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Technical Specification

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UICC - Contactless Front-end (CLF) Interface;
Part 1: Physical and data link layer characteristics
(Release 7)

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Introduction

The present document defines a communication interface between the UICC and a contactless frontend (CLF) in the terminal. This interface allows the card emulation mode independent of the power state of the terminal as well as the reader mode when the terminal is battery powered.

The aim of the present document is to ensure interoperability between a UICC and the CLF in the terminal independently of the respective manufacturer, card issuer or operator. Any internal technical realization of either the UICC or the CLF is only specified where these are reflected over the interface.

1 Scope

The present document specifies the Single Wire Protocol (SWP). SWP is the interface between the UICC and the CLF.

The present document defines:

- Layer1: The physical layer which is responsible for activating, maintaining and deactivating the physical link between the UICC and the CLF. It defines electrical (voltage and current levels, timing and coding of voltage and current levels), mechanical (physical connectors and wiring) and functional (data rates, max. transmission distances) specifications. It also defines the initial communication establishment and the end of the connection.
- Layer 2: The data link layer which is responsible for the physical addressing of the data through frames and Link Protocol Data Unit (LPDU). The data link layer is also responsible for error notification, ordered delivery of frames and flow control. This layer can be split into two sub-layers:
  - The Medium Access Control (MAC) layer which manages frames.
  - The Logical Link Control layer which manages LPDU and is responsible for the error-free exchange of data between nodes. Three different Logical Link Control layers are defined in this specification.

2 References

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2.1 Normative references

The following referenced documents are indispensable for the application of the present document. For dated references, only the edition cited applies. For non-specific references, the latest edition of the referenced document (including any amendments) applies.

[1] ETSI TS 102 221: "Smart Cards; UICC-Terminal interface; Physical and logical characteristics".

[2] ISO/IEC 14443-2: "Identification cards - Contactless integrated circuit(s) cards - Proximity cards - Part 2: Radio frequency power and signal interface".

[3] ISO/IEC 14443-3: "Identification cards - Contactless integrated circuit(s) cards - Proximity cards - Part 3: Initialization and anticollision".

[4] ISO/IEC 14443-4: "Identification cards - Contactless integrated circuit(s) cards - Proximity cards - Part 4: Transmission protocol".

[5] ISO/IEC 13239: "Information technology - Telecommunications and information exchange between systems - High-level data link control (HDLC) procedures".

[6] ETSI TS 102 600: "Smart Cards; UICC-Terminal interface; Characteristics of the USB interface".

[7] ETSI TS 102 223: "Smart Cards; Card Application Toolkit (CAT)".

[8] ISO/IEC 18092: "Information technology - Telecommunications and information exchange between systems - Near Field Communication - Interface and Protocol (NFCIP-1)".

3 Definitions, symbols, abbreviations and coding conventions

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

card emulation mode: a mode where the UICC emulates a contactless card through the CLF

class A operating conditions: terminal or a smart card operating at 5 V ± 10 %

class B operating conditions: terminal or a smart card operating at 3 V ± 10 %

class C operating conditions: terminal or a smart card operating at 1,8 V ± 10 %

contactless frontend: circuitry in the terminal which:

- handles the analogue part of the contactless communication;
- handles communication protocol layers of the contactless transmission link;
- exchanges data with the UICC.

full duplex: Simultaneous bidirectional data flow

half duplex: Sequential bidirectional data flow

idle bit: bit with logical value 0 sent outside a frame in order to maintain signalling synchronization when no data are transmitted

master: entity which provides the S1 signal

reader mode: mode where the UICC act as a contactless reader through the CLF

state H: high electrical level of a signal (voltage or current)

state L: low electrical level of a signal (voltage or current)

S1: signal from the master to a slave

S2: signal from the slave to the master

slave: entity which is connected to the master and provides the S2 signal

TS 102 221 interface: this term refers to the asynchronous serial UICC-Terminal interface defined in TS 102 221 [1], using RST on contact C2, CLK on contact C3 and I/O on contact C7

UICC powering modes:

- **Full power mode:** the UICC is powered according to TS 102 221 [1] limitations in operating state.

- **Low power mode:** the UICC is running in a reduced power mode as defined in the present specification.

wakeup bit: first dummy bit transmitted by the master and/or the slave during a resume

3.2 Symbols

For the purposes of the present document, the following symbols apply:

Gnd	Ground
I_H	Current signalling state H of S2
I_L	Current signalling state L of S2
T	Bit duration
T_{H1}	Duration of the state H for coding a logical 1 of S1
T_{H0}	Duration of the state H for coding a logical 0 of S1
T_{CLF}	Processing time of the CLF for a packet of data
T_{RFn}	Transfer time of contactless command or response over the RF interface
T_{SWP}	Transfer time a single SWP packet of date
T_{UICC}	Processing time of the UICC for a contactless command
t_F	Fall time
t_R	Rise time
Vcc	Supply Voltage
V_{IH}	Input Voltage (high)
V_{IL}	Input Voltage (low)
V_{OH}	Output Voltage (high)
V_{OL}	Output Voltage (low)

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

ACT	ACTivation protocol
CLF	ContactLess Frontend
CLK	CLocK
CLT	ContactLess Tunnelling protocol
EOF	End Of Frame
HDLC	High level Data Link Control
I/O	Input/Output
ISO	International Organization for Standardization
LLC	Logical Link Control
LPDU	Link Protocol Data Unit
LSB	Least Significant Bit
MAC	Medium Access Control
MSB	Most Significant Bit
NFCIP-1	Near Field Communication - Interface and Protocol
P2P	Peer to Peer communication
PCD	Proximity Coupling Device
PICC	Proximity Integrated Circuit Card
RFU	Reserved for Future Use
RST	ReSeT
SHDLC	Simplified High Level Data Link Control
SOF	Start Of Frame
SWIO	Single Wire protocol Input/Output
SWP	Single Wire Protocol
USB	Universal Serial Bus

3.4 Coding conventions

For the purposes of the present document, the following coding conventions apply:

- all lengths are presented in bytes, unless otherwise stated. Each byte is represented by bits b8 to b1, where b8 is the Most Significant Bit (MSB) and b1 is the Least Significant Bit (LSB). In each representation, the leftmost bit is the MSB.
- Hexadecimal values are enclosed in single quotes ('xx').

In the UICC, all bytes specified as RFU shall be set to '00' and all bits specifies as RFU shall be set to 0.

4 Principle of the Single Wire Protocol

The SWP interface is a bit oriented, point-to-point communication protocol between a UICC and a contactless frontend (CLF) as shown in figure 4.1.

The CLF is the master and the UICC is the slave.

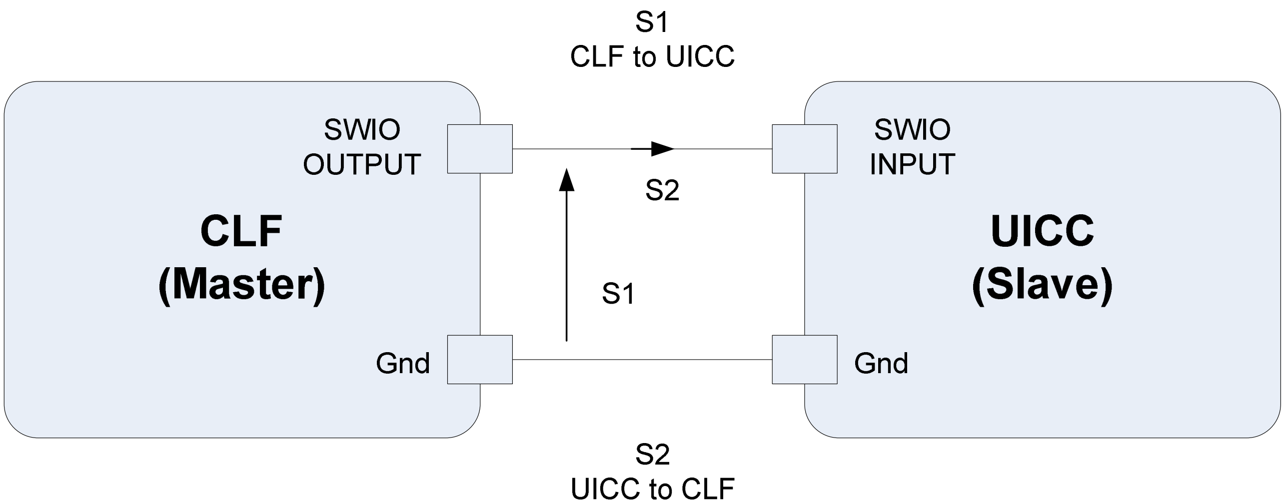


Figure 4.1: SWP data transmission

The principle of the Single Wire Protocol is based on the transmission of digital information in full duplex mode:

- The signal S1 is transmitted by a digital modulation (L or H) in the voltage domain.
- The signal S2 is transmitted by a digital modulation (L or H) in the current domain.

When the master sends S1 as state H then the slave may either draw a current (state H) or not (state L) and thus transmit S2. With pulse width modulation bit coding of S1, it is possible to transmit a transmission clock, as well as data in full duplex mode. This bit coding of S1 is described in clause 8.1 of the present document. S2 is meaningful only when S1 is in state H.

