$T_{ADT}$: Active delay time, sense time between RF off Initiator/Target and Target/Initiator.

($768/fc \leq T_{ADT} \leq 2\,559/fc$)

$T_{RFW}$: RF waiting time. ($512/fc$)

$n$: Randomly generated number of Time Periods for $T_{RFW}$. ($0 \leq n \leq 3$)

$T_{ARFG}$: Active guard time between switching on RF field and start to send command. ($T_{ARFG} > 1024/fc$)

## 11.2 Passive communication mode

### 11.2.1 Initialisation and Single Device Detection at *fc*/128

See ISO/IEC 14443-3, Clause 6 with the coding of SAK as specified in Table 2.

**Table 2 — coding of SAK**

| bit 8 | bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 | Meaning |
|---|---|---|---|---|---|---|---|---|
| x | x | x | x | x | 1 | x | x | UID not complete, see Table 9 of ISO/IEC 14443-3. |
| x | x | 1 | x | x | 0 | x | x | UID complete, see Table 9 of ISO/IEC 14443-3. |
| x | x | 0 | x | x | 0 | x | x | UID complete, see Table 9 of ISO/IEC 14443-3. |
| x | 1 | x | x | x | 0 | x | x | UID complete, Target compliant with NFCIP-1 transport protocol. Request for Attributes supported. |
| x | 0 | x | x | x | 0 | x | x | UID complete, Target does not supportNFCIP-1 transport protocol, Request for Attributes not supported. |

The uid0 shall be set to '08'.

If bit 3 is (1)b the Initiator shall ignore any other bit of SAK. If bit 3 is (0)b the Initiator shall interpret bit 7 and ignore the other bits. When bit 3 is set to (1)b then the Target should set all other bits of SAK to (0)b.

NOTE 1 UID replaces NFCID1 of ISO/IEC 18092:2004 and uid* replaces nfcid1 of ISO/IEC 18092:2004.

NOTE 2 If bit 6 is (1)b in SAK then device supports protocol as defined in ISO/IEC 14443-4.

### 11.2.2 Initialisation and SDD at *fc*/64 and *fc*/32

#### 11.2.2.1 Start and end of communication

The start of the Passive communication shall be signalled by the presence of the carrier frequency. The communication shall start with the preamble sequence of at least 48 bits of Manchester encoded ZERO. The end of communication shall be forecasted from the Length field of the frame. Figure 6 illustrates the start and end of communication.

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MASIMO 1054
Masimo v. Apple
IPR2023-00734

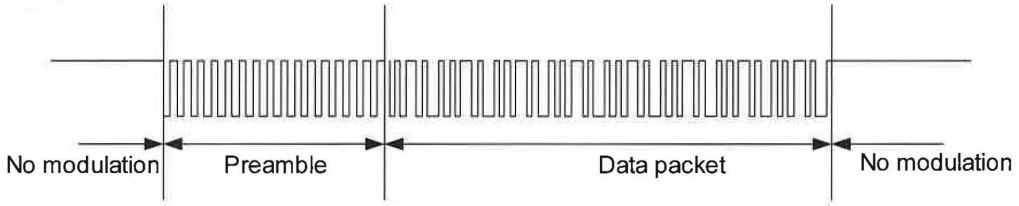


**Figure 6 — Start and end of communication**

After one NFCIP-1 device has finished communication, the other shall delay for a period of at least 8 × 64/*fc* before starting transmission by sending the preamble sequence as shown in Figure 7.

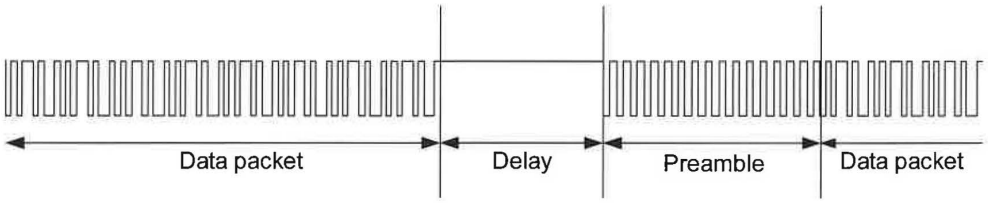


**Figure 7 — Delay between consecutive frames**

#### 11.2.2.2 Frame format

The frame format of shall consist of Preamble, SYNC, Length, Payload, and CRC, see Figure 8.

The Preamble shall be 48 bits minimum all logical ZEROs.

The SYNC shall be 2 bytes. The 1st byte of the SYNC shall be 'B2' and the 2nd byte shall be '4D'.

| Preamble | SYNC | Length | Payload | CRC |
|---|---|---|---|---|

**Figure 8 — Frame format**

The Length shall be an 8-bit field and it shall be set to the number of bytes to be transmitted in Payload plus 1. The range of the Length shall be 2 to 255, and other settings are RFU.

The Payload shall consist *n* 8-bit-bytes of data where *n* is indicated by the number of data bytes.

The CRC shall be calculated according to A.3.

#### 11.2.2.3 Single Device Detection at *fc*/64 and *fc*/32

The basic technique of the SDD procedure shall be the Time Slot method. The number of the Slot shall be the integer value beyond zero. The Initiator shall send Polling Requests. The Target shall respond at random in each Time Slot. The Initiator shall be able to read NFCID2 data (see 11.2.2.4) of Target(s) in different Time Slots.

After obtaining NFCID2 data from Target(s) in the operating field, the Initiator may communicate with multiple Targets.


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MASIMO 1054
Masimo v. Apple
IPR2023-00734

Up to 16 Time Slots may be supported by agreement between the interchange parties. The number of Time Slot may be indicated by the value TSN in the Polling Request Frame from the Initiator.

A Target, which is already powered up, responds to the Initiator according to the following rules after receiving the Polling Request Frame from the Initiator.

1. The Target shall generate a random number *R* in the range 0 to TSN.

2. The Target shall wait until the Time Slot is matched to *R*, then send the Polling Response Frame and wait for the next Request. The Target may ignore a Polling Request to reduce instances of collision of Responses.

The communication between the Initiator and the Target shall be initiated as follows:

1. The Target gets power from the operating field generated by the Initiator.

2. The Target shall become ready for receiving a Polling Request from the Initiator in maximum 2 seconds from power up.

3. The Target shall wait for a Polling Request sent from the Initiator. The Initiator may send a Polling Request without waiting for the Target to become ready.

4. If the Initiator fails to receive Polling Response, then the Initiator may send Polling Request again. The Initiator of the Passive communication mode shall keep RF power on while executing the SDD procedure.

The delay T*d* between the end of the Request Frame and the first Time Slot shall be 512 × 64/*fc*.

The Time Slot unit T*s* shall be 256 × 64/*fc*.

Figure 9 illustrates an example situation of the SDD by Time Slot. In this example, 5 Targets are responding. The Initiator may be able to get the Response information of the Target 2, 4, and 5 excluding 1 and 3. Because a collision has occurred at the Time Slot 1.

The Initiator may repeat SDD procedure.

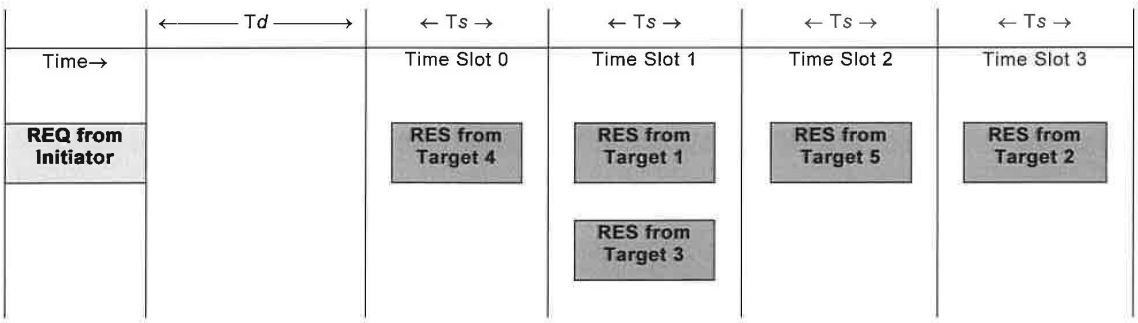


**Figure 9 — Single Device Detection by Time Slot**

#### 11.2.2.4 NFCID2 contents

NFCID2 shall be an 8-byte number for identifying NFCIP-1 devices. The 2-byte prefix code shall be followed by a 6-byte number in the NFCID2. The prefix code shall define the characteristics for the 6-byte number.

The 6-byte number shall be randomly generated while the prefix code is '01' 'FE'. Other settings for the prefix code are RFU.

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MASIMO 1054
Masimo v. Apple
IPR2023-00734

#### 11.2.2.5 Polling Request Frame format

To find Targets, an Initiator shall send a Polling Request frame, see Figure 10.

| Preamble (48 bit min.) | SYNC (16 bit) | Length (8 bit) | Payload | | | | | CRC (16 bit) |
|---|---|---|---|---|---|---|---|---|
| | | | '00' | 'FF' | 'FF' | '00' | TSN | |

**Figure 10 — Polling Request Frame format**

The Preamble shall be 48 bits minimum all logical ZEROs.

The synchronisation (SYNC) pattern shall be 2 byte. The 1st byte of the synchronisation pattern shall be 'B2' and the 2nd byte shall be '4D'.

The Length shall be set to '06'.

The 1st byte of the Payload shall be set to '00'.

The 2nd byte and the 3rd of Payload shall be set to 'FF' and other settings are RFU.

The 4th byte of Payload shall be set to '00', and other settings are RFU.

The TSN shall be '00', '01', '03', '07', or '0F'. Any other settings are RFU.

The CRC shall be calculated according to A.3.

Figure 9 illustrates an example where the TSN is '03'. If the TSN is set to '00' then only the Time Slot 0 shall be used.

#### 11.2.2.6 Polling Response Frame format

Target shall send the following frame as the Polling Response toward the Polling Request, see Figure 11.

| Preamble (48 bit min.) | SYNC (16 bit) | Length (8 bit) | Payload | | | CRC (16 bit) |
|---|---|---|---|---|---|---|
| | | | '01' | NFCID2 | Pad | |

**Figure 11 — Polling Response Frame format**

The Preamble shall be 48 bits minimum all logical "ZERO".

The synchronisation (SYNC) pattern shall be 2 byte. The 1st byte of the synchronisation pattern shall be 'B2' and the 2nd byte shall be '4D'.

The Length field shall be set '12'.

The start byte of the Payload shall be set to '01'. The Payload shall contain 8-byte of NFCID2 and 8-byte of Pad. The Pad shall be ignored for data interchange.

The CRC shall be calculated according to A.3.


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MASIMO 1054
Masimo v. Apple
IPR2023-00734

## 11.3 Active communication mode

### 11.3.1 Initialisation at *fc*/128, *fc*/64, and *fc*/32

The application switches to Initiator for the Active communication mode and may choose *fc*/128, *fc*/64 or *fc*/32.

### 11.3.2 Active communication mode RF Collision Avoidance

The RF Collision Avoidance shall be executed according to the timing chart in Figure 12.

— The Initiator shall perform the initial RF Collision Avoidance.

— The first command sends by the Initiator is the ATR_REQ in the Active communication mode at a selected transfer speed.

— The Initiator shall switch off the RF field.

— The Target performs the response RF Collision Avoidance.

— The Target sends the ATR_RES as a response to the ATR_REQ in the same transfer speed as it has received the ATR_REQ and switch of the RF field.

— The Initiator performs the response RF Collision Avoidance with $n = 0$.

— The Initiator sends the PSL_REQ in order to change parameter or sends the DEP_REQ to start the data exchange protocol.

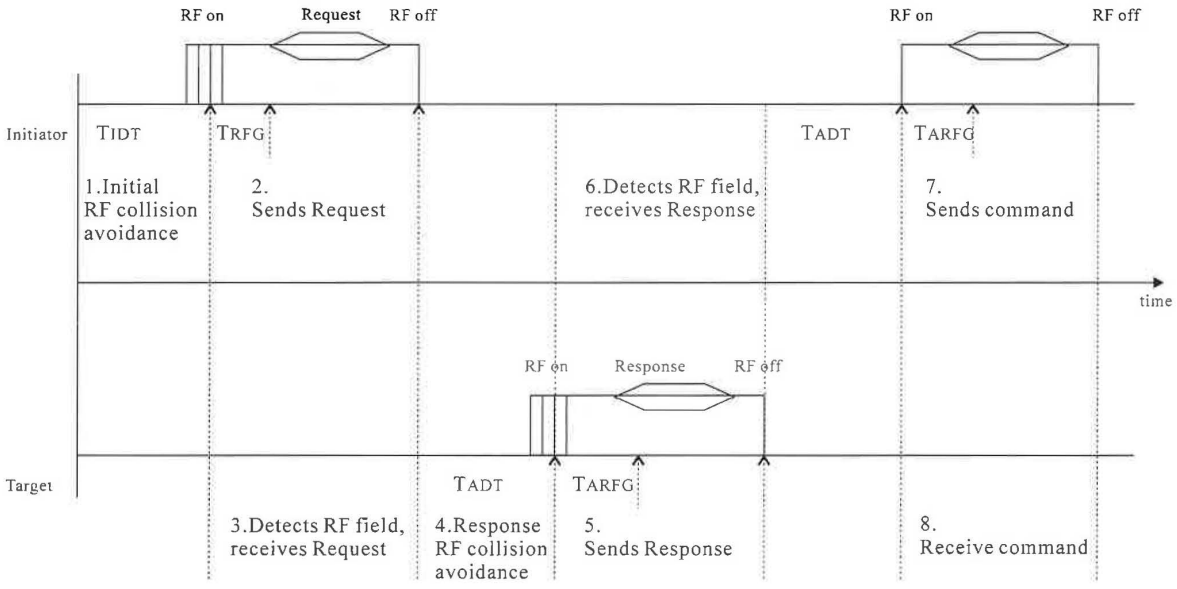


**Figure 12 — Initialisation flow for Active communication mode**

#### 11.3.2.1 Collision Avoidance for Active communication mode

In case where 2 Targets or more are in the field the one with the lowest *n* will answer first and the other will not answer.

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MASIMO 1054
Masimo v. Apple
IPR2023-00734

In case of 2 or more Targets answering in exactly the same Time Period, the Initiator will detect a collision and it will re-send the ATR_REQ, which is described in 12.5.1.1.

After the first Target response is detected by the Initiator, the Initiator and Target shall use $n = 0$ for further communication.

# 12 Transport Protocol

The transport protocol is handled in three parts:

— Activation of the protocol, which includes the Request for Attributes and the Parameter Selection.

— The data exchange protocol, and

— The deactivation of the protocol including the Deselect and the Release.

## 12.1 Transport Data

User data shall be transported in the Transport Data field in the Frame format. Figure 13 specifies the position of the Transport Data field in each Frame format.

The structure for the Frame format for *fc*/128 is specified in ISO/IEC 14443-3, 6.2.3.2. The start byte SB shall be set to 'F0'. The LEN byte shall be set to the length of the Transport Data field plus 1. The range of the LEN shall be in the range of 3 to 255. The E1 is the CRC for the Frame format of *fc*/128 as described in A.1. Other settings of LEN are prohibited by this International Standard.

11.2.2.2 specifies the frame format for *fc*/64 and *fc*/32 including the Preamble PA and the Synchronous pattern bytes SYNC.

The LEN byte shall be set to the length of the Transport Data field plus 1. The value of LEN shall be in the range of 3 to 255. The E2 is the CRC for the Frame format of *fc*/64 and *fc*/32 as described in A.3. Other settings of LEN are prohibited by this International Standard.

The Transport data field contains the mandatory command bytes CMD1 and CMD2 as described in 12.4 and the data bytes Byte 1 to Byte *n*. The content of Byte 1 to Byte *n* depends on the command byte CMD2 and may contain information. In that case they are mandatory. Data bytes are optional.

