137.

[00278] The higher layer processor 1123 may manage physical layer's behaviors (the DL transmitter's and the UL receiver's behaviors) and provide higher layer parameters to the physical layer. The higher layer processor 1123 may obtain transport blocks from the physical layer. The higher layer processor 1123 may send/acquire higher layer messages such as an RRC message and MAC message to/from a UE's higher layer. The higher layer processor 1123 may provide the PDSCH transmitter transport blocks and provide the PDCCH transmitter transmission parameters related to the transport blocks.

[00279] The DL transmitter 1125 may multiplex downlink physical channels and downlink physical signals (including reservation signal) and transmit them via transmission antennas 1131. The UL receiver 1133 may receive multiplexed uplink physical channels and uplink physical signals via receiving antennas 1131 and demultiplex them. The PUCCH receiver 1135 may provide the higher layer processor 1123 UCI. The PUSCH receiver 1137 may provide the higher layer processor 1123 received transport blocks.

[00280] Figure 12 is a block diagram illustrating one implementation of a UE 1202. The UE 1202 may include a higher layer processor 1223, a UL transmitter 1251, a DL receiver 1243, and one or more antenna 1231. The UL transmitter 1251 may include a PUCCH transmitter 1253 and a PUSCH transmitter 1255. The DL receiver 1243 may include a PDCCH receiver 1245 and a PDSCH receiver 1247.

[00281] The higher layer processor 1223 may manage physical layer's behaviors (the UL transmitter's and the DL receiver's behaviors) and provide higher layer parameters to the physical layer. The higher layer processor 1223 may obtain transport blocks from the physical layer. The higher layer processor 1223 may send/acquire higher layer messages such as an RRC message and MAC message to/from a UE's higher layer. The higher layer processor 1223 may provide the PUSCH transmitter transport blocks and provide the PUCCH transmitter 1253 UCI.

[00282] The DL receiver 1243 may receive multiplexed downlink physical channels and downlink physical signals via receiving antennas 1231 and de-multiplex them. The PDCCH receiver 1245 may provide the higher layer processor 1223 DCI. The PDSCH receiver 1247 may provide the higher layer processor 1223 received transport blocks.

[00283] It should be noted that names of physical channels described herein are examples. The other names such as "NRPDCCH, NRPDSCH, NRPUCCH and NRPUSCH", "new Generation-(G)PDCCH, GPDSCH, GPUCCH and GPUSCH" or the like can be used.

[00284] Figure 13 illustrates several examples of long PUCCH duration design. In the example of Figure 13(a), a long PUCCH spans over the whole UL only slot.

[00285] In the example of Figure 13(b), a long PUCCH spans over multiple UL only slots.

[00286] In the example of Figure 13(c), a long PUCCH spans over the whole UL centric slot.

[00287] In the example of Figure 13(d), a long PUCCH spans over the whole UL centric slot and one or more consecutive UL only slots.

[00288] In the example of Figure 13(e), a long PUCCH spans over some symbols to the end of a UL centric slot or a UL only slot.

[00289] In the example of Figure 13(f), a long PUCCH spans over some symbols to the end of a UL centric slot or a UL only slot and one or more consecutive UL only slots.

[00290] In the example of Figure 13(g), a long PUCCH spans over some symbols of a UL centric slot or a UL only slot.

[00291] In the example of Figure 13(h), a long PUCCH starts in the middle of a UL centric slot or a UL only slot. The long PUCCH spans over one or more consecutive UL only slots and ends in the middle of a UL only slot.

[00292] Figure 14 illustrates examples of two demodulation reference signals (DMRS) 1401 in every 7 symbols for normal cyclic prefix (NCP) or 6 symbols for extended cyclic prefix (ECP). A first DMRS pattern (Pattern 1) 1403 includes 2 RS in every 7 or 6 symbols. With this pattern, a long PUCCH format has 2 DMRS 1401 in every 7 symbols for normal CP (NCP), and 2 DMRS 1401 in every 6 symbols for extended CP (ECP) within a slot.

[00293] A first example (a) shows a DMRS pattern 1 1403a for Normal cyclic prefix (CP). A second example (b) shows a DMRS pattern 1 1403b for extended CP.

[00294] Figure 15 illustrates examples of the minimum number of symbols for a long PUCCH. In the example of Figure 15(a), $X=3$ if the long PUCCH covers the end of a slot. In the example of Figure 15(b), $X=4$ if the long PUCCH can start/end at any symbol of a slot.

[00295] In Figure 15, there are symbols depicted that are not used or allocated for a long PUCCH. The remaining symbols (including a DMRS symbol) are allocated for a long PUCCH. Thus, in Figure 15(a), it is a long PUCCH at the last 3 symbols. In Figure 15(b), it is a long PUCCH allocated in the middle of the slot, from the 2nd to 5th symbols.

[00296] Figure 16 illustrates examples of one DMRS 1601 in every 7 symbols for NCP or 6 symbols for ECP. A second DMRS pattern (Pattern 2) 1603 includes one RS in every 7 or 6 symbols. With this pattern, a long PUCCH format has 1 DMRS 1601 in every 7 symbols for normal CP (NCP), and 1 DMRS 1601 in every 6 symbols for extended CP (ECP) within a slot.

[00297] A first example (a) shows a DMRS pattern 2 1603a for Normal cyclic prefix (CP). A second example (b) shows a DMRS pattern 2 1603b for extended CP.

[00298] Figure 17 illustrates fixed hopping candidates for PUCCH based on fixed DMRS patterns. In a first example, 2 DMRS symbols may be in every 7 symbols for

normal CP. In a second example, 2 DMRS symbols may be in every 7 symbols for extended CP. In a third example, 1 DMRS symbol may be in every 7 symbols for normal CP. In a fourth example, 1 DMRS symbol may be in every 7 symbols for extended CP.

[00299] Fixed frequency hopping location candidates are also depicted in Figure 17. Depending on the starting and ending symbols of a long PUCCH in a slot, only 1 hop may be supported. The hopping location may be determined based on the closest location to the middle of the long PUCCH duration of N symbols. In other words, hopping location may be determined based on the closest fixed hopping location relative to the end of the X th symbol where $X = \text{floor}(N/2)$ [or $\text{ceil}(N/2)$].

[00300] Figure 18 illustrates examples of PUCCH DMRS basic blocks in a hop. PUCCH from 2 to 7 symbols are depicted. In one configuration, the PUCCH may have 1 DMRS. In another configuration, the PUCCH may have 2 DMRSs. The DMRS location may be determined in each hop based on basic structures of building blocks of different length. Since the long PUCCH duration in a slot may vary between 4–14 symbols, if frequency hopping is applied, each hop may have 2 to 7 symbols.

[00301] Each hopping may have 1 or 2 DMRSs. For a single hop length greater than or equal to 4 symbols, whether 1 or 2 DMRSs in a hop may be configured by higher layer signaling.

[00302] For a slot with 6 symbols for extended CP or 7 symbols for normal CP, if frequency hopping is not configured or supported, a long PUCCH may be configured with 1 or 2 DMRS following the pattern in the basic blocks. For normal CP, the 4 to 7 symbols structures can be applied in a long PUCCH. For extended CP, the 4 to 6 symbols structures can be applied in a long PUCCH. The long PUCCH may be configured with either 1 DMRS or 2 DMRS symbols.

[00303] If frequency hopping is configured or supported, the hopping location may be determined at the middle of a given long PUCCH with length of N symbols, where N is greater than or equal to 4, and smaller than or equal to the number of symbols in a slot. The hop may occur at the end of the X th symbol where $X = \text{floor}(N/2)$ or $\text{ceil}(N/2)$. Then, the DMRS positions are determined based on the length of each hop from the basic

building blocks of each length and the number of DMRS configured for each hop if applicable. The basic blocks of 2–4 symbol structures can be applied in each hop. Figure 18 shows the frequency hopping locations for long PUCCH duration of 4–7 symbols if configured. Two DMRS are required if frequency hopping is configured for a long PUCCH.

[00304] For a slot with 12 symbols for extended CP or 14 symbols for normal CP, if the length of a long PUCCH is smaller than or equal to 6 symbols for extended CP or smaller than or equal to 7 symbols for normal CP, the same method as described above is used. In other words, if frequency hopping is not configured or supported, a long PUCCH may be configured with 1 or 2 DMRS following the pattern in the basic blocks. For normal CP, the 4 to 7 symbols structures can be applied in a long PUCCH. For extended CP, the 4 to 6 symbols structures can be applied in a long PUCCH. The long PUCCH may be configured with either 1 DMRS or 2 DMRS symbols.

[00305] If frequency hopping is configured or supported, the hopping location is determined at the middle of a given long PUCCH with length of N symbols, where N is greater or equal to 4, and smaller or equal to the number of symbols in a slot. The hop may occur at the end of the X th symbol where $X = \text{floor}(N/2)$ or $\text{ceil}(N/2)$. Then, the DMRS positions are determined based on the length of each hop from the basic building blocks of each length and the number of DMRS configured for each hop if applicable. The basic blocks of 2-4 symbol structures can be applied in each hop. Figure 18 shows the frequency hopping locations for long PUCCH duration of 4–7 symbols if configured. Two DMRS are required if frequency hopping is configured for a long PUCCH.

[00306] If the length of a long PUCCH is greater than 6 symbols for extended CP or greater than 7 symbols for normal CP, first, the hopping location may be determined at the middle of a given long PUCCH with length of N symbols, where N is greater than or equal to 6 for extended CP and greater than 7 for normal CP, and is smaller than or equal to the number of symbols in a slot. The hop may occur at the end of the X th symbol where $X = \text{floor}(N/2)$ or $\text{ceil}(N/2)$. Then, the DMRS positions are determined based on the length of each hop from the basic building blocks of each length and the number of

DMRS configured for each hop if applicable. The basic blocks of 4–7 symbol structures can be applied in each hop. It should be noted that the same structure may be applied regardless whether frequency hopping is configured or not.

[00307] This method provides optimal DMRS locations for all long PUCCH durations between 4–14 symbols. With this method, the long PUCCH may be included in a single slot, or in continuous symbols cross over in multiple slots. It should be noted that the frequency hopping may be mandatory for all long PUCCH lengths in a slot.

[00308] The method can be used to determine the DMRS location/pattern regardless whether frequency hopping is configured or not on a long PUCCH. Two approaches can be considered if frequency hopping is not configured. In one approach, for any long PUCCH lengths between 4–14 symbols, the same DMRS position is determined as if frequency hopping is configured. In another approach, if the long PUCCH duration is between 4–7 symbols inclusively, the DMRS position may be determined with the pattern of one hop given in Figure 18.

[00309] Figures 19A and 19B illustrate examples of DMRS patterns for different durations. In one case, long PUCCH may be configured with 1 DMRS symbol in a hop. In another case, long PUCCH may be configured with 2 DMRS symbol in a hop. The DMRS patterns and frequency hopping location for 1 or 2 DMRSs are shown for long PUCCH durations.

[00310] In Figure 19A, for PUCCH length of 4 to 7 symbols, if there is only one DMRS, no frequency hopping is supported, as shown on the left side under 1 DMRS in a hop. For PUCCH length of 4 to 7 symbols, if there are two DMRS symbols, frequency hopping may be supported with the given location as shown on the right side under 2 DMRS in a hop. It should be noted that in this case, there may be only 1 DMRS in each hop if frequency hopping is applied.

[00311] Figure 20 illustrates examples of RS patterns with frequency division multiplexing (FDM) among UEs for two DMRS in every 7 symbols for NCP. Different UEs 102 are assigned with different RS patterns that are not overlapping with other UEs 102. Figure 20 shows several examples of RS multiplexing for different UEs 102 with

pattern 1 where two RS symbols are used in every 7 symbols for NCP. Different UEs 102 are assigned with different subcarriers for RS transmission in the two DMRS symbols. In the Figures, each crosshatch represents the DMRS of a different UE.

[00312] In implementation (a), a UE 102 may be configured with 2 subcarriers for RS transmission within each DMRS symbol. Thus, an RB can be multiplexed with 6 UEs 102.

[00313] In implementation (b), a UE 102 may be configured with 3 subcarriers for RS transmission within each DMRS symbol. Thus, an RB can be multiplexed with 4 UEs 102.

[00314] In implementation (c), a UE 102 may be configured with 4 subcarriers for RS transmission within each DMRS symbol. Thus, an RB can be multiplexed with 3 UEs 102.

[00315] In implementation (d), a UE may be configured with 6 subcarriers for RS transmission within each DMRS symbol. Thus, an RB can be multiplexed with 2 UEs 102.

[00316] Figure 21 illustrates examples of RS patterns with FDM among UEs for two DMRS in every 6 symbols for ECP. Different UEs 102 are assigned with different RS patterns that are not overlapping with other UEs 102. Figure 21 shows several examples of RS multiplexing for different UEs 102 with pattern 1 where two RS symbols are used in every 6 symbols for ECP. Different UEs 102 are assigned with different subcarriers for RS transmission in the two DMRS symbols.

[00317] In implementation (a), a UE 102 may be configured with 2 subcarriers for RS transmission within each DMRS symbol. Thus, an RB can be multiplexed with 6 UEs 102.

[00318] In implementation (b), a UE 102 may be configured with 3 subcarriers for RS transmission within each DMRS symbol. Thus, an RB can be multiplexed with 4 UEs 102.

[00319] In implementation (c), a UE 102 may be configured with 4 subcarriers for RS transmission within each DMRS symbol. Thus, an RB can be multiplexed with 3 UEs 102.

[00320] In implementation (d), a UE may be configured with 6 subcarriers for RS transmission within each DMRS symbol. Thus, an RB can be multiplexed with 2 UEs 102.

[00321] Figure 22 illustrates examples of a shifted RS pattern with FDM among UEs for two DMRS in every 7 symbols for NCP. For CP-OFDM based transmission with 2 RS symbols in each 7 symbols for NCP and every 6 symbols for ECP, the RS can also be located at the beginning. Thus, a shifted RS pattern can be applied.

[00322] In implementation (a), a UE 102 may be configured with 2 subcarriers for RS transmission within each DMRS symbol. Thus, an RB can be multiplexed with 6 UEs 102.

[00323] In implementation (b), a UE 102 may be configured with 3 subcarriers for RS transmission within each DMRS symbol. Thus, an RB can be multiplexed with 4 UEs 102.

[00324] In implementation (c), a UE 102 may be configured with 4 subcarriers for RS transmission within each DMRS symbol. Thus, an RB can be multiplexed with 3 UEs 102.

[00325] In implementation (d), a UE may be configured with 6 subcarriers for RS transmission within each DMRS symbol. Thus, an RB can be multiplexed with 2 UEs 102.

[00326] Figure 23 illustrates examples of long PUCCH with one DMRS every 7 symbols for NCP. The same FDM combinations can be used on the pattern with a single RS symbol in every 7 symbols for NCP and every 6 symbols for ECP. In this case, the RS position should be the same as in DFT-S-OFDM based transmission, and no shift of RS position is needed. Figure 23 shows several examples for a long PUCCH with a single DMRS in every 7 symbols for NCP with different UE multiplexing capabilities.

[00327] In implementation (a), a UE 102 may be configured with 2 subcarriers for RS transmission within each DMRS symbol. Thus, an RB can be multiplexed with 6 UEs 102.

[00328] In implementation (b), a UE 102 may be configured with 3 subcarriers for RS transmission within each DMRS symbol. Thus, an RB can be multiplexed with 4 UEs 102.

[00329] In implementation (c), a UE 102 may be configured with 4 subcarriers for RS transmission within each DMRS symbol. Thus, an RB can be multiplexed with 3 UEs 102.

[00330] In implementation (d), a UE may be configured with 6 subcarriers for RS transmission within each DMRS symbol. Thus, an RB can be multiplexed with 2 UEs 102.

[00331] Figure 24 illustrates examples of DMRS allocation at frequency domain. Figure 24 shows several examples of DMRS spreads in the frequency domain. A first example is for 2 RS per RB. A second example is for 3 RS per RB. A third example is for 4 RS per RB.

[00332] Figure 25 illustrates examples of UE multiplexing with different DMRS patterns. Figure 25 shows several examples where four UEs 102 are multiplexed with different DMRS patterns. In Figure 25, each crosshatch represents the DMRS pattern of a given UE 102. In Figure 25, each crosshatch represents the DMRS pattern of a given UE 102.

[00333] A first example is for two RS per RB in the frequency domain. A second example is for three RS per RB in the frequency domain. A third example is for four RS per RB in the frequency domain.

[00334] Figure 26 illustrates examples of frequency hopping for long PUCCH formats. To provide frequency diversity, frequency hopping of a long PUCCH can be configured. In this case, separate PUCCH regions or subbands should be configured for a UE 102, and the PUCCH can be transmitted with frequency hopping in different regions/subbands, as shown in Figure 26.

[00335] A first example (a) illustrates frequency hopping at slot level or every 7 symbols for NCP. A second example (b) illustrates frequency hopping within 7 symbols for NCP.

[00336] Figure 27 illustrates examples of self-contained DMRS patterns in each symbol. The UE multiplexing within a RB can be reduced or eliminated. Furthermore, DMRS of 1 symbol short PUCCH can be used in each symbol. Figure 27 shows the reference signal pattern designs for 2 RS, 3 RS, 4 RS and 6 RS per RB. For each RS setting, at least two patterns can be defined, denoted as pattern 1 and pattern 2.

[00337] Figure 28 illustrates various components that may be utilized in a UE 2802. The UE 2802 described in connection with Figure 28 may be implemented in accordance with the UE 102 described in connection with Figure 1. The UE 2802 includes a processor 2803 that controls operation of the UE 2802. The processor 2803 may also be referred to as a central processing unit (CPU). Memory 2805, which may include read-only memory (ROM), random access memory (RAM), a combination of the two or any type of device that may store information, provides instructions 2807a and data 2809a to the processor 2803. A portion of the memory 2805 may also include non-volatile random access memory (NVRAM). Instructions 2807b and data 2809b may also reside in the processor 2803. Instructions 2807b and/or data 2809b loaded into the processor 2803 may also include instructions 2807a and/or data 2809a from memory 2805 that were loaded for execution or processing by the processor 2803. The instructions 2807b may be executed by the processor 2803 to implement the methods described above.

[00338] The UE 2802 may also include a housing that contains one or more transmitters 2858 and one or more receivers 2820 to allow transmission and reception of data. The transmitter(s) 2858 and receiver(s) 2820 may be combined into one or more transceivers 2818. One or more antennas 2822a-n are attached to the housing and electrically coupled to the transceiver 2818.

[00339] The various components of the UE 2802 are coupled together by a bus system 2811, which may include a power bus, a control signal bus and a status signal bus, in addition to a data bus. However, for the sake of clarity, the various buses are illustrated in

Figure 28 as the bus system 2811. The UE 2802 may also include a digital signal processor (DSP) 2813 for use in processing signals. The UE 2802 may also include a communications interface 2815 that provides user access to the functions of the UE 2802. The UE 2802 illustrated in Figure 28 is a functional block diagram rather than a listing of specific components.

[00340] Figure 29 illustrates various components that may be utilized in a gNB 2960. The gNB 2960 described in connection with Figure 29 may be implemented in accordance with the gNB 160 described in connection with Figure 1. The gNB 2960 includes a processor 2903 that controls operation of the gNB 2960. The processor 2903 may also be referred to as a central processing unit (CPU). Memory 2905, which may include read-only memory (ROM), random access memory (RAM), a combination of the two or any type of device that may store information, provides instructions 2907a and data 2909a to the processor 2903. A portion of the memory 2905 may also include non-volatile random access memory (NVRAM). Instructions 2907b and data 2909b may also reside in the processor 2903. Instructions 2907b and/or data 2909b loaded into the processor 2903 may also include instructions 2907a and/or data 2909a from memory 2905 that were loaded for execution or processing by the processor 2903. The instructions 2907b may be executed by the processor 2903 to implement the methods described above.

