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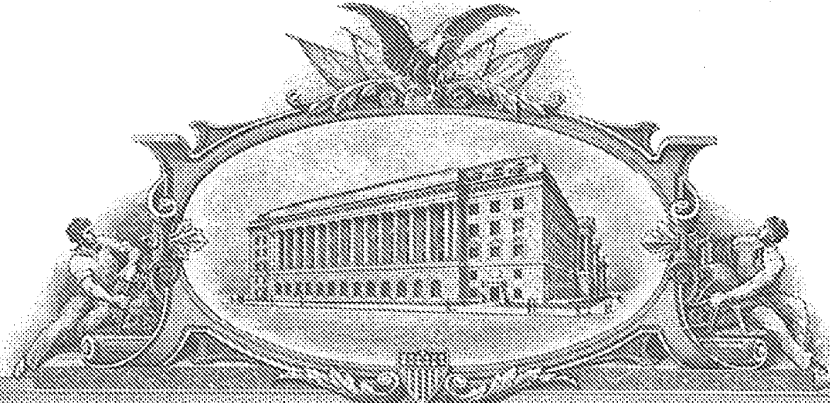
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*August 22, 2017*

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**APPLICATION NUMBER: 62/372,324**  
**FILING DATE: *August 09, 2016***

**THE COUNTRY CODE AND NUMBER OF YOUR PRIORITY APPLICATION, TO BE USED FOR FILING ABROAD UNDER THE PARIS CONVENTION, IS *US62/372,324***



**Certified by**

*Michelle M. Lee*

**Under Secretary of Commerce  
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|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|------------------------|--------------|
| <b>Application Data Sheet 37 CFR 1.76</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                       | Attorney Docket Number | UT16-1105-US |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                       | Application Number     |              |
| Title of Invention                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | REPETITION LEVEL OF SC-PtM FOR ENHANCED NB-IoT SYSTEM |                        |              |
| 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.<br>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 |        |
|                                                                                                           | Seokmin                            |                                   | SHIN        |        |        |
| Residence Information (Select One)    US Residency    •    Non US Residency    Active US Military Service |                                    |                                   |             |        |        |
| City                                                                                                      | Seoul                              | Country of Residence <sup>i</sup> | KR          |        |        |
| Mailing Address of Inventor:                                                                              |                                    |                                   |             |        |        |
| Address 1                                                                                                 | 19, Yangjae-daero 11gil, Seocho-gu |                                   |             |        |        |
| Address 2                                                                                                 |                                    |                                   |             |        |        |
| City                                                                                                      | Seoul                              | State/Province                    |             |        |        |
| Postal Code                                                                                               | 06772                              | Country <sup>i</sup>              | KR          |        |        |
| Inventor                                                                                                  | 2                                  |                                   |             |        | Remove |
| Legal Name                                                                                                |                                    |                                   |             |        |        |
| Prefix                                                                                                    | Given Name                         | Middle Name                       | Family Name | Suffix |        |
|                                                                                                           | Joonkui                            |                                   | AHN         |        |        |
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| City                                                                                                      | Seoul                              | Country of Residence <sup>i</sup> | KR          |        |        |
| Mailing Address of Inventor:                                                                              |                                    |                                   |             |        |        |
| Address 1                                                                                                 | 19, Yangjae-daero 11gil, Seocho-gu |                                   |             |        |        |
| Address 2                                                                                                 |                                    |                                   |             |        |        |
| City                                                                                                      | Seoul                              | State/Province                    |             |        |        |
| Postal Code                                                                                               | 06772                              | Country <sup>i</sup>              | KR          |        |        |
| Inventor                                                                                                  | 3                                  |                                   |             |        | Remove |
| Legal Name                                                                                                |                                    |                                   |             |        |        |

|                                           |                                                       |              |
|-------------------------------------------|-------------------------------------------------------|--------------|
| <b>Application Data Sheet 37 CFR 1.76</b> | Attorney Docket Number                                | UT16-1105-US |
|                                           | Application Number                                    |              |
| Title of Invention                        | REPETITION LEVEL OF SC-PIM FOR ENHANCED NB-IoT SYSTEM |              |

| Prefix | Given Name | Middle Name | Family Name | Suffix |
|--------|------------|-------------|-------------|--------|
|        | Hyangsun   |             | YOU         |        |

Residence Information (Select One)    US Residency    ☒ Non US Residency    Active US Military Service

|      |       |                                   |    |
|------|-------|-----------------------------------|----|
| City | Seoul | Country of Residence <sup>i</sup> | KR |
|------|-------|-----------------------------------|----|

**Mailing Address of Inventor:**

|             |                                    |                                       |    |
|-------------|------------------------------------|---------------------------------------|----|
| Address 1   | 19, Yangjae-daero 11gil, Seocho-gu |                                       |    |
| Address 2   |                                    |                                       |    |
| City        | Seoul                              | State/Province                        |    |
| Postal Code | 06772                              | Country <sup>i</sup>                  | KR |
| Inventor    | 4                                  | <input type="button" value="Remove"/> |    |

**Legal Name**

| Prefix | Given Name | Middle Name | Family Name | Suffix |
|--------|------------|-------------|-------------|--------|
|        | Seunggye   |             | HWANG       |        |

Residence Information (Select One)    US Residency    ☒ Non US Residency    Active US Military Service

|      |       |                                   |    |
|------|-------|-----------------------------------|----|
| City | Seoul | Country of Residence <sup>i</sup> | KR |
|------|-------|-----------------------------------|----|

**Mailing Address of Inventor:**

|                                                                                                                                                                                |                                    |                      |    |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|----------------------|----|
| Address 1                                                                                                                                                                      | 19, Yangjae-daero 11gil, Seocho-gu |                      |    |
| Address 2                                                                                                                                                                      |                                    |                      |    |
| City                                                                                                                                                                           | Seoul                              | State/Province       |    |
| Postal Code                                                                                                                                                                    | 06772                              | Country <sup>i</sup> | KR |
| All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the <b>Add</b> button. <input type="button" value="Add"/> |                                    |                      |    |

**Correspondence Information:**

|                                                                                                                                       |                   |                                          |                                             |
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| Enter either Customer Number or complete the Correspondence Information section below.<br>For further information see 37 CFR 1.33(a). |                   |                                          |                                             |
| <input type="checkbox"/> An Address is being provided for the correspondence information of this application.                         |                   |                                          |                                             |
| Customer Number                                                                                                                       | 67487             |                                          |                                             |
| Email Address                                                                                                                         | info@kpatent.com  | <input type="button" value="Add Email"/> | <input type="button" value="Remove Email"/> |
| Email Address                                                                                                                         | uspto@kpatent.com | <input type="button" value="Add Email"/> | <input type="button" value="Remove Email"/> |

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| <b>Application Data Sheet 37 CFR 1.76</b> | Attorney Docket Number                                | UT16-1105-US |
|                                           | Application Number                                    |              |
| Title of Invention                        | REPETITION LEVEL OF SC-PiM FOR ENHANCED NB-IoT SYSTEM |              |

**Application Information:**

|                                         |                                                       |                                           |                          |
|-----------------------------------------|-------------------------------------------------------|-------------------------------------------|--------------------------|
| Title of the Invention                  | REPETITION LEVEL OF SC-PiM FOR ENHANCED NB-IoT SYSTEM |                                           |                          |
| Attorney Docket Number                  | UT16-1105-US                                          | Small Entity Status Claimed               | <input type="checkbox"/> |
| Application Type                        | Provisional                                           |                                           |                          |
| Subject Matter                          | Utility                                               |                                           |                          |
| Total Number of Drawing Sheets (if any) |                                                       | Suggested Figure for Publication (if any) |                          |