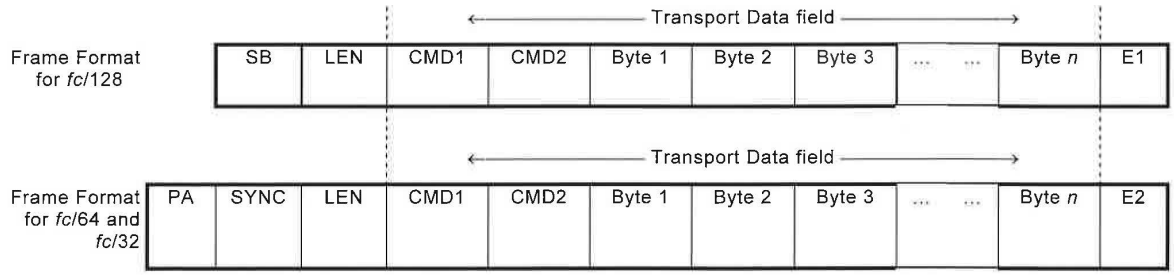


**Figure 13 — Transport Data Frame format**

## 12.2 Passive communication mode Activation flow

The following activation sequence shall be applied:

1. The Initiator shall perform the initial RF Collision Avoidance sequence as defined in 11.1.1.


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Masimo v. Apple
IPR2023-00734

2. The Initiator shall perform the Initialisation and SDD for the Passive communication mode at a chosen transfer speed as defined in 11.2.

3. The support of the NFCIP-1 protocol shall be checked at the different transfer speeds according to the Attribute Request as described in 12.5.1.1.

4. The Target may fall back to the Initialisation and SDD if no ATR_REQ is supported.

5. The ATR_REQ may be send by the Initiator as a next command after receiving the Attribute Request is available.

6. The Target shall send its ATR_RES as answer to the ATR_REQ. The Target shall only answer to the ATR_REQ if the ATR_REQ is received directly after selection.

7. If the Target supports any changeable parameter in the ATR_REQ, a PSL_REQ may be used by the Initiator as the next command after receiving the ATR_REQ to change parameters.

8. The Target shall send a PSL_RES as answer to the PSL_REQ.

9. A Target does not need to complement the Parameter Selection, if it does not support any changeable parameters in the ATR_RES.

10. The transparent data shall be sent using the data exchange transport protocol.

The Initiator activation sequence for a Target in the Passive communication mode is shown in Figure 14.

### 12.3 Active communication mode Activation flow

The following activation sequence for the protocol in the Active communication mode shall be applied:

1. The Initiator shall perform the initial RF Collision Avoidance sequence as defined in 11.1.1.

2. The Initiator shall switch to the Active communication mode and select the transfer speed.

3. The Initiator shall send the ATR_REQ.

4. The Target shall send its ATR_RES in response to the ATR_REQ. After a successful response the device is selected.

5. If the Initiator detects a collision of data the ATR_REQ shall be re-sent.

6. It the Target supports any changeable parameter in the ATR_RES, a PSL_REQ may be used by the Initiator as the next command after receiving the ATR_RES to change parameters.

7. The Target shall send a PSL_RES in response to the PSL_REQ.

8. A Target does not need to complement the Parameter Selection, if it does not support any changeable parameters in the ATR_RES.

The Initiator activation sequence for a Target in the Active communication mode is shown in Figure 15.

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MASIMO 1054
Masimo v. Apple
IPR2023-00734

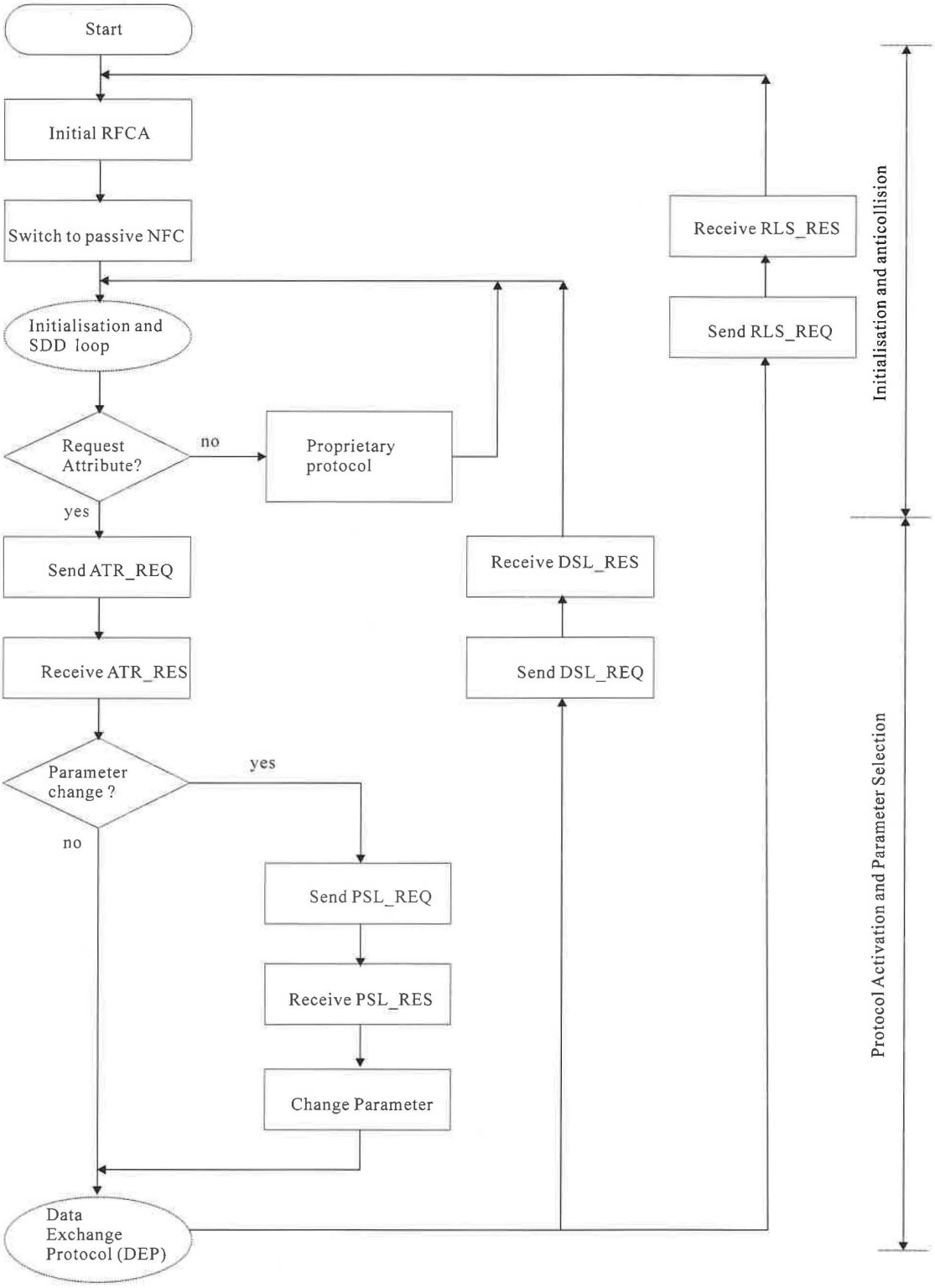


**Figure 14 — Activation protocol in Passive communication mode**



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Masimo v. Apple
IPR2023-00734

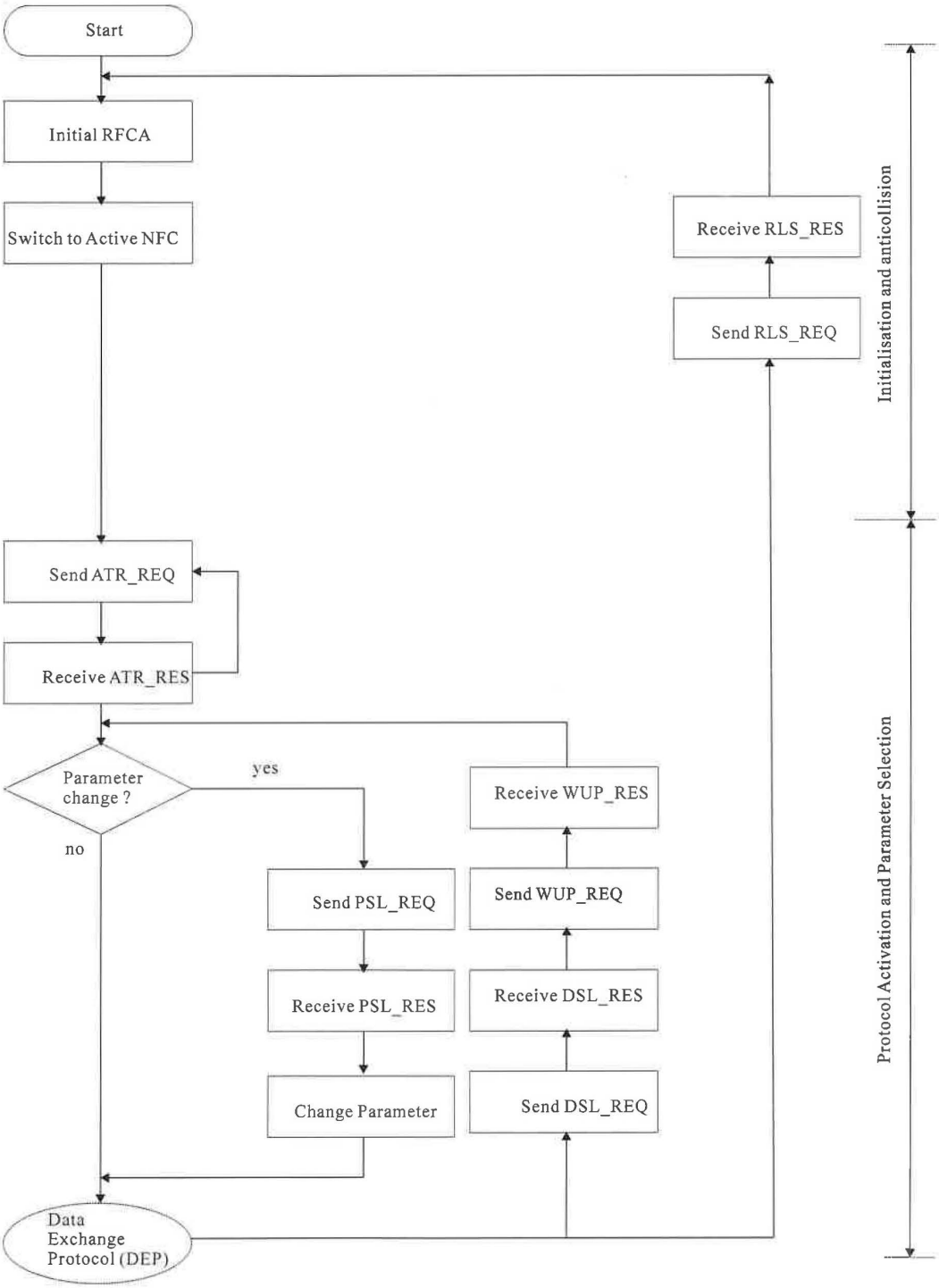


**Figure 15 — Activation Protocol in Active communication mode**

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Masimo v. Apple
IPR2023-00734

## 12.4 Commands

The Command Bytes consist of CMD1 and CMD2 as specified in Table 3.

**Table 3 — NFCIP-1 Protocol Command Set**

| Mnemonic | Command Bytes | | Definition |
|---|---|---|---|
| | CMD1 | CMD2 | |
| ATR_REQ | 'D4' | '00' | Attribute Request (sent by Initiator) |
| ATR_RES | 'D5' | '01' | Attribute Response (sent by Target) |
| WUP_REQ | 'D4' | '02' | Wakeup Request (sent by Initiator in Active mode only) |
| WUP_RES | 'D5' | '03' | Wakeup Response (sent by Target in Active mode only) |
| PSL_REQ | 'D4' | '04' | Parameter Selection Request (sent by Initiator) |
| PSL_RES | 'D5' | '05' | Parameter Selection Response (sent by Target) |
| DEP_REQ | 'D4' | '06' | Data Exchange Protocol Request (sent by Initiator) |
| DEP_RES | 'D5' | '07' | Data Exchange Protocol Response (sent by Target) |
| DSL_REQ | 'D4' | '08' | Deselect Request (sent by Initiator) |
| DSL_RES | 'D5' | '09' | Deselect Response (sent by Target) |
| RLS_REQ | 'D4' | '0A' | Release Request (sent by Initiator) |
| RLS_RES | 'D5' | '0B' | Release Response (sent by Target) |

## 12.5 Activation of the protocol

### 12.5.1 Attribute Request and Response Commands

#### 12.5.1.1 Attribute Request (ATR_REQ)

This clause defines the Attribute Request ATR_REQ with all its parameter bytes, see Figure 16. The Initiator shall send the ATR_REQ to the selected Target.

| CMD 1 | CMD 2 | Byte 1 | ... | Byte 10 | Byte 11 | Byte 12 | Byte 13 | Byte 14 | Byte 15 | ... | Byte *n* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 'D4' | '00' | nfcid3i1 | ... | nfcid3i10 | DIDi | BSi | BRi | PPi | [Gi[1]] | ... | [Gi[*n*]] |

**Figure 16 — Structure of the ATR_REQ**

##### 12.5.1.1.1 Definition of the ATR_REQ bytes

**CMD 1:** Shall be set to 'D4'.

**CMD 2: ATR_REQ**

The ATR_REQ byte shall specify the Attribute Request for the Initiator. The value of ATR_REQ shall be set to '00'.


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Masimo v. Apple
IPR2023-00734

**Byte 1 to Byte 10: NFCID3i**

The 10 nfcid3i bytes define the random identifier NFCID3i of the Initiator. NFCID3 shall be an ID dynamically generated by the application and be fixed during one communication. For Passive communication mode *fc*/64 and *fc*/32 the NFCID3i shall be replaced by NFCID2t.

**Byte 11: DIDi**

The DID byte shall be used for multiple data transport protocol activation with more than one Target. The range of the DIDi shall be defined between 1 and 14. The value ZERO shall be used, if no DIDi is used during the data transport protocol. All other values are prohibited by this International Standard.

**Byte 12: BSi**

The Initiator device shall specify its supported send-bit rates (D) in the BSi byte, see Figure 17.

| bit 8 | bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 |
|---|---|---|---|---|---|---|---|
| ZERO | ZERO | ZERO | ZERO | DSi | DSi | DSi | DSi |

**Figure 17 — Coding of the BSi byte**

The coding of bits is as follows:

— bit 8 to bit 5: shall be set to ZERO, all other values are RFU.

— bit 4: if DSi = ONE then D = 64 is supported

— bit 3: if DSi = ONE then D = 32 is supported

— bit 2: if DSi = ONE then D = 16 is supported

— bit 1: if DSi = ONE then D = 8 is supported

**Byte 13: BRi**

The Initiator device shall specify its supported bit rates (see Table 1) in the BRi byte, see Figure 18. The coding of bits is as follows:

| bit 8 | bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 |
|---|---|---|---|---|---|---|---|
| ZERO | ZERO | ZERO | ZERO | DRi | DRi | DRi | DRi |

**Figure 18 — Coding of the BRi byte**

— bit 8 to bit 5: shall be set to ZERO, all other values are RFU.

— bit 4: if DRi = ONE then D = 64 is supported

— bit 3: if DRi = ONE then D = 32 is supported

— bit 2: if DRi = ONE then D = 16 is supported

— bit 1: if DRi = ONE then D = 8 is supported

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Masimo v. Apple
IPR2023-00734

**Byte14: PPi**

The PPi byte specifies optional parameters used by Initiator device, see Figure 19. The coding of bits shall be as follows:

| bit 8 | bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 |
|---|---|---|---|---|---|---|---|
| SECi | RFU | LRi | LRi | RFU | RFU | Gi | NAD |

**Figure 19 — Coding of the PPi byte**

— bit 8: SECi. If set to ONE the Initiator supports NFC-SEC; ZERO indicates no support.