[00341] The gNB 2960 may also include a housing that contains one or more transmitters 2917 and one or more receivers 2978 to allow transmission and reception of data. The transmitter(s) 2917 and receiver(s) 2978 may be combined into one or more transceivers 2976. One or more antennas 2980a-n are attached to the housing and electrically coupled to the transceiver 2976.

[00342] The various components of the gNB 2960 are coupled together by a bus system 2911, which may include a power bus, a control signal bus and a status signal bus, in addition to a data bus. However, for the sake of clarity, the various buses are illustrated in Figure 29 as the bus system 2911. The gNB 2960 may also include a digital signal processor (DSP) 2913 for use in processing signals. The gNB 2960 may also include a

communications interface 2915 that provides user access to the functions of the gNB 2960. The gNB 2960 illustrated in Figure 29 is a functional block diagram rather than a listing of specific components.

[00343] Figure 30 is a block diagram illustrating one implementation of a UE 3002 in which systems and methods for a long PUCCH design for 5G NR operations may be implemented. The UE 3002 includes transmit means 3058, receive means 3020 and control means 3024. The transmit means 3058, receive means 3020 and control means 3024 may be configured to perform one or more of the functions described in connection with Figure 1 above. Figure 28 above illustrates one example of a concrete apparatus structure of Figure 30. Other various structures may be implemented to realize one or more of the functions of Figure 1. For example, a DSP may be realized by software.

[00344] Figure 31 is a block diagram illustrating one implementation of a gNB 3160 in which systems and methods for a long PUCCH design for 5G NR operations may be implemented. The gNB 3160 includes transmit means 3117, receive means 3178 and control means 3182. The transmit means 3117, receive means 3178 and control means 3182 may be configured to perform one or more of the functions described in connection with Figure 1 above. Figure 29 above illustrates one example of a concrete apparatus structure of Figure 31. Other various structures may be implemented to realize one or more of the functions of Figure 1. For example, a DSP may be realized by software.

[00345] Figure 32 is a flow diagram illustrating a method 3200 for implementing a multiple slot long PUCCH design for 5G NR. The method 3200 may be implemented by a UE 102. The UE 102 may determine 3202 that an uplink control channel (PUCCH) spans over multiple slots based on a signaling from a gNB 160. The uplink control channel (PUCCH) may occupy continuous symbols in multiple slots. Alternatively, the uplink control channel (PUCCH) may have gaps between the symbols in each slot.

[00346] The UE 102 may determine 3204 a demodulation reference signals (DMRS) structure in the configured multi-slot PUCCH. The number of PUCCH symbols in each slot of a multi-slot uplink control channel (PUCCH) may be greater than or equal to 4.

The reference symbol (RS) pattern in each slot may be determined on a per slots basis by a long PUCCH format of a given the number of PUCCH symbols in the slot.

[00347] The UE 102 may determine 3206 a frequency hopping method of the configured multi-slot PUCCH. In one approach, frequency hopping may be applied at slot boundaries in a multi-slot PUCCH (i.e., inter-slot hopping). In another approach, frequency hopping is applied within each slot in a multi-slot PUCCH (i.e., intra-slot hopping). In yet another approach, whether the frequency hopping is inter-slot or intra-slot can be configured by higher layer signaling for a multi-slot PUCCH.

[00348] The UE 102 may determine 3208 UCI encoding and loading methods on the configured multi-slot PUCCH. If the uplink control channel (PUCCH) occupies continuous symbols in multiple slots, the UCI is encoded, rate matched and loaded across all UCI carrying symbols of the multi-slot PUCCH. If the bit capacity of PUCCH UCI carrying symbols in any slot is less than the number of UCI encoded bits, UCI encoded bits are rate matched and loaded to all PUCCH UCI carrying symbols of the multi-slot long PUCCH. If the bit capacity of PUCCH UCI carrying symbols in all slots is greater than or equal to the number of UCI encoded bits, UCI encoded bits are rate matched and loaded to all to PUCCH UCI carrying symbols of each slot of the long PUCCH separately.

[00349] The UE 102 may determine 3210 a resource of a control channel for UCI feedback. The UE 102 may transmit 3212 UCI on the selected channel.

[00350] Figure 33 is a flow diagram illustrating a method 3300 for implementing a multiple slot long PUCCH design for 5G NR. The method 3300 may be implemented by a base station (gNB) 160. The gNB 160 may determine 3302 an uplink control channel (PUCCH) spans over multiple slots. The gNB 160 may determine 3304 a demodulation reference signals (DMRS) structure in the configured multi-slot PUCCH. The gNB 160 may determine 3306 a frequency hopping method of the configured multi-slot PUCCH. The gNB 160 may determine 3308 UCI encoding and loading methods on the configured multi-slot PUCCH. The gNB 160 may determine 3310 a resource of a control channel for

UCI feedback. The gNB 160 may receive 3312 UCI on a selected channel. These steps may be accomplished as described in connection with Figure 32.

[00351] Figure 34 illustrates different cases for multiple slot long PUCCH with continuous UL symbol. A long PUCCH may be over multiple slots with continuous UL symbols. In one method, a long PUCCH over multiple slots has to occupy continuous UL symbols in multiple slots (i.e., no gap is allowed within a long PUCCH). Under this condition, there are several cases as shown in Figure 34.

[00352] In a first case (Case 1), the long PUCCH starts in one slot, and ends in the slot after. The number of symbols is greater than or equal to 4, and smaller than or equal to the number of symbols in a slot.

[00353] In one approach, since the length is smaller than a slot length, this case may be treated as a long PUCCH within a slot, and the same DMRS structure and frequency hopping methods defined for single slot structure can be used. In other words, a single slot long PUCCH may support floating position that may start from any symbol and ends at any symbol in the same or consecutive slot. Similarly, the same UCI encoding and rate matching methods as in long PUCCH within a slot can be applied in this case, and OCC may be applied in frequency domain and/or time domain.

[00354] With this approach, the UCI encoding and rate matching methods should be the same as a long PUCCH within a slot. In other words, OCC may be applied in frequency domain and/or time domain over all UCI carrying symbols in the long PUCCH.

[00355] In another approach, the DMRS pattern can be determined on a per slot basis. The DMRS may be optimized based on the number of PUCCH symbols in each slot. In yet another approach, a common DMRS pattern (e.g., the same DMRS pattern) can be applied in both slots. For example, a full slot DMRS pattern may be applied in each slot, with unused UL symbols punctured out. This provides a simple solution with fixed DMRS locations. In both slot structure based approaches, some further restrictions may be applied, e.g. the number of PUCCH symbols in each slot should be greater or equal to 4.

[00356] For frequency hopping, several methods can be considered. Only one hop is applied with inter-slot hopping at slot boundary. This reserves the PUCCH structure in each slot. Since each slot has 4 or more symbols, intra-slot hopping can be applied in each slot. Thus, multiple hopping occurs during the multi-slot PUCCH transmission.

[00357] Furthermore, inter-slot or intra-slot hopping may be determined by slot length. If slot length = 7 symbols for NCP or 6 symbols for ECP, only inter-slot hopping should be applied. If slot length = 14 for NCP or 12 for ECP, intra-slot may be applied. In another approach, inter-slot or intra-slot hopping may be determined by the number of PUCCH symbols in a slot length. If the number of PUCCH symbols in a slot is smaller than or equal to a threshold value (e.g., 7 symbols for NCP or 6 symbols for ECP, inter-slot hopping may be applied. Otherwise, intra-slot may be applied.

[00358] In all cases, if there is only 1 DMRS for the PUCCH symbols in a slot, intra-slot hopping is not supported. The frequency hopping method can be pre-defined by choosing one of the methods, or can be configured by higher layer signaling or physical layer signaling.

[00359] In a second case (Case 2), a multiple slot long PUCCH starts in one slot, and ends in another slot after the starting slot. The number of symbols in a long PUCCH is greater than the number of symbols in a slot.

[00360] Since the multi-slot PUCCH is longer than a slot length, the existing slot structure cannot be applied directly. Several approaches can be considered for case 2.

[00361] In one approach, the DMRS pattern can be determined per slot basis. In this approach the DMRS is optimized based on the number of PUCCH symbols in each slot, as provided above for slot structure.

[00362] In yet another approach, a common DMRS pattern (e.g., the same DMRS pattern) can be applied in both slots. For example, a full slot DMRS pattern may be applied in each slot, with unused UL symbols punctured out. This provides a simple solution with fixed DMRS locations.

[00363] Figure 35 illustrates examples of frequency hopping methods. For frequency hopping, several methods can be considered. In one method, frequency hopping is applied

with inter-slot hopping at slot boundary only, as shown in Figure 35 (a). This reserves the PUCCH structure in each slot, and reduces the number of hops.

[00364] In another method, since each slot has greater or equal to 4 symbols, intra-slot hopping can be applied in each slot, as shown in Figure 35 (b). Thus, more hopping occurs during the multi-slot PUCCH transmission.

[00365] In yet another method, a single hop happens in the middle of a long PUCCH. If a multi-slot long PUCCH occupies an odd number of slots, the hopping location is in the middle of the center slot, as shown in Figure 35 (c). If a multi-slot long PUCCH occupying an even number of slots, the hopping location is at the slot boundary in the middle, as shown in Figure 35 (d).

[00366] Furthermore, among the first two methods, inter-slot or intra-slot hopping may be determined by slot length. If slot length = 7 symbols for NCP or 6 symbols for ECP, only inter-slot hopping should be applied. If slot length = 14 for NCP or 12 for ECP, intra-slot may be applied. In another approach, inter-slot or intra-slot hopping may be determined by a number of PUCCH symbols in a slot length. If the number of PUCCH symbols in a slot is less than or equal to a threshold value (e.g., 7 symbols for NCP or 6 symbols for ECP), inter-slot hopping may be applied. Otherwise, intra-slot may be applied.

[00367] Moreover, inter-slot or intra-slot hopping may be determined by slot length. If slot length = 7 symbols for NCP or 6 symbols for ECP, only inter-slot hopping should be applied. If slot length = 14 for NCP or 12 for ECP, intra-slot may be applied.

[00368] In all cases, if there is only 1 DMRS for the PUCCH symbols in a slot, intra-slot hopping is not supported.

[00369] The frequency hopping method can be pre-defined by choosing one of the methods, or can be configured by higher layer signaling or physical layer signaling. Since a multi-slot long PUCCH occupies continuous symbols in adjacent slots, for UCI encoding and rate matching on multi-slot long PUCCH resources, several methods can be considered.

[00370] A first method (Method 1) includes joint encoding and rate matching over all available UCI carrying symbols. The UCI is encoded and the encoded bits are rate

matched to all UCI carrying symbols of the multi-slot long PUCCH. This method is similar to a long PUCCH within a slot. OCC may be applied in frequency domain and/or time domain over all UCI carrying symbols in the long PUCCH.

[00371] A second method (Method 2) includes joint UCI encoding with separate rate matching and bit loading to each slot. The UCI may be encoded. The encoding output is rate matched to the available UCI carrying symbols in each slot independently. With this method, each slot can be viewed as a long PUCCH, and the same UCI is encoded and repeated in consecutive long PUCCHs in different slots.

[00372] In a third method (Method 3), the UCI bits are segmented into multiple segments, each segment for each slot of a multi-slot PUCCH. Each UCI segment is separately encoded and rate matched to the PUCCH symbols in the given slot. The UCI bits may be segmented proportional to the number of UCI carrying symbols in each slot.

[00373] Although Method 3 simplifies the UCI encoding in each slot, it reduces the joint coding gain of all UCI bits compared with Method 1 and Method 2. In Method 2, since different slots may have different number of PUCCH symbols, the coding rate may be different in different slots. If the number of PUCCH symbols in one or more slots is too small, the encoded UCI bit may not fit into the available resources. Therefore, Method 1 may be preferred for a multi-slot long PUCCH with continuous symbols.

[00374] Alternatively, Method 1 and Method 2 can be determined based on the minimum available PUCCH resource in all slots. If the encoded bits can fit in PUCCH UCI carrying symbols in all configured slots, Method 2 (joint coding with repetition in each slot) may be used. Otherwise, Method 1 (joint coding and rate matching among all slots) may be used.

[00375] Figure 36 illustrates examples of how a multi-slot long PUCCH may span over continuous or dis-continuous slots. In this case, gaps are allowed within a long PUCCH transmission. In configured slots for a long PUCCH, some symbols may be allocated for a long PUCCH in each slot. The PUCCH symbols in a slot should be continuous, but the symbols in different slots may have gap in between.

[00376] The configured slots for a long PUCCH may be continuous slots, as shown in Figure 36 (a). The configured slots for a long PUCCH may allocate discontinuous slots (e.g., with a given pattern), as shown in Figure 36 (b).

[00377] Figure 37 illustrates examples of how the number of PUCCH symbols in each slot may be the same or different. In one approach, the number of PUCCH symbols for the given long PUCCH may be the same in each configured slot. The same PUCCH symbol location may be allocated in each slot, as shown in Figure 37 (a). Alternatively, different PUCCH symbol locations may be applied in different slots even though the number of PUCCH symbols in each slot is the same.

[00378] In another approach, the number of PUCCH symbols for the given long PUCCH may be different for a different slot in the configured slots for a multi-slot long PUCCH, as shown in Figure 37 (b).

[00379] The PUCCH symbols in each slot should be continuous and the number of PUCCH symbols in each slot should be greater than or equal to 4.

[00380] Figure 38 illustrates examples of frequency hopping for multi-slot long PUCCH. The DMRS pattern of a multi-slot long PUCCH may be determined per slot basis. In other words, the DMRS may be optimized based on the number of PUCCH symbols in each slot, as provided above for slot structure.

[00381] Since each slot contains a long PUCCH format, several methods can be considered for frequency hopping. In one method, frequency hopping is applied with inter-slot hopping at a slot boundary only, as shown in Figure 38 (a). This reserves the PUCCH structure in each slot, and reduces the number of hops.

[00382] In another method, since each slot has 4 or more symbols, intra-slot hopping can be applied in each slot, as shown in Figure 38 (b). Thus, more hopping occurs during the multi-slot PUCCH transmission. This method can maintain the same frequency hopping structure for the long PUCCH in each slot.

[00383] Figure 39 is a flow diagram illustrating a method 3900 for UCI encoding and rate matching into a multi-slot long PUCCH. A UE 102 may receive 3902 UCI bits. The UCI bits may be encoded 3904 with a FEC encoder. The UE 102 may determine 3906

whether a multi-slot long PUCCH spans over continuous symbols. If a multi-slot long PUCCH spans over continuous symbols in multiple slots, UCI encoded bits are rate matched and loaded 3908 to all PUCCH UCI carrying symbols of the long PUCCH.

[00384] If a multi-slot long PUCCH spans over multiple slots with gaps between PUCCH symbols, the UE 102 has to compare whether the bit capacity of PUCCH carrying symbols in each slot is sufficient to carry all encoded UCI bits.

[00385] If UE 102 determines 3910 that the bit capacity of PUCCH UCI carrying symbols in any slot is smaller than the number of UCI encoded bits, UCI encoded bits are rate matched and loaded 3908 to all PUCCH UCI carrying symbols of the long PUCCH.

[00386] If UE 102 determines 3910 that the bit capacity of PUCCH UCI carrying symbols in all slots is larger than or equal to the number of UCI encoded bits, UCI encoded bits are rate matched and loaded 3912 to PUCCH UCI carrying symbols of each slot of the long PUCCH separately. As a special case, if the number of PUCCH symbols in each slot is the same, the PUCCH format and encoded UCI in each slot is repeated in multiple slots.

[00387] The term “computer-readable medium” refers to any available medium that can be accessed by a computer or a processor. The term “computer-readable medium,” as used herein, may denote a computer- and/or processor-readable medium that is non-transitory and tangible. By way of example, and not limitation, a computer-readable or processor-readable medium may comprise RAM, ROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium that can be used to carry or store desired program code in the form of instructions or data structures and that can be accessed by a computer or processor. Disk and disc, as used herein, includes compact disc (CD), laser disc, optical disc, digital versatile disc (DVD), floppy disk and Blu-ray® disc where disks usually reproduce data magnetically, while discs reproduce data optically with lasers.

[00388] It should be noted that one or more of the methods described herein may be implemented in and/or performed using hardware. For example, one or more of the methods described herein may be implemented in and/or realized using a chipset, an

application-specific integrated circuit (ASIC), a large-scale integrated circuit (LSI) or integrated circuit, etc.

[00389] Each of the methods disclosed herein comprises one or more steps or actions for achieving the described method. The method steps and/or actions may be interchanged with one another and/or combined into a single step without departing from the scope of the claims. In other words, unless a specific order of steps or actions is required for proper operation of the method that is being described, the order and/or use of specific steps and/or actions may be modified without departing from the scope of the claims.

[00390] It is to be understood that the claims are not limited to the precise configuration and components illustrated above. Various modifications, changes and variations may be made in the arrangement, operation and details of the systems, methods, and apparatus described herein without departing from the scope of the claims.

[00391] A program running on the gNB 160 or the UE 102 according to the described systems and methods is a program (a program for causing a computer to operate) that controls a CPU and the like in such a manner as to realize the function according to the described systems and methods. Then, the information that is handled in these apparatuses is temporarily stored in a RAM while being processed. Thereafter, the information is stored in various ROMs or HDDs, and whenever necessary, is read by the CPU to be modified or written. As a recording medium on which the program is stored, among a semiconductor (for example, a ROM, a nonvolatile memory card, and the like), an optical storage medium (for example, a DVD, a MO, a MD, a CD, a BD, and the like), a magnetic storage medium (for example, a magnetic tape, a flexible disk, and the like), and the like, any one may be possible. Furthermore, in some cases, the function according to the described systems and methods described above is realized by running the loaded program, and in addition, the function according to the described systems and methods is realized in conjunction with an operating system or other application programs, based on an instruction from the program.

[00392] Furthermore, in a case where the programs are available on the market, the program stored on a portable recording medium can be distributed or the program can be transmitted to a server computer that connects through a network such as the Internet. In this case, a storage device in the server computer also is included. Furthermore, some or all of the gNB 160 and the UE 102 according to the systems and methods described above may be realized as an LSI that is a typical integrated circuit. Each functional block of the gNB 160 and the UE 102 may be individually built into a chip, and some or all functional blocks may be integrated into a chip. Furthermore, a technique of the integrated circuit is not limited to the LSI, and an integrated circuit for the functional block may be realized with a dedicated circuit or a general-purpose processor. Furthermore, if with advances in a semiconductor technology, a technology of an integrated circuit that substitutes for the LSI appears, it is also possible to use an integrated circuit to which the technology applies.

[00393] Moreover, each functional block or various features of the base station device and the terminal device used in each of the aforementioned embodiments may be implemented or executed by a circuitry, which is typically an integrated circuit or a plurality of integrated circuits. The circuitry designed to execute the functions described in the present specification may comprise a general-purpose processor, a digital signal processor (DSP), an application specific or general application integrated circuit (ASIC), a field programmable gate array (FPGA), or other programmable logic devices, discrete gates or transistor logic, or a discrete hardware component, or a combination thereof. The general-purpose processor may be a microprocessor, or alternatively, the processor may be a conventional processor, a controller, a microcontroller or a state machine. The general-purpose processor or each circuit described above may be configured by a digital circuit or may be configured by an analogue circuit. Further, when a technology of making into an integrated circuit superseding integrated circuits at the present time appears due to advancement of a semiconductor technology, the integrated circuit by this technology is also able to be used.