**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.

|                    |                                                  |                        |                                                         |
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| Please Select One: | <input checked="" type="radio"/> Customer Number | US Patent Practitioner | <input type="radio"/> Limited Recognition (37 CFR 11.9) |
| Customer Number    | 67487                                            |                        |                                                         |

|                                           |                                                       |                        |              |
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| <b>Application Data Sheet 37 CFR 1.76</b> |                                                       | Attorney Docket Number | UT16-1105-US |
|                                           |                                                       | Application Number     |              |
| Title of Invention                        | REPETITION LEVEL OF SC-PtM FOR ENHANCED NB-IoT SYSTEM |                        |              |

### 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.

|                                                                                                                       |                      |                                       |
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| Prior Application Status                                                                                              | <input type="text"/> | <input type="button" value="Remove"/> |
| Application Number                                                                                                    | Continuity Type      | Prior Application Number              |
| <input type="text"/>                                                                                                  | <input type="text"/> | <input type="text"/>                  |
| Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the <b>Add</b> button. |                      | <input type="button" value="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)<sup>1</sup> 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 <sup>i</sup> | Filing Date (YYYY-MM-DD) | <input type="button" value="Remove"/>    |
| <input type="text"/>                                                                                   | <input type="text"/> | <input type="text"/>     | Access Code <sup>j</sup> (if applicable) |
| Additional Foreign Priority Data may be generated within this form by selecting the <b>Add</b> button. |                      |                          | <input type="button" value="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.

|                                           |                                                       |                        |              |
|-------------------------------------------|-------------------------------------------------------|------------------------|--------------|
| <b>Application Data Sheet 37 CFR 1.76</b> |                                                       | Attorney Docket Number | UT16-1105-US |
|                                           |                                                       | Application Number     |              |
| Title of Invention                        | REPETITION LEVEL OF SC-PIM FOR ENHANCED NB-IoT SYSTEM |                        |              |

## 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.

|                                           |                                                       |              |
|-------------------------------------------|-------------------------------------------------------|--------------|
| <b>Application Data Sheet 37 CFR 1.76</b> | Attorney Docket Number                                | UT16-1105-US |
|                                           | Application Number                                    |              |
| Title of Invention                        | REPETITION LEVEL OF SC-PtM FOR ENHANCED NB-IoT SYSTEM |              |

## 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.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |                                                  |                |                                       |
| <b>Applicant</b> 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |                                                  |                | <input type="button" value="Remove"/> |
| 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. |                                          |                                                  |                |                                       |
| <input type="button" value="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:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                          |                                                  |                |                                       |
| <div></div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                          |                                                  |                |                                       |
| Name of the Deceased or Legally Incapacitated Inventor: <div></div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |                                                  |                |                                       |
| If the Applicant is an Organization check here. <input type="checkbox"/>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                          |                                                  |                |                                       |
| Prefix                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Given Name                               | Middle Name                                      | Family Name    | Suffix                                |
| <div></div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <div></div>                              |                                                  | <div></div>    | <div></div>                           |
| <b>Mailing Address Information For Applicant:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                          |                                                  |                |                                       |
| Address 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                          | <div></div>                                      |                |                                       |
| Address 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                          | <div></div>                                      |                |                                       |
| City                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          | State/Province                                   | <div></div>    |                                       |
| Country                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <div></div>                              | Postal Code                                      | <div></div>    |                                       |
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| Email Address                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                          | <div></div>                                      |                |                                       |
| Additional Applicant Data may be generated within this form by selecting the Add button.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                          |                                                  |                | <input type="button" value="Add"/>    |

## Assignee Information including Non-Applicant Assignee Information:

|                                                                                                                                                                                     |
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|                                           | Application Number                                    |              |
| Title of Invention                        | REPETITION LEVEL OF SC-PtM FOR ENHANCED NB-IoT SYSTEM |              |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                      |                      |                      |                      |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|----------------------|----------------------|----------------------|
| <b>Assignee</b>                                                                                                                                                                                                                                                                                                                                                                                                                                        | 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. |                      |                      |                      |                      |
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| If the Assignee or Non-Applicant Assignee is an Organization check here. <input type="checkbox"/>                                                                                                                                                                                                                                                                                                                                                      |                      |                      |                      |                      |
| Prefix                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Given Name           | Middle Name          | Family Name          | Suffix               |
| <input type="text"/>                                                                                                                                                                                                                                                                                                                                                                                                                                   | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> |
| <b>Mailing Address Information For Assignee including Non-Applicant Assignee:</b>                                                                                                                                                                                                                                                                                                                                                                      |                      |                      |                      |                      |
| Address 1                                                                                                                                                                                                                                                                                                                                                                                                                                              |                      | <input type="text"/> |                      |                      |
| Address 2                                                                                                                                                                                                                                                                                                                                                                                                                                              |                      | <input type="text"/> |                      |                      |
| City                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <input type="text"/> | State/Province       | <input type="text"/> |                      |
| Country <sup>i</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                   | <input type="text"/> | Postal Code          | <input type="text"/> |                      |
| Phone Number                                                                                                                                                                                                                                                                                                                                                                                                                                           | <input type="text"/> | Fax Number           | <input type="text"/> |                      |
| Email Address                                                                                                                                                                                                                                                                                                                                                                                                                                          | <input type="text"/> |                      |                      |                      |
| Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button. <div>Add</div>                                                                                                                                                                                                                                                                                                                       |                      |                      |                      |                      |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                  |           |                   |                           |
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|                                           |                                                       | Application Number     |              |
| Title of Invention                        | REPETITION LEVEL OF SC-PtM FOR ENHANCED NB-IoT SYSTEM |                        |              |

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PROVISIONAL APPLICATION FOR UNITED STATES PATENT  
IN THE NAMES OF

**Seokmin SHIN, Joonkui AHN, Hyangsun YOU and  
Seunggye HWANG**

for

**REPETITION LEVEL OF SC-PtM FOR ENHANCED NB-IoT SYSTEM**

Customer Number: 67487

Attorney Docket Number: UT16-1105-US

Total Number of pages: 16 (including cover)

표준특허의뢰서

|                 |                                                       |  |
|-----------------|-------------------------------------------------------|--|
| CTO) 차세대 표준 연구소 | 발송일: 2016                                             |  |
| 발명자             | 신석민, 안준기, 유항선, 황승계                                    |  |
| 발명의 명칭          | Repetition level of SC-PtM for enhanced NB-IoT system |  |

|        |               |        |  |
|--------|---------------|--------|--|
| 표준화기구  | 3GPP TSG RAN1 | 발표예정회의 |  |
| 관련기술분야 | LTE-A, MTC    |        |  |
| 관련표준규격 |               |        |  |

1. Purpose of Invention

본 발명에서는 SC-PtM을 NB-LTE system에 동작 시키려 할 경우, MCCH/MTCH의 control/data를 전송하는 N-PDCCH/N-PDSCH 등의 CE(coverage enhancement) level을 효율적으로 설정해 주는 방법에 대해 제안 한다.

2. Prior Art

Techniques, apparatus and systems described herein can be used in various wireless access technologies such as code division multiple access (CDMA), frequency division multiple access (FDMA), time division multiple access (TDMA), orthogonal frequency division multiple access (OFDMA), single carrier frequency division multiple access (SC-FDMA), etc. The CDMA may be implemented with a radio technology such as Universal Terrestrial Radio Access (UTRA) or CDMA2000. The TDMA may be implemented with a radio technology such as Global System for Mobile communications (GSM)/ General Packet Radio Service (GPRS)/ Enhanced Data Rates for GSM Evolution (EDGE). The OFDMA may be implemented with a radio technology such as institute of electrical and electronics engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802-20, evolved-UTRA (E-UTRA) etc. The UTRA is a part of a universal mobile telecommunication system (UMTS). 3rd generation partnership project (3GPP) long term evolution (LTE) is a part of an evolved-UMTS (E-UMTS) using the E-UTRA. The 3GPP LTE employs the OFDMA in downlink and employs the SC-FDMA in uplink [1]. LTE-advanced (LTE-A) is an evolution of the 3GPP LTE. For clarity, this application focuses on the 3GPP LTE/LTE-A. However, technical features of the present invention are not limited thereto.