5 System architecture

5.1 General overview

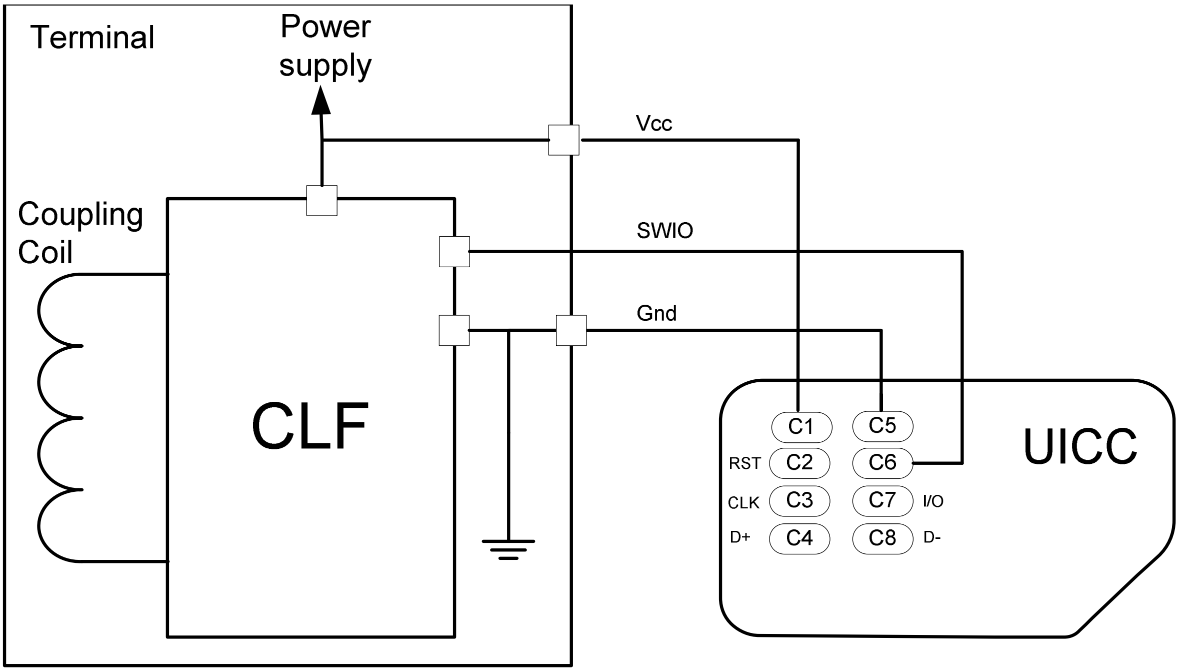


Figure 5.1: CLF-UICC physical link

Figure 5.1 represents the physical link between the CLF and the UICC. The contact C6 of the UICC is connected to the CLF for the transmission of S1 and S2.

5.2 TS 102 221 support

A UICC supporting the SWP interface and a terminal supporting SWP shall remain compliant with TS 102 221 [1]. In order to maintain low power characteristics needed by some operating mode, a terminal supporting the SWP interface shall not support class A operating condition.

For the low power mode, the electrical characteristics of contact C1 (Vcc) are extended by the present document. Contacts C2, C3 and C7 shall behave as specified in TS 102 221 [1].

5.3 Configurations

The terminal indicates the support of SWP interface in the terminal capability as defined in TS 102 221 [1]. The UICC indicates support of SWP interface in the Global Interface bytes of the ATR as defined in TS 102 221 [1].

When both the terminal and the UICC are supporting the SWP interface, several operation modes become possible in addition to the operation modes already supported by terminal not supporting the SWP interface and the UICC:

- Only the SWP interface is activated. This may occur while the whole terminal is powered and other interfaces (e.g. the TS 102 221 [1] or TS 102 600 [6] interfaces) are idle or not activated, or while the terminal is switched OFF (i.e. the whole terminal may not be operative).

- The SWP interface is activated while a session on another terminal-UICC interface is in progress (e.g. the TS 102 221 [1] or TS 102 600 [6] interface). In this case, the different interfaces shall be active concurrently, and therefore actions on the SWP interface shall not disturb the terminal-UICC exchange on the other interfaces and vice-versa.

5.4 Interaction with other interfaces

Communication between a terminal supporting the SWP interface and a UICC supporting the SWP interface take place either over the SWP interface on contact C6 as specified in the present document, or over the interfaces using contacts C2, C3, C4, C7 and C8 as defined in TS 102 221 [1] and TS 102 600 [6]. Signalling on a contact assigned to one interface shall not affect the state of other contacts assigned to another interface. This also applies to the activation sequence of the UICC. The power provided on contacts C1 (Vcc) and C5 (Gnd) shall cover the power consumption of all active interfaces of the UICC.

Operation of the SWP interface after activation shall be independent from operation of other interfaces (e.g. the TS 102 221 [1] or TS 102 600 [6] interface) that may be implemented on the UICC.

Any reset signalling (RST signal on contact C2 as specific to the TS 102 221 [1] interface or logical reset on TS 102 600 [6] interface) shall only affect the UICC protocol stack related to these interfaces. SWP-related processes shall not be affected by another interface reset signal.

A logical reset signalling on the data link layer (SHDLC RSET) over the SWP interface as well as activation and deactivation of SWP interface shall not affect any of the other interfaces.

6 Physical characteristics

6.1 Temperature range for card operation

In the present document, all parameter values for the SWP interface shall apply for the standard temperature range for storage and full operation as defined in TS 102 221 [1].

6.2 Contacts

6.2.1 Provision of contacts

Vcc (contact C1) and Gnd (contact C5) provided in the UICC shall be reused by the terminal to provide power supply.

SWIO (contact C6) of the UICC shall be used for data exchange between the UICC and the CLF.

6.2.2 Contact activation and deactivation

The terminal shall connect, activate and deactivate contacts C2, C3 and C7 of the UICC in accordance with the operating procedures specified in TS 102 221 [1] and the contacts C4 and C8 in accordance with the operating procedures specified in TS 102 600 [6] when these interfaces are used. The terminal shall activate the contact C1 (Vcc) according to the TS 102 221 [1].

A terminal may decide not to perform the contact and interface activation of SWP if it detected in either this or a previous card session that the UICC does not support the SWP.

6.2.2.1 SWP contact activation

As long as Vcc (contact C1) is not activated, the terminal shall keep SWIO (C6) in the **DEACTIVATED** state (S1 state L).

The terminal activates Vcc (Contact C1) in order to either activate the SWP interface or the contact Vcc (Contact C1) is activated due to the activation of another interface on the UICC.

The activation of the SWIO (Contact C6) takes place when the terminal sets the SWIO signal from state L to state H. This indicates to the UICC to activate its SWP interface.

6.2.2.2 SWP contact deactivation

The terminal shall set SWIO (Contact C6) to the **DEACTIVATED** state as defined in clause 8.3 (S1 state L) prior to deactivating the Vcc.

6.2.2.3 Deactivation of the UICC

In addition to the deactivation as given in TS 102 221 [1] and TS 102 600 [6] the terminal shall deactivate SWIO (contact C6) before deactivating Vcc (Contact C1).

6.2.3 Interface activation

After the activation of the SWIO (contact C6) the CLF shall put SWP into **SUSPENDED** state to indicate that it is ready to exchange data via SWP.

The process following thereafter makes use of the ACT LLC layer as described in clause 9.4.

The sequence is as follows:

- The UICC shall indicate that it is ready to exchange data via SWP by resuming SWP and sending the 1st ACT_SYNC frame. The CLF shall put SWP into **ACTIVATED** state and receive the 1st ACT_SYNC frame with the bit duration in the default range as described in clause 8.1.
  - In case the CLF responds to the SWP resume condition, the UICC shall recognize interface activation of SWP.
  - In case the CLF does not put SWP into **ACTIVATED** state upon "SWP resume by the UICC condition", the UICC shall stop the SWP resume sequence (see $T_{S2\_INHIBIT}$ in table 6.1), The UICC shall not respond to further attempts from the CLF to communicate via SWP and shall wait for UICC deactivation or shall retrieve information about SWP capability of the terminal via any other UICC interface (see clause 6.2.4).
  - In case the CLF does not recognize SWP resume by the UICC, the CLF shall assume that the UICC does not support SWP interface and the CLF may deactivate SWIO (contact C6) or may deactivate the UICC.
- When the CLF has received the 1st ACT_SYNC frame from the UICC, the CLF shall take the following actions:
  - If the CLF has received a correct ACT_SYNC frame and the terminal provides full power mode, the CLF shall respond with an ACT_POWER_MODE frame indicating full power mode.
  - If the CLF has received a correct ACT_SYNC frame and the terminal provides low power mode, the CLF may respond with an ACT_POWER_MODE frame indicating low power mode.
  - If the CLF has received a corrupted frame the CLF shall request the UICC to repeat the last ACT_SYNC frame by sending an ACT_POWER_MODE frame with FR bit set to 1 indicating the current terminal power mode.
- When the UICC has received an ACT_POWER_MODE frame, the UICC shall take the following actions:
  - If the UICC has received a correct ACT_POWER_MODE and the FR bit of this frame is 1, then the UICC shall repeat the ACT_SYNC frame. If the FR bit is 0 then the UICC shall respond with an ACT_READY frame.
  - If the UICC has received a corrupted frame, the UICC shall not respond.

NOTE: The UICC may change its power mode as described in clause 8.4.

- When the CLF has received an ACT frame in response to an ACT_POWER_MODE frame, the CLF shall take the following actions:
  - If the CLF has received a correct ACT frame, it shall not send further ACT frames.

- If the CLF has received a corrupted ACT frame, the CLF shall request the UICC to repeat the last ACT frame by sending an ACT_POWER_MODE frame with FR bit set to 1 indicating the current terminal power mode.

- When the CLF has not received an ACT frame in response to an ACT_POWER_MODE frame, the CLF shall take the following actions:

    - In this case, the CLF shall request the UICC to repeat the last ACT frame by sending an ACT_POWER_MODE frame with FR bit set to 1 indicating the current terminal power mode.

- The CLF shall not send more than three ACT_POWER_MODE frames with the FR bit set to 1.

The interface activation is called successful when both of the following two conditions are met:

- the CLF has received a correct ACT_SYNC frame;

- if the CLF has sent an ACT_POWER_MODE frame that was correctly responded to by the UICC with an ACT frame.

If the interface activation was not successful the CLF shall assume that the UICC does not support SWP interface. In this case the CLF may deactivate SWIO (contact C6) or may deactivate the UICC.