[00394] What is claimed is:

CLAIMS

1. A user equipment (UE), comprising:
a processor; and
memory in electronic communication with the processor, wherein instructions stored in the memory are executable to:
determine an uplink control channel (PUCCH) spans over multiple slots
based on a signaling from a base station (gNB);
determine a demodulation reference signals (DMRS) structure in the
configured multi-slot PUCCH;
determine a frequency hopping method of the configured multi-slot
PUCCH;
determine UCI encoding and loading methods on the configured multi-slot
PUCCH;
determine a resource of a control channel for UCI feedback; and
transmit UCI on a selected channel.
2. The UE of claim 1, wherein the number of PUCCH symbols in each slot of a multi-slot uplink control channel (PUCCH) is greater than or equal to 4, and the reference symbol (RS) pattern in each slot is determined on a per slots basis by a long PUCCH format of a given the number of PUCCH symbols in the slot.
3. The UE of claim 1, wherein the number of PUCCH symbols may be the same in each slot of a multi-slot uplink control channel (PUCCH), and the same PUCCH symbol location may be allocated in each slot.
4. The UE of claim 1, wherein UCI encoded bits are rate matched and loaded to all to PUCCH UCI carrying symbols of each slot of the long PUCCH separately. If the number of PUCCH symbols in each slot is the same, the PUCCH format and encoded UCI in each slot is repeated in multiple slots.

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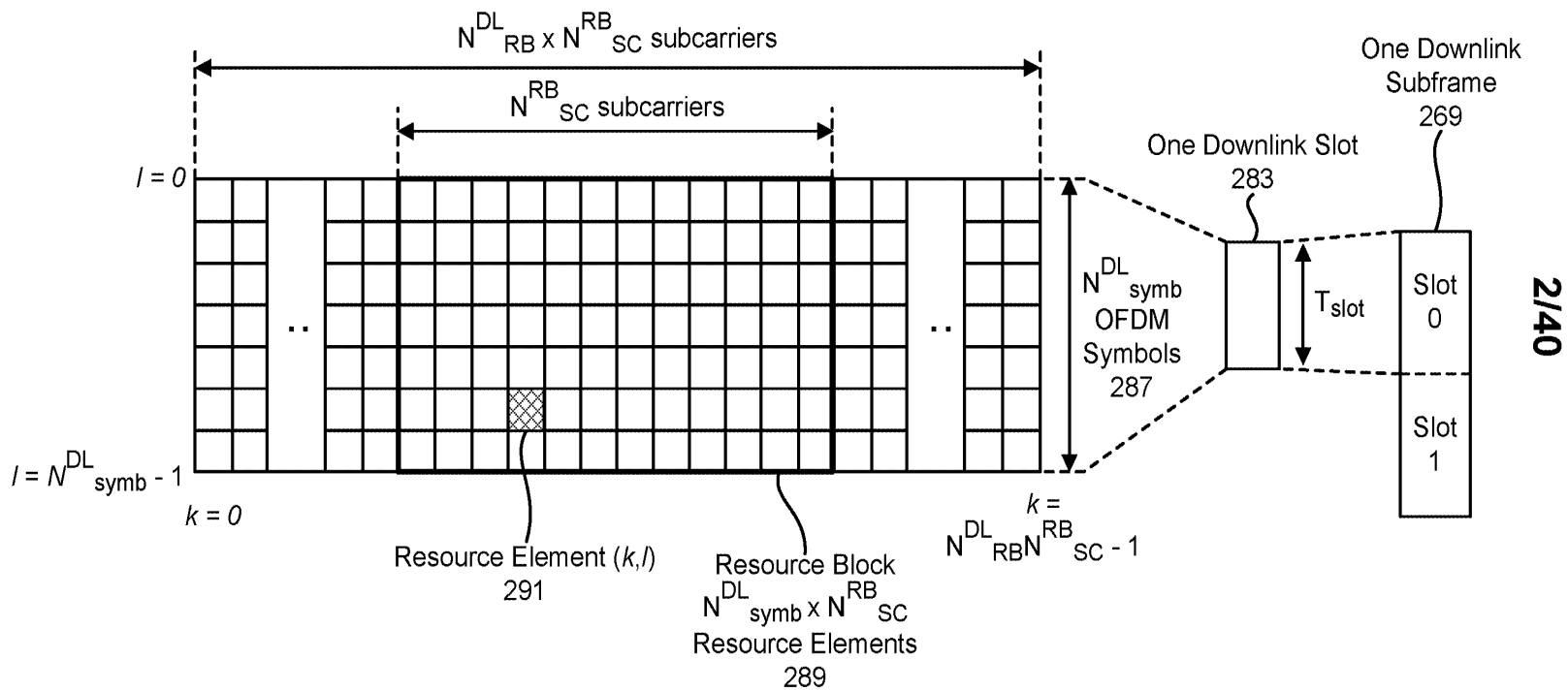
5. The UE of claim 1, wherein the frequency hopping is applied at slot boundaries in a multi-slot PUCCH.
6. The UE of claim 1, wherein the frequency hopping is applied within each slot in a multi-slot PUCCH.
7. The UE of claim 1, wherein whether the frequency hopping is inter-slot or intra-slot can be configured by higher layer signaling for a multi-slot PUCCH.
8. A base station (gNB), comprising:
 - a processor; and
 - memory in electronic communication with the processor, wherein instructions stored in the memory are executable to:
 - determine an uplink control channel (PUCCH) spans over multiple slots;
 - determine a demodulation reference signals (DMRS) structure in the configured multi-slot PUCCH;
 - determine a frequency hopping method of the configured multi-slot PUCCH;
 - determine UCI encoding and loading methods on the configured multi-slot PUCCH;
 - determine a resource of a control channel for UCI feedback; and
 - receive UCI on a selected channel.
9. The gNB of claim 8, wherein the number of PUCCH symbols in each slot of a multi-slot uplink control channel (PUCCH) is greater than or equal to 4, and the reference symbol (RS) pattern in each slot is determined on a per slots basis by a long PUCCH format of a given the number of PUCCH symbols in the slot.

10. The UE of claim 8, wherein the number of PUCCH symbols may be the same in each slot of a multi-slot uplink control channel (PUCCH), and the same PUCCH symbol location may be allocated in each slot.
11. The gNB of claim 8, wherein UCI encoded bits are rate matched and loaded to all to PUCCH UCI carrying symbols of each slot of the long PUCCH separately. If the number of PUCCH symbols in each slot is the same, the PUCCH format and encoded UCI in each slot is repeated in multiple slots.
12. The gNB of claim 8, wherein the frequency hopping is applied at slot boundaries in a multi-slot PUCCH.
13. The gNB of claim 8, wherein the frequency hopping is applied within each slot in a multi-slot PUCCH.
14. The gNB of claim 8, wherein whether the frequency hopping is inter-slot or intra-slot can be configured by higher layer signaling for a multi-slot PUCCH.
15. A method by a user equipment (UE), comprising:
 - determining an uplink control channel (PUCCH) spans over multiple slots based on a signaling from a base station (gNB);
 - determining a demodulation reference signals (DMRS) structure in the configured multi-slot PUCCH;
 - determining a frequency hopping method of the configured multi-slot PUCCH;
 - determining UCI encoding and loading methods on the configured multi-slot PUCCH;
 - determining a resource of a control channel for UCI feedback; and
 - transmitting UCI on a selected channel.

16. A method by a base station (gNB), comprising:
 - determining an uplink control channel (PUCCH) spans over multiple slots;
 - determining a demodulation reference signals (DMRS) structure in the configured multi-slot PUCCH;
 - determining a frequency hopping method of the configured multi-slot PUCCH;
 - determining UCI encoding and loading methods on the configured multi-slot PUCCH;
 - determining a resource of a control channel for UCI feedback; and
 - receiving UCI on a selected channel.

ABSTRACT

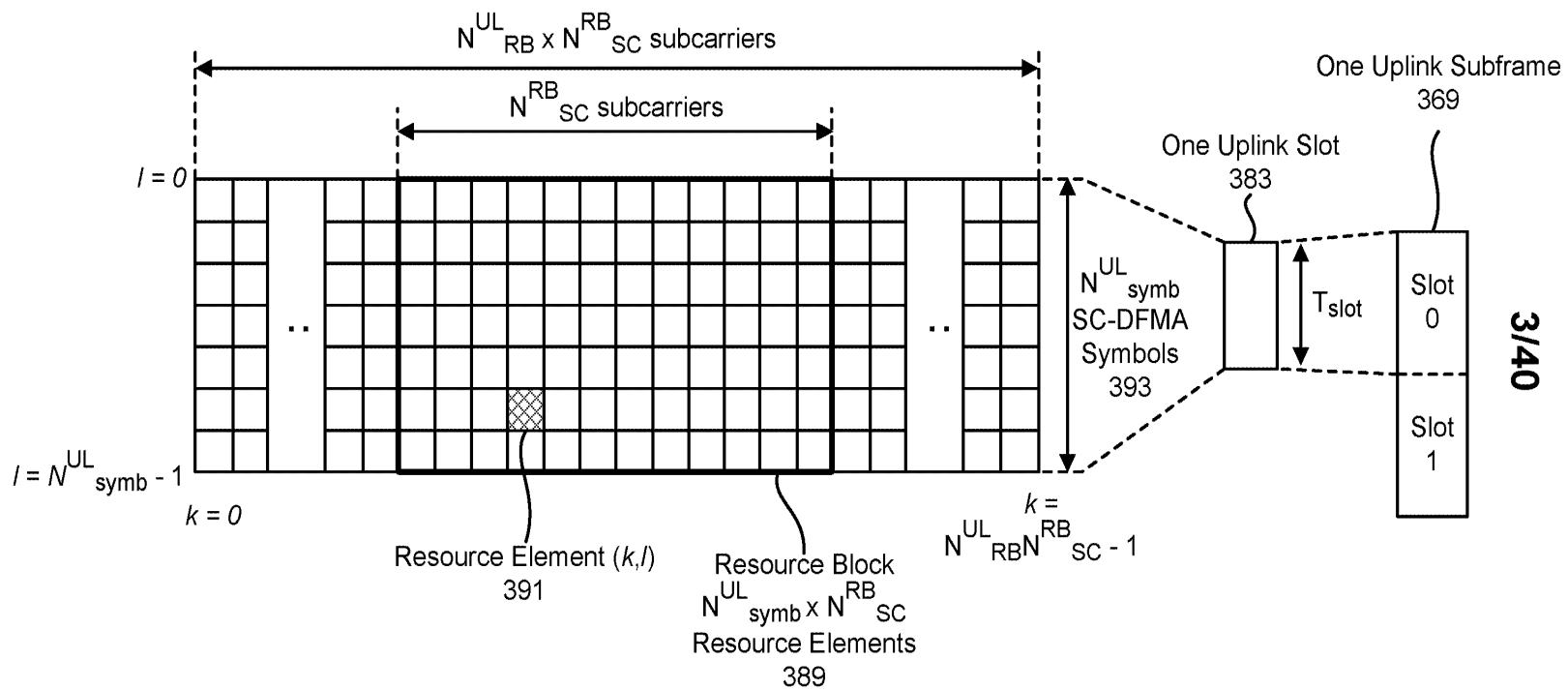
A user equipment (UE) is described. The UE includes a processor and memory in electronic communication with the processor. Instructions stored in the memory are executable to determine an uplink control channel (PUCCH) spans over multiple slots based on a signaling from a base station (gNB). The instructions are also executable to determine a demodulation reference signals (DMRS) structure in the configured multi-slot PUCCH. The instructions are further executable to determine a frequency hopping method of the configured multi-slot PUCCH. The instructions are additionally executable to determine uplink control information (UCI) encoding and loading methods on the configured multi-slot PUCCH. The instructions are also executable to determine a resource of a control channel for UCI feedback. The instructions are further executable to transmit UCI on a selected channel.



