UM0801-03

PN533 User Manual

Rev. 03 **User Manual**

Document information

Info	Content
Keywords	NFC, PN533, V2.7
Abstract	This document describes the firmware V2.7 embedded in the PN533.

Revision history

01	2008-04-01	Initial version for firmware version **V2.6 (PN533)**
02	2008-07-31	Update the user manual for the firmware version **V2.7 (PN533)**
03	2009-01-14	Perform some corrections in the User Manual. This UM is applicable for the firmware version **V2.7 (PN533)**

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1. Introduction

1.1 Purpose and Scope

The PN533 is a highly integrated transmission module for contactless communication at 13.56 MHz including microcontroller functionality based on an 80C51 core with 44 Kbytes of ROM and 1232 bytes of RAM.

The PN533 combines a modulation and demodulation concept completely integrated for different kinds of contactless communication methods and protocols at 13.56 MHz with an easy-to-use firmware for the different supported modes and the USB host controller interface.

This document describes the firmware embedded in the PN533 chip, in particular the global behavior in the system depending if the PN533 device is used as initiator or target.

1.2 Intended audience

This document has been written to allow the use of the PN533 from the host controller point of view.

All the RF protocols used by the PN533 are not described in this document. The reader is supposed to have knowledge on NFCIP-1 (Reference [3]) and ISO/IEC14443 (Reference [1] & [2]).

1.3 Glossary

APDU	Application Protocol Data Unit
ATQA	Answer To Request, type A
ATQB	Answer To Request, type B
C-APDU	Command APDU
CIU	Contactless Interface Unit
CL	ContactLess
CPU	Central Processing Unit
CT	Cascade Tag
DEP	ISO/IEC18092 Data Exchange Protocol
DRI	Bit duration of Target to Initiator
DSI	Bit duration of Initiator to Target
E.S.M	Energy Saving Mode
FSL	Maximum value for the Frame Length
I2C	Inter Integrated Circuit
IC	Integrated Circuit
ID	Card Identifier
N/A	Not Applicable
NAD	Node ADdress
NFC-SEC	NFC Secure
N/I	Not Implemented
NU	Not Used
PCB	Protocol Control Byte (ISO/IEC14443-4)

PCD	Proximity Coupling Device (Contactless PCD)
PFB	Control Information for Transaction (NFCIP-1)
PPS	Protocol and Parameter Selection
R-APDU	Response APDU
RATS	Request for Answer To Select
RFA	Radio Frequency Activation
RFU	Reserved for Future Use
SDD	Single Device Detection
SEP	Secure Exchange Protocol
SRS	Software Requirements Specification
TBD	To Be Defined
TLV	Encoding method (Type, Length, Value)
TPE	NFC Transport Protocol Equipped (DEP.Data Exchange Protocol)
TSN	Time Slot Number
T=CL	ISO/IEC14443-4 protocol
UID	Unique Identifier, Type A

1.4 References

[1]	ISO/IEC 14443-3	Identification cards – Contactless integrated circuit(s) cards - Proximity card(s) Part 3: Initialization and anti-collision
[2]	ISO/IEC 14443-4	Identification cards – Contactless integrated circuit(s) cards - Proximity card(s) Part 4: Transmission protocol
[3]	ISO/IEC 18092[1]	Near Field Communication - Interface and Protocol (NFCIP-1)
[4]	PN533/C1 Product Datasheet	PN533 NFC Controller Product data sheet
[5]	AN10682_2	PN533 Application Note
[6]	AN010207-4	Smart Card Reader Application with TDA8029
[7]	NFC-PRIV-P2P	Privacy feature for NFCIP-1 for Peer-to-Peer Communication
[8]	Paypass 1.1	Paypass - ISO/IEC 14443 Implementation Specification 1.1
[9]	EMVco 2.0	EMV Contactless Specifications for Payment Systems 2.0
[10]	USB 2.0	Universal Serial Bus Specification revision 2.0
[11]	I2C 3.0	I²C bus Specification revision 3.0

[1] Purchase of an NXP Semiconductors IC that complies with one of the NFC Standards (ISO/IEC18.092;ISO/IEC21.481) does not convey an implied license under any patent right on that standards.
A license for the portfolio of the NFC Standards patents of NXP B.V. needs to be obtained at Via Licensing, the pool agent of the NFC Patent Pool, e-mail: info@vialicensing.com.

1.5 General presentation of the PN533

- The embedded firmware and the internal hardware support the handling of the host controller protocol for USB interface.

The host controller protocol is defined in chapter 7 (p.34).

The firmware of the PN533 supports the following operating modes:

- PCD mode for FeliCa (212 kbps & 424 kbps), ISO/IEC14443 Type A & B (from 106 kbps to 847 kbps), MIFARE (106 kbps), RFA cards (106 kbps) and Innovision Jewel cards (106 kbps).
- NFC IP-1 (with NFC Secure compliancy) mode.

  The NFC IP-1 mode offers different baud rates from 106 kbps up to 424 kbps. The PN533 handles the complete NFC framing and error detection.
- The PN533 manages an I2C master interface. The PN533 is configured as master and is able to communicate with external EEPROM (address 0xA0) and a smart card reader (TDA8029).
- PN533 in PCD mode is compliant with Paypass specification V1.1 and EMV contactless specification V2.0.

In this document:

- PN533 refers to PN533/V2.7.

2. Configuration Modes

The PN533 has 3 possible modes that can be chosen by using two GPIOs during the reset phase of the IC:

Table 1. Configuration modes

	Selection Pins	
Mode	**P70_IRQ** (pin #21)	**P35** (pin #20)
Standard	1	1
	0	0
PN512 emulation	1	0
RF field ON	0	1

2.1 Standard Mode

This is the default mode of the PN533.

The description of this mode is detailed in this document starting from chapter 3 (p.9).

2.2 PN512 emulation mode

In this test mode, the PN533 is configured to act as real PN512 IC using serial interface.

The PN512 is a transmission module for contactless communication at 13.56 MHz. It integrates a modulation and demodulation concept for different kind of contactless communication methods and protocols.

Then, the PN533 can be easily interfaced with the PN512 dedicated host controller software, as e.g. **Joiner PC Serial**.

The link used is RS232 at 9600 bauds[2]. It is not possible to change the value of the baud rate; the *SerialSpeedReg* register is not emulated.

The emulation of the PN512 IRQ pin is supported as well; the pin used is P70_IRQ. The level of the P70_IRQ pin is low when an interrupt occurs. The bit *IRQInv* in the register *CommIEnReg* has no effect (see [4]).

[2] The RS232 link used here is the standard UART, not the High Speed UART. Consequently, in this mode the PN533 must be interconnected with P30 (pin#24) for the RS232_RX line and P31 (pin#31) for the RS232_TX line.

2.3 RFfieldON Mode

In this mode, the PN533 is configured to switch on its RF field immediately after the reset.

The modulation and the baud rate used depend on the selection GPIOs P33_INT1 and P34/SIC_CLK and random data bytes are continuously sent.

In this mode, the temperature sensor is not activated, so that tests can be done at temperature higher than 125°C.

Table 2. TX framing and TX speed in RFfieldON configuration

	Selection Pins	
TX framing – TX speed	**P33_INT1** (pin #33)	**P34/SIC_CLK** (pin #34)
MIFARE - 106 kbps	1	1
	0	0
FeliCa - 212 kbps	0	1
FeliCa - 424 kbps	1	0

3. Power management

The design of the firmware embedded in the PN533 takes care of power consumption, in a sense that it minimizes the overall power consumption.

This chapter defines the strategy used to save current consumption. The firmware can play with different parameters described hereafter:

- Power modes of the CPU,
- Power modes of the CL front-end,
- Management of pin configuration.

3.1.1 Power modes of the PN533

The PN533 has different power modes which are listed in the following table (refer to [4] to have a complete description).

3.1.1.1 Power modes for CPU

Table 3. Power modes for CPU

Power Mode	Description
Hard Power Down	The CPU is in reset state. This mode can be reached only by an external action on RSTPDN pin, not by a firmware action.
Normal	The CPU is running.
Power Down	Oscillator is stopped, needs delay to be waken up (typ. 500µs).

3.1.1.2 Power modes for Contact Less interface

Table 4. Power modes for CL interface

Power Mode	Description
Hard Power Down	The contactless UART and the analog front end are in reset state. This mode can be reached only by external action on RSTPDN pin, not by a firmware action.
CL_A	The contactless UART is running. The analog front end is operational. RF field is **not** generated.
CL_B	The contactless UART is running. The analog front end is operational. **RF field** is generated.
CL_C	The contactless UART is in Power Down mode. The analog front end is partially operational (only the RF level detector is active). RF field is **not** generated.
CL_D	The contactless UART and the analog front end are set in the mode in which the power consumption is the minimum, i.e. power down with RF level detector not activated.

3.1.1.3 Power modes for the TDA8029

Table 5. Power modes for the TDA8029

Power Mode	Description
Hard Power Down	The TDA8029 is in reset state
Shutdown	The CPU of the TDA8029 is set in powerdown mode.
Normal	The TDA8029 is running

3.1.2 Operating modes of the PN533

3.1.2.1 Mode dispatcher

The firmware adapts the overall power consumption to the real needs depending on the state where it is.

Several cases have to be considered; the power modes involved being different:

- Standby mode,
- Initiator / PCD mode,
- Target mode.

The transition between the three defined modes is automatically done by the firmware, either due to a change in the internal state machine (PN533 acting as target has been released for example) or by the reception of a command from the host controller.

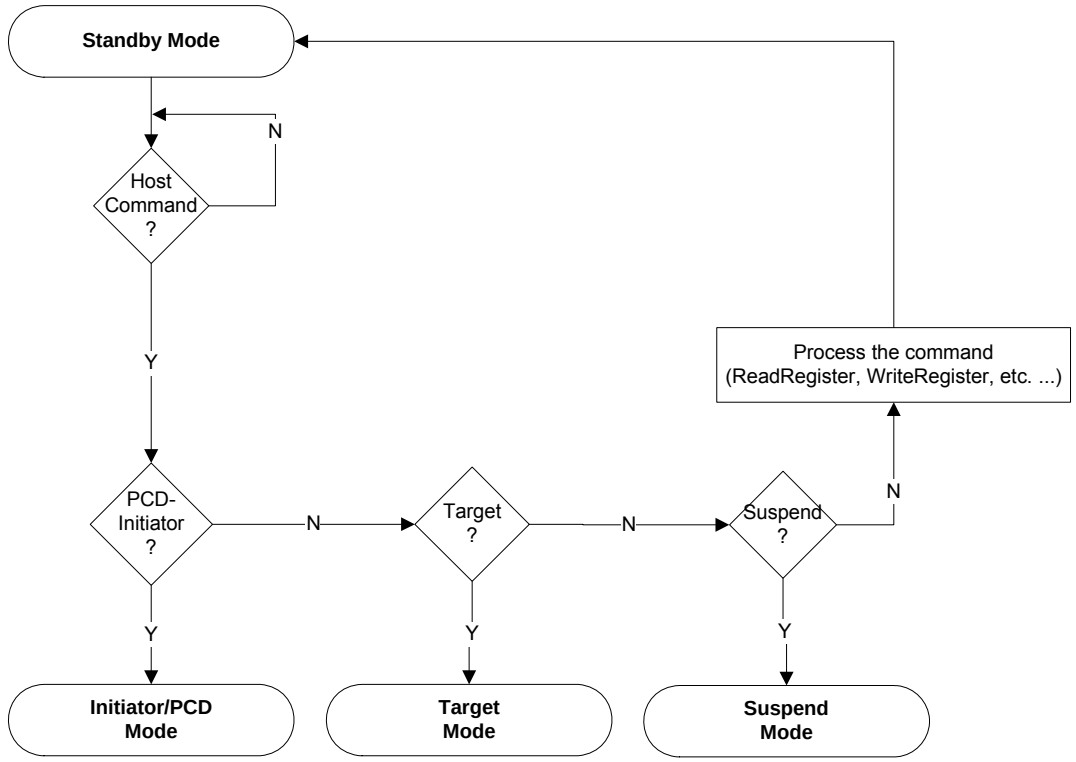


Fig 1. Mode Dispatcher

3.1.2.2 Standby mode

The Standby mode is the starting mode after reset; the PN533 stays in this mode until it is not commanded to go into any other mode.

After reset, the PN533 stays in Normal mode regarding the CPU, and in CL_D mode regarding the contact less interface. (see Table 3, p.10).

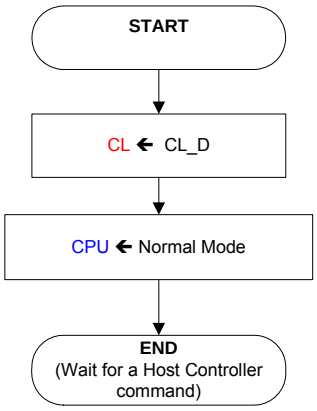


Fig 2. Standby mode

3.1.2.3 Suspend mode

The Suspend mode is the preferred mode to save power consumption.

PN533 may enter in suspend mode due to the host entering a suspend mode of its own. In addition, PN533 shall also enter in Suspend mode when the computer hub port is disabled (according to reference §7.1.7.6 of [10]).

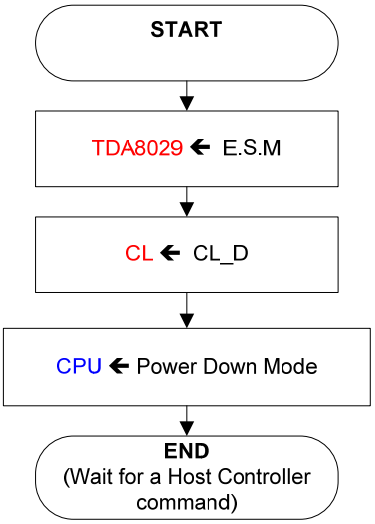


Fig 3. Suspend mode

3.1.2.4 Initiator / PCD mode

This mode is the one used when the PN533 has one target (or card) activated.

All the initiator commands listed in Table 14, p.48 are using this mode.

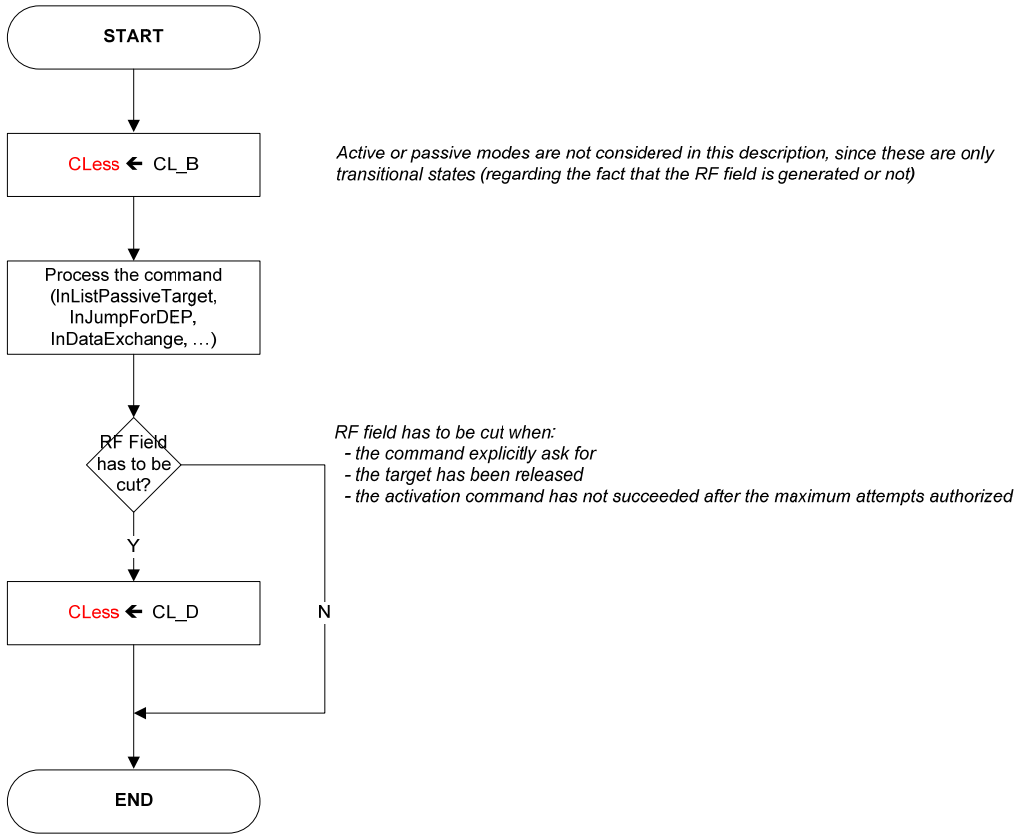


Fig 4. Initiator / PCD mode

3.1.2.5 Target Mode

This mode is the one used when the PN533 is configured as target.

All the target commands listed in Table 14, p.48 are using this mode.

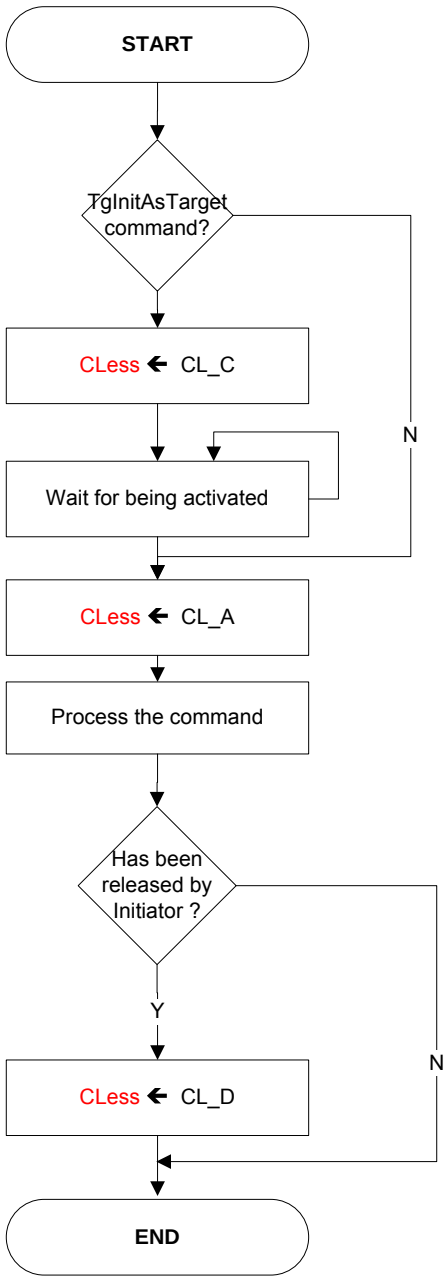


Fig 5. Target mode

3.1.2.6 Management of GPIO configuration

A management of GPIO configuration of the PN533 ports P3 and P7 is implemented in order to reduce the power consumption in power-down mode.

If a GPIO is forced in low state by external conditions, the following actions are taken before going into power-down mode:

- The initial configuration of the GPIO is saved (input, quasi-bidirectional or output mode),
- The GPIO is then configured in input mode.

When the PN533 exits the power-down mode, the initial configuration of the GPIO is restored. Therefore, every GPIO of the ports P3 and P7 recovers its initial configuration.

3.1.2.7 Management of RF field in the activation commands

The activation commands are the first RF communication commands used to initialize a communication session. The usual activation commands are **`InListPassiveTarget`**, **`InJumpForDEP`**, **and `InJumpForPSL`** (see Table 14, p.48).

When these commands are launched, they send activation requests until a target is found.

The abortion of an on-going activation command will automatically switch off the RF field in order to reduce the power consumption.

The RF field is also switch off if no target has been found before the number of retries (see §8.4.1, p.73) is over.

4. NFC Secure

NFC Secure Standard specifies an application layer on top of NFCIP-1 interface and protocol. The NFC Secure layer protects the communication on the RF interface against eavesdropping and data modification (at the NFCIP-1 message level) by cryptographic methods. The protocol can be activated either by the Initiator or by the Target.

This layer is implemented on the application level. The PN533 provides only a pipe of exchange; all the cryptographic methods are implemented on the application layer.

During a secured DEP, the upper 3 bits of the NFCIP-1 Data Exchange Protocol PFB byte shall be set to 001. The remaining bits of the PFB byte shall be identical to the ones used in a normal Data Exchange Protocol Request and they are used in the same way.

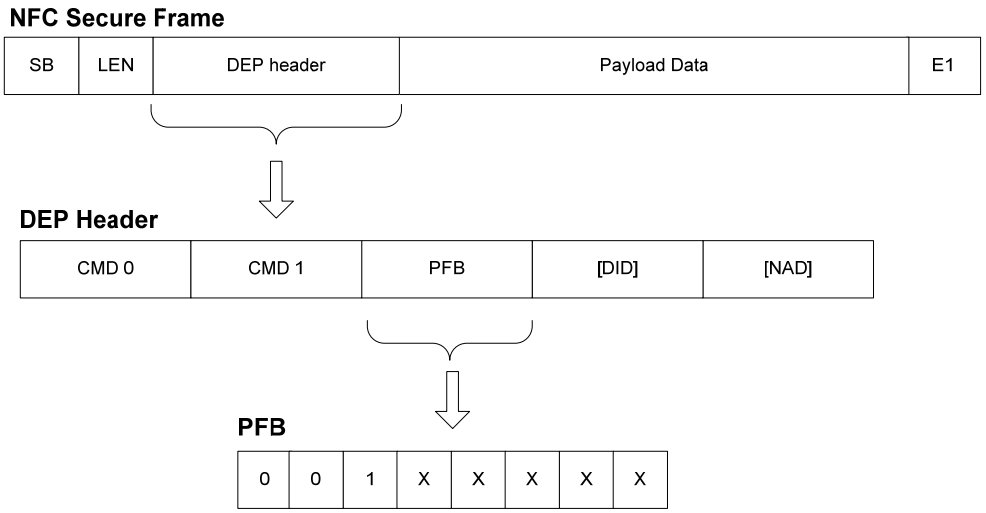


Fig 6. NFC Secure frame

Two examples of Secret Channel establishment activated either by the Initiator or by the Target are shown below. Acknowledge are not shown on these figures.

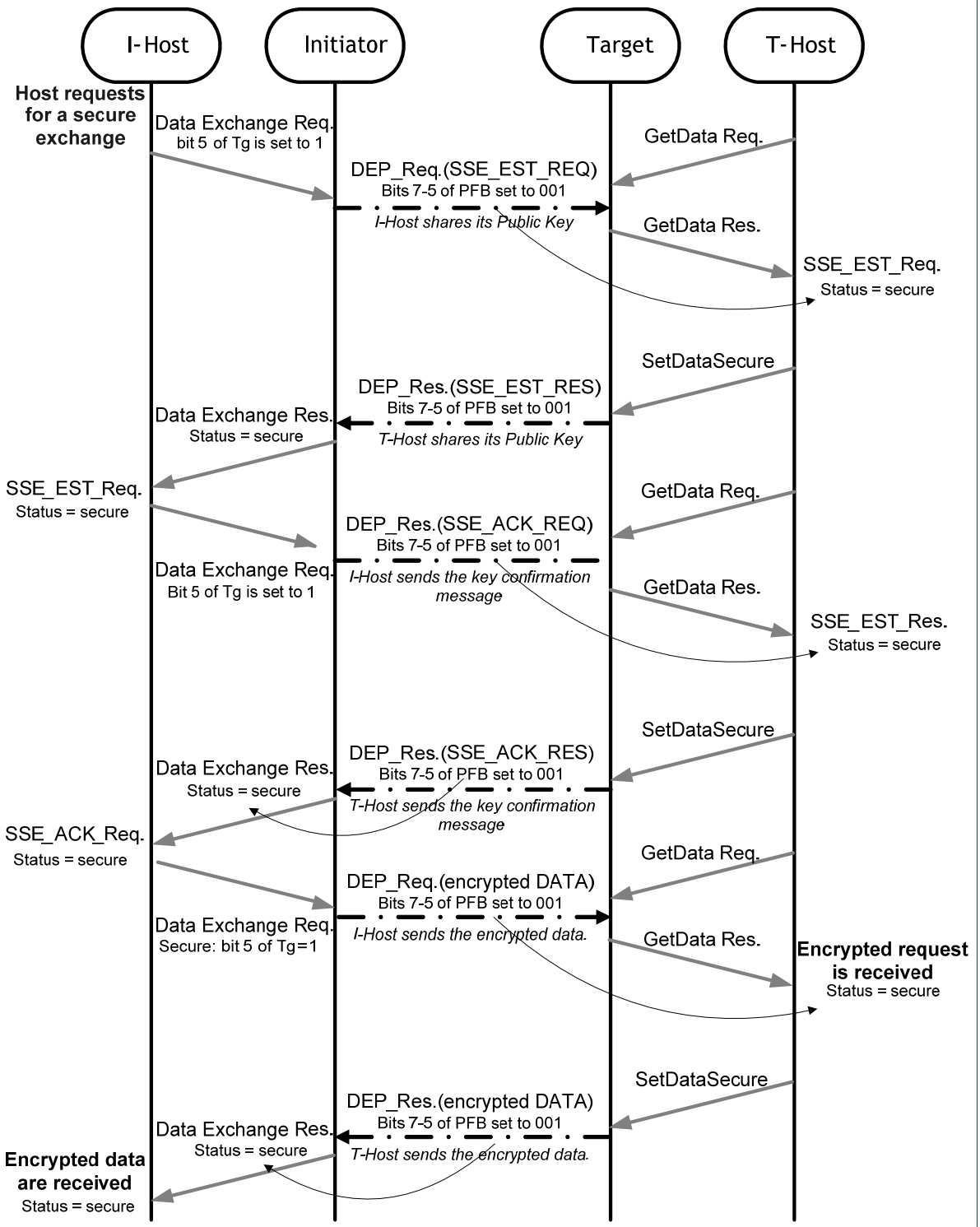


Fig 7. Secured DEP started by the Initiator

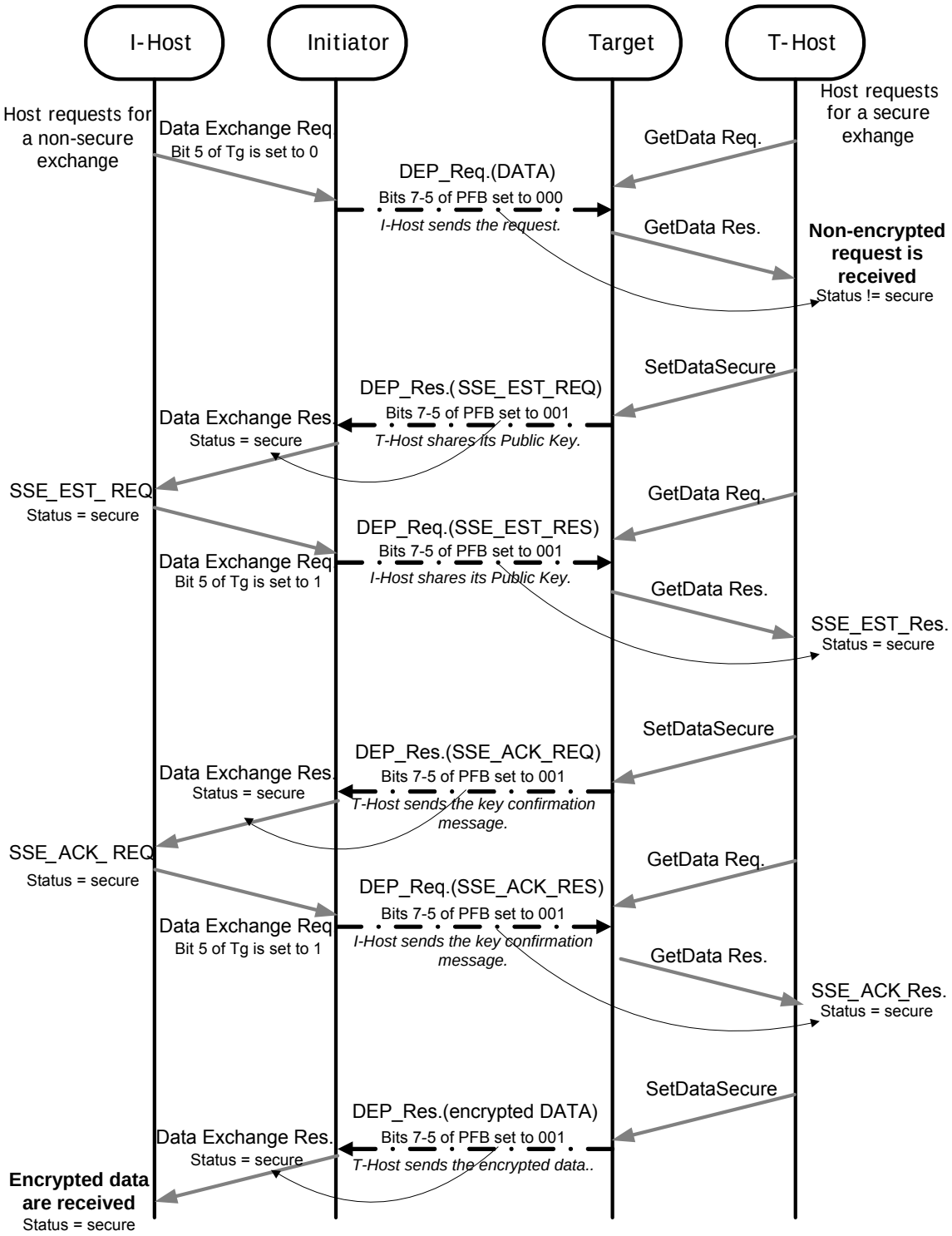


Fig 8. **Secured DEP activated by the Target**

Table 6. Sequence of secured DEP started by Initiator

Step	Description
1	In case of Secured DEP activated by the Initiator, the I-Host activates this secure channel by sending its Public key with InDataExchange command (See §8.4.8, p.100). Bits 7:5 of the Tg field are set to 001.
2	The T-Host is informed that the communication has to be secured, because the returned status of the GetData response (See §8.4.17, p. 135) is equal to 0x20 (See Table 15, p. 50).
3	The T-Host replies with a SetDataSecure command with contained its Public Key.
4	The I-Host receives the T-Host Public Key within the InDataExchange response. And the returned status of this command is equal to: 0x20 (if the RF communication was successful).
5	A same exchange is done with SSE_ACK_REQ and SSE_ACK RES to confirm the Public Keys.
6	Lastly, the exchange of data can be done in secure mode.

Table 7. Sequence of secured DEP started by Target

Step	Description
1	In this case, the I-Host starts a basic Data Exchange Protocol, but the T-Host requests for a secure communication. The T-Host activates this secure channel by sending its Public key with SetDataSecure command (See §8.4.19, p. 138).
2	The I-Host is informed that the communication has to be secured, because the returned status of the InDataExchange response (See §8.4.8, p.100) is equal to 0x20 (See Table 15, p. 50).
3	The I-Host replies with an InDataExchange command with contained its Public Key.
4	The T-Host receives the I-Host Public Key within the TgGetData response. And the returned status of this command is equal to: 0x20 (if the RF communication was successful).
5	A same exchange is done with SSE_ACK_REQ and SSE_ACK RES to confirm the Public Keys.
6	Afterwards, the target will send the encrypted data to the Initiator in secure mode.

Remark 1: If the **`InDataExchange`** command is used with the 5th bit of Tg field equal to 1, or **`SetDataSecure`** command is used, or **`SetMetaDataSecure`** command is used, then the PN533 shall set bits 7:5 of the PFB to 001.

Remark 2: If bits 7:5 of PFB are set to 001, then the communication is secured and the returned status of the **`GetData`** or **`InDataExchange`** response is set to 0x20 (if the RF communication was successful).

Remark 3: For enabling the NFC Secure layer, the Host has to set the fSecure bit of the **`SetParameters`** command to 1 (see §8.2.8, p.66).

5. Host controller Interface

5.1 General points

5.1.1 Introduction

The system host controller communicates with the PN533 by using the USB link.

The protocol between the host controller and the PN533, on top of this physical link is described in §7, p.34.

5.1.2 USB interface

The figure below shows an USB modeling of the PN533:

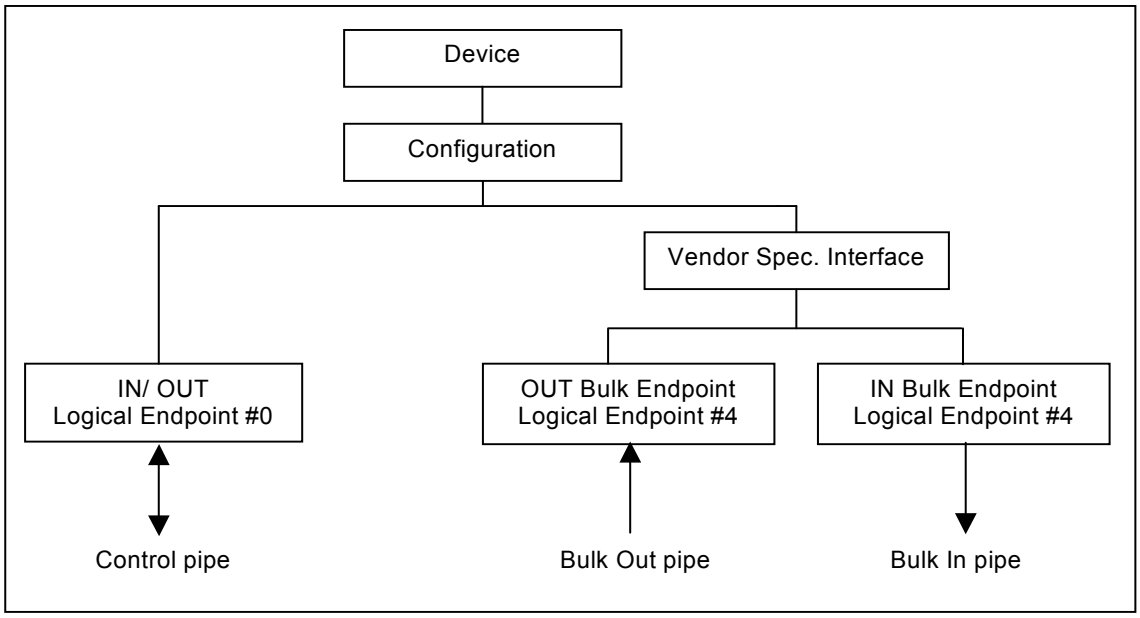


Fig 9. USB Description of the PN533

PN533 uses 2 endpoints which are part of the Vendor Specific Interface in addition to two mandatory default endpoint IN/OUT #0.

Logical endpoint 0, **control in/out**:

- It is needed for initializing and configuring the logical device once the device is attached and powered
- It provides access to the device's information and allows generic USB status and control access
- Supports control transfers

Logical endpoint 4, **bulk out**:

- This endpoint performs transfers to supply data to the PN533

Logical endpoint 4, **bulk in**:

- This endpoint performs transfers to retrieve data from the PN533

Logical endpoints 1, 2 and 3, **interrupt in**:

- Not used

5.1.2.1 Default USB descriptors

USB descriptors report the attributes of an USB device. They are data structures with a fixed format defined in the document Universal Serial Bus Specification.

The default descriptors of the PN533 are listed below:

Table 8. Device Descriptor

Offset	Field	Size	Value	Description
0	bLength	1	12h	18 bytes of descriptor length
1	bDescriptorType	1	01h	**Device descriptor**
2	bcdUSB	2	0200h	USB Spec. 2.0 compliant
4	bDeviceClass	1	00h	--
5	bDeviceSubClass	1	00h	--
6	bDeviceProtocol	1	00h	--
7	bMaxPacketSize0	1	08h	**Max. packet size of 8 bytes**
8	IdVendor	2	04CCh	**VendorID**
10	IdProduct	2	2533h	**ProductID**
12	bcdDevice	2	0100h	Device release number 1.0
14	iManufacturer	1	01h	--
15	iProduct	1	02h	--
16	iSerialNumber	1	00h	**--**
17	bNumConfiguration	1	01h	**1 configuration available**

Table 9. Configuration Descriptor

Offset	Field	Size	Value	Description
0	bLength	1	09h	9 bytes of descriptor length
1	bDescriptorType	1	02h	Configuration Descriptor
2	wTotalLength	2	0020h	39 bytes of total length (9 + 9 + 7 + 7)
4	bNumInterfaces	1	01h	**1 interface available**
5	bConfigurationValue	1	01h	--
6	iConfiguration	1	00h	--
7	bmAttributes	1	80h	**Bus powered, No Remote wakeup**
8	MaxPower	1	32h	**100 mA of max. power**.

Table 10. Interface Descriptor

Offset	Field	Size	Value	Description
0	bLength	1	09h	9 bytes of descriptor length
1	bDescriptorType	1	04h	**Interface descriptor**
2	bInterfaceNumber	1	00h	--
3	bAlternateSetting	1	00h	--
4	bNumEndpoints	1	02h	**2 endpoints available**
5	bInterfaceClass	1	FFh	**Vendor Specific**
6	bInterfaceSubClass	1	FFh	**Vendor Specific**
7	bInterfaceProtocol	1	FFh	**Vendor Specific**
8	iInterface	1	00h	--

Table 11. Endpoint 4 Descriptor IN

Offset	Field	Size	Value	Description
0	bLength	1	07h	7 bytes of descriptor length
1	bDescriptorType	1	05h	Endpoint descriptor
2	bEndpointAddress	1	84h	**Physical Ept #4, type IN**
3	bmAttributes	1	02h	**BULK endpoint**
4	wMaxPacketSize	2	0040h	**64 bytes of max. packet size**
6	bInterval	1	04h	255 ms

Table 12. Endpoint 4 Descriptor OUT

Offset	Field	Size	Value	Description
0	bLength	1	07h	7 bytes of descriptor length
1	bDescriptorType	1	05h	Endpoint descriptor
2	bEndpointAddress	1	04h	**Physical Ept #4, type OUT**
3	bmAttributes	1	02h	**BULK endpoint**
4	wMaxPacketSize	2	0040h	**64 bytes of max. packet size**
6	bInterval	1	04h	255 ms

Remote WakeUp

The PN533 is an USB device which does not support Remote WakeUp functionality (ability reported in bmAttributes of Configuration Descriptor; see Table 9, p.22).

6. I2C master interface

The I2C master interface of the PN533 is compliant with the I2C bus specification (see reference document [11]).

The PN533 is configured as master on this I2C link and it is able to communicate with an external EEPROM (address 0xA0) and with the TDA8029 (contact card reader, address 0x50).