2-1. LTE system architecture

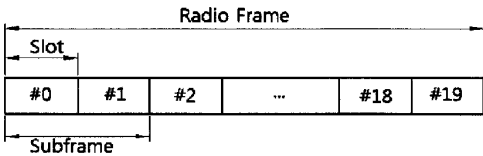


Figure 1. Structure of a radio frame of 3GPP LTE

In Figure 1, a radio frame includes 10 subframes. A subframe includes two slots in time domain. A time for transmitting one subframe is defined as a transmission time interval (TTI). For example, one subframe may have a length of 1 millisecond (ms), and one slot may have a length of 0.5 ms. One slot includes a plurality of orthogonal frequency division multiplexing (OFDM) symbols in time domain. Since the 3GPP LTE uses the OFDMA in the downlink, the OFDM symbol is for representing one symbol period. The OFDM symbol may also be referred to as an SC-FDMA symbol or a symbol period. A resource block (RB) is a resource allocation unit, and includes a plurality of contiguous subcarriers in one slot. The structure of the radio frame is shown for exemplary purposes only. Thus, the number of subframes included in the radio frame or the number of slots included in the subframe or the number of OFDM symbols included in the slot may be modified in various manners.

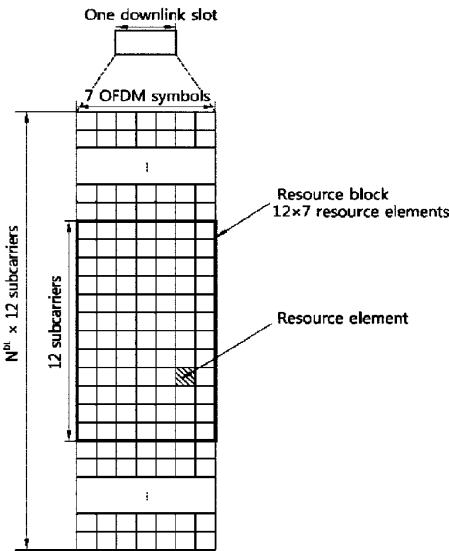


Figure 2. Resource grid for one downlink slot

In Figure 2, a downlink slot includes a plurality of OFDM symbols in time domain. It is described herein that one downlink slot includes 7 OFDM symbols, and one resource block (RB) includes 12 subcarriers in frequency domain as an example. However, the present invention is not limited thereto. Each element on the resource grid is referred to as a resource element (RE). One RB includes  $12 \times 7$  REs. The number NDL of RBs included in the downlink slot depends on a downlink transmit bandwidth. The structure of an uplink slot may be same as that of the downlink slot.

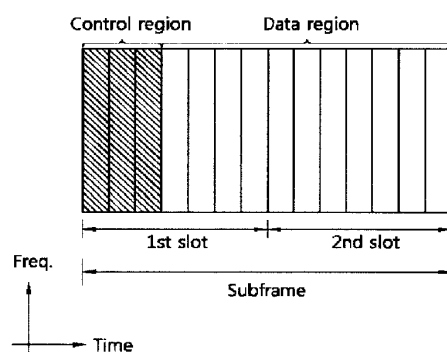


Figure 3. Structure of downlink subframe

In Figure 3, a maximum of three OFDM symbols located in a front portion of a first slot within a subframe correspond to a control region to be assigned with a control channel. The remaining OFDM symbols correspond to a data region to be assigned with a physical downlink shared channel (PDSCH). Examples of downlink control channels used in the 3GPP LTE includes a physical control format indicator channel (PCFICH), a physical downlink control channel (PDCCH), a physical hybrid ARQ indicator channel (PHICH), etc. The PCFICH is transmitted at a first OFDM symbol of a subframe and carries information regarding the number of OFDM symbols used for transmission of control channels within the subframe. The PHICH is a response of uplink transmission and carries an HARQ acknowledgment (ACK)/not-acknowledgment (NACK) signal. Control information transmitted through the PDCCH is referred to as downlink control information (DCI). The DCI includes uplink or downlink scheduling information or includes an uplink transmit (Tx) power control command for arbitrary UE groups.

The PDCCH may carry a transport format and a resource allocation of a downlink shared channel (DL-SCH), resource allocation information of an uplink shared channel (UL-SCH), paging information on a paging channel (PCH), system information on the DL-SCH, a resource allocation of an upper-layer control message such as a random access response transmitted on the PDSCH, a set of Tx power control commands on individual UEs within an arbitrary UE group, a Tx power control command, activation of a voice over IP (VoIP), etc. A plurality of PDCCHs can be transmitted within a control region. The UE can monitor the plurality of PDCCHs. The PDCCH is transmitted on an aggregation of one or several consecutive control channel elements (CCEs). The CCE is a logical allocation unit used to provide the PDCCH with a coding rate based on a state of a radio channel. The CCE corresponds to a plurality of resource element groups (REGs). A format of the PDCCH and the number of bits of the available PDCCH are determined according to a correlation between the number of CCEs and the coding rate provided by the CCEs. The BS determines a PDCCH format according to a DCI to be transmitted to the UE, and attaches a cyclic redundancy check (CRC) to control information. The CRC is masked with a unique identifier (referred to as a radio network temporary identifier (RNTI)) according to an owner or usage of the PDCCH. If the PDCCH is for a specific UE, a unique identifier (e.g., cell-RNTI (C-RNTI)) of the UE may be masked to the CRC. Alternatively, if the PDCCH is for a paging message, a paging indicator identifier (e.g., paging-RNTI (P-RNTI)) may be masked to the CRC. If the PDCCH is for system information (more specifically, a system information block (SIB) to be described below), a system information identifier and a system information RNTI (SI-RNTI) may be masked to the CRC. To indicate a random access response

that is a response for transmission of a random access preamble of the UE, a random access-RNTI (RA-RNTI) may be masked to the CRC.

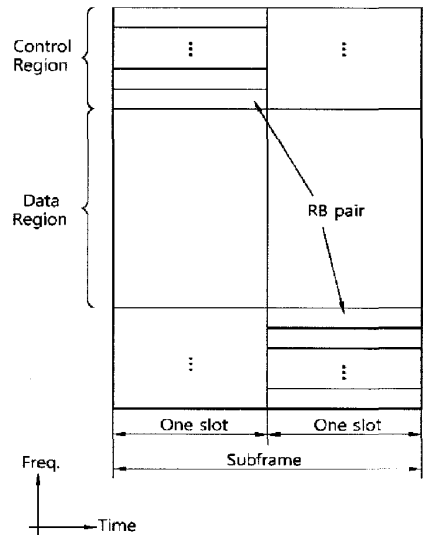


Figure 4. Structure of uplink subframe

In Figure 4, an uplink subframe can be divided in a frequency domain into a control region and a data region. The control region is allocated with a physical uplink control channel (PUCCH) for carrying uplink control information. The data region is allocated with a physical uplink shared channel (PUSCH) for carrying user data. To maintain a single carrier property, one UE does not simultaneously transmit the PUCCH and the PUSCH. The PUCCH for one UE is allocated to an RB pair in a subframe. RBs belonging to the RB pair occupy different subcarriers in respective two slots. This is called that the RB pair allocated to the PUCCH is frequency-hopped in a slot boundary.