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FIG. 2



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FIG. 3

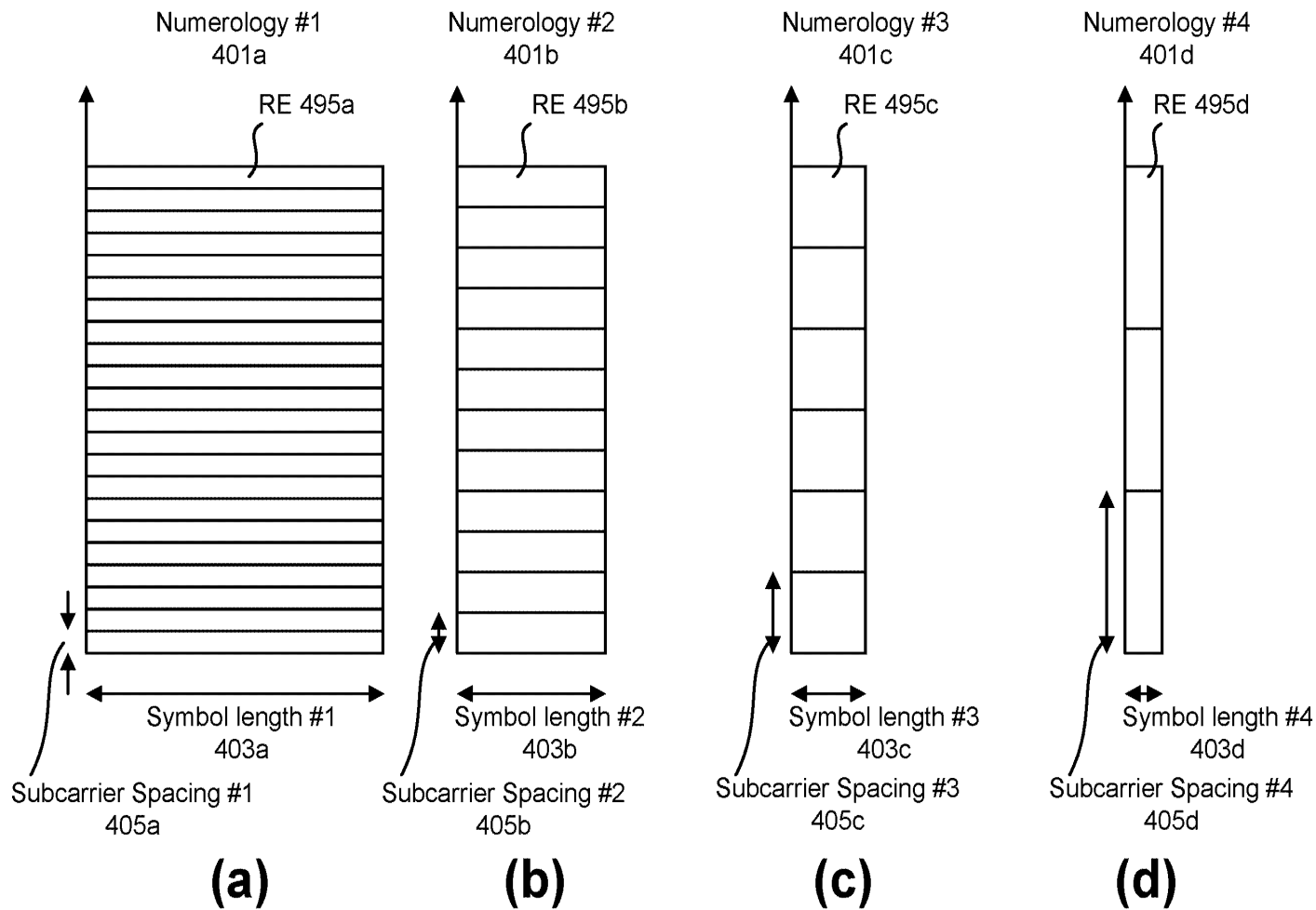


FIG. 4

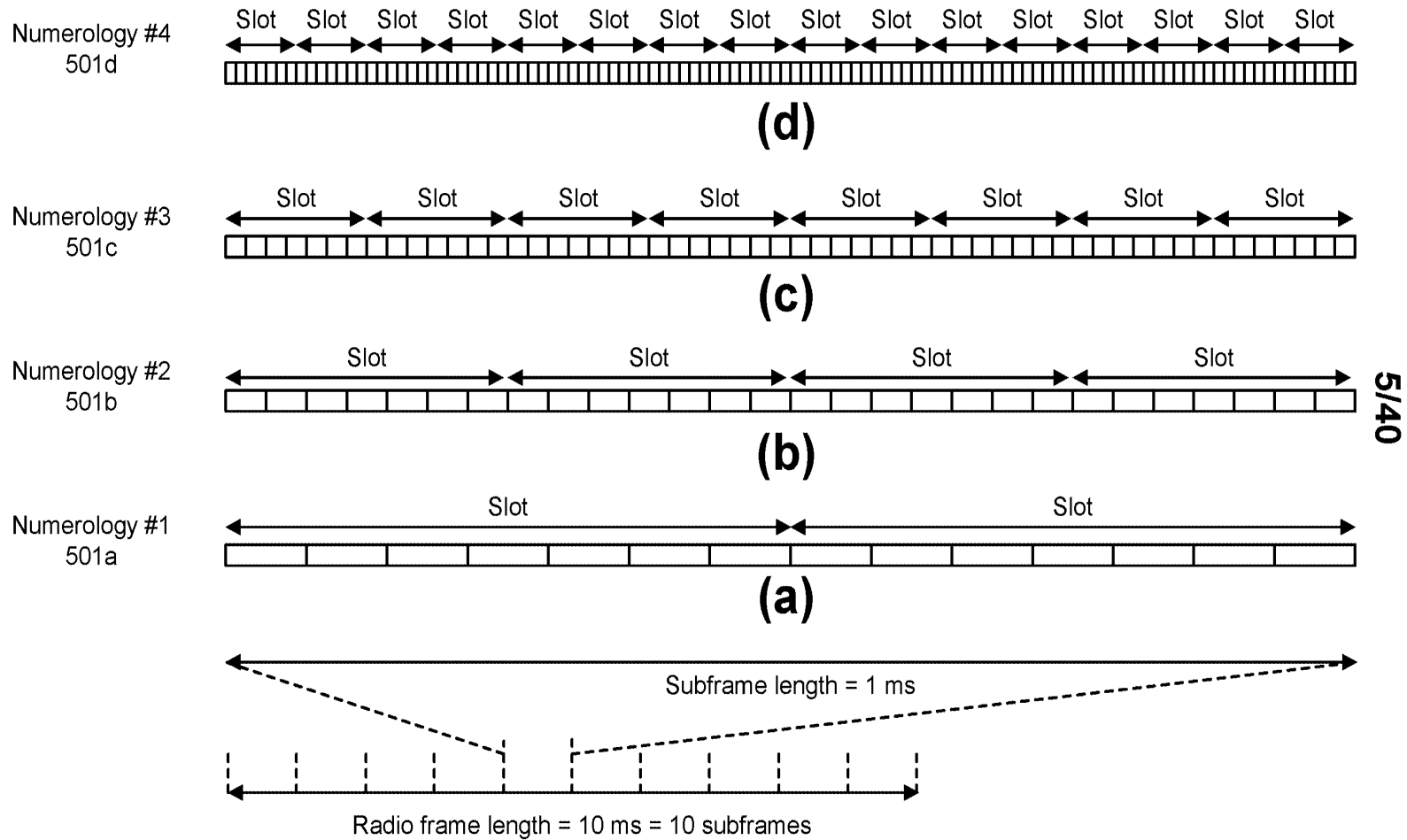


FIG. 5

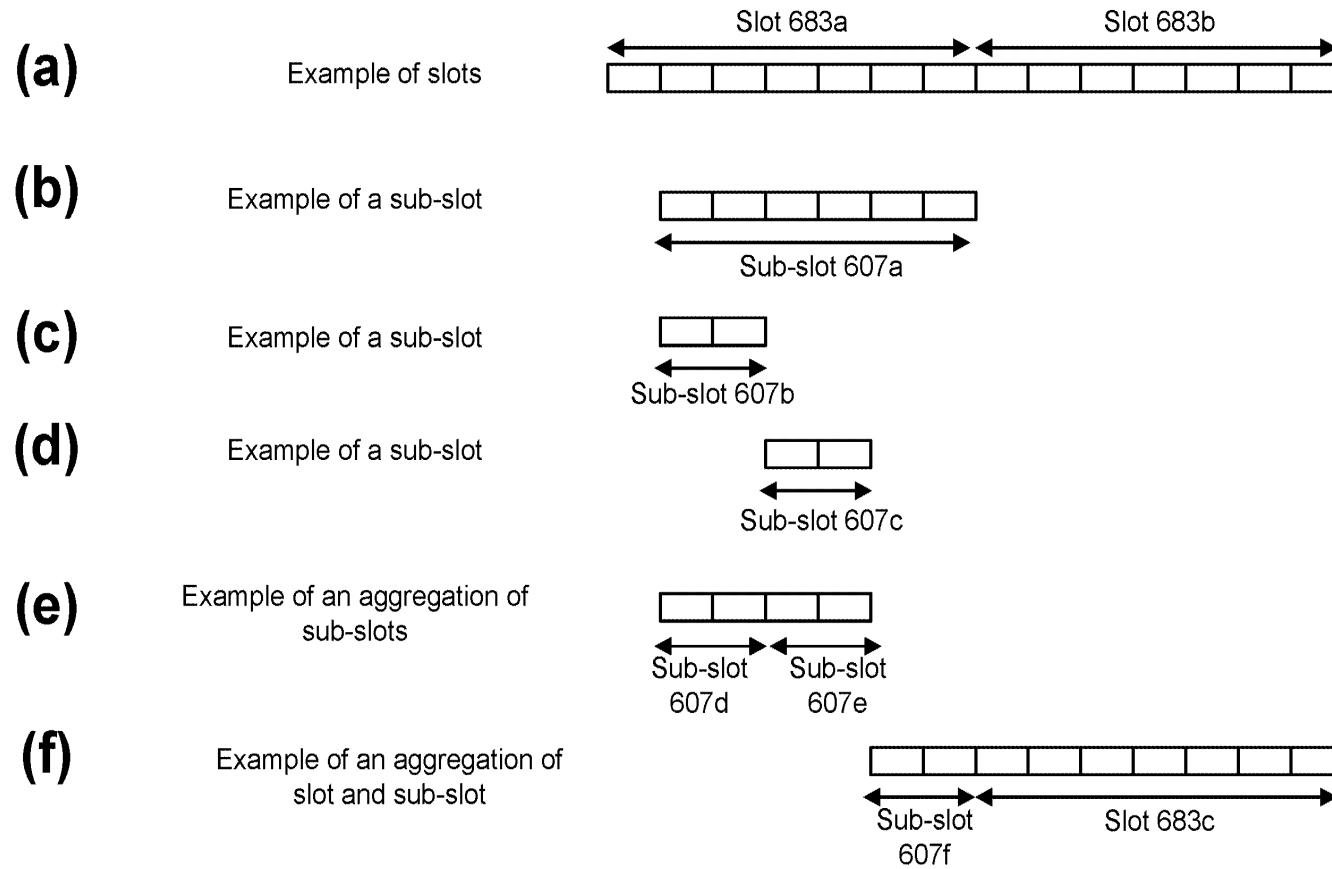


FIG. 6

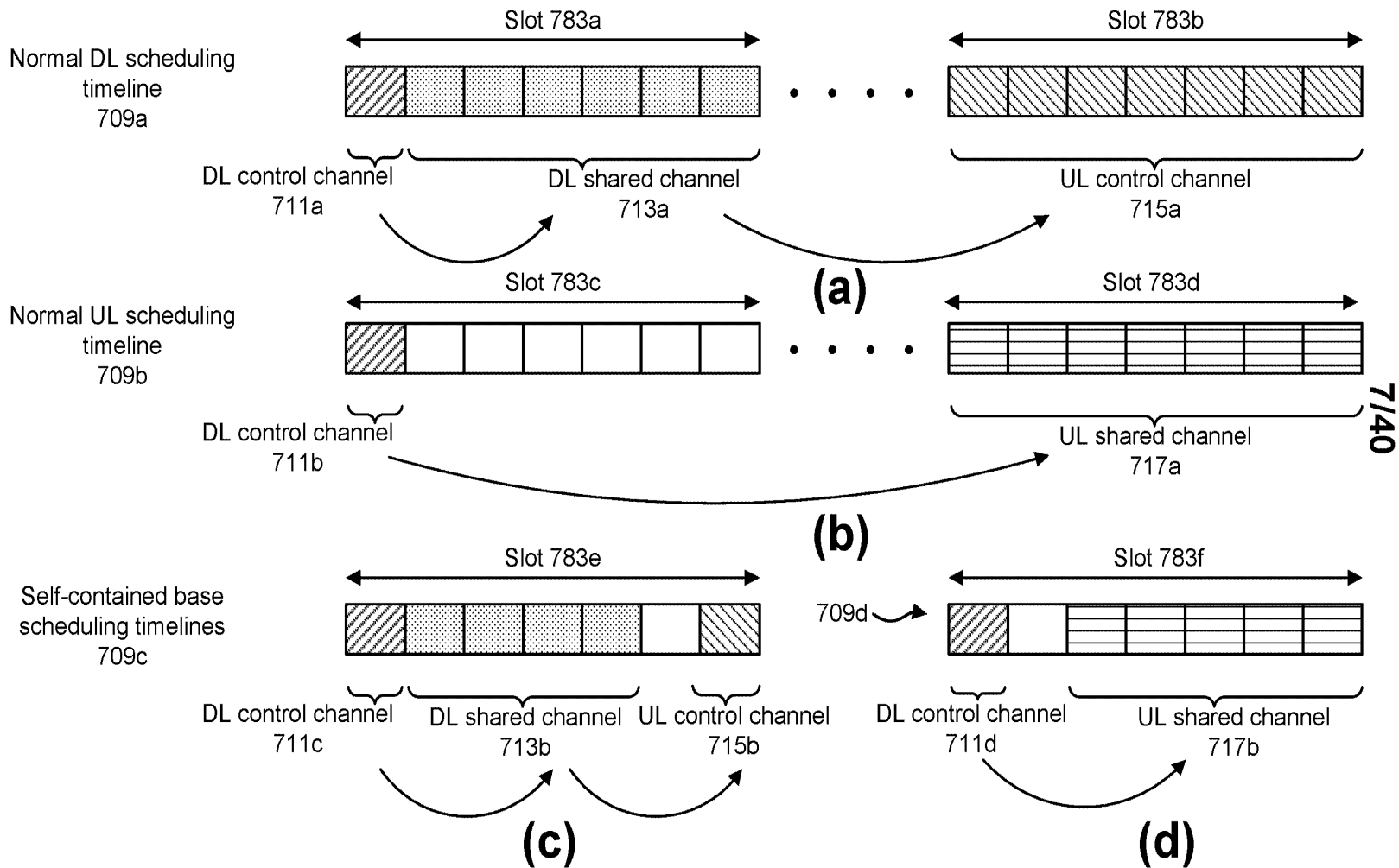
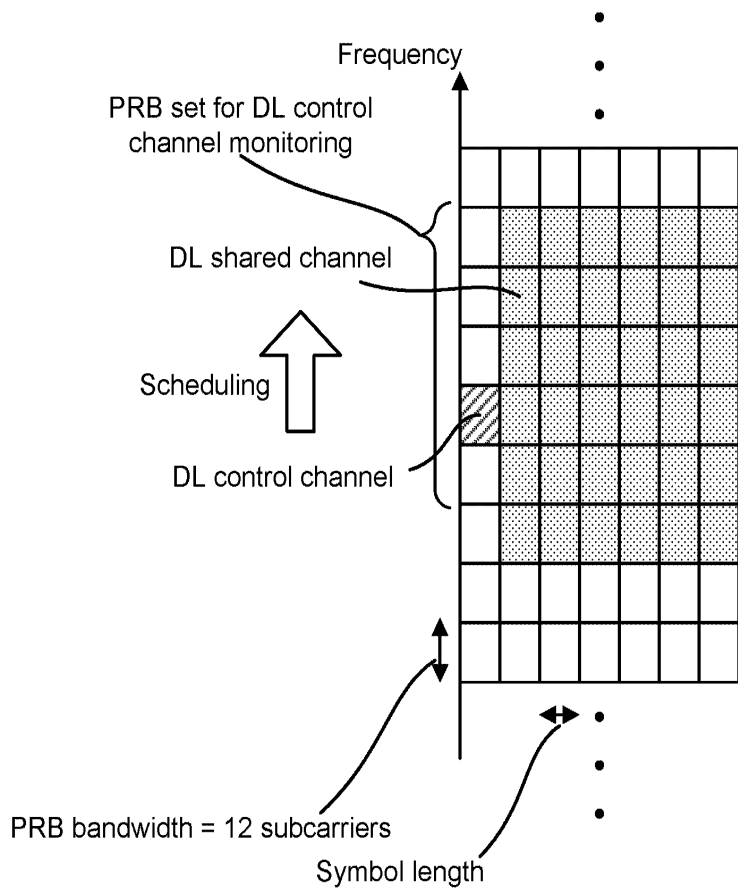
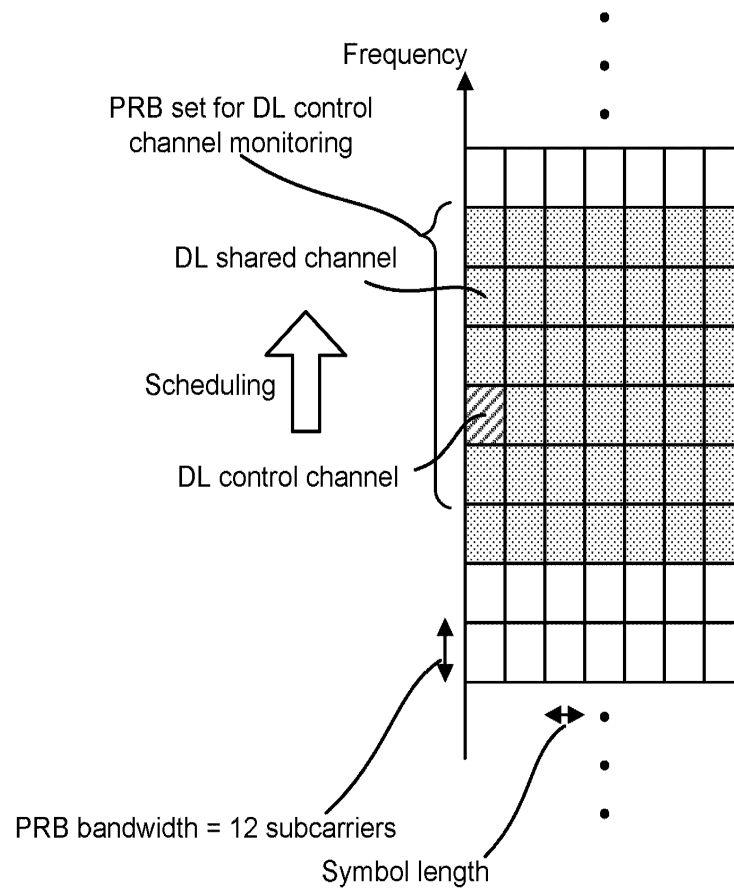


FIG. 7



(a)

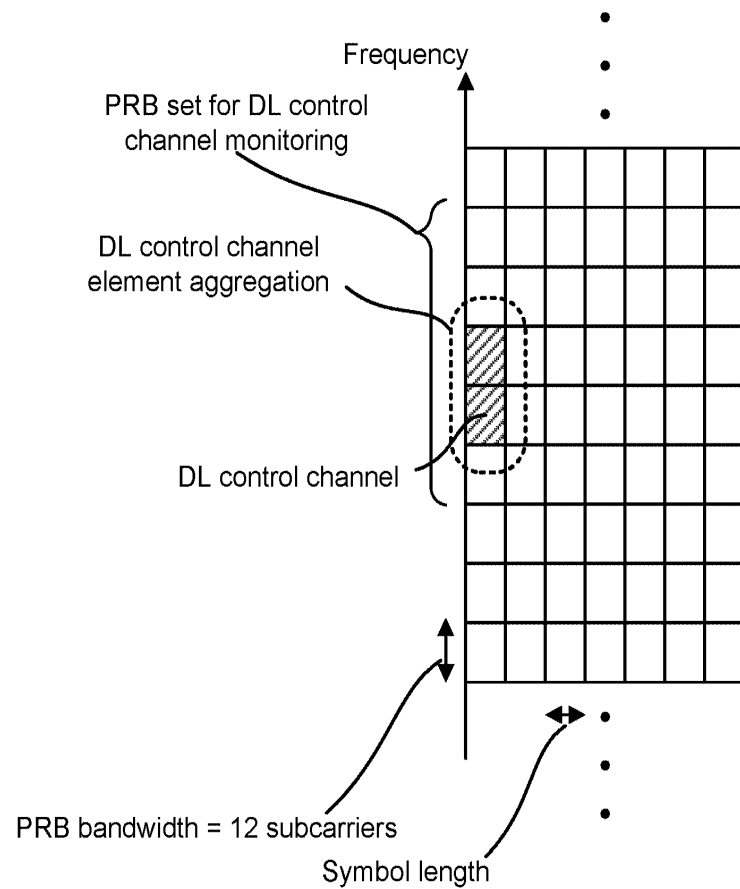


(b)

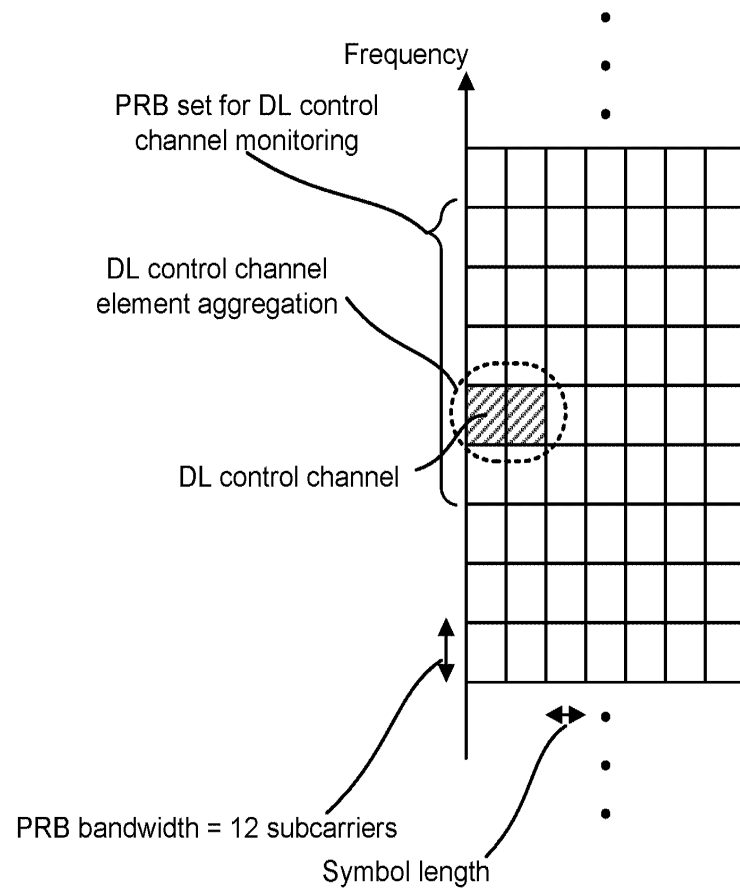
FIG. 8

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(a)



(b)

FIG. 9

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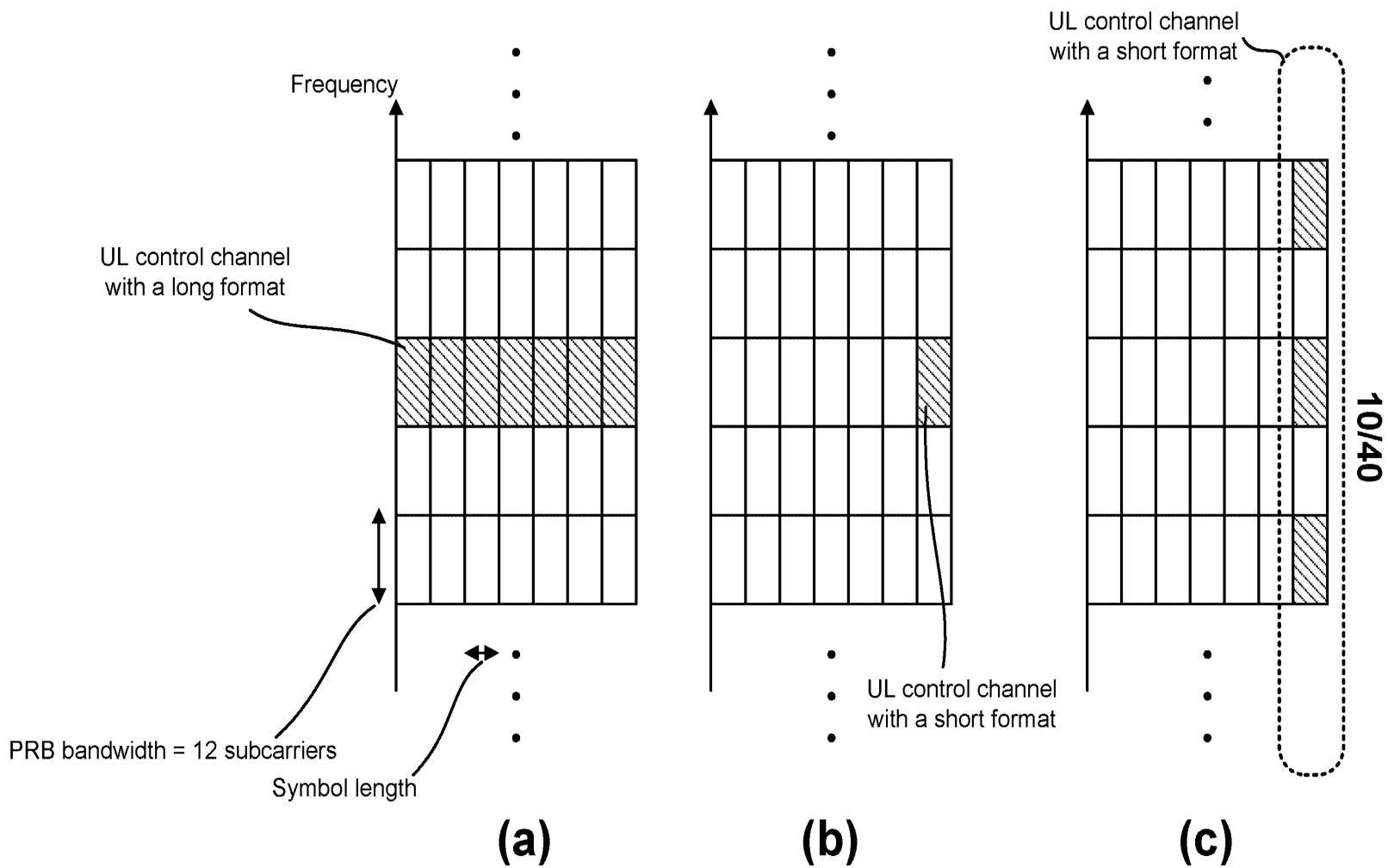