This interface activation sequence shall also be applied when the SWP is activated from the state **DEACTIVATED**, with the following modifications:

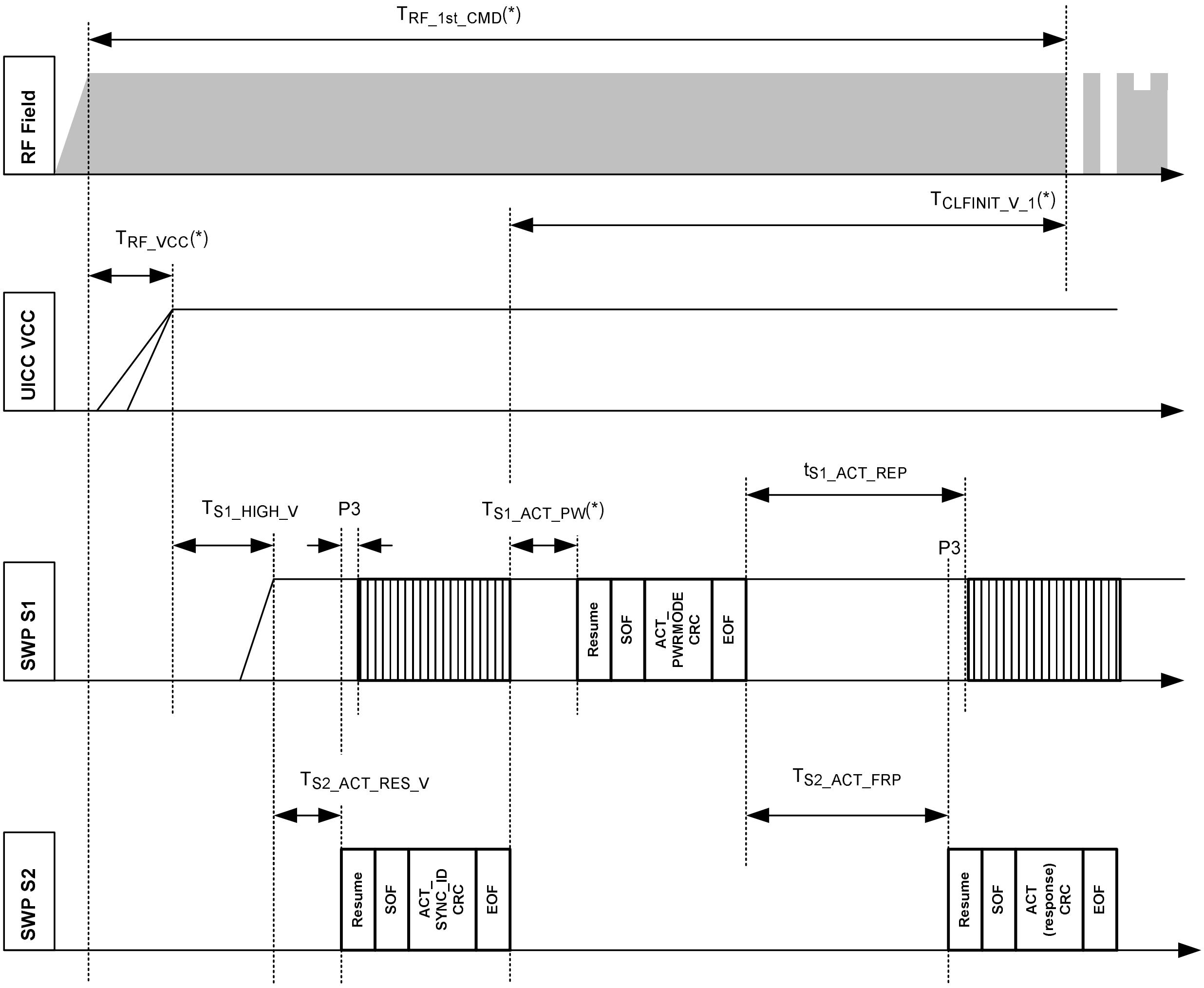
- The UICC shall not send an ACT_INFORMATION field in any of the ACT frames.

- If the previous successful interface activation indicated full power mode, and when the CLF has received the 1st ACT_SYNC frame from the UICC, the CLF shall take the following action:

    - If the CLF has received a correct ACT_SYNC frame, the CLF may respond with an ACT_POWER_MODE frame indicating full power mode.

    - If the CLF has received a corrupted frame the CLF shall request the UICC to repeat the last ACT_SYNC frame by sending an ACT_POWER_MODE frame with FR bit set to 1 indicating full power mode.

Figure 6.1 shows the timing conditions for the initial interface activation after Vcc (contact C1) activation, for the case when an ACT_POWER_MODE frame is sent. Table 6.1 gives the timing values.



NOTE 1: The relationship to RF-field appearance is shown for information only.

NOTE 2: Timing marked (*) are informative. The compliancy to the startup time of the RF application $T_{RF\_1st\_CMD}$ (for ISO/IEC 14443-3 [3]: 5msec from RF-field 1.5A/m to be able to receive REQA, REQB) is achieved by the CLF by balancing T_{RF_VCC}, $T_{S1\_ACT\_PW}$, $T_{CLFINIT}$ and the SWP bit rate properly. The system is designed in a way, that the CLF may keep the timing constraints when relying on the 1st SYNC_ID transmission. In case this fails it is up to the CLF to request resending SYNC_ID and go for the next REQA, REQB.

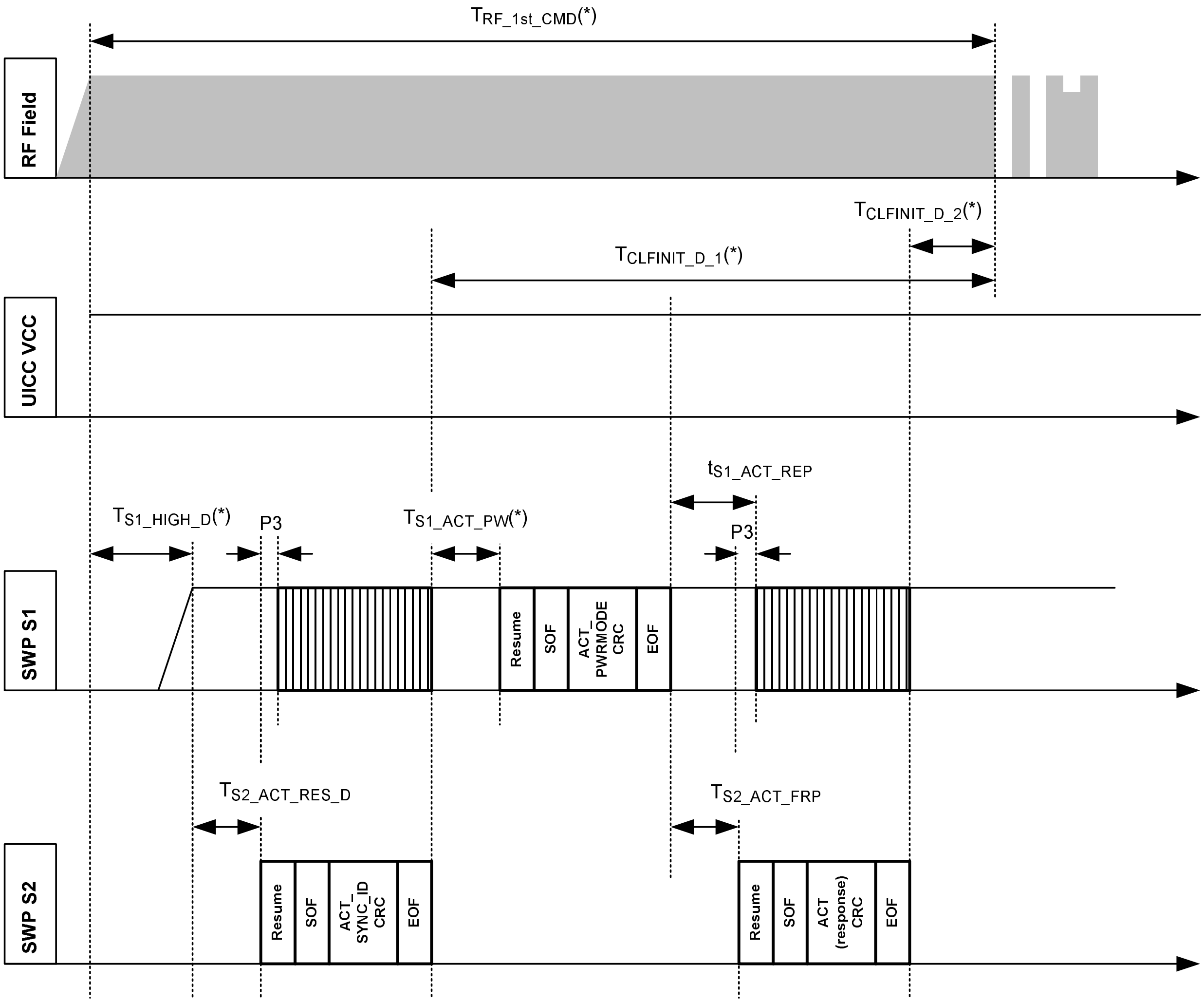
NOTE 3: The value of $T_{S1\_ACT\_REP}$ implemented by the CLF should be greater than $T_{S1\_ACT\_FRP}$ + the SWP resume time. This is to ensure that an ACT frame from the CLF is not sent when an ACT(response) frame from the UICC is sent.