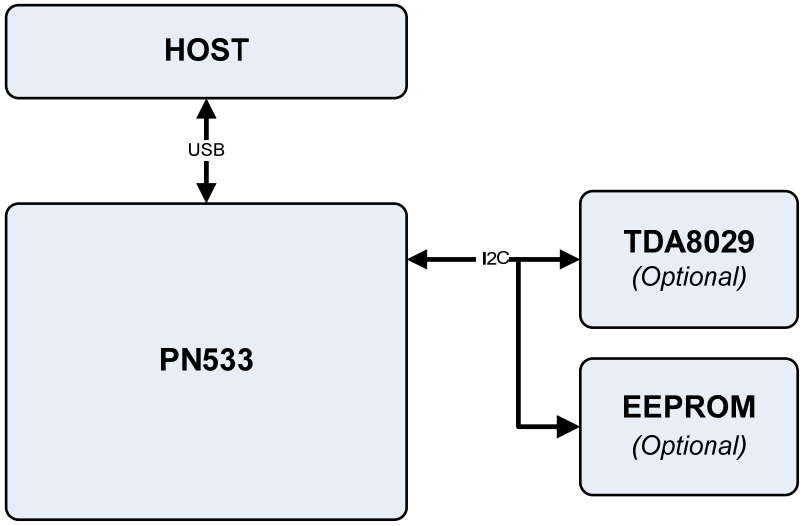


Fig 10. PN533 links overview

As specified in the I2C-bus specification, only two lines have to be used for managing the serial link between the TDA8029 or EEPROM and the host controller:

- ⇨ A serial data line (SDA), has to be connected on pin 33 of the PN533
- ⇨ And a serial clock line (SCL), has to be connected on pin 32 of the PN533.

The maximum SCL frequency for the TDA is #45 kHz. For the EEPROM, transactions are performed at a frequency of 400 kHz.

6.1 External EEPROM mapping

6.1.1 EEPROM data organization

The TLV system is used for organizing data in EEPROM. Each block of data is preceded by its tag and its length.

The EEPROM mapping is shown below:

Fig 11. EEPROM mapping

The remaining free bytes at the end of the EEPROM have to be set to 0xFF. At least one 0xFF has to be present at the end of EEPROM mapping.

Each block of data has to be present only one time in EEPROM. The sequence of these blocks is not important.

If one of Tags 2, 3, 4 and 5 is present then all these Tags have to be present.
If there is one error in the EEPROM mapping, then the information embedded in it are not used. In this case PN533 will boot with the default settings located in ROM code.

6.1.2 List of EEPROM tags

Tags allow PN533 to identify each block of data in the EEPROM. The list of EEPROM tags is the following:

- 0x01 ⇔ RF settings block,
  - 106kbps communication Type A,
  - 212kbps/424kbps communication for FeliCa,
  - 106/212/424/847kbps communication Type B,
  - 212/424/847kbps communication Type A,
- 0x02 ⇔ Fixed USB descriptor block,
  - Device Descriptor,
  - Configuration Descriptor,
  - Interface Descriptor,
  - OUT endpoint Descriptor,
  - IN Endpoint Descriptor.
- 0x03 ⇔ Device ID String Descriptor,
- 0x04 ⇔ Manufacturer ID String Descriptor,
- 0x05 ⇔ String Descriptor 0.

6.1.2.1 RF settings block description

- 106kbps communication Type A

This information is related with the RF Configuration command (Cfgitem = 0Ah: Analog settings for the baud rate 106 kbps type A).

Byte #	Register
0	CIU_RFCfg
1	CIU_GsNOn
2	CIU_CWGsP
3	CIU_ModGsP
4	CIU_DemodRfOn
5	CIU_RxThreshold
6	CIU_DemodRfOff
7	CIU_GsNOff
8	CIU_ModWidth
9	CIU_MifNFC
10	CIU_TxBitPhase

- 212kbps/424kbps communication for FeliCa

This information is related with the RF Configuration command (Cfgitem = 0Bh: Analog settings for the baud rate 212/424 kbps).

Byte #	Register
11	CIU_RFCfg
12	CIU_GsNOn
13	CIU_CWGsP
14	CIU_ModGsP
15	CIU_DemodRfOn
16	CIU_RxThreshold
17	CIU_DemodRfOff
18	CIU_GsNOff

- 106/212/424/847kbps communication Type B

This information is related with the RF Configuration command (Cfgitem = 0Ch: Analog settings for the type B).

Byte #	Register
19	CIU_GsNOn
20	CIU_ModGsP
21	CIU_RxThreshold

- 212/424/847kbps communication Type A

This information is related with the RF Configuration command (Cfgitem = 0Dh: Analog settings for the baud rate 212/424 and 847 kbps with ISO14443-4 protocol).

Byte #	Register	Baud rate
22	CIU_RxThreshold	212 kbps
23	CIU_ModWidth	
24	CIU_MifNFC	
25	CIU_RxThreshold	424 kbps
26	CIU_ModWidth	
27	CIU_MifNFC	
28	CIU_RxThreshold	847 kbps
29	CIU_ModWidth	
30	CIU_MifNFC	

6.1.2.2 Fixed USB descriptor block description

- Device Descriptor:

Byte #	Field	Size
0	*bLength*	1
1	*bDescriptor Type*	1
2	*bcdUSB*	2
4	*bDevice Class*	1
5	*bDevice Subclass*	1
6	*bDevice Protocol*	1
7	*bMax Packet Size*	1
8	*idVendor*	2
10	*idProduct*	2
12	*bcdDevice*	2
14	*iManufacturer*	1
15	*iProduct*	1
16	*iSerialNumber*	1
17	*bNumConfigurations*	1

- Configuration Descriptor:

Byte #	Field	Size
18	*bLength*	1
19	*bDescriptor Type*	1
20	*wTotalLenght*	2
22	*bNumInterfaces*	1
23	*bConfigurationValue*	1
24	*iConfiguration*	1
25	*bmAttributes*	1
26	*bMaxPower*	1

- Interface Descriptor:

Byte #	Field	Size
27	*bLength*	1
28	*bDescriptor Type*	1
29	*bNumInterfaces*	1
30	*bAlternateSettings*	1
31	*bNumEndpoints*	1
32	*bInterfaceClass*	1
33	*bInterfaceSubClass*	1
34	*bInterfaceProtocol*	1
35	*iInterface*	1

- OUT Endpoint Descriptor:

Byte #	Field	Size
36	*bLength*	1
37	*bDescriptor Type*	1
38	*bEndpointAddress*	1
39	*bmAttributes*	1
40	*wMaxPacketSize*	2
42	*bInterval*	1

- IN Endpoint Descriptor:

Byte #	Field	Size
43	*bLength*	1
44	*bDescriptor Type*	1
45	*bEndpointAddress*	1
46	*bmAttributes*	1
47	*wMaxPacketSize*	2
49	*bInterval*	1

6.1.2.3 Device ID String Descriptor description

- String Descriptor (Device ID):

Byte #	Field	Size
0	*bLength*	1
1	*bDescriptor Type*	1
2	*bString (Unicode encoded string)*	N[3]

6.1.2.4 Manufacturer ID String Descriptor description

- String Descriptor (Manufacturer ID):

Byte #	Field	Size
0	*bLength*	1
1	*bDescriptor Type*	1
2	*bString (Unicode encoded string)*	N[4]

6.1.2.5 String Descriptor 0 description

String Descriptor 0 (Specifying languages supported by the device):

Byte #	Field	Size
0	*bLength*	1
1	*bDescriptor Type*	1
2	*wLANGID[0]*	2
…	…	…
N[5]	*wLANGID[x]*	2

[3] Due to RAM limitation the value of N has to be defined within 0 and 30 bytes.

[4] Due to RAM limitation the value of N has to be defined within 0 and 30 bytes.

[5] Due to RAM limitation the value of N has to be defined within 0 and 30 bytes.

6.2 Read data in EEPROM

The PN533 is able to fetch a modified USB descriptor and modified RF settings from the external EEPROM during the startup of the IC. Moreover, the host is able to read and write data in EEPROM through two specific commands.

- **Sequence for fetching information during enumeration:**

Table 13. Sequence for fetching information of EEPROM during enumeration

Step	Description
1	When the PN533 is switched on, it shall check if some information (USB desc. + RF settings) are contained in the EEPROM.
2	During this step, PN533 will look for tags: 0x01, 0x02, 0x03, 0x04 and 0x05 (see §6.1.2, p.25). Once a tag is discovered, the firmware will read the content of its associated block and store it in RAM. If the 4 blocks corresponding to USB information (tags 0x02, 0x03, 0x04 and 0x05) have been read correctly in EEPROM, EEPROM USB information are used as initial values after power-on, otherwise ROM code USB information are used as initial values. If the RF Settings block (tag 0x01) has been read correctly in EEPROM, EEPROM RF Settings information is used as initial values after power-on, otherwise ROM code information are used as initial values. If there is one error in the EEPROM mapping, ROM code information (USB desc. + RF Settings) are used as initial values after power-on.
3	PN533 shall activate the USB_SoftConnect switch (see Fig 12, p.32). The voltage of D+ will be set to ‘1’.
4	The host shall detect this voltage modification and it shall send a request to ask for USB device information for the enumeration phase.
5	The PN533 has to fill the IN Bulk Endpoint with its USB information.
6	The Host has to read the content of the IN Bulk Endpoint. After this reading, the PN533 is enumerated.

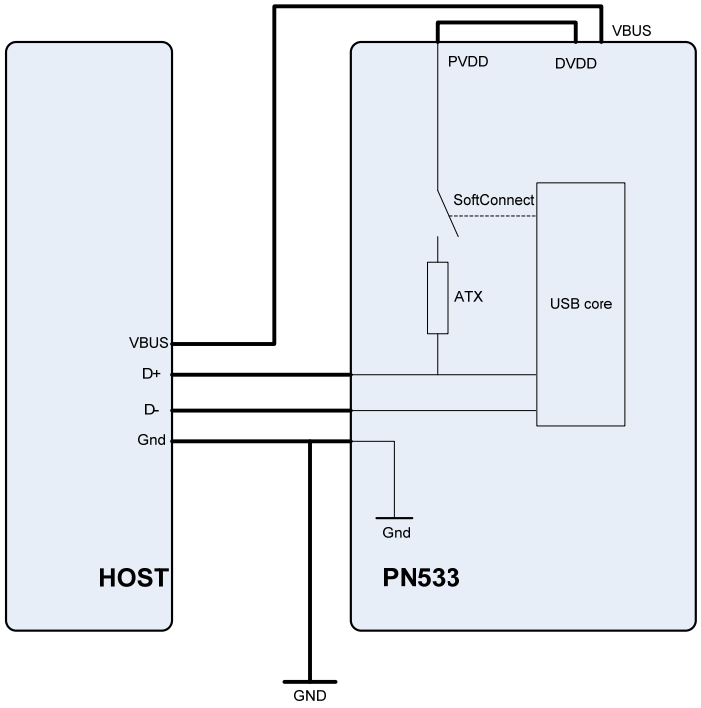


Fig 12. USB connection of the PN533 device

Two commands are defined to Read or Write in the EEPROM.

- **Reading data in EEPROM**

  Refer to **`ReadRegister`** command (§8.2.4, p.59).

- **Writing data in EEPROM**

  Refer to **`WriteRegister`** command (§8.2.5, p.61).

.

6.3 I2C TDA8029

In addition to I2C specification, we shall use three other lines to manage Energy Saving Mode mechanism of the TDA8029:

- **WakeUpSlave** line is used to wake up the TDA8029. It has to be connected between INT1 (pin 30 of the TDA8029) and P31 (pin 29) of the PN533.
- **SlaveI2CMute** line is used by the TDA8029 to indicate to the host controller either that it is ready to receive a command frame, or to send the corresponding answer, or to signal a hardware event. It has to be connected between pin 24 of the TDA8029 and P33 (pin 31) of the PN533.
- **Shut-down** line is used for entering in the TDA8029 shut-down mode. This mode is set when the TDA8029 SDWN_N pin is set to 0. The only way to leave shut-down mode is when pin SDWN_N is set to 1.

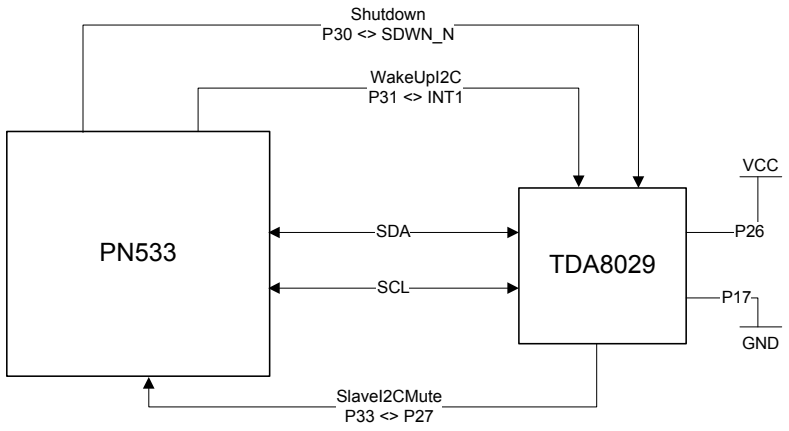


Fig 13. PN533 and TDA connection

One command is defined to access to the TDA8029 through the PN533.

Refer to **`AlparCommandForTDA`** command (§8.3, p. 70).

The I2C transactions use the ‘ALPAR’ protocol described in [6].

7. Host controller communication protocol

7.1.1 Frames structure

Communication between the host controller and the PN533 is performed through frames, in a half-duplex mode.

Four different types of frames are used in one or both directions (host controller to the PN533 and PN533 to the host controller).

7.1.1.1 Normal information frame

Information frames are used to convey:

- Commands from the host controller to the PN533,
- And responses to these commands from the PN533 to the host controller.

The structure of this frame is the following:

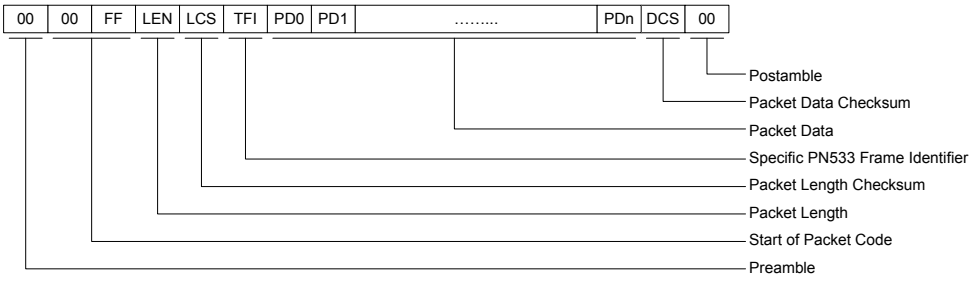


Fig 14. Normal information frame

- **PREAMBLE** 1 byte[6],
- **START CODE** 2 bytes (0x00 and 0xFF),
- **LEN** 1 byte indicating the number of bytes in the data field (TFI and PD0 to PDn),
- **LCS** 1 Packet Length Checksum LCS byte that satisfies the relation: Lower byte of [LEN + LCS] = 0x00,
- **TFI** 1 byte frame identifier, the value of this byte depends on the way of the message

  - **D4h** in case of a frame from the host controller to the PN533,
  - **D5h** in case of a frame from the PN533 to the host controller.

- **DATA** LEN-1 bytes of Packet Data Information

  The first byte PD0 is the Command Code,
- **DCS** 1 Data Checksum DCS byte that satisfies the relation:

  Lower byte of [TFI + PD0 + PD1 + … + PDn + DCS] = 0x00,
- **POSTAMBLE** 1 byte[7].

The amount of data that can be exchanged using this frame structure is limited to 255 bytes (including TFI).

[6] The preamble field is represented here as byte whose value is 0x00.
In the way from the host controller to the PN533, refer to each host link communication detailed paragraphs.

[7] The postamble field is represented here as byte whose value is 0x00.
In the way from the host controller to the PN533, refer to each host link communication detailed paragraphs.

7.1.1.2 Extended information frame

The information frame has an extended definition allowing exchanging more data between the host controller and the PN533 (theoretically up to 64 kB).
In the firmware implementation of the PN533, the maximum length of the packet data is limited to 264 bytes (265 bytes with TFI included).

The structure of this frame is the following:

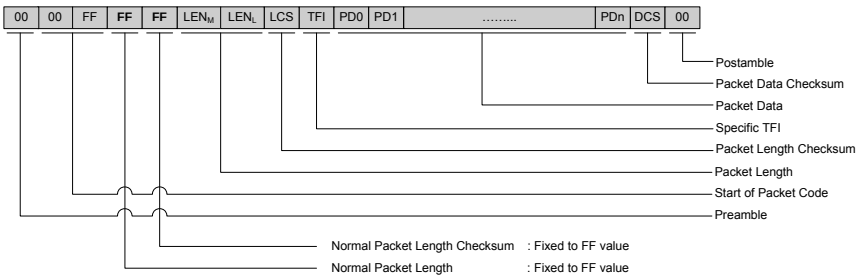


Fig 15. Extended Information frame

The normal **LEN** and **LCS** fields are fixed to the **0xFF** value, which is normally considered as erroneous frame, due to the fact that the checksum does not fit.

The real length is then coded in the two following bytes $\mathbf{LEN_M}$ (MSByte) and $\mathbf{LEN_L}$ (LSByte) with:

LENGTH = $\mathbf{LEN_M}$ x 256 + $\mathbf{LEN_L}$ coding the number of bytes in the data field (TFI and PD0 to PDn)

- **LCS** 1 Packet Length Checksum LCS byte that satisfies the relation:
  Lower byte of [$\mathbf{LEN_M}$ + $\mathbf{LEN_L}$ + **LCS**] = 0x00,
- **DATA** **LENGTH**-1 bytes of Packet Data Information
  The first byte PD0 is the Command Code.

The host controller, for sending frame whose length is less than 255 bytes, can also use this type of frame.
But, the PN533 always uses the suitable type of frame, depending on the length (Normal Information Frame for frame <= 255 bytes and Extended Information Frame for frame > 255 bytes).

7.1.1.3 ACK frame

The specific ACK frame is used for the synchronization of the packets and also for the abort mechanism.

This frame may be used either from the host controller to the PN533 or from the PN533 to the host controller to indicate that the previous frame has been successfully received.

ACK frame:

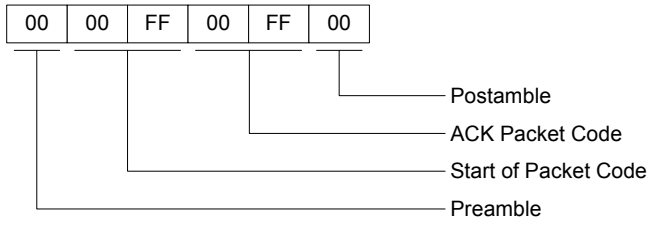


Fig 16. ACK frame

7.1.1.4 NACK frame

The specific NACK frame is used for the synchronization of the packets.

This frame is used only from the host controller to the PN533 to indicate that the previous response frame has not been successfully received, then asking for the retransmission of the last response frame from the PN533 to the host controller.

NACK frame:

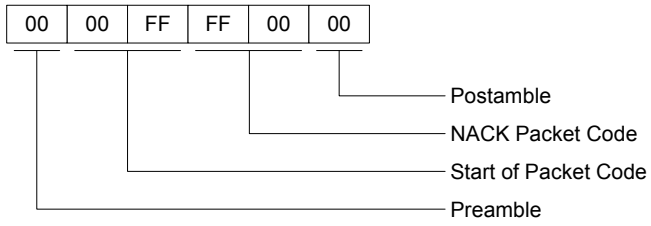


Fig 17. NACK frame

7.1.1.5 Error frame

The syntax error frame is used to inform the host controller that the PN533 has detected an error at the application level.

Error frame:

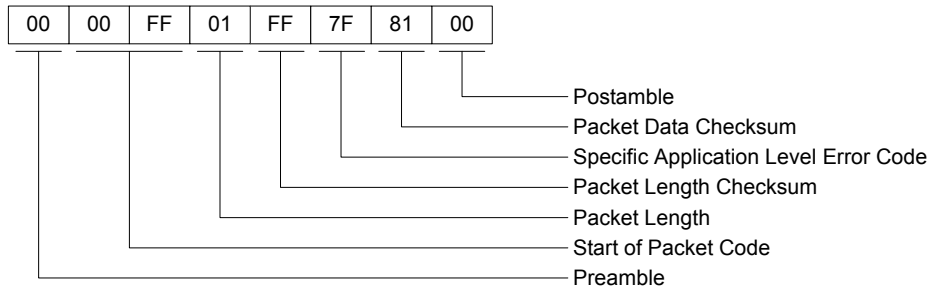


Fig 18. Error frame

7.1.1.6 Preamble and Postamble

These two specific fields of the frames are described in the previous paragraphs as single byte, which the value is 0x00.

In fact, these fields can be composed with an undetermined number of bytes:

o Preamble

The preamble field is composed of an undetermined number of bytes in which two consecutives bytes are not equal to 0x00 0xFF (otherwise specified in host controller link communication details, see §7.1.3, p.46).

The PN533 uses this synchronization pattern (0x00 0xFF) to detect the beginning of a frame; all the previous data are ignored.

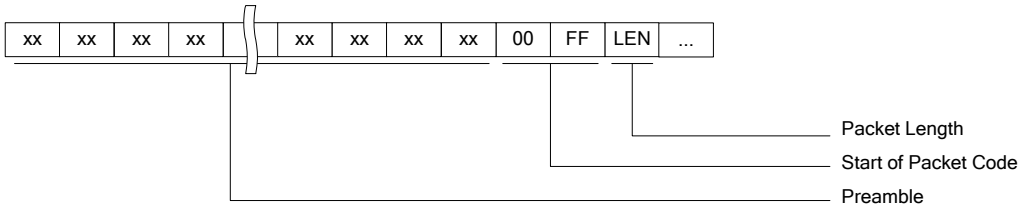


Fig 19. Preamble

o Postamble

The postamble field is composed of an undetermined number of bytes in which two consecutives bytes are not equal to 0x00 0xFF (otherwise specified in host controller link communication details, see §7.1.3, p.46).

The PN533 receives and analyses the frame until the DCS byte. After this checksum byte, the common synchronization pattern detection starts again.

Thus, all the data comprised between the DCS byte and the next synchronization pattern (0x00 0xFF) is ignored.

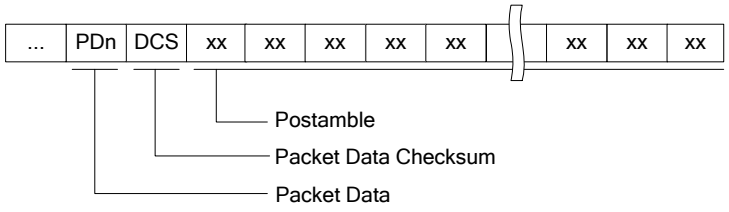


Fig 20. Postamble

o Frames sent by the PN533

Concerning the frames sent by the PN533 to the host controller, both the preamble and the postamble are constituted of only one 0x00 byte.

o Examples

All the following frames are the same for the PN533's point of view (**`GetFirmwareVersion`**).

xx xx xx xx xx **00 FF 02 FE D4 02 2A** xx xx xx xx
00 FF 02 FE D4 02 2A xx xx xx xx
xx xx xx xx xx **00 FF 02 FE D4 02 2A**
00 FF 02 FE D4 02 2A

7.1.2 Dialog structure

The following chapters explain the dialog structure.

The host controller is always the master of the complete exchange:

It sends a command to the PN533,

The PN533 sends back an acknowledge to inform the host controller that the command has been successfully received,

The PN533 executes the command,

The PN533 sends back the corresponding answer to the host controller,

Optionally, the host controller may send an ACK frame to indicate to the PN533 that the answer has been successfully received.

7.1.2.1 Data link level

a) Successful exchange at data link level

The figure below describes a normal exchange:

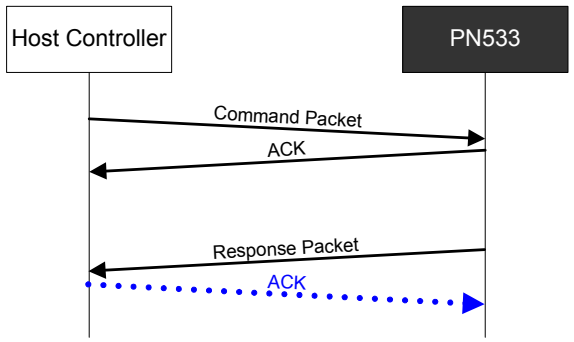


Fig 21. Data link level: normal exchange

b) Error at data link level, from host controller to PN533

When an error is detected by the PN533 at the data link level, it does not send back an ACK frame to the host controller.

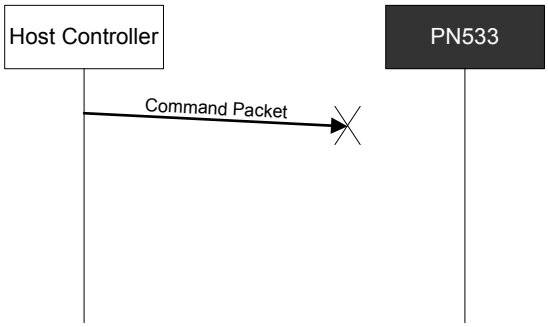


Fig 22. Data link level: error from the host controller to the PN533

The following errors are considered by the PN533 as data link level errors:

- LCS error,
- DCS error.

c) Error at data link level, from the PN533 to the host controller

When the host controller detects an error in the response packet (erroneous frame or no response), it uses a NACK frame to ask for the PN533 to send again the last response frame.

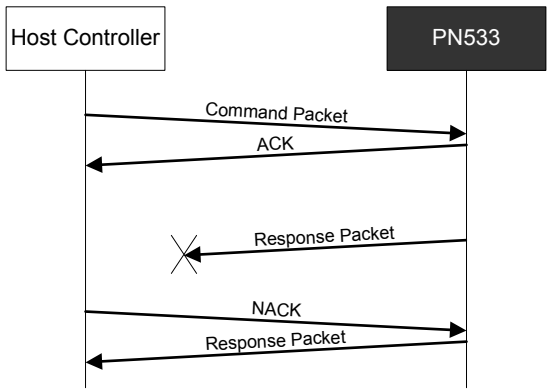


Fig 23. Data link level: error from the PN533 to the host controller

d) Abort

The host controller may send an ACK frame to force the PN533 to abort the current process.

In that case, the PN533 discontinues the last processing and does not answer anything to the host controller.

Then, the PN533 starts again waiting for a new command.

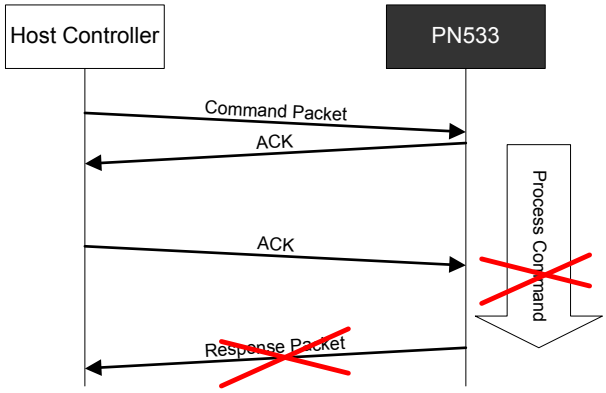


Fig 24. Data link level: Host controller aborts the current command

7.1.2.2 Application level

a) Successive exchanges

The host controller sends a new command after having received the answer of the previous one.

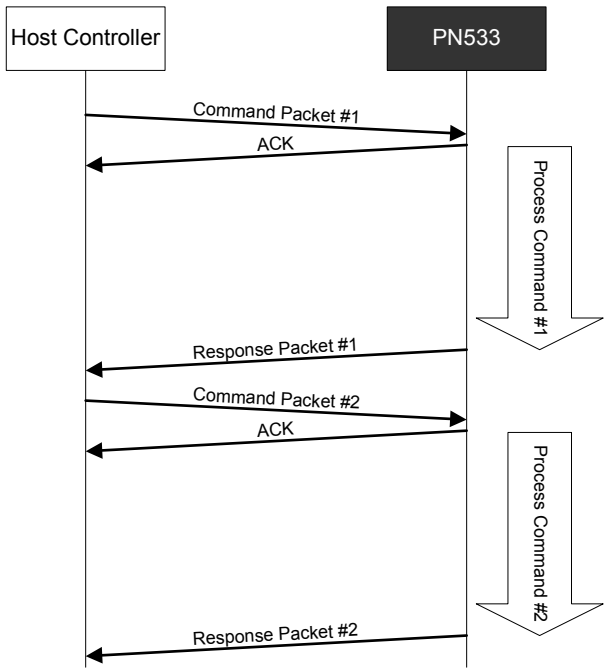


Fig 25. Application level: Successive exchanges

b) Abort

The host controller can force the PN533 to abort an ingoing process thanks to two different methods.

1. *Abort previous command with a ACK frame*

The host controller may send an ACK frame to force the PN533 to abort the current process.

In that case, the PN533 discontinues the last processing and does not answer anything to the host controller.

Then, the PN533 starts again waiting for a new command.

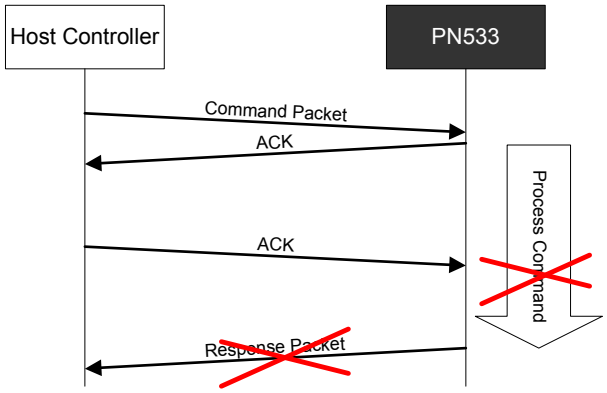


Fig 26. Data link level: Abort

2. *Abort previous command with a new command*

If the PN533 receives a command before having answered to the previous one, it stops the current process and start processing the new command received. It will send only the response to the last command. This statement is true for all commands, except the TDA commands (for more information see §8.3, p.70).

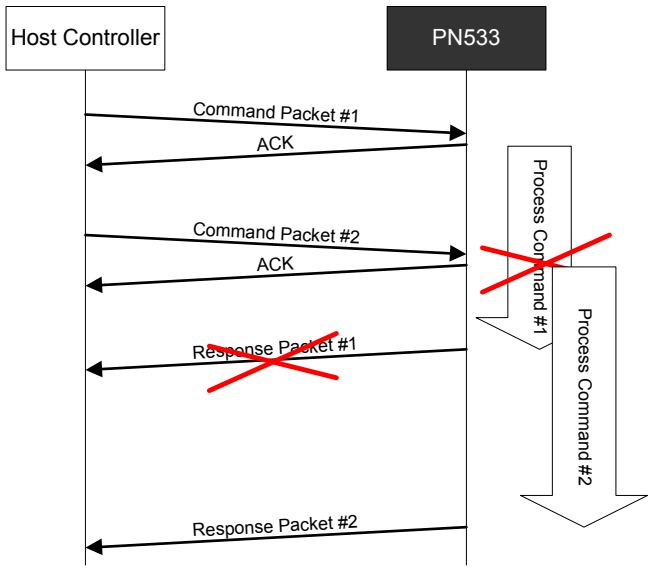


Fig 27. Application level: Abort a command and process a new one

c) Error at application level

When the PN533 detects an error at the application level, it sends back the specific “Syntax Error frame” to the host controller (see §7.1.1.5, p.37).

An application level error may be due to one of the following reasons:

- Unknown **Command Code** sent by the host controller in the command frame,
- Unexpected frame length,
- Incorrect parameters in the command frame.

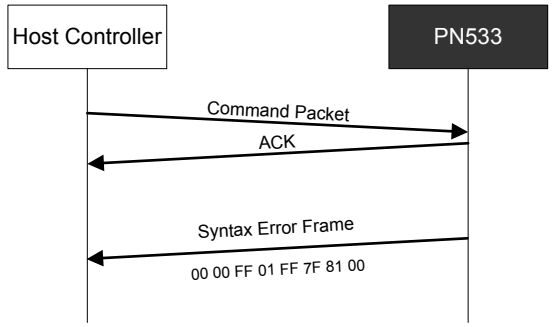


Fig 28. Application level: Error detected

7.1.3 USB communication details

The USB device interface of the PN533 is built around:

- A Control Endpoint 0 (8bytes IN/ 8 bytes OUT),
- A BULK IN Endpoint (64 bytes),
- A BULK OUT Endpoint (64 bytes).

The command is sent by the system controller over the BULK OUT endpoint and the response is received in the BULK IN endpoint.

The host polls the BULK IN after BULK OUT has been sent.

The frames used when communicating with the USB are exactly the same as defined in the previous paragraphs §7.1.2

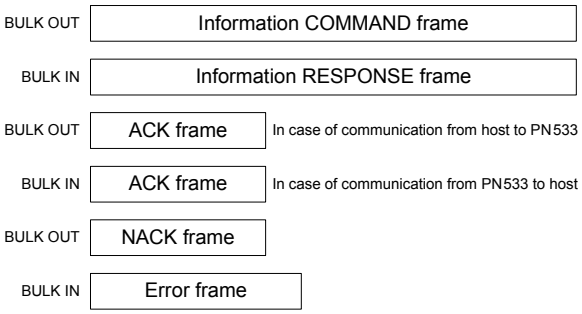


Fig 29. USB link: frames

The figure below depicts the normal scheme of communication with the USB:

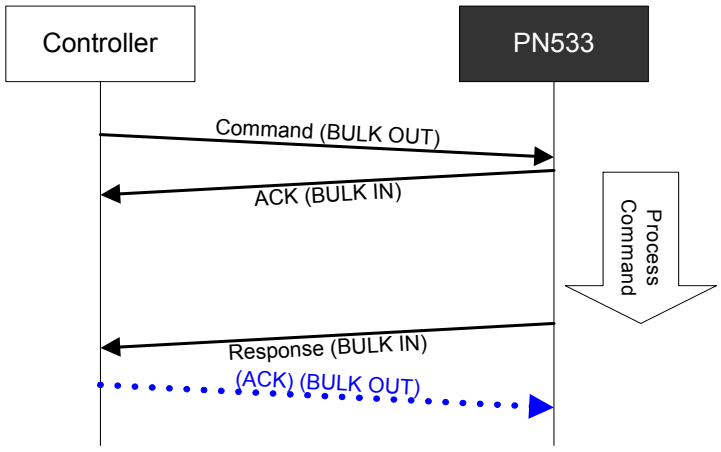


Fig 30. USB link: general principle of communication

The PN533 has to respond to the incoming command frame within 15 ms ($T_{Max\ Response\ Time:}$ delay between the command frame and the ACK frame).

In the case the host controller does not detect an ACK frame within these 15 ms, the host controller should resend the same command frame.

Preamble and Postamble:

In the way from the host controller to the PN533, both the preamble and postamble fields may have a length different from one byte (0 to n) and the value has no impact on the frame processing.

8. Commands supported

The following description of the commands details:

- The frame structure[8] including the type and amount of data:
  - That the host controller has to deliver to the PN533 (***Input***),
  - That the PN533 returns to the host controller (***Output***).
- When existing, the possible causes of syntax error (***Syntax Error Conditions***),
- A description of the process attached to the command (***Description***).

For Input and Output data, optional bytes are written into square brackets (**[ ]**).

List of commands:

A cross (X) in the PN533 column indicates if the command may be used with the PN533 configured as initiator or/and with the PN533 configured as target.

The “Command Code” column gives the value of the command code (CC in the two represented frames below) that is used in the frame from the host controller to the PN533.

00	00	FF	LEN	LCS	D4	CC	Optional Input Data	DCS	00

00	00	FF	LEN	LCS	D5	CC+1	Optional Output Data	DCS	00

For the “RF Communication” commands, when commands are dedicated to the PN533 as initiator (respectively Target) a **In** prefix has been added (respectively **Tg** prefix).

Table 14. Command set

Command	PN533 as Initiator	PN533 as Target	Command Code	Page
Miscellaneous				
Diagnose	**X**	**X**	0x00	52
GetFirmwareVersion	**X**	**X**	0x02	56
GetGeneralStatus	**X**	**X**	0x04	57
ReadRegister	**X**	**X**	0x06	59
WriteRegister	**X**	**X**	0x08	61
ReadGPIO	**X**	**X**	0x0C	63
WriteGPIO	**X**	**X**	0x0E	64
SetParameters	**X**	**X**	0x12	66
AlparCommandForTDA	**X**	**X**	0x18	70

[8] The frame representation does not include the complete frame, but only the following field:

- TFI,
- Command Code,
- When needed the input or output data.

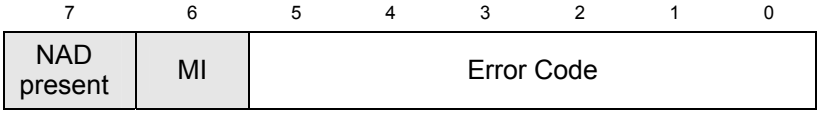
Thus, the Preamble, Start of Packet, LEN, LCS, DCS and Postamble are omitted in this description.

Command	PN533 as Initiator	PN533 as Target	Command Code	Page
RF communication				
RFConfiguration	X	X	0x32	73
RFRegulationTest	X	X	0x58	79
Initiator				
InJumpForDEP	X		0x56	80
InJumpForPSL	X		0x46	85
InListPassiveTarget	X		0x4A	87
InATR	X		0x50	95
InPSL	X		0x4E	98
InDataExchange	X		0x40	100
InCommunicateThru	X		0x42	109
InQuartetByteExchange	X		0x38	112
InDeselect	X		0x44	115
InRelease	X		0x52	116
InSelect	X		0x54	117
InActivateDeactivatePaypass	X		0x48	120
Target				
TgInitAsTarget		X	0x8C	126
TgSetGeneralBytes		X	0x92	133
TgGetData		X	0x86	135
TgSetData		X	0x8E	137
TgSetDataSecure		X	0x96	138
TgSetMetaData		X	0x94	139
TdSetMetaDataSecure		X	0x98	141
TgGetInitiatorCommand		X	0x88	142
TgResponseToInitiator		X	0x90	144
TgGetTargetStatus		X	0x8A	146

8.1 Error handling

In some of the commands detailed hereafter, there is a status byte returned by the PN533 reflecting if the RF communication has been successful or not. In case of unsuccessful command, only the status byte is sent back to the host controller.

Moreover, this byte contains two separated bits (bits 7 and 6) used for specific purposes.



- The **NADPresent** bit informs the host controller that the payload data contained in the PN533 answer frame for the **`InDataExchange`** or **`TgGetData`** contain a NAD byte. See **`SetParameters`** command §8.2.8, p.66;
- The **MI** bit informs the host controller that the PN533 has received data from the initiator (in DEP mode) or from the PICC (on ISO14443-4 PCD mode) with MI bit set. Thus, chaining in reception is on going. See how the chaining is handled either by the initiator or by the target in examples given in §8.5.4: Chaining mechanism, p.152;
- The Error Code (bits 0 to 5) informs the host controller on the result of the command. When null, the operation has gone properly. When Error Code is equal to 0x20 a secure command was done properly.