— bit 7: RFU. The Initiator shall set it to ZERO. The Target shall ignore it.

— bit 6 and bit 5: Length Reduction value.

**Table 4 — Definition of LRi**

| LRi | $LEN_{MAX}$ |
|---|---|
| 00 | Only Byte 1 to Byte 64 is valid in the Transport Data |
| 01 | Only Byte 1 to Byte 128 is valid in the Transport Data |
| 10 | Only Byte 1 to Byte 192 is valid in the Transport Data |
| 11 | Only Byte 1 to Byte 252 is valid in the Transport Data |

— bit 4 and bit 3: RFU. The Initiator shall set it to ZERO. The Target shall ignore it.

— bit 2: If bit is set to ONE then it indicates General bytes are available.

— bit 1: If bit is set to ONE then it indicates the Initiator uses NAD.

**Byte 15 to Byte *n*: Gi[1] to Gi[*n*]**

The general bytes shall be optional and designate general information. The maximum length of the ATR_REQ subtracted by the mandatory bytes give the maximum number of general bytes.

### 12.5.1.2 Attribute Response (ATR_RES)

The ATR_RES, see Figure 20 shall be the response to the ATR_REQ and shall be sent by the selected NFCIP-1 Target device.

| CMD 1 | CMD 2 | Byte 1 | ... | Byte 10 | Byte 11 | Byte 12 | Byte 13 | Byte 14 | Byte 15 | Byte 16 | ... | Byte *n* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 'D5' | '01' | nfcid3t1 | ... | nfcid3t10 | DIDt | BSt | BRt | TO | PPt | [Gt1]] | ... | [Gt[*n*]] |

**Figure 20 — Structures of the ATR_RES**

#### 12.5.1.2.1 Definition of the ATR_RES bytes

**CMD 1:** Shall be set to 'D5'.


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Masimo v. Apple
IPR2023-00734

**CMD 2: ATR_RES**

The ATR_RES byte shall specify the Target's Response to the ATR_REQ send by the Initiator. The value of CMD1 for ATR_RES shall be set to '01'.

**Byte 1 to Byte 10: NFCID3t**

The 10 nfcid3t bytes define the random identifier NCID3t of the Target. NFCID3 should be an ID generated by the application. The content of NFCID3 may be the same as NFCID1 or NFCID2.

**Byte 11: DIDt**

The DID byte shall be used for multiple data transport protocol activation with more than one Target. The DIDt shall have the same value as the DIDi. All other values are prohibited by this International Standard. For usage of DIDt see 12.5.1.1.1.

**Byte 12: BSt**

The BSt byte shall specify the supported bit rates of the Target device, see Figure 21. The coding of bits is defined as follows:

| bit 8 | bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 |
|---|---|---|---|---|---|---|---|
| ZERO | ZERO | ZERO | ZERO | DSt | DSt | DSt | DSt |

**Figure 21 — Coding of the BSt byte**

— bit 8 to bit 5: Shall be set to ZERO.

— bit 4: if DSt = ONE then D = 64 is supported

— bit 3: if DSt = ONE then D = 32 is supported

— bit 2: if DSt = ONE then D = 16 is supported

— bit 1: if DSt = ONE then D = 8 is supported

**Byte 13: BRt**

The BRt byte shall specify the supported receive bit rates of the Target device, see Figure 22. The coding of bits is defined as follows:

| bit 8 | bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 |
|---|---|---|---|---|---|---|---|
| ZERO | ZERO | ZERO | ZERO | DRt | DRt | DRt | DRt |

**Figure 22 — Coding of the BRt byte**

— bit 8 to bit 5: Shall be set to ZERO.

— bit 4: if DRt = ONE then D = 64 is supported

— bit 3: if DRt = ONE then D = 32 is supported

— bit 2: if DRt = ONE then D = 16 is supported

— bit 1: if DRt = ONE then D = 8 is supported

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MASIMO 1054
Masimo v. Apple
IPR2023-00734

**Byte 12: TO**

The TO byte shall specify the timeout value of the Target NFCIP-1 device for the data transport protocol, see Figure 23. The timeout calculation shall start with the last bit send by the Initiator and stop with the first bit send by the Target. The timeout is specified as follows:

| bit 8 | bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 |
|---|---|---|---|---|---|---|---|
| ZERO | ZERO | ZERO | ZERO | WT | WT | WT | WT |

**Figure 23 — Coding of the TO byte**

— bit 8 to bit 5: Shall be set to all ZEROs.

— bit 4 to bit 1: WT: Waiting Time.

The Response Waiting Time (RWT) shall be calculated by the following formula:

$$RWT = (256 \times 16 / fc) \times 2^{WT}$$

Where the value of WT shall be the range from 0 to 14 and the value of 15 is RFU. The default value of WT shall be 14.

For WT = 0, RWT = $RWT_{MIN}$ (302 µs)

For WT = 14, RWT = $RWT_{MAX}$ (4 949 ms)

**Byte 15: PPt**

The PPt byte specifies optional parameters used by Target device, see Figure 4. The coding of bits shall be as follows:

| bit 8 | bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 |
|---|---|---|---|---|---|---|---|
| ZERO | ZERO | LRt | LRt | ZERO | ZERO | Gt | NAD |

**Figure 24 — Coding of the PPt byte**

— bit 8 and bit 7: Shall be set to ZERO.

— bit 6 and bit 5: Length Reduction value, see Table 5.

**Table 5 — Definition of LRt**

| LRt | $LEN_{MAX}$ |
|---|---|
| 00 | Only Byte 1 to Byte 64 is valid in the Transport Data |
| 01 | Only Byte 1 to Byte 128 is valid in the Transport Data |
| 10 | Only Byte 1 to Byte 192 is valid in the Transport Data |
| 11 | Only Byte 1 to Byte 252 is valid in the Transport Data |


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Masimo v. Apple
IPR2023-00734

— bit 4 and bit 3: Shall be set to ZERO.

— bit 2: If bit is set to ONE then it indicates General bytes available.

— bit 1: If bit is set to ONE then it indicates the Target uses NAD.

**Byte 15 to Byte *n*: Gt[1] to Gt[*n*]**

The Gt bytes shall be optional and designate general information. The maximum length of the ATR_RES subtracted by the mandatory bytes gives the maximum number of general bytes.

#### 12.5.1.3 Handling of ATR_REQ and ATR_RES

##### 12.5.1.3.1 Initiator rules

When the Initiator has sent the ATR_REQ and receives a valid ATR_RES the Initiator shall continue with operation.

In any other case the Initiator shall retransmit the ATR_ REQ before it shall use the deactivation sequence as defined in 12.7.

In case of failure of the deactivation sequence it may use the HLTA command only for Passive communication mode at *fc*/128. The HLTA command is specified 6.4.3 of ISO/IEC 14443-3.

##### 12.5.1.3.2 Target rules

When the Target has been selected by the last command (for passive mode only) and

a) Receives a valid ATR_REQ, the Target

   — shall send its ATR_RES,

   — shall disable to receive a subsequent ATR_REQ.

b) Receives any other valid or invalid frame, except a HLTA command (see 12.5.1.3.1) only for Passive communication mode at *fc*/128, the Target

   — ignores the block and

   — remains in receive mode.

#### 12.5.1.4 Handling of timeout TO

Defined by the initially chosen mode, the communication is either active or passive. The handling of the timeout is different for active and passive communication mode.

##### 12.5.1.4.1 Handling in active mode

In active mode the communication flow is handled by switching the carrier frequency.

**Initiator**: The Initiator shall ignore a Target that exceeded RWT calculated using TO byte in ATR_REQ from a Target device and continue operation.

**Target**: The Target shall use a TO value that allows common communication and shall use a supervisory pdu containing a timeout extension to extend the defined RWT. See 12.6.1.1.1.

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MASIMO 1054
Masimo v. Apple
IPR2023-00734

#### 12.5.1.4.2 Handling of timeout in passive mode

In passive mode the communication is only handled by communication flow. The carrier frequency is not switched.

**Initiator**: The Initiator shall first use error handling and if no response is received ignores a Target device, that has exceeded the specified timeout and continue communication.

**Target**: The Target shall use a TO value that allows common communication and shall use a supervisory pdu containing a timeout extension to extend the defined RWT. See 12.6.1.1.1.

#### 12.5.1.5 Handling of DID

#### 12.5.1.5.1 Handling of DID in active and in passive mode.

When the Initiator has sent a ATR_REQ containing a DID equal to ZERO and

a) received an ATR_ RES containing DID equal to ZERO

- shall send pdu's containing no DID to the Target and
- shall not activate any other Target while this Target is not deactivated.

b) received an ATR_RES containing DID not equal to ZERO

- shall continue with error handling

When the Initiator has sent a ATR_REQ containing a DID not equal to ZERO and

a) received an ATR_RES containing the same DID

- shall send pdu's containing the DID to the Target and
- shall not use the DID for any other Targets and
- shall not use DID=0 for any other Targets.

b) received an ATR_RES containing any other DID

- shall continue with error handling.

### 12.5.2 Wakeup Request and Response Commands

The Wakeup Request and Response commands are only defined for the Active communication mode.

#### 12.5.2.1 Wakeup Request (WUP_REQ)

Figure 25 specifies the Wakeup Request for Attributes WUP_REQ with its parameter bytes. The Initiator sends the WUP_REQ to the Target only in the Active communication mode. It shall be applied to reactivate a distinct Target device by its NFCID3, which was deactivated by the DSL command.

| CMD 1 | CMD 2 | Byte 1 | ... | Byte 10 | Byte 11 |
|---|---|---|---|---|---|
| 'D4' | '02' | nfcid3t1 | ... | nfcid3t10 | DID |

**Figure 25 — Structure of the WUP_REQ**


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MASIMO 1054
Masimo v. Apple
IPR2023-00734

#### 12.5.2.1.1 Definition of the WUP_REQ bytes

**CMD 1:** Shall be set to 'D4'.

**CMD 2: WUP_REQ**

The WUP_REQ byte shall specify the command Wake Up for the Initiator device. The value of WUP_REQ shall be '02'.

**Byte 1 to Byte 10: NFCID3t**

The 10 nfcid3t bytes shall be defined as the random identifier of the Target. For the WUP_REQ command the Initiator shall send the known NFCID3t random identifier to wake up the Target.

**Byte 11: DID**

The DID byte shall be used for multiple data transport protocol activation with more than one Targets. The range of the DID shall be defined between 1 and 14. The value 0 shall be used, if no DID is used during the data transport protocol. All other values are prohibited by this International Standard. The Initiator may assign a different value to the Target, as used before the last DSL command.

### 12.5.2.2 Wakeup Response (WUP_RES)

Figure 26 specifies the structure of the Wakeup Response for attributes, WUP_RES. The WUP_RES shall be the response to the WUP_REQ and shall be sent by the selected NFCIP-1 Target device.

| CMD 1 | CMD 2 | Byte 1 |
|---|---|---|
| 'D5' | '03' | DID |

**Figure 26 — Structure of the WUP_RES**

#### 12.5.2.2.1 Definition of the WUP_RES bytes

**CMD 1:** Shall be set to 'D5'.

**CMD 2: WUP_RES**

The WUP_RES byte shall specify the response to the WUP_REQ. The value of WUP_RES shall be (03).

**Byte 1: DID**

The DID byte shall be used for multiple data exchange protocol activation with more than one Targets. The DIDt shall have the same value as the DIDi. All other values are prohibited by this International Standard.

### 12.5.2.3 Handling of WUP_REQ and WUP_RES

#### 12.5.2.3.1 Initiator rules

When the Initiator has sent a WUP_REQ and receives a valid WUP_RES the Initiator shall continue with operation.

In any other case the Initiator shall retransmit the WUP_REQ before it shall use the deactivation sequence as defined in 12.7.

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MASIMO 1054
Masimo v. Apple
IPR2023-00734

In case of failure of the deactivation sequence for *fc*/128 in Passive communication mode, it may use the HLTA command (see 6.4.3 of ISO/IEC 14443-3).

#### 12.5.2.3.2 Target rules

When the Target has been de-selected by the last command (for the Active communication mode only) and

a) receives a WUP_REQ with its NFCID3, the Target

   — shall send its WUP_RES and

   — shall disable in order to not receive a subsequent WUP_REQ.

b) receives any other valid or invalid frame, except a HLTA command only for passive communication mode at *fc*/128, the Target

   — ignores the block and

   — remains in receive mode.

### 12.5.3 Parameter Selection Request and Response Commands

#### 12.5.3.1 Parameter Selection Request (PSL_REQ)

The Initiator may switch parameters for the subsequent transport protocol using the PSL_REQ command, see Figure 27.

| CMD 1 | CMD 2 | Byte 1 | Byte 2 | Byte 3 |
|---|---|---|---|---|
| 'D4' | '04' | DID | BRS | FSL |

**Figure 27 — Structure of the PSL_REQ**

#### 12.5.3.1.1 Definition of the PSL_REQ bytes

**CMD 1:** Shall be set to 'D4'.

**CMD 2: PSL_REQ**

The PSL_REQ byte shall specify the command Parameter Selection for the Initiator device. The value of PSL_REQ shall be '04'.

**Byte 1: DID**

The DID shall be similar to the DID defined during ATR or WUP.

**Byte 2: BRS**

The BRS byte, see Figure 28 shall specify the selected bit rates for Initiator and Target device.

| bit 8 | bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 |
|---|---|---|---|---|---|---|---|
| ZERO | ZERO | DSI | DSI | DSI | DRI | DRI | DRI |

**Figure 28 — Coding of the BRS byte**


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MASIMO 1054
Masimo v. Apple
IPR2023-00734

— bit 8 and bit 7: Shall be set to ZERO.

— bit 6 to bit 4: Bit duration of Initiator to Target, see Table 6.

— bit 3 to bit 1: Bit duration of Target to Initiator, see Table 6.

**Table 6 — Coding of DRI and DSI**

| DRI and DSI | Divisor D |
|---|---|
| 000 | 1 |
| 001 | 2 |
| 010 | 4 |
| 011 | 8 |
| 100 | 16 |
| 101 | 32 |
| 110 | 64 |
| 111 | RFU |

**Byte 3: FSL**

The FSL byte defines the maximum value for the Frame Length, see Figure 29.

| bit 8 | bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 |
|---|---|---|---|---|---|---|---|
| ZERO | ZERO | ZERO | ZERO | ZERO | ZERO | LR | LR |

**Figure 29 — Coding of FSL bytes**

— bit 8 to bit 3: Shall be set to all ZERO.

— bit 2 and bit 1: Length Reduction (LR) value, see Table 7.

**Table 7 — Definition of LR**

| LR | $LEN_{MAX}$ |
|---|---|
| 00 | Only Byte 1 to Byte 64 is valid in the Transport Data |
| 01 | Only Byte 1 to Byte 128 is valid in the Transport Data |
| 10 | Only Byte 1 to Byte 192 is valid in the Transport Data |
| 11 | Only Byte 1 to Byte 252 is valid in the Transport Data |

#### 12.5.3.2 Parameter Selection Response (PSL_RES)

Figure 30 specifies the frame Structure of PSL_RES.

| CMD 1 | CMD 2 | Byte 1 |
|---|---|---|
| 'D5' | '05' | DID |

**Figure 30 — Structure of PSL_RES**

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MASIMO 1054
Masimo v. Apple
IPR2023-00734

#### 12.5.3.2.1 Definition of the PSL_RES bytes

**CMD1:** Shall be set to 'D5'.

**CMD2: PSL_RES**

The PSL_RES byte shall specify the command Parameter Selection response for the Target device. The value of PSL_RES shall be '05'.

**Byte 1: DID**

The DID shall be the same as the DID defined during ATR or WUP.