Figure 6.1: Initial interface activation on RF-field appearance (example)

Table 6.1: Timing parameters for initial interface activation on RF-field appearance

Symbol	Parameter	Minimum	Maximum	Unit
$T_{S1\_HIGH\_V}$	SWIO (contact C6) activation time after Vcc (contact C1) activation.	1 000	-	µs
$T_{S2\_ACT\_RES\_V}$	UICC resumes SWP for sending 1st ACT_SYNC frame.	0	700	µs
$T_{S2\_ACT\_FRP}$	UICC responds 2nd ACT_SYNC frame after ACT POWER MODE (calculated from last bit of EOF to SWP resume).	0	2 000	µs
$T_{S2\_INHIBIT}$	UICC re-enters SUSPENDED in case the CLF did not respond to resume	-	100	ms

The interface activation from the SWP **DEACTIVATED** state is given in figure 6.2 for the case when an ACT_POWER_MODE frame is sent. The timing values are given in table 6.2.



NOTE 1: The relationship to RF-field appearance is shown for information only.

NOTE 2: Timing marked (*) are informative. The compliancy to the startup time of the RF application $T_{RF\_1st\_CMD}$ (for ISO/IEC 14443-3 [3]: 5 ms from RF-field 1,5 A/m to be able to receive REQA, REQB) is achieved by the CLF by balancing $T_{S1\_HIGH\_D}$, $T_{S1\_ACT\_PW}$, $T_{CLFINIT\_D}$ and the SWP bit rate properly. The system is designed in a way, that the CLF may keep the timing constraints when relying on the 2nd SYNC_ID transmission in case the 1st transmission fails.

Figure 6.2: Interface activation from the DEACTIVATED state on RF-field appearance (example)

Table 6.2: Timing parameters for the interface activation from the deactivated state on RF-field appearance

Symbol	Parameter	Minimum	Maximum	Unit
$T_{S2\_ACT\_RES\_D}$	UICC resumes SWP for sending 1st ACT_SYNC frame	0	500	µs

Depending on the power state of the UICC the following conditions for the interfaces shall apply:

- If the UICC is in "low power mode" the terminal shall not activate the TS 102 221 [1] interface and if the UICC supports the USB interface according to TS 102 600 [6], it shall not perform an attachment on the USB interface.
- If the UICC is in "full power mode", the terminal may independently activate any other UICC interfaces.

- If the UICC was activated according to TS 102 221 [1], an additional activation of the SWP interface shall be considered as selected application on the UICC.

6.2.4 Behaviour of a UICC in a terminal not supporting SWP

The UICC shall take care of terminals having C6 contact connected with low impedance to Vcc or electrically isolated

When the UICC detects that the contact C6 is not connected to Vcc it shall connect the C6 contact with a low impedance to Gnd within 2 seconds after detecting that the terminal does not indicate the support of SWP interface.

NOTE: Implementation has to take care to minimize SWP related power consumption.

6.2.5 Behaviour of terminal connected to a UICC not supporting SWP

When the terminal detects that the UICC does not support SWP, it shall keep SWIO in the deactivated state (state L).

6.2.6 Inactive contacts

The conditions for inactive contacts as defined in TS 102 221 [1] shall apply to contact C6.

7 Electrical characteristics

7.1 Operating conditions

The voltage levels for the CLF (Master) and the UICC (Slave) signal S1 are illustrated in figure 7.1.

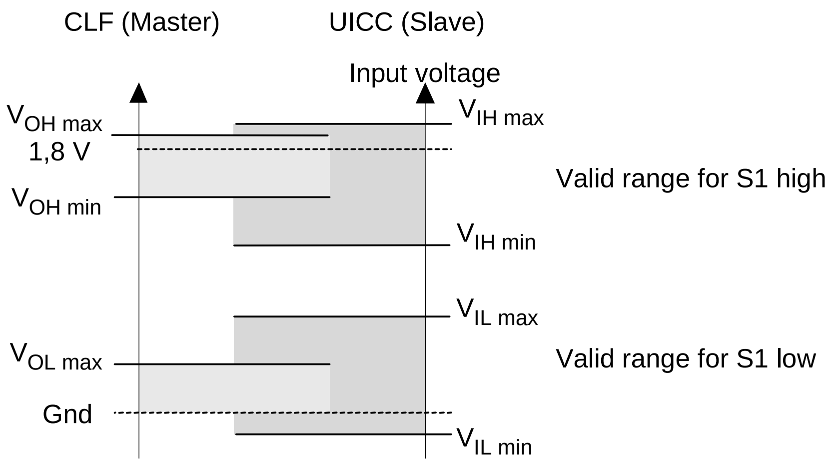


Figure 7.1: Voltage definitions for the signal S1

V_{IH} and V_{IL} refers to the receiving device signal level (Slave). V_{OH} and V_{OL} refers to the sending device signal level (Master). All voltages are referenced to Gnd.

The SWP interface uses a second signal S2 which is the current from the master to the slave and allows data to be sent back from the slave to the master. S2 values are defined when S1 is state H. The current levels for S2 are defined in clause 7.1.4.1, as shown in figure 7.2.

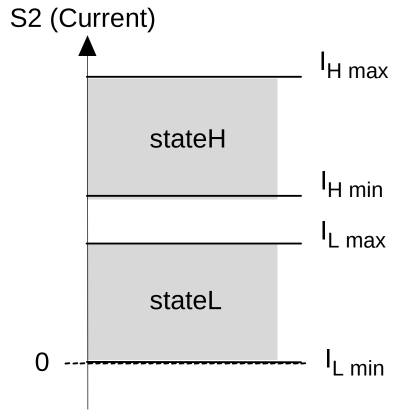


Figure 7.2: Definitions of the current level for S2 on SWIO

7.1.1 Supply voltage classes

A UICC supporting the SWP interface shall support the voltage classes B and C, as defined in TS 102 221 [1].

7.1.2 V_{cc} (C1) low power mode definition

When the system operates in low power mode table 7.1 applies.

Table 7.1: Electrical characteristics of V_{CC} in low power mode

Symbol	Conditions	Minimum	Maximum	Unit
V_{CC}	Class C	1,62	1,98	V
I_{CC}	Class C		5	mA
NOTE: The current value is averaged over 1 ms.				

The maximum current in the table 7.1 is defined for the UICC. The terminal may deliver more. The voltage value shall be maintained within the specified range despite transient power consumption as defined in table 7.2.

Table 7.2: Spikes on I_{CC}

Class	Maximum charge (see note 1)	Maximum duration	Maximum variation of I_{CC} (see note 2)
C	6 nA.s	400 ns	30 mA
NOTE 1: The maximum charge is half the product of the maximum duration and the maximum variation. NOTE 2: The maximum variation is the difference in supply current with respect to the average value.			

7.1.3 Signal S1

S1 is a signal in the voltage domain to transmit data from the CLF to the UICC on SWIO (contact C6). S1 shares the same electrical contact as S2 as defined in clause 7.1.4. Electrical characteristics of S1 are given in tables 7.3 and 7.4.

Table 7.3: Electrical characteristics of SWIO for S1 under normal operating conditions in voltage class B

Symbol	Parameter	Conditions	Minimum	Maximum	Unit
V_{OH}	Output High Voltage (high)	$I_{L\ min} \leq I \leq I_{H\ max}$	1,40	1,98 (see note)	V
V_{OL}	Output Low Voltage (low)	-20 µA ≤ I ≤ 20 µA	0 (see note)	0,3	V
V_{IH}	Input High Voltage (high)	$I_{L\ min} \leq I \leq I_{H\ max}$	1,13	2,28 (see note)	V
V_{IL}	Input Low Voltage (low)	$I_{L\ min} \leq I \leq I_{H\ max}$	-0,3	0,48	V
NOTE: To allow for overshoot the voltage on SWIO shall remain between -0,3 V and $V_{OH\ max}$ + 0,3 V during dynamic operation.					

Table 7.4: Electrical characteristics of SWIO for S1 under normal operating conditions in voltage class C

Symbol	Parameter	Conditions	Minimum	Maximum	Unit
V_{OH}	Output High Voltage (high)	$I_{L\ min} \leq I \leq I_{H\ max}$	0,85 x V_{CC}	V_{CC} (see note)	V
V_{OL}	Output Low Voltage (low)	-20 µA ≤ I ≤ 20 µA	0 (See note)	0,15 x V_{CC}	V
V_{IH}	Input High Voltage (high)	$I_{L\ min} \leq I \leq I_{H\ max}$	0,7 x V_{CC}	V_{CC}+0,3	V
V_{IL}	Input Low Voltage (low)	$I_{L\ min} \leq I \leq I_{H\ max}$	-0,3	0,25 x V_{CC}	V
NOTE: To allow for overshoot the voltage on SWIO shall remain between -0,3 V and V_{CC}+ 0,3 V during dynamic operation.					

7.1.4 Signal S2

S2 is a signal in the current domain to transmit data from the UICC to the master. S2 shares the same electrical contact as S1 (contact C6). In this clause the electrical characteristics of S2 are described.

7.1.4.1 Operating current for S2

S2 is considered as in state H when the current drawn on SWIO is between $I_{H\ min}$ and $I_{H\ max}$ and is considered in state L when the current drawn on SWIO is between $I_{L\ min}$ and $I_{L\ max}$.

Table 7.5: Electrical characteristics of SWIO for S2 under normal operating conditions

Symbol	Parameter	Conditions	Minimum	Maximum	Unit
I_H	High Current	$V_{IHmin} \leq S1 \leq V_{IHmax}$	600	1000	µA
I_L	Low Current	$V_{IHmin} \leq S1 \leq V_{IHmax}$	0	20	µA

8 Physical transmission layer

8.1 S1 Bit coding and sampling time (Self-synchronizing code)

The bit coding of S1 is illustrated in figure 8.1.