Otherwise, the possible error code values are the following:

Table 15. Error code list

Error cause	Error code
Time Out, the target has not answered	0x01
A CRC error has been detected by the CIU	0x02
A Parity error has been detected by the CIU	0x03
During an anti-collision/select operation (ISO/IEC14443-3 Type A and ISO/IEC18092 106 kbps passive mode), an erroneous Bit Count has been detected	0x04
Framing error during MIFARE operation	0x05
An abnormal bit-collision has been detected during bit wise anti-collision at 106 kbps	0x06
Communication buffer size insufficient	0x07
RF Buffer overflow has been detected by the CIU (bit BufferOvfl of the register *CIU_Error*)	0x09
In active communication mode, the RF field has not been switched on in time by the counterpart (as defined in NFCIP-1 standard)	0x0A
RF Protocol error (cf. [4], description of the *CIU_Error* register)	0x0B
Temperature error: the internal temperature sensor has detected overheating, and therefore has automatically switched off the antenna drivers	0x0D
Internal buffer overflow	0x0E

Error cause	Error code
Invalid parameter (range, format, …)	0x10
DEP Protocol: The PN533 configured in target mode does not support the command received from the initiator (the command received is not one of the following: ATR_REQ, WUP_REQ, PSL_REQ, DEP_REQ, DSL_REQ, RLS_REQ [1]).	0x12
DEP Protocol, MIFARE or ISO/IEC14443-4: The data format does not match to the specification. Depending on the RF protocol used, it can be: • Bad length of RF received frame, • Incorrect value of PCB or PFB, • Invalid or unexpected RF received frame, • NAD or DID incoherence.	0x13
MIFARE: Authentication error	0x14
Target or Initiator does not support NFC Secure	0x18
I2C bus line is Busy. A TDA transaction is on going	0x19
ISO/IEC14443-3: UID Check byte is wrong	0x23
DEP Protocol: Invalid device state, the system is in a state which does not allow the operation	0x25
Operation not allowed in this configuration (host controller interface)	0x26
This command is not acceptable due to the current context of the PN533 (Initiator vs. Target, unknown target number, Target not in the good state, …)	0x27
The PN533 configured as target has been released by its initiator	0x29
PN533 and ISO/IEC14443-3B only: the ID of the card does not match, meaning that the expected card has been exchanged with another one.	0x2A
PN533 and ISO/IEC14443-3B only: the card previously activated has disappeared.	0x2B
Mismatch between the NFCID3 initiator and the NFCID3 target in DEP 212/424 kbps passive.	0x2C
An over-current event has been detected	0x2D
NAD missing in DEP frame	0x2E

8.2 Miscellaneous commands

8.2.1 Diagnose

This command is designed for self-diagnosis.

Input:

D4	00	NumTst	[InParam]

- **NumTst** Test number to be executed by the PN533 (1 byte),
- **InParam** Input parameters needed for some of the tests.

Output:

D5	01	OutParam

- **OutParam** Parameters returned to the host controller (after execution of the test).

Syntax Error Conditions:

- Unknown test number (NumTst).

Description:

There are some parameters in command packet. The controller sends a command packet with parameter length and parameter itself.

The PN533 returns result (**OutParam**) with 1 to 262 bytes length parameters.

Processing time of this command varies depending on the content of the processing.

NumTst = 0x00: Communication Line Test

This test is for communication test between host controller and the PN533. “Parameter Length” and “Parameters” in response packet are same as “Parameter Length” and “Parameter” in command packet.

- Parameter Length : m (0 <= m <= 262),
- Parameter : Data,
- Result Length : Same value of m + 1.

OutParam consists of NumTst concatenate with InParam.

NumTst = 0x01: ROM Test

This test is for checking ROM data by 8 bits checksum.

- Parameter Length : 0,
- Result Length : 1,
- Result : 0x00 ➔ OK,
  0xFF ➔ Not Good.

NumTst = 0x02: RAM Test

This test is for checking RAM; 976 bytes of XRAM and 128 bytes of IDATA. The test method used consists of saving original content, writing test data, checking test data and finally restore original data. So, this test is non destructive.

- Parameter Length : 0,
- Result Length : 1,
- Result : 0x00 ➔ OK,
  0xFF ➔ Not Good.

NumTst = 0x04 : Polling Test to Target

This test is for checking the percentage of failure regarding response packet receiving after polling command transmission. In this test, the PN533 sends a FeliCa polling command packet 128 times to target. The PN533 counts the number of fails and returns the failed number to host controller. This test doesn't require specific system code for target.
Polling is done with system code (0xFF, 0xFF). The baud rate used is either 212 kbps or 424 kbps.

One polling is considered as defective after no correct polling response within 4 ms.

During this test, the analog settings used are those defined in command **`RFConfiguration`** within the item n°7 (§8.4.1, p.73).

- Parameter Length : 1,
- Parameter : 0x01 ➔ 212 kbps,
  0x02 ➔ 424 kbps.
- Result Length : 1,
- Result : Number of fails (Maximum 128).

NumTst = 0x05 : Echo Back Test

In this test, the PN533 is configured in target mode. The analog settings used are those defined by using the command **`RFConfiguration`** with the item n°6 (§8.4.1, p.73). This test is running as long as a new command is not received from the host controller.

The principle of this test is that the PN533 waits for a command frame coming from the initiator and after the Reply Delay, sends it back to it whatever its content and its length are.

- Parameter Length : 3,
- Parameter 1 : Reply Delay (step of 0.5 ms),
- Parameter 2 : Content of the CL_TxMode (@0x6302) register defining the baud rate and the modulation type in transmission,
- Parameter 3 : Content of the CL_RxMode (@0x6303) register defining the baud rate and the modulation type in reception,
- Result Length : no result, the test runs infinitely, so no output frame is sent to the host controller.

For example:

- The PN533 is configured to receive frame with passive 106 kbps modulation type. The frames are sent back immediately.
  The MSB bit (CRC enable) of CL_TxMode and CL_RxMode must be set to 0.

D4	00	05	00	00	00

- The PN533 is configured to receive frame with passive 212 kbps modulation type. The frames are sent back with a delay of 64 ms.
  The MSB bit (CRC enable) of CL_TxMode and CL_RxMode must be set to 1.

D4	00	05	80	92	92

- The PN533 is configured to receive frame with passive 424 kbps modulation type. The frames are sent back immediately.
  The MSB bit (CRC enable) of CL_TxMode and CL_RxMode must be set to 1.

D4	00	05	00	A2	A2

- The PN533 is configured to receive frame with passive 847 kbps modulation type. The frames are sent back immediately.
  The MSB bit (CRC enable) of CL_TxMode and CL_RxMode must be set to 1.

D4	00	05	00	B2	B2

NumTst = 0x06 : Check Presence for DEP target, Felica card, ISO/IEC14443-4 card and MIFARE card

This test can be used by an initiator to ensure that a target/card/PICC is still in the field:

- In case of DEP target, an Attention Request command is sent to the target, and it is expected to receive the same answer from the target. In that case, the test is declared as successful;
- In case of ISO/IEC14443-4 card, a R(NACK) block is sent to the card and it is expected to receive either a R(ACK) block or the last I-Block. In that case, the test is declared as successful (ISO/IEC14443-4 card is still in the RF field).
- In case of MIFARE UL card, a read command is sent to the target, and it is expected to receive a successful answer. In that case, the test is declared as successful.
- In case of MIFARE Classic card, two cases have to be considered :
  - If PN533 is not authenticated, we stored the MIFARE Classic UID. Then we poll for MIFARE Classic card. Once poll is done, PN533 has to compare the UID discovered and UID of the remote device for which presence check is running. If there is no difference between UID, the test is declared as successful.
  - If PN533 is authenticated, PN533 has to know for which block number it is authenticated. Then PN533 send a read command on this block number, and it is expected to receive a successful answer. In that case, the test is declared as successful.

- In case of FeliCa card, PN533 read the production ID (8 bytes) of the target. An InDataExchange command with parameters *[04(1 byte); Production ID(8 bytes)]* is sent to the target, and it is expected to receive a successful answer *[05(1 byte) ; Production ID(8 bytes); Mode(1 byte)]* . In that case, the test is declared as successful.

In case of no or incorrect response, the Result informs about the status of the transaction (refer. to §8.1, p.50)

- Parameter Length : 0,
- Result Length : 1,
- Result : 0x00 ➔ OK,
  different from 0x00 ➔ Not OK, Status byte.

NumTst = 0x07 : Self Antenna Test

This test is used to check the continuity of the transmission paths of the antenna.

- Parameter Length : 1,
- Parameter : Threshold used for antenna detection
  (applied in register **Andet_Control** (**@610C**), see [4]),

7	6	5	4	3	2	1	0
andet_bot	andet_up	andet_ithl[1:0]		andet_ithh[1:0]			andet_en

- Result Length : 1,
- Result : 0x00 ➔ OK (antenna is detected),
  different from 0x00 ➔ not OK (no antenna is detected).

8.2.2 GetFirmwareVersion

The PN533 sends back the version of the embedded firmware.

Input:

D4	02

Output:

D5	03	IC	Ver	Rev	Support

- **IC** Version of the IC. For PN533, the contain of this byte is 0x33,
- **Ver** Version of the firmware,
- **Rev** Revision of the firmware,
- **Support** indicates which are the functionalities supported by the firmware.

  When the bits are set to 1, the functionality is supported, otherwise (bit is set to 0) it is not.

RFU	RFU	RFU	RFU	RFU	ISO18092	ISO/IEC 14443 TypeB	ISO/IEC 14443 TypeA
7	6	5	4	3	2	1	0

Description:

In the case of the PN533, the version is 2.7.

That leads to **IC** : 0x33,
Ver : 0x02,
Rev : 0x07.
Support : 0x07.

8.2.3 GetGeneralStatus

This command allows the host controller to know at a given moment the complete situation of the PN533.

Input:

D4	04

Output:

D5	05	Err	Field	NbTg	[Tg]	[BrRx]	[BrTx]	[Type]
					RFU			

- **Err** is an error code corresponding to the latest error detected by the PN533,
- **Field** indicates if an external RF field is present and detected by the PN533 (**Field = 0x01**) or not (**Field = 0x00**),
- **NbTg** is the number of targets currently controlled by the PN533 acting as initiator: has to be always equal to 0 or 1. PN533 can not manage 2 targets,
- For the target controlled by the PN533:
  - **Tg** : logical number
  - **BrRx** : bit rate in reception
    - 0x00 : 106 kbps
    - 0x01 : 212 kbps
    - 0x02 : 424 kbps
    - 0x03 : 847 kbps
  - **BrTx** : bit rate in transmission
    - 0x00 : 106 kbps
    - 0x01 : 212 kbps
    - 0x02 : 424 kbps
    - 0x03 : 847 kbps
  - **Type** : modulation type
    - 0x00 : MIFARE, RFA, ISO/IEC14443-3 Type A, ISO/IEC14443-3 Type B, ISO/IEC18092 passive 106 kbps
    - 0x10 : FeliCa, ISO/IEC18092 passive 212/424 kbps
    - 0x01 : ISO/IEC18092 Active mode
    - 0x02 : Innovision Jewel tag

Description:

Err:

Err contains error code as defined in the error code paragraph (§8.1, p.50). After the execution of the **`GetGeneralStatus`** command, the content of the latest error is cleared.

Field:

The PN533 scans the RF field to inform the host controller if an external field is detected or not.

Tg, BrRx, BrTx and Type:

When the PN533 is configured as initiator, for the target handled by the PN533, the indication of the baud rate used and the modulation is given. The **Tg** information corresponds to the logical target number attributed by the PN533 when a previous **`InListPassiveTarget`**, **`InJumpForDEP`** or **`InJumpForPSL`** command has been used (is equal to 0 for the target handled by the PN533).

8.2.4 ReadRegister

This command is used to read the content of one or several internal registers of the PN533 (located either in the SFR area, in external EEPROM or in the XRAM memory space).

Input:

D4	06	$ADR1_H$	$ADR1_L$	…	$ADRn_H$	$ADRn_L$

- **$ADR1_H$ $ADR1_L$** First address (High and Low bytes),
- **$ADRn_H$ $ADRn_L$** n^{th} address (High and Low bytes).

Output:

D5	07	Status	VAL1	…	VALn

- **Status** indicates if the command is accepted or not (see §8.1, p.50).

  If Status returned is equal to 0x19 (I2C bus line is busy) then values corresponding of EEPROM are fixed at 0xFF, the others values are available for XRam or SFR.
- **VAL1** Value read in the register located at address ADR1,
- **VALn** Value read in the register located at address ADRn.

Syntax Error Conditions:

- Unknown SFR address.

Description:

For each address **ADR**, the PN533 performs a reading operation in the register (located either in the SFR area or in the XRAM memory space) or in the external EEPROM at address **ADR**. Then the value is returned in the **VAL** parameter.

The table below shows information which is readable by ReadRegister Command.

ADR	readable information
0x00 00 to 0x03 C7	XRam memory.
0xA0 00 to 0xA0 FF	EEPROM (128 or 256 bytes): (0xA0 00 address corresponds to 0x00 of the EEPROM).
0xFF 80 to 0xFF FF	SFR (64 bytes).

Fig 31. ReadRegister: Memory mapping

- SFR registers.

  The host controller has to set the High Byte of the address to 0xFF, the real address of the register is given by the low byte.

  The list of the SFR registers accessible for the host controller is configured in the firmware. The firmware gives access control to the following SFR registers:

Table 16.List of SFR registers

Address	Register	Address	Register	Address	Register
0x87	PCON	0xA3	FSIZE	0xD7	P5
0x9A	RWL	0xA8	IEN0	0xE8	IEN1
0x9B	TWL	0xAB	HSU_STATUS	0xF4	P7CFGA
0x9C	FIFOFS	0xAC	HSU_CONTROL	0xF5	P7CFGB
0x9D	FIFOFF	0xAD	HSU_PRESCALER	0xF7	P7
0x9E	SFF	0xAE	HSU_COUNTER	0xF8	IP1
0x9F	FIT	0xB0	P3	0xFC	P3CFGA
0xA1	FITEN	0xB8	IP	0xFD	P3CFGB
0xA2	FDATA	0xD1	CL_COMMAND		

- XRAM memory mapped registers

  The complete address is given by the high and low bytes of address.
  See [4].

Example:

The host controller reads the value 0xF0 in the register *RX_THRESHOLD* located at address 0x6308, the value 0x55 in the *IEN1* register (SFR) located at address 0xE8 and the value 0xAA in EEPROM at the address 0x20.

The frame from the host controller to the PN533 is:

D4	06	63	08	FF	E8	A0	20

And the one returned by the PN533 is:

D5	07	00	F0	55	AA

8.2.5 WriteRegister

This command is used to overwrite the content of one or several internal registers of the PN533 (located either in the SFR area or in the XRAM memory space) or the content of one or several bytes of the EEPROM.

Input:

D4	08	ADR1H	$ADR1_L$	VAL1	…	$ADRn_H$	$ADRn_L$	VALn

- **$ADR1_H$ $ADR1_L$** First address (High and Low bytes),
- **VAL1** First value to be written,
- **$ADRn_H$ $ADRn_L$** n^{th} address (High and Low bytes),
- **VALn** n^{th} value to be written.

Output:

D5	09	Status

- **Status** indicates if the command is accepted or not (see §8.1, p.50).
  If status returned is 0x19 then the value are not written in EEPROM, but the others values are written in XRam or SFR.

Syntax Error Conditions:

- Unknown SFR address.

Description:

For each address **ADR**, the PN533 performs a writing operation of the value **VAL** in the register or in the EEPROM byte located at address **ADR**.

The table below shows information which is writable by WriteRegister Command.

ADR	writable information
0x00 00 to 0x03 C7	XRam memory.
0xA0 00 to 0xA0 FF	EEPROM (128 or 256 bytes): (0xA0 00 address corresponds to 0x00 of the EEPROM).
0xFF 80 to 0xFF FF	SFR (64 bytes).

Fig 32. WriteRegister: Memory mapping

- SFR registers.

  The host controller has to set the High Byte of the address to 0xFF, the real address of the register is given by the low byte.

  The list of SFR registers that may be acceded is the same as the one defined in the **`ReadRegister`** command (§8.2.4, p.59).

- XRAM memory mapped registers.

  The complete address is given by the high and low bytes of address. See [4].

Example:

The host controller writes the value 0xF0 in the register *RX_THRESHOLD* located at address 0x6308 and the value 0x55 in the *IEN1* register (SFR) located at address 0xE8.

The frame from the host controller to the PN533 is:

D4	08	63	08	F0	FF	E8	55

and the frame returned by the PN533 is:

D5	09	00

Warning:

The behavior of the PN533 may be altered by this command.

This command is only recommended for debug purposes.

8.2.6 ReadGPIO

The PN533 reads the value for each port and returns the information to the host controller.

Input:

D4	0C

Output:

D5	0D	P3	P7	I0/I1

- The field **P3** contains the state of the GPIO located on the P3 port,

0	0	P35	P34	P33	P32	P31	P30
		5	4	3	2	1	0

- The field **P7** contains the state of the GPIO located on the P7 port,

0	0	0	0	0	P72	P71	rfu
					2	1	0

- The field **I0I1** is reserved for future used.

0	0	0	0	0	0	rfu	rfu
						1	0

Description:

The GPIOs may be used with the following limitations of usage:

- **P32** corresponds to the pin P32_INT0.

  P32 can be used as standard GPIO and is therefore not used as external interrupt trigger.

- **P33** corresponds to the pin P33_INT1.

  P33 can be used as standard GPIO and is therefore not used as external interrupt trigger.

- **P71** and **P72** are used as GPIO.
- **I0** and **I1** are not used.

8.2.7 WriteGPIO

The PN533 applies the value for each port that is validated by the host controller (bit **Val** of each port).

Input:

D4	0E	P3	P7

- The field **P3** contains the value to apply to the GPIO located on the P3 port,

Val	nu	P35	P34	rfu	P32	rfu	rfu
7		5	4	3	2	1	0

- The field **P7** contains the value to apply to the GPIO located on the P7 port.

Val	nu	nu	nu	nu	P72	P71	0
7					2	1	0

Output:

D5	0F

Description:

For each port that is validated (bit **Val** = 1), all the bits are applied simultaneously. It is not possible for example to modify the state of the port P32 without applying a value to the ports P34 and P35.

As for the command **`ReadGPIO`** (see §8.2.6, p.63), the GPIO may be used with the following limitations of usage:

- **P32** corresponds to the pin P32_INT0. It can be used as standard GPIO and is therefore not used as external interrupt trigger.
- **P34** can be used as standard GPIO.
- **P71** and **P72** are used as GPIO.

Example:

The host controller wants to:

- set P32,
- reset P34 and P35,
- leave P71 and P72 unchanged.

The frame from the host controller to the PN533 is:

D4	0E	84	00

And the frame returned by the PN533 is:

D5	0F

The host controller wants to set all the bits of P3 and P7:

The frame from the host controller to the PN533 is:

D4	0E	BF	86

And the frame returned by the PN533 is:

D5	0F

8.2.8 SetParameters

This command is used to set internal parameters of the PN533, and then to configure its behavior regarding different cases.

Input:

D4	12	Flags

- **Flags** is a bit-field byte which individual definition is the following:

RFU	RFU	5	4	3	2	1	0

- bit 0: fNADUsed ➔ Use of the NAD information in case of initiator configuration (DEP and ISO/IEC14443-4 PCD).
- bit 1: fDIDUsed ➔ Use of the DID information in case of initiator configuration (or CID in case of ISO/IEC14443-4 PCD configuration).
- bit 2: fAutomaticATR_RES ➔ Automatic generation of the ATR_RES in case of target configuration.
- bit 3: fTDApowered ➔ Allow the host to manage the power of TDA.
- bit 4: fAutomaticRATS ➔ Automatic generation of the RATS in case of ISO/IEC14443-4 PCD mode.
- bit 5: fSecure ➔ Enable the PN533 to support the NFC Secure layer.
- bit 6: RFU ➔ **Must** be set to 0.
- bit 7: RFU ➔ **Must** be set to 0.

Output:

D5	13

Syntax Error Conditions:

- **Flags** parameter is missing,
- Incorrect command length.

Description:

fNADUsed (DEP and ISO/IEC14443-4 PCD):

***In DEP mode*:**

By default, the PN533 initiator does not use the NAD byte in the Transport Protocol, so the host controller must set this flag in order to use NAD. The NAD value itself is set by the host controller directly in the **`InDataExchange`** command (see §8.4.8, p.100).

On the opposite side, when the PN533 configured as target is in front of an initiator using NAD byte, the NAD value received by the PN533 will be transmitted to the PN533 host controller for further analysis, and the NAD value to be returned to the initiator will be elaborated by the host controller of the PN533 (so, the NAD values are transported respectively within the **`TgGetData`** and **`TgSetData`** commands).

In both cases (PN533 initiator or PN533 target in Fig 33), the host controller (**A** or **B**) knows that the payload data of the transport commands include NAD values by checking the higher bit of the status byte returned (see §8.1: Error handling, p.50 and Fig 34).

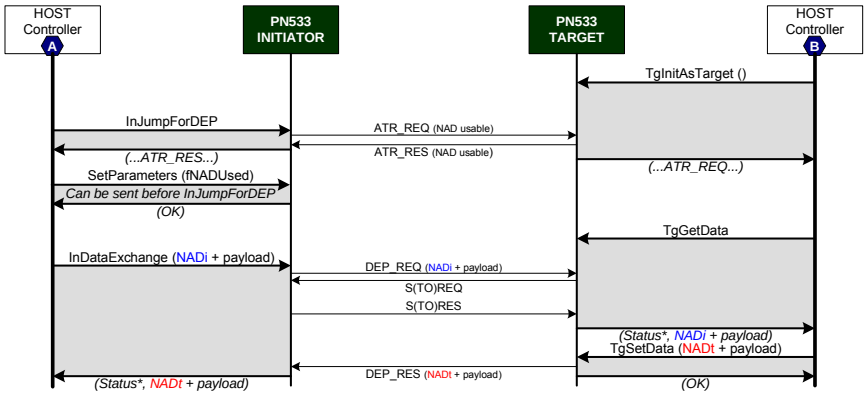


Fig 33. fNADUsed

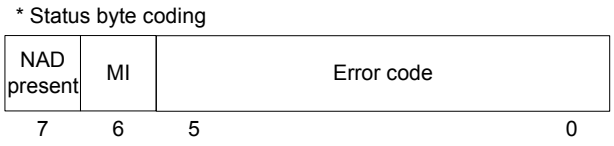


Fig 34. Status Byte definition

***In ISO/IEC14443-4 PCD mode*:**

By default, the PN533 initiator does not use the NAD byte in the Transport Protocol, so the host controller must set this flag in order to use NAD. The NAD value itself is set by the host controller directly in the **`InDataExchange`** command (see §8.4.8, p.100).

In reception mode, the NAD value received by the PN533 will be transmitted to the PN533 host controller.

fDIDUsed (DEP and ISO/IEC14443-4 PCD):

By default, the PN533 initiator does not use the DID byte for DEP and the CID byte for ISO/IEC14443-4 PCD in the Transport Protocol (not multi-target configuration). So the host controller must set this flag in order to use DID / CID. In that case, the DID / CID value itself is completely handled internally by the firmware.

The DID / CID has a fixed value of 0x01 when fDIDUsed is set to 1.

fAutomaticATR_RES:

By default, the PN533 target sends back to the initiator the ATR_RES after having received an ATR_REQ.

For various reasons, the host controller of the PN533 may want to choose the content of the Gt (general bytes of the target), only after having received the general bytes of the initiator. In that case, the host controller must set this flag to 0.

To have a detailed description of these two possibilities, see the commands **`TgSetGeneralBytes`** (see §8.4.16, p.133) and **`TgInitAsTarget`** (see §8.4.14, p.120).

fTDApowered:

When the flag fTDApowered is set to one, the PN533 shall wake-up the TDA8029. The PN533 set the SHUTDOWN pin of the TDA to one.

When the flag fTDApowered is set to zero, the PN533 shall shutdown the TDA8029. The PN533 set the SHUTDOWN pin of the TDA to zero.

Refer to **`I2C TDA8029`** (see §6.3 p.33) to have more details on this functionality.

fAutomaticRATS:

When executing the command **`InListPassiveTarget`** at 106 kbps, the PN533 may initialize cards supporting ISO/IEC14443-4 protocol (the PN533 knows that the target is ISO/IEC14443-4 compliant by analyzing the SEL-RES - SAK byte).

In that case, and if the flag fAutomaticRATS is set, the first command sent to the card is a RATS command. This command is automatically elaborated by the PN533.

If the user does not want to use the ISO/IEC14443-4 protocol with a card that is ISO/IEC14443-4 compliant, this flag must be set to 0.

fSecure:

When the flag fSecure is set to one, the NFC Secure feature is enabled.

When the flag fSecure is set to zero, the NFC Secure feature is disabled.

Summary of the default settings:

If the user does not use the **`SetParameters`** command, the following settings apply:

Table 17. Default values of internal flags

Property	Default value
fNADUsed	No
fDIDUsed	No
fAutomaticATR_RES	Yes, automatic
fTDAPowered	No
fAutomaticRATS	Yes, automatic
fSecure	No

8.3 AlparCommandForTDA

This command is used to communicate with the TDA8029 through the PN533.

To be able to send an ALPAR command to the TDA, you have to switch on the TDA with the **`SetParameter`** command (see §8.2.8, p.66).

Input:

D4	18	ALPAR STRUCTURE IN

Output:

D5	19	Status	[ALPAR STRUCTURE OUT]

- **Status** is a byte indicating if the process has been terminated successfully or not (see §8.1, p.50). In case of error, there is no ALPAR STRUCTURE OUT.

Syntax Error Conditions:

- **ALPAR STRUCTURE IN** parameter missing,
- Incorrect using of ALPAR protocol.

This protocol encapsulates the useful data of a message in an invariant frame structure and defines a dialog structure of messages exchanges.

- **ALPAR structure:**

Header (4bytes)	C-APDU or R-APDU (0 to 249 bytes)	LRC (1byte)

Fig 35. ALPAR structure definition

- **The header includes:**

1st byte								2nd byte	3rd byte	4th byte
X	1	1	0	0	0	0	0	LENGTH_H	LENGTH_L	COMMAND
X = 0 => ACK, X = 1 => NACK								Data length to transmit excluding header and LRC		Command byte

Fig 36. ALPAR Header definition

The LRC (Longitudinal Redundancy Check) byte is such that the exclusive-or (XOR) of all bytes including LRC is null.
See [6] for more details about commands bytes.

Contact command aborts all other commands. See figure below:

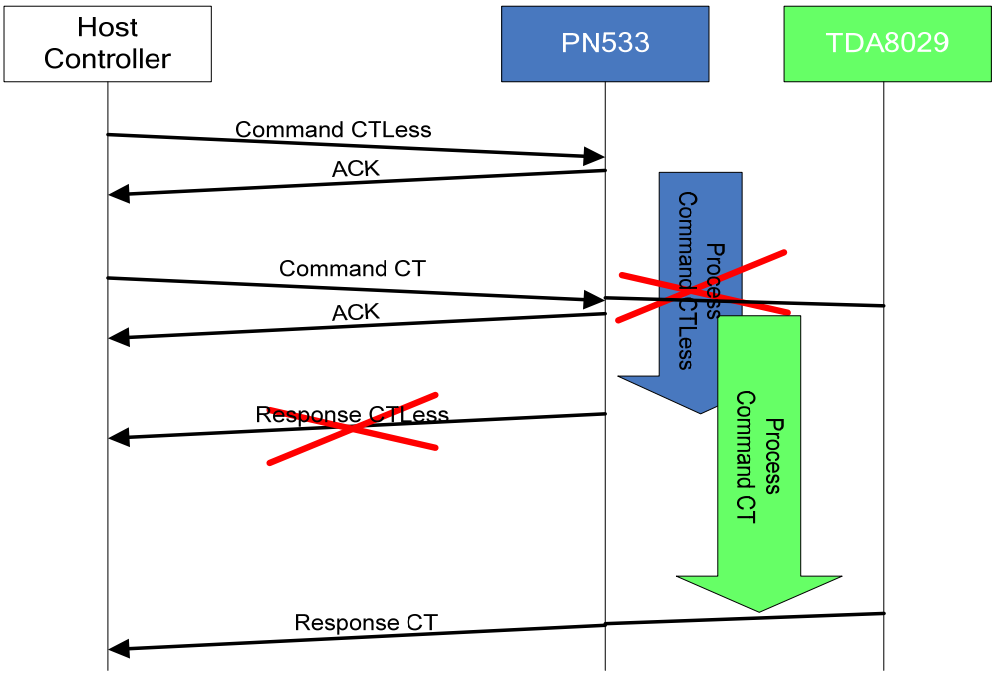


Fig 37. CT Command aborts other commands

Contact command can be aborted by all other commands. See figures below:

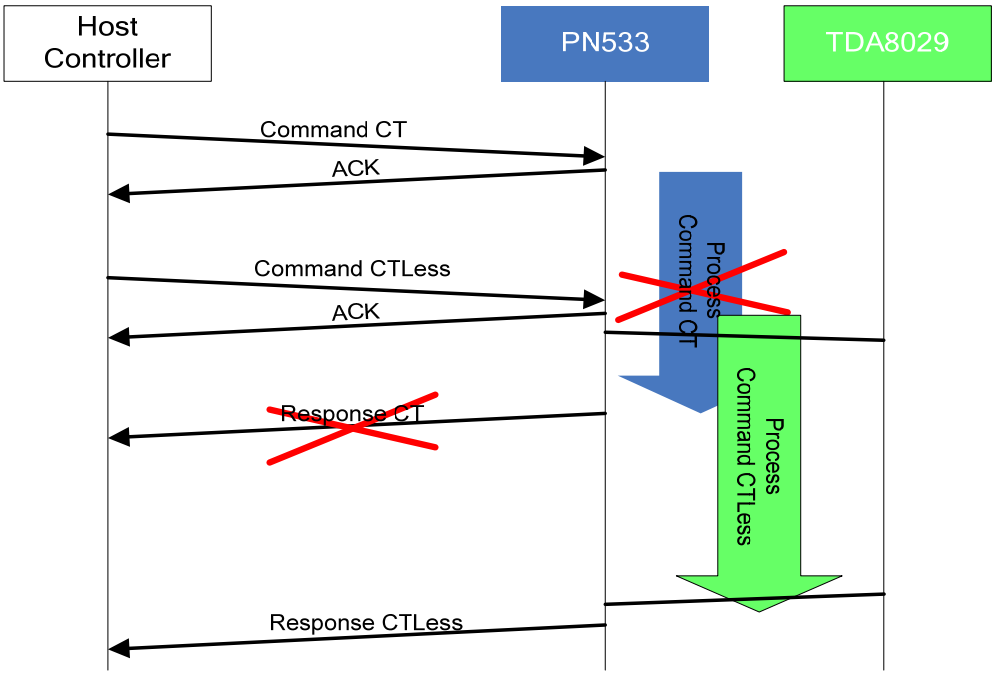


Fig 38. CTLess command aborts a CT command

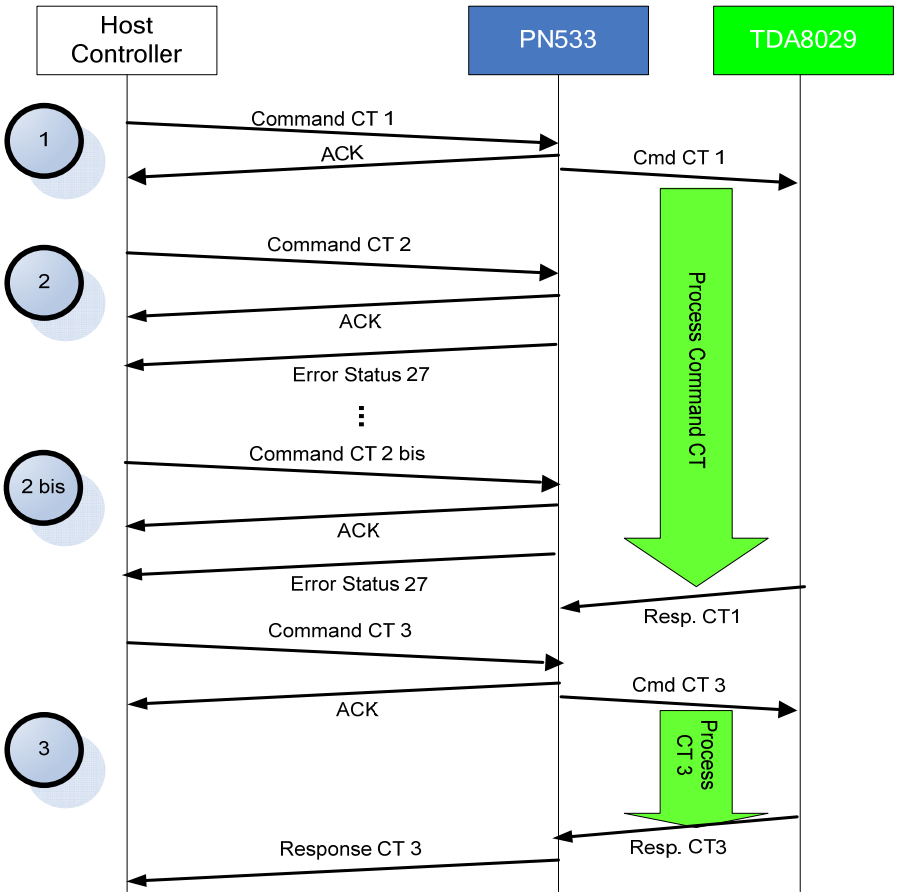


Fig 39. CT Command can be aborted by another CT command

In this case, Contact command (1) is aborted by a second one (2) then an error status 0x27 is returned to the host.

While the TDA is busy, every Contact commands (2bis) return an error 0x27. When the TDA is free, a new Contact command will terminate successfully (3).

8.4 RF Communication command

8.4.1 RFConfiguration

This command is used to configure the different settings of the PN533 as described in the input section of this command.

Input:

D4	32	CfgItem	ConfigurationData [ ]

The **ConfigurationData [ ]** field length and content depend on the **CfgItem** as follows:

- **CfgItem = 0x01: RF field** (**ConfigurationData [ ]** length is 1 byte)

  RFConfiguration allows switching **on** or **off** the RF field immediately.

7	6	5	4	3	2	1	0
nu	nu	nu	nu	nu	nu	Auto RFCA	RF on/off
						0: Off 1: On	0: Off 1: On

  When the bit **AutoRFCA** is off, the PN533 does not need to take care of external field before switching on its own field.

  In other words, if the bit **AutoRFCA** is off and **RFon/off** is on, the PN533 will generate RF field whatever external field is (present or not).

- **CfgItem = 0x02: Various timings** (3 bytes)

Table 18. _Various timings

Byte #	Variable definition	Variable name
Byte 1	RFU	
Byte 2	ATR_RES TimeOut	fATR_RES_Timeout
Byte 3	TimeOut during non-DEP communications	fRetryTimeout

The **first byte** is RFU.

The **second byte** in this item defines the timeout between ATR_REQ and ATR_RES when the PN533 is in initiator mode. A target is considered as mute if no valid ATR_RES is received within this timeout value. In this way, the PN533 can easily detect non TPE target in passive 212-424 kbps mode.

The default value for this parameter is 0x0B (102.4 ms).

The **third byte** defines the timeout value that the PN533 uses in the **`InCommunicateThru`** (§8.4.9, p.109) command to give up reception from the target in case of no answer.

The default value for this parameter is 0x0A (51.2 ms).

This timeout definition is also used with **`InDataExchange`** (§8.4.8, p.100) when the target is a FeliCa or a MIFARE card (Ultralight, Standard …).

For the timings of CfgItem 0x02, the coding is the following:

In case n = 0 No timeout

In case 1 ≤ n ≤ 16 $T_{(\mu s)} = 100 \times 2^{(n-1)}$

Table 19. Timings definition for RFConfiguration command

Byte Value (n)	Timeout Value
0x00	no timeout
0x01	100 µs
0x02	200 µs
0x03	400 µs
0x04	800 µs
0x05	1.6 ms
0x06	3.2 ms
0x07	6.4 ms
0x08	12.8 ms
0x09	25.6 ms
0x0A	51.2 ms
0x0B	102.4 ms
0x0C	204.8 ms
0x0D	409.6 ms
0x0E	819.2 ms
0x0F	1.64 sec
0x10	3.28 sec

- **CfgItem = 0x04: MaxRtyCOM** (1 byte)

  The information **MaxRtyCOM** (1 byte) defines the number of retry that the PN533 will use in the **`InCommunicateThru`** (§8.4.9, p.109) command in case of mute target or error detected. This information is also used with **`InDataExchange`** (§8.4.8, p.100) when the target is a FeliCa or a MIFARE card.

  The specific value 0xFF means that the PN533 retries eternally.

  The default value of this parameter is 0x00 (no retry, only one try).

- **CfgItem = 0x05: MaxRetries** (3 bytes)

Table 20. Maximum retries

Byte #	Variable name
Byte 1	MxRtyATR
Byte 2	MxRtyPSL
Byte 3	MxRtyPassiveActivation

The parameters **MxRtyATR**, **MxRtyPSL** and **MxRtyPassiveActivation** define the number of retries that the PN533 will use in case of the following processes:

- **MxRtyATR** is a byte containing the number of times that the PN533 will retry to send the ATR_REQ in case of incorrect reception of the ATR_RES (or no reception at all - timeout).

  For **active mode**, value 0xFF means to try endlessly, 0x00 means only once (no retry, only one try). The default value of this parameter is 0xFF.

  For **passive mode**, the value is always overruled with 0x02 (two retries).

- **MxRtyPSL** is a byte containing the number of times that:
  - The PN533 will retry to send the PSL_REQ in case of incorrect reception of the PSL_RES (or no reception at all) for the NFCIP-1 protocol,
  - The PN533 will retry to send the PPS request in case of incorrect reception of the PPS response (or no reception at all) for the ISO/IEC14443-4 protocol.

  Value 0xFF means to try eternally, 0x00 means only once (no retry, only one try).The default value of this parameter is 0x01 (the PSL_REQ/PPS request is sent twice in case of need).

- **MxRtyPassiveActivation** is a byte containing the number of times that the PN533 will retry to activate a target in **`InListPassiveTarget`** command (§8.4.5, p.87).

  Value 0xFF means to try eternally, 0x00 means only once (no retry, only one try).
  The default value of this parameter is 0xFF (infinitely).

- **CfgItem = 0x0A: Analog settings for the baudrate 106 kbps type A** (11 bytes)

This CfgItem is used to choose the analog settings that the PN533 will use for the baudrate 106kbps type A.