### 12.5.3.3 Handling of PSL_REQ and PSL_RES

#### 12.5.3.3.1 Initiator rules

The Initiator may change protocol parameters by sending the PSL_REQ to the Target. After reception of a valid PSL_RES, the Initiator

— shall change the framing to the format, which is defined in 12.1 and

— shall continue with operation.

In any other case the Initiator may retransmit the PSL_REQ before it shall use the deactivation sequence as defined in 12.7.

In case of failure of deactivation sequence at *fc*/128 in Passive communication mode, it may use the HLTA command (see 12.5.1.3.2).

#### 12.5.3.3.2 Target rules

When the Target has received a ATR_REQ, sent its ATR RES and

a) receives a valid PSL_REQ, the Target
   - shall send its PSL_RES,
   - shall disable the PSL_REQ (stop responding to received PSL_REQ),
   - shall change all parameters to the defined values, which are specified in 12.5.3 and
   - shall remain in receive mode.

b) receives an invalid frame, the Target
   - shall ignore the block,
   - shall disable the PSL_REQ (stop responding to received PSL_REQ),
   - shall remain with the current framing and
   - shall remain in receive mode.

c) receives a valid frame, except a PSL_REQ, the Target
   - shall disable the PSL_REQ (stop responding to received PSL_REQ),
   - shall remain with the current framing and
   - shall continue operation.


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MASIMO 1054
Masimo v. Apple
IPR2023-00734

## 12.6 Data Exchange Protocol

### 12.6.1 Data Exchange Protocol Request and Response

#### 12.6.1.1 Data Exchange Protocol Request (DEP_REQ) and Response (DEP_RES)

The protocol shall be half-duplex protocol supporting block oriented data transmission with error handling. For data, which does not fit in one frame a chaining mechanism is defined Format of the protocol frame shall be as follows:

**Transport Data field**

| CMD 1 | CMD 2 | Byte 1 | Byte 2 | Byte 3 | Byte 4 | Byte 5 | ... | Byte *n* |
|---|---|---|---|---|---|---|---|---|

**Data Exchange Protocol Header**

| CMD 1 | CMD 2 | PFB | [DID] | [NAD] | |
|---|---|---|---|---|---|

**Transport data bytes**

| Data byte 1 | Data byte 2 | ... | Data byte *n* |
|---|---|---|---|

**Figure 31 — Definition of the protocol frames**

In information interchange, the content of the payload of the Transport Data Field requires agreement between the interchanging parties.

##### 12.6.1.1.1 Definition of the Data Exchange Protocol Header bytes

**CMD 1:**

If the CMD2 is DEP_REQ then the CMD1 shall be set to 'D4'.

If the CMD2 is DEP_RES then the CMD1 shall be set to 'D5'.

**CMD 2: DEP_REQ**

The DEP_REQ bytes specify the command for the data exchange protocol for the Initiator device. The value of the DEP_REQ shall be '06'.

**CMD 2: DEP_RES**

The DEP_RES bytes specify the command for data exchange for the Target device. The value of the DEP_RES shall be '07'.

**Byte 1: PFB**

The PFB byte shall contain bits to control the data transmission and error recovery. The PFB byte is used to convey the information required controlling the transmission. The data exchange protocol defines these fundamental types of pdus:

— Information pdus to convey information for the application layer.

— ACK/NACK pdus to convey positive or negative acknowledgements. An ACK / NACK pdu never contains a data field. The acknowledgement relates to the last received block.

— Protected pdus using the NFC-SEC Option as specified in ISO/IEC 13157-1.

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MASIMO 1054
Masimo v. Apple
IPR2023-00734

— Supervisory pdus to exchange control information between the Initiator and the Target. Two types of supervisory pdus are defined.

— Timeout extensions containing a 1 byte long data field.

— Attention containing no data field.

Table 8 specifies the coding of PFB.

**Table 8 — Coding of the PFB bits 8 to 6**

| bit 8 | bit 7 | bit 6 | PFB |
|---|---|---|---|
| 0 | 0 | 0 | Information pdu |
| 0 | 0 | 1 | Protected pdu |
| 0 | 1 | 0 | ACK/NACK pdu |
| 1 | 0 | 0 | Supervisory pdu |
| Other settings are RFU | | | |

**Figure 32 specifies the structure of the Information pdu.**

| bit 8 | bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 |
|---|---|---|---|---|---|---|---|
| ZERO | ZERO | ZERO | MI | NAD | DID | PNI | PNI |

**Figure 32 —the information pdu**

— bit 8 to bit 6: Shall be set to all ZEROs.

— bit 5: If bit set to ONE then it indicates Multiple Information (MI) chaining activated.

— bit 4: If bit set to ONE then it indicates NAD available.

— bit 3: If bit set to ONE then it indicates DID available.

— bit 2 and bit 1: PNI packet number information.

The Packet Number Information (PNI) counts the number of packet send by the Initiator to the Target and vice versa starting by 0. These bytes are used for error detection during the protocol handling.

**Figure 33 specifies the structure of the ACK/NACK pdu.**

| bit 8 | bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 0 |
|---|---|---|---|---|---|---|---|
| ZERO | ONE | ZERO | ACK/NACK | NAD | DID | PNI | PNI |

**Figure 33 —ACK/NACK pdu**

— bit 8: Shall be set to ZERO.

— bit 7: Shall be set to ONE.


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Masimo v. Apple
IPR2023-00734

— bit 6: Shall be set to ZERO.

— bit 5: If bit set to ONE then it indicates NACK, otherwise ACK.

— bit 4: If bit set to ONE then it indicates NAD available.

— bit 3: If bit set to ONE then it indicates DID available.

— bit 2 and bit 1: PNI packet number

**Figure 34 specifies the Supervisory pdu (Attention-Target Present, Timeout extensions).**

| bit 8 | bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 |
|---|---|---|---|---|---|---|---|
| ONE | ZERO | ZERO | Attention/ Timeout | NAD | DID | ZERO | ZERO |

**Figure 34 —The supervisory pdu**

— bit 8: Shall be set to ONE.

— bit 7 and bit 6: shall be set to ZERO.

— bit 5: If ATTENTION then set to ZERO. If TIME–OUT_EXTENTION then set to ONE.

— bit 4: If bit set to ONE then it indicates NAD available.

— bit 3: If bit set to ONE then it indicates DID available.

— bit 2 and bit 1: Shall be set to ZERO.

**Byte 2: DID**

The DID byte shall be the same as defined during activation of the protocol.

**Byte 3: NAD**

The NAD byte is reserved to build up and address different logical connections on both the Initiator and the Target device. Bit 8 to bit 5 code the logical address of the Initiator, bits 4 to 1 code the logical address of the Target. The following definitions shall apply for the usage of the NAD.

— The NAD shall only be used for the data exchange protocol.

— When the Initiator uses an NAD, the Target shall also use an NAD.

— If MI bit is set, the NAD shall only be transmitted in the first frame.

— The Initiator shall never use the NAD to address two different Targets.

**Byte 4 to Byte *n*: User data bytes**

The data field shall contain the transported data and is optional. When present, it conveys either application data or status information. The length of the data field is calculated by subtracting the mandatory and optional send bytes of the data exchange transport header from the length byte and additionally subtracting one.

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MASIMO 1054
Masimo v. Apple
IPR2023-00734

#### 12.6.1.2 Handling of pdu number information

##### 12.6.1.2.1 Initiator rules

The PNI of the Initiator shall be initialized for each Target with all ZEROs.

When an information or acknowledge pdu with an equal PNI is received, the Initiator shall increment the current PNI for that Target before optionally sending a new frame.

##### 12.6.1.2.2 Target rules

The PNI of the Target shall be initialized with all ZEROs.

When an information or acknowledge pdu with an equal PNI was received the Target shall send its response with this PNI and shall increment the PNI afterwards.

#### 12.6.1.3 Handling of Blocks

##### 12.6.1.3.1 General rules

The first pdu shall be sent by the Initiator.

When a data pdu indicating more information is received, the pdu shall be acknowledged by an ACK pdu.

Supervisory pdus are only used in pairs. A Supervisory Request shall always be followed by a Supervisory Response.

##### 12.6.1.3.2 Initiator rules

When an invalid pdu was received a NACK pdu shall be sent (except in the case of DSL or RLS).

When a timeout occurs, an attention command shall be sent (except a NACK has been sent before).

When a timeout occurs and a NACK has been sent before, the NACK shall be retransmitted.

When an ACK pdu is received, if its pdu number is equal to the current PNI of the Initiator, the chaining shall be continued.

If the DSL_REQ is not answered by a valid DSL_RES the DSL_REQ may be retransmitted or the Target command ignored.

##### 12.6.1.3.3 Target rules

The Target is allowed to send an RTO pdu instead of a data pdu.

When a data pdu not containing chaining is received it shall be acknowledged by a data pdu.

When an NACK pdu is received, if the PNI is equal to the PNI of the previous sent pdu, the previous block shall be re-transmitted.

When an erroneous pdu is received the Target shall not answer but stay in same State.

When a Supervisory pdu coding an attention command is received, the Target shall respond sending a supervisory attention pdu response.


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Masimo v. Apple
IPR2023-00734

### 12.6.2 Response timeout extension

The response timeout extension shall only be used by the Target. When a Target needs more time to process the received block from the Initiator than defined in RWT, it shall use a supervisory pdu using response timeout extension request, see Figure 35. A response timeout extension request contains 1 byte long data field. The definition of the byte is shown in Figure 35.

| Bit 8 | bit 7 | bit 6 | Bit 5 | bit 4 | bit 3 | bit 2 | bit 1 |
|---|---|---|---|---|---|---|---|
| ZERO | ZERO | RTOX | RTOX | RTOX | RTOX | RTOX | RTOX |

**Figure 35 —Response timeout extension byte**

— bit 8 and bit 7: Shall be set to ZERO.

— bit 6 to bit 1: RTOX value.

For RTOX the values 0 and 60 to 63 are RFU. For all other values the intermediate $RWT_{INT}$ shall be calculated by the following formula:

$$RWT_{INT} = RWT \times RTOX$$

The $RWT_{INT}$ starts after the Initiator has sent its RTOX response to the Target. In case $RWT_{INT}$ exceeds $RWT_{MAX}$, $RWT_{MAX}$ shall be used. The $RWT_{INT}$ is valid until the next frame has been received by the Initiator.

### 12.6.3 Attention – Target present

The Initiator shall send the attention command to the Target to ensure the Target is still in field for passive mode or to be able to detect a Target loss during multi-activation. This command shall not change the current State of the Target.

The Target shall respond to a valid Attention Request sending an attention command containing the identical data field to the Initiator.

If the Target receives an incorrect pdu it shall not respond and shall stay in the same State.

### 12.6.4 Protocol operation

After the activation sequence the Target shall wait for a block as only the Initiator has the right to send. After sending a block, the Initiator shall switch to receive mode and wait for a block before switching back to transmit mode. The Target may transmit blocks only in response to received blocks. After responding, the Target shall return to the receive mode.

The Initiator shall not initiate a new pair of Request/Response until the current pair of Request/Response has been completed or if the frame waiting time is exceeded without response.

### 12.6.5 Multi Activation

The Multi-Activation feature allows the Initiator to hold several Targets active simultaneously. It allows switching directly between several Targets without needing additional time for deactivation of a Target and activation of another Target.

For an example of Multi-Activation see Table 9. The Initiator needs to handle a separate package number information for each activated Target.

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MASIMO 1054
Masimo v. Apple
IPR2023-00734

**Table 9 — Multi Activation**

| Initiator Action | Status Target 1 | Status Target 2 | Status Target 3 |
|---|---|---|---|
| Choose active mode | | | |
| Activate Target 1 with DID=1 | Selected (1) | Sense | Sense |
| Any communication with DID=1 | Selected (1) | Sense | Sense |
| ... | | | |
| Activate Target 2 with DID=2 | Selected (1) | Selected (2) | Sense |
| Any communication with DID=1,2 | Selected (1) | Selected (2) | Sense |
| ... | | | |
| Activate Target 3 with DID=3 | Selected (1) | Selected (2) | Selected (3) |
| Any communication with DID=1,2,3 | Selected (1) | Selected (2) | Selected (3) |
| ... | | | |
| Deactivation Sequence with DID=1 | Sleep | Selected (2) | Selected (3) |
| Any communication with DID=2,3 | Sleep | Selected (2) | Selected (3) |
| ... | | | |
| Deactivation Sequence with DID=2 | Sleep | Sleep | Selected (3) |
| Any communication with DID=3 | Sleep | Sleep | Selected (3) |
| ... | | | |
| Deactivation Sequence with DID=3 | Sleep | Sleep | Sleep |
| ... | | | |

### 12.6.6 More information (Chaining)

The chaining feature allows the Initiator or Target to transmit information that does not fit in a single block, by dividing the information into several blocks. Each of those blocks shall have a length less than or equal to the maximum frame size ($LEN_{MAX}$).

The chaining bit in the PFB of a protocol frame controls the chaining of frames. Each frame with the chaining bit set shall be acknowledged by an ACK pdu.

The chaining feature is shown in Figure 36 using a 16 byte long string transmitted in three blocks.

## 12.7 Deactivation of the protocol

After exchange of data by using the data exchange protocol, the Initiator may apply a deactivation of the data exchange protocol. After successful deactivation Initiator and Target shall stay in the initially chosen mode, but the Initiator may choose one of the defined bit rates for reactivation.

See 6.4.1 of ISO/IEC 14443-3 and 12.5.2 for reactivation of Targets in passive mode and active mode, respectively.

After successful deactivation the Target shall not respond to subsequent ATR_REQ commands.

The RLS_REQ command shall switch the Target back to POWER ON State. See 12.7.2.1. In this State, the Target shall answer to all initial communication schemes and shall also answer to an ATR_REQ.


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MASIMO 1054
Masimo v. Apple
IPR2023-00734

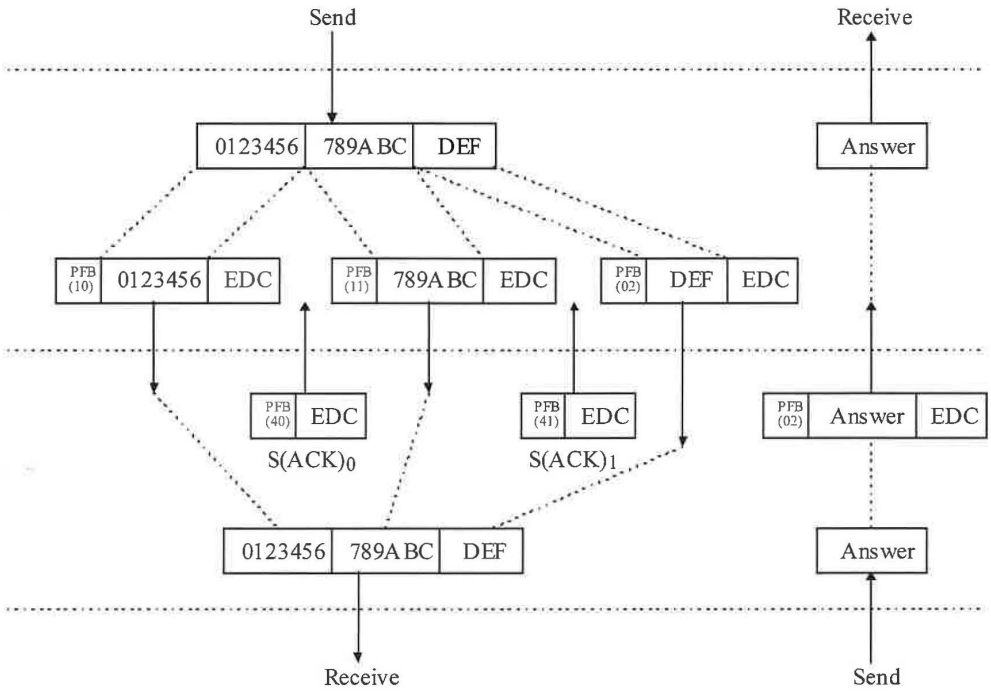


**Figure 36 — More Information (Chaining)**

### 12.7.1 Deselect Request and Response command

#### 12.7.1.1 Deselect request (DSL_REQ)

Figure 37 specifies the deselect command DSL_REQ. The DSL_REQ is sent from Initiator to the Target.

| CMD1 | CMD2 | Byte 1 |
|---|---|---|
| 'D4' | '08' | [DID] |

**Figure 37 — Structure of the DSL_REQ**

##### 12.7.1.1.1 Definition of DSL_REQ bytes

**CMD 1:** Shall be set to 'D4'.

**CMD 2: DSL_REQ**

The DSL_REQ byte specifies the command deselect for the Initiator device. The value of DSL_REQ shall be '08'.