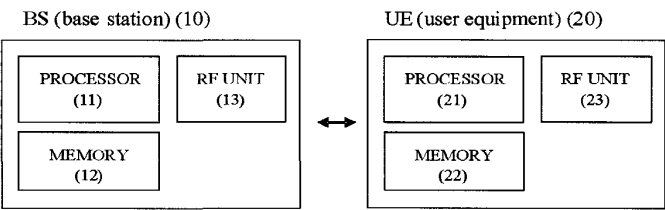


Figure 5. System for implementing present invention

In Figure 5, a wireless communication system includes a BS 10 and one or more UE 20. In downlink, a transmitter may be a part of the BS 10, and a receiver may be a part of the UE 20. In uplink, a transmitter may be a part of the UE 20, and a receiver may be a part of the BS 10. A BS 10 may include a processor 11, a memory 12, and a radio frequency (RF) unit 13. The processor 11 may

be configured to implement proposed procedures and/or methods described in this application. The memory 12 is coupled with the processor 11 and stores a variety of information to operate the processor 11. The RF unit 13 is coupled with the processor 11 and transmits and/or receives a radio signal. A UE 20 may include a processor 21, a memory 22, and a RF unit 23. The processor 21 may be configured to implement proposed procedures and/or methods described in this application. The memory 22 is coupled with the processor 21 and stores a variety of information to operate the processor 21. The RF unit 23 is coupled with the processor 21 and transmits and/or receives a radio signal. The BS 10 and/or the UE 20 may have single antenna and multiple antennas. When at least one of the BS 10 and the UE 20 has multiple antennas, the wireless communication system may be called as multiple input multiple output (MIMO) system.

## 2-2. Component carrier aggregation in LTE-A

As the increased demands for the high data rate transmission, the mobile communication system composed of aggregated multiple CCs (component carriers) is now being researched. For example, Figure 6 (b) illustrates the DL/UL subframe structure considered in 3GPP LTE-A (LTE Advanced) system where multiple CCs are aggregated (in this example, 3 carriers exist), while Figure 6 (a) illustrates a single carrier operation as in conventional systems. As shown in Figure 6 (b), a UE can monitor and receive DL signal/data from multiple DL CCs at the same time. However, even if a cell is managing N DL CCs, the network may configure a UE with M DL CCs where  $M \leq N$  so that the UE's monitoring of the DL signal/data is limited to those M DL CCs. In addition, the network may configure L DL CCs as the main DL CCs from which the UE should monitor/receive DL signal/data with a priority, either UE-specifically or cell-specifically, where  $L \leq M \leq N$ .

여기서 CC는 Cell로 구분될 수 있으며, 등가의 개념으로 표현될 수 있다.

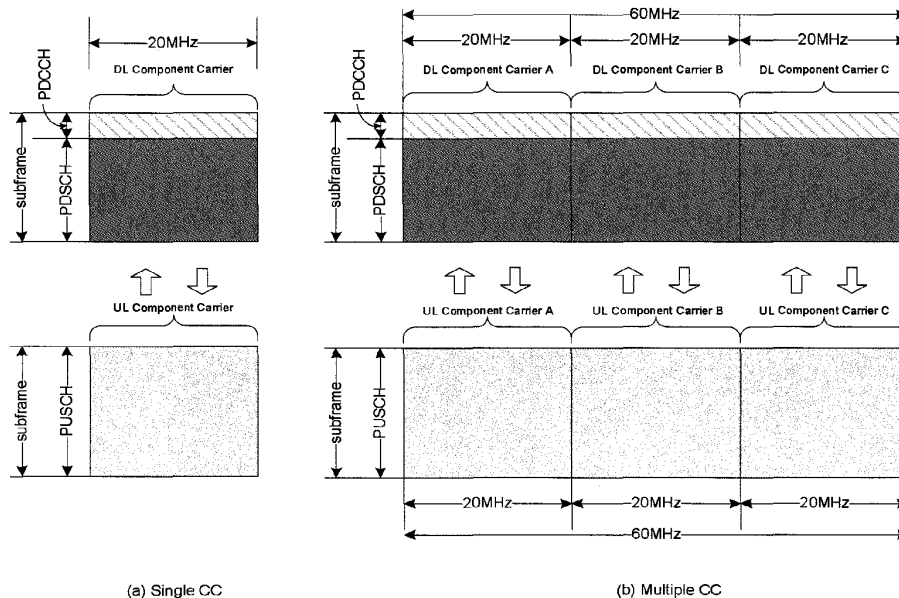


Figure 6. Subframe structure of 3GPP LTE Release-8 system and LTE-A system with CC aggregation

Carrier aggregation을 지원하는 시스템에서 cell은 다음 Figure 7과 같이 구분할 수 있다.

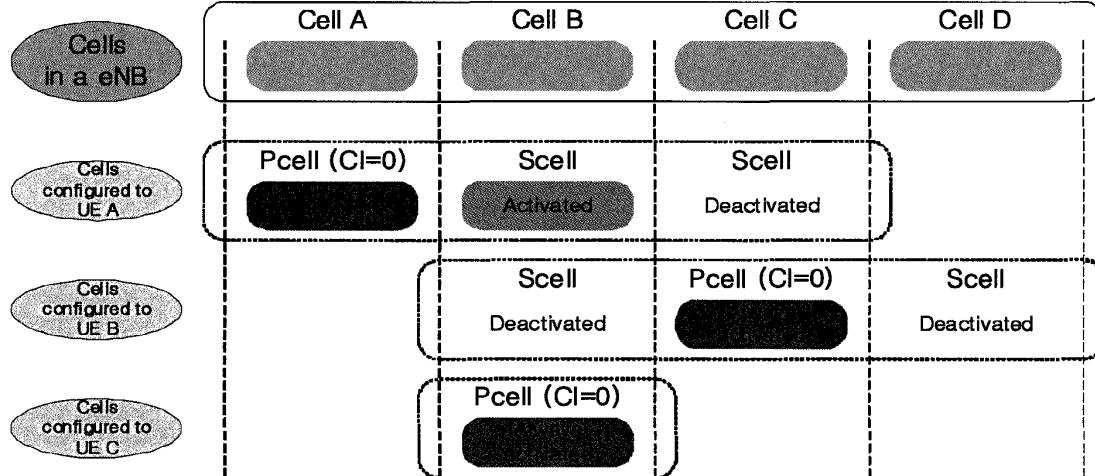


Figure 7. Configured cell, activated cell, de-activated cell

Configured cell은 Figure 7에서와 같이 기지국의 cell 중에서 measurement report를 근거로 carrier aggregation할 수 있도록 한 cell로서 UE별로 설정된다. Configured cell은 PDSCH 전송에 대한 ACK/NACK 전송을 위한 resource를 미리 예약해 놓게 된다. Activated cell은 configured cell 중에서 실제로 PDSCH/PUSCH를 전송하도록 설정된 cell로서 PDSCH/PUSCH 전송을 위한 CSI report와 SRS transmission을 수행하게 된다. De-activated cell은 기지국의 명령 또는 timer 동작에 의해서 PDSCH/PUSCH 전송을 하지 않도록 하는 cell로서 CSI report 및 SRS 전송도 중단된다.

## 2-3 Synchronization signal (SS) in LTE-A FDD

SS는 P-SS와 S-SS로 구성되며, 셀 탐색을 수행할 때 사용되는 신호이다.

Figure 8 (a)와 (b)는 각각 기본 CP와 확장 CP를 사용하는 시스템의 경우 SS의 전송을 위한 프레임 구조를 도시한 것이다. SS는 inter-RAT measurement의 용이함을 위해 GSM 프레임 길이인 4.6ms를 고려하여 부프레임 0번과 부프레임 5번의 두 번째 슬롯에서 각각 전송되고, 해당 라디오 프레임에 대한 경계는 S-SS를 통해 검출 가능하다. P-SS는 해당 슬롯의 맨 마지막 OFDM 심볼에서 전송되고, S-SS는 P-SS 바로 앞 OFDM 심볼에서 전송된다. SS는 3개의 P-SS와 168개의 S-SS의 조합을 통해 총 504개의 물리계층 셀 식별자(physical cell ID)를 전송할 수가 있다. 또한, SS 및 PBCH는 시스템 대역폭 내의 가운데 6RB 내에서 전송되어, 전송 대역폭에 관계없이 UE가 검출 혹은 복호할 수 있도록 한다.