When using this command, the host controller has to provide 11 values (**ConfigurationData [ ]**) for the following internal registers:

Table 21. Analog settings for the baudrate 106 kbps type A

Byte #	Register	Default values
Byte 1	CIU_RFCfg	0x5A
Byte 2	CIU_GsNOn	0xF4
Byte 3	CIU_CWGsP	0x3F
Byte 4	CIU_ModGsP	0x11
Byte 5	CIU_DemodRfOn *when own RF is On*	0x4D
Byte 6	CIU_RxThreshold	0x85
Byte 7	CIU_DemodRfOff *when own RF is Off*	0x61
Byte 8	CIU_GsNOff	0x6F
Byte 9	CIU_ModWidth	0x26
Byte 10	CIU_MifNFC	0x62
Byte 11	CIU_TxBitPhase	0x87

Note:

Actually, there is only one **Demod** register which defines a setting used by the reader in reception only. But depending on the RF condition, two different settings can be used for this register:

- **CIU_Demod when own RF is On** defines a setting when its RF field is on during a reception i.e. initiator passive mode,
- **CIU_Demod when own RF is Off** defines a setting when its RF field is off during a reception i.e. initiator active mode.

It is the same case for the **GsN** register:

- **CIU_GsnOn** defines a setting to be used by a reader (or a target) when the RF field is on.
- **CIU_GsnOff** defines a setting to be used by a reader (or a target) when the RF field is off.

- **CfgItem = 0x0B: Analog settings for the baudrate 212/424 kbps** (8 bytes)

This CfgItem is used to choose the analog settings that the PN533 will use for baudrates 212/424kbps.

When using this command, the host controller has to provide 8 values (**ConfigurationData [ ]**) for the following internal registers:

Table 22. Analog settings for the baudrate 212/424 kbps

Byte #	Register	Default values
Byte 1	CIU_RFCfg	0x6A
Byte 2	CIU_GsNOn	0xFF
Byte 3	CIU_CWGsP	0x3F
Byte 4	CIU_ModGsP	0x11
Byte 5	CIU_DemodRfOn *when own RF is On*	0x41
Byte 6	CIU_RxThreshold	0x85
Byte 7	CIU_DemodRfOff *when own RF is Off*	0x61
Byte 8	CIU_GsNOff	0x6F

Note:

Actually, there is only one **CIU_Demod** register which defines a setting used by the reader in reception only. But depending on the RF condition, two different settings can be used for this register:

- **CIU_Demod when own RF is On** defines a setting when its RF field is on during a reception i.e. initiator passive mode,
- **CIU_Demod when own RF is Off** defines a setting when its RF field is off during a reception i.e. initiator active mode.

- **CfgItem = 0x0C: Analog settings for the type B** (3 bytes)

This CfgItem is used to choose the analog settings that the PN533 will use for the type B when configured as PCD.

When using this command, the host controller has to provide 3 new values (**ConfigurationData [ ]**) for the following internal registers:

Table 23. Analog settings for the type B

Byte #	Register	Default values
Byte 1	CIU_GsNOn	0xFF
Byte 2	CIU_ModGsP	0x17
Byte 3	CIU_RxThreshold	0x85

Except for these three specific settings, the 8 remaining analog settings are the same as the CfgItem 106 kbps type A.

- **CfgItem = 0x0D: Analog settings for baudrates 212/424 and 847 kbps with ISO/IEC14443-4 protocol** (9 bytes)

  This CfgItem is used to choose the analog settings that the PN533 will use for the baud rates 212/424/847 kbps with ISO/IEC14443-4 cards.

  When using this command, the host controller has to provide 9 values (**ConfigurationData [ ]**) for the following internal registers:

Table 24. Analog settings for the baudrate 212/424 and 847 kbps with ISO/IEC14443-4 protocol

Byte #	Register	Default values	Baudrate
Byte 1	CIU_RxThreshold	0x85	212 kbps
Byte 2	CIU_ModWidth	0x15	
Byte 3	CIU_MifNFC	0x8A	
Byte 4	CIU_RxThreshold	0x85	424 kbps
Byte 5	CIU_ModWidth	0x0A	
Byte 6	CIU_MifNFC	0xB2	
Byte 7	CIU_RxThreshold	0x85	847 kbps
Byte 8	CIU_ModWidth	0x04	
Byte 9	CIU_MifNFC	0xDA	

Except for these three specific registers (CIU_RxThreshold, CIU_ModWidth and CIU_MifNFC), the 8 remaining analog registers are the same as the previous CfgItem 0x0A.

Output:

D5	33

Syntax Error Conditions:

- Various timings values greater than 0x10 (item 2),
- Incorrect **CfgItem** value (0x00, 0x03, 0x06, 0x07, 0x08, 0x09 and greater than 0x0D),
- Incorrect command length.

8.4.2 RFRegulationTest

This command is used for radio regulation test.

Input:

D4	58	TxMode

- **TxMode** is the definition of the bit rate and of the framing used for data transmission.

7	6	5	4	3	2	1	0
nu	TxSpeed			nu	nu	TxFraming	

000: 106 kbps
001: 212 kbps
010: 424 kbps
011: 847 kbps

00: MIFARE
10: FeliCa

Output:

This command never stops, so no output frame is sent.

Description:

The PN533 makes RF transmission with pseudo random numbers by using the PRBS15 bit of the *CIU_TestSel2* register (see [4]). The transmission speed and the framing are indicated by the host controller with the **TxMode** parameter.

The **TxMode.TxSpeed** parameter defines the bit rate that is used during the transmission (106, 212, 424 kbps or 847 kbps).

The **TxMode.TxFraming** parameter defines the type of modulation (MIFARE or FeliCa modulation).

The PN533 transmits data until a new command comes from the host controller.

8.4.3 InJumpForDEP

This command is used by a host controller to activate a target using either active or passive communication mode.

If a target is in the field, it will then be ready for DEP exchanges.

Input:

D4	56	ActPass	BR	Next	[PassiveInitiatorData] (4 or 5 bytes)
					[NFCID3i [0..9]]
					[Gi [0..n]]

- **ActPass** is the communication mode requested by the host controller
  - 0x00 : Passive mode,
  - 0x01 : Active Mode.
- **BR** is the Baud Rate to be used during the activation
  - 0x00 : 106 kbps,
  - 0x01 : 212 kbps,
  - 0x02 : 424 kbps.
- **Next** indicates if the optional fields of the command (**PassiveInitiatorData**, **NFCID3i** and **Gi**) are present (bit = 1) or not (bit = 0).
  - bit 0 : PassiveInitiatorData is present in the command frame,
  - bit 1 : NFCID3i is present in the command frame,
  - bit 2 : Gi is present in the command frame.
- **PassiveInitiatorData [ ]** is an array of data to be used during the initialization of the target in case of passive communication mode (**ActPass**). Depending on the Baud Rate specified, the content of this field is different:
  - **106 kbps:**

    The field is optional and is present only when the host controller wants to initialize a target with a known ID (according to [1], the first byte of this ID should be 0x08 for a TPE target). In that case, **PassiveInitiatorData [ ]** contains the ID of the target (4 bytes).
  - **212/424 kbps:**

    In that case, this field is mandatory in passive communication mode and contains the complete payload information that should be used in the polling request command (5 bytes, length byte is excluded) as defined in [3], §11.2.2.5.
- **NFCID3i** is the NFCID3 of the initiator that is used by the PN533 within the ATR_REQ. Depending on the baud rate specified and the communication mode, the use of this field is different:
  - **106/212/424 kbps, active mode:**
    The field is used to build the ATR_REQ frame. If not present, the PN533 will use a random value.
  - **106 kbps, passive mode:**
    The field is used to build the ATR_REQ frame. If not present, the PN533 will use a random value.

– **212/424 kbps, passive mode:**

This field is not used. The NFCID3i field of the ATR_REQ is filled with the value of the NFCID2t of the target received in the POL_RES frame (refer to process description in passive mode).

- **Gi** contains the general bytes for the ATR_REQ (optional, max. 48 bytes).

Output:

D5	57	Status	Tg	NFCID3t[0..9]	DIDt	BSt	BRt
					TO	PPt	[Gt [0..n]]

- **Status** is a byte indicating if the process has been terminated successfully or not (see §8.1, p.50),
- **Tg** is the logical number attributed to the activated target.

  The target number returned within this output frame is always 0x01 (only one TPE target is supported).

The following parameters are part of the **ATR_RES** sent by the target:

- **NFCID3t[0..9]** is an array of bytes containing the random identifier of the target,
- **DIDt** is the DID byte sent by the target,
- **BSt** specifies the supported send-bit rate by the target,
- **BRt** specifies the supported receive-bit rate of the target,
- **TO** specifies the timeout value of the target in transport protocol,
- **PPt** specifies the optional parameters of the target (Length reduction, NAD usable and General bytes),
- **Gt [0..n]** are the optional general bytes (max. 47 bytes). They contain general information.

Syntax Error Conditions:

- Incorrect Baud Rate (**BR**),
- Incorrect **ActPass** parameter,
- Bad TSN (Time Slot Number) value in **PassiveInitiatorData**, in passive 212/424 kbps mode (different from 0x00, 0x01, 0x03, 0x07 or 0x0F),
- Incorrect command length.

Description:

The process is different depending on the communication mode (Active or Passive):

ACTIVE MODE

- Do Initial RFCA
- ATR_REQ
  - Set the communication settings (Active mode, baud rate **BR**)
  - Send ATR_REQ constructed with **NFCID3i [ ]** and **Gi [ ]**.
    Depending on the value of the internal parameter fDIDUsed (set by the host controller with **`SetParameters`** command (§8.2.8, p.66)), the PN533 constructs the ATR_REQ with or without a DID parameter. If used, the DID value is fixed by the PN533 to 0x01.
  - Receive ATR_RES.
    The PN533 waits for this answer from the target a maximum time (timeout defined with the **`RFConfiguration`** command (§8.4.1, p.73)). In case of incorrect ATR_RES received, the PN533 sends again ATR_REQ (MxRtyATR times)
- If a correct ATR_RES is received then the PN533 stores the NFCID3t and attributes a logical number for this new target (**Tg**). The target number returned within this output frame is always 0x01.

  The complete **ATR_RES** (CMD0 CMD1 = 0xD5 0x01 excepted) is sent back to the host controller

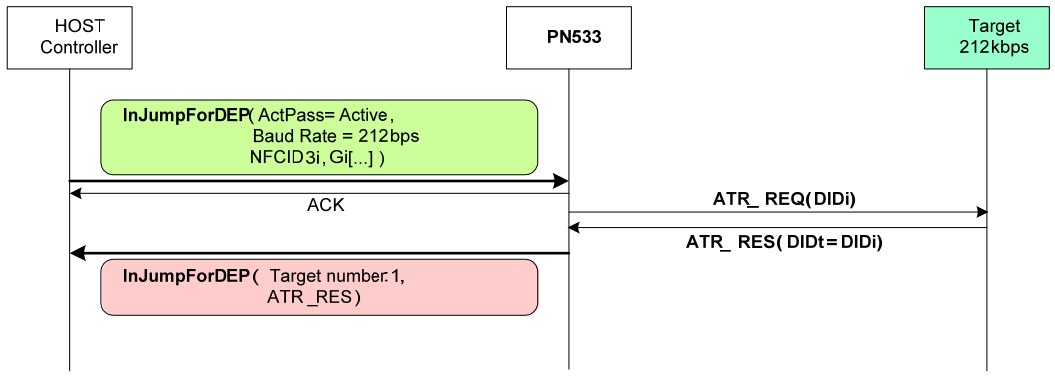


Fig 40. InJumpForDEP – Active communication mode – DID used

PASSIVE MODE

- Do Initial RFCA
- If BR = 106 kbps
  - Select one target (SENS_REQ, SDD_REQ, SEL_REQ)
    - If no Transport Protocol Equipped (TPE) target is detected, try again the process (SENS_REQ …). The absence of target is detected with a ~5 ms timeout value,
  - Store the NFCID1t for further use,
  - Send an ATR_REQ constructed with **NFCID3i [ ]** and **Gi [ ]**.
    Depending on the value of the internal parameter fDIDUsed, the ATR_REQ contains or not a DID parameter. If used, the DID value is fixed by the PN533 to 0x01.
- Else if BR = 212, 424 or 847 kbps
  - Process a time slot SDD: send a POL_REQ with a **PassiveInitiatorData** given by the host controller. This POL_REQ command is sent under a timeout control which value depends on the Time Slot Number (see **`InListPassiveTarget`** §8.4.5, p.87).
    - If a correct POL_RES answer is received, then store the NFCID2t for further use.
    - If no valid POL_RES is received in due time, try again the process (POL_REQ).
  - Send an ATR_REQ constructed with an overruled **NFCID3i [ ]** and **Gi [ ]**.
    Depending on the value of the internal parameter fDIDUsed, the ATR_REQ contains or not a DID parameter. If used, the DID value is fixed by the PN533 to 0x01.
    To allow selection between several targets, the NFCID3i field of the ATR_REQ is filled with the value of the NFCID2t of the target received in the POL_RES.
    The sizes of NFCID3i and NFCID2t are different, so following padding is used:

NFCID3i									
0	1	2	3	4	5	6	7	8	9
NFCID2t0	NFCID2t1	NFCID2t2	NFCID2t3	NFCID2t4	NFCID2t5	NFCID2t6	NFCID2t7	0x00 (padding)	0x00 (padding)

- Receive ATR_RES

  In case of success (no timeout), the target is Transport Protocol Equipped. In that case, the NFCID3t is memorized in the PN533 and the ATR_RES is sent back to the host controller (CMD0 CMD1 = 0xD5 0x01 excepted).

  The PN533 waits for this ATR_RES coming from the target a maximum time (timeout defined with the **`SetParameters`** command (§8.2.8, p.66)).

  Twice ATR_REQ are sent by PN533, in case of incorrect ATR_RES received. The MxRtyATR parameter from the **`RFConfiguration`** command (§8.4.1, p.73) is not take into account.

- If correct ATR_RES is received then the PN533 stores the NFCID3t and attributes a logical number for this new target (**Tg**).

  The target number returned within this output frame is always 0x01.

The following figure depicts the **InJumpForDEP** process in case of passive mode activation at 106 kbps.

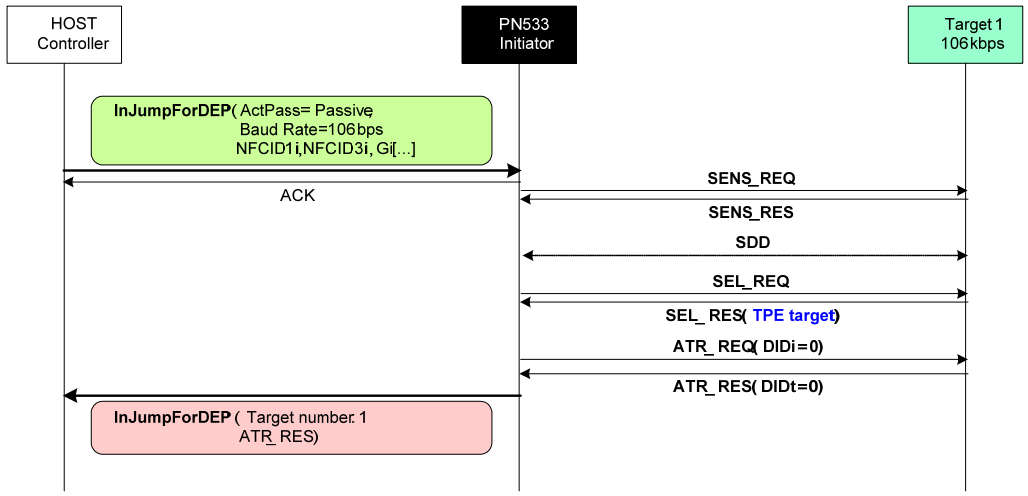


Fig 41. InJumpForDEP – Passive Communication Mode – DID not used

Remark: In any cases (active or passive mode), if this command is aborted by the host controller without any target activated, the RF field is automatically switched off to decrease power consumption (see chapter §3.1.2.7, p.16).

8.4.4 InJumpForPSL

This command is used by a host controller to activate a target using either active or passive communication mode.

If a target is in the field, it will then be ready for PSL or DEP exchanges.

Input:

D4	46	ActPass	BR	Next	[PassiveInitiatorData] (4 or 5 bytes)
					[NFCID3i [0..9]]
					[Gi [0..n]]

- **ActPass** is the communication mode requested by the host controller
  - 0x00 : Passive mode
  - 0x01 : Active Mode
- **BR** is the Baud Rate to be used during the activation
  - 0x00 : 106 kbps
  - 0x01 : 212 kbps
  - 0x02 : 424 kbps
- **Next** indicates if the optional fields of the command (**PassiveInitiatorData**, **NFCID3i** and **Gi**) are present (bit = 1) or not (bit = 0).
  - bit 0 : PassiveInitiatorData is present in the command frame
  - bit 1 : NFCID3i is present in the command frame
  - bit 2 : Gi is present in the command frame
- **PassiveInitiatorData [ ]** is an array of data to be used during the initialization of the target in case of passive communication mode (**ActPass**). Depending on the Baud Rate specified, the content of this field is different:
  - **106 kbps:**

    The field is optional and is present only when the host controller wants to initialize a target with a known ID. In that case, **PassiveInitiatorData [ ]** contains the ID of the target (4 bytes).
  - **212/424 kbps:**

    In that case, this field is mandatory in passive communication mode and contains the complete payload information that should be used in the polling request command (5 bytes, length byte is excluded) as defined in [3], §11.2.2.5.
- **NFCID3i** is the NFCID3 of the initiator that is used by the PN533 within the ATR_REQ. Depending on the baud rate specified and the communication mode, the use of this field is different:
  - **106/212/424 kbps, active mode:**
    The field is used to build the ATR_REQ frame. If not present, the PN533 will use a random value.
  - **106 kbps, passive mode:**
    The field is used to build the ATR_REQ frame. If not present, the PN533 will use a random value.

– **212/424 kbps, passive mode:**

This field is not used. The NFCID3i field of the ATR_REQ is filled with the value of the NFCID2t of the target received in the POL_RES frame. Refer to **`InJumpForDEP`** (§8.4.3, p.80).

- **Gi** contains the general bytes for the ATR_REQ (optional, max. 48 bytes).

Output:

D5	47	Status	Tg	NFCID3t[0..9]	DIDt	BSt	BRt
					TO	PPt	[Gt [0..n]]

- **Status** is a byte indicating if the process has been terminated successfully or not (see §8.1, p.50),
- **Tg** is the logical number attributed to the activated target.

  The target number returned within this output frame is always 0x01 (only one TPE target is supported).

The following parameters are part of the **ATR_RES** sent by the target:

- **NFCID3t[0..9]** is an array of bytes containing the random identifier of the target,
- **DIDt** is the DID byte sent by the target,
- **BSt** specifies the supported send-bit rate by the target,
- **BRt** specifies the supported receive-bit rate of the target,
- **TO** specifies the timeout value of the target in transport protocol,
- **PPt** specifies the optional parameters of the target (Length reduction, NAD usable and General bytes),
- **Gt [0..n]** are the optional general bytes. They contain general information.

Syntax Error Conditions:

- Incorrect Baud Rate (**BR**),
- Incorrect **ActPass** parameter,
- Bad TSN (Time Slot Number) value in **PassiveInitiatorData**, in passive 212/424 kbps mode (different from 0x00, 0x01, 0x03, 0x07 or 0x0F),
- Incorrect command length.

Description:

The process of this command is exactly the same than the one of **`InJumpForDEP`** (§8.4.3, p.80).

8.4.5 InListPassiveTarget

The goal of this command is to detect targets (maximum **MaxTg**) in passive mode.

Input:

D4	4A	MaxTg	BrTy	[InitiatorData[ ]]

- **MaxTg** is the maximum number of targets to be initialized by the PN533.

  The PN533 is capable of handling 1 target maximum at once, so this field should not exceed 0x01.

- **BrTy** is the baud rate and the modulation type to be used during the initialization
  - 0x00 : 106 kbps type A (ISO/IEC14443 Type A or MIFARE) or 106 kbps RFA tag,
  - 0x01 : 212 kbps (FeliCa polling),
  - 0x02 : 424 kbps (FeliCa polling),
  - 0x03 : 106 kbps type B (ISO/IEC14443-3B)[9],
  - 0x04 : 106 kbps Innovision Jewel tag.
  - 0x05 : rfu
  - 0x06 : 212 kbps type B (ISO/IEC14443-3B)[10]
  - 0x07 : 424 kbps type B (ISO/IEC14443-3B)[11]
  - 0x08 : 847 kbps type B (ISO/IEC14443-3B)[12]

- **InitiatorData [ ]** is an array of data to be used during the initialization of the target(s). Depending on the Baud Rate specified, the content of this field is different:

  – 106 kbps type A:

  The field is optional and is present only when the host controller wants to initialize a target with a known UID.
  In that case, **InitiatorData [ ]** contains the UID of the card (or part of it). **The UID must include the cascade tag CT if it is cascaded level 2 or 3**.

  Cascade Level 1

UID1	UID2	UID3	UID4

  Cascade Level 2

CT	UID1	UID2	UID3	UID4	UID5	UID6	UID7

  Cascade Level 3

CT	UID1	UID2	UID3	CT	UID4	UID5	UID6	UID7	UID8	UID9	UID10

[9] During activation phase, PN533 will negociate a maximum baud rate of 106kbps.
[10] During activation phase, PN533 will negociate a maximum baud rate of 212kbps.
[11] During activation phase, PN533 will negociate a maximum baud rate of 424kbps.
[12] During activation phase, PN533 will negociate a maximum baud rate of 847kbps.

– **106/212/424/847 kbps type B[13]:**

In this case, **InitiatorData[ ]** is formatted as following:

AFI (1 byte)	[Polling Method]

- **AFI:**
  The AFI (Application Family Identifier) parameter represents the type of application targeted by the PN533 and is used to pre-select the PICCs before the ATQB.
  This field is mandatory.

- **Polling Method:**
  This field is optional. It indicates the approach to be used in the ISO/IEC14443-3B initialization:
  - If bit 0 = 1: Probabilistic approach (option 1) in the ISO/IEC14443-3B initialization,
  - If bit 0 = 0: Timeslot approach (option 2) in the ISO/IEC14443-3B initialization,
  - If this field is absent, the timeslot approach will be used.

– **212/424 kbps:**

In that case, this field is mandatory and contains the complete payload information that should be used in the polling request command (5 bytes, length byte is excluded) as defined in [3] §11.2.2.5.

– **106 kbps Innovision Jewel tag:**

This field is not used.

– **106 kbps RFA tag:**

This field is not used.

[13] This NXP IC is licensed under Innovatron's ISO/IEC 14443 Type B patent license.

Output:

D5	4B	NbTg	[TargetData [ ]]

- **NbTg** is the Number of initialized Targets (minimum 0, maximum 1 target),
- **TargetData [ ]** contains the information about the detected target and depends on the baud rate selected. The following information is given for one target.
  - **106 kbps Type A:**

Tg	SENS_RES[14] (2 bytes)	SEL_RES (1 byte)	NFCIDLength (1 byte)	NFCID1[ ] (NFCIDLength bytes)	[ATS[ ]] (ATSLength bytes[15])

  - **106/212/424/847 kbps Type B:**

Tg	ATQB Response (12 bytes)	ATTRIB_RES Length (1 byte)	ATTRIB_RES[ ] (ATTRIB_RES Length)

  - **212/424 kbps:**

Tg	POL_RES length	0x01 (response code)	NFCID2t	Pad	SYST_CODE (optional)
1 byte	1 byte	1 byte	8 bytes	8 bytes	2 bytes
	POL_RES (18 or 20 bytes)				

  - **106 kbps Innovision Jewel tag:**

Tg	SENS_RES (2 bytes)	JEWELID[ ] (4 bytes)

  - **106 kbps RFA tag:**

Tg	SENS_RES[16] (2 bytes)	SEL_RES (1 byte)	RFAIDLength (1 byte)	RFAID1[ ] (RFAIDLength bytes)

Syntax Error Conditions:

- **MaxTg** value is incorrect (0 or higher than 1) for the targets 106 kbps type A, 106/212/424/847 kbps type B, 212/424 kbps felica, 106kbps Innovision Jewel® and 106 kbps RFA.
- **BrTy** value is incorrect,
- TSN number in the **InitiatorData** is incorrect in passive 212/424 kbps mode (different from 0x00, 0x01, 0x03, 0x07 or 0x0F),
- AFI parameter missing for Type B,
- Incorrect command length.

[14] The first byte is the MSB, the second one the LSB.

[15] The first byte of the ATS frame sent by an ISO14443-4 card in response to RATS is the length of the complete ATS (cf. [2]). Thus here, the ATS structure is

[ATSLength xx_1 xx_2 xx_3 xx_4 … $xx_{ATSLength-2}$ $xx_{ATSLength-1}$]

[16] The first byte is the MSB, the second one the LSB.

Description:

Depending on the baud rate and the modulation type requested, the PN533 will use a MIFARE, FeliCa, ISO/IEC14443-3B or Innovision Jewel initialization.

The default analog settings or those that have been modified by the host controller with the **`RFConfiguration`** command (CfgItem 0x0A, 0x0B, 0x0C, 0x0D) are used during the activation.

- **if BrTy = 0x00 (106 kbps Type A) or RFA tag**
  - As long as there is no target detected (maximum = **MaxTg**),

    (*This process is done MxRtyPassiveActivation times (§*8.4.1*, p.73, CfgItem 0x05), if no answer is detected the command is terminated and the field **NbTg** in the output buffer contains 0x00, meaning that no target has been detected with the number of allowed trials).*
    - Probe the field for targets using either SENS_REQ or ALL_REQ command with timeout control of ~5 ms.

      The ALL_REQ command is sent if the **InitiatorData[ ]** input data contains a UID of a card. The ID includes the cascade tag CT if it is cascaded level 2 or 3.
    - If one of several target(s) has been detected with the previous command, handle the anti-collision (SDD_REQ) and then select one target (SEL_REQ command).
    - If the selection is successful, the PN533 attributes a logical number for the current target. This logical number will then be used by the host controller in all the target-related commands (**`InDataExchange`**, **`InATR`**, **`InPSL`**, **`InSelect`** …) to identify the target.

      The first target found when executing this command will have the number Tg=1.
      The information relative to previously initialized targets (stored inside the PN533) is lost.
    - Fill the **TargetData [ ]** output buffer with all the information relative to the target (Tg, SENS_RES, SEL_RES, length of the NFCID1t field, NFCID1t)
    - If the target indicates that it is ISO/IEC14443-4 compliant, then the PN533 carries out the ISO/IEC14443-4 activation, sending a RATS and waiting for a ATS response from the card.

      In that case, the complete ATS response frame is sent back to the host controller in **TargetData [ ]**.
  - The real number of initialized target is indicated to the host controller in the **NbTg** field ($0 \leq$ **NbTg** $\leq$ MaxTg).
  - The latest target initialized remains active and is not put in HALT state. Thus, the host controller is able to exchange data with this target more quickly.

Remark 1: The NFCID1t does not include the cascade tag CT if it is cascaded level 2 or 3.

Remark 2: In case of multiple targets activation, when a collision is detected on the SENS_RES, the SENS_RES field in **TargetData [ ]** is filled with value (0x00, 0x00).

- **if BrTy = 0x03, 0x06, 0x07 or 0x08 (106/212/424 or 847 kbps Type B)**
  - As long as there is no target detected (maximum = **MaxTg**),

    (*This process is done MxRtyPassiveActivation times (§8.4.1, p.73, CfgItem 5), if no answer is detected the command is terminated and the field **NbTg** in the output buffer contains 0x00, meaning that no target has been detected with the number of allowed trials).*

    - Probe the field for targets using either REQB or WUPB command with timeout control of ~5 ms.

      The WUPB command is sent if the **InitiatorData[ ]** input data indicates that the card is initially in HALT state.
    - If one of several target(s) have been detected with the previous command, handle the anti-collision using of REQB command if the probabilistic approach is used (ISO144443-3B option 1), SLOT_MARKER command in the timeslot approach (ISO/IEC14443-3B option 2) and then select one target (ATTRIB command[17]).
    - If the selection is successful, the PN533 attributes a logical number for the current target. This logical number will then be used by the host controller in all the target-related commands (InDataExchange, InATR, InPSL, InSelect …) to identify the target.

      The first target found when executing this command will have the number Tg =1.

      The information relative to previously initialized targets (stored inside the PN533) is lost.
    - Fill the **TargetData [ ]** output buffer with all the information relative to the target (Tg, ATQB_RES, length of the ATTRIB_RES and the ATTRIB_RES.
  - The real number of initialized target is indicated to the host controller in the **NbTg** field ($0 \leq$ **NbTg** $\leq$ MaxTg).
  - The latest target initialized remains active and is not put in HALT state. Thus, the host controller is able to exchange data with this target more quickly.

- **if BR = 0x01 or 0x02 (212 kbps or 424 kbps)**
  - As long as there is no target detected (with a maximum number MxRtyPassiveActivation of retries), process a time slot SDD: send a POL_REQ with the PolReqPayload information given by the host controller.

    This command is sent with a timeout control whose value depends on the Time Slot Number (TSN) chosen by the host controller in the **InitiatorData [ ]** field:

    TOvalue = Td + (TSN+1) x Ts

    TOvalue = 512 x 64/fc + (TSN+1) x 256 x 64/fc

    TOvalue = 2.42 ms + (TSN+1) x 1.21 ms

    *(This process is done MxRtyPassiveActivation times (§8.4.1, p.73, CfgItem 5), if no answer is detected the command is terminated and the field **NbTg** in the output buffer contains 0x00, meaning that no target has been detected with the number of allowed trials).*
  - When one or several targets have answered to the polling request command, the PN533 checks the coherence of the answer(s):
    - The command byte in the polling response has to be equal to 1,

[17] Value of Param2 Parameter of ATTRIB command will depend on BrTy value.

- The PN533 has to receive 18 bytes or 20 bytes of polling response frame. The response frame length depends on POL_REQ type and Card model.

All the targets that do not satisfy these conditions are rejected.

If the POL_RES is correct, the PN533 attributes a logical number for the current target. This logical number will then be used by the host controller in all the target-related commands (**`InDataExchange`**, **`InATR`**, **`InPSL`**, **`InSelect`** …) to identify the target.

The first target found when executing this command will have the number Tg=1. If previous targets were initialized previously, the information relative to these targets (stored inside the PN533) is lost.

Fill the **TargetData [ ]** output buffer with the answer of the valid target:

- 1 byte containing the logical number attributed (Tg),
- 1 byte indicating the length of the POL_RES (2 + IDm (NFCID2t) + Pad + [SystCode] ➔ 18 or 20 bytes),
- 1 response code byte, fixed value 0x01,
- 8 bytes for NFCID2t (IDm),
- 8 bytes for the Pad,
- 2 possible bytes for the System Code of the target when the polling response frame is 20 bytes long.

– The real number of initialized target is indicated to the host controller in the **NbTg** field (0 ≤ **NbTg** ≤ MaxTg).

- **If BrTy = 0x04 (106 kbps Innovision Jewel tag)**
  – As long as there is no target detected (maximum 1 target),
    - Probe the field for targets using the ATQA_REQ command with timeout control of ~5 ms,
    - If one target has been detected with the previous command, read the identification of the Jewel tag using the RID command,
    - If the reading of identification is successful, the PN533 attributes the logical number 1 for the current target. This logical number will then be used by the host controller in all the target-related commands (**`InDataExchange`**, **`InSelect`** …) to identify the target.
    - Fill the **TargetData [ ]** output buffer with all the information relative to the target (ATQA_RES, RID_RES).

Remark: If this command is aborted by the host controller without any target activated, the RF field is automatically switched off to decrease power consumption (see chapter §3.1.2.7, p.16).

Examples:

- In the first example, the host controller requires the initialization of one target at 106 kbps type A.

```
➔ D4 4A  01  00
🡐 D5 4B  01  01  04 00  08  04  92 2E 58 32
```

In the answer frame, it is indicated that one target has been initialized with the following parameters:

- Logical Number **01**
- SENS_RES **04 00**
- SEL_RES **08**
- NFCID1t length **04**
- NFCID1t content **92 2E 58 32**

- In the second example, the host requires the initialization of one ISO/IEC14443-3B card with the default parameters (AFI = 0x00).

```
➔ D4 4A  01  03  00    (deterministic approach)
➔ D4 4A  01  03  00  01  (probabilistic approach)
🡐 D5 4B  01  01  50  01 02 03 04 00 00 00 00 00 00 00 01 01
              <---------------- ATQB ------------->
```

One target of 106 kbps type B is detected in the field and gives the following responses:

- ATQB_RES[12] **50 01 02 03 04 00 00 00 00 00 00 00**
- ATTRIB_RES length **01**
- ATTRIB_RES **01**

- In the third example, the host controller requires the initialization of one target at 212 kbps with the POL_REQ payload 00 FF FF 01 00 (system code requested).

```
➔ D4 4A  01 01 00 FF FF 01 00
🡐 D5 4B  01 01 14 01 01 01 06 01 67 02 A5 15
             03 00 4B 02 4F 49 8A 8A  FF FF
```

In the answer frame, it is indicated that one target has been initialized with the following parameters:

- Logical number **01**
- POL_RES length **14**
- response code byte **01**
- NFCID2t **01 01 06 01 67 02 A5 15**
- PAD **03 00 4B 02 4F 49 8A 8A**
- System Code **FF FF**

- In this fourth example, the host controller requires to detect and to initialize an Innovision Jewel tag

  ➔ D4 4A 01 04
  ➔ D5 4B 01 01 04 00 92 2E 58 32

  In the answer frame, it is indicated that one target has been initialized with the following parameters:
  - Logical Number **01**
  - ATQA_RES **04 00**
  - RID content **92 2E 58 32**

8.4.6 InATR

This command is used by a host controller to launch an activation of a target in case of passive mode.

Input:

D4	50	Tg	Next	[NFCID3i [0..9]]	[Gi [0..n]]

- **Tg** is the logical number of the relevant target,
- **Next** indicates if the optional fields of the command (**NFCID3i** and **Gi**) are present (bit = 1) or not (bit = 0).
  - Bit 0 : NFCID3i is present,
  - Bit 1 : Gi is present.
- **NFCID3i** is the NFCID3 of the initiator that is used by the PN533 within the ATR_REQ. Depending on the baud rate, the use of this field is different:
  - **106 kbps, passive mode:**

    The field is used to build the ATR_REQ frame. If not present, the PN533 will use a random value.
  - **212/424 kbps, passive mode:**

    This field is not used. The NFCID3i field of the ATR_REQ is filled with the value of the NFCID2t of the target received in the POL_RES frame. Refer to **`InJumpForDEP`** (§8.4.3, p.80).
- **Gi** contains the general bytes for the ATR_REQ (optional, max. 48 bytes)

Output:

D5	51	Status	NFCID3t [0..9]	DIDt	BSt	BRt	TO	PPt	[Gt [0..n]]

- **Status** is a byte indicating if the process has been terminated successfully or not. (see §8.1, p.50)

  The following parameters are part of the **ATR_RES** sent by the target:
- **NFCID3t [0..9]** is an array of bytes containing the random identifier of the target,
- **DIDt** is the DID byte sent by the target,
- **BSt** specifies the supported send-bit rate by the target,
- **BRt** specifies the supported receive-bit rate of the target,
- **TO** specifies the timeout value of the target in transport protocol,
- **PPt** specifies the optional parameters of the target (Length reduction, NAD usable and General bytes),
- **Gt [0..n]** are the optional general bytes (max. 47 bytes).
  They contain general information.

Syntax Error Conditions:

- **Tg** and **Next** parameters are missing.

Description:

It is assumed that the target **Tg** has been initialized before (see command **`InListPassiveTarget`** §8.4.5, p.87).

If the **Tg** number is unknown, the PN533 informs the host controller with a specific error code (**Status =** 0x27).

The Baud Rate and the modulation type defined for the target **Tg** in the former **`InListPassiveTarget`** command are re-used.

The following process is performed:

- the process of activation of the target is the same whatever the mode of activation or the baud rate are:
  - Set the communication settings (Passive mode, baud rate **BR**),
  - Depending of the baud rate:

    106 kbps: send ATR_REQ constructed by means of **NFCID3i** and **Gi** at **BR**. If the NFCID3i is not present, a random value is used.

    212/424 kbps: send ATR_REQ with the NFCID3i field filled with the value of the NFCID2t of the target received in the POL_RES frame during the initialization with 0x00 padding (two last bytes).

  Depending on the value of the internal parameter fDIDUsed (set by the host controller with the **`SetParameters`** command (§8.2.8, p.66)), the PN533 constructs the ATR_REQ with or without a DID parameter. If used, the DID value is fixed by the PN533 to 0x01.

  If **Gi** is not present in the command, the PN533 constructs the ATR_REQ without **Gi** bytes.

  - Receive ATR_RES.

    The complete ATR_RES received from the target is returned back to the host controller in the **ATR_RES** field for further decision (CMD0 CMD1 = 0xD5 0x01 excepted).
    The NFCID3t is stored internally in the PN533, as part of the total information relative to the target number **Tg**.

  The reception of the ATR_RES is done under conditions of timeout. This timeout value is defined in the **`SetParameters`** command (§8.2.8, p.66).

  If no valid ATR_RES is received (MxRtyATR attempts), the PN533 returns in the **Status** byte an error code.

  The PN533 waits for this ATR_RES coming from the target a maximum time (timeout defined with the **`SetParameters`** command (§8.2.8, p.66)).

  In case of incorrect ATR_RES received, the PN533 sends again ATR_REQ (MxRtyATR times).

Example:

The **InATR** command may be used in a step-by-step process when the host controller wants to activate a target.

The following sequence:

```
Tg = InListPassiveTarget (1, 106)

InATR (Tg …)

InPSL (Tg …)
```

Is equivalent to

```
InJumpForDEP (Passive, 106)
```

8.4.7 InPSL

This command is used by a host controller to change the defined bit rates either with a TPE target or with a ISO/IEC14443-4 target.

Input:

D4	4E	Tg	BRit	BRti

- **Tg** is the logical number of the relevant target,
- **BRit** is the Baud Rate to be negotiated for communication from the initiator to the target
  - 0x00 : 106 kbps
  - 0x01 : 212 kbps
  - 0x02 : 424 kbps
  - 0x03 : 847 kbps
- **BRti** is the Baud Rate to be negotiated for communication from the target to the initiator
  - 0x00 : 106 kbps
  - 0x01 : 212 kbps
  - 0x02 : 424 kbps
  - 0x03 : 847 kbps

Output:

D5	4F	Status

- **Status** is a byte indicating if the process has been terminated successfully or not (see §8.1, p.50).

Syntax Error Conditions:

- **BRit** value is incorrect,
- **BRti** value is incorrect,
- Incorrect command length (not equal to 5).

Description:

It is assumed that the target **Tg** has been activated before (see commands **`InListPassiveTarget`** (§8.4.5, p.87), **`InATR`** (§8.4.6, p.95) and **`InJumpForPSL`** (§8.4.4, p.85)).

If this is not the case, or if the **Tg** number is unknown, the PN533 informs the host controller with a specific error code (**Status =** 0x27).

In the case of a **TPE target**, a Parameter Selection is launched with the target **Tg**:

- Send a PSL_REQ (based on the parameters **BRti** and **BRit**).