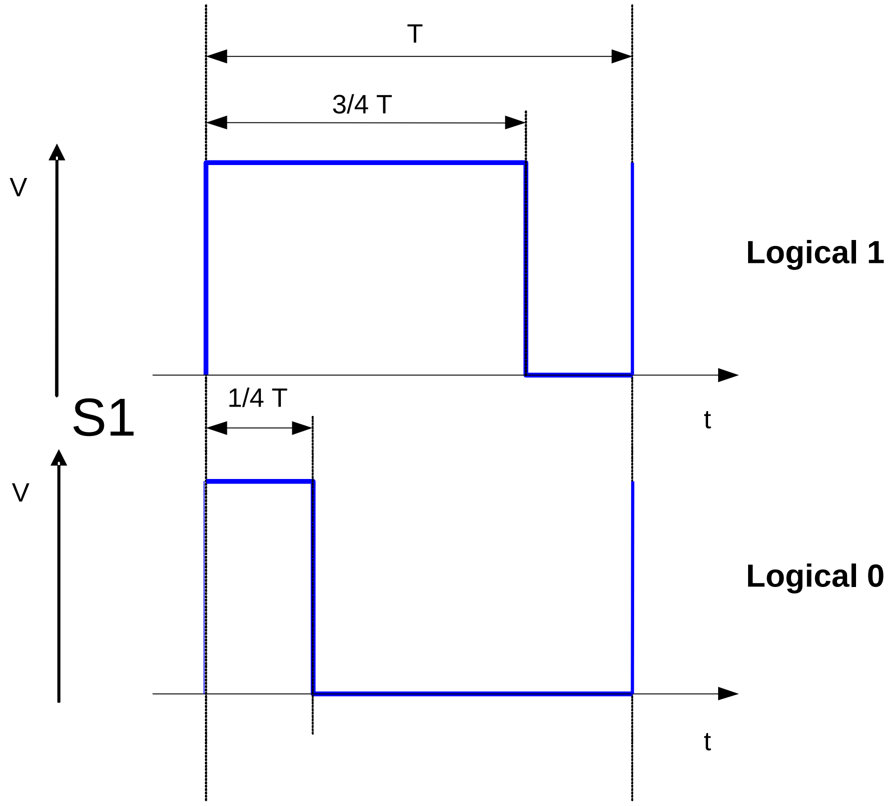


Figure 8.1: Bit-coding of S1

The nominal duration of the state H for a logical 1 is 0,75 x T, the nominal duration of the state H for a logical 0 is 0,25 x T.

All bits shall be transmitted consecutively. The bit-duration may be different for each transmitted bit.

Before the start of a transmission of consecutive bits, SWIO shall be in **SUSPENDED** state (S1 state H) as defined in clause 8.3.

At the end of the bit-duration T, the master shall always set S1 to state H.

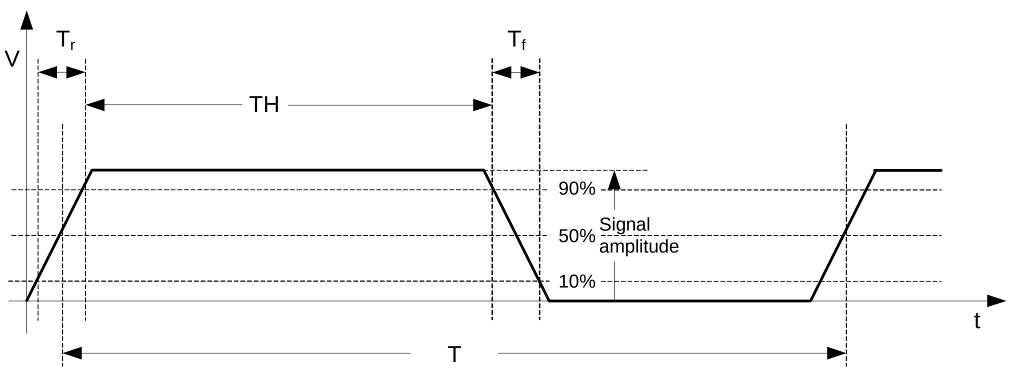


Figure 8.2: S1 waveform

The input capacitance of the UICC (C_{LOAD}) on the C6 contact shall not exceed 10 pF. Table 8.1 gives S1 waveform timing.

Table 8.1: S1 waveform timings

Symbol	Parameter	Conditions	Minimum	Nominal	Maximum	Unit
t_F	Fall time	C_{LOAD} ≤ 10 pF T < 5 000 ns	5 ns	-	0,05 x T	
		C_{LOAD} ≤ 10 pF T > 5 000 ns	5 ns	-	250 ns	
t_R	Rise time	C_{LOAD} ≤ 10 pF T < 5 000 ns	5 ns	-	0,05 x T (see note 1)	
		C_{LOAD} ≤ 10 pF T > 5 000 ns	5 ns	-	250 ns (see note 1)	
T_{H1}	Duration of the state H for coding a logical 1 of S1		0,70 x T	0,75 x T	0,80 x T	
T_{H0}	Duration of the state H for coding a logical 0 of S1		0,20 x T	0,25 x T	0,30 x T	
T (see note 2)	Default Bit duration		1	-	5	µs
	Extended bit duration		0,295	-	10	µs
NOTE 1: Valid for the leading edge and the trailing edge of each bit. NOTE 2: Extended bit durations are indicated as per table 9.3.						

8.2 S2 switching management

S2 is valid only when S1 is in state H. The UICC (Slave) shall only perform switching of S2 when S1 is in state L. Figure 8.3 illustrates the timing of S2 related to S1.

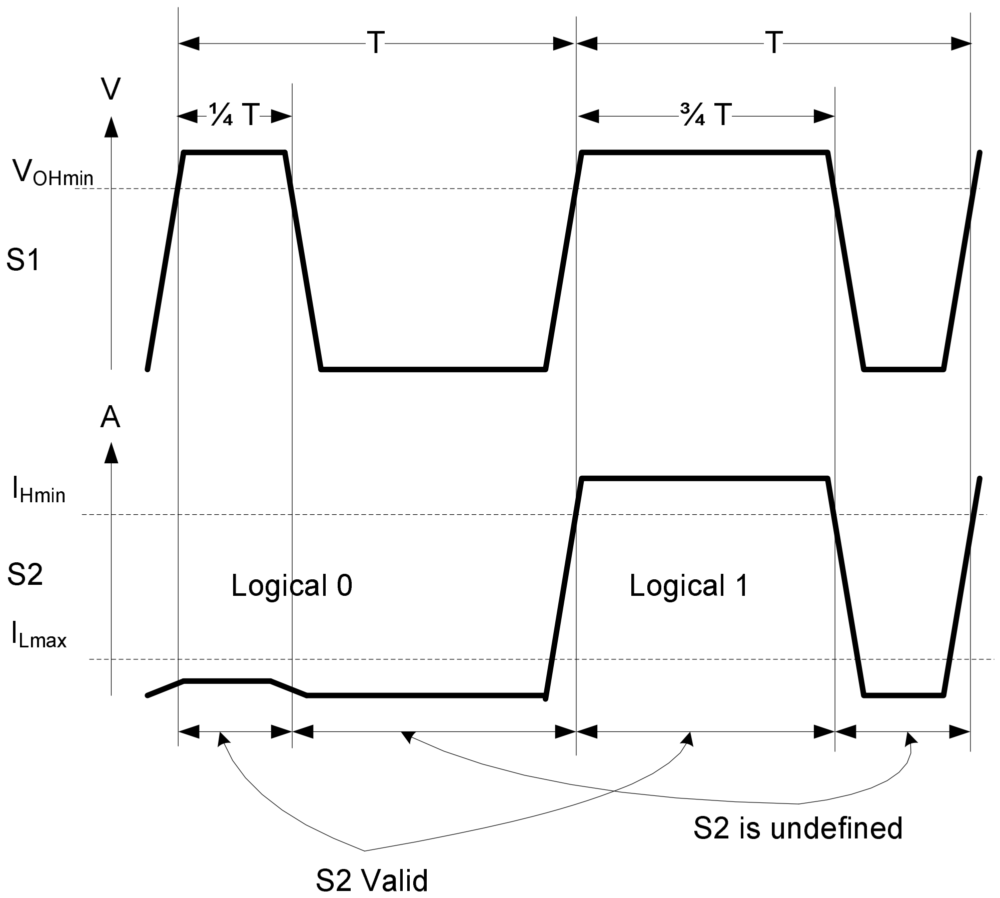


Figure 8.3: S2 timing

8.3 SWP interface states management

SWIO has three different states:

ACTIVATED:

In this state a data exchange is on going.

S1 provides a continuous sequence of logical 0 and logical 1.

SWIO remains in this state until a *SUSPEND* condition is provided.

SUSPENDED:

In this state S1 is in state H and S2 is in state L. This state is the initial state of SWIO at activation of the SWP interface.

SWIO remains in this state until a *RESUME* or *DEACTIVATE* condition is provided on the SWIO.

DEACTIVATED:

In this state the signal S1 is in state L and the signal S2 is in state L.

SWIO remains in this state until an *ACTIVATE* condition is provided on the SWIO.

The following transitions between these states are defined as follow:

RESUME:

Signal condition to exit from **SUSPENDED** state to **ACTIVATED** state. Both the master and the slave may execute a *RESUME* to bring SWIO in **ACTIVATED** state at any time.

The master resumes by sending P2 consecutive idle bits. SWIO exits the **SUSPENDED** state and enters the **ACTIVATED** state after the last of these bits sent by the master.

The slave resumes by drawing a current (S2 in state H) for more than $P3_{min}$ time, the master shall respond by setting S1 in state L for a time T_{H0} in less than $P3_{max}$ time. After this resume sequence, SWIO exits the **SUSPENDED** state and enters the **ACTIVATED** state when the master sets S1 in state H. After this wakeup bit, the slave shall send a SOF not later than a maximum of 4 idle bits.