**Byte 1: DID**

The DID shall be the same as defined during ATR or WUP commands.

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Masimo v. Apple
IPR2023-00734

#### 12.7.1.2 Deselect response (DSL_RES)

Figure 38 specifies the Deselect Response command DSL_RES. The DSL_RES is the response to the DSL_REQ and is sent from the Target to the Initiator.

| CMD1 | CMD2 | Byte 1 |
|---|---|---|
| 'D5' | '09' | [DID] |

**Figure 38 — Structure of the DSL_RES**

##### 12.7.1.2.1 Definition of Deselect Response bytes

**CMD 1:** Shall be set to 'D5'.

**CMD 2: DSL_RES**

The DSL_RES byte specifies the command deselect response for the Target device. The value of DSL_RES shall be '09'.

**Byte 1: DID**

The DID shall be the same as in DSL_REQ.

#### 12.7.1.3 Handling of DSL_REQ and DSL_RES

##### 12.7.1.3.1 Initiator rules

When the Initiator has sent a DSL_REQ and received a valid DLS_RES, the Target has been successfully halted. The DID assigned to the Target has been released.

##### 12.7.1.3.2 Target rules

When the Target has received a DSL_REQ and sent its DSL_RES, the Target

— shall stay in initially chosen mode,

— shall enable to receive the default bit rates defined in 11.2 for the Passive communication mode and in 11.3 for the Active communication mode.

— shall remain in receive mode until a valid ALL_REQ is received in passive communication mode at *fc*/128 or a WUP_REQ is received in active communication mode.

### 12.7.2 Release Request and Response commands

#### 12.7.2.1 Release Request (RLS_REQ)

Figure 39 specifies the release command RLS_REQ. The RLS_REQ is sent from the Initiator to the Target.

| CMD1 | CMD2 | Byte 1 |
|---|---|---|
| 'D4' | '0A' | [DID] |

**Figure 39 — Structure of RLS_REQ**


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Masimo v. Apple
IPR2023-00734

#### 12.7.2.1.1 Definition of RLS_REQ bytes

**CMD 1:** Shall be set to 'D4'.

**CMD 2: RLS_REQ**

The RLS_REQ bytes specify the command release for the Initiator device. The value of the RLS_REQ bytes shall be '0A'.

**Byte 1:DID**

The DID shall be the same as defined in ATR or WUP commands.

### 12.7.2.2 Release response RLS_RES

The RLS_RES is the response to the RLS_REQ sent from the Target to the Initiator, see Figure 40.

| CMD1 | CMD2 | Byte 1 |
|---|---|---|
| 'D5' | '0B' | [DID] |

**Figure 40 — Structure of RLS_RES**

#### 12.7.2.2.1 Definition of RLS_RES bytes

**CMD 1:** Shall be set to 'D5'.

**CMD 2: RLS_RES**

The RLS_RES bytes specify the command release for the Target device. The value of the RLS_RES bytes shall be '0B'.

**Byte 1:DID**

The DID shall be the same as defined in RLS_REQ command.

### 12.7.2.3 Handling of RLS_REQ and RLS_RES

#### 12.7.2.3.1 Initiator rules

When the Initiator has sent a RLS_REQ and received a valid RLS_RES, the Target has been successfully released. The Initiator may return to initial State.

#### 12.7.2.3.2 Target rules

When the Target has received a RLS_REQ and sent its RLS_RES, the Target shall return to initial State.

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MASIMO 1054
Masimo v. Apple
IPR2023-00734

# Annex A
(normative)

# CRC calculation

## A.1 CRC for Active and Passive communication mode at *fc*/128

The frame CRC shall be a function of $k$ data bits, which consist of all the data bits in the frame, excluding parity bits, S and E, and the CRC itself. Since data is encoded in bytes, the number of bits $k$ shall be a multiple of 8. For error checking, the two CRC bytes shall be sent in the Standard Frame, after the bytes and before the E.

The CRC shall be calculated by the following polynomial. The pre-set value shall be (6363) and the register content shall not be inverted after calculation.

$$G(x) = x^{16} + x^{12} + x^5 + 1$$

For an example of the CRC calculation for the Active and the Passive mode at *fc*/128. See A.2.

## A.2 Example of CRC calculation at *fc*/128

This example is provided for explanatory purposes and indicates the bit patterns that will exist in the physical layer. It is included for the purpose of checking the Passive communication mode implementation at *fc*/128 encoding.

The process of encoding and decoding may be conveniently carried out by a 16-stage cyclic shift register with appropriate feedback gates. According to ITU-T Recommendation (ITU-T V.41, Code-independent error control system), Annex I, figures I-1/V.41 and I-2/V.41 the flip-flops of the register shall be numbered from FF1 to FF16. FF1 shall be the leftmost flip-flop where data is shifted in. FF16 shall be the rightmost flip-flop where data is shifted out. Table A.1 defines the initial content of the register.

**Table A.1 — Initial content of 16-stage shift register according to value (6363)**

| FF1 | FF2 | FF3 | FF4 | FF5 | FF6 | FF7 | FF8 | FF9 | FF10 | FF11 | FF12 | FF13 | FF14 | FF15 | FF16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 |

Consequently, FF1 corresponds to the msb and FF16 to the lsb.

Examples of bit patterns that will be transmitted via Standard Frames.

Example 1: Transmission of data, first byte = '00', second byte = '00', CRC appended, see Figure A.1.

Calculated CRC = (1EA0), see Table A.2.



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MASIMO 1054
Masimo v. Apple
IPR2023-00734

First bit transmitted

| S | 0000 0000 | 1 | 0000 0000 | 1 | 0000 0101 | 1 | 0111 1000 | 1 | E |
|---|---|---|---|---|---|---|---|---|---|
| | (00) | P | (00) | P | (A0) | P | (1E) | P | |

**Figure A.1 — Example 1 for CRC encoding**

**Table A.2 — Content of 16-stage shift register according to value (1EA0)**

| FF1 | FF2 | FF3 | FF4 | FF5 | FF6 | FF7 | FF8 | FF9 | FF10 | FF11 | FF12 | FF13 | FF14 | FF15 | FF16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |

Example 2: Transmission of data block, first byte = '12', second byte = '34', CRC appended, see Figure A.2.

Calculated CRC = 'CF26', see Table A.3.

First bit transmitted

| S | 0100 1000 | 1 | 0010 1100 | 0 | 0110 0100 | 0 | 1111 0011 | 1 | E |
|---|---|---|---|---|---|---|---|---|---|
| | (12) | P | (34) | P | (26) | P | (CF) | P | |

**Figure A.2 — Example 2 for CRC encoding**

**Table A.3 — Content of 16-stage shift register according to value (CF26)**

| FF1 | FF2 | FF3 | FF4 | FF5 | FF6 | FF7 | FF8 | FF9 | FF10 | FF11 | FF12 | FF13 | FF14 | FF15 | FF16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 |

## A.3 CRC for Active and Passive communication mode at *fc*/64 and *fc*/32

The CRC shall be calculated by the CCITT CRC-16, the scope of which shall include the Length field and the Payload field. Calculation in a $G(x)$ shall be defined by:

$G(x) = x^{16} + x^{12} + x^5 + 1$

Pre-set value shall be 0. For an example of the CRC calculation for the Active and the Passive mode at *fc*/64 and *fc*/32. See A.4.

## A.4 Example of CRC calculation at *fc*/64 and *fc*/32

The sample Frame is as follows: '00' '00' '00' '00' '00' '00' 'B2' '4D' '03' 'AB' 'CD' '90' '35'

'B2' '4D' is SYNC. '03' is the length. 'AB' 'CD' is the user data. '90' '35' is the corresponding CRC.

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Masimo v. Apple
IPR2023-00734

# Annex B
(informative)

# SAK

Figure B.1 illustrates the combination of SAK use in ISO/IEC 14443 and ISO/IEC 18092.

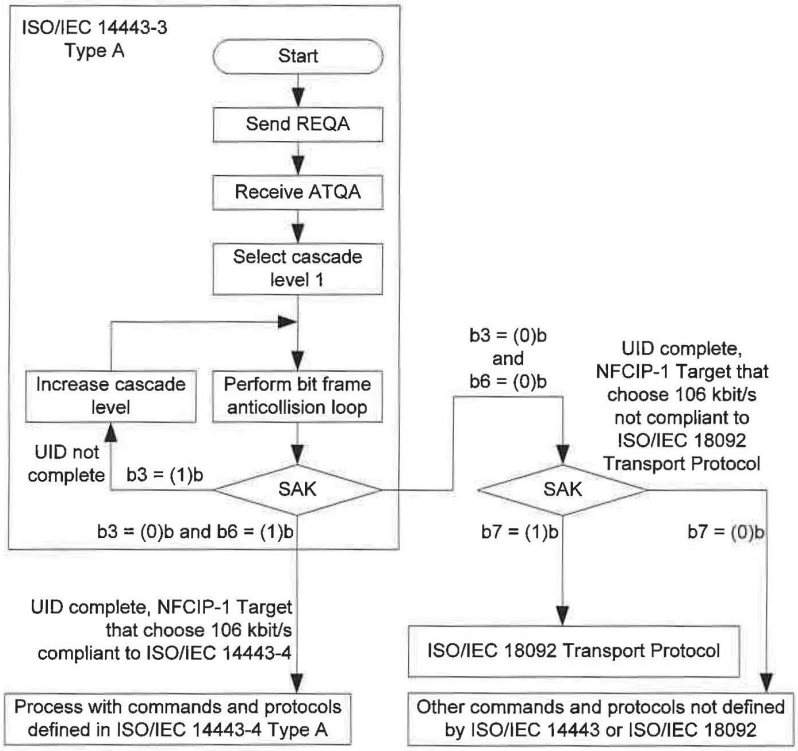


**Figure B.1 — Combination of SAK**


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Masimo v. Apple
IPR2023-00734

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**Masimo v. Apple**
**IPR2023-00734**

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**Masimo v. Apple**
**IPR2023-00734**

# Technical Overview

Near Field Communication (NFC) is a contactless communication technology operating over a radio using a base frequency of 13.56 MHz with a typical range of up to 2cm and data rate from 46kbit/s up to 1.7Mbp/s. In addition to data connections, NFC is unique in that one side can also transmit power over the connection allowing for battery-less

door locks, along with battery-less use case like tags in apparel, packaging, and other consumer products. The Certified Complaint range of NFC Forum connections is 5mm.

# Designed for Flexibility

NFC communication technology is used by several different existing contactless communication protocols in the market which use  different coding for signal and load modulation. The NFC Forum created a set of specifications allowing  NFC Forum Devices to use these different communication protocols. As a result,  NFC Forum Devices are able to communicate with:

**ISO/IEC 14443 Type A compliant Readers and Cards**

**ISO/IEC 14443 Type B compliant Readers and Cards**

**ISO/IEC 15693 compliant Cards**

**ISO/IEC 18092 compliant Devices**

**JIS-X 6319-4 compliant Readers and Cards**

**NFC Forum Tags**

**Other NFC Forum Devices**

Additionally the NFC Forum has defined a variety of modes of operation that allow NFC devices emulate a contactless card, become a reader or writing device of tags or cards, and most recently the ability to transmit up to 1W of power for wireless charging.

# Designed for Contactless

consumer wireless technologies. NFC must start, negotiate a connection while also determining power requirements of the target entity, if needed, power up the remote device, and then transmit with error correction while also gracefully disconnecting all in an instant - the time it takes a user to tap. The primary properties of this connection include:

**Remarkably Fast Startup**

**Power Sensing**

**Short Connection Time**

**Small Data Payload**

The NFC Forum defines several operating modes, the most common today is Card Emulation Mode. This allows a device like a mobile phone or wearable, to emulate a contactless card and connect into an existing framework like payment. The service provider does not need to know it is connecting with a smart device, only that it "looks like" a card.

# Operating Modes

## Card Emulation mode

The NFC Forum Device operates like a contactless card that is able to communicate with a contactless reader device. Typical use cases are the emulation of contactless banking cards for payment or to emulate contactless tickets for public transport.

## Reader / Writer mode

The NFC Forum Device operates like a contactless reader communicating with contactless tags or devices. Mobile application developers can design custom applications that can interact with NFC tags and other devices both reading and then writing data over the tap-based connection. This mode also allows devices to read tags that can include web addresses, contact info, or automations.

## Wireless Charging mode

This mode is used for dedicated transfer of up to 1W of power over the NFC connection. Communication is performed to manage the power transfer. This mode will charge small devices with a limited power supply such as a stylus, headset, fitness tracker, smartwatch, or other small consumer products.

## Host Card Emulation

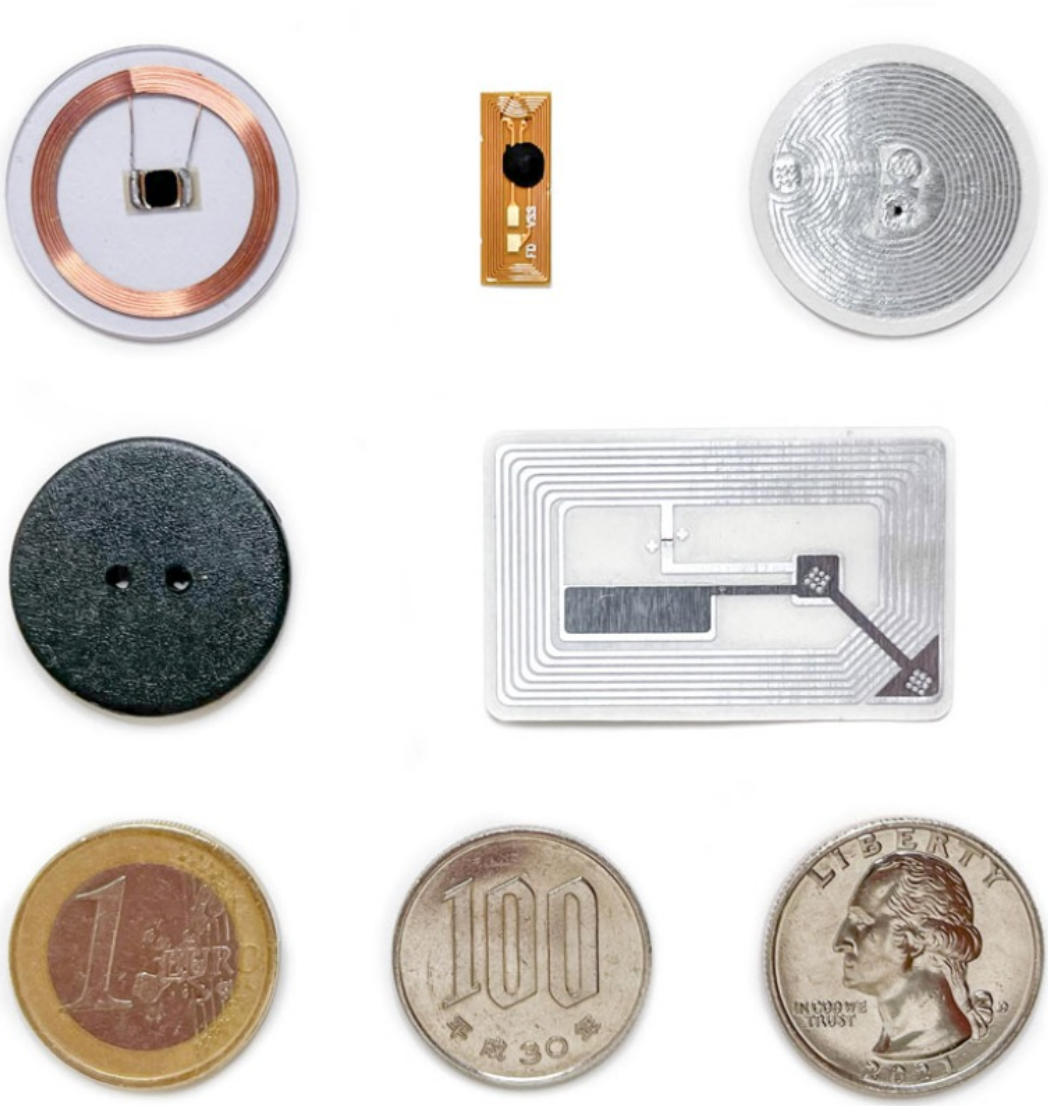
With this implementation, an HCE app located in the Device Host is taking care of emulating the contactless card. In this configuration, the NFC Controller is forwarding all received contactless commands to the Device Host. The HCE app can then communicate with the contactless reader device by using the NFC API.