  The FSL parameter of the PSL_REQ is fixed to 0x00, meaning that the maximum length of the Transport protocol field is 64 bytes.
- If a PSL_RES is correctly received (**MxRtyPSL** retries: §8.4.1, p.73)
  - The PN533 takes internally into account the parameters changes,
  - The **Status** byte is set to 0x00 and sent back to the host controller.
- Else the PN533 gives up and answers to the host controller with a **status** byte different from 0x00.

In the case of an **ISO/IEC14443-4 card**, a Protocol and Parameter Selection (PPS) is launched with the target **Tg**:

- Send a PPS request based on the parameters **BRti** = **DRi** and **BRit** = **DSi**.
- If a PPS response is correctly received (**MxRtyPSL** retries: §8.4.1, p.73)
  - The PN533 takes internally into account the parameters changes,
  - The **Status** byte is set to 0x00 and sent back to the host controller,
  - The register values contained in the RFConfiguration CfgItem 0x0D are then applied to the respective registers (CIU_RxThreshold, CIU_ModWidth and CIU_MifNFC) depending on the chosen baud rate.
- Else the PN533 gives up and answers to the host controller with a **Status** byte different from 0x00.

This command is only valid for Type A cards (not Type B).

Possible errors returned (Status byte):

- Negotiation already performed with the relevant target

  ➔ *Operation not allowed error code is returned (**Status** = 0x26)*
- The target is neither a TPE nor ISO/IEC14443-4

  ➔ *Operation not allowed error code is returned (**Status** = 0x26)*
- Unknown target number

  ➔ *Command not acceptable error code is returned (**Status** = 0x27)*
- InPSL command was sent to a Type B card

  ➔ *Command not acceptable error code is returned (**Status** = 0x27)*

8.4.8 InDataExchange

This command is used to support protocol data exchanges between the PN533 as initiator and a target.

Input:

D4	40	Tg	[DataOut [ ]]

- **Tg** is a byte containing the logical number of the relevant target.

  This byte contains also a *More Information* (MI) bit (bit 6) indicating, when set to 1, that the host controller wants to send more data that all the data contained in the **DataOut [ ]** array (see Chaining mechanism §8.5.4, p.152). This bit is only valid for a TPE target or an ISO/IEC14443-4 card.

  This byte contains also a *Secure bit* (bit 5). When it is set to 1, the transaction is secured.

- **DataOut** is an array of raw data (from 0 up to 262 bytes) to be sent to the target by the PN533 (see §8.5.5, p.161).

Output:

D5	41	Status	[DataIn [ ]]

- **Status** is a byte indicating if the process has been terminated successfully or not (see §8.1, p.50).

  When either in DEP or in ISO/IEC14443-4 PCD mode, this byte indicates also if *NAD* is used and if the transfer of data is not completed with bit *More Information* (see §8.5.4, p.152).

- **DataIn** is an array of raw data (from 0 up to 262 bytes) received by the PN533.

Syntax Error Conditions:

- In case of MIFARE card:
  - **Cmd** value is incorrect,
  - Bad number of data for Authentication command (Data 0..9),
  - Bad number of data for 16 bytes writing command (Data 0..15),
  - Bad number of data for 4 bytes writing command (Data 0..3).

- In case of Jewel tag:
  - **Cmd** value is incorrect.

Description:

When using this command, it is assumed that a target has been first activated. The baud rate and the modulation type that have been chosen by using one of the 3 possible commands: **`InListPassiveTarget`**, **`InJumpForDEP`** or **`InJumpForPSL`**.

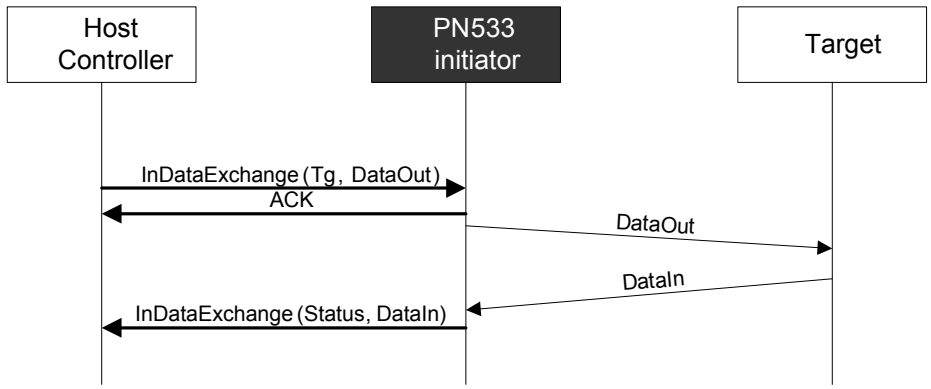


Fig 42. InDataExchange – General context

If the target number is unknown, the PN533 returns a specific error code (**Status** = *0x*27).

The PN533 has stored internally all the necessary information needed about all the initialized targets:

- Type (DEP, MIFARE card, Jewel tag, RFA tag, ISO/IEC14443-4 card or FeliCa card),
- Baud rate, communication mode (active or passive),
- Internal state (selected, deselected, released …).

So, first of all, the PN533 applies all the correct configuration settings corresponding to the target **Tg** (Baud Rate, modulation type …).

Then, if the target **Tg** is not currently selected (current state memorized inside the PN533), the PN533 initiates the selection.

The detailed process of the selection depends on the type of the target; it is given in the **`InSelect`** (§8.4.13, p.117) command description.

After this selection stage, the PN533 takes in charge the data exchange.

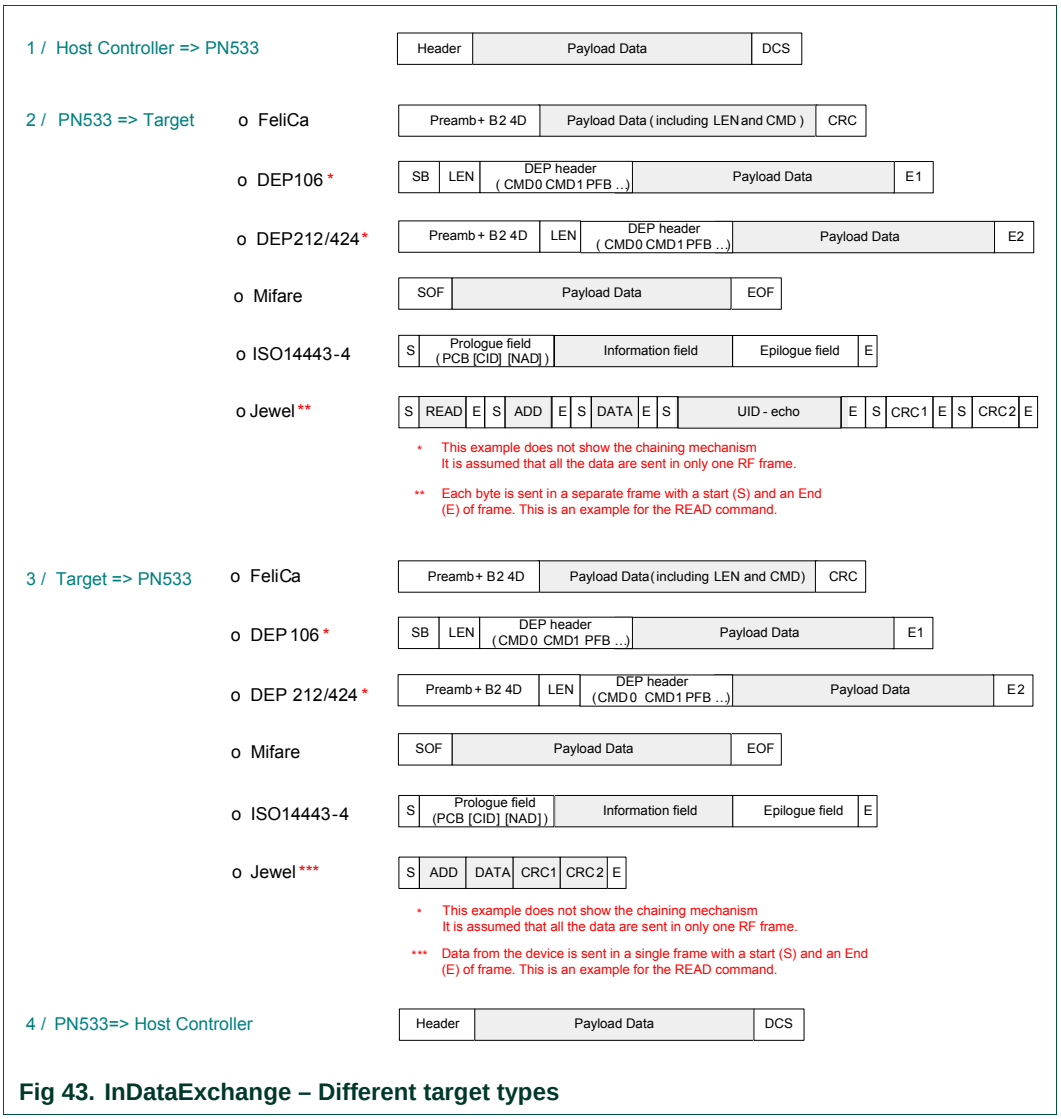


Fig 43. InDataExchange – Different target types

The way of exchanging data is different depending on the real nature of the target (DEP, MIFARE card, Jewel and RFA tag, FeliCa card or ISO/IEC14443-4 card):

- **MIFARE card**

When the target **Tg** is MIFARE compliant, the input parameters are interpreted by the PN533 to execute a MIFARE exchange. The PN533 sends the command and waits for the answer with a default timeout value of 51.2 ms.

This value can be changed by using the command **`RFConfiguration`** §8.4.1, p.73.

The **DataOut [ ]** data must be formatted in the following way:

Cmd	Addr	[Data 0..15]

- **Cmd** is the MIFARE specific command byte,
- **Addr** is the address associated with the MIFARE command,
- **Data 0..15** is an array of maximum 16 bytes containing either
  - the data to be sent to the card during a writing operation,
  - or the data to be used during an authentication operation:
    - Data 0..5 contain the 6 bytes key,
    - Data 6..9 contain the 4 bytes serial number of the card.

The **DataIn [ ]** data are formatted in the same way:

[Data 0..15]

- **Data 0..15** is an array of maximum 16 bytes containing data read from the card in case of a reading command.

The MIFARE specific command byte **Cmd** may take one of the possible values:

0x60 / 0x61	Authentication A / Authentication B
0x30	16 bytes reading
0xA0	16 bytes writing
0xA2	4 bytes writing
0xC1	Incrementation
0xC0	Decrementation
0xB0	Transfer
0xC2	Restore

Refer to MIFARE cards (Classic and Ultralight) documentation and [5] to have a more detailed description of the MIFARE command set.

Examples:

It is assumed in these examples that the logical number attributed by the PN533 to the card is #01.

- **`D4 40 01 60 02 FF FF FF FF FF FF E2 3F B8 1E`**
  Authenticate using the keys 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF to the address 0x02 of a MIFARE Standard card whose UID number is 0xE2 0X3F 0xB8 0x1E.
- **`D4 40 01 30 02`**
  Read 16 bytes from the address 0x02.
- **`D4 40 01 A0 02 01 02 03 04 05 06 07 08`**
  `09 0A 0B 0C 0D 0E 0F 10`
  Write 16 bytes 0x01 to 0x10 from the address 0x02.

- **ISO/IEC14443-4 card**

When the target **Tg** is ISO/IEC14443-4 compliant, the input parameters are interpreted by the PN533 to execute an ISO/IEC14443-4 exchange.

The PN533 uses the data contained in the **DataOut [ ]** buffer to build frames.

The main ISO/IEC14443-4 protocol mechanisms are implemented:

- o Chaining,
- o Waiting time Extension,
- o Error handling.

The payload data returned by the target are sent back to the host controller in **DataIn [ ]**.

The C-APDU command length can be up to 261 bytes (CLA-INS-P1-P2-P3-255 data bytes-Le) and the R-APDU returned to the host controller can have a length of 258 bytes (256 data bytes-SW1-SW2).

Remark: Both **DataIn [ ]** and **DataOut [ ]** can contain NAD information.

See **`SetParameters`** command (§8.2.8, p.66) for having a complete description.

Example:

It is assumed in this example that the logical number attributed by the PN533 to the card is 0x01. The command sent to the card is a “read” command, 16 bytes are read.

➔ **`D4 40 01 00 B0 82 00 10`**
➔ **`D5 41 00 00 01 02 03 04 … 0F 90 00`**

The value of the status byte is 0x00, indicating that the RF exchange is correct.

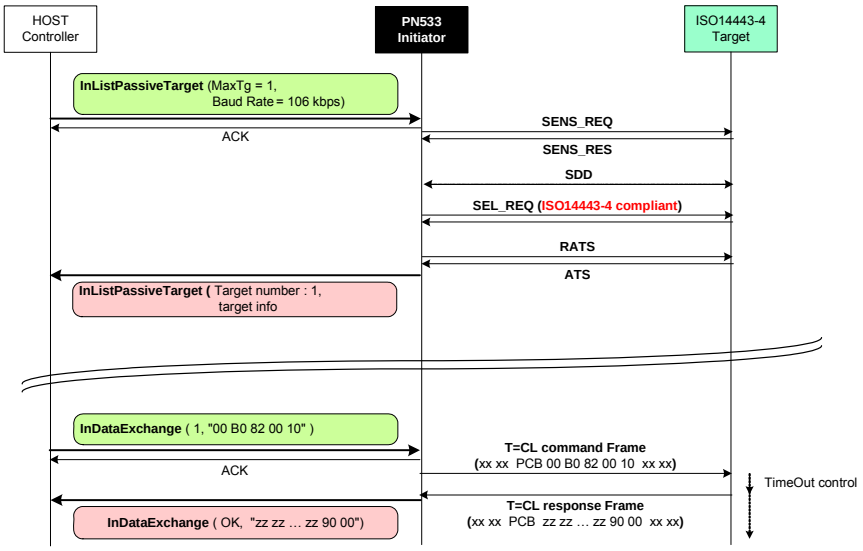


Fig 44. InDataExchange – Example of a ISO/IEC14443-4 exchange

During the exchanges, the following timeout control is used between the ISO/IEC14443-4 command and the response from the card:

$$TimeOut = FWT + 3*2^{FWI} \text{ etu}$$

Concerning the error handling, the PN533 tolerates up to 3 errors detected in the communication flow before returning an error code to the host controller. Also, a S(DESELECT) request is automatically send to fulfill ISO/IEC14443-4 standard.

- **FeliCa card**

When the target **Tg** is a FeliCa card, the PN533 just transfers the data contained in the **DataOut [ ]** buffer as they are.

The **Len** and **Cmd** bytes of the FeliCa protocol must be present in this buffer (the frame is completely built by the host controller).

Len	Cmd	[Data]

- **Len** is the length of the total **DataOut [ ]** buffer,
- **Cmd** is the FeliCa specific command byte,
- **Data** is an optional array of data bytes depending on the command used.

After having sent the command frame, the PN533 waits for a reply from the card and sends back the received frame to the host controller in **DataIn [ ]**.

A mute target can be detected by using a timeout mechanism after the transmitted frame (default value is 102.4 ms). The configuration of this timeout is done with the **`RFConfiguration`** command (§8.4.1, p.73), CfgItem 0x02 (fRetryTimeout) and 0x04 (MaxRtyCOM).

Examples:

It is assumed in this example that the logical number attributed by the PN533 to the card is 0x01. The card does an echo of the received frame.

➔ **D4 40 01 06 F0 00 FF 11 22**
➔ **D5 41 00 06 F0 00 FF 11 22**

The value of the status byte is 0x00, indicating that the RF exchange is correct.

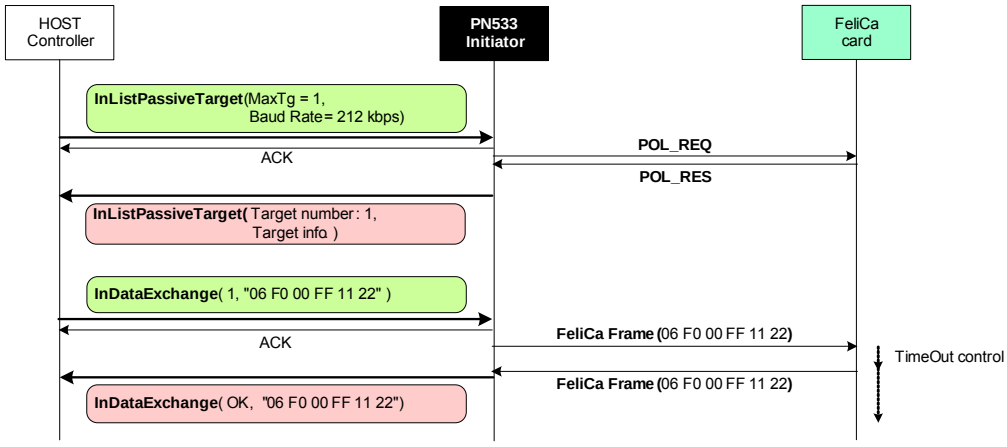


Fig 45. InDataExchange – Example of a FeliCa exchange

➔ **D4 40 01 06 F0 00 FF 11 22**
➔ **D5 41 01**

Here, the status byte informs of a timeout detected by the PN533.

- **DEP target**

When the target **Tg** is a NFC-DEP, the PN533 takes care of the protocol internally.

The PN533 sends the data contained in the **DataOut [ ]** array either in one or several stages (chaining mechanism as described in [3] and §8.5.4, p.152) depending of the total length of the frame to send.

The PN533 uses a fixed value of Length Reduction of 64 bytes, even if the target indicates a higher capability.

The error handling and the timeout extensions ($S(TO)_{REQ}$ and $S(TO)_{RES}$) are also completely internally managed by the PN533.

If the *More Information* bit is not set in the **Tg** field of the host controller command, the PN533 waits for a DEP_RES. After having received a complete frame from the target, the PN533 sends back the data received in the **DataIn [ ]** array.

If the *More Information* bit is set in the **Tg** field of the host controller command, the PN533 returns no data to its host controller but takes care of the target with the timeout extensions request and response.

Remark: Both **DataIn [ ]** and **DataOut [ ]** can contain NAD information.

See **`SetParameters`** command §8.2.8, p.66 to have a complete description.

Example:

It is assumed in this example that the logical number attributed by the PN533 to the target is #01. The target does an echo of the received frame.

➔ **`D4 40 01 11 22 33 44`**
➔ **`D5 41 00 11 22 33 44`**

The value of the status byte is 0x00, indicating that the RF exchange is correct.

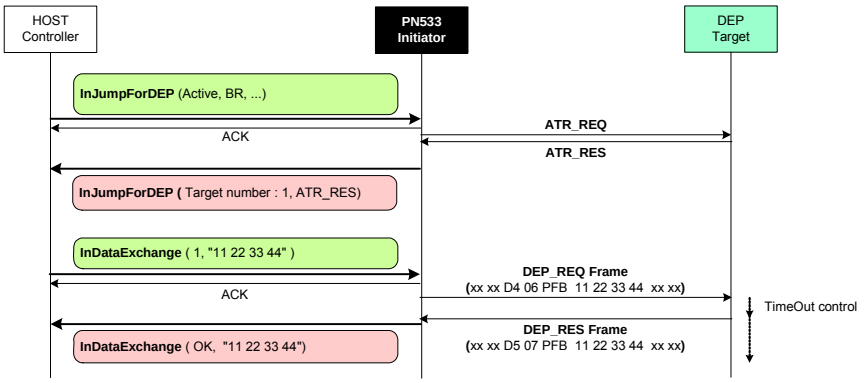


Fig 46. InDataExchange – Example of a DEP exchange

To simplify the figure, DID and NAD are not used in this example.

- **Innovision Jewel tag**

When the target is an Innovision Jewel tag, the input parameters are interpreted by the PN533 to execute a Jewel exchange. The PN533 sends the command and waits for the answer with a default timeout value of 51.2 ms.

This value can be changed by using the command **`RFConfiguration`** §8.4.1, p.73.

The **DataOut [ ]** data must be formatted in the following way:

Cmd	Addr	[Data1..8]

- **Cmd** is the Jewel specific command byte,
- **Addr** is the address associated with the Jewel command,
- **Data1..8** is an array of maximum 8 bytes containing the data to be sent to the card during a writing operation.

The **DataIn [ ]** data are formatted in the same way:

[Data1..255]

- **Data1...255** is an array of maximum 255 bytes containing data read from the card.

The Jewel specific command byte **Cmd** may take one of the possible values:

0x00	Read all bytes (maximum 255 bytes including HR, UID, data, LOCK and OTP bytes)
0x01	Read a single byte
0x03	Read 8 bytes
0x10	Read segment (RSEG)
0x1A	Write-no-Erase a single byte
0x1C	Write-no-Erase 8 bytes
0x53	Write-with-Erase a single byte
0x55	Write-with-Erase 8 bytes
0x78	Read ID – Use to read the metal-mask ROM and UID0-3 from block 0

Refer to Jewel tag documentation to have a more detailed description of the Jewel command set and on the frames structure (7 or 8 bit data and CRC).

Examples:

Read all bytes –read from 0x00 to 0x79 (there are 122 bytes on this tag)

```
➔   D4  40  01  00
➔   D5  41  00  01 3C CC 15 30 FF 01 01 25 00 12 …
                 AA 00 00 00 00 01 60 00 00 OO 00 00 00
```

Write-no-Erase a single byte 55 at the address 0x02 of block 0

```
➔   D4  40  01  1A 02 55
➔   D5  41  00
```

Write-with-Erase 8 bytes 0x01…0x08 from the address 0x02 of block 0

```
➔   D4  40  01  55 02 01 02 03 04 05 06 07 08
➔   D5  41  00
```

8.4.9 InCommunicateThru

This command is used to support basic data exchanges between the PN533 and a target.

Input:

D4	42	[DataOut [ ]]

- **DataOut** is an array of raw data to be sent to the target by the PN533 (max. 264 bytes, cf. §8.5.5, p.161).

Output:

D5	43	Status	[DataIn [ ]]

- **Status** is a byte indicating if the process has been terminated successfully or not (see §8.1, p.50),
- **DataIn** is an array of raw data received by the PN533 (coming from the target).

Description:

When using this command, it is assumed that a target has been first activated. The baud rate and the modulation type that have been chosen by a former **`InListPassiveTarget`** command (§8.4.5, p87) are used for transmitting the **DataOut [ ]** and for receiving the **DataIn [ ]** bytes.

This command is complementary of the **`InDataExchange`** command (§8.4.8, p.100).

The main difference compared to **`InDataExchange`** is that here the PN533 does not handle with all the protocol features (chaining, error handling …).

The host controller has to take care of the selection of the target it wants to reach (whereas when using the **`InDataExchange`** command, it is done automatically).

The process performed by this function is:

- Send the data by encapsulating the raw data (**DataOut [ ]**) in accordance with the current baud rate used. The CRC is automatically calculated and added by the PN533:

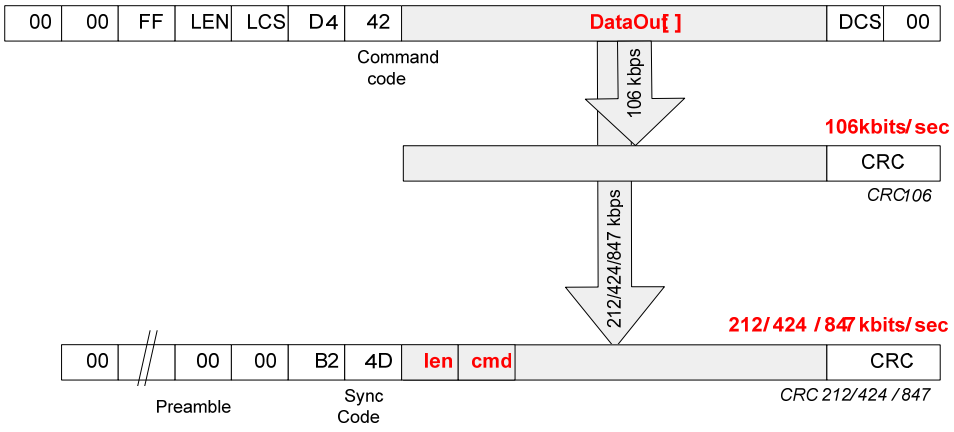


Fig 47. InCommunicateThru (1)

- Receive the data coming from the target in accordance with the current baud rate in use and de-encapsulate them (**DataIn [ ]**). The received CRC is checked but does not appear in **DataIn [ ]**:

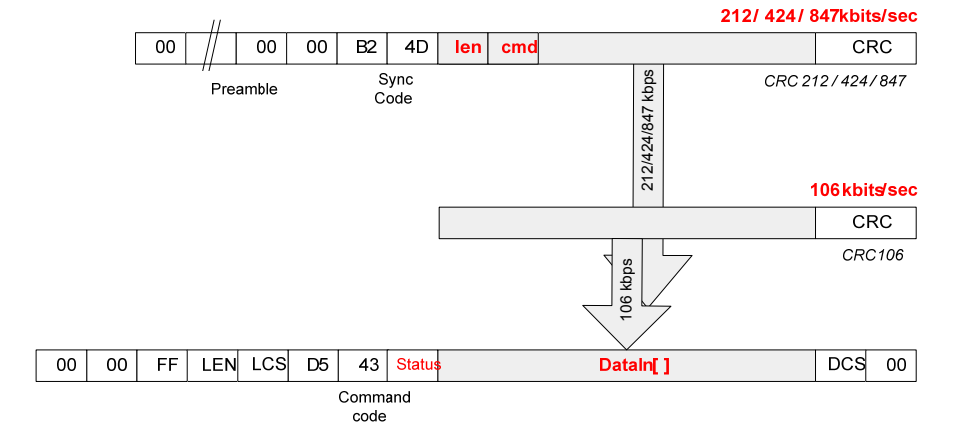


Fig 48. InCommunicateThru (2)

The following figure depicts the complete exchange of data between the host controller and the target.

In that case, the PN533 acts only as RF-transceiver between the host controller and the selected target.

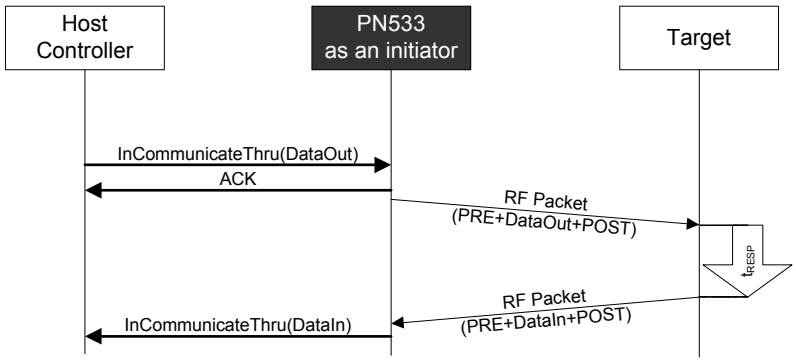


Fig 49. InCommunicateThru (3)

If the parameter **fRetryTimeout** of the command **`RFConfiguration`** (§8.4.1, p.73) is 0x00, no time out is managed on the delay (t_{RESP}) used by the target to send back its answer. The host controller has to manage timeout by itself.

Otherwise (**fRetryTimeout** is different from 0x00), the PN533 checks the response delay (t_{RESP}) to detect mute target (delay greater than **fRetryTimeout** parameter).

In case of error (either mute target or communication error), the PN533 sends again the RF packet to the target as many times as defined in the **MaxRtyCOM** parameter (cf. **`RFConfiguration`** command in §8.4.1, p.73).

In any case, the host controller can stop the current **`InCommunicateThru`** command by using one of the two dedicated ways of stopping: ACK frame or new command frame.

8.4.10 InQuartetByteExchange

This command is a specific command used to support basic data exchanges between the PN533 and a card (RFA tag or MIFARE card).

Input:

D4	38	Tg	Type	DataOut[]

- **Tg** is the logical number of the relevant target,
- **Type** is the type of expected input data:
  - Single pass and a time out is expected : 0x01
  - Single pass and an Ack is expected : 0x02
  - Single pass and data are expected : 0x04
  - Double pass and a time out is expected : 0x11
  - Double pass and an Ack is expected : 0x12
  - Double pass and data are expected : 0x14
- **DataOut** is an array of raw data to be sent to the target by the PN533. The total length of this array is determined by the host⇔PN533 protocol layer (max 264 bytes, §8.5.5, p.161).

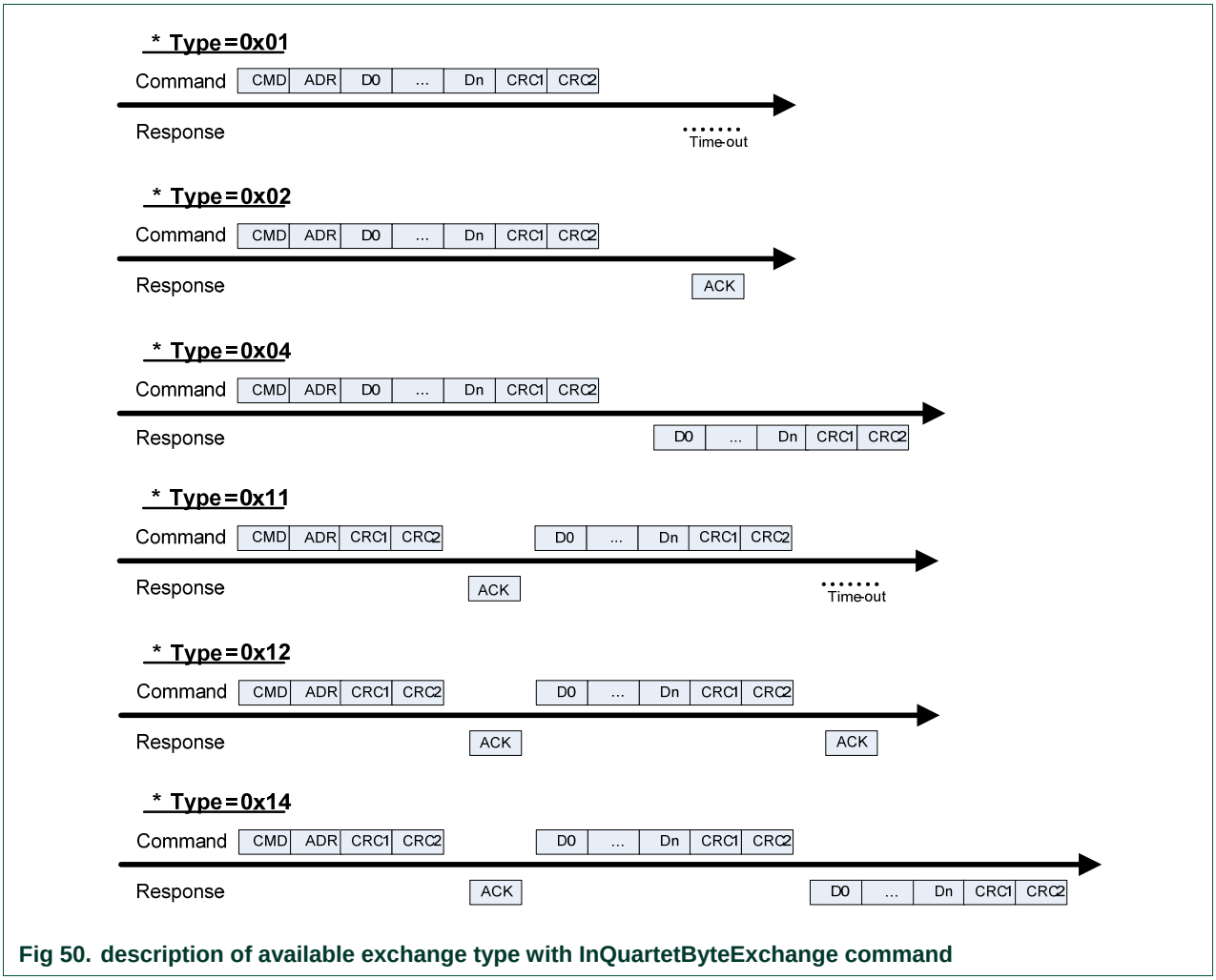


Fig 50. description of available exchange type with InQuartetByteExchange command

Output:

D5	39	Status	DataIn[]

- **Status** is a byte indicating if the process has been terminated successfully or not (see §8.1, p.50).
- **DataIn** is an array of raw data received by the PN533 (coming from the target).

Description:

When using this command, it is assumed that the card has been first activated by an **`InListPassiveTarget`** command (§8.4.5, p.87).

This command is complementary of the **`InDataExchange`** command (§8.4.8, p.100) and the **`IncommunicateThru`** command (§8.4.9, p.109).

The InQuartetByteExchange works like the InCommunicateThru command, but the InQuartetByteExchange is able to manage different type of Input Data (Coming from the PICC) as quartets (Ack / Nack), data bytes or time out.

The host has to specify the type of response which is expected after the issuance of the command.

- **RFA tag**

When the target is RFA compliant, the input parameters are interpreted by the PN533 to execute a RFA exchange. The PN533 sends the command and waits for the answer with a default timeout value of 51.2 ms.

This value can be changed by using the command **`RFConfiguration`** §8.4.1, p.73.

The **DataOut [ ]** data must be formatted to be RFA compliant.

Examples:

Read 16 bytes in the RFA card

30	Addr

Addr is the address associated with the RFA command.

Write 4 bytes in the RFA card

A2	Addr	Data [0..3]

Addr is the address associated with the RFA command.

Data [0..3] is an array of maximum 4 bytes containing the data to be sent to the card during a writing operation.

Authenticate to the RFA card

A5	Addr	Act-Token [0..15]

Addr is the address associated with the RFA command.

Act-Token [0..15] is the authentication code.

A part of RFA commands which are recognized by the PN533 are listed below:

0x30 16 bytes reading

0xA2 4 bytes writing

0xA5 Authentication

0xA8 Test

0xAB Test disable

Refer to RFA card documentation to have a more detailed description of the RFA command set.

Examples:

- **Read 16 bytes from the address 0x02**

  ➔ D4 38 01 04 30 02
  ➔ D5 39 00 01 02 03 … 0D 0E 0F

- **Write 4 bytes 0x01..0x04 from the address 0x02**

  ➔ D4 38 01 02 A2 02 01 02 03 04
  ➔ D5 39 00

- **Run RFA test Mode**

  ➔ D4 38 01 04 A8
  ➔ D5 39 00 02

8.4.11 InDeselect

The goal of this command is to deselect the target **Tg**. The PN533 keeps all the information relative to this target.

Input:

D4	44	Tg

- **Tg** is a byte containing the logical number of the relevant target (0x00 is a specific value indicating all targets).

Output:

D5	45	Status

- **Status** is a byte indicating if the process has been terminated successfully or not (see §8.1, p.50).

Description:

If the target is unknown (**Tg** number not attributed by the PN533) a specific error code is returned (**Status** = 0x27).

If the target is already deselected, no action is performed and **Status** OK is returned.

The process depends on the way that the target or the targets has or have been initialized.
In case of **Tg** equals to 0x00, this process is done for all the known targets.

Table 25. InDeselect RF actions

Target Type	Action
DEP compliant target (whatever the baud rate and the communication mode are)	Send **DSL_REQ**
106 kbps Type A card	Send **HLTA**
106 kbps Type B card	Send **HLTB**
MIFARE card	Send **HLTA**
ISO/IEC14443-4 compliant card	Send **DESELECT**
FeliCa card	No action
Innovision Jewel tag	No action
RFA® tag	Send **HLTA**

8.4.12 InRelease

The goal of this command is to release the target **Tg**.

Input:

D4	52	Tg

- **Tg** is the logical number of the relevant target. (0x00 is a specific value indicating all available targets).

Output:

D5	53	Status

- **Status** is a byte indicating if the process has been terminated successfully or not (see §8.1, p.50).

Description:

Releasing a target means that the host controller has finished the communication with the target, so the PN533 erases all the information relative to it (them).

This command is used whatever the target type and its current state (initialized, activated, deselected) is.

The process depends on the way that the target has been initialized.

In case of **Tg** equals to 0x00, this process is done for all the known targets.

Table 26. InRelease RF actions

Target Type	Action
DEP compliant target (whatever the baud rate and the communication mode are)	Send **RLS_REQ**
106 kbps Type A card	Send **HLTA**
106 kbps Type B card	Send **HLTB**
MIFARE card	Send **HLTA**
ISO/IEC14443-4 compliant card	Send **DESELECT**
FeliCa card	No action
Innovision Jewel tag	No action
RFA® tag	Send **HLTA**

In all the cases (DEP compliant or not), the logical numbers of the released targets are freed, meaning that no further data exchanges will be possible with the target(s).

If there is no more activated target after the release of the **Tg** one, the PN533 automatically returns in the ***Standby mode*** as defined in §3.1.2.2, p.12, meaning that the RF field is switched off and the CL frond end is put in low power mode.

8.4.13 InSelect

The goal of this command is to select the target **Tg**.

Input:

D4	54	Tg

- **Tg** is the logical number of the target to be selected.

Output:

D5	55	Status

- **Status** is a byte indicating if the process has been terminated successfully or not (see §8.1, p.50).

Description:

If this target is unknown (**Tg** number not attributed by the PN533) a specific error code is returned (**Status** = 0x27).

If the target is already selected, no action is performed and **Status** OK is returned.

The process depends on the way that the target has been initialized (see Table 27, p.117).

Table 27. InSelect RF actions

Target Type	Action
DEP compliant target Active communication mode (whatever the baud rate is)	• Wake up of the deselected target (**WUP_REQ**).
DEP compliant target Passive communication mode 106 kbps	• Initialization and Single Device Detection (**ALL_REQ**, **SEL_REQ**) using the *NFCID1t* of the target that has been stored during the initial activation of this target. • Send a **ATR_REQ** in which the *NFCID3i* is replaced by the *NFCID3t* of the target that has been stored during the initial activation of this target.
DEP compliant target Passive communication mode 212/424 kbps	• Initialization and Single Device Detection (**POL_REQ**). • Send a **ATR_REQ** in which the *NFCID3i* is replaced by the *NFCID2t* of the target that has been stored during the initial activation of this target (using padding as described in **`InJumpForDEP`**, §8.4.3, p.80).
106 kbps Type A card	• Initialization, anti-collision loop and Selection (**WUPA**, **Anti-collision** and **SELECT**) using the UID (*NFCID1* field of **InListPassiveTarget** see §8.4.5, p87) of the target that has been stored during the initial activation of this target.
106 kbps Type B card	• Initialization (**WUPB**, **ATTRIB** commands) using N =1 and indicating the card is initially in HALT state.
MIFARE card	• Initialization, anti-collision loop and Selection (**REQA**, **Anti-collision** and **SELECT**) using the UID (*NFCID1* field of **`InListPassiveTarget`** see §8.4.5, p87)

Target Type	Action
RFA® tag	• Initialization, anti-collision loop and selection (**REQA**, **Anti-collision** and **SELECT**) using the UID (*NFCID1* field of **`InListPassiveTarget`** see §8.4.5, p87)
ISO/IEC14443-4 Type A compliant card	• Initialization, anti-collision loop and Selection (**WUPA**, **Anti-collision** and **SELECT**) using the UID (*NFCID1* field of **`InListPassiveTarget`** see §8.4.5, p87) of the target that has been stored during the first activation of this target. • Send an **RATS**.
ISO/IEC14443-4 Type B compliant card	• Initialization (**WUPB**, **ATTRIB** commands) using N =1 and indicating the card is initially in HALT state.
FeliCa card	• Initialization and Single Device Detection (**POL_REQ**).
Innovision Jewel tag	• No action

Note: This command can be used in combination with **`InDeselect`** command (§8.4.11, p.115), as described in the following figure.