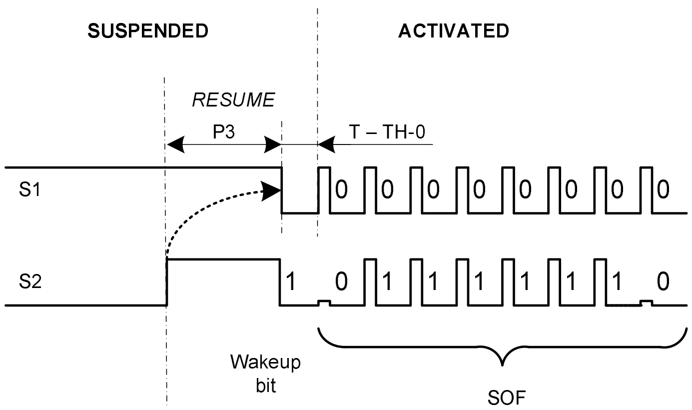


Figure 8.4: Resume by the slave timing

SUSPEND:

If there is no activity on SWIO, other than idle bits (logical 0 on S1 and S2) during P1 time, the master may switch SWIO to the **SUSPENDED** state by maintaining S1 in state H.

DEACTIVATE:

If SWIO is in **SUSPENDED** state, the master may switch the line to the **DEACTIVATED** state by maintaining SWIO in state L for longer than P4 time.

ACTIVATE:

If SWIO is in **DEACTIVATED** state, the master shall switch the line to the **SUSPENDED** state by putting SWIO in state H and initiate the interface activation procedure as described in clause 6.2.3. The slave may request activation of the interface by using the ACTIVATE INTERFACE command as defined in TS 102 223 [7].

Figure 8.5 illustrates an example of SWIO activities.

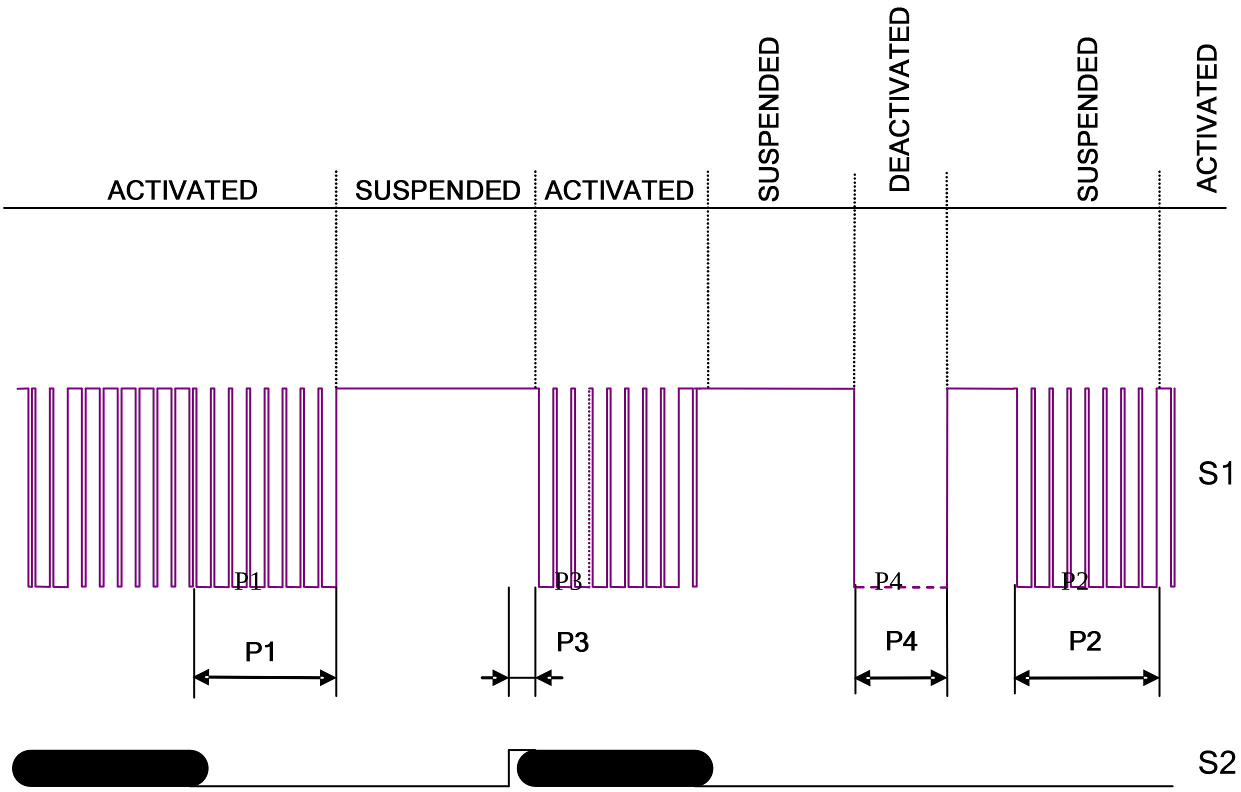


Figure 8.5: Bus activity

Table 8.2 gives SWIO management timings.

Table 8.2: SWIO Management Timing

Symbol	Parameter	Minimum	Maximum	Unit
P1	Suspend sequence	7	7	Bit
P2	Slave Resume sequence (By the master)	8	8	Bit
P3	Master Resume time (By the slave)	0,5	5	µs
P4	Deactivation time	30	-	µs

8.4 Power mode states/transitions and Power saving mode

When the terminal activates Vcc (contact C1) the UICC shall enter the initial power state. This initial power state of the UICC shall conform to TS 102 221 [1].

Thereafter the terminal may activate the interfaces as described in clause 6.2. Upon activation of at least one interface, the UICC enters the operational power state.

NOTE 1: The initial power state and the operational power state are part of the full power mode.

If during SWP interface activation the terminal sends a power mode frame indicating low power mode, the UICC shall enter this mode. Switching from low power mode to full power mode shall be done by an upper layer command out of the scope of this specification. This transition may interrupt an ongoing contactless transaction due to internal UICC processing.

Switching from full power mode to low power mode requires deactivation of Vcc (contact C1).

The UICC shall enter the power saving mode when all of the following conditions for activated interfaces are given:

- clock stop mode according to TS 102 221 [1] if this interface is activated (if UICC is in full power mode);
- suspend mode according to TS 102 600 [6] if this interface is activated (if UICC is in full power mode);
- SWP contact deactivated (if UICC is in full power mode or in low power mode). The UICC shall enter the power saving mode no later than 10ms after the SWP interface is deactivated.

When the UICC is in power saving mode it shall not exceed the current defined for clock stop mode in TS 102 221 [1] or the limit given for suspend mode in TS 102 600 [6] whatever the interface is activated.

The UICC shall exit the power saving mode when at least one of the UICC interfaces is resumed from these conditions.

NOTE 2: In full power mode, all the resources in the terminal (e.g. display, keyboard, etc.) may not be available for the UICC applications.

9 Data link layer

9.1 Overview

The Data Link layer manages LPDUs (Link Protocol Data Unit) as illustrated in figure 9.1. This layer can be divided into two sub-layers:

- MAC layer is in charge of framing.
- LLC layer is in charge of error management and flow control.

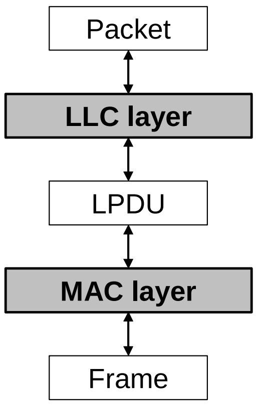


Figure 9.1: Data link layer overview

9.2 Medium Access Control (MAC) layer

9.2.1.1 Bit order

The bit order of the SWP communication channel is **MSB first**.

9.2.1.2 Structure

Figure 9.2 illustrates the format of a frame sent from the master to the slave.

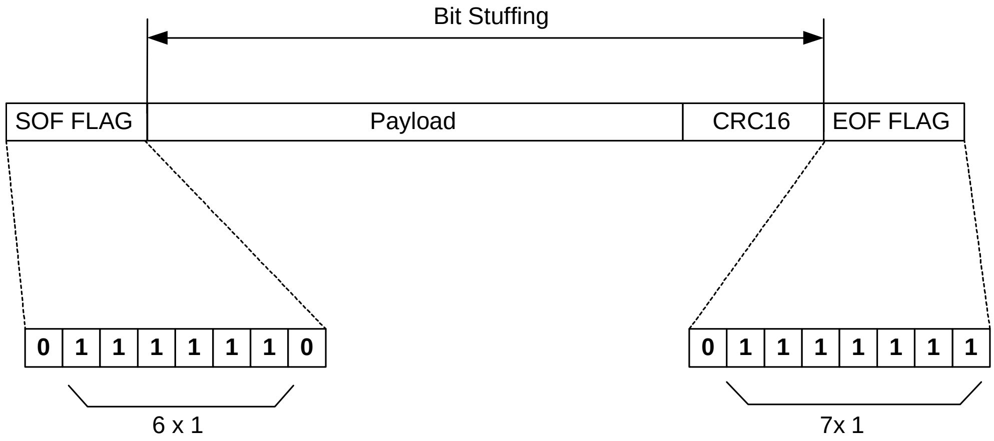


Figure 9.2: Frame structure sent by master

The SOF flag has the value '7E' and the EOF flag has the value '7F'. Between frames, idle bits (logical value 0) are sent. There is at least one idle bit between frames.

Figure 9.3 illustrates the format of a frame sent from the slave to the master.