## Peer-to-Peer mode

Two NFC Forum Devices are touched together to exchange data. This mode is used to easily exchange the contact data of the device users for example or to make a quick connection to transfer the music connection between two sets of speakers.

## Secure Element based Card Emulation

Device or an NFC enabled SIM card inserted in the NFC Forum Device. For both solutions, the commands received from the contactless reader will be forwarded to the secure element for processing. This implementation allows the same high-security level for transactions as those provided by contactless smart card solutions.



NFC Forum Tags are contactless memory cards hosting a specially formatted data payload specified as an NDEF record (NFC Data Exchange Format) defined by an NFC Forum Specification.

Tags are available in a wide variety of form factors. The NFC Forum has defined five different NFC Forum Tag types to allow the usage of many different implementations of sizes, capacities, cost, and functionality. These different NFC Forum Tag types differ by the underlying communication protocol and data structure to store NDEF messages but the resulting overall behavior of NFC Forum Tags is identical.

An NFC Forum Device reading the NDEF message from an NFC Forum Tag will initiate a specific action according to the information stored in this NDEF message. As lots of information can be stored in an NFC Forum Tag, there are many different actions triggered when read by the NFC Forum Device. The following table shows some of the common used data types and the typical corresponding actions initiated by the NFC Forum Device:

| Information stored on NFC Forum Tag | Action initiated at NFC Forum Device |
|---|---|
| Internet Link | Show the linked website |
| Phone number | Initiate a phone call |
| Short message | Send a short message |
| E-mail | Send an e-mail |
| Point of interest | Shows a map with the point of interest |
| Address | Start navigation to this address |
| Contact data | Store the contact data on the NFC Forum Device |

WiFi keys

Login at the WLAN router

# Getting Started

**The NFC Forum Specification and Test Cases define both the digital and analog properties of NFC connectivity. Specifications are available to most members for free, and for a nominal cost to Adopter Members and non-members. Depending on your application and if you are using a Certified Product, you may not necessarily need to access all of the specifications as your supplier can help you through your implementation.**

## NDEF Records

Most tap-based consumer use cases are implemented with an NDEF Record. Even the most casual of implementors should access this Specification and become familiar with both the syntax and operation of tags with differing mobile Operating System providers. There are also a variety of NFC Tag Reading/Writing applications for mobiles that will help those new to the domain learn about tag operation and functionality. One example is NFC Tools in our Product Showcase. Generally in many of these applications the NFC Tag is the simple to use entry-point into a connected web app. Understanding tag capabilities, encoding, and serialization before you start to build the online experience is paramount.

## Developer Tools

Many of the silicon providers in the market provide SDKs and development kits for more sophisticated applications of NFC. We encourage developers to learn the unique capabilities of each supplier, their possible integration or encoding capabilities, and production capacities. It is common for NFC applications, especially in the consumer market, to require high volume capacity so while this isn't a development issue, it is an important design consideration.

Mobile Operating System system providers include various levels of NFC functionality in their developer tool suites. Generally, these implementations can create a read or write session, transmit data across the connection, and provide user feedback throughout the process. Most tag-based application implementations simply hand off processing to the basic NFC reading functionality of the handset which when tapped will present the user a dialog confirming an URL to visit. So while this is most simple implementation, your application can extend this functionality through an SDK.

## Tools for Success

The NFC Forum offers other programs as you navigate development to market availability. Product designers should consider integrating the NFC Branding Marks to help users identify the location of the NFC antenna for a positive user experience. Additionally the NFC Forum has a network of Authorized Test Labs that are experts with Authorized Test Tools and NFC functionality that can help you navigate NFC

**MASIMO 1054**
**Masimo v. Apple**
**IPR2023-00734**

Throughout the year, the NFC Forum hosts webinars and Member Meetings where the community shares new ideas, business connections, and best practices. As a member of the NFC Forum, you are connected into this network and wealth of knowledge.

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# Comparative Analysis of Different Wireless Technologies

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**Abstract**— This paper gives brief understanding of different wireless technologies. Comparative analysis between them with the help of suitable pictures, graphs and tables. This paper covers different wireless technologies including Bluetooth, Infrared, Zigbee, NFC and Wi-Fi. Now a days, wireless technologies becoming more and more advance.In this era, it is more important to do analysis of these technologies to use these at it's maximum.

**Index Terms**— Bluetooth, Infrared, NFC, Wi-Fi, Wireless technology, Zigbee

## I. INTRODUCTION

Wireless technology used to share the data, information between two or more points which are not physically connected. The communication distance between the points can be short, medium and long. Communication can be happened between few meters to kilometers range. The two points can be a mobile, tablet, Television, PDA, Computer, Laptop, wireless keyboard, mouse, GPS unit and many more. Through wireless technology, one can communicate and share the data in long range, which can not be possible through physical interface or wires. Wireless communication canbe possible via radio frequency, microwave and infrared. Technologies like Bluetooth, Wifi, Zigbee and NFC uses radio frequencies to communicate between two points whereas Infrared uses Infrared waves for communication. Using wireless technology, information can be exchange in long range, fastly and securely.

Different technologies used for different purpose according to its need. For example Bluetooth is used in mobile phones, tablets and laptops to send\receive data, sharing networks and listening audio. It's dependent on the need to use which technology where. Range is also a big factor to choose the technology. Whether we have to send the data in short distance or long distance. There are many factors on which we can compare these technologies and conclude that when and where these technologies will be more effective and useful.

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All the comparative analysis will be covered in more detail in this paper.

## II. DIFFERENT WIRELESS TECHNOLOGIES

### Bluetooth

Bluetooth is a short range wireless technology originally intended to replace the cable(s) connecting portable and/or fixed electronic devices. It's a technology standard using short range radio links. Bluetooth operates Frequency Hopping Spread Spectrum (FHSS) to avoid any interference. Bluetooth radios operate in the unlicensed ISM band at 2.4 Gigahertz using 79 channels between 2.402 GHz to 2.480 GHz.

A data channel hops randomly 1600 times per second between the 79 RF channels. Each channel is divided into time slots 625 microseconds long. The range of Bluetooth communication is 0-100 meters, dependent upon power of devices. Every Bluetooth device is classified in three classes (class 1, class 2, and class 3) dependent upon its range.

There are two types of data transfer between devices: SCO (Synchronous Connection Oriented) and ACL (Asynchronous Connectionless). There are different Bluetooth versions available in the market, which are designed for downward compatibility. Now days, Bluetooth is a common feature in many electronic devices including mobile phones, tablets, laptops etc.

Bluetooth technology works using two concepts. Bluetooth Protocol and Bluetooth profiles. Bluetooth protocol defines – how Bluetooth works and Bluetooth

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profiles define – how to use Bluetooth. Bluetooth Special Interest group (SIG) has developed the Bluetooth Protocol stack. Main objective of this specification to achieve interoperability between different device manufacturer companies. There are many Bluetooth profiles like A2DP, AVRCP, DUN, PAN, HFP, HSP, FTP, PBAP, SDP, MAP, HID, HDP, OPP, OBEX, BPP, BIP etc. Every profile is defined for specific purpose. For example A2DP profile is used to listen audio.

**Infrared**

Infrared allows devices to communicate via short-range wireless signals. Through infrared, devices can transfer data bidirectionally. Infrared networks were designed to support direct two connections only, created temporarily as the need arises. Infrared have a frequency in the electromagnetic spectrum in the range just below that of red light. Objects radiate infrared in proportion to their temperature. The main reason for using IrDA had been wireless data transfer over the "last one meter" using point and shoot principles. Thus, it has been implemented in portable devices as mobile phones, laptops, cameras, printers, medical devices and many more. Main characteristics of this kind of optical wireless communication is physically secure data transfer, Line-of-Sight (LOS) and very low bit error rate (BER) that makes it very efficient.

Infrared, a direct or incoming network connection to a remote access server using an infrared port. Infrared technology is the use of the lesser frequency of light for electronic purposes. It needs the hindsight of touch or nearness. Infrared technology is used mainly in television remotes and low budget mobiles. They work through a processor and sensor and need both to be in plain sight of each other. If that is not done, the technology won't work. It works even on reflection and mirrors or water provide genuine reflectors for infrared technology. The general distance between the transmitter and receptor needs to be less than 10 meters.

Infrared radiation is traditionally divided into four categories based on the wavelength. Near Infrared: 750-1500 nanometers. Middle Infrared: 1500-6000 nanometers. Far Infrared: 6000-40,000 nanometers. Far far Infrared: 40.000-1milimeter.

The Infrared Data Association (IrDA) is an industry driven interest group that was founded in 1993 by around 50 companies. IrDA provides specifications for a complete set of protocols for wireless infrared communications and the name "IrDA" also refers to that set of protocols.

**Near Field Communication (NFC)**

Near Field Communication (NFC) is a set of standards for smartphones and similar devices to establish radio communication with each other by touching them together or bringing them into close proximity, usually no more than a few centimeters. NFC used in wide range including contactless transactions, data exchange and use other wireless technology like Bluetooth, wifi in easier way. Communcication is also possible between an NFC device and an unpowered NFC chip called a "tag". NFC builds upon Radio-frequency identification (RFID) systems by allowing two-way communication between endpoints, where earlier systems such as contactless smart cards

TABLE 1
COMPARISON BETWEEN 802.11/A/B/G STANDARD

| | 802.11a | 802.11b | 802.11g |
|---|---|---|---|
| Frequency Band | 5 GHz | 2.4 GHz | 2.4 GHz |
| Speed | 54 Mbps | 11 Mbps | 54 Mbps |
| Bandwidth | Less Interference, more bandwidth | Not as fast as other technologies | Faster than 802.11b |
| Range | Not as widely implemented, shorter range | Best over-all coverage range | better range than 802.11a and Less range than 802.11b |

*Table 1 shows comparison between different Wi-Fi standards*

were one-way only. Since unpowered NFC "tags" can also be read by NFC devices, it is also capable of replacing earlier one-way applications.

NFC is set of short-range wireless technologies, typically requiring a distance of 4 cm or less. NFC operates at 13.56 MHz on ISO/IEC 18000-3 air interface and at rates ranging from 106 kbit/s to 424 kbit/s. NFC always

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IPR2023-00734

involves an initiator and a target; the initiator actively generates an RF field that can power a passive target. This enables NFC targets to take very simple form factors such as tags, stickers, key fobs, or cards that do not require batteries. NFC peer-to-peer communication is possible, provided both devices are powered. NFC tags contain data and are typically read-only but may be rewriteable. They can be custom-encoded by their manufacturers or use the specifications provided by the NFC Forum, an industry association charged with promoting the technology and setting key standards. The tags can securely store personal data such as debit and credit card information, loyalty program data, PINs and networking contacts, among other information. The NFC Forum defines four types of tags which provide different communication speeds and capabilities in terms of configurability, memory, security, data retention and write endurance. Tags currently offer between 96 and 4,096 bytes of memory.

NFC standards cover communications protocols and data exchange formats, and are based on existing radio-frequency identification (RFID) standards including ISO/IEC 14443 and FeliCa. The standards include ISO/IEC 18092 and those defined by the NFC Forum, which was founded in 2004 by Nokia, Philips and Sony, and now has more than 160 members. The Forum also promotes NFC and certifies device compliance.

**Wireless Fidelity (Wi-Fi)**

Wireless Fidelity (Wi-Fi) is a generic term that refers to the IEEE 802.11 communications standard for wireless local area networks (WLANs). Wi-Fi network connect computers to each other, to internet and to the wired network.

The 802.11 standard has been developed to enable wireless local area networking in either the 2.4 GHz or 5.2 GHz ISM bands (Industrial, Scientific, and Medical band) which is qualified by Federal Communications Commission (FCC). Specifically, the frequencies used by 802.11 fall in the unlicensed bands, these are frequency bands which anyone can use for radio communication (without a license). The exact frequencies used (and how they are used) depends on whether the system follows 802.11b, 802.11a, or 802.11g.

There are many security methods available, which is used to prevent wi-fi from unauthorized access or security threat. Most common security methods are Wireless Equivalent Privacy (WEP) and Wi-Fi Protected Access (WPA). WEP is one of the least secure method, which is replaced by WPA. WPA2 is advance version of WPA, which is more secure than WPA.

Both Wi-Fi and Bluetooth wireless technology share spectrum and will often be located in close physical proximity to one another. Wi-Fi and Bluetooth both occupy a section of the 2.4 GHz ISM band that is 83 MHz-wide. So Interference is possible. Due to this data packets get corrupted and are resend again and again. During Interference, when transmitting data on Asynchronous Connection-Less (ACL) links, it will degrade data throughput as more packets need to be resent. However, when using Synchronous Connection Oriented (SCO) links to transmit time-sensitive information such as voice, packets can be lost.

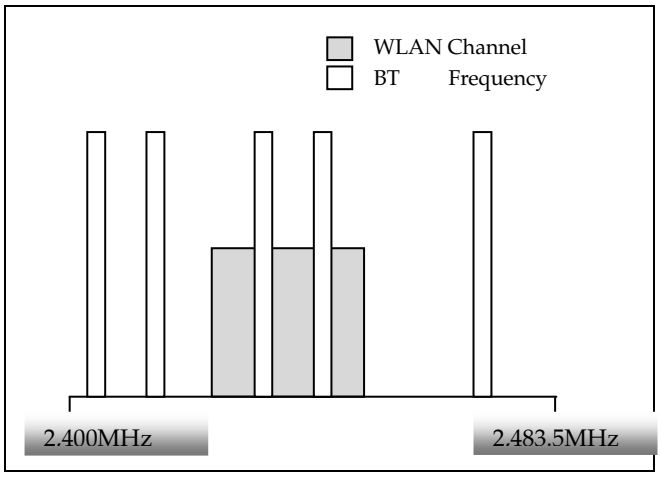


Fig. 1. BT-Wifi Channel Interference

Figure 1 shows BT/Wifi channels. Bluetooth uses Frequency Hopping Spread Spectrum (FHSS) and is allowed to hop between 79 different 1 MHz-wide channels in this band at a rate of 1600hops/s. Wi-Fi uses Direct Sequence Spread Spectrum (DSSS) divides 83 MHz into 11 channels with 22MHz wide. Channels do not hop or change frequency and remains centered on one channel. Bluetooth uses AFH(Adaptive Frequency Hopping) which classifies good and bad channels so that bad channels are avoided and replaced by pseudo-randomly selecting out of the remaining good or free channels.