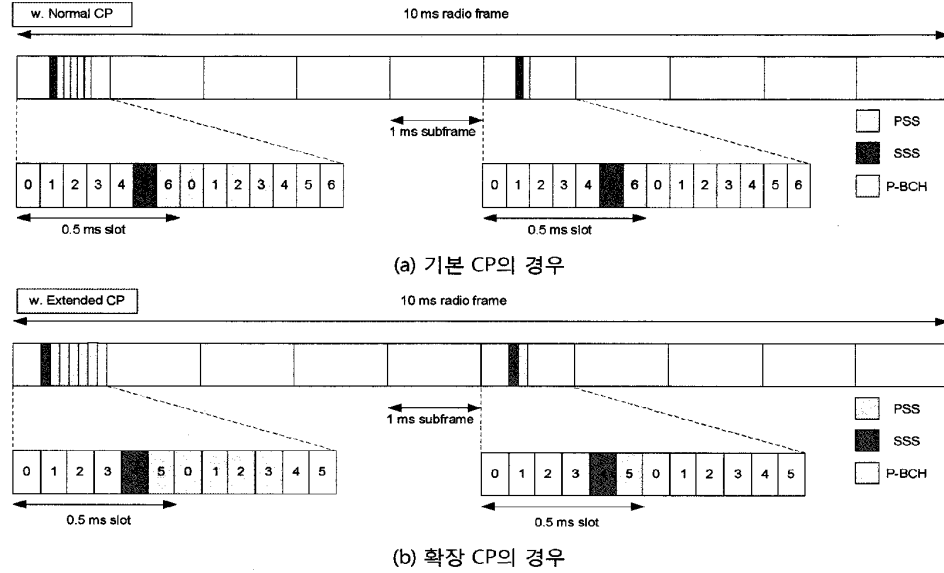


Figure 8. SS 전송을 위한 프레임 구조

SS의 전송 다이버시티 방식은 단일 안테나 포트 (single antenna port)만을 사용하고, 표준에서는 따로 정의하지 않는다. 즉, 단일 안테나 전송 혹은 UE에 투명한(transparent) 전송 방식 (예를 들어 PVS, TSTD, CDD) 을 사용할 수가 있다.

#### a. P-SS 부호

길이 63의 ZC (Zadoff-Chu) 시퀀스를 주파수 영역에서 정의하여 P-SS의 시퀀스로 사용한다. ZC 시퀀스는 식 (1)에 의해 정의되며, DC 부반송파에 해당되는 시퀀스 요소(element),  $n=31$ 은 천공 (puncturing)한다. 식 (1)에서  $N_{zc}=63$ 이다.

$$d_u(n) = e^{-j \frac{\pi n(n+1)}{N_{zc}}} \quad (1)$$

가운데 부분의 6RB (=72 부반송파) 중 9개의 남은 부반송파는 항상 0의 값으로 전송하며, 동기 수행을 위한 필터 설계에 용이함을 가져다 준다. 총 3개의 P-SS를 정의하기 위해 식 (1)에서  $u=25, 29$ , 그리고 34의 값을 사용한다. 이 때, 29와 34는 켈레대칭(conjugate symmetry) 관계를 가지고 있어서, 2개의 상관(correlation)을 동시에 수행할 수가 있다. 여기서, 켈레대칭은 다음 식 (2)의 관계를 의미하며 이 특성을 이용하여  $u=29$ 와 34에 대한 원샷 상관기(one-shot correlator)의 구현이 가능하며, 전체적인 연산량을 약 33.3% 감소시킬 수 있다.

$$\begin{aligned} d_u(n) &= (-1)^n (d_{N_{zc}-u}(n))^*, \text{ when } N_{zc} \text{ is even number.} \\ d_u(n) &= (d_{N_{zc}-u}(n))^*, \text{ when } N_{zc} \text{ is odd number.} \end{aligned} \quad (2)$$

#### b. S-SS 부호

S-SS를 위해 사용되는 시퀀스는 길이 31의 두 개 m-시퀀스를 인터리빙된 조합을 하고 두 개의 시퀀스를 조합하여 168 셀 그룹 식별자 (cell group ID)를 전송한다. S-SS의 시퀀스로서 m-시퀀스는 주파수 선택적 환경에서 강건하고, 고속 하다마드 변환 (Fast

Hadamard Transform)을 이용한 고속 m-시퀀스 변환으로 연산량을 줄일 수가 있다. 또한, 두 개의 짧은 부호 (short code)로 S-SS를 구성하는 것은 단말의 연산량을 줄이기 위해 제안되었다.

Figure 9은 논리 영역에서의 두 개의 시퀀스가 물리 영역에서 인터리빙되어 매핑되는 것을 보여주는 그림이다. S-SS부호 생성을 위해 사용되는 두 개의 m-시퀀스를 각각 S1, S2라고 정의할 때, 부프레임 0의 S-SS가 (S1, S2) 두 조합으로 셀 그룹 식별자를 전송한다면, 부프레임 5의 S-SS는 (S2,S1)으로 교환(swapping)하여 전송함으로써, 10ms 프레임 경계를 구분할 수 있게 된다. 이 때, 사용되는 S-SS 부호는  $x^5 + x^2 + 1$ 의 생성다항식을 사용하며, 서로 다른 순환 천이 (circular shift)를 통해 총 31개의 부호를 생성할 수가 있다.

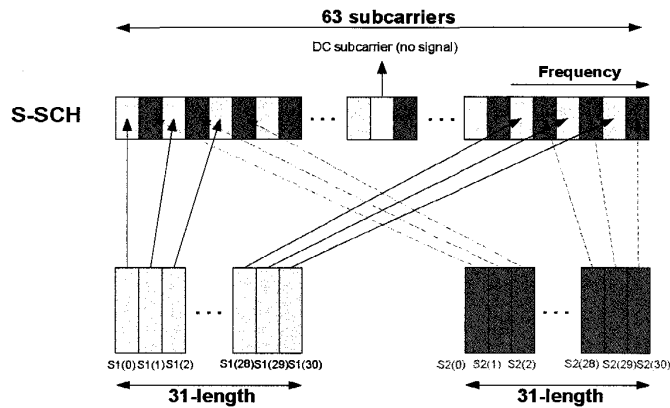


Figure 9. S-SS 부호 생성 방식

수신 성능을 향상시키기 위하여, P-SS 기반 (P-SS-based)의 서로 다른 두 개의 시퀀스를 정의하여, S-SS에 스크램블링 하되 S1과 S2에 서로 다른 시퀀스로 스크램블링 한다. 그 후, S1 기반 (S1-based)의 스크램블링 부호를 정의하여, S2에 스크램블링을 수행한다. 이 때, S-SS의 부호는 5ms 단위로 교환되지만 P-SS 기반의 스크램블링 부호는 교환되지 않는다. P-SS 기반의 스크램블링 부호는  $x^5 + x^3 + 1$ 의 생성 다항식으로부터 생성된 m-시퀀스에서 P-SS 인덱스에 따라 6개의 순환 천이 버전으로 정의하고, S1 기반의 스크램블링 부호는  $x^5 + x^4 + x^2 + x^1 + 1$ 의 다항식으로부터 생성된 m-시퀀스에서 S1의 인덱스에 따라 8개의 순환 천이 버전으로 정의한다.

Followings are the criterion of out-of-synch in LTE in system

- The UE shall monitor the downlink link quality based on the cell-specific reference signal in order to detect the downlink radio link quality of the PCell as specified in [2].
- The UE shall estimate the downlink radio link quality and compare it to the thresholds  $Q_{out}$  and  $Q_{in}$  for the purpose of monitoring downlink radio link quality of the PCell.
- The threshold  $Q_{out}$  is defined as the level at which the downlink radio link cannot be reliably received and shall correspond to 10% block error rate of a hypothetical PDCCH transmission taking into account the PCFICH errors with transmission parameters in [3].
- The threshold  $Q_{in}$  is defined as the level at which the downlink radio link quality can be significantly more reliably received than at  $Q_{out}$  and shall correspond to 2% block error rate of

a hypothetical PDCCH transmission taking into account the PCFICH errors with transmission parameters specified in [3].