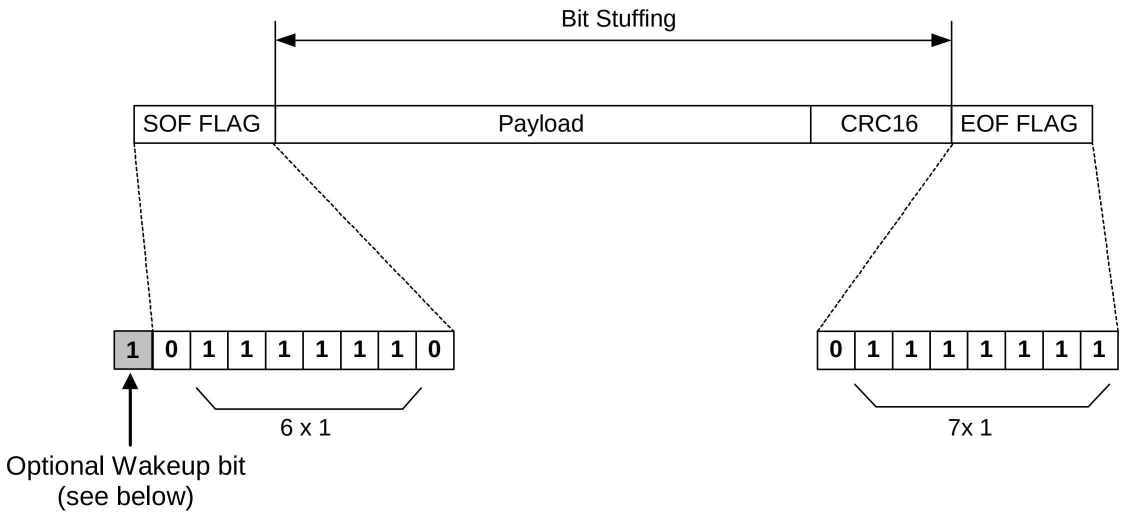


Figure 9.3: Frame structure sent by slave

A wakeup bit (logical value 1) shall be inserted before the first frame from the slave to the master when the slave issue a *RESUME* sequence and may be inserted before each frame from the slave to the master in order to avoid deadlock states when the slave starts a transmission just before the bus suspend sequence.

The payload size is limited to 30 bytes. The CRC field is 16 bits long.

9.2.1.3 Bit Stuffing

In order to detect the SOF and EOF flags, the bit stuffing principle is applied within the SWP frames between the SOF and EOF flags. After five (5) consecutive logical one (1) bits, a bit with the logical value 0 is inserted. The frame decoding applies the reverse principle.

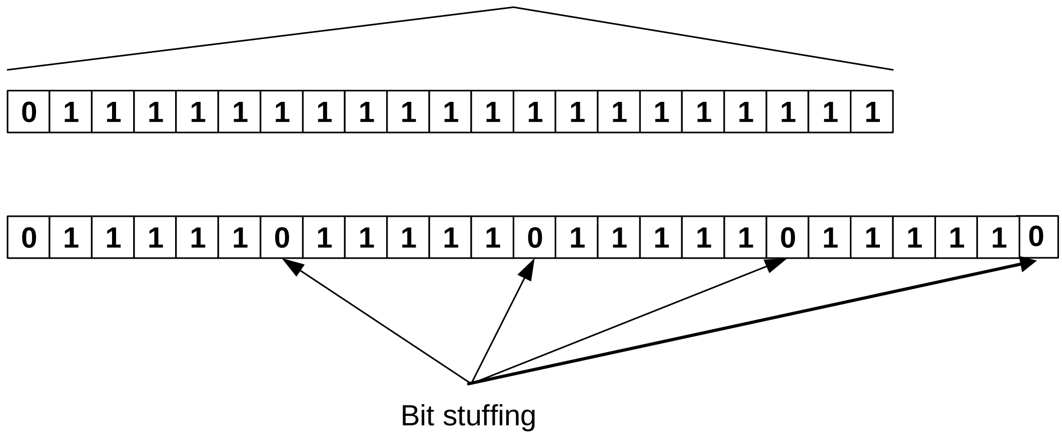


Figure 9.4: Bit stuffing

9.2.1.4 Error detection

The detection of errors in a frame is based on the standard CRC-16 CITT. The CRC polynomial is:

$$X^{16}+X^{12}+X^{5}+1.$$

Its initial value is 0xFFFF.

The CRC is computed on the bits between SOF and EOF both excluded.

9.3 Supported LLC layers

Three Logical Link Control (LLC) layers using the previously defined MAC layer are defined in this specification:

- SHDLC: This is the generic LLC used during most of the contactless transactions. SHDLC is defined in the following sub clauses of the present document. Support of this LLC in mandatory in the CLF and the UICC.
- CLT: This LLC is used for some proprietary protocol handling. CLT mode is defined in the clause 11. Support of this LLC is optional in the CLF and optional (application dependant) in the UICC.
- ACT: This LLC consist of frames used during interface activation. After UICC and CLF have started communication using SHDLC or CLT, UICC and CLF shall not respond to any received ACT frame. Support of this LLC is mandatory in the CLF and the UICC.

Table 9.1: LLC Control field coding

Frame Types	Bit Field							
	8	7	6	5	4	3	2	1
RFU	0	0	All settings					
ACT	0	1	1	ACT type				
CLT	0	1	0	CLT CMD				
SHDLC	1	All settings						

The control field is the first byte of the SWP frame payload. Definition for the different LLC layers can be found in table 9.1.

The LPDUs payload shall be structured according to figure 9.5.

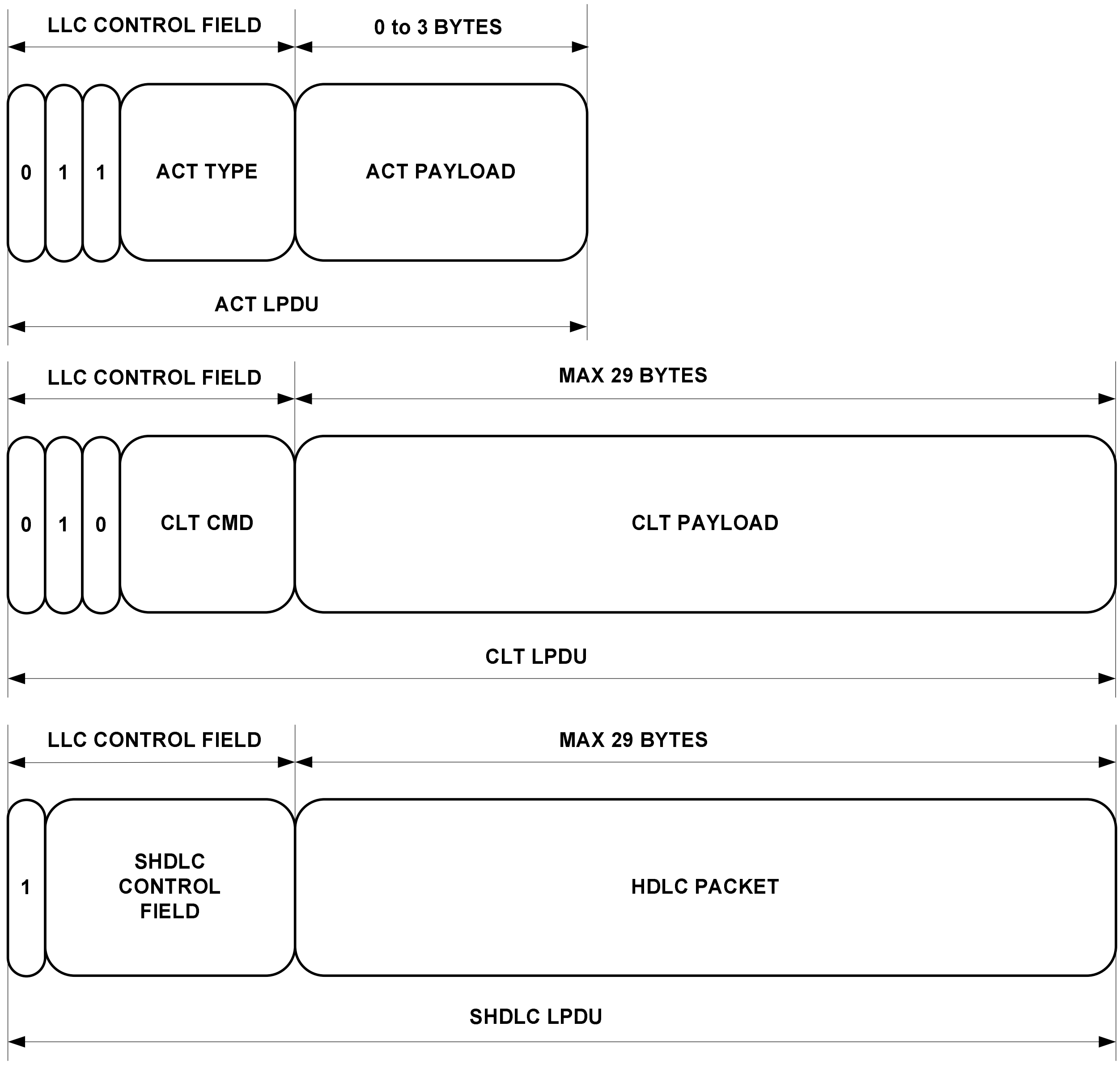


Figure 9.5: LPDU structure of the 3 defined LLC layers

9.4 ACT LLC definition

The ACT LPDU shall be structured according to figure 9.6.

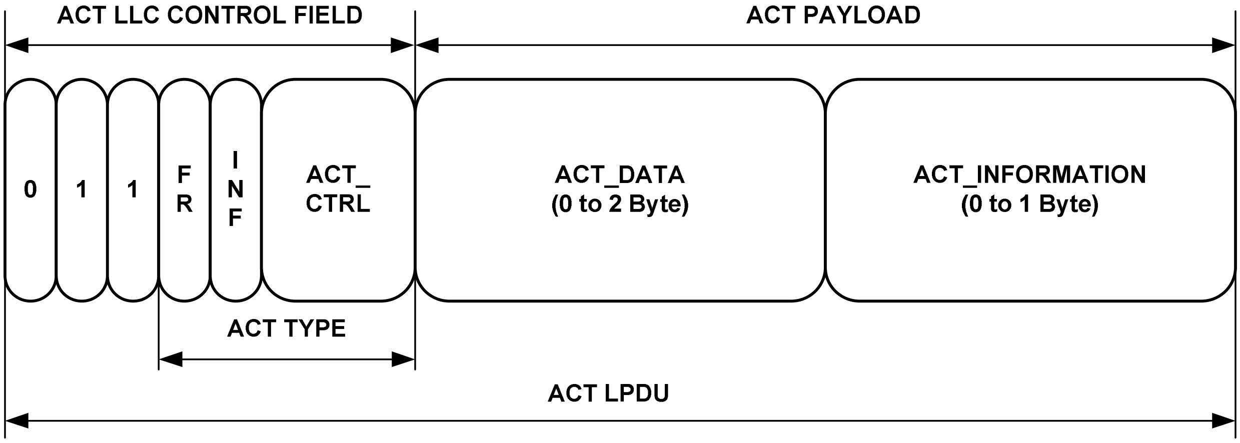


Figure 9.6: ACT LPDU structure

Coding of ACT TYPE:

- Meaning of FR in a frame when received by the UICC:
  - FR = 1: The UICC shall repeat the last sent ACT frame.
  - FR = 0: The UICC shall not repeat the last ACT frame.
- Meaning of FR in a frame when received by the CLF:
  - The CLF shall ignore the FR bit.