FIG. 10

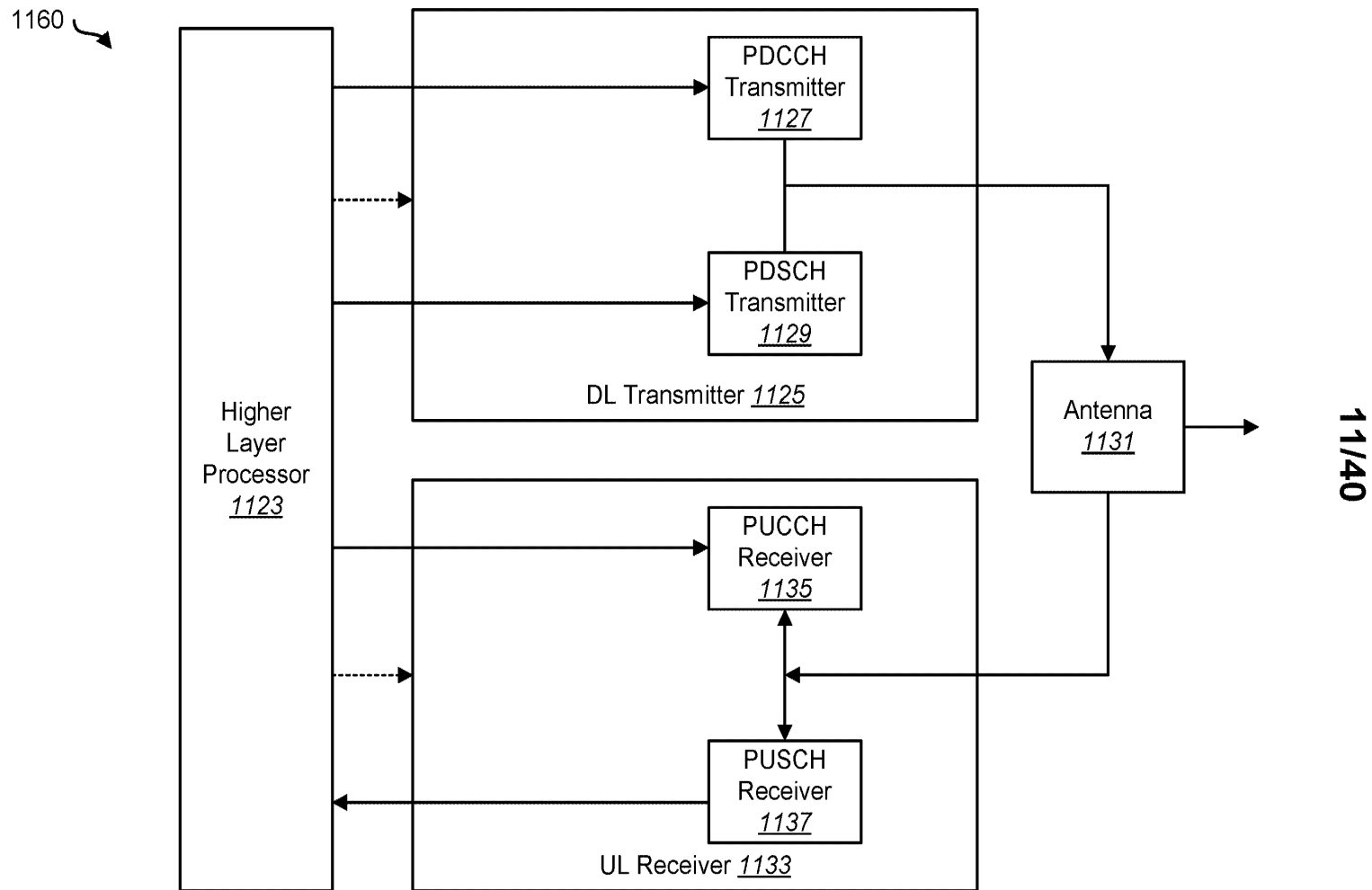
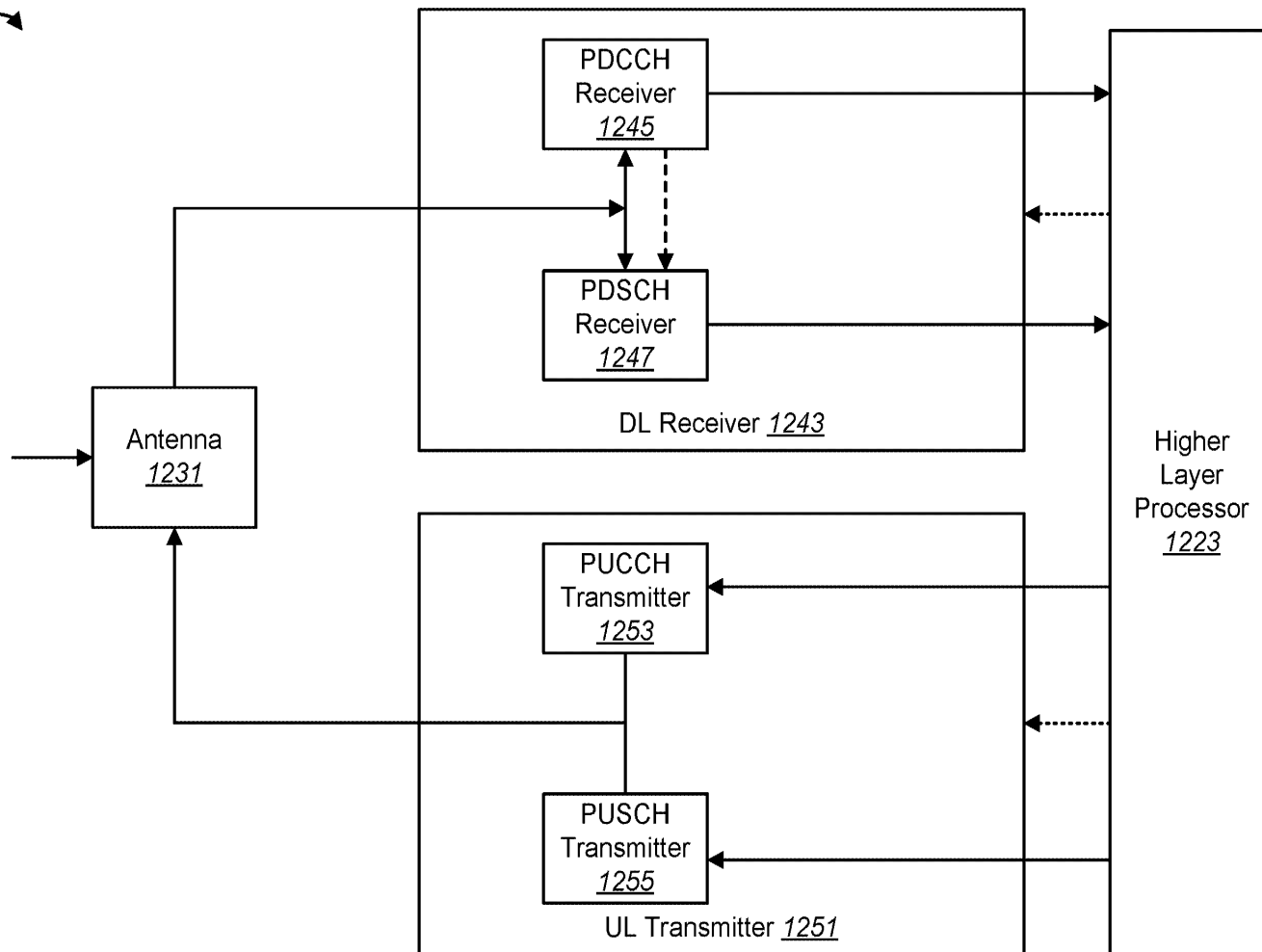


FIG. 11

1202 ↗



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FIG. 12



a) long PUCCH spans over the whole UL only slot



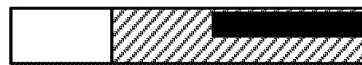
b) long PUCCH spans over the multiple UL only slots



c) long PUCCH spans over the whole UL centric slot



d) long PUCCH spans over the whole UL centric slot and one or more consecutive UL only slots



e) long PUCCH spans over some symbols to the end of a UL centric slot or a UL only slot



f) long PUCCH spans over some symbols to the end of a UL centric slot or a UL only slot and one or more consecutive UL only slots

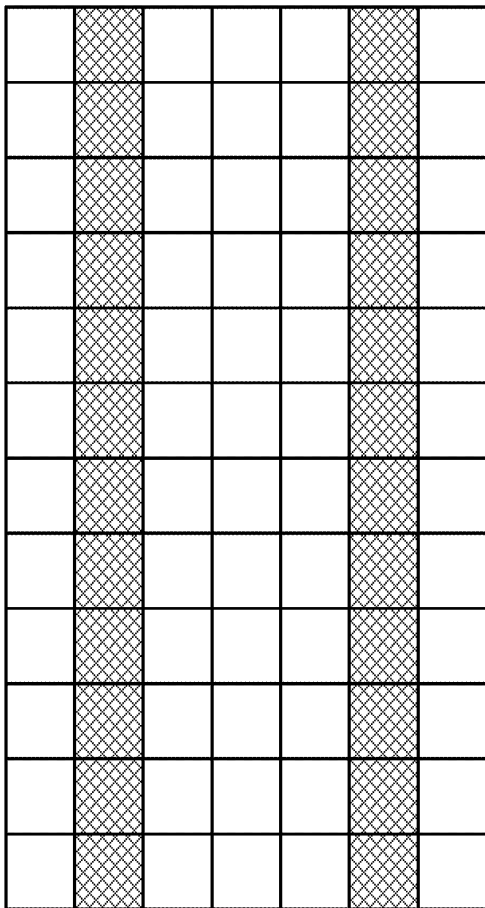


g) long PUCCH spans over some symbols of a UL centric slot or a UL only slot



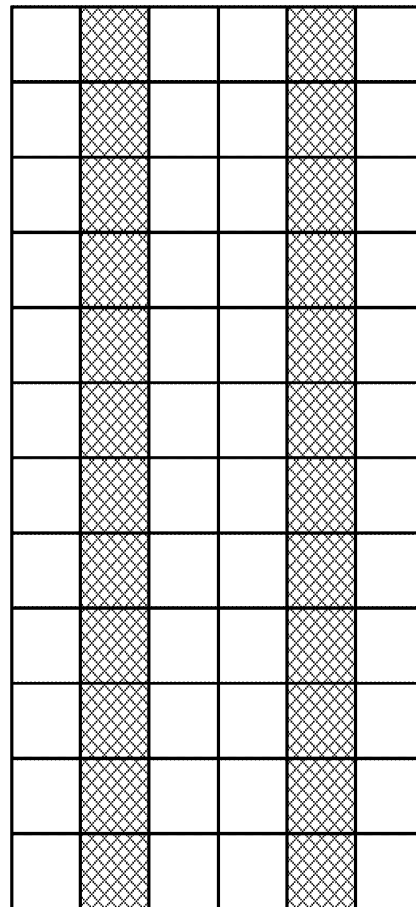
h) long PUCCH starts in the middle a UL centric slot or a UL only slot, spans over one or more consecutive UL only slots, and ends in the middle of a UL only slot

FIG. 13



DMRS Pattern 1 for Normal CP
1403a

(a)



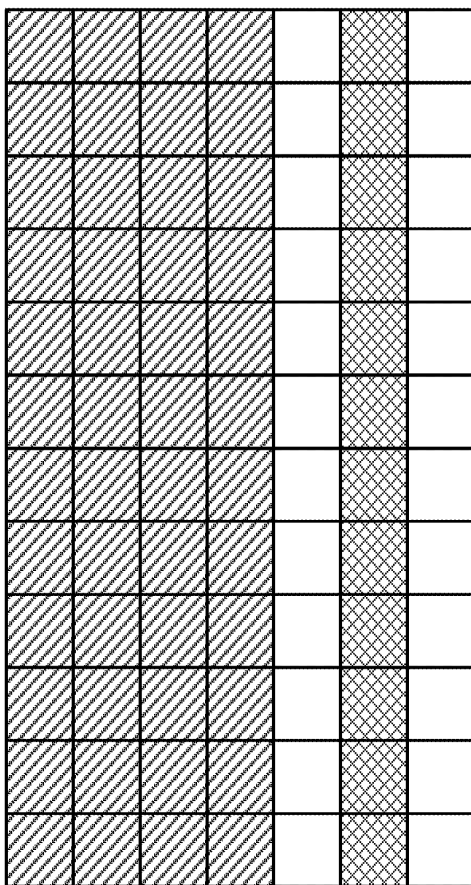
DMRS Pattern 1 for Extended CP
1403b

(b)

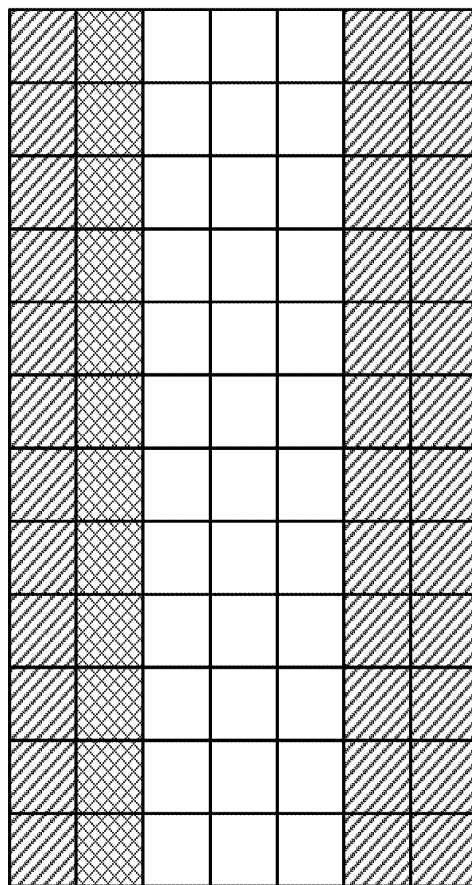


DMRS 1401

FIG. 14



a) $X=3$ if the long PUCCH covers the end of a slot



b) $X=4$ if the long PUCCH can start/end at any symbol of a slot

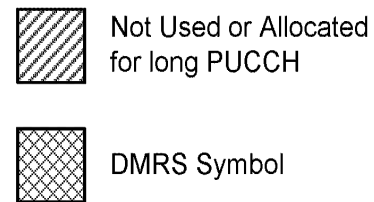
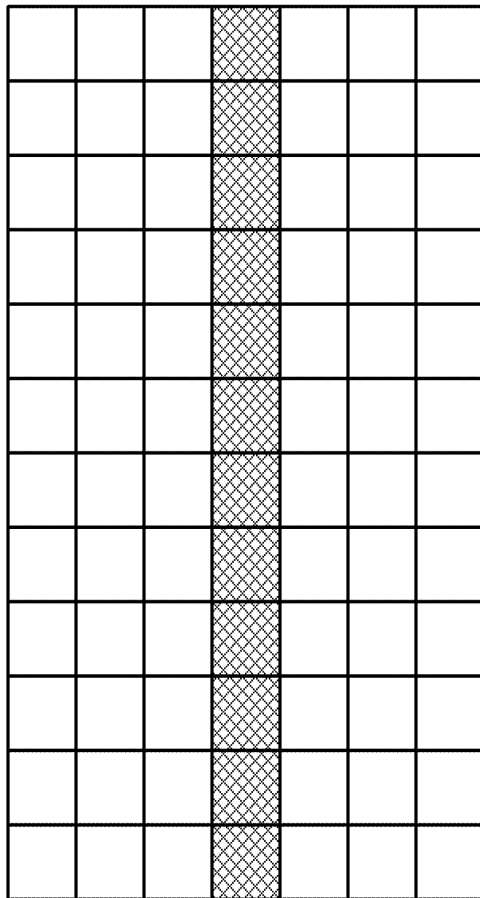
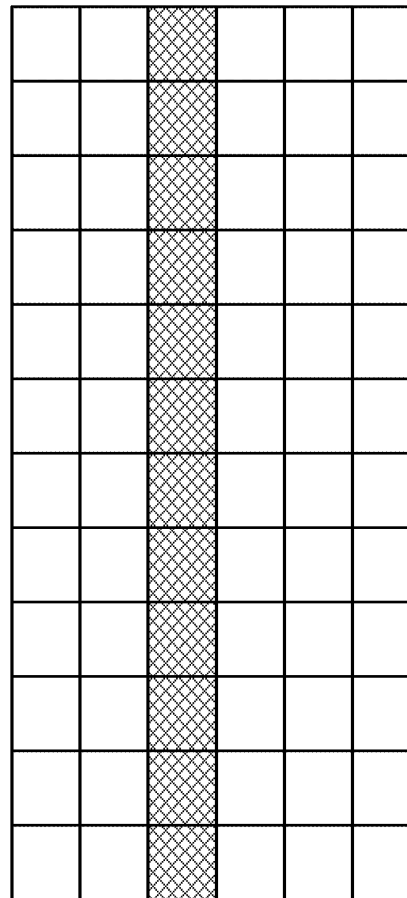


FIG. 15



DMRS Pattern 2 for Normal CP
1603a

(a)



DMRS Pattern 2 for Extended CP
1603b

(b)



DMRS 1601

FIG. 16

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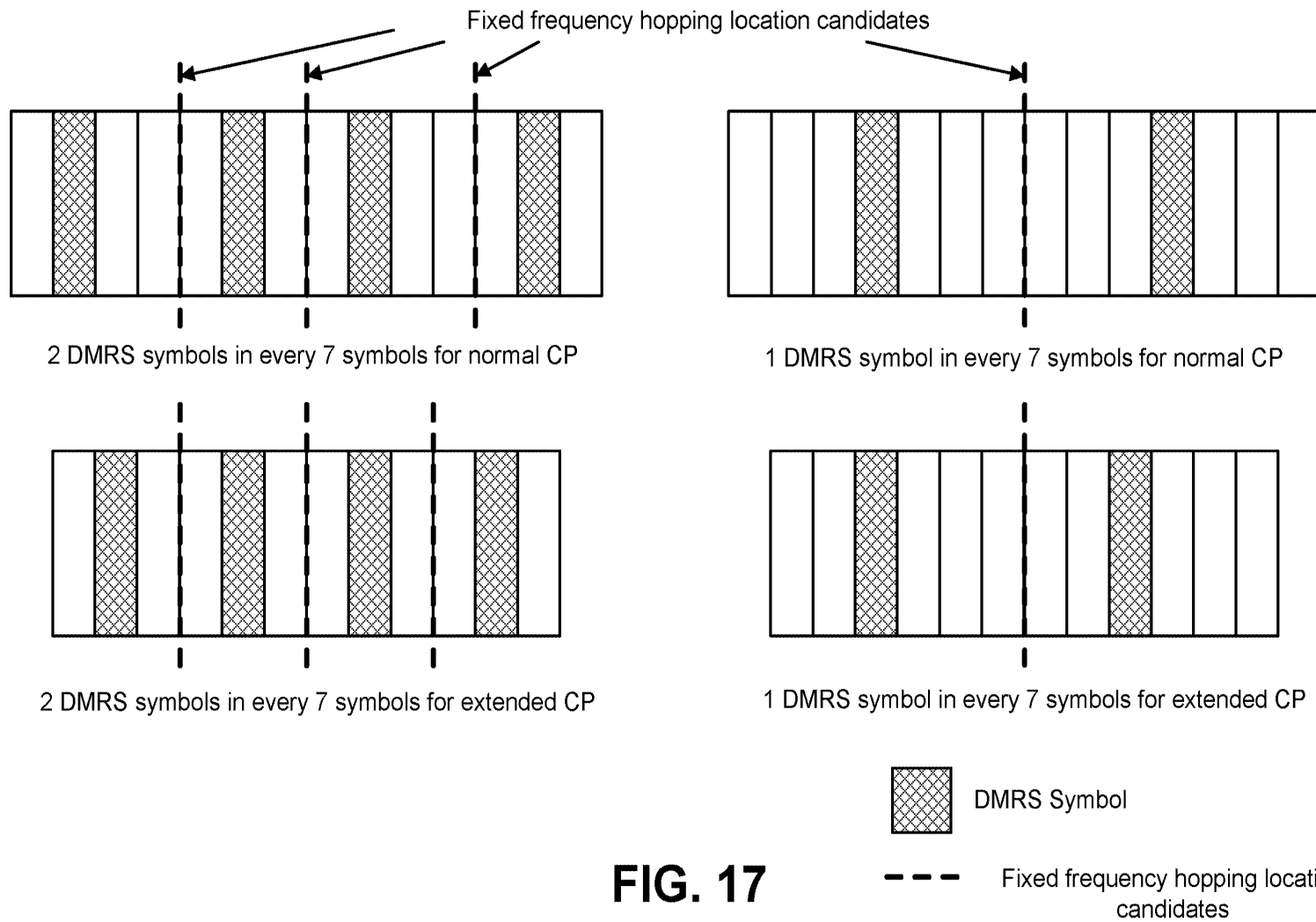