When using the **`InDataExchange`** command (§8.4.8, p.100), the Select/Deselect sequence is done automatically.

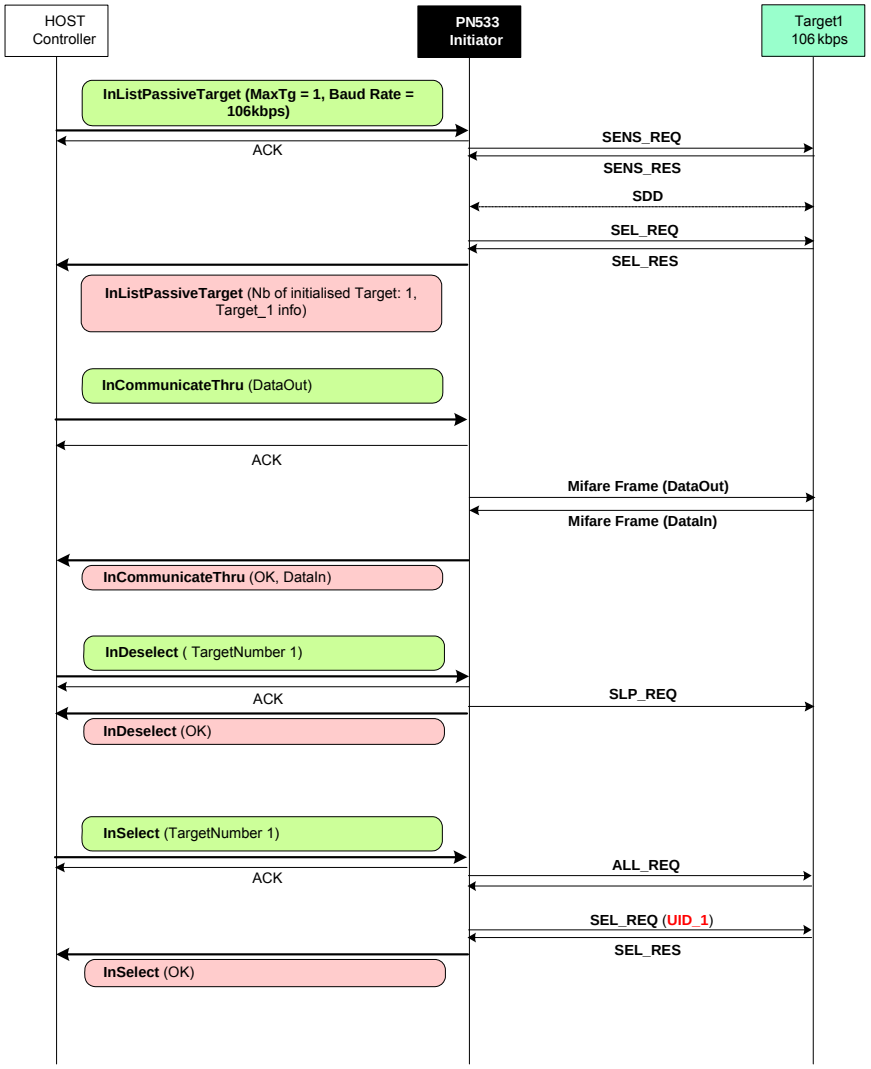


Fig 51. InSelect

8.4.14 InActivateDeactivatePaypass

The goal of this command is to poll ISO14443-4 PICCs with respect to Paypass1.1 and EMVco2.0 specifications.

Input:

D4	48	Paypass Item

- **Paypass Item** specifies the type of Paypass action:
  - 0x01 : Polling / anti-Collision / Activation for Paypass 1.1
  - 0x02 : PICC removal procedure for Paypass 1.1
  - 0x03 : Polling / Anti-Collision / Activation for EMVCo 2.0
  - 0x04 : PICC removal procedure for EMVCo 2.0

Output:

- **Paypass Item = 0x01 : Polling / Anti Collision / Activation for Paypass 1.1**

  This Paypass Item is used to poll a PICC when we have to be compliant with the Paypass specification version 1.1. The firmware will execute several procedures (polling, collision detection and PICC activation).

D5	49	Status	PAYPASS Type	[PICCData []]

  - **Status** is a byte indicating if the process has been terminated successfully or not (see §8.1, p.50).
  - **PAYPASS type:**

    If a PICC was found, it indicates the polled target type. If the PICC was not found, it indicates a collision error, transmission error or time-out error.

    All possible values of the field **PAYPASS TYPE** are listed below:
    - 0x01 : Type A target found,
    - 0x02 : Type B target found,
    - 0x10 : Transmission error reported,
    - 0x11 : Protocol error reported,
    - 0x12 : Collision error reported,
    - 0x13 : Time-out error reported
  - **PICCData[]** contains the information about the detected PICC and depends on the target type found. The following information is given for one PICC.
    - **106 kbps type A:**

SENS_RES (2 bytes)	SEL_RES (1 byte)	NFCIDLength (1 byte)	NFCID1[] (NFCIDLength bytes)	[ATS[ ]] (ATSLength bytes)

    - **106 kbps type B:**

ATQB Response (12 bytes)	ATTRIB_RES Length (1 byte)	ATTRIB_RES[ ] (ATTRIB_RES Length)

- **Paypass Item = 0x02 : PICC removal procedure for Paypass 1.1**

  This Paypass Item is used to remove a PICC when we have to be compliant with the Paypass specification version 1.1. This procedure is executed when a Paypass transaction is completed.

  The PN533 shall deactivate the PICC. After the PICC has been deactivated successfully, the PCD shall poll for the PICC until it is removed from the operating field.

D5	49	Status	PAYPASS Type

  - **Status** is a byte indicating if the process has been terminated successfully or not (see §8.1, p.50).
  - **PAYPASS type:**

    If a PICC is removed, it indicates a Time-out error.

    If a PICC is still close to the antenna, the PN533 will poll until the PICC is removed from the antenna.

    If an error occurred during this removal procedure, it indicates a collision error or transmission error.

    All possible values of the field **PAYPASS TYPE** are listed below:

    - 0x10 : Transmission error reported,
    - 0x11 : Protocol error reported,
    - 0x13 : Time-out error reported

- **Paypass Item = 0x03 : Polling / Anti-Collision / Activation for EMVCo 2.0**

  This Paypass Item is used to poll a PICC when we have to be compliant with the EMVCo specification version 2.0. The firmware will execute several procedures (polling, collision detection and PICC activation).

D5	49	Status	PAYPASS Type	[PICCData []]

  - **Status** is a byte indicating if the process has been terminated successfully or not (see §8.1, p.50).
  - **PAYPASS type:**

    If a PICC was found, it indicates the polled target type.

    If a PICC was not found, it indicates a collision error, transmission error or time-out error.

    All possible values of the field **PAYPASS Type** are listed below :

    - 0x01 : Type A target found,
    - 0x02 : Type B target found,
    - 0x10 : Transmission error reported,
    - 0x11 : Protocol error reported,
    - 0x12 : Collision error reported,
    - 0x13 : Time-out error reported
  - **PICCData[]** contains the information about the detected PICC and depends on the baud rate selected. The following information is given for one PICC.

    - **106 kbps type A:**

ATQA_RES (2 bytes)	SAK (1 byte)	UIDLength (1 byte)	UID1[] (NFCIDLength bytes)	[ATS[ ]] (ATSLength bytes)

    - **106 kbps type B:**

ATQB Response (12 bytes)	ATTRIB_RES Length (1 byte)	ATTRIB_RES[ ] (ATTRIB_RES Length)

- **Paypass Item = 0x04 : PICC removal procedure for EMVCo 2.0**

  This Paypass Item is used to remove a PICC when we have to be compliant with the EMVCo specification version 2.0. This procedure is executed when a Paypass transaction is completed.

  The PN533 shall deactivate the PICC. After the PICC has been deactivated, the PCD shall poll for the PICC until it is removed from the operating field.

D5	49	Status	PAYPASS Type

  - **Status** is a byte indicating if the process has been terminated successfully or not (see §8.1, p.50).
  - **PAYPASS type:**

    If a PICC is removed, it indicates a Time-out error.

    If a PICC is still close to the antenna, the PN533 will poll until the PICC is removed from the antenna.

    If an error occurred during this removal procedure, it indicates a collision error or transmission error.

    All possible values of the field **PAYPASS TYPE** are listed below:

    - 0x10 : Transmission error reported,
    - 0x11 : Protocol error reported,
    - 0x13 : Time-out error reported

Syntax Error Conditions:

- The **PayPass Item** parameter is missing,
- Invalid **PayPass Item** parameter.

Description:

- **Paypass 1.1 – Main loop.**

The figure below depicts the Paypass 1.1 – main loop. This loop is fully compliant with Paypass – ISO/IEC14443 Implementation Specification 1.1 (see [8]).

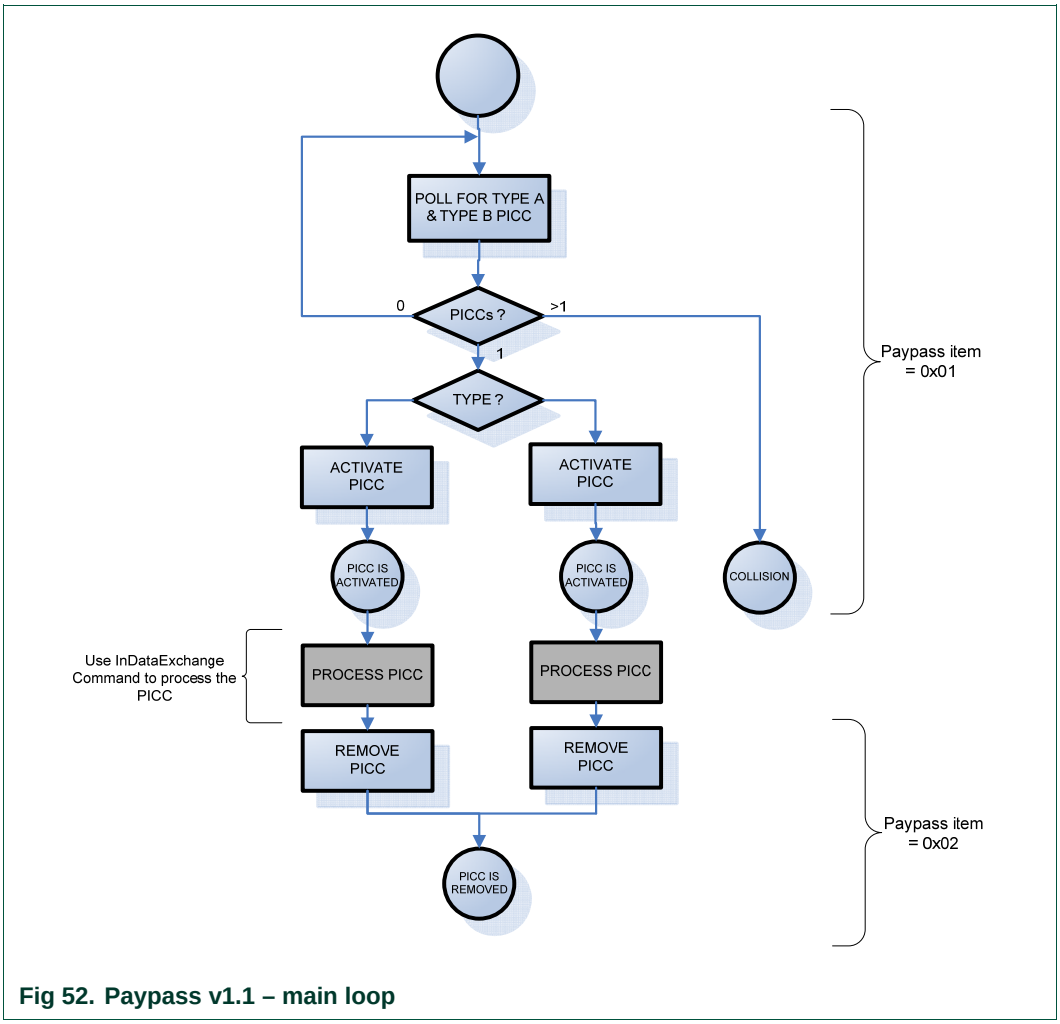


Fig 52. Paypass v1.1 – main loop

Step	Procedure
1	To detect PICCs that are in the Operating Field, the PCD sends repeated Type A and Type B wake-up commands. The PCD must ensure that there is only a single PICC in the Operating Field before the terminal may initiate the transaction. This phase is compliant with Paypass 1.1 specification (see [8]).
2	If the PCD receives a response from more than one PICC, then the PCD reports a collision to the host.
3	If there is only one PICC in the Operating Field, then the PCD activates the PICC.
4	After the PICC has been activated, the PN533 is initialized with respect to [8]. The PCD performs the transaction with the **`InDataExchange`** command (see §8.4.8, p.100). The transaction processing is situated on the application layer.
5	When the transaction is finished the host asks the PCD to deactivate the PICC and to wait until the PICC is removed from the Operating Field.

- **EMVCo 2.0 – Main loop.**

The figure below depicts the EMVCo 2.0 – main loop. This loop is compliant with EMV Contactless Communication Specification 2.0 (see [9]).

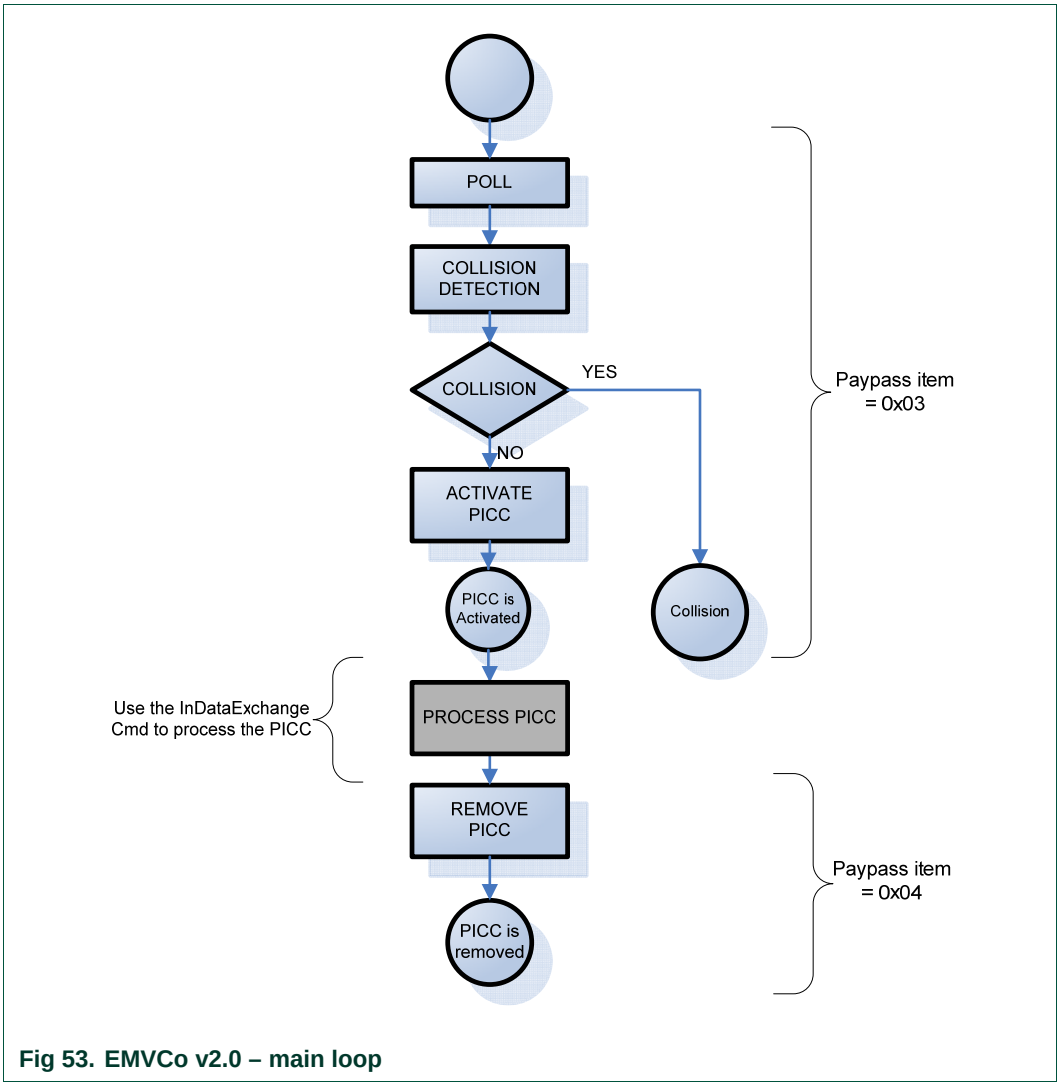


Fig 53. EMVCo v2.0 – main loop

The PN533 proceeds as follow:

Step	Procedure
1	To detect PICCs which are in the Operating Field, the PN533 polls for the different communication signal interfaces (Type A and Type B).
2	During the collision detection procedure, the PN533 ensures that there is only one PICC in the Operating Field. If the PCD receives a response from more than one PICC, then the chip reports a collision to the host.
3	If there is only one PICC in the Operating Field, then the PN533 activates the PICC.
4	After the PICC has been activated, the PCD installs the half-duplex transmission protocol.
5	When the transaction is finished the PCD waits until the PICC is removed from the Operating Field. When the PICC is removed from the Operating Field, the PCD reports a time-out error.

8.4.15 TgInitAsTarget

The host controller uses this command to configure the PN533 as target.

Input:

D4	8C	Mode	MIFAREParams[ ] (6 bytes)	FeliCaParams[ ] (18 bytes)		NFCID3t (10 bytes)
				LEN Gt	[Gt[0..n]]	LEN Tk

- **Mode** is a byte indicating which mode the PN533 should respect

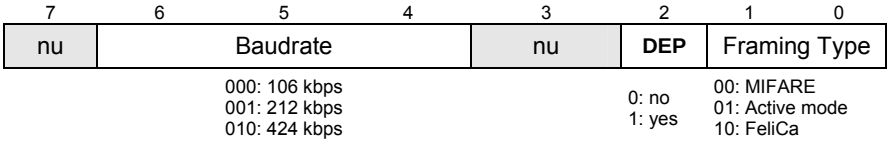
7	6	5	4	3	2	1	0
nu	nu	nu	nu	nu	nu	DEP only	Passive only
						0: no 1: yes	0: no 1: yes

  - *PassiveOnly* flag is used to configure the PN533 to accept to be initialized only in passive mode, i.e. to refuse active communication mode;
  - *DEPOnly* flag is used to configure the PN533 to accept to be initialized only as DEP target, i.e. receiving an ATR_REQ frame. The PN533 can be activated either in passive or active mode, but if the PN533 receives a proprietary command frame as first command following AutoColl process, it will be rejected and the PN533 returns automatically in the AutoColl state;
- **MIFAREParams[ ]** is the information needed to be able to be activated at 106 kbps in passive mode. **MIFAREParams[ ]** is composed of:
  - *SENS_RES (2 bytes LSB first, as defined in ISO/IEC14443-3).*
  - *NFCID1t has a fixed length of 3 bytes containing the nfcid11 to nfcid13 bytes. Indeed, the PN533 can handle only NFCID1t in single size,*
  - *SEL_RES (1 byte), typical value = 0x40 (for DEP)*
- **FeliCaParams[ ]** contain the information to be able to respond to a polling request at 212/424 kbps in passive mode. **FeliCaParams[ ]** is composed of:
  - *NFCID2t (8 bytes),*
  - *PAD (8 bytes),*
  - *System Code (2 bytes), these two bytes are returned in the POL_RES frame if the 4th byte of the incoming POL_REQ command frame is 0x01.*
- **NFCID3t** is used in the ATR_RES in case of ATR_REQ received from the initiator,
- **LEN Gt** codes the number of general bytes (max. 47 bytes). This field is mandatory. When set to 0, there are no general bytes following,
- **Gt[ ]** is an array containing the general bytes to be used in the ATR_RES. This information is optional and the length is not fixed (max. 47 bytes),
- **LEN Tk** codes the number of historical bytes (max. 48 bytes). This field is mandatory. When set to 0, there are no historical bytes following.

Output:

D5	8D	Mode	InitiatorCommand[ ]

- **Mode** is a byte indicating in which mode the PN533 has been activated:



- **InitiatorCommand** is an array containing the first valid frame received by the PN533 once the PN533 has been initialized.

  This frame is different depending on the mode in which the PN533 has been initialized (DEP, passive 106 kbps or 212/424 kbps).

Syntax Error Conditions:

- ***LEN Gt*** exceeds 47 bytes,
- ***LEN Tk*** exceeds 48 bytes,
- Incorrect command length.

Description:

When this command is used by the host controller, the PN533 first stores the input parameters in the dedicated area of the internal CIU and then activates the AutoColl command.
This AutoColl command handles FeliCa polling and MIFARE anti-collision automatically.

Thus, **`TgInitAsTarget`** is ended when a complete command frame has been received from the external initiator. Depending on the initialization type, the 3 following scenarios are possible:

- 106 kbps passive (BR=106, Framing=MIFARE):
  - When a SENS_REQ command is detected, the PN533 sends back the SENS_RES contained in **MIFAREParams**,
  - Then the PN533 uses the NFCID1t part of **MIFAREParams** during the anti-collision process,
  - At the end of the selection, the PN533 sends the SEL_RES to the initiator,
  - Then the PN533 waits for a command coming from the initiator that closes the AutoColl internal command,
  - This command may be an ATR_REQ, a SLP_REQ, or a proprietary command.
    - *ATR_REQ*: if the flag *fAutomaticATR_RES* is set (§8.2.8, p.66), the PN533 sends back automatically the ATR_RES frame to the initiator (example in Fig 54).

      Otherwise, the ATR_RES will be sent back to the initiator only after having received a **`TgSetGeneralBytes`** (§8.4.16, p.133) from the host controller.

      The complete ATR_REQ is returned to the host controller.

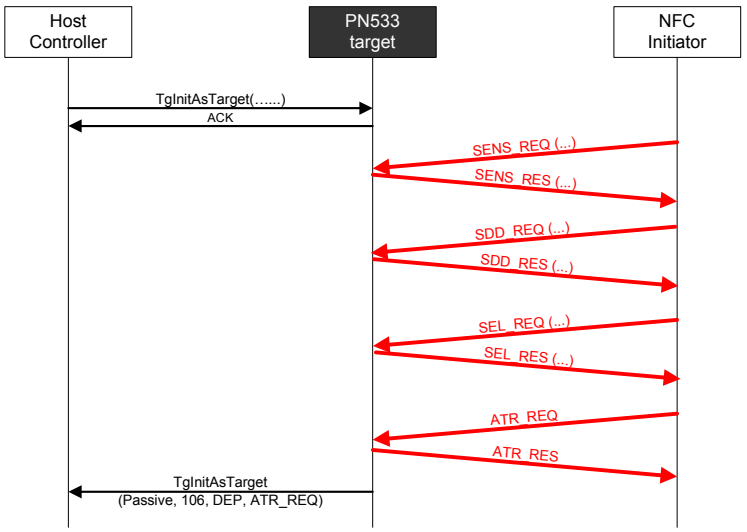


Fig 54. TgInitAsTarget – Passive DEP 106 kbps

- *SLP_REQ:* the PN533 starts again an AutoColl sequence and therefore is ready to receive a new activation command (**`TgInitAsTarget`** process is still running).

- *proprietary command:* the PN533 does nothing with this command (example in Fig 55).

  If the bit *DEPOnly* is not set, the complete proprietary command is returned to the host controller.

  If the bit *DEPOnly* is set, the command is refused and the PN533 starts a new AutoColl sequence.

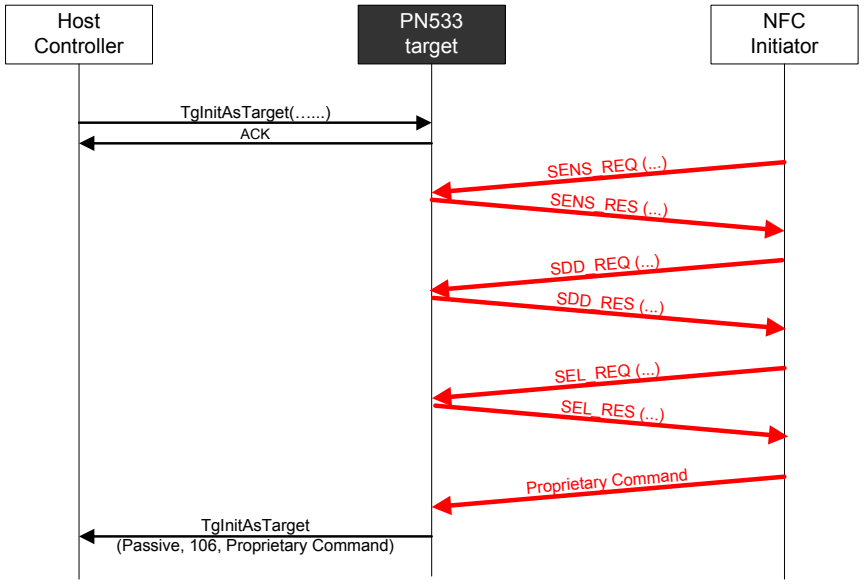


Fig 55. TgInitAsTarget – Proprietary command

- 212/424 kbps passive (BR=212/424, Framing=FeliCa):
  - When a POL_REQ command is detected, the PN533 sends back the POL_RES contained in **FeliCaParams**.

    If requested by the initiator (4th byte of the POL_REQ = 0x01), the system code information is added in the POL_RES.
  - Then the PN533 waits for a command coming from the initiator that closes the AutoColl process.
  - This command may be an ATR_REQ (Fig 56) or a proprietary command (Fig 57). In case of the reception of an ATR_REQ, the NFCID3i **must** be the specified NFCID2t with 0x00 padding (last two bytes):
    - If not, the PN533 rejects the command and starts a new AutoColl sequence,
    - If yes, the PN533 sends automatically the ATR_RES frame (except if the flag *fAutomaticATR_RES* is not set (§8.2.8, p.66); this is the case in Fig 56).

If the bit *DEPOnly* is set, the command received must be an ATR_REQ.

The PN533 refuses all other commands and starts a new AutoColl sequence.

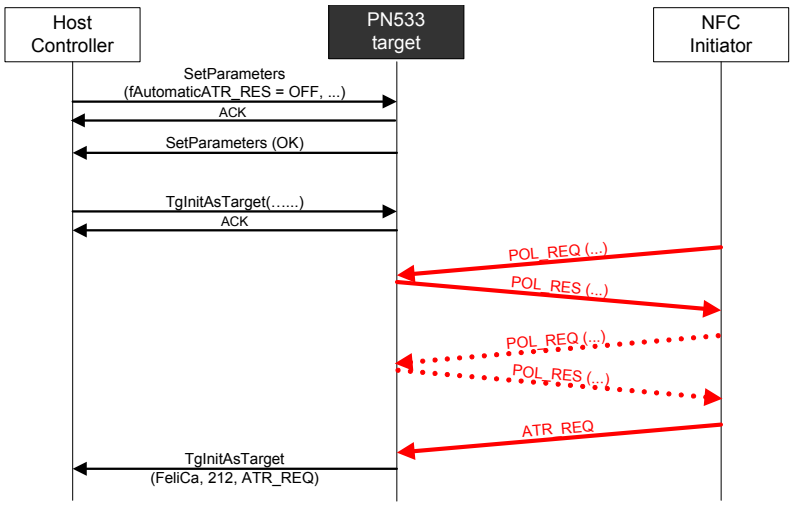


Fig 56. TgInitAsTarget – Passive DEP 212/424 kbps

- *proprietary command:* the PN533 does nothing with this command (example in Fig 55).

  If the bit *DEPOnly* is not set, the complete proprietary command is returned to the host controller.

  If the bit *DEPOnly* is set, the command is refused and the PN533 starts a new AutoColl sequence.

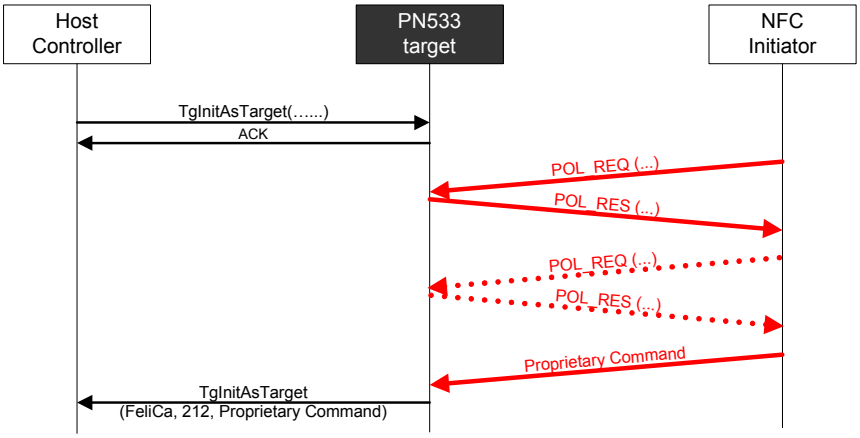


Fig 57. TgInitAsTarget – Passive 212/424 kbps – Proprietary command

- 106/212/424 kbps active (BR=106/212/424, Framing=Active mode):
  - The PN533 waits for a command coming from the initiator that closes the AutoColl process (at this stage, the baud rate and the communication mode are now determined and sent back to the host controller within **Mode** parameter);
  - The command received should be an ATR_REQ. If the incoming RF frame does not fit with ATR_REQ, the PN533 starts a new sequence of AutoColl;
  - Depending on the flag *fAutomaticATR_RES* (§8.2.8, p.66), the PN533 sends automatically the ATR_RES frame (Fig 58) or not. If not, the host controller shall use the **`TgSetGeneralBytes`** (§8.4.16, p.133);

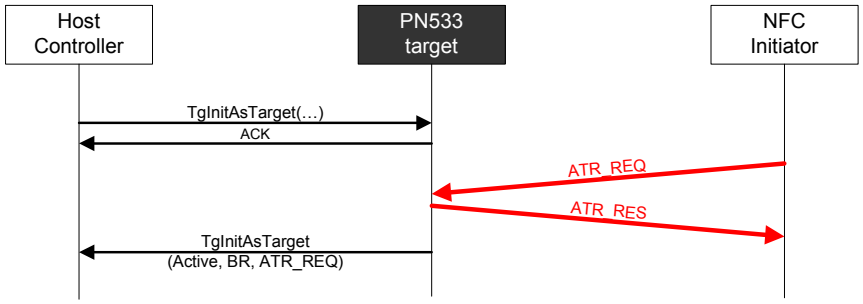


Fig 58. TgInitAsTarget – Active mode

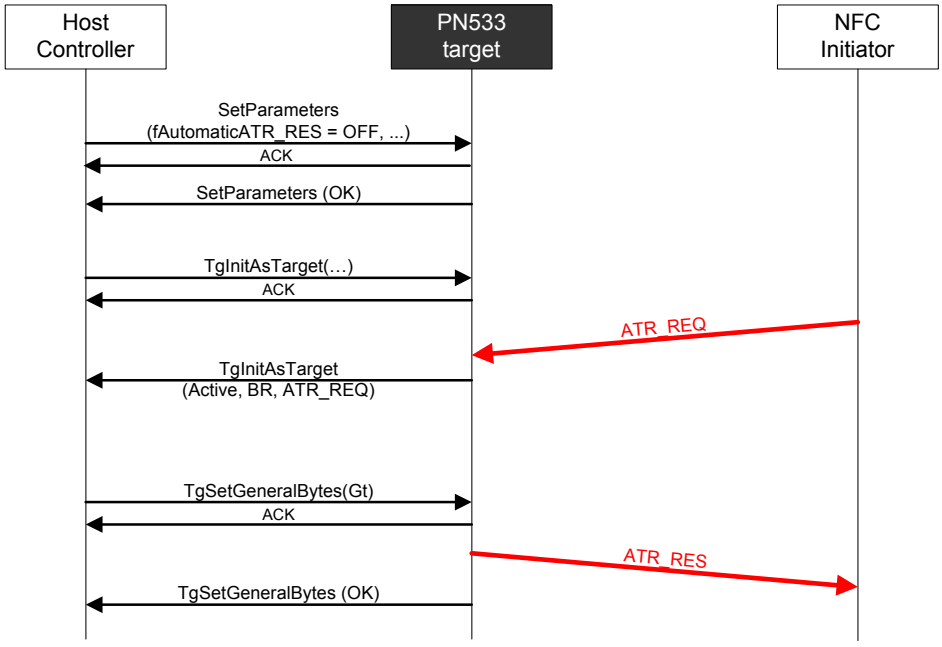


Fig 59. TgInitAsTarget – Active mode and use of TgSetGeneralBytes

Once the PN533 is configured as target, it can handle some of the DEP commands without any help of its host controller.

The PN533 builds the corresponding answer frame and updates its internal state (released, deselected, activated, …). This is the case for the following command frame:

Table 28. Target configuration – Automatic response

Command Received	Automatic Response	DEP mode
ATR_REQ	ATR_RES may need **`TgSetGeneralBytes`** if *fAutomaticATR_RES* is not set	Y
PSL_REQ	PSL_RES	Y
DSL_REQ	DSL_RES	Y
RLS_REQ	RLS_RES	Y
WUP_REQ	WUP_RES	Y

8.4.16 TgSetGeneralBytes

This command is used in combination with the **`TgInitAsTarget`** command (§8.4.14, p.120) to give the General Bytes.

The PN533 uses them to build the ATR_RES sent to the initiator.

Input:

D4	92	Gt[0..n]

- **Gt[ ]** is an array containing the general bytes to be used in the ATR_RES. The length of this field is not fixed (max. 47 bytes).

Output:

D5	93	Status

- **Status** is a byte indicating if the process has been terminated successfully or not (see §8.1, p.50).

Syntax Error Conditions:

- **Gt[ ]** length exceeds 47 bytes,

Description:

By default (flag *fAutomaticATR_RES* is set, §8.2.8, p.66), the PN533 uses the general bytes given in **`TgInitAsTarget`** command (present or not in the input parameters).

The command **`TgSetGeneralBytes`** allows the host controller to build the General Bytes of the target after having analyzed the ATR_REQ coming from the initiator.

When used, the command **`TgSetGeneralBytes`** must follow the **`TgInitAsTarget`**, as described in the following figure (Fig 60).

The PN533 does not send ATR_RES before the command **`TgSetGeneralBytes`**. Then, the PN533 prepares the ATR_RES with the **Gt[ ]** bytes and sends the complete ATR_RES to the initiator.

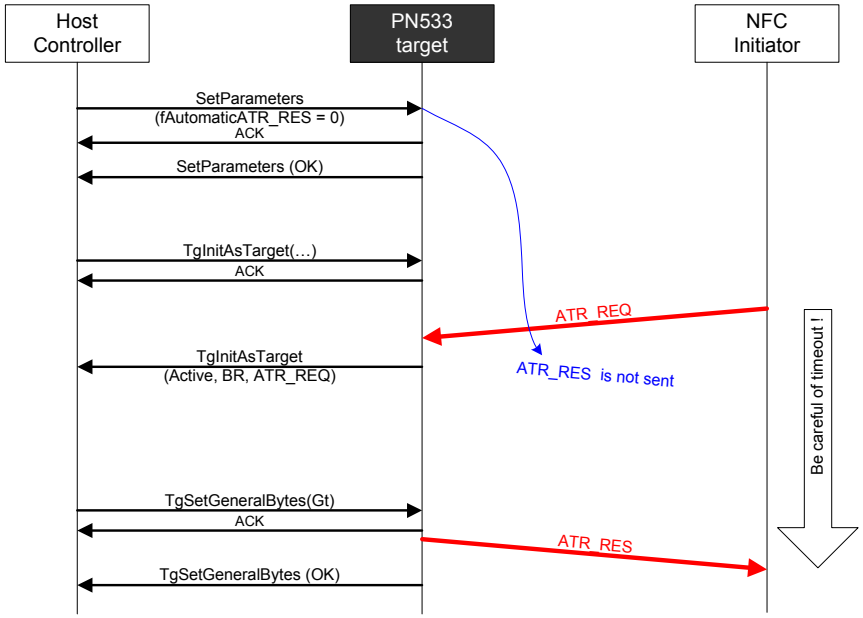


Fig 60. TgSetGeneralBytes

Remark: The NFC initiator controls a timeout after having sent an ATR_REQ (see [3]), so the host controller of the PN533 must take care of that, meaning that if the ATR_RES is not ready in time, the initiator will stop the transaction with the target.

8.4.17 TgGetData

This command is used in case of the PN533 configured as target for Data Exchange Protocol (DEP).

Input:

D4	86

Output:

D5	87	Status	[DataIn [ ]]

- **Status** is a byte indicating if the process has been terminated successfully or not (see §8.1, p.50).

  When in DEP mode, Status is equal to 0x20 then the secured transaction has terminated successfully.

  When in DEP mode, this byte indicates also if *NAD* is used and if the transfer of data is not completed with bit *More Information* (see §8.5.4, p.152).

- **DataIn[ ]** is an array of data (from 0 up to 262 bytes) received by the PN533 coming from the initiator (see §8.5.5, p.161).

Description:

This command allows the host controller to get back the data received by the PN533 from its initiator (in **DataIn [ ]** array).

The delay between a reception from its initiator and the transmission of the corresponding response elaborated by the host controller is not completely under the PN533 control (the host controller may take a long time to prepare the data to be returned).
To bypass this potential problem, the PN533 automatically generates the necessary Supervisory pdu ($S(TO)_{REQ}$) for DEP.

DEP Protocol

Regarding the DEP protocol, a typical data exchange between the PN533 as target and a NFC Initiator can be represented as follows (Fig 61):

- When the host controller wants to retrieve a command message coming from the initiator, it uses the **`TgGetData`** command,
- In that case, the PN533 sends back an ACK frame to the host controller and then waits for available data from the initiator. It may take a long time before data are available (T_{cmd}),
- As soon as it has received a complete RF frame from the initiator, the PN533 uses a supervisory frame to ask for time extension to the initiator (7 x 154 ms = 1.078s)[18],
- Then, the PN533 sends the received RF frame back to the host controller,

[18] 7 is the default value of the RTOX parameter sent by the PN533 in an $S(TO)_{REQ}$.
154 ms corresponds to the default value of RWT (Response Waiting Time) for the PN533 configured as target.