## SC-PTM

### 5.8a.1 Introduction

#### 5.8a.1.1 General

SC-PTM control information is provided on a specific logical channel: the SC-MCCH. The SC-MCCH carries the *SCPTMConfiguration* message which indicates the MBMS sessions that are ongoing as well as the (corresponding) information on when each session may be scheduled, i.e. scheduling period, scheduling window and start offset. The *SCPTMConfiguration* message also provides information about the neighbour cells transmitting the MBMS sessions which are ongoing on the current cell.

A limited amount of SC-PTM control information is provided on the BCCH. This primarily concerns the information needed to acquire the SC-MCCH.

#### 5.8a.1.2 SC-MCCH scheduling

The SC-MCCH information (i.e. information transmitted in messages sent over SC-MCCH) is transmitted periodically, using a configurable repetition period. SC-MCCH transmissions (and the associated radio resources and MCS) are indicated on PDCCH.

#### 5.8a.1.3 SC-MCCH information validity and notification of changes

Change of SC-MCCH information only occurs at specific radio frames, i.e. the concept of a modification period is used. Within a modification period, the same SC-MCCH information may be transmitted a number of times, as defined by its scheduling (which is based on a repetition period). The modification period boundaries are defined by SFN values for which  $\text{SFN} \bmod m = 0$ , where  $m$  is the number of radio frames comprising the modification period. The modification period is configured by means of *SystemInformationBlockType20*.

When the network changes (some of) the SC-MCCH information, it notifies the UEs about the change in the first subframe which can be used for SC-MCCH transmission in a repetition period. LSB bit in 8-bit bitmap when set to '1' indicates the change in SC-MCCH. Upon receiving a change notification, a UE interested to receive MBMS services transmitted using SC-PTM acquires the new SC-MCCH information starting from the same subframe. The UE applies the previously acquired SC-MCCH information until the UE acquires the new SC-MCCH information.

#### 5.8a.1.4 Procedures

The SC-PTM capable UE receiving or interested to receive MBMS service(s) via SC-MRB applies SC-PTM procedures described in section 5.8a and the MBMS interest indication procedure as specified in 5.8.5.

## 5.8a.2 SC-MCCH information acquisition

### 5.8a.2.1 General

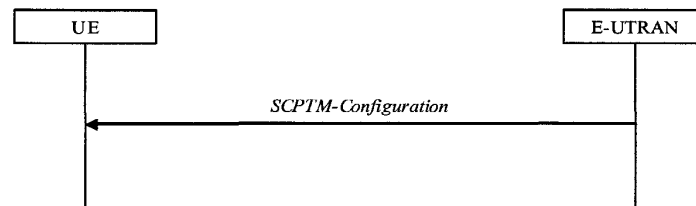


**Figure 5.8a.2.1-1: SC-MCCH information acquisition**

The UE applies the SC-MCCH information acquisition procedure to acquire the SC-PTM control information that is broadcast by the E-UTRAN. The procedure applies to SC-PTM capable UEs that are in RRC\_IDLE or in RRC\_CONNECTED.

### 5.8a.2.2 Initiation

A UE interested to receive MBMS services via SC-MRB shall apply the SC-MCCH information acquisition procedure upon entering the cell broadcasting *SystemInformationBlockType20* (e.g. upon power on, following UE mobility) and upon receiving a notification that the SC-MCCH information has changed. A UE that is receiving an MBMS service via SC-MRB shall apply the SC-MCCH information acquisition procedure to acquire the SC-MCCH information that corresponds with the service that is being received, at the start of each modification period.

Unless explicitly stated otherwise in the procedural specification, the SC-MCCH information acquisition procedure overwrites any stored SC-MCCH information, i.e. delta configuration is not applicable for SC-MCCH information and the UE discontinues using a field if it is absent in SC-MCCH information unless explicitly specified otherwise.

### 5.8a.2.3 SC-MCCH information acquisition by the UE

A SC-PTM capable UE shall:

- 1> if the procedure is triggered by an SC-MCCH information change notification:
  - 2> start acquiring the *SCPTMConfiguration* message from the subframe where the change notification was received;

NOTE 1: The UE continues using the previously received SC-MCCH information until the new SC-MCCH information has been acquired.

- 1> if the UE enters a cell broadcasting *SystemInformationBlockType20*:
  - 2> acquire the *SCPTMConfiguration* message at the next repetition period;
- 1> if the UE is receiving an MBMS service via an SC-MRB:
  - 2> start acquiring the *SCPTMConfiguration* message from the beginning of each modification period.

### 5.8a.2.4 Actions upon reception of the *SCPTMConfiguration* message

No UE requirements related to the contents of this *SCPTMConfiguration* apply other than those specified elsewhere e.g. within procedures using the concerned system information, the corresponding field descriptions.

### 5.8a.3 SC-PTM radio bearer configuration

#### 5.8a.3.1 General

The SC-PTM radio bearer configuration procedure is used by the UE to configure RLC, MAC and the physical layer upon starting and/or stopping to receive an SC-MRB transmitted on SC-MTCH. The procedure applies to SC-PTM capable UEs that are in RRC\_CONNECTED or in RRC\_IDLE and are interested to receive one or more MBMS services via SC-MRB.

NOTE: In case the UE is unable to receive an MBMS service via an SC-MRB due to capability limitations, upper layers may take appropriate action e.g. terminate a lower priority unicast service.

#### 5.8a.3.2 Initiation

The UE applies the SC-MRB establishment procedure to start receiving a session of a MBMS service it has an interest in. The procedure may be initiated e.g. upon start of the MBMS session, upon entering a cell providing via SC-MRB a MBMS service in which the UE has interest, upon becoming interested in the MBMS service, upon removal of UE capability limitations inhibiting reception of the concerned service.

The UE applies the SC-MRB release procedure to stop receiving a session. The procedure may be initiated e.g. upon stop of the MBMS session, upon leaving the cell where a SC-MRB is established, upon losing interest in the MBMS service, when capability limitations start inhibiting reception of the concerned service.

#### 5.8a.3.3 SC-MRB establishment

Upon SC-MRB establishment, the UE shall:

- 1> establish an RLC entity in accordance with the configuration specified in 9.1.1.7;
- 1> configure a SC-MTCH logical channel applicable for the SC-MRB and instruct MAC to receive DL-SCH on the cell where the *SCPTMConfiguration* message was received for the MBMS service for which the SC-MRB is established and using *g-RNTI* and *sc-mtch-SchedulingInfo* (if included) in this message for this MBMS service;
- 1> configure the physical layer in accordance with the *sc-mtch-InfoList*, applicable for the SC-MRB, as included in the *SCPTMConfiguration* message;
- 1> inform upper layers about the establishment of the SC-MRB by indicating the corresponding *tmgi* and *sessionId*;

#### 5.8a.3.4 SC-MRB release

Upon SC-MRB release, the UE shall:

- 1> release the RLC entity as well as the related MAC and physical layer configuration;
- 1> inform upper layers about the release of the SC-MRB by indicating the corresponding *tmgi* and *sessionId*;

### — SystemInformationBlockType20

The IE *SystemInformationBlockType20* contains the information required to acquire the control information associated transmission of MBMS using SC-PTM.