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Masimo v. Apple
IPR2023-00734

**ZigBee**

ZigBee is a specification for a suite of high level communication protocols using small, low-power digital radios based on an IEEE 802 standard for personal area network. ZigBee devices are often used in mesh network form to transmit data over longer distances, passing data through intermediate devices to reach more distant ones.

ZigBee is targeted at applications that require a low data rate, long battery life, and secure networking. ZigBee has a defined rate of 250 kbit/s, best suited for periodic or intermittent data or a single signal transmission from a sensor or input device. Applications include wireless light switches, electrical meters with in-home-displays, traffic management systems, and other consumer and industrial equipment that requires short-range wireless transfer of data at relatively low rates.

ZigBee is a low-cost, low-power, wireless mesh network standard. The low cost allows the technology to be widely deployed in wireless control and monitoring applications. Low power-usage allows longer life with smaller batteries. Mesh networking provides high reliability and more extensive range. ZigBee chip vendors typically sell integrated radios and microcontrollers with between 60 KB and 256 KB flash memory.

Zigbee bases itself on the IEEE 802.15.4-2003 specifications which lay down standards for the Physical and MAC layers. The protocol stack is completed by adding Zigbee's own Network and Application Layers. Drawing analogies from the OSI protocol stack simplifies the study of Zigbee protocol. ZigBee devices are of three types – ZigBee Coordinator (ZC), ZigBee Router (ZR), and ZigBee End Device (ZED).

ZigBee Alliance is a group of more than 300 companies including industry majors like Philips, Mitsubishi Electric, Epson, Atmel, Texas Instruments etc. which are committed towards developing and promoting this standard. The alliance is responsible for publishing and maintaining the ZIgbee specification and has updated it time and again. The manufacturers which are members of the Alliance provide software, hardware and reference designs to anyone who wants to build applications using Zigbee.

## III. Comparative analysis

Wireless technologies can be compared on the basis of different benchmarks. Table 2 gives summary of main differences among the five wireless technologies. For example Wifi provide high data rate, while Bluetooth and ZigBee gives lower data rate.

**Frequency Band**

Bluetooth, Wifi and ZigBee works in 2.4 GHz ISM (Industrial-Scientific-Medical) band.Bluetooth uses frequency hopping (FHSS) with 79 channels, while ZigBee uses direct sequence spread spectrum (DSSS) with 16 channels and 2 MHz bandwidth. Wi-Fi uses DSSS (802.11), complementary code keying (CCK, 802.11b), or OFDM modulation (802.11a/g) with 14 RF channels. Infrared uses 875 nm whereas NFC works at 13.56 MHz frequency.

**Data rate**

Bluetooth works in the range of 1-100m, Infrared 0.2-1m, NFC less than 0.2m, Wifi 100m and Zigbee 1-100m. Bluetooth data transfer rate is 3 Mbit/s, Infrared 4 Mbit/s, NFC 424 Kbit/s, Wifi 54 Mbit/s and Zigbee 250Kbit/s. Maximum number of nodes supported in Bluetooth network is 8(1 master + 7 slave), Infrared - 2, NFC - 2, Wifi – 2007 and Zigbee greater than 65000.

**Security**

Wireless technologies use different encryption and authentication methods to securely transfer the data. Bluetoth uses E0 stream cipher for encrypting the data whereas in Infrared encryption is not used. NFC uses AES encyprion me thod, Wifi uses RC4 stream cipher and Zigbee uses AES block cipher for encrypting the data.

In Bluetooth authentication is done using shared secret key, no authentication is done in Infrared, NFC uses in-built authentication, Wifi has different authentication method and Zigbee uses CBC-MAC.

## IV. Conclusion

This paper is not prepared to show which the best wireless technology is. This paper describes what the differences between various wireless technogy are and which technology fulfils the needs of particular user. Comparison is based on frequency band, range, data transfer rate, modulation type etc.

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MASIMO 1054
Masimo v. Apple
IPR2023-00734

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Orthogonal frequency division multiplexing), COFDM (coded OFDM), MB-OFDM (multiband OFDM), M-QAM (M-ary quadrature amplitude Modula

TABLE 2

DIFFERENCE BETWEEN WIRELESS TECHNOLOGIES

| Standard | Bluetooth | Infrared | NFC | Wi-Fi | ZigBee |
|---|---|---|---|---|---|
| **Governing Body** | Bluetooth SIG | Infrared Data Association | NFC Forum | Wifi Alliance | ZigBee Alliance |
| **IEEE Specification** | 802.15.1 | 802.11 | 802.2 | 802.11a/b/g | 802.15.4 |
| **Frequency Band** | 2.4 GHz | 875 nm +- | 13.56 MHz | 2.4 GHz, 5 MHz | 868/915 MHz, 2.4 GHz |
| **Standard Range** | 1-100m | 0.2-1m | < 0.2 m | 100m | 10-100m |
| **Number of RF channels** | 79 | 50 | 1 | 14 | 1/10, 16 |
| **Max number of nodes** | 8 | 2 | 2 | 2007 | >65000 |
| **Data Transfer Rate** | 3 Mbit/s | 4 Mbit/s | 424 Kbit/s | 54 Mbit/s | 250 Kbit/s |
| **Modulation type** | GFSK | pulse | ASK | BPSK, QPSK, COFDM, CCK, M-QAM | BPSK (+ ASK), O-QPSK |
| **Spreading** | FHSS | PPM | NA | DSSS, CCK, OFDM | DSSS |
| **Basic Cell** | Piconet | Point to Point | Point to point | BSS | Star |
| **Encryption method** | E0 stream cipher | NA | AES | RC4 stream cipher (WEP), AES block cipher | AES block cipher |
| **Authentication** | Shared secret | NA | In-built | WPA2 | CBC-MAC |
| **Data Protection** | 16-bit CRC | 16-bit CRC | 32-bit CRC | 32-bit CRC | 16-bit CRC |
| | | | | | |

*Table 2 shows difference between wireless technologies*

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**MASIMO 1054**
**Masimo v. Apple**
**IPR2023-00734**

# EXHIBIT AAAA

**MASIMO 1054**
**Masimo v. Apple**
**IPR2023-00734**

UNITED STATES PATENT AND TRADEMARK OFFICE

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| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 17/672,653 | 02/15/2022 | Fletcher R. Rothkopf | P22914USC8 | 5302 |

62579 7590 04/20/2022

APPLE INC./BROWNSTEIN
c/o Brownstein Hyatt Farber Schreck, LLP
410 Seventeenth Street
Suite 2200
Denver, CO 80202

| EXAMINER | |
|---|---|
| GEDEON, BRIAN T | |

| ART UNIT | PAPER NUMBER |
|---|---|
| 3792 | |

| NOTIFICATION DATE | DELIVERY MODE |
|---|---|
| 04/20/2022 | ELECTRONIC |

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

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

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

patentdocket@bhfs.com



**MASIMO 1054**
**Masimo v. Apple**
**IPR2023-00734**

| *Office Action Summary* | **Application No.** 17/672,653 | **Applicant(s)** Rothkopf et al. | |
|---|---|---|---|
| | **Examiner** BRIAN T GEDEON | **Art Unit** 3792 | **AIA (FITF) Status** Yes |

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

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

1)☑ Responsive to communication(s) filed on 24 February 2022.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL.** 2b) ☑ This action is non-final.

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

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims***

5) ☑ Claim(s) 21-40 is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6) ☐ Claim(s) _____ is/are allowed.

7) ☑ Claim(s) 21-40 is/are rejected.

8) ☐ Claim(s) _____ is/are objected to.

9) ☐ Claim(s) _____ are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

**Application Papers**

10)☐ The specification is objected to by the Examiner.

11)☑ The drawing(s) filed on 15 February 2022 is/are: a)☑ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

**Priority under 35 U.S.C. § 119**

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

**Certified copies:**

a)☐ All b)☐ Some** c)☐ None of the:

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

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

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

** See the attached detailed Office action for a list of the certified copies not received.

**Attachment(s)**

1) ☑ Notice of References Cited (PTO-892)

2) ☑ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☐ Other: _____.



**MASIMO 1054**
**Masimo v. Apple**
**IPR2023-00734**

## DETAILED ACTION

### *Notice of Pre-AIA or AIA Status*

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

### *Priority*

2. This application is a continuation of US Application nos. 17/188,966 and 17/188,995 both filed 1 March 2021, both are continuations of US Application no. 16/826,130, now US Patent no. 10,942,491 filed 20 March 2020, which is a continuation of US Application nos. 15/261, 914 now US Patent no. 10,613,485, 15/261,912, now US Patent no. 10,620,591, and 15/261,917 now US Patent no. 10,627,783 filed 10 September 2016, which are continuations of US Application no. 14/842,617, now US Patent no. 10,599,101 filed 1 September 2015, which claims the benefit of domestic priority of US Provisional Application no. 62/044,974 filed 2 September 2014.

### *Information Disclosure Statement*

3. The information disclosure statement filed 15 February 2022 has been considered.

### *Response to Amendment*

4. The preliminary amendment filed 24 February 2022 has been acknowledged. Claims 21-40 are pending.

### *Claim Objections*

5. Claim 24 is objected to because of the following informalities: claim 24 is a duplicate of claim 23. Appropriate correction is required.

6. Claim 27 is objected to because of the following informalities: claim 27 is a duplicate of claim 25. Appropriate correction is required.

### *Claim Rejections - 35 USC § 103*

7. In the event the determination of the status of the application as subject to AIA 35 U.S.C. 102 and 103 (or as subject to pre-AIA 35 U.S.C. 102 and 103) is incorrect, any correction of the statutory basis for the rejection will not be considered a new ground of rejection if the prior art relied upon, and the rationale supporting the rejection, would be the same under either status.

8. The following is a quotation of 35 U.S.C. 103 which forms the basis for all obviousness rejections set forth in this Office action:

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

9. Claims 21, 22, 26, 28-30, 33-35, 37, 39, and 40 is/are rejected under 35 U.S.C. 103 as being unpatentable over Hong et al. (US Publication no. 2014/0275852).

In regard to claims 21, 28, and 35, Hong et al. describe a wearable device in the embodiment of a wearable watch for biometric monitoring. Figures 2a and 2b show a housing of the wearable device, wherein figure 2a shows the front surface and figure 2b depicts the rear surface. The housing is attached to a band for attaching to a user. The

illustration in figure 2a is considered to describe a front surface opening of the housing with an electronics package and display, wherein the screen of the display is considered to comprise a front cover and front exterior surface. The display may include capacitive touch detection to make the display touch sensitive (para 239, 272, and 280). Figure 2b depicts the rear portion of the wearable device with a second opening in which an optical sensor is located. The optical sensor has a rear cover that is optically transparent (para 145, 146, and 155) and defines a protruding convex exterior surface at the sensor (para 153 and 154). The optical sensor is configured as a PPG biosensor which measures a heart rate (para 36, 37, 39, and 136-156). This input from this sensor would comprise a first physiological signal. Hong et al. also contemplates that other types of sensors may be incorporated with the wearable device. Such sensors are found in Table 1 (para 110), wherein such additional sensors include ECG and galvanic skin conductance electrodes (para 110 and 186). The input from these sensors is considered to comprise a second physiological signal. This contemplation is considered suggestive to one of ordinary skill in the art the combination of the additional sensors within the wearable device. It is also considered that one of ordinary skill in the art would readily recognize that the skin conductance and ECG sensors necessarily require electrodes for proper functioning and signal measurement. Hong et al. does fail to suggest is that the electrodes for such sensors may be located on the rear portion of the housing. Instead, Hong et al. teaches that skin conductance electrodes may be mounted on the strap. However, this difference merely pertains to the location of the electrode sensors, not to the function. The function of the sensors is independent or location, whether in the housing or on the band the sensors would function in the same

manner and provide the same data. Thus, the location of the sensor, as long as it contacts the skin, does not affect or influence the operation of the sensor and presents little critical structure. Therefore it is considered to have been obvious to one of ordinary skill in the art at the time of the invention to modify Hong et al. to include electrode sensors for either galvanic skin conductance or ECG because the reference explicitly suggests the addition. The modification in this case would pertain to the combination of prior art elements as conventionally known to yield predictable results. Additionally, modifying Hong et al. to include such sensors on the housing as opposed to the attachment band is considered to have been obvious to one of ordinary skill in the art since the modification would pertain to rearranging the location of working elements, wherein the rearranged location would continue to provide similar measurements from such sensors.

In regard to claim 22, Hong et al. includes an attachment band as shown in figure 2A. The optical sensor of Hong et al. is configured as a PPG sensor to measure heart rate (para 36, 37, 39, and 136-156). Further, as discussed, Hong et al. suggests incorporation of additional sensors which may be used to measure ECG signals ((para 110 and Table 1). The ECG sensor proposed by Hong et al. would comprise a second physiological signal.

In regard to claim 26, as discussed, Hong et al. suggests incorporation of additional sensors which may be used to measure galvanic skin conductance (para 186). The galvanic skin conductance sensor proposed by Hong et al. would comprise a second physiological signal.

In regard to claims 29 and 39, the rear side of Hong et al., as depicted in figure 2b, includes a convex portion which is considered to define a convex exterior surface (para 153-154).

In regard to claim 30, the convex cover portion of Hong et al. includes an optically transparent window, such as a lens, for light transmission (para 153-154).

In regard to claim 33, the optical sensor of Hong et al. is configured as a PPG sensor to measure heart rate (para 36, 37, 39, and 136-156). This signal is considered to comprise a first physiological signal.

In regard to claim 35, as discussed, Hong et al. suggests incorporation of additional sensors which may be used to measure ECG signals ((para 110 and Table 1). The ECG sensor proposed by Hong et al. would comprise a second physiological signal. Additionally, one of ordinary skill in the art is considered to readily recognize that such sensor requires at least one electrode for proper operation and measurement.

In regard to claim 40, figure 4b of Hong et al. shows the optical sensor configuration comprising an optical light emitter in the form of LEDs and an optical sensor in the form of a photodetector for receiving reflected portions of light from the target vein. The light is transmitted and reflected through a convex optical lens.

10. Claim 34 is/are rejected under 35 U.S.C. 103 as being unpatentable over Hong et al. (US Publication no. 2014/0275852) in view of Memering et al. (US Publication no. 2015/0085429).

In regard to claim 34, Hong et al. is considered to substantially suggest the invention as claimed, including a convex cover portion comprising an optically

transparent window, such as a lens, for light transmission (para 153-154). However, Hong et al. does not teach that the lens material is sapphire. Memering et al. teaches that sapphire is a suitable transparent material for manufacturing as a cover and as improved resistance to scratches and damage (abstract and para 5, 20 ,26). In view of these properties, sapphire is considered a suitable material for the claimed intended use. Therefore, modification of Hong et al. to use sapphire for the convex covering of the optical sensor is considered to have been obvious to one of ordinary skill in the art since Memering et al. teaches the suitability of the material for the intended use, and it has been held by the reviewing courts that where the selection of a preferred material for an intended use only requires routine skill in the art.

11. Claims 23, 24, 31, 32, and 36 is/are rejected under 35 U.S.C. 103 as being unpatentable over Hong et al. (US Publication no. 2014/0275852) in view of Lo et al. (US Patent no. 5,738,104).

In regard to claims 23, 24, 31, 32, and 36, Hong et al. is considered to substantially suggest a wrist wearable sensor that may include electrodes for sensing ECG or galvanic skin conductance signals. However, Hong et al. does not teach that the ECG is signal measuring portion includes a first, second, and third electrode. Lo et al. show a wrist based monitor for ECG and heart rate that utilizes a three contact approach for measuring ECG. The three contact approach uses three electrodes which are connected to differential amplifiers in order to suppress common mode noise (col Three electrodes are considered to be conventional for ECG measurements. Therefore modification of the suggested ECG and/or galvanic skin response electrodes in Hong et

al. to include at least three electrodes is considered to have been obvious to one of ordinary skill in the art at the time of the invention since the modification would pertain to the application of a conventional technique for acquiring ECG signals to a known device to yield predictable results.