FIG. 17

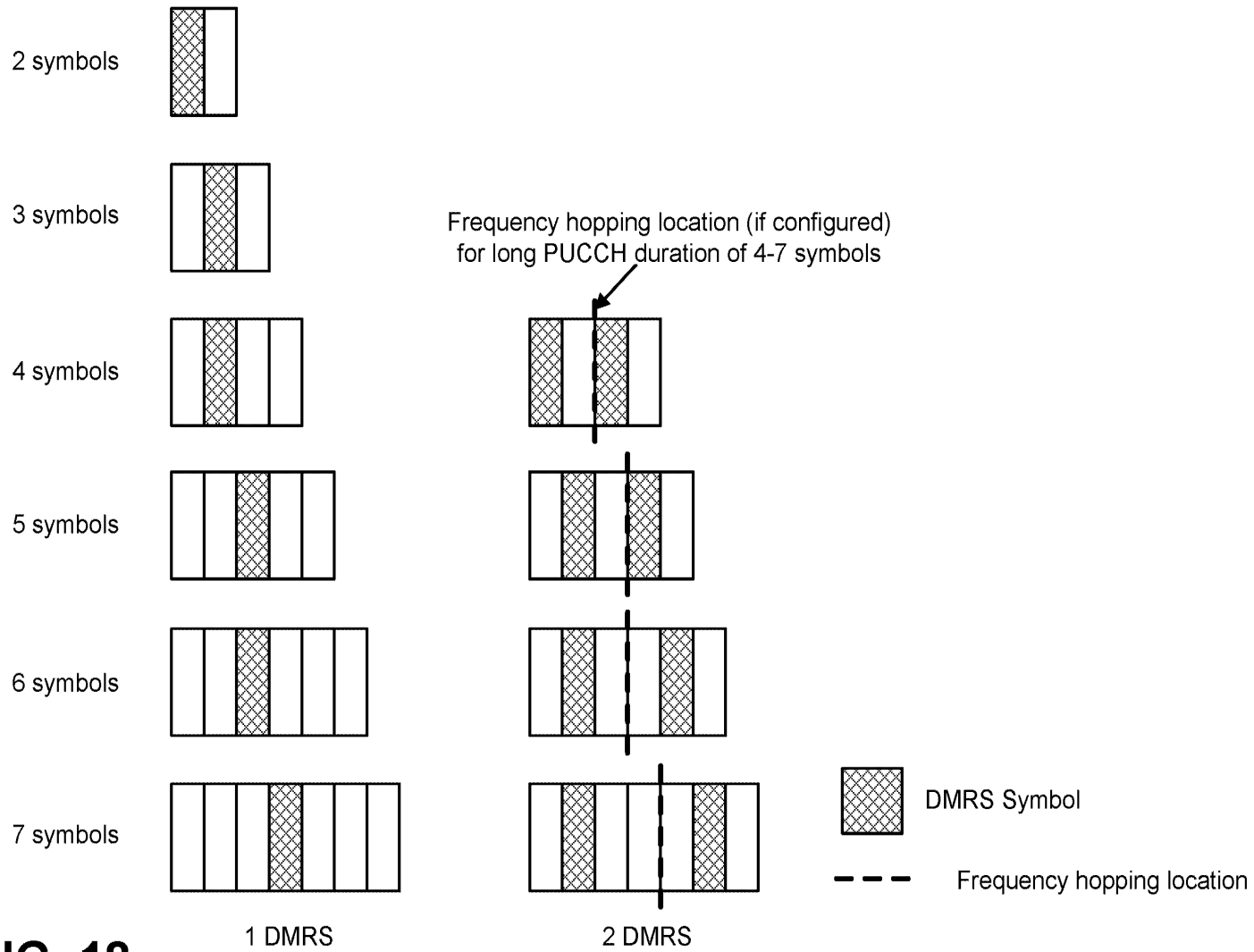
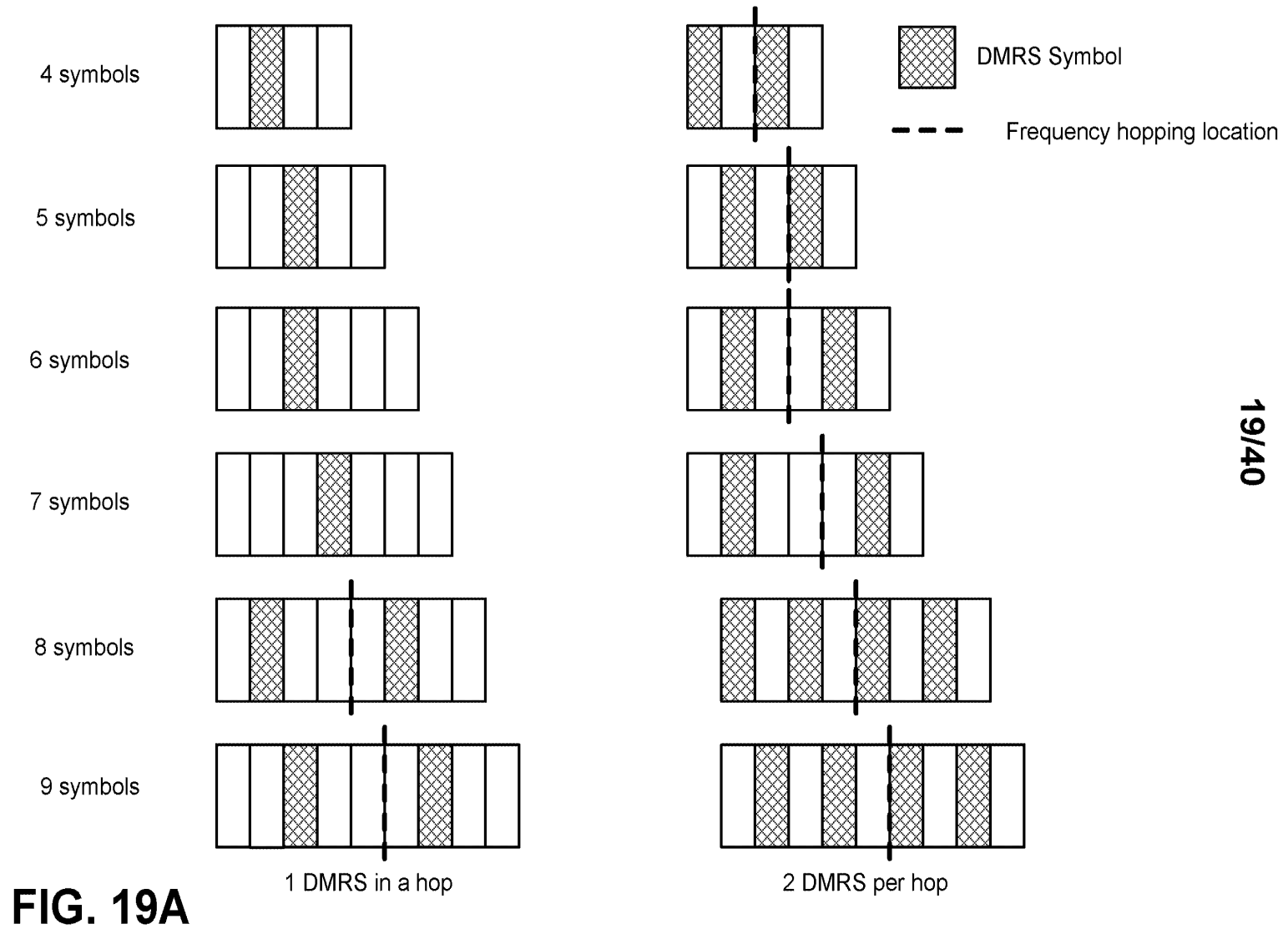


FIG. 18

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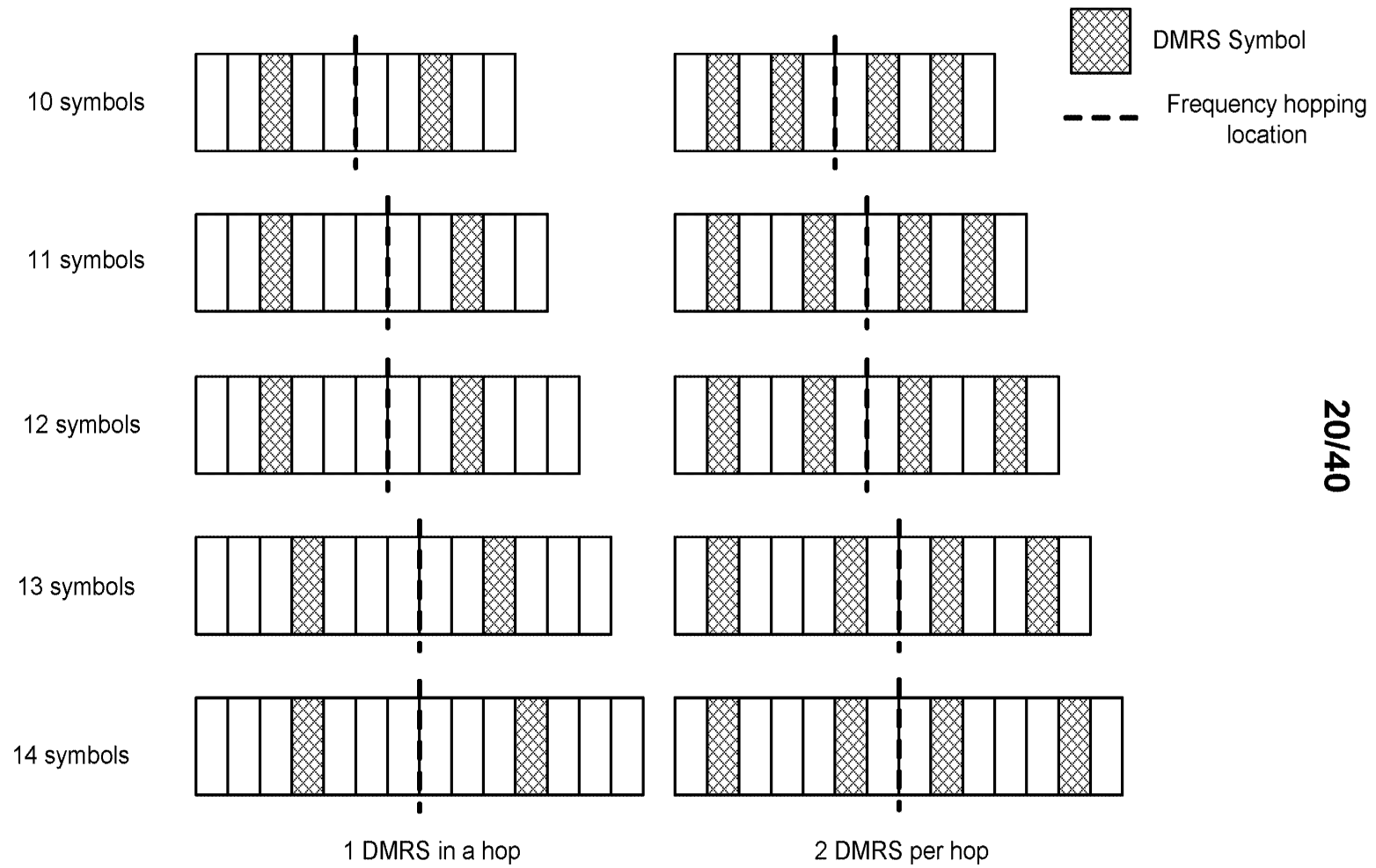
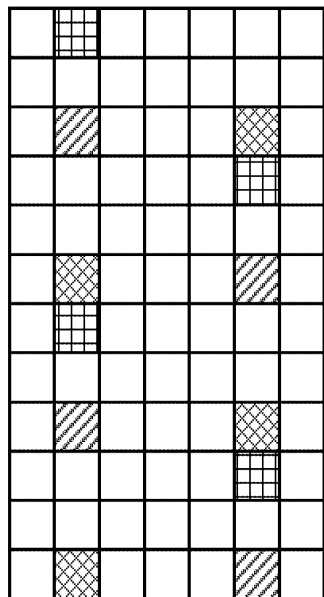
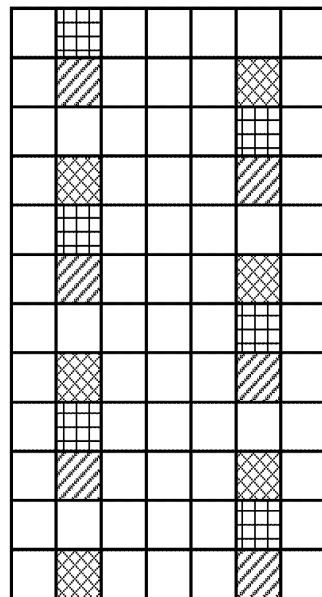


FIG. 19B

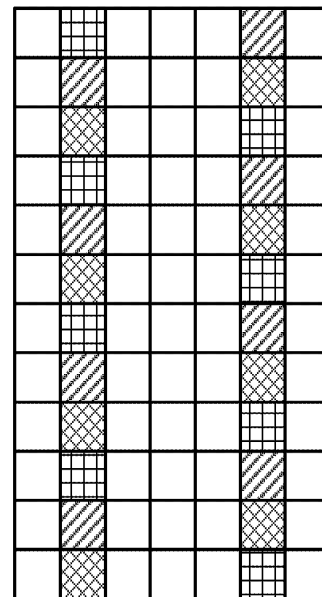
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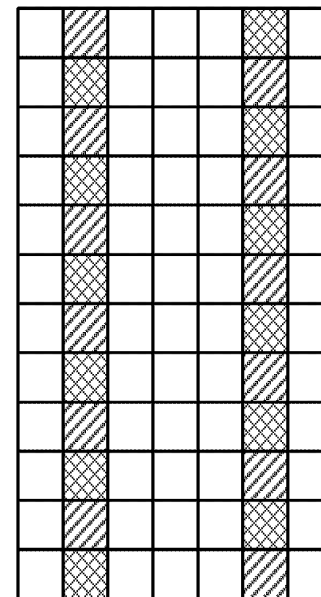
2 RS per RB per UE,
up to 6 UE multiplexing



3 RS per RB per UE,
up to 4 UE multiplexing



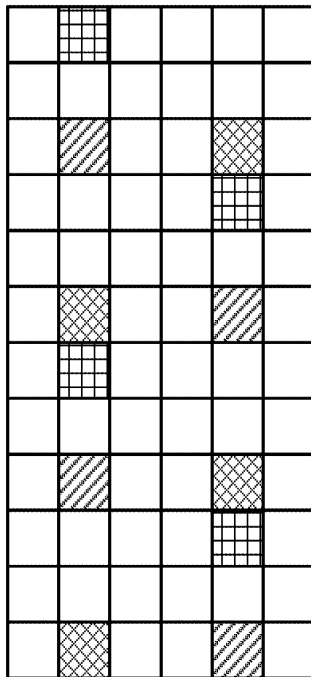
4 RS per RB per UE,
up to 3 UE multiplexing



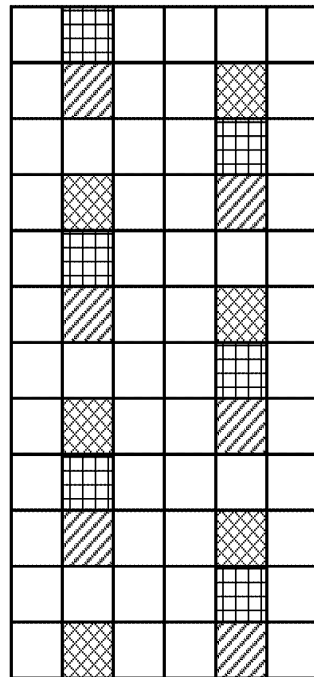
6 RS per RB per UE,
up to 2 UE multiplexing

FIG. 20

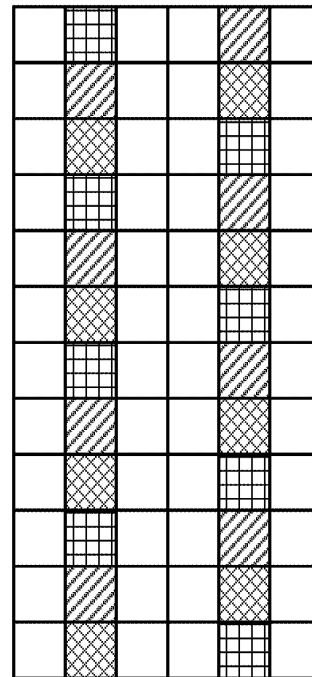
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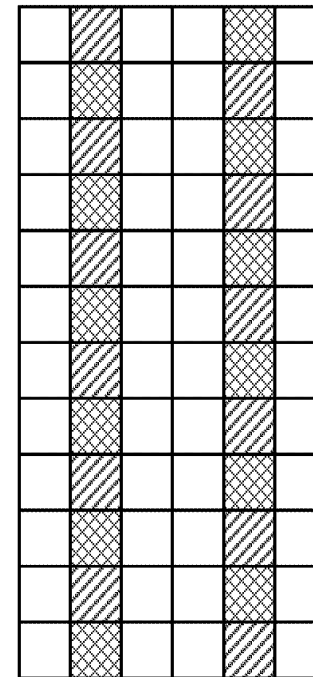
2 RS per RB per UE,
up to 6 UE multiplexing



3 RS per RB per UE,
up to 4 UE multiplexing



4 RS per RB per UE,
up to 3 UE multiplexing



6 RS per RB per UE,
up to 2 UE multiplexing

FIG. 21

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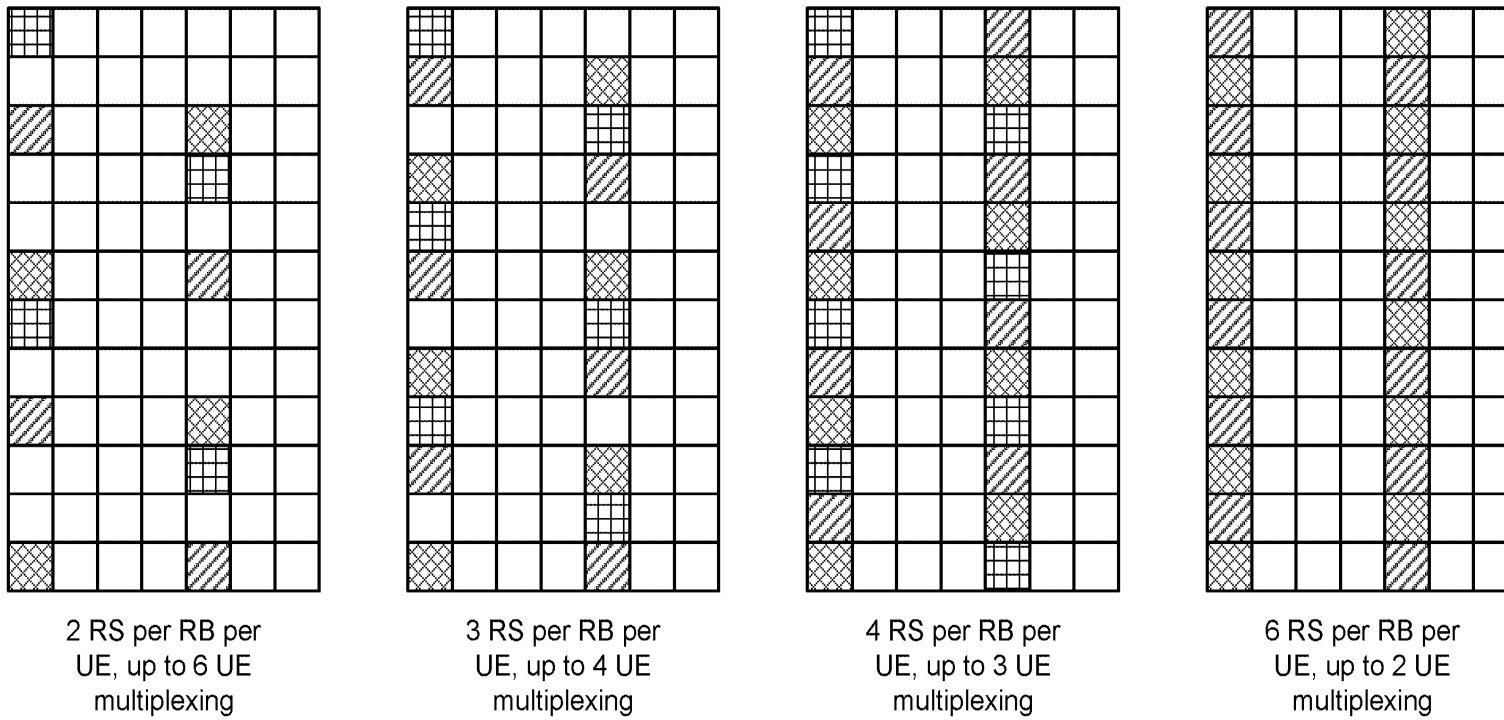