#### SystemInformationBlockType20 information element

-- ASN1START

```
SystemInformationBlockType20-r13 ::= SEQUENCE {
    sc-mcch-RepetitionPeriod-r13    ENUMERATED {rf2, rf4, rf8, rf16, rf32, rf64, rf128, rf256},
```

```
sc-mcch-Offset-r13          INTEGER (0..10),
sc-mcch-FirstSubframe-r13   INTEGER (0..9),
sc-mcch-duration-r13        INTEGER (2..9) OPTIONAL,
sc-mcch-ModificationPeriod-r13 ENUMERATED {rf2, rf4, rf8, rf16, rf32, rf64, rf128, rf256,
                                           rf512, rf1024, rf2048, rf4096, rf8192, rf16384, rf32768,
                                           rf65536},
lateNonCriticalExtension     OCTET STRING OPTIONAL,
...
}
-- ASN1STOP
```

| SystemInformationBlockType20 field descriptions                                                                                                                                                                                                                                                                                                                                                                       |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>sc-mcch-ModificationPeriod</b><br>Defines periodically appearing boundaries, i.e. radio frames for which $\text{SFN mod } sc\text{-}mcch\text{-}ModificationPeriod = 0$ . The contents of different transmissions of SC-MCCH information can only be different if there is at least one such boundary in-between them. Value rf2 corresponds to 2 radio frames, value rf4 corresponds to 4 radio frames and so on. |
| <b>sc-mcch-duration</b><br>Indicates, starting from the subframe indicated by <i>sc-mcch-FirstSubframe</i> , the duration during which SC-MCCH may be scheduled in non-MBSFN subframes. Absence of this IE means that SC-MCCH is only scheduled in the subframe indicated by <i>sc-mcch-FirstSubframe</i> .                                                                                                           |
| <b>sc-mcch-Offset</b><br>Indicates, together with the <i>sc-mcch-RepetitionPeriod</i> , the radio frames in which SC-MCCH is scheduled i.e. SC-MCCH is scheduled in radio frames for which: $\text{SFN mod } sc\text{-}mcch\text{-}RepetitionPeriod = sc\text{-}mcch\text{-}Offset$ .                                                                                                                                 |
| <b>sc-mcch-FirstSubframe</b><br>Indicates the first subframe in which SC-MCCH is scheduled                                                                                                                                                                                                                                                                                                                            |
| <b>sc-mcch-RepetitionPeriod</b><br>Defines the interval between transmissions of SC-MCCH information, in radio frames, Value rf2 corresponds to 2 radio frames, rf4 corresponds to 4 radio frames and so on.                                                                                                                                                                                                          |

### 3. Composition of Invention

Narrowband (NB)-LTE는 LTE system의 1 PRB에 해당하는 system BW를 갖는 낮은 complexity, 낮은 power consumption을 지원하기 위한 system이다. 이는 주로 machine-type communication (MTC)와 같은 device를 cellular system에서 지원하여 internet of things (IoT)를 구현하기 위한 통신 방식으로 이용될 수 있다. 기존의 LTE의 subcarrier spacing 등의 OFDM parameter들을 LTE와 같은 것을 사용함으로써 추가적인 band 할당 없이 legacy LTE band에 1 PRB를 NB-LTE 용으로 할당하여 주파수를 효율적으로 사용할 수 있는 장점이 있다. NB-LTE의 physical channel은 downlink의 경우, N-PSS/N-SSS, N-PBCH, N-PDCCH/N-EPDCCH, N-PDSCH 등으로 정의하고, LTE와 구별하기 위해 N-을 더해서 부르기로 한다.

Unicast와는 구분되는 multicast나 broadcast 측면에서 LTE system에서는 MBMS service를 위해 MBSFN subframe을 도입하거나, SC-PtM 방식을 도입하였다. NB-LTE system 또한 broadcast 혹은 multicast와 같은 service가 필요한 상황에서(e.g., software update) MBMS service를 사용할 수 있도록 고려해야 한다. 그리고, NB-LTE system과 같이 일부 UE들에게 coverage enhancement가 필요한 상황이 발생할 수 있기 때문에, multicast transmission에 대해서도 CE level을 고려해 줄 필요가 있다. 따라서 본 발명에서는 SC-PtM을 NB-LTE system에 동작 시키려 할 경우, MCCH/MTCH의 control/data를 전송하는 N-PDCCH/N-PDSCH 등의 CE(coverage enhancement) level을 효율적으로 설정해 주는 방법에 대해 제안한다.

문서의 통일성을 위해 다음과 같이 용어를 정하도록 한다. 'anchor-type PRB'는 e-NB 관점에서 initial access를 위해 N-PSS/N-SSS/N-PBCH/N-PDSCH for N-SIB 등을 전송하는 PRB를 의미 한다. 상황에 따라 하나의 anchor-type PRB가 존재할 수도 있으며 다수개의 anchor-type PRB들이 존재할 수도 있다. 다음으로, 하나 혹은 다수개의 anchor-type PRB가 있는 상황에서, UE가 initial access를 통해 특정 anchor-type PRB를 선택했다면 해당 PRB를 'anchor PRB'라고 약속한다. 또한, initial access 이후 downlink 과정을 진행하기 위해 e-NB로부터 할당된 PRB를 'additional PRB'라고 약속 한다. 추가적으로, NB-LTE system에서 각 UE는 single PRB를 각각의 carrier로 인식하고 있기 때문에, 본 문서에서 언급하고 있는 PRB는 carrier와 같은 의미를 지니고 있다고 할 수 있다.

#### 3.1. CE level of N-PDCCH/N-PDSCH for SC-PtM

A. 우선적으로, SC-PtM 정보를 전달하는 N-PDCCH 혹은 N-PDSCH의 CE level을 single CE level로 설정하는 방법을 고려할 수 있다. 이 때, CE level이라 함은 N-PDCCH 혹은 N-PDSCH의 repetition number set을 의미하거나 maximum repetition number를 의미할 수 있다. 따라서 CE level이 달라진다고 함은 N-PDCCH 혹은 N-PDSCH의 repetition number set이 달라지거나 maximum repetition number가 달라짐을 의미할 수 있다. 또한 각 CE level에 대응되는 N-PDCCH 혹은 N-PDSCH의 repetition number set이나 maximum repetition number가 정의/설정될 수 있다. 하나의 CE level을 사용한다는 것은 system 구현 측면에서 complexity가 낮기 때문에 장점이 있다. 상기 방법에 대한 실시 예를 들면 다음과 같다.

1. System에서 사용하는 CE level을 fixed CE level(fixed CE level에 대응되는 repetition number set 또는 maximum repetition number)로 설정하는 방법(i.e., 모든 cell에서 NB-IoT multicast CE level은 특정 fixed CE level을 사용하도록 함):

이 방법은 MCCH 또는 MTCH의 control 정보를 전달하는 N-PDCCH의 CE level을 결정하는데 모두 적용할 수 있는 방법으로, 가령 fixed CE level을 maximum CE level(maximum CE level에 대응되는 repetition number set 또는 maximum repetition number)로 설정하게 되면, 해당 system(혹은 Cell)에 속한 대부분의 UE들에게 service가 가능하게 되므로 채널 상황이 좋지 않은 곳(e.g., 지하, 창고 등)에 UE가 많이 존재하는 system에 유리할 수 있다. 하지만,

채널 상황이 좋은 곳에 있는 UE에게는 필요 없는 반복이 될 수 있기 때문에 불리하게 작용할 수 있다.

2. Cell specific 하게 각각의 Cell이 하나의 CE level 값으로 설정하고, eNB가 UE에게 system information 을 통해 이를 알려주는 방법:

이 방법은 MCCH 또는 MTCH의 control 정보를 전달하는 N-PDCCH의 CE level을 결정하는데 모두 적용할 수 있는 방법으로, eNB가 자신에게 configured된 UE들의 채널 특성과 해당 UE들의 위치 등을 파악하여, 평균적으로 어떠한 채널 상황을 가지고 있는지 판단한 뒤, CE level 값을 semi statistic 하게 설정하여 system information 을 통해서 알려준다고 설정할 수 있다. 이 방법을 사용하면, cell specific하게 CE level을 결정할 수 있기 때문에, 각 system 구현 측면에서도 complexity가 낮고, 필요 없는 반복을 줄일 수 있는 장점이 있다.