- After having processed these data, the host controller shall use the **`TgSetData`** command (§8.4.18, p.137) to complete the exchange.

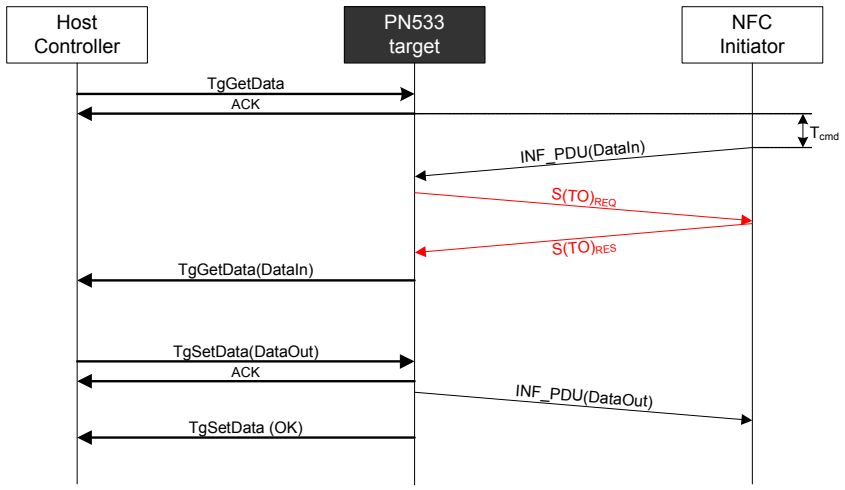


Fig 61. TgGetData (1)

In this schematic representation, no chaining is shown.

Refer to §8.5.4, p.152 to have a more detailed explanation of the chaining mechanism in case of the PN533 configured as target.

The PN533 can also accept a INF_PDU incoming frame from the initiator even if it has not received yet a **`TgGetData`** command from the host controller. The protocol exchange with the initiator is then preserved by using $S(TO)_{REQ}$.

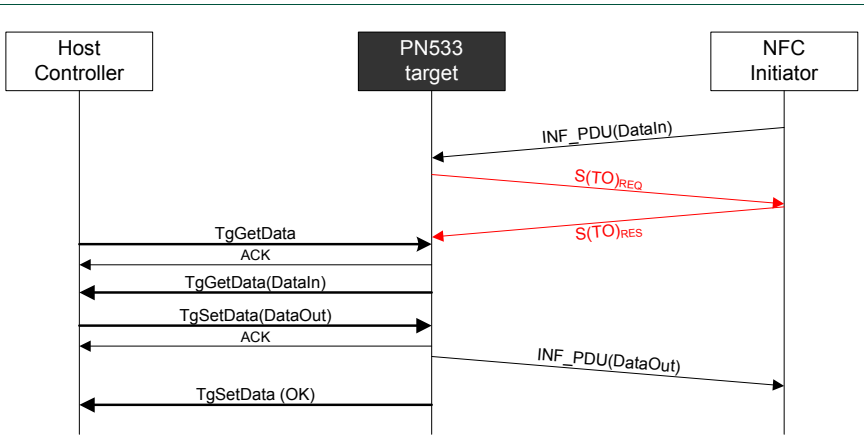


Fig 62. TgGetData (2)

Possible errors returned:

- Target is not in a correct state to perform this operation (not in DEP protocol)

  ➔ A specific error code is returned (**Status** = 0x25)

- Target has been released

  ➔ A specific error code is returned (**Status** = 0x29)

8.4.18 TgSetData

This command is used in case of the PN533 configured as target for Data Exchange Protocol (DEP). The overall amount of data to be sent can be transmitted in one frame (262 bytes maximum).

Input:

D4	8E	[DataOut [ ]]

- **DataOut [ ]** is an array of data (from 0 up to 262 bytes) to be sent by the PN533 as response to its initiator (see §8.5.5, p.161).

Output:

D5	8F	Status

- **Status** is a byte indicating if the process has been terminated successfully or not (see §8.1, p.50).

Description:

It allows the host controller to supply the PN533 with the data that it wants to send back to the initiator (in response of the previous RF DEP_REQ frame(s) for DEP).

The PN533 sends in the RF link the data contained in **DataOut [ ]** array.

The protocol management (chaining, error handling) is completely managed internally by the PN533.

A typical data exchange between the PN533 as target and a NFC Initiator is represented in the **`TgGetData`** command description.

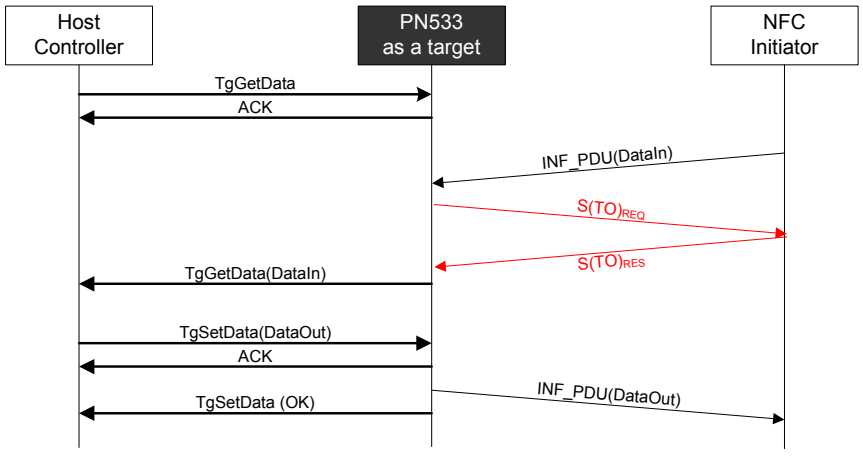


Fig 63. TgSetData

Examples given in §8.5.4, p.152 show how the chaining is handled either by the initiator or by the target.

8.4.19 TgSetDataSecure

This command is used in case of the PN533 configured as target for Secret Exchange Protocol (SEP). The overall amount of data to be sent can be transmitted in one frame (262 bytes maximum).

Input:

D4	96	[DataOut [ ]]

- Means that the Data exchange is secured
- **DataOut [ ]** is an array of **secured data** (from 0 up to 262 bytes) to be sent by the PN533 as response to its initiator (see §8.5.5, p.161).

Output:

D5	97	Status

- **Status** is a byte indicating if the process has been terminated successfully or not (see §8.1, p.50).

Description:

It allows the host controller to supply the PN533 with the data that it wants to send back to the initiator.

The PN533 sends in the RF link the secured data contained in **DataOut [ ]** array.

The protocol management (chaining, error handling) is completely managed internally by the PN533.

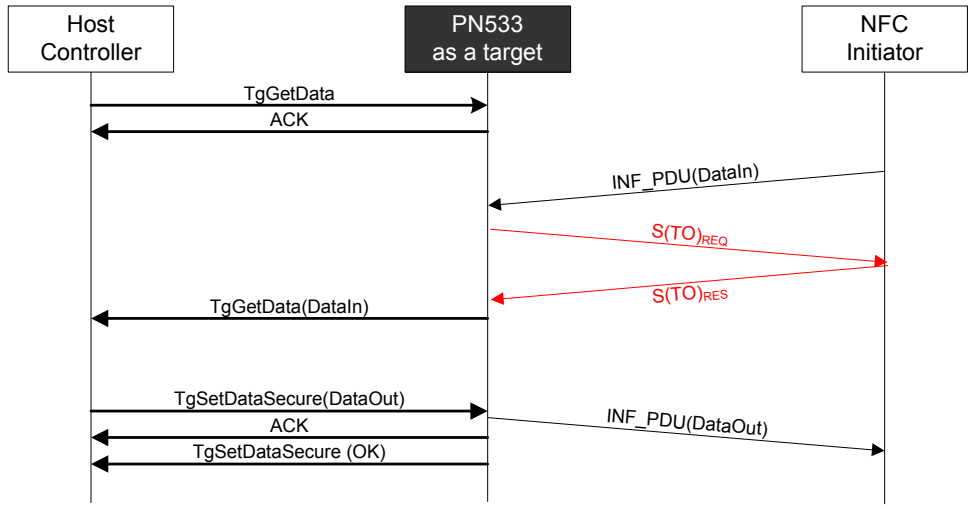


Fig 64. TgSetDataSecure

The examples given in §8.4.21, p141: show how the chaining is handled either by the initiator or by the target.

8.4.20 TgSetMetaData

This command is used in case of the PN533 configured as target for Data Exchange Protocol (DEP) if the overall amount of data to be sent cannot be transmitted in one frame (more than 262 bytes).

Input:

D4	94	DataOut [ ]

- **DataOut [ ]**is an array of data (from 0 up to 262 bytes) to be sent by the PN533 as response to its initiator.

Output:

D5	95	Status

- **Status** is a byte indicating if the process has been terminated successfully or not (see §8.1, p.50)

Description:

The main difference compared to the **`TgSetData`** command (see §8.4.18, p.137) is therefore that in the last chained packet sent by the PN533 to the initiator, the PFB control byte will contain the More Information bit set to one.

A typical data exchange using this command is shown in the following figure:

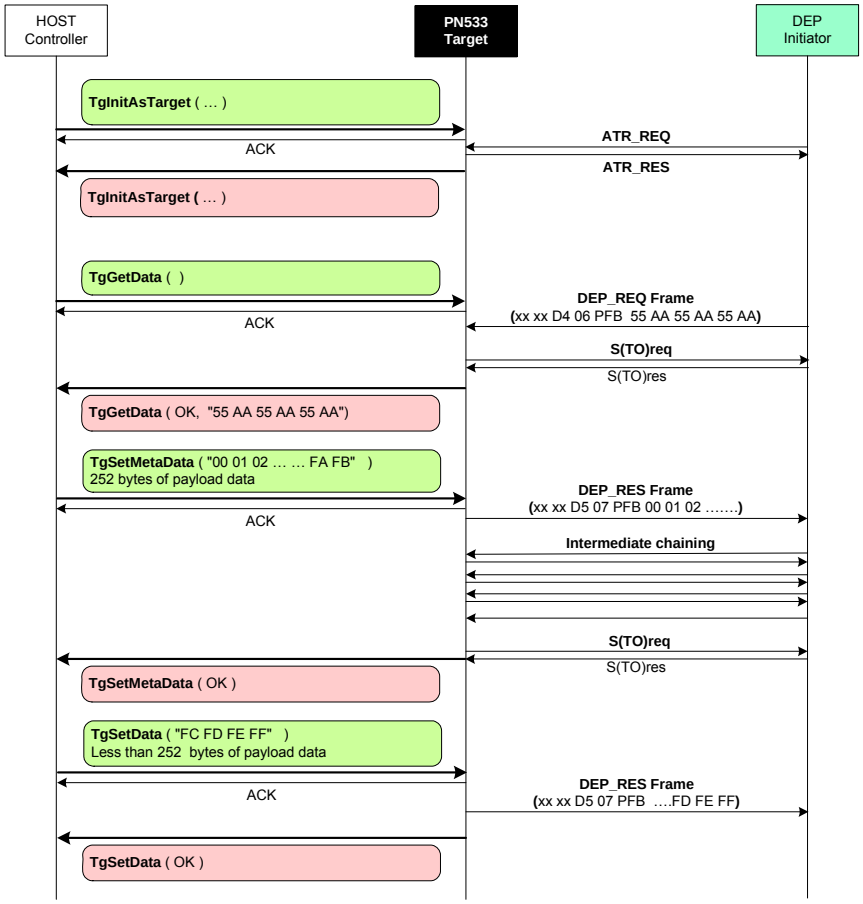


Fig 65. TgSetMetaData

8.4.21 TgSetMetaDataSecure

This command is used in case of the PN533 configured as target for Secure Exchange Protocol (SEP) if the overall amount of data to be sent cannot be transmitted in one frame (more than 262 bytes).

Input:

D4	98	DataOut [ ]

- **DataOut [ ]**is an array of data (from 0 up to 262 bytes) to be sent by the PN533 as response to its initiator.

Output:

D5	99	Status

- **Status** is a byte indicating if the process has been terminated successfully or not (see §8.1, p.50)

Description:

This command is approximately the same than the **`TgSetDataSecure`** one (see §8.4.18, p.137), except that it is used when the host controller of the target wants to transfer data which length is greater than what the PN533 can send in a single transaction. This command is used during a secure exchange.

The main difference compared to the **`TgSetDataSecure`** command is therefore that in the last chained packet sent by the PN533 to the initiator, the PFB control byte will contain the More Information bit set to one.

8.4.22 TgGetInitiatorCommand

This command is used to get a packet of data from an initiator and to send it back to the host controller.

Input:

D4	88

Output:

D5	89	Status	InCommand[ ]

- **Status** is a byte indicating if the process has been terminated successfully or not (see §8.1, p.50).
- **InCommand** is an array of raw data (from 0 up to 262 bytes) received by the PN533 (command from the initiator).

Description:

This command is used when the PN533 is configured as target (see **`TgInitAsTarget`**, §8.4.14, p.120).

The received data are simply returned to the host controller (in **`InCommand[]`** array) that will process them and then use the **`TgResponseToInitiator`** command (§8.4.23, p.144) to give the response to the initiator.

Depending on the mode and the baud rate used, the frame received from the initiator will be de-encapsulated before sending back data to the host controller.

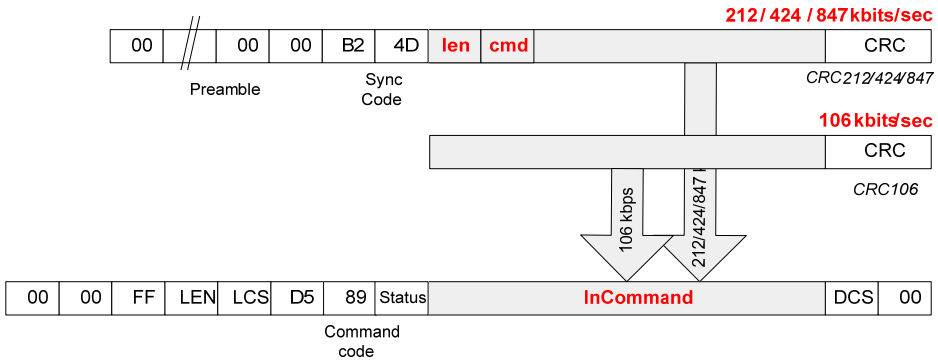


Fig 66. TgGetInitiatorCommand (1)

This command is complementary of the **TgGetData** command.

The main difference compared to **TgGetData** is that here the PN533 does not handle at all the protocol (DEP) features (Supervisory, chaining, error handling…). As a consequence, the **TgGetData** command may be used to carry information whatever the protocol used.

So, this command combined with **TgResponseToInitiator** (§8.4.23, p.144) may be used to build exchanges without using the protocol handled by the PN533 (DEP).

The following figure depicts the linking of the exchanges between the initiator and the PN533 and between the host controller and the PN533.

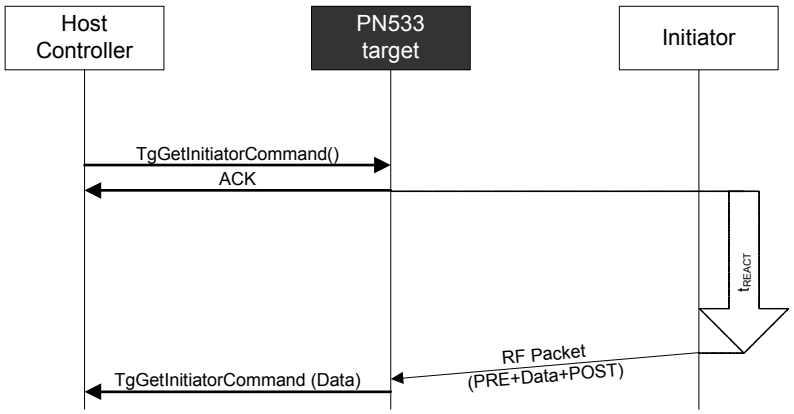


Fig 67. TgGetInitiatorCommand (2)

No control is done on the delay (t_{REACT}) used by the initiator to send its command frame.

The host controller has to manage timeout by itself (it can stop the current **TgGetInitiatorCommand** command by using one of the two dedicated ways of stopping: ACK frame or new command frame).

8.4.23 TgResponseToInitiator

This command is used to send a response packet of data to an initiator.

Input:

D4	90	TgResponse[ ]

- **TgResponse** is an array of raw data (from 0 up to 262 bytes) to be sent by the PN533 (response to the initiator).

Output:

D5	91	Status

- **Status** is a byte indicating if the process has been terminated successfully or not (see §8.1, p.50).

Description:

This command is usually used in co-operation with **`TgGetInitiatorCommand`** (§8.4.21, p.141).

The received data from the host controller (**TgResponse [ ]** array) are simply encapsulated in the RF frame which format depends on the mode and the RF baud rate used.

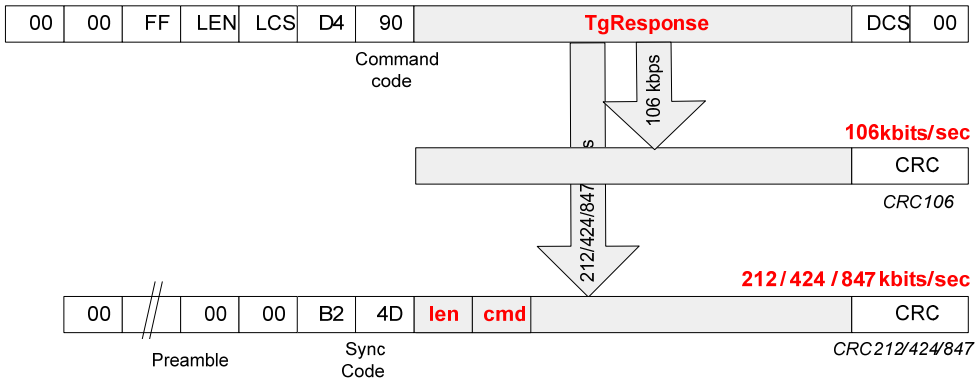


Fig 68. TgResponseToInitiator (1)

This command is complementary of the **`TgSetData`** command.

The main difference compared to **`TgSetData`** is that here the PN533 does not handle at all the protocol (DEP) features (Supervisory, chaining, error handling …).

This command, coupled with the **`TgGetInitiatorCommand`**, is the counterpart of the **`InCommunicateThru`** (see §8.4.9, p.109) command from the initiator side.

The following figure depicts how the exchanges between the initiator and the PN533, but also between the host controller and the PN533 are cascaded.

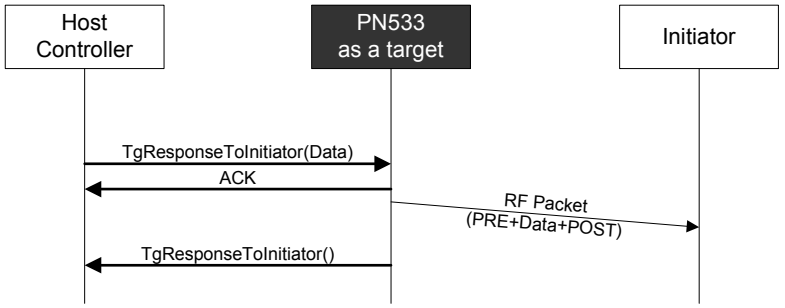


Fig 69. TgResponseToInitiator (2)

The **`TgResponseToInitiator`** command ends as soon as the RF frame is sent to the initiator.
If an error is detected, **Status** byte is filled in with an error code indicating the communication error.

8.4.24 TgGetTargetStatus

This command is used by the host controller to know what the current state of the PN533 is.

Input:

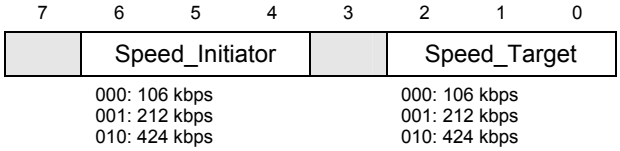
D4	8A

Output:

D5	8B	State	BRit

- **State** gives information about the current state of the PN533.
  - 0x00 TG_IDLE / TG_RELEASED
    the PN533 (acting as NFCIP-1 target) waits for an initiator or has been released by its initiator,
  - 0x01 TG_ACTIVATED
    the PN533 is activated as NFCIP-1 target,
  - 0x02 TG_DESELECTED
    the PN533 (acting as NFCIP-1 target) has been de-selected by its initiator,

- **BRit** gives information about the baud rate used only when in TG_ACTIVATED state:



Description:

The goal of this command is to offer the possibility for the host controller to know if the PN533 target has been either de-selected or released.

In addition, the baud rates used in both directions are also returned.

8.5 Commands summary

The host controller has several commands that can be used when the PN533 is configured either as initiator or as target:

8.5.1 Commands for Initiator mode

The Fig 70 summarizes all the possible commands that can be used when the PN533 is configured as initiator.

Initialization / Activation:

- InJumpForDEP
- InJumpForPSL
- InListPassiveTarget
- InATR
- InPSL
- InActivateDeactivatePaypass

Data Exchange:

- InDataExchange
- InCommunicateThru
- InQuartetByteExchange

Selection / De-Selection / Release:

- InSelect
- InDeselect
- InRelease

Alpar Communication:

- AlparCommandForTDA

8.5.2 Commands for Target mode

The Fig 71 summarizes all the possible commands that can be used when the PN533 is configured as target.

Initialization:

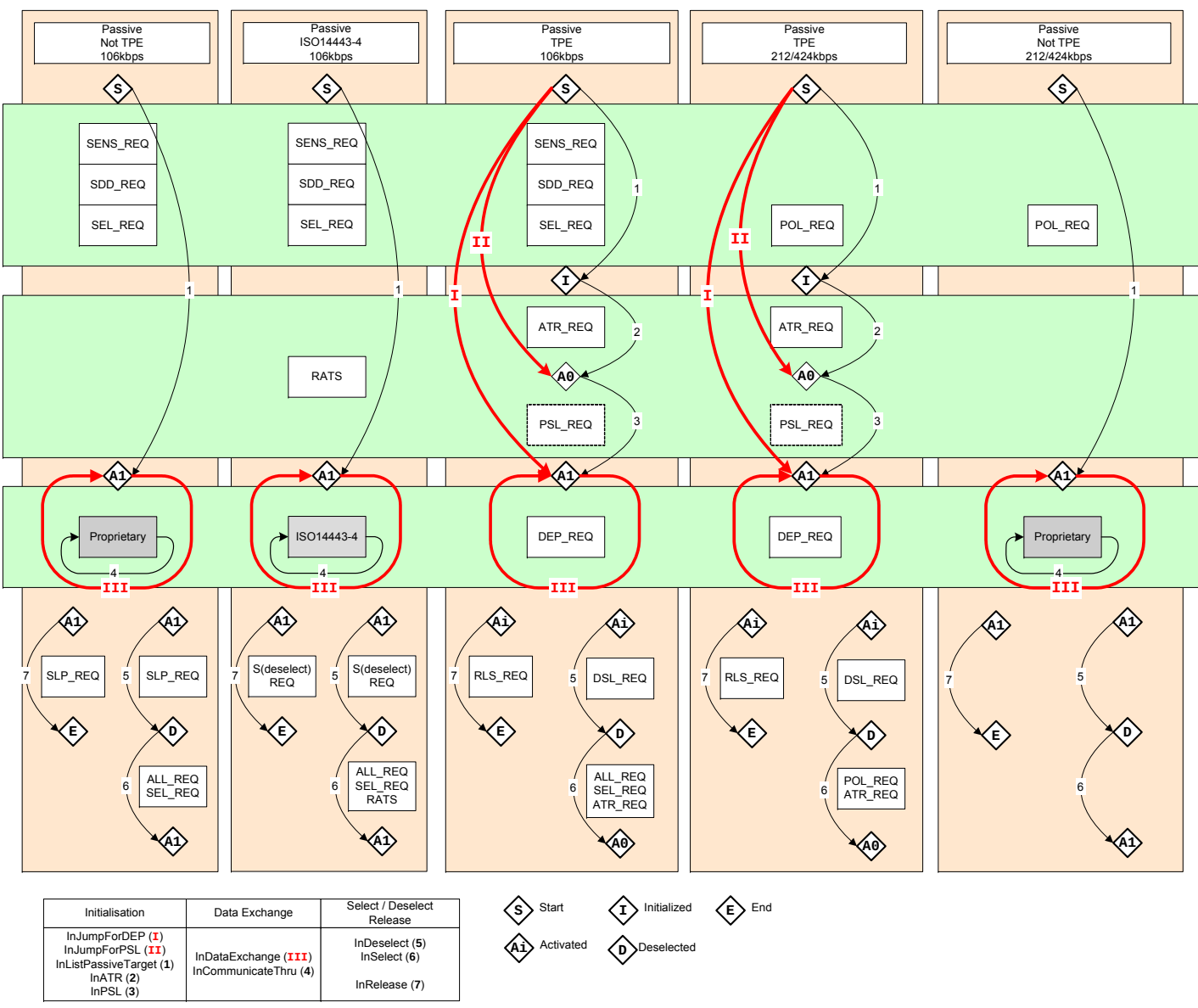
- TgInitAsTarget
- TgSetGeneralBytes

Data Exchange:

- TgGetData
- TgSetData
- TgSetDataSecure
- TgSetMetaData
- TgSetMetaDataSecure
- TgGetInitiatorCommand
- TgResponseToInitiator

8.5.3 Target states summary

The Fig 72 details all the possible states for the PN533 configured as target in passive communication mode.



Initialisation	Data Exchange	Select / Deselect Release
InJumpForDEP (**I**) InJumpForPSL (**II**) InListPassiveTarget (**1**) InATR (**2**) InPSL (**3**)	InDataExchange (**III**) InCommunicateThru (**4**)	InDeselect (**5**) InSelect (**6**) InRelease (**7**)

S Start
I Initialized
E End
Ai Activated
D Deselected

Fig 70. Initiator commands

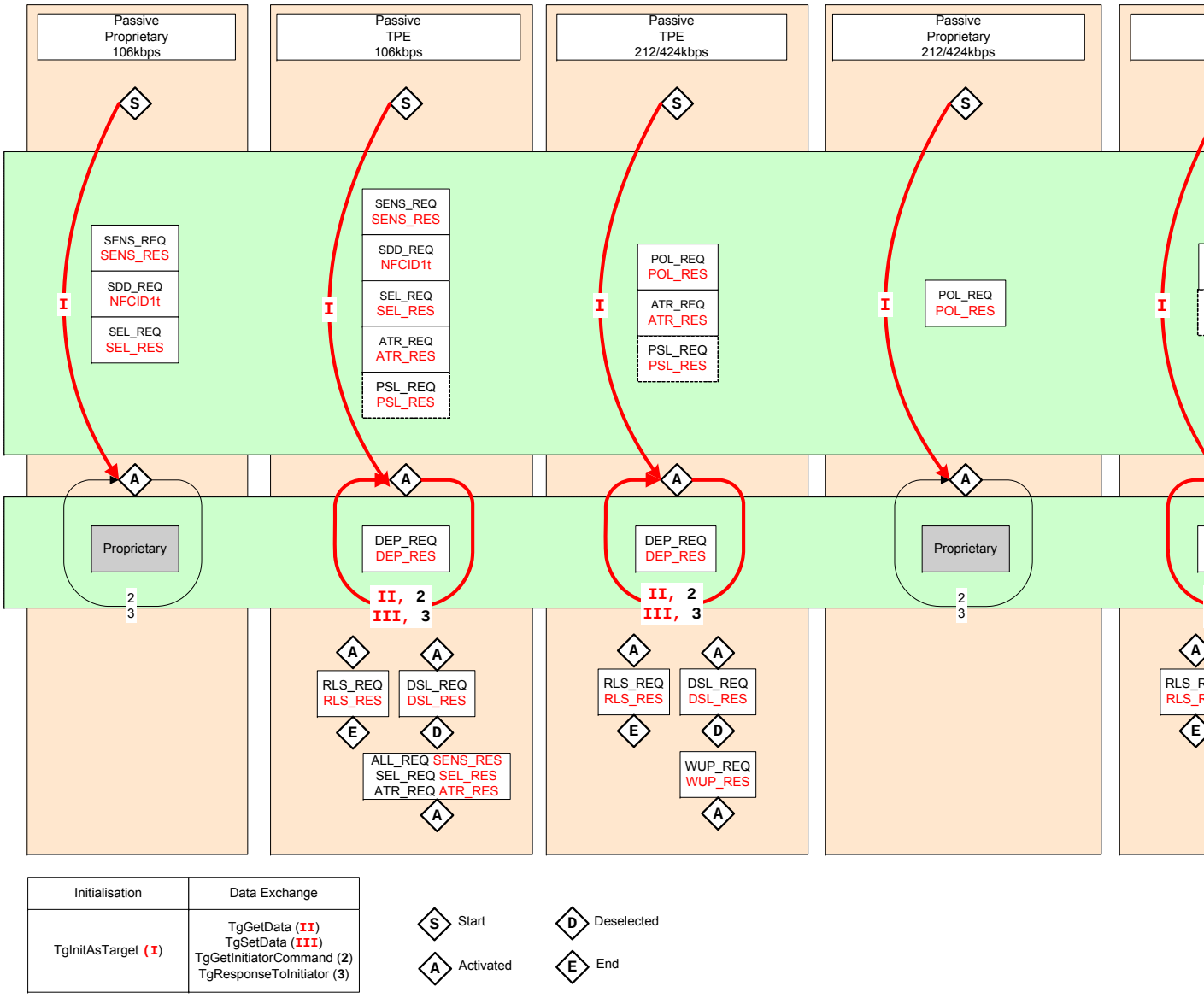


Fig 71. Target commands

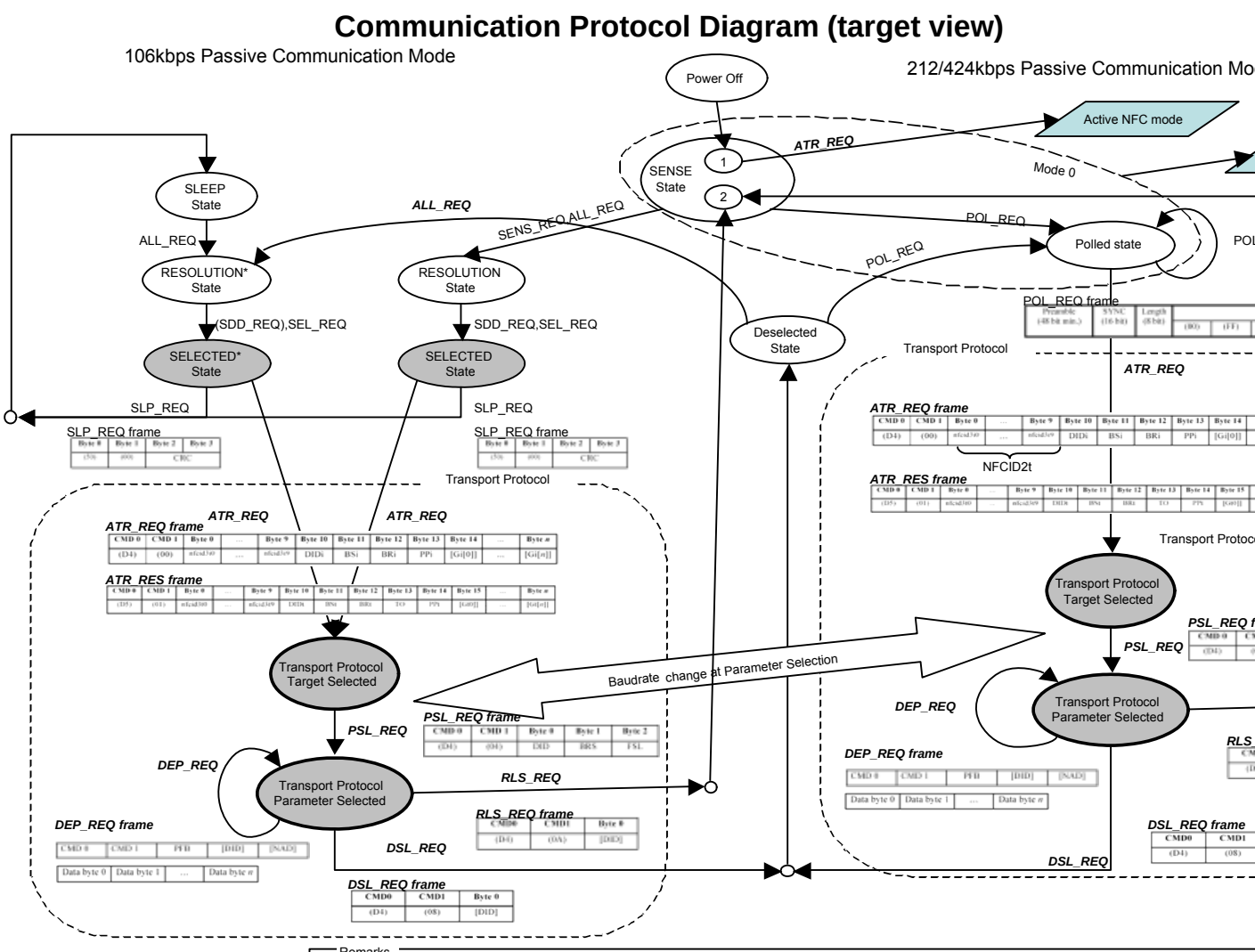


Fig 72. Target states

8.5.4 Chaining mechanism

8.5.4.1 ISO/IEC14443-4 chaining mechanism

This chapter details how the PN533 configured as initiator handles the ISO/IEC14443-4 chaining mechanism. Two examples are given.

The following symbolic representation is used:

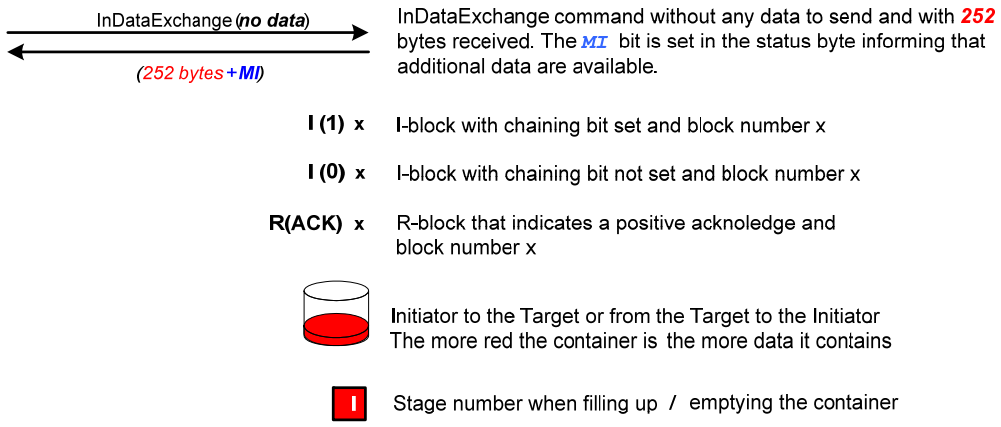


Fig 73. Legend used for the figures describing the ISO14443-4 chaining of data

In the *first and second examples*, the PN533 uses the Chaining functionality to allow transfer of “large” amount of data.

The Fig 74 represents the case of data to be transferred from the initiator to the target and the Fig 75 details the opposite case (data to be transferred from target to initiator).

In the first example (Fig 74), one will notice how the **MI** bit is used in the **`InDataExchange`** command.

On the other hand, in the second example (Fig 75), the comparative use of the **`InDataExchange`** command with no data after receiving a response of **`InDataExchange`** with **MI** bit set in the returned status.