FIG. 22

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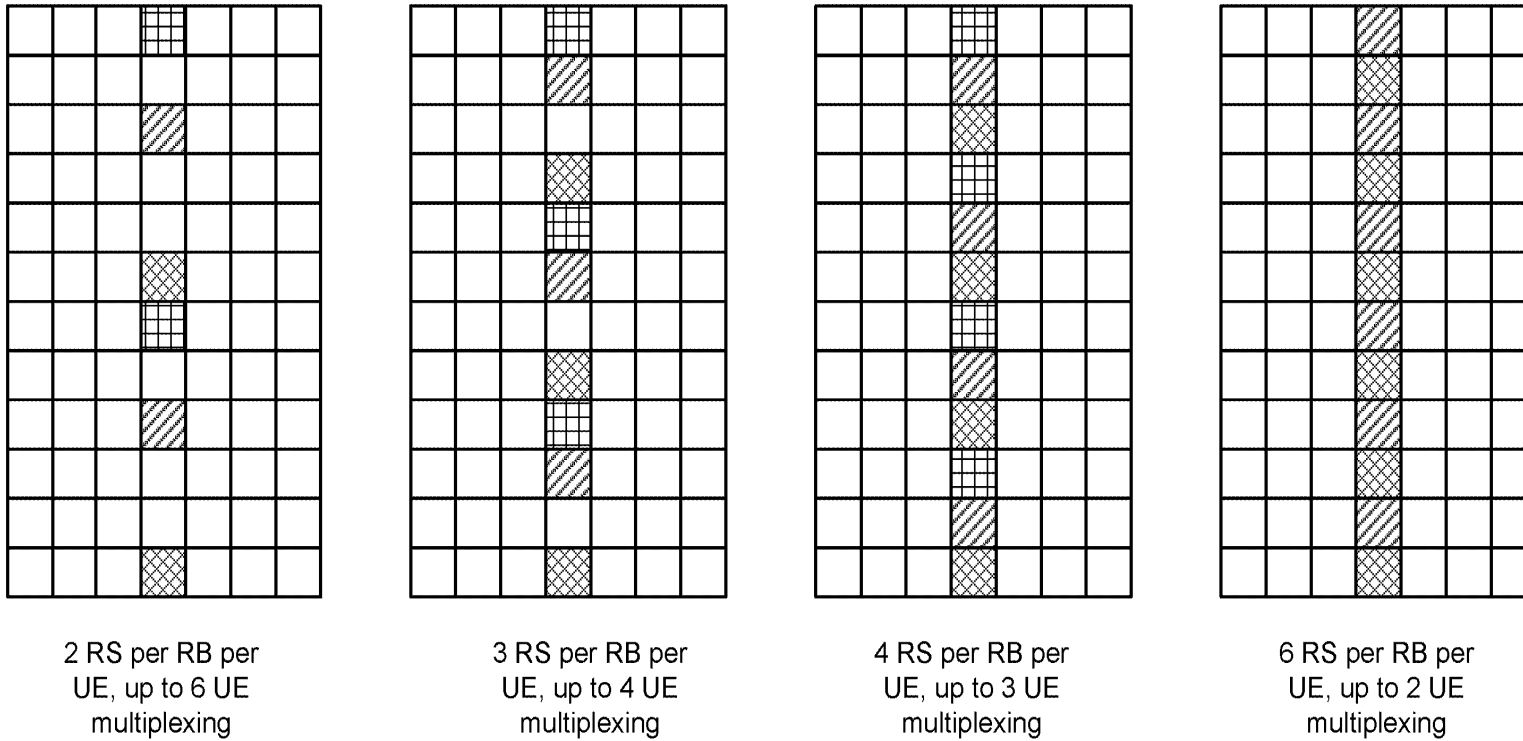


FIG. 23

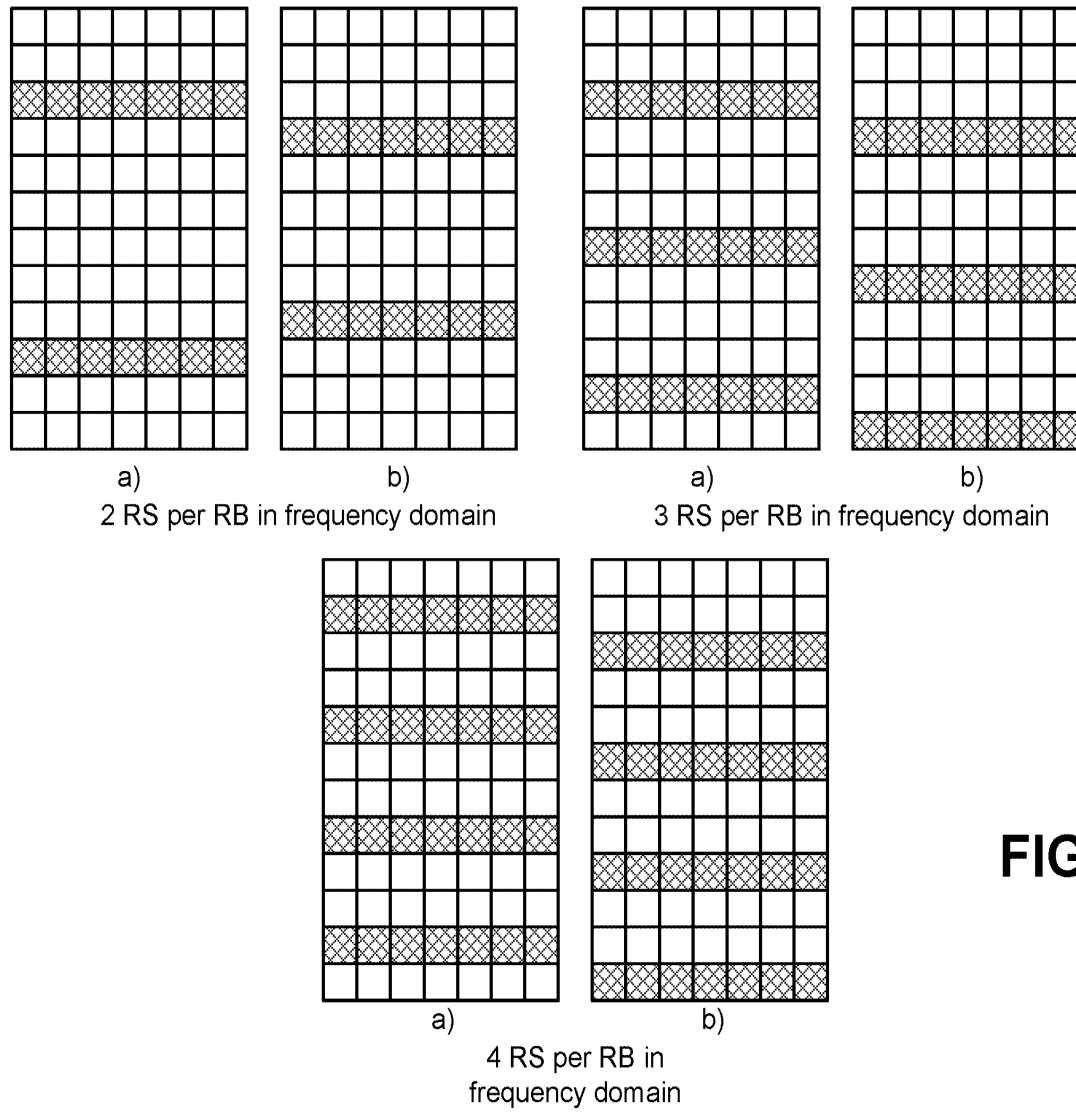
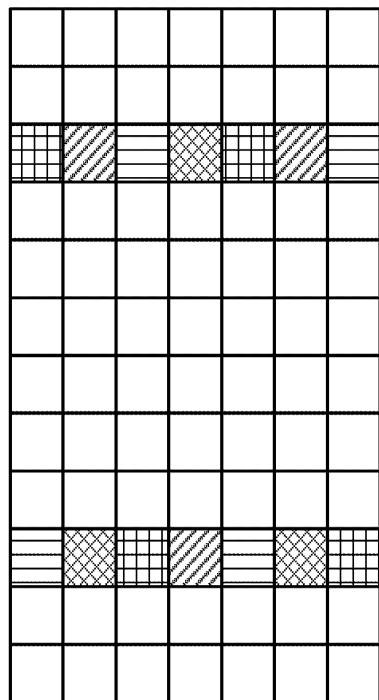
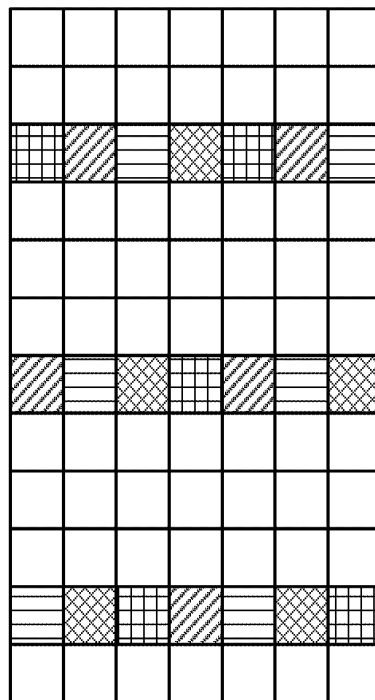


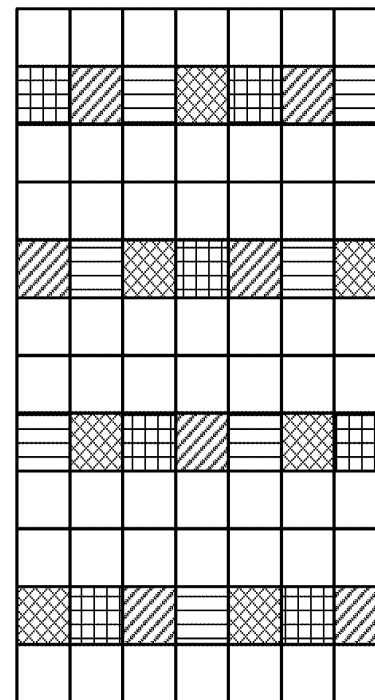
FIG. 24



2 RS per RB in frequency domain



3 RS per RB in frequency domain

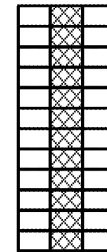
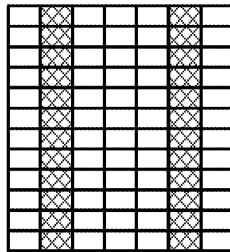
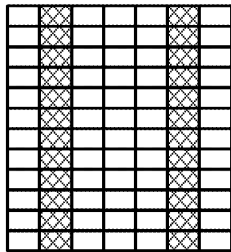
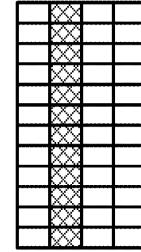
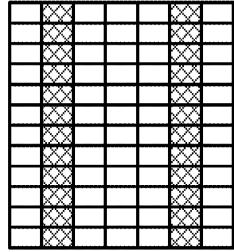
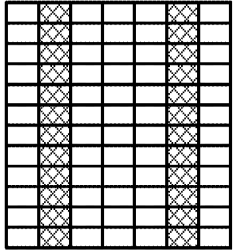


4 RS per RB in frequency domain

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FIG. 25



a) frequency hopping at slot or every 7 symbols for NCP

b) frequency hopping within 7 symbols for NCP

FIG. 26

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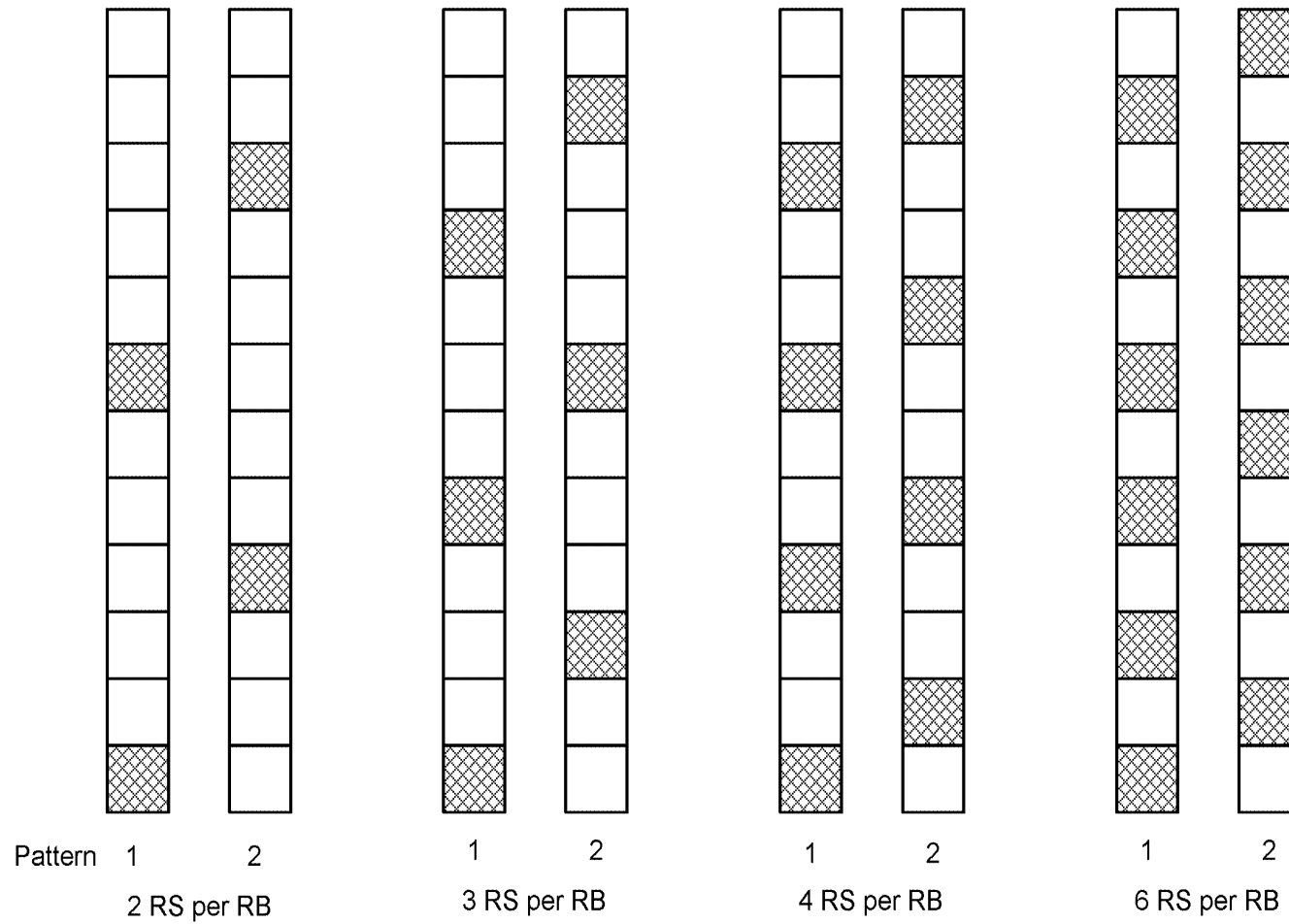


FIG. 27

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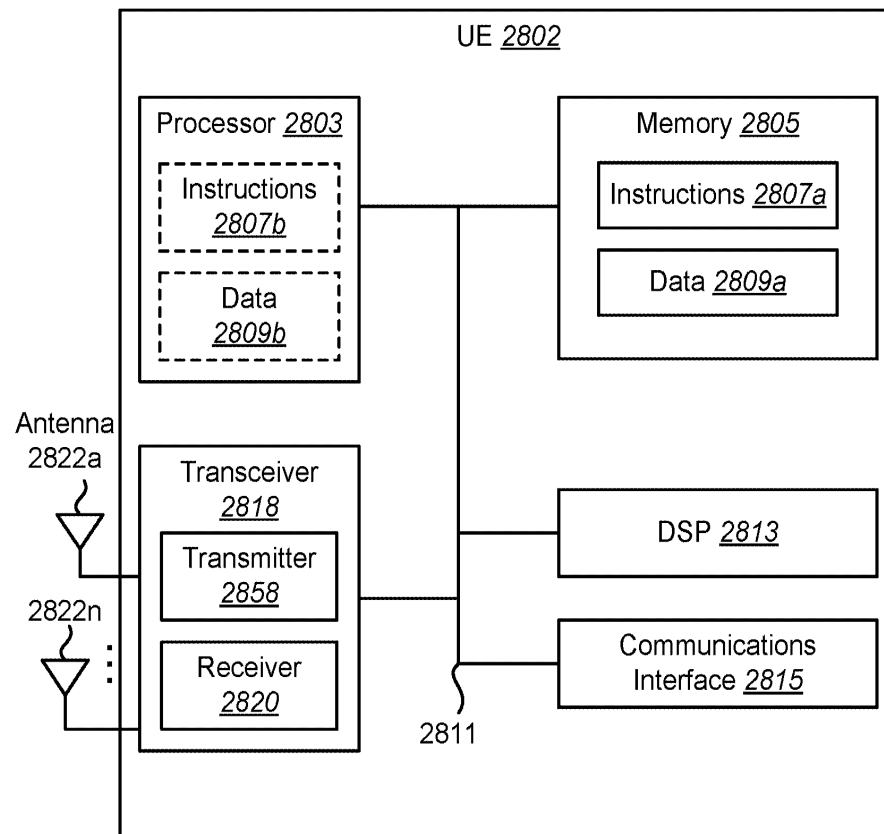