- B. 다음으로, SC-PtM 정보를 전달하는 N-PDCCH 혹은 N-PDSCH의 CE level을 multiple CE levels(i.e., repetition number sets, multiple maximum repetition numbers)로 설정하는 방법을 고려할 수 있다. 다수개의 CE level들을 사용한다는 것은 UE의 채널 상황에 따라, 혹은 multicast service type에 따라서 CE level을 다르게 설정하여 필요 없는 반복을 줄일 수 있는 장점이 있고, 상황에 따라 적절하게 CE level을 적용할 수 있다는 장점이 있다. 상기 방법에 대한 실시 예를 들면 다음과 같다.

1. TMGI(혹은 G-RNTI 혹은 service type)별로 CE level을 eNB와 단말 간에 미리 알고 있다고 설정하는 방법:

이 방법은 MTCH의 control 정보를 전달하는 N-PDCCH의 CE level and/or MTCH를 전달하는 N-PDSCH의 CE level을 결정하는데 적용할 수 있는 방법으로, MCCH N-PDSCH를 통해 알 수 있는 TMGI(혹은 G-RNTI 혹은 service type)별로 CE level을 다르게 설정하는 것이다. 즉, 예를 들어, multicast service type이 모든 UE가 즉시 수행해야 하는 중요한 update라면, CE level을 크게 설정하여 채널 환경이 좋지 않은 UE들에게도 모두 수신 가능하도록 설정해 줄 수 있고, multicast service type이 채널 환경이 좋은 곳에 위치한 UE들을 위한 group call이라고 가정하면, 해당 UE들이 수신할 수 있는 최소한의 CE level로 설정하여 필요 없는 repetition 이 발생하지 않도록 설정할 수 있다. 특징적으로 이러한 TMGI(혹은 G-RNTI 혹은 service type) 별 CE level 설정정보는 RRC signal 또는 MCCH를 통해 UE에게 전송될 수 있다.

2. UE group(혹은 각 UE) 별로 CE level을 다르게 설정하는 방법:

이 방법은 MCCH 또는 MTCH의 control 정보를 전달하는 N-PDCCH and/or MCCH 또는 MTCH를 전달하는 N-PDSCH의 CE level을 결정하는데 모두 적용할 수 있는 방법으로, eNB 측면에서는 MCCH 또는 MTCH의 control 정보 and/or MCCH 또는 MTCH를 전달하는 N-PDSCH를 서로 다른 PRB를 사용하여 서로 다른 CE level을 사용하여 전송한다고 설정할 수 있다. 이때 사용되는 CE level들은 각 cell 마다 독립적으로 설정할 수 있지만, 특정 PRB에 전송되는 CE level에 대해서는 모든 UE에게 system information을 통해서 전송해줘야 한다고 설정할 수 있다. 해당 system information을 수신한 UE입장에서는 각 UE별로 원하는 CE level을 선택하여, 해당 control 정보가 전송되는 PRB로 이동하여 MCCH 또는 MTCH의 control 정보를 수신한다고 설정할 수 있다. 이 방법을 사용하면, 각 UE별로 자신이 처한 채널 환경에 따라 자신이 원하는 CE level을 선택할 수 있다는 장점이 있지만, eNB 측면에서는 다수의 PRB들을 사용하여 repetition만 다를 뿐 같은 정보를 보내야 한다는 단점이 존재한다.

추가적으로, eNB 측면에서 MCCH 또는 MTCH의 control 정보를 서로 다른 PRB를 사용하지 않고, 동일한 PRB를 사용하되, 서로 다른 subframe(i.e., timing)을 사용하여 서로 다른 CE level 을 사용하여 전송한다고 설정할 수 있다. 이때 사용되는 CE level들은 앞서 언급한 것과 같이 각 cell 마다 독립적으로 설정할 수 있지만, 서로 다른 CE level을

맞는 N-PDCCH 가 allocation 되는 subframe(i.e., timing)을 모든 UE에게 system information을 통해서 전송해 줘야 한다고 설정할 수 있다. 해당 system information을 수신한 UE입장에서는 각 UE별로 원하는 CE level을 선택하여, 해당 해당 subframe이 전송되는 timing에 맞춰서 MCCH 또는 MTCH의 control 정보를 수신할 수 있다고 설정할 수 있다. 이 방법을 사용하면, 앞서 발생했던, eNB 측면에서 다수의 PRB를 사용하여 같은 정보를 보내야 한다는 단점을 줄일 수 있으나, 각각의 UE가 원하는 repetition 만큼을 모두 support 하기 위해서 존재하는 delay 문제는 발생할 수 있다.

#### 4. Effectiveness of Invention

본 발명에서는 SC-PtM을 NB-LTE system에 동작 시키려 할 경우, MCCH/MTCH의 control/data를 전송하는 N-PDCCH/N-PDSCH 등의 CE(coverage enhancement) level을 효율적으로 설정해 주는 방법에 대해 제안 했다. 추가적으로 본 발명에서 주로 다루는 내용은 NB-IoT system 이지만, 이와 비슷한 narrow band system(e.g., LTE MTC 등)으로도 확장 가능하다.

#### 5. References

- [1] 3GPP TS 36.211 V13.2.0, *Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation (Release 13)*
- [2] 3GPP TS 36.213 V13.2.0, *Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures (Release 13)*
- [3] 3GPP TS 36.331 V13.2.0, *Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification (Release 13)*

| Electronic Acknowledgement Receipt   |                                                       |
|--------------------------------------|-------------------------------------------------------|
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| Application Number:                  | 62372324                                              |
| International Application Number:    |                                                       |
| Confirmation Number:                 | 5858                                                  |
| Title of Invention:                  | REPETITION LEVEL OF SC-PtM FOR ENHANCED NB-IoT SYSTEM |
| First Named Inventor/Applicant Name: | Seokmin SHIN                                          |
| Customer Number:                     | 67487                                                 |
| Filer:                               | Andrew S. Park                                        |
| Filer Authorized By:                 |                                                       |
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| Authorized User                                                                                                | Andrew PARK           |
| The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: |                       |

| <b>File Listing:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                |                   |                                          |                  |                  |
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| Document Number                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Document Description           | File Name         | File Size(Bytes)/<br>Message Digest      | Multi Part /.zip | Pages (if appl.) |
| 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Application Data Sheet         | UT16-1105_ADS.pdf | 1826342                                  | no               | 9                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                |                   | b5cc5dd380d0ca123b5d662f53ce9c33a2d5aef2 |                  |                  |
| <b>Warnings:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                |                   |                                          |                  |                  |
| <b>Information:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                |                   |                                          |                  |                  |
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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                |                   | eb809ac9357f4dbdb325de290ce66563da7a1e77 |                  |                  |
| <b>Warnings:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                |                   |                                          |                  |                  |
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| <b>Information:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                |                   |                                          |                  |                  |
| 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Fee Worksheet (SB06)           | fee-info.pdf      | 29784                                    | no               | 2                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                |                   | 1c2cabb1c13a900fefa5037f8cd0066356c876c3 |                  |                  |
| <b>Warnings:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                |                   |                                          |                  |                  |
| <b>Information:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                |                   |                                          |                  |                  |
| <b>Total Files Size (in bytes):</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                |                   | 3685352                                  |                  |                  |
| <p><b>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.</b></p> <p><b><u>New Applications Under 35 U.S.C. 111</u></b><br/> 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.</p> <p><b><u>National Stage of an International Application under 35 U.S.C. 371</u></b><br/> 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.</p> <p><b><u>New International Application Filed with the USPTO as a Receiving Office</u></b><br/> 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.</p> |                                |                   |                                          |                  |                  |