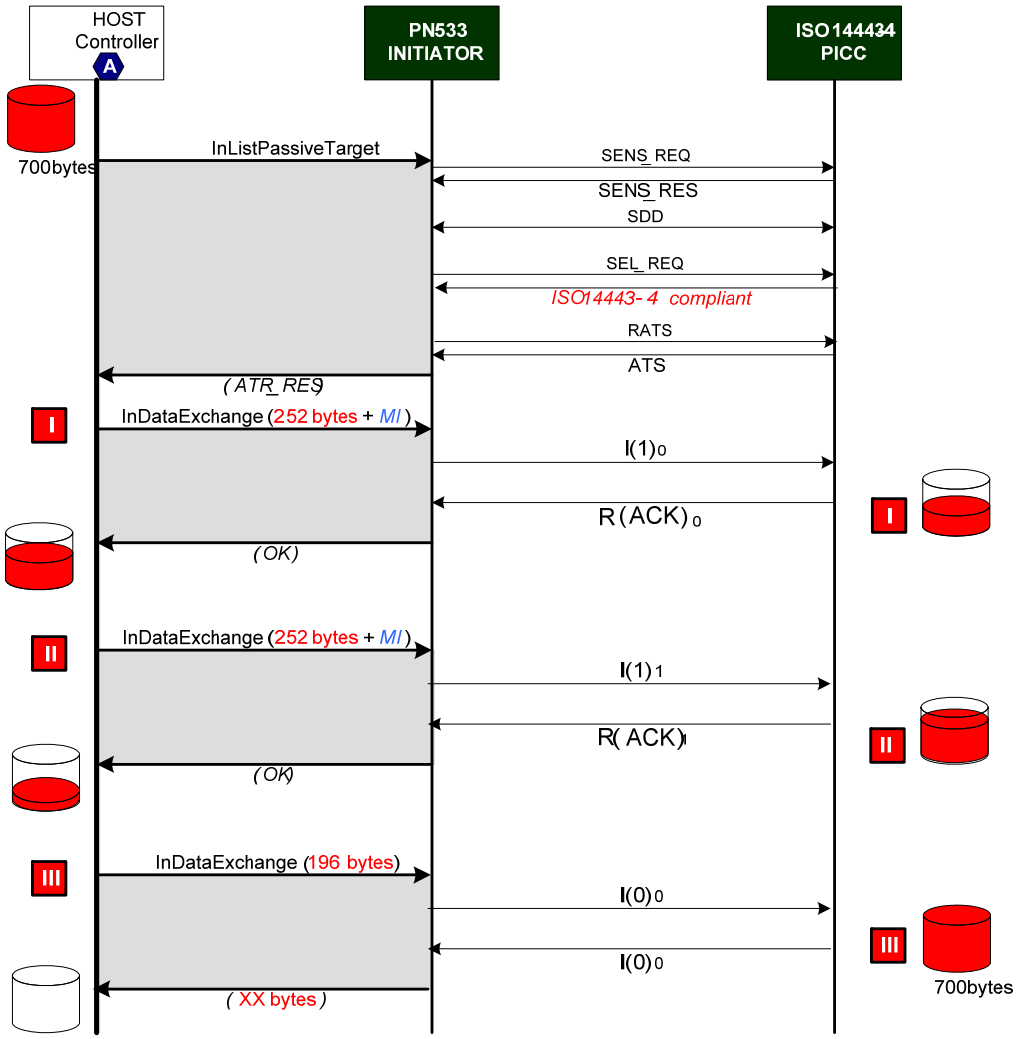


Fig 74. ISO14443-4 chaining mechanism: Transfer from PCD to PICC

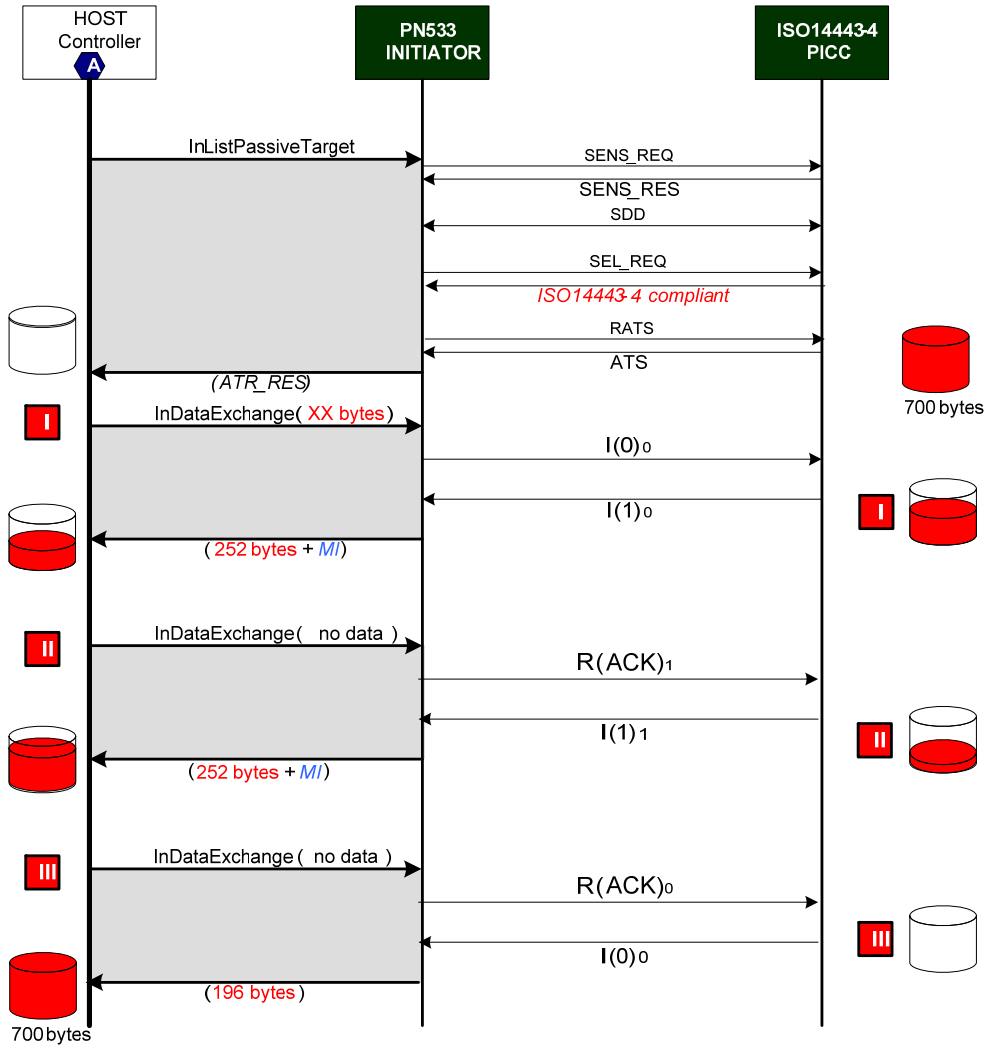


Fig 75. ISO14443-4 chaining mechanism: Transfer from PICC to PCD

8.5.4.2 DEP chaining mechanism

This chapter details how the PN533 configured as initiator or as target handles the DEP chaining mechanism. Four examples are given.

The following symbolic representation is used:

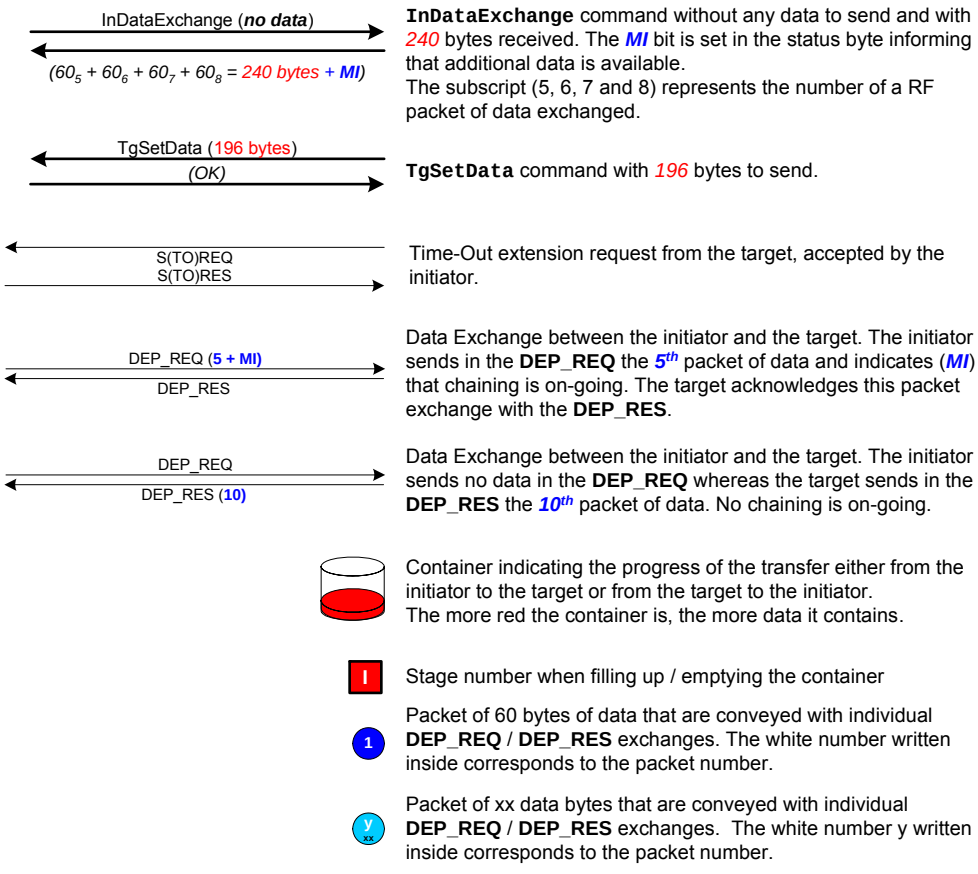


Fig 76. Legend used for the figures describing the chaining of data

In the *first example* shown (Fig 77), both the initiator and the target are supposed to be a PN533 which are **not using** Meta-Chaining.

The host controller of the initiator (A) sends packets of 262 bytes (maximal capacity of the **InDataExchange** command, see §8.4.8, p.100).

The target indicates a length reduction of 64 bytes, i.e. payload of 60 bytes[19].

The PN533 initiator cuts out the 262 bytes packet of data into individual packets of 60 bytes and sends these packets to the target.

After having received the 5th individual packet, the PN533 target sends back a $S(TO)_{REQ}$ RF frame to the initiator, and sends the information data (262 bytes) to its host controller (**B**).

In this example, **B** knows that these first 262 bytes are only a part of the complete "file" to transfer (header information for example) and then has no data to send back to **A**. Consequently, it uses **TgSetData** without data.

When the PN533 target receives this **TgSetData** command, it can send back a DEP_RES frame to the initiator.

This mechanism goes on until all the data are transferred.

In the *second example* (Fig 78), the initiator has a large memory area, meaning that the complete "file" to be transferred is ready in its memory.

The scenario is then a little bit different; the initiator maintains the **MI** bit in the PFB byte to 1 until the complete data are transferred.

The difference compared to the first example is that the PN533 target returns always the **MI** information to the host controller **B**. In that case, **B** does not need to use **TgSetData** as in the first example.

In the *third and fourth examples*, the PN533 uses Meta-Chaining functionality to allow transfer of "large" amount of data.

The Fig 79 represents the case of data to be transferred from the initiator to the target and the Fig 80 details the opposite case (data to be transferred from target to initiator).

In the third example, one will notice how the **MI** bit is used both in the **InDataExchange** and the **TgGetData** commands.

On the other hand, in the fourth example (Fig 80), the comparative use of the **TgSetMetaData** and **TgSetData** commands is shown.

[19] The total Transport Frame length indicated by the target is maximum **64** bytes. Thus the maximum payload data length is then **60** bytes, as there are **CMD0**, **CMD1** and **PFB** bytes to deduct (see [3], §12.1 and Fig.23).

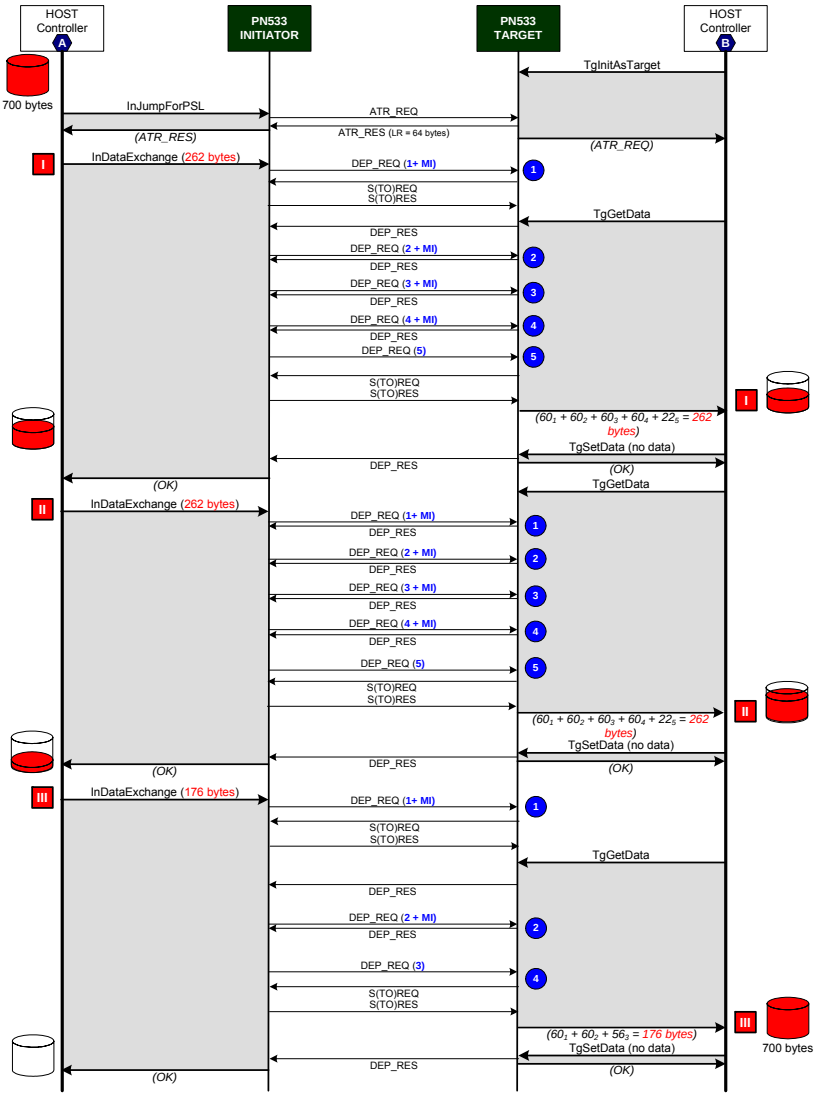


Fig 77. DEP chaining mechanism: packets transfer

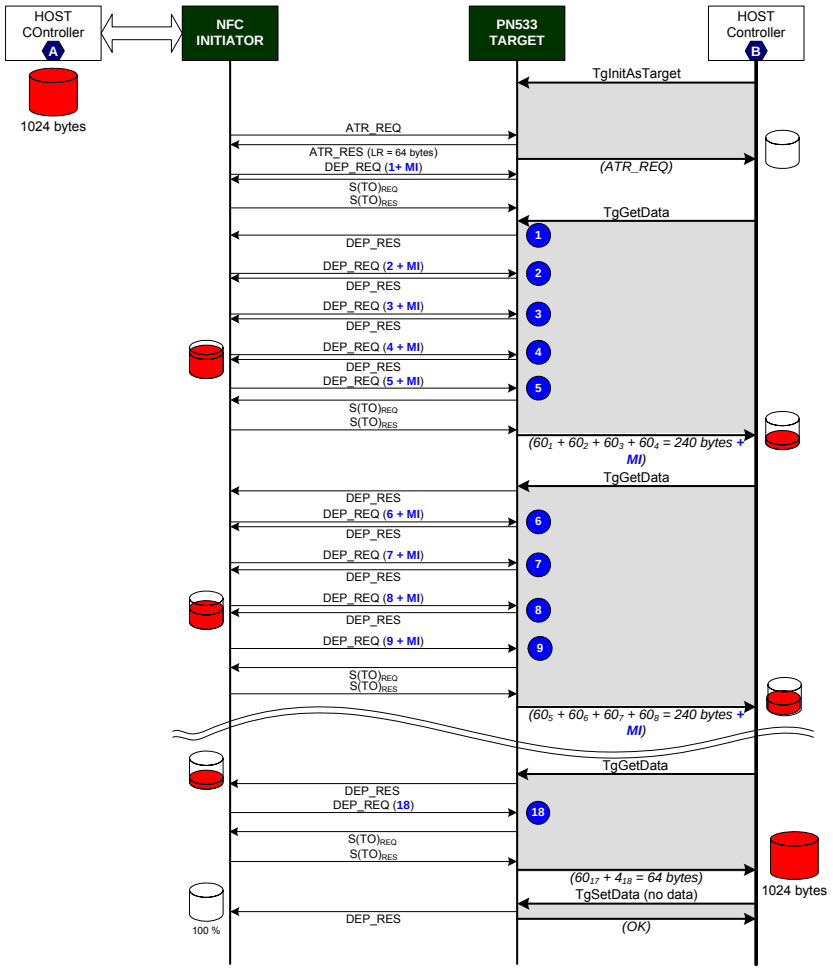


Fig 78. DEP chaining mechanism: “streaming” transfer from initiator to target

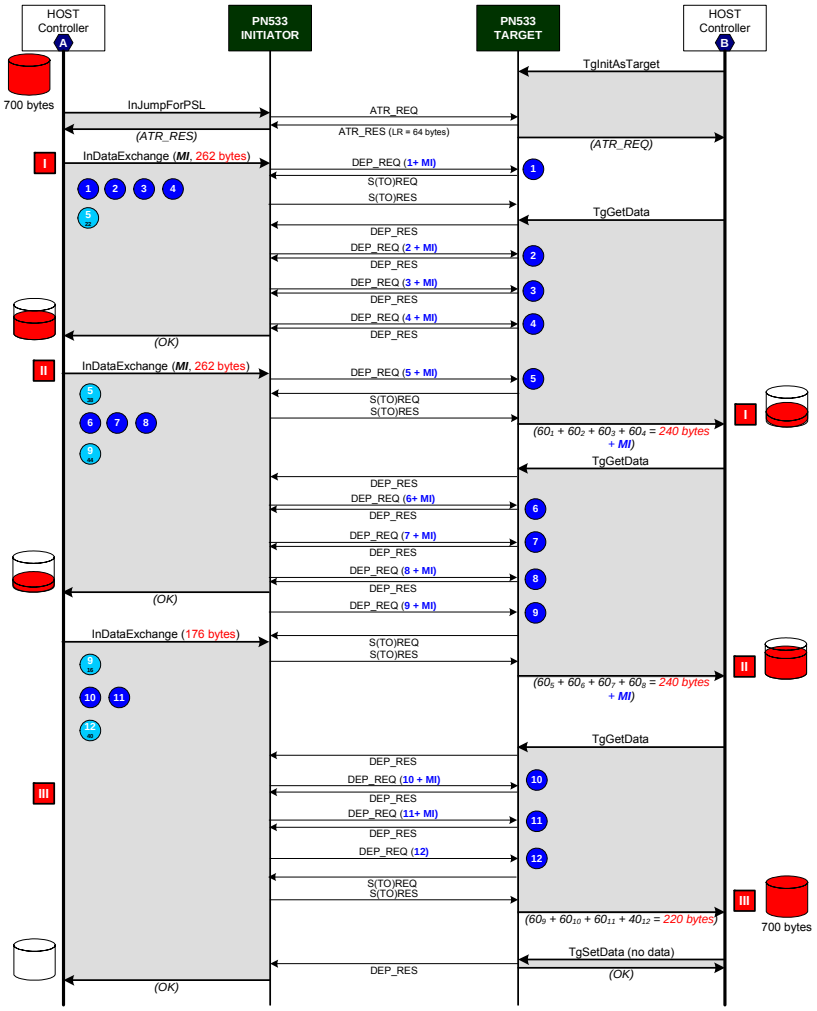


Fig 79. DEP chaining mechanism: transfer with Meta-Chaining – Initiator case

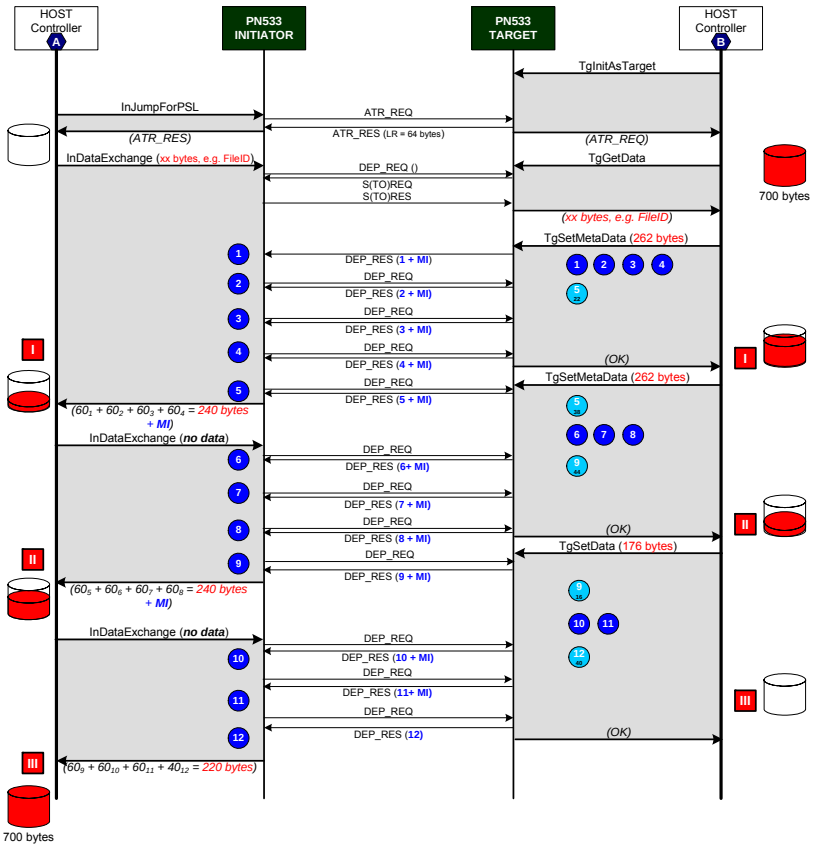


Fig 80. DEP chaining mechanism: transfer with Meta-Chaining – Target case

8.5.5 Comparison of the length of Payload data field

The following figure depicts the available length for the payload field at two different levels:

- In the host controller protocol, for the commands used to get or set data either in initiator or target configuration.
  - **`InDataExchange`**,
  - **`TgGetData`**, **`TgSetData, and TgSetMetaData`**
- In the NFC Data Exchange Protocol (DEP).

This shows that the capacity of the payload data field at DEP level is lower than the one between the host controller and the PN533, even when DID field is not used (251 bytes vs. 250).

That means that if the host controller uses the total capacity of the **`InDataExchange`** command, the PN533 will have to handle chaining even with a target having a length reduction of 255 bytes (example shown in Fig 77).

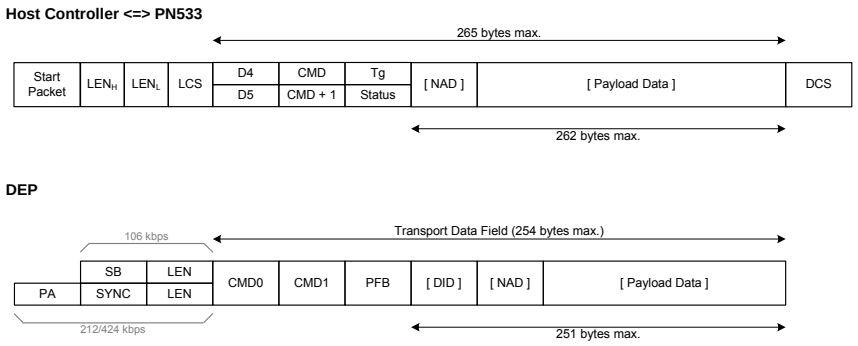


Fig 81. Payload data field maximum capacity

8.6 Examples of use

This paragraph gives some examples of use, detailing the commands used.

8.6.1 PN533 acting as MIFARE PCD

The following example describes a short session with a MIFARE Standard card.

The first step consists of initializing the MIFARE card (the PN533 does not answer to the host controller as long as there is no target detected).

Then, in the second step, the PN533 makes the authentication of the MIFARE card to allow reading and writing operations.

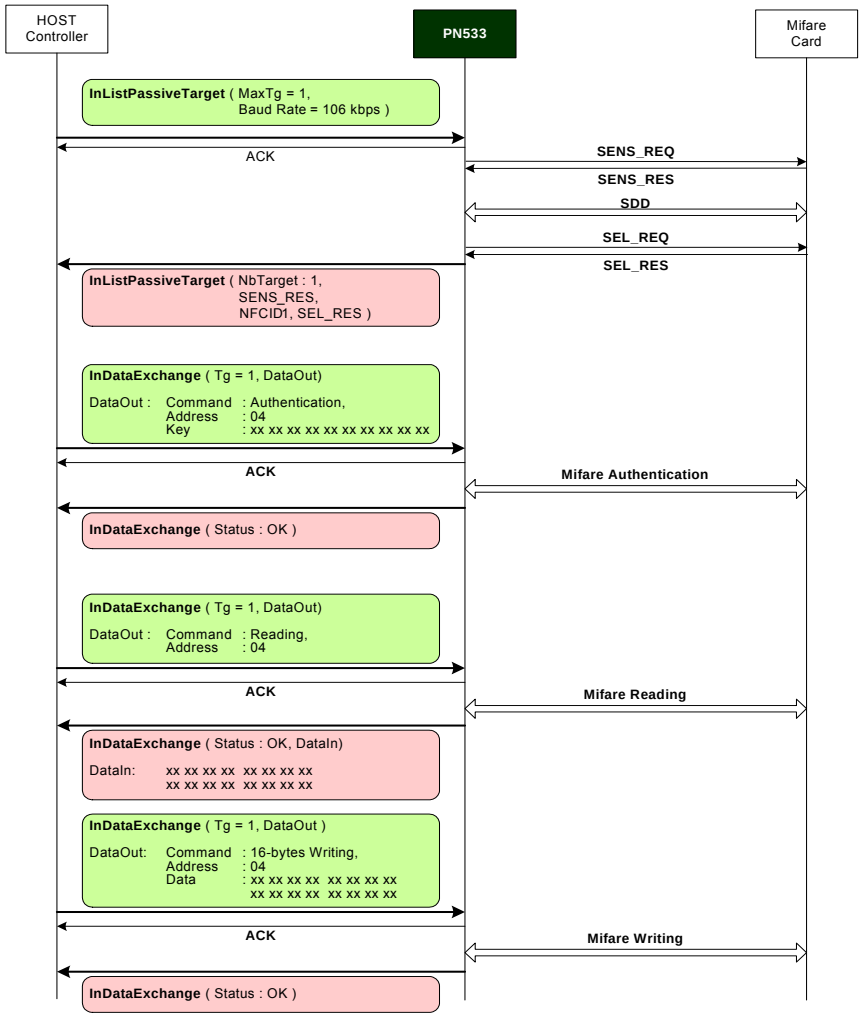


Fig 82. MIFARE PCD example

8.6.2 PN533 acting as FeliCa PCD

The following example describes a short session with a FeliCa card.

The first step consists of initializing the FeliCa card (the PN533 does not answer to the host controller as long as there is no target detected). In the second step, the PN533 exchanges data with the FeliCa card using the **`InDataExchange`** command.

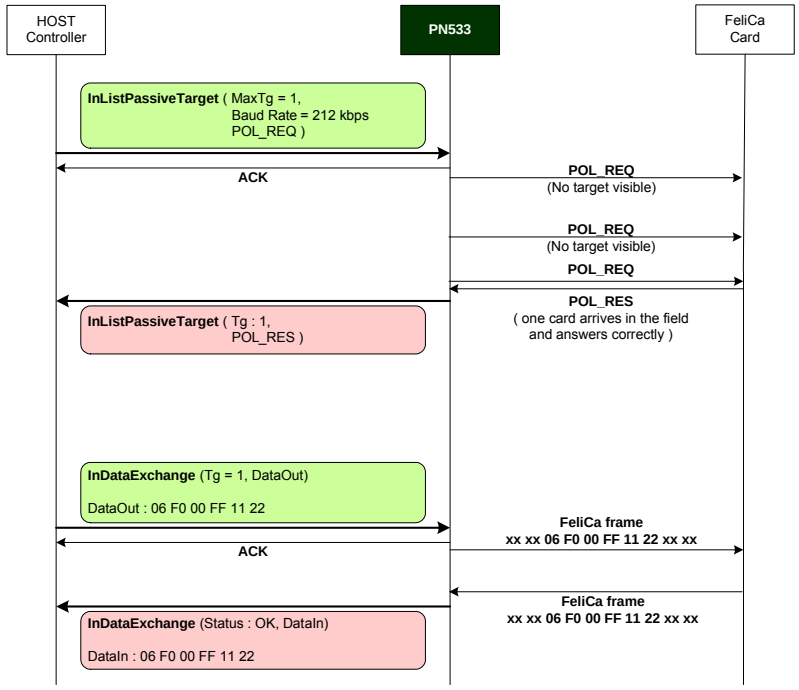


Fig 83. FeliCa PCD example

8.6.3 PN533 acting as 106 kbps target

This example shows how the PN533 behaves in front of a MIFARE PCD, when it has been configured as target:

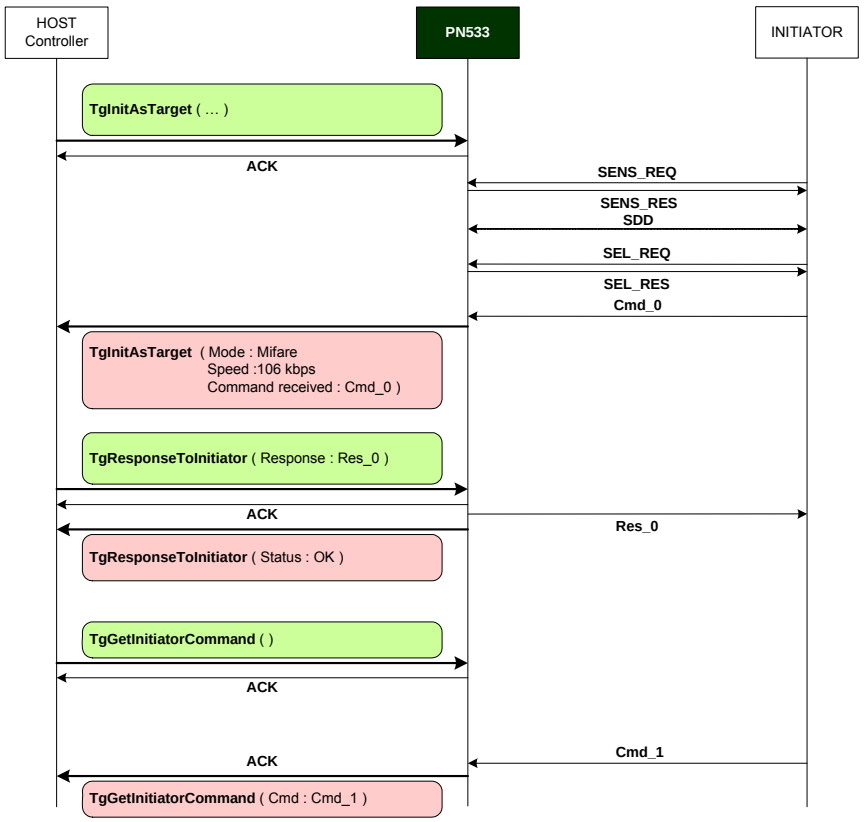


Fig 84. 106 kbps non-DEP target example

8.6.4 PN533 acting as 212 kbps target

This example shows how the PN533 behaves in front of a 212 kbps initiator, when it has been configured as target:

In this example, there are two POL_REQ / POL_RES exchanges during the initialization of the target.

This is just to show that **`TgInitAsTarget`** ends only after having received a command frame different from POL_REQ.

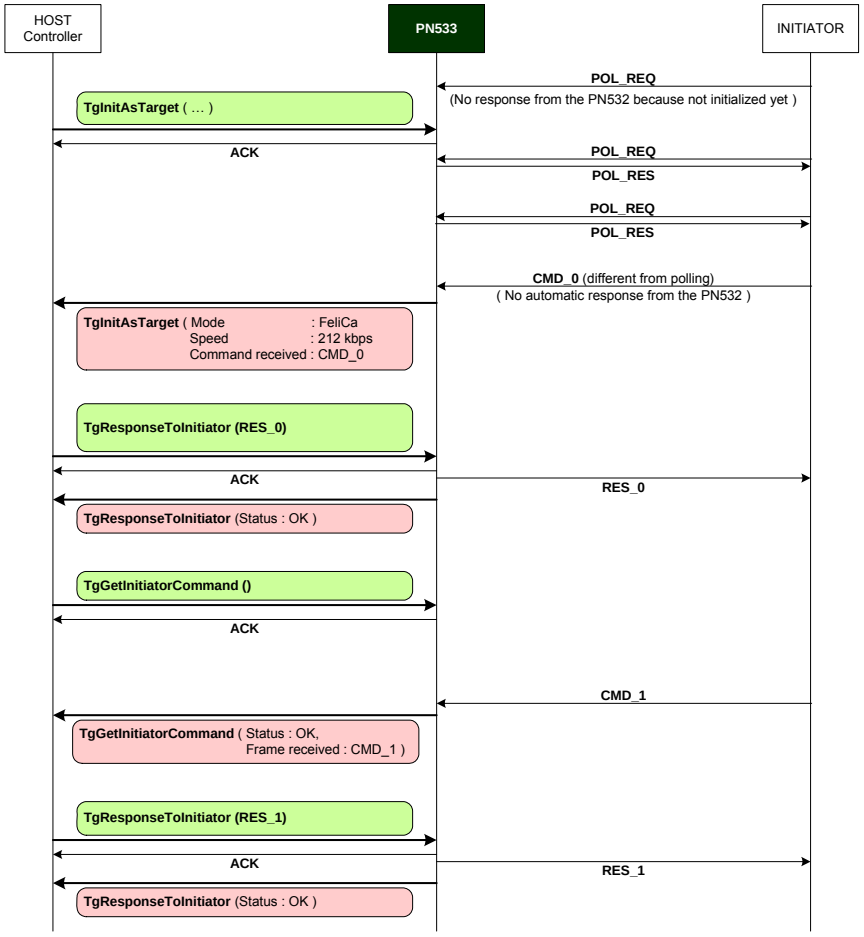


Fig 85. 212 kbps target example

8.6.5 Peer to Peer example with two PN533 (passive mode)

This example shows how to make a peer to peer communication in passive mode using two PN533 ICs.

The three **`InDataExchange`** commands at the initiator side and **`TgGetData`** and **`TgSetData`** at the target side allow building a communication based on the NFC-DEP protocol.

In this example, the communication is established in passive mode at 212 kbps. Other examples are available in §8.5.4, p.152, where the DEP chaining mechanism is considered.

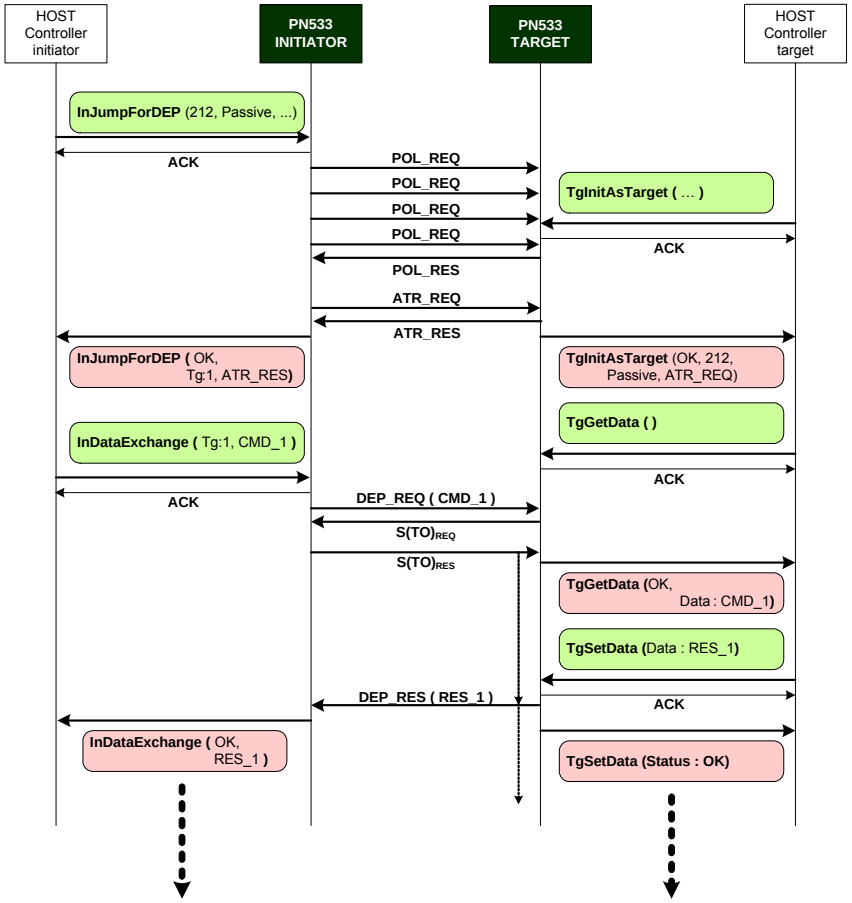


Fig 86. Peer to Peer communication example (passive mode)

8.6.6 Peer to Peer example with two PN533 (active mode)

This example shows how to make a peer-to-peer communication in active mode using two PN533 ICs.

The three commands **`InDataExchange`** at the initiator side and **`TgGetData`** and **`TgSetData`** at the target side allow building a communication based on the NFC-DEP protocol.

In this example, the communication is established in active mode whatever the baud rate is. From the host controller point of view (the one of the PN533 initiator and the one of the PN533 target), the set of commands to use is the same in active and in passive communication modes.

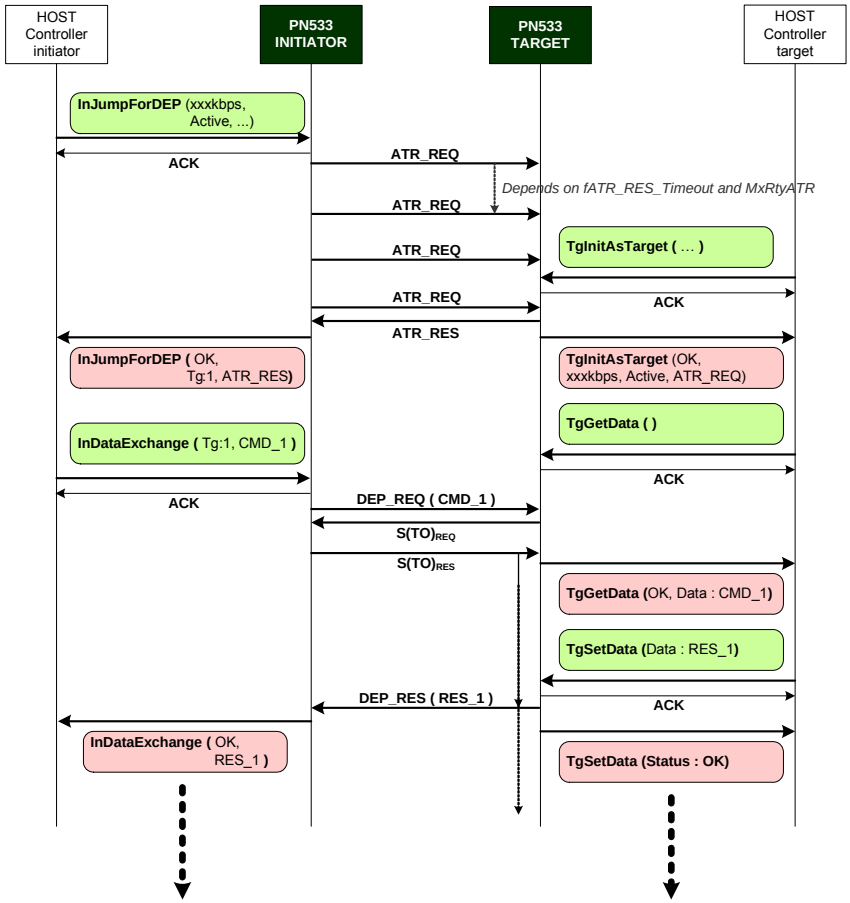


Fig 87. Peer to Peer communication example (active mode)

9. Appendix

9.1 Command set

The available commands are listed below:

Table 29. Command set

Command	Command Code	Page
Miscellaneous		
Diagnose	0x00	52
GetFirmwareVersion	0x02	56
GetGeneralStatus	0x04	57
ReadRegister	0x06	59
WriteRegister	0x08	61
ReadGPIO	0x0C	63
WriteGPIO	0x0E	64
SetParameters	0x12	66
AlparCommandForTDA	0x18	70
RF communication		
RFConfiguration	0x32	73
RFRegulationTest	0x58	79
Initiator		
InJumpForDEP	0x56	80
InJumpForPSL	0x46	85
InListPassiveTarget	0x4A	87
InATR	0x50	95
InPSL	0x4E	98
InDataExchange	0x40	100
InCommunicateThru	0x42	109
InQuartetByteExchange	0x38	112
InDeselect	0x44	115
InRelease	0x52	116
InSelect	0x54	117

Command	Command Code	Page
InActivateDeactivatePaypass	0x48	120
T a r g e t		
TgInitAsTarget	0x8C	126
TgSetGeneralBytes	0x92	133
TgGetData	0x86	135
TgSetData	0x8E	137
TgSetDataSecure	0x96	138
TgSetMetaData	0x94	139
TgSetMetaDataSecure	0x98	141
TgGetInitiatorCommand	0x88	142
TgResponseToInitiator	0x90	144
TgGetTargetStatus	0x8A	146

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continued >>

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