FIG. 28

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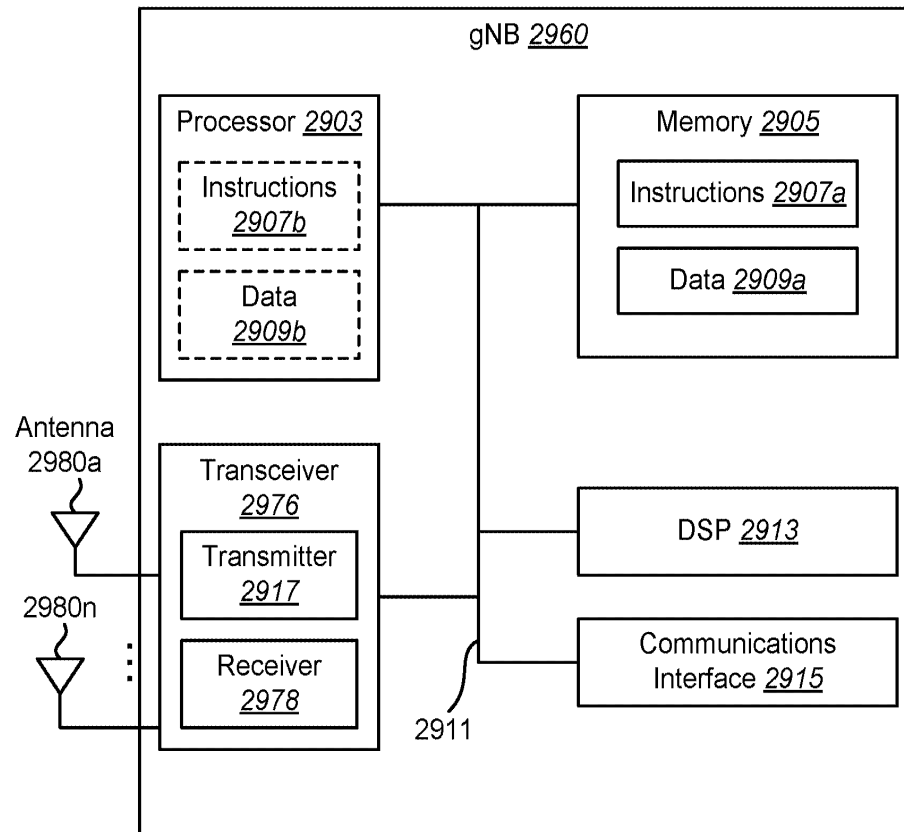


FIG. 29

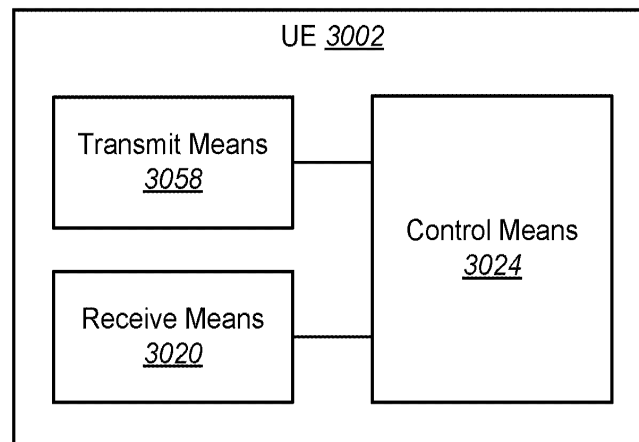


FIG. 30

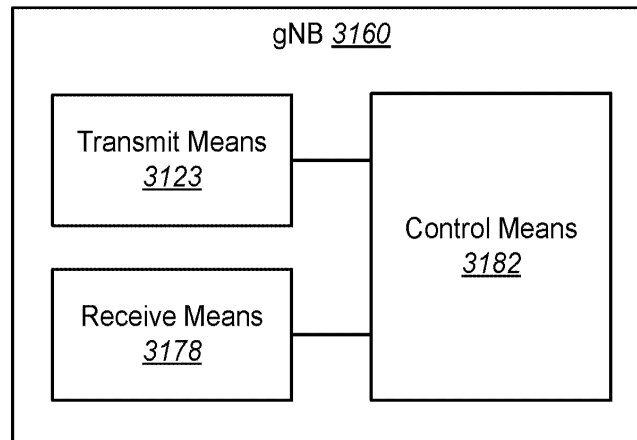
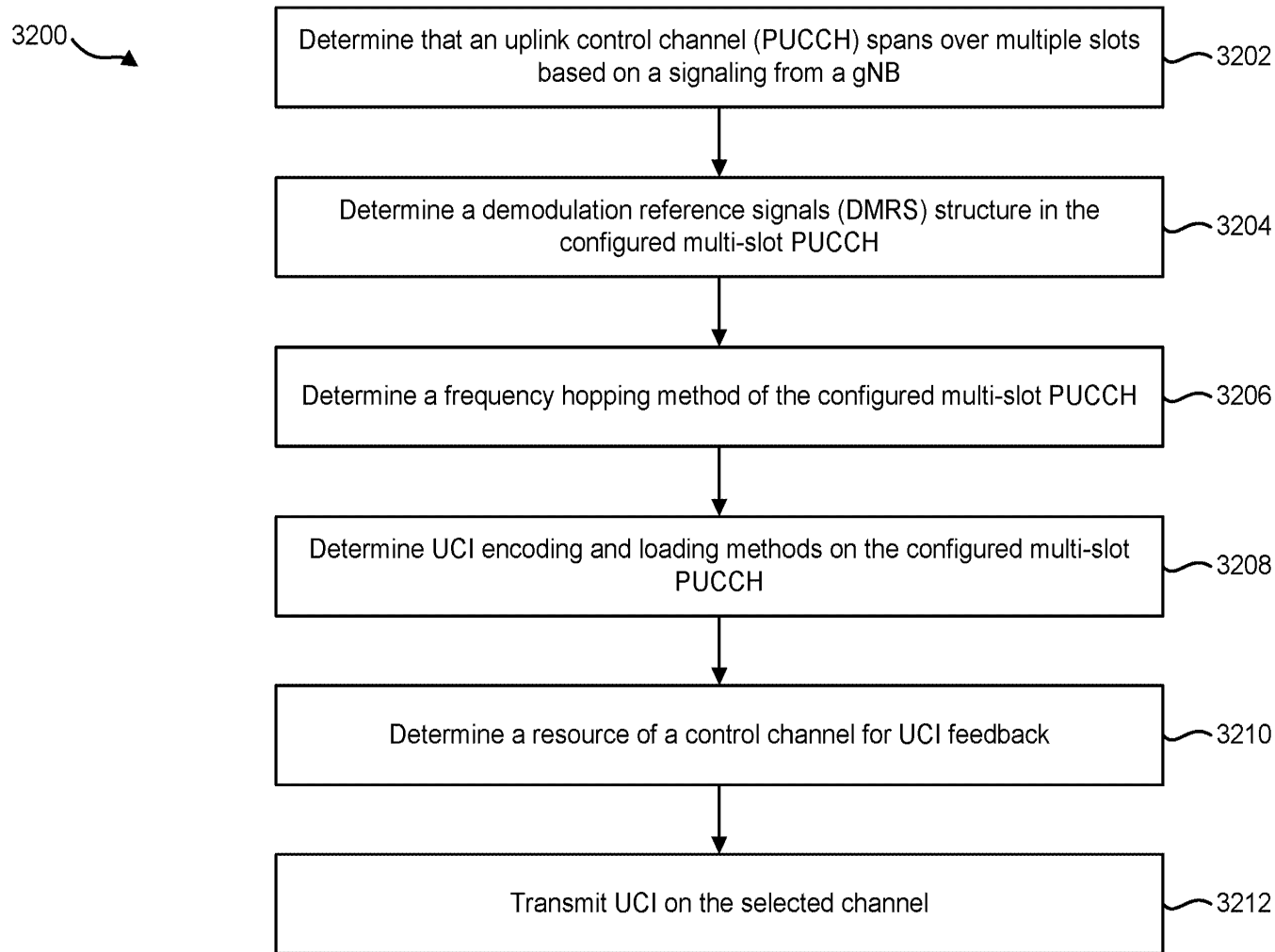
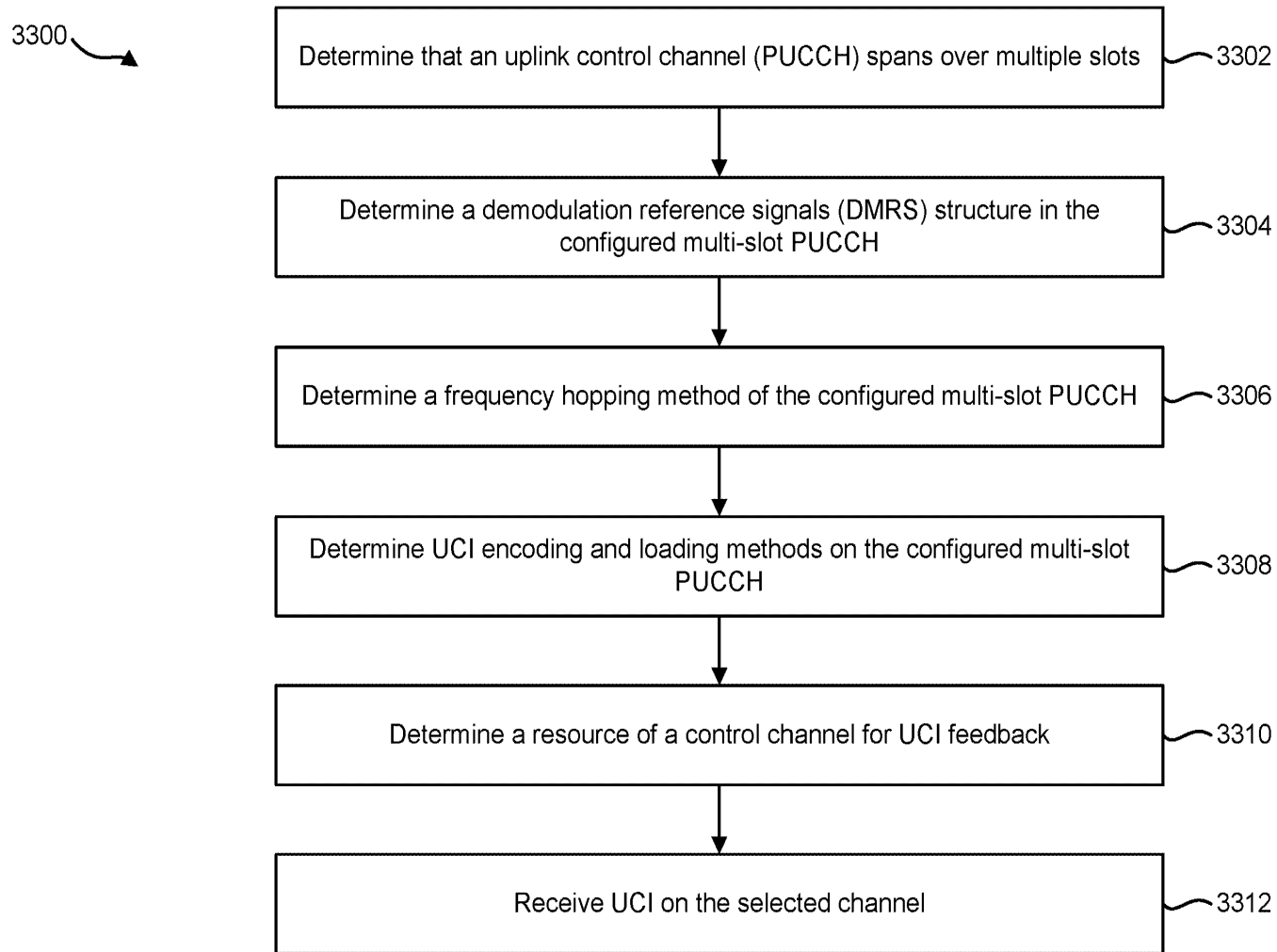


FIG. 31

**FIG. 32**

**FIG. 33**



Case 1: Long PUCCH in contiguous symbols in two consecutive slots, total number of symbols $\leq$ slot length



Case 2: Long PUCCH in contiguous symbols in consecutive slots, total number of symbols $>$ slot length

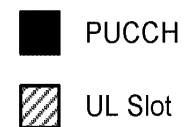
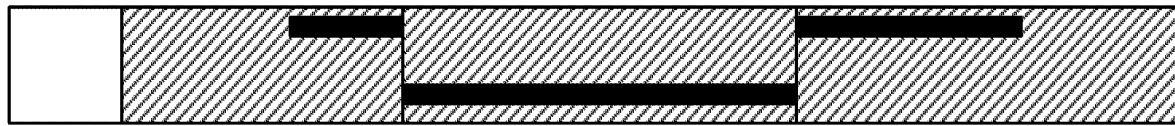


FIG. 34

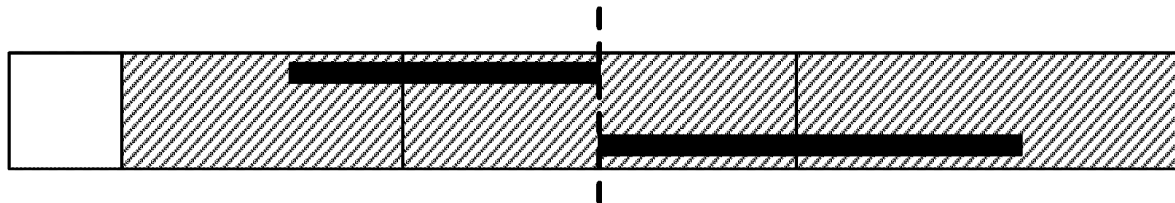
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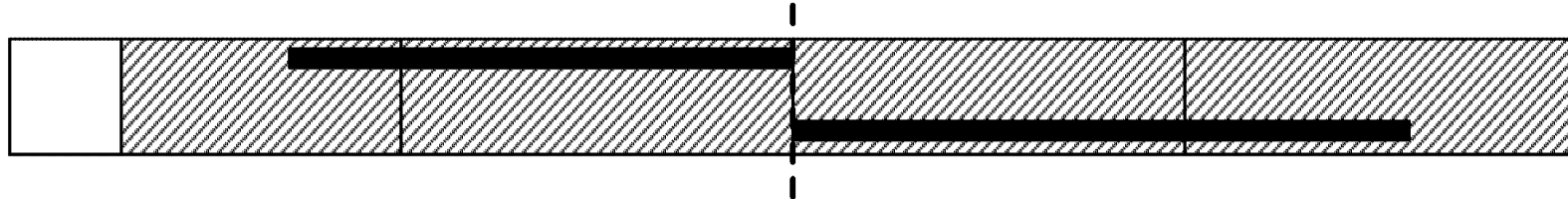
(a) Inter-slot hopping at slot boundary



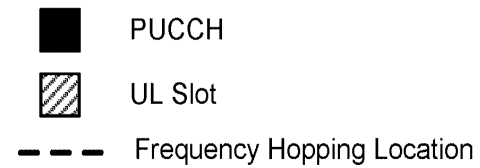
(b) Intra-slot hopping within each slot



(c) One frequency hopping only in the center slot in case of odd number of slots in a multi-slot long PUCCH



(d) One frequency hopping only at the slot boundary in the middle in case of even number of slots in a multi-slot long PUCCH

**FIG. 35**

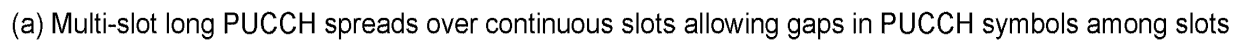


FIG. 36

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(a) Multi-slot long PUCCH with the same PUCCH structure in each slot



(b) Multi-slot long PUCCH with different PUCCH structures in different slots

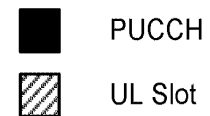
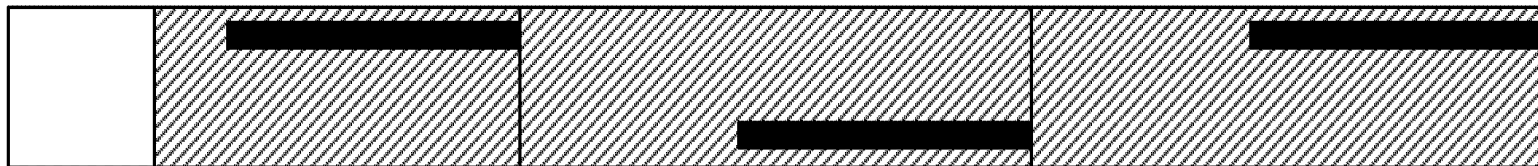


FIG. 37

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(a) Inter-slot hopping at slot boundary



(b) Intra-slot hopping within each slot

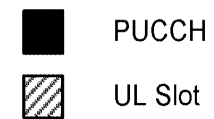


FIG. 38

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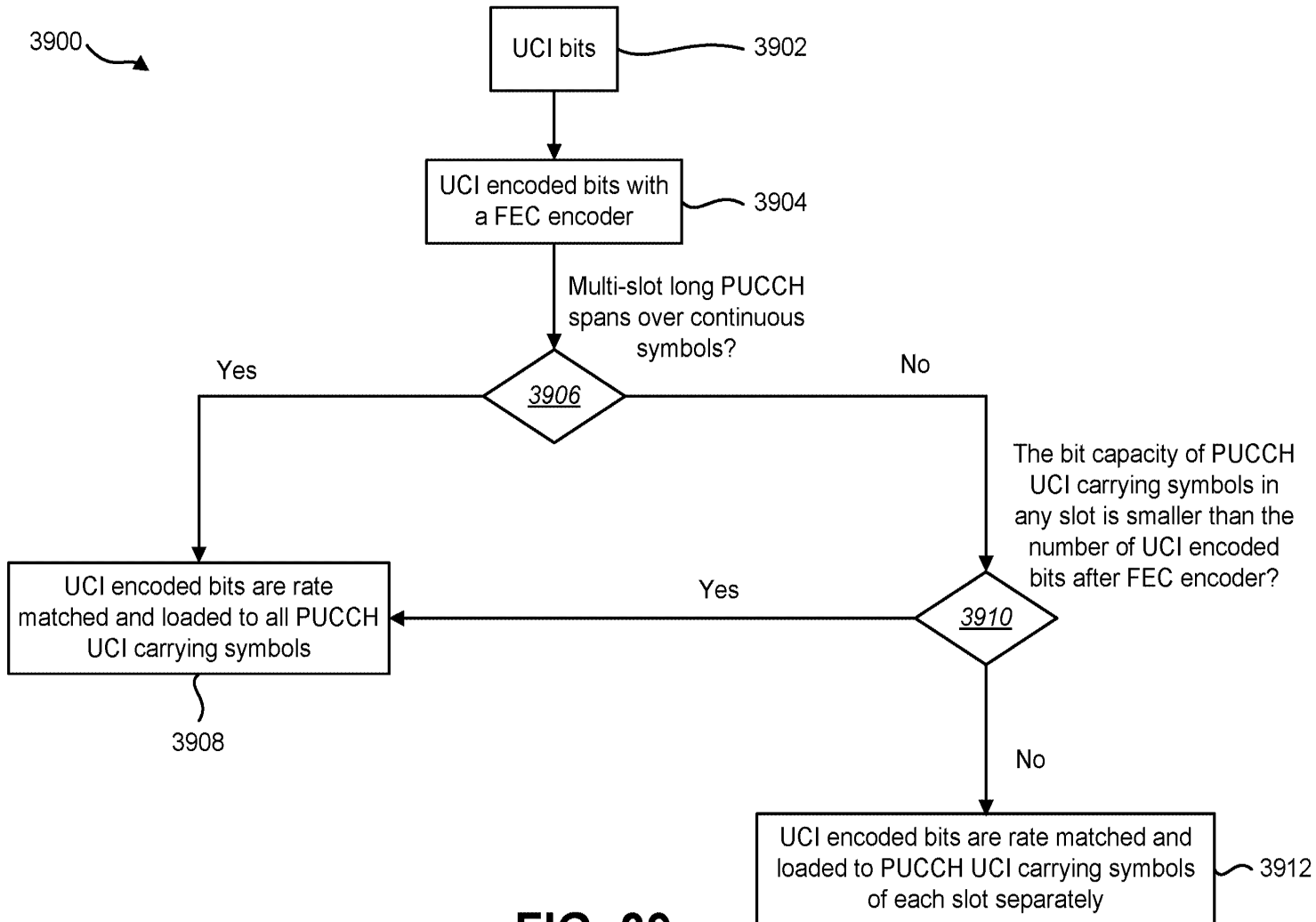


FIG. 39