12. Claims 25, 27, and 38 is/are rejected under 35 U.S.C. 103 as being unpatentable over Hong et al. (US Publication no. 2014/0275852) in view of Ikegami (US Patent no. 4,274,152).

In regard to claims 25, 27, and 38, Hong et al. is considered to substantially suggest the invention as claimed, however does not teach an input mechanism that permits rotational and translation motion as an input form, mounted on the side of the watch housing. Ikegami shows a wrist watch and demonstrates it is common to set watch settings using a setting mechanism (such as crown or winding stem) located on the side of the watch housing and configured for rotational and axial translational setting motion (col 4 lines 18-40). The rotational and translational crown is considered a conventional structural element for enabling input on a watch to provide setting selection and adjustment. Modification of Hong et al. to include a rotational and translational input setting mechanism is considered to have been obvious to one of ordinary skill in the art at the time of the invention since it would pertain to the application of a known element and technique conventionally utilized in the watch art to enable setting adjustment to a similarly known device to yield a predictable result.

***Conclusion***

13. Any inquiry concerning this communication or earlier communications from the examiner should be directed to BRIAN T GEDEON whose telephone number is (571)272-3447. The examiner can normally be reached M-F 8:00 am to 5:30 PM ET.

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

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Carl H Layno can be reached on 571-272-4949. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of published or unpublished applications may be obtained from Patent Center. Unpublished application information in Patent Center is available to registered users. To file and manage patent submissions in Patent Center, visit: https://patentcenter.uspto.gov. Visit https://www.uspto.gov/patents/apply/patent-center for more information about Patent Center and https://www.uspto.gov/patents/docx for information about filing in DOCX format. For additional questions, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/BRIAN T GEDEON/
Primary Examiner, Art Unit 3792
18 April 2022

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

| | | | |
|---|---|---|---|
| Inventor(s): | Fletcher R. Rothkopf et al. | | |
| App. No.: | 17/672,653 | Con. No.: | 5302 |
| Filed: | February 15, 2022 | Art Unit: | 3792 |
| Title: | WEARABLE ELECTRONIC DEVICE | Examiner: | Brian T. Gedeon |

**AMENDMENT AND RESPONSE TO OFFICE ACTION**

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

Commissioner:

In response to the Office action dated April 20, 2022, please consider the following remarks and amend the above-identified application as follows:

**Amendments to the Claims** begin on page 2 of this paper.

**Remarks** begin on page 7 of this paper.



**MASIMO 1054**
**Masimo v. Apple**
**IPR2023-00734**

**Amendments to the Claims:**

1. – 20. (Cancelled)

21. (Currently Amended) A wearable electronic device comprising:

a housing defining a first opening and a second opening;

a display positioned at least partially within the first opening;

a front cover positioned over the display and defining at least a portion of a front exterior surface of the wearable electronic device; and

a biosensor module comprising:

a rear cover positioned at least partially within the second opening and defining an optically transparent window and a protruding convex surface;

an optical sensor aligned with the optically transparent window;

a first electrode positioned along a rear surface of the wearable electronic device; and

a second electrode positioned along the rear surface of the wearable electronic device; and

a third electrode positioned along a side of the wearable electronic device, wherein:

the wearable electronic device is configured to measure a first physiological parameter of a wearer using the optical sensor; and

the wearable electronic device is configured to measure a second physiological parameter using the first electrode, [[and]] the second electrode, and the third electrode.

22. (Previously Presented) The wearable electronic device of claim 21, wherein:

the wearable electronic device further includes a watch band coupled to the housing and configured to couple the wearable device to a wearer;

the optical sensor is a heart-rate sensor;

the first electrode is an electrode of an electrocardiograph sensing system; and

the second parameter is an electrocardiogram.

23. (Cancelled)

24. (Cancelled)



**MASIMO 1054**
**Masimo v. Apple**
**IPR2023-00734**

25. (Previously Presented) The wearable electronic device of claim 21, further comprising an input device positioned along a side of the housing and configured to receive at least one of a rotational input or a translational input.

26. (Previously Presented) The wearable electronic device of claim 21, wherein the second physiological parameter is a galvanic skin response.

27. (Previously Presented) The wearable electronic device of claim 21, further comprising an input device positioned along a side of the housing and configured to receive at least one of a rotational input or a translational input.

28. (Currently Amended) An electronic watch comprising:

a display;

a housing at least partially enclosing the display;

a front cover positioned over the display and defining at least a portion of a front exterior surface of the electronic watch;

a biosensor module defining at least a portion of a rear exterior surface of the electronic watch opposite the front exterior surface, the biosensor module comprising:

a rear cover defining an optically transparent window;

an optical sensor positioned below the optically transparent window;

a first electrode positioned along the rear exterior surface of the electronic watch; and

a second electrode positioned along the rear exterior surface of the electronic watch; and

a third electrode positioned along a side of the electronic watch, wherein:

the electronic watch is configured to measure a first physiological parameter of a wearer using the optical sensor; and

the electronic watch is configured to measure a second physiological parameter using the first electrode, [[and]] the second electrode, and the third electrode.

29. (Previously Presented) The electronic watch of claim 28, wherein the rear cover defines a convex exterior surface.



**MASIMO 1054**
**Masimo v. Apple**
**IPR2023-00734**

30. (Previously Presented) The electronic watch of claim 29, wherein the optically transparent window is located within a portion of the rear cover that defines the convex exterior surface.

31. (Cancelled)

32. (Currently Amended) The electronic watch of claim 28 [[31]], wherein the first electrode, the second electrode, and the third electrode are part of an electrocardiograph sensing system.

33. (Previously Presented) The electronic watch of claim 28, wherein the first physiological parameter is a heart rate.

34. (Previously Presented) The electronic watch of claim 28, wherein the rear cover comprises sapphire.

35. (Currently Amended) A wearable electronic device comprising:

a housing;

a band attached to the housing and configured to couple the wearable electronic device to a user;

a touch-sensitive display positioned at least partially within the housing;

a rear cover positioned at least partially within a rear opening defined along a rear portion of the housing, the rear cover defining at least a portion of a rear exterior surface of the wearable electronic device and having an optically transparent portion;

an optical sensor positioned within the housing and configured to emit an optical signal through the optically transparent portion;

a first electrode positioned along the rear exterior surface of the wearable electronic device; [[and]]

a second electrode positioned along the rear exterior surface of the wearable electronic device; and

a third electrode positioned along a side of the wearable electronic device, wherein:

the wearable electronic device is configured to measure a first physiological parameter using the optical sensor; and



**MASIMO 1054**
**Masimo v. Apple**
**IPR2023-00734**

the wearable electronic device is configured to measure a second physiological parameter using the first electrode, [[and]] the second electrode, and the third electrode.

36. (Cancelled)

37. (Currently Amended) The wearable electronic device of claim 35, wherein:

the first electrode, [[and]] the second electrode, and the third electrode are part of an electrocardiograph sensing system; and

the second physiological parameter is an electrocardiogram.

38. (Previously Presented) The wearable electronic device of claim 35, further comprising an input device positioned along a side of the housing and configured to receive at least one of a rotational input or a translational input.

39. (Previously Presented) The wearable electronic device of claim 35, wherein the rear cover defines a convex exterior surface.

40. (Previously Presented) The wearable electronic device of claim 35, wherein the optical sensor comprises:

an optical emitter configured to emit the optical signal through the optically transparent portion; and

an optical receiver configured to receive a reflected portion of the optical signal through the rear cover.

41. (New) The wearable electronic device of claim 21, wherein the optical sensor comprises:

an optical emitter configured to emit the optical signal; and

an optical receiver configured to receive a reflected portion of the optical signal.

42. (New) The wearable electronic device of claim 41, wherein:

the optical emitter is a first optical emitter configured to emit light having a first wavelength; and

the optical sensor further comprises a second optical emitter configured to emit light having a second wavelength different from the first wavelength.



**MASIMO 1054**
**Masimo v. Apple**
**IPR2023-00734**

43. (New) The wearable electronic device of claim 21, further comprising an input device positioned along a side of the housing and configured to receive a rotational input and a translational input.

44. (New) The wearable electronic device of claim 21, further comprising a wireless charging system configured to receive power wirelessly, from an external charging dock, through the rear exterior surface of the electronic watch.



**MASIMO 1054**
**Masimo v. Apple**
**IPR2023-00734**

## REMARKS

This paper is submitted in response to the Office action mailed on April 20, 2022. This paper amends claims 21, 28, 32, 35, and 37, cancels claims 23-24, 31, and 36, and adds claims 41-44. The amendments and arguments presented herein, as well as any claim cancellations, are made solely for the purpose of advancing prosecution, and do not indicate acquiescence to the rejections or to any characterizations of the cited references or the instant claims. Moreover, all amendments and remarks herein are made without prejudice to, disclaimer of, or dedication of any subject matter, and a right is specifically reserved to file continuation and/or divisional applications claiming any subject matter disclosed in the application.

After entry of this Amendment and Response, claims 21-22, 25-30, 32-35, and 37-44 will be pending.

*I. Claim Objections*

Claims 24 and 27 are objected to because of certain informalities. Appropriate correction has been made. Claims 24 and 27 have been cancelled, rendering the rejection of these claims moot. The Assignee respectfully requests that the rejection be withdrawn.

*II. Claim Rejections Under 35 U.S.C. § 103*

Claims 21, 22, 26, 28-30, 33-35, 37, 39, and 40 are rejected under 35 U.S.C. § 103 as being unpatentable over U.S. Publication No. 2014/0275852 to Hong et al. (hereinafter "Hong"). These claims are believed to be patentable at least because Hong does not teach or suggest all the limitations of the amended independent claims.

Amended claim 21 recites (emphasis added):

> A wearable electronic device comprising:
>
> a housing defining a first opening and a second opening;
>
> a display positioned at least partially within the first opening;
>
> a front cover positioned over the display and defining at least a portion of a front exterior surface of the wearable electronic device; and
>
> a biosensor module comprising:
>
> a rear cover positioned at least partially within the second opening and defining an optically transparent window and a protruding convex surface;
>
> an optical sensor aligned with the optically transparent window;



**MASIMO 1054**
**Masimo v. Apple**
**IPR2023-00734**

> **a first electrode positioned along a rear surface of the wearable electronic device; and**
>
> **a second electrode positioned along the rear surface of the wearable electronic device; and**
>
> **a third electrode positioned along a side of the wearable electronic device**, wherein:
>
> the wearable electronic device is configured to measure a first physiological parameter of a wearer using the optical sensor; and
>
> **the wearable electronic device is configured to measure a second physiological parameter using the first electrode, the second electrode, and the third electrode**.

Thus, amended claim 21 recites a wearable electronic device with "a first electrode **positioned along a rear surface** of the wearable electronic device," "a second electrode **positioned along the rear surface of the wearable electronic device**," and "a third electrode **positioned along a side of the wearable electronic device**." Thus, claim 21 recites a wearable electronic device with at least three electrodes, with two electrodes "positioned along the rear surface of the wearable electronic device" and a third "positioned along a side of the wearable electronic device." Thus, for example, the first and second electrodes "make contact with the skin of the user's wrist when the device is being worn" while the third electrode can be contacted by a user's finger, such as "when the user pinches the device 100 between two digits." Specification as filed, ¶ 196.

The Office action acknowledges that Hong "fail[s] to suggest [] that the electrodes for such sensors may be located on the rear portion of the housing," and is not cited for and does not describe "a third electrode positioned along a side of the wearable electronic device," as recited by amended claim 21. Rather, Hong describes that "galvanic skin response electrodes may be hidden in the band." Hong, ¶ 186. Thus, Hong fails to describe the particular configuration of the electrodes as claimed in amended claim 21.

Moreover, it would not be obvious to a person of ordinary skill in the art to modify Hong to move the electrodes from being "hidden in the band" to the locations recited in amended claim 21. For example, in the context of wearable electronic devices, such as watches, health monitoring devices, and the like, the integration of sophisticated electronic systems, such as those that interact with the human body for physiological measurements, is a complex engineering task. Components of such systems, such as skin-contacting electrodes, cannot simply be moved to another location without incurring significant engineering challenges. For example, in the case of Hong, moving electrodes from a band to a rear and a



**MASIMO 1054**
**Masimo v. Apple**
**IPR2023-00734**

side of the device would require significant reengineering of the "portable monitoring device," including its existing optical sensor. Nor would one of ordinary skill in the art have a reasonable expectation that the modification could be performed successfully without impacting the operation of the device (e.g., negatively affecting the operation of the electrodes and associated sensors, the optical sensing system, etc.). Accordingly, such modification is not obvious to one of ordinary skill in the art.

Further, while Lo (cited against dependent claim 23, for example) describes a "heart rate monitor" with "three electrodes," the arrangement of Lo's electrodes is different from that of amended claim 21. In particular, Lo describes a digital watch in which "[t]wo electrical contacts 14 and 16 are placed on the front of the watch for the user to place his or her fingers on when the pulse mode is entered" and "[a] third electrical contact is located on the back side of the watch." Thus, Lo does not describe any electrical contacts "positioned along a side of the wearable electronic device," nor does it describe two electrodes "positioned along the rear surface of the wearable electronic device," as recited by amended claim 21. Even assuming for the sake of argument that one of ordinary skill in the art were to combine Lo with Hong, the combination would still fail to teach or suggest the device of claim 21, as the electrodes would have a completely different physical arrangement than claim 21. One of ordinary skill in the art would also not find it obvious to rearrange Lo's electrodes to meet the arrangement recited in claim 21, as there is no teaching or suggestion in any of the references of the claimed arrangement, let alone any suggestion that the rearrangement could be undertaken without encountering significant engineering challenges or without impacting the functioning of the device.

Amended claim 21 is therefore believed to be allowable, along with its dependent claims, over the rejection of record. Amended independent claims 28 and 35 are believed to be patentable, along with their respective dependent claims, for the same or similar reasons as those described above with respect to claim 21. The Assignee therefore respectfully requests the withdrawal of the § 103 rejection of claims .

Claim 34 is rejected under 35 U.S.C. § 103 as being unpatentable over Hong, in view of U.S. Publication No. 2015/0085429 to Memering et al. (hereinafter "Memering").

Claims 23, 24, 31, 32, and 36 are rejected under 35 U.S.C. § 103 as being unpatentable over Hong, in view of U.S. Patent No. 5,738,104 to Lo et al. (hereafter "Lo").

Claims 25, 27, and 38 are rejected under 35 U.S.C. § 103 as being unpatentable over Hong, in view of U.S. Patent No. 4,274,152 to Ikegami et al. (hereafter "Ikegami").



**MASIMO 1054**
**Masimo v. Apple**
**IPR2023-00734**

Thus, claims 23-25, 27, 31-32, 34, 36, and 38 are rejected based on Hong in view of one or more additional references. Claims 23-24, 31, and 36 are cancelled, rendering the rejection of these claims moot. Claims 25, 27, 32, 34, and 38 each depend from independent claims 21, 28, or 35, and are believed to be allowable at least insofar as the claims depend from patentably distinct base claims. Accordingly, the Assignee submits that dependent claims 25, 27, 32, 34, and 38 are in condition for allowance. The Assignee makes this statement without waiving and without reference to any independent bases of patentability within the claims and thus reserves the right to argue such bases in a future paper if necessary.

*III. Conclusion*

The Assignee thanks the Examiner for the thorough review of the application. The Assignee respectfully submits the present application, as amended, is in condition for allowance and respectfully requests the issuance of a Notice of Allowability as soon as practicable.

The Assignee believes no fees or petitions are due with this filing. However, should any such fees or petitions be required, please consider this a request therefor and authorization to charge Deposit Account No. 504621 as necessary.

If the Examiner should require any additional information or amendment, please contact the undersigned attorney.

Dated: July 20, 2022

Respectfully submitted,

/Peter J. Nagle/

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**MASIMO 1054**
**Masimo v. Apple**
**IPR2023-00734**