  A frame sent from the UICC to the CLF shall have the FR bit set to 0.
- Meaning of INF in a frame when received by the CLF:
  - INF = 1: Last byte of ACT payload contains the ACT_INFORMATION field.
  - INF = 0: ACT_INFORMATION field not available.
- Meaning of INF in a frame when received by the UICC:
  - The UICC shall ignore the INF bit.

  A frame sent from the CLF to the UICC shall have the INF bit set to 0.

The meaning of ACT_CTRL and ACT_DATA is given in table 9.2.

Table 9.2: Meaning of ACT_CTRL and ACT_DATA

ACT_CTRL	Meaning	ACT_DATA FIELD
000	ACT_READY Sent from UICC to CLF	0 Byte
010	ACT_POWER_MODE Sent from CLF to UICC to indicate the power mode for the UICC.	1 Byte '00': Low power mode '01': Full power mode (see Note)
001	ACT_SYNC: VERIFY_SYNC_ID Sent from UICC to CLF to control the SYNC_ID verification process.	2 Byte SYNC_ID
All other values (see note)		
NOTE: All other values are reserved for future use. These values shall not be set by the transmitting entity and shall be ignored by the receiving entity.		

ACT_INFORMATION: By sending this field, the UICC indicates extended capabilities as defined in table 9.3.

Table 9.3: Extended capability indication in ACT_INFORMATION field

Bit field	Value	Meaning
8	0	Reserved for future use
7	0	Reserved for future use
6	0	Reserved for future use
5	0	Reserved for future use
4	0	Reserved for future use
3	1 0	SWP bit durations down to 295 ns supported (the value of bit field 2 shall be 1) SWP bit durations down to 295 ns not supported
2	1 0	SWP bit durations down to 590 ns supported SWP bit durations down to 590 ns not supported
1	1 0	SWP bit durations up 10000 ns supported SWP bit rates down to 10000 ns not supported

9.4.1 SYNC_ID verification process

The purpose of the SYNC_ID Verification is to protect RF communication parameters in the CLF that have been provided by the UICC. The SYNC_ID Verification process consists of the following steps:

- The UICC presents the SYNC_ID to the CLF. The presented SYNC_ID is named *verification data*.
- The CLF compares *verification data* with *reference data*. These *reference data* are stored in the CLF during system configuration (or reconfiguration).

If both values are equal, UICC and CLF are called synchronized.

For the SYNC_ID Verification, the following conditions shall apply:

- The CLF and the UICC shall support SYNC_ID verification.
- The SYNC_ID Verification shall always be executed when the SWP interface is activated (see clause 6.2.3).

The CLF shall perform the SYNC_ID verification process based on ACT frames received from the UICC as outlined below:

- In case the ACT_CTRL field "VERIFY SYNC_ID" is received, the CLF shall use the ACT_DATA field as *verification data*.

If the CLF evaluates that *verification data* and *reference data* are not equal (UICC and CLF are not synchronized), the CLF shall inhibit all contactless card emulation services for the UICC up to the next system reconfiguration.

A system reconfiguration shall - with respect to the SYNC_ID Verification process - execute the following steps:

- The UICC shall generate a new SYNC_ID.
- The UICC sends the RF communication parameters and the SYNC_ID to the CLF.

For this process the following rules shall apply:

- UICC and CLF shall use the HCI framework to transmit this reconfiguration information.
- The CLF shall store RF communication parameters and the SYNC_ID transmitted over the physical SWP interconnection between UICC and CLF.
- Applications on the UICC using the SWP interface for contactless communication between the terminal and a reader device shall send RF communication parameters and the SYNC_ID over the physical SWP interface.

- The generation of subsequent SYNC_ID values shall incorporate a random element.

10 SHDLC LLC definition

10.1 SHDLC overview

The SWP SHDLC layer as defined in the present document is a simplified version of ISO's High-level Data Link Control (HDLC ISO/IEC 13239 [5]) specification. It is responsible for the error-free transmission of data between network nodes.

The SHDLC layer shall ensure that data passed up to the next layer has been received exactly as transmitted (i.e. error free, without loss and in the correct order). Also, the SHDLC layer manages the flow control, which ensures that data is transmitted only as fast as the receiver may receive it.

SHDLC ensures a minimum of overhead in order to manage flow control, error detection and recovery. If data is flowing in both directions (full duplex), the data frames themselves carry all the information required to ensure data integrity.

The concept of a sliding window is used to send multiple frames before receiving confirmation that the first frame has been received correctly. This means that data may continue to flow in situations where there may be long "turnaround" time lags without stopping to wait for an acknowledgement.

10.2 Endpoints

SHDLC communication occurs between two endpoints. Those endpoints are identified as the CLF and the UICC. Either of the endpoints may initiate the link establishment. There is no priority of traffic.

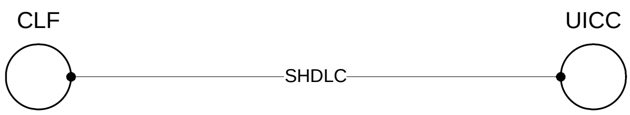


Figure 10.1: Endpoints

10.3 SHDLC frame types

SHDLC uses several types in order to transfer data and to manage or supervise the communication channel between the two endpoints (ends of the communication channel):

- **Frames (Information frames):** Carry upper-layer information and some control information. I-frame functions include sequencing, flow control, and error detection and recovery. I-frames carry send and receive sequence numbers.
- **S-Frames (Supervisory Frames):** Carry control information. S-frame functions include requesting and suspending transmissions, reporting on status, and acknowledging the receipt of I-frames. S-frames carry only receive sequence numbers.
- **U-Frames (Unnumbered Frames):** Carry control information. U-frame functions include link setup and disconnection, as well as error reporting. U-frames carry no sequence numbers.

10.4 Control Field

The SHDLC control field has the structure described in table 10.1, including the first bits of the payload.

Table 10.1: SHDLC Control field coding

Frame Types	Bit Field						
	8	7	6	5	4	3	2	1
I	1	0	N(S)			N(R)		
S	1	1	0	TYPE		N(R)		
U	1	1	1	M				

where:

- N(S): Number of the information frame
- N(R): Number of next information frame to receive
- TYPE: Type of S-Frame
- M: Modifier bits for U-Frame

The size of the sliding window is four frames by default. Frames types may be interleaved. For example, a U-Frame may be inserted between I-Frames.

10.4.1 I-Frames coding

The functions of the information command and response is to transfer sequentially numbered frames, each containing an information field, across the data link.

10.4.2 S-Frames coding

Supervisory(S) commands and responses are used to perform numbered supervisory functions such as acknowledgment, temporary suspension of information transfer, or error recovery. Frames with the S format control field do not contain an information field.

Supervisory Format commands and responses are as follows:

- **RR**: Receive Ready is used by an endpoint to indicate that it is ready to receive an information frame and/or acknowledge previously received frames.
- **RNR**: Receive Not Ready is used to indicate that an endpoint is not ready to receive any information frames or acknowledgments.
- **REJ**: Reject is used to request the retransmission of frames.
- **SREJ**: Selective Reject is used by an endpoint to request retransmission of specific frames. An SREJ shall be transmitted for each erroneous frame; each frame is treated as a separate error. Only one SREJ shall remain outstanding on the link at any one time.

The type coding is given by the table 10.2.

Table 10.2: Type coding of the S-frames

Frames	Type	Status
RR	00	Mandatory
REJ	01	Mandatory
RNR	10	Mandatory
SREJ	11	Optional

Optional type of frame shall not be used before capability negotiation is defined during initialization.

10.4.3 U-Frames coding

The unnumbered format commands and responses are used to extend the number of data link control functions. The unnumbered format frames (see clause 10.4) have 5 modifier bits which allow for up to 32 additional commands and responses. Only a subset of the HDLC commands and responses are used for SHDLC:

- **RSET**: Reset of the data link layer is used to reset the receive state variable in the addressed endpoint.
- **UA**: Unnumbered Acknowledgment is used to acknowledge the receipt and acceptance of a RSET command.

Table 10.3: Modifier coding of the U-frames

Frames	Modifier	Status
RSET	11001	Mandatory
UA	00110	Mandatory

10.5 Changing sliding window size and endpoint capabilities

The sliding window size is a physical property of the link. It shall not change during device life but may be lower than the default value due to limited resources. In consequence, an endpoint may want to ask the other endpoint to lower the sliding window size.

The RSET frame may carry a configuration field in order to change the sliding window size (down to 2). If the default size (in case of an RSET command without configuration field) or the size provided is too large at a RSET frame reception, the receiver shall not acknowledge it. Instead, the receiver shall send a RSET frame with an appropriate sliding window size (which is lower than the window size offered by the other endpoint).

An endpoint shall obey to window size reconfiguration if the requested window size is lower than its default configuration. It acknowledges the new size with a UA frame.

SREJ support is negotiated in the same way. The RSET frame may carry a configuration field in order to indicate the capability of the endpoint to support this frame.

10.5.1 RSET frame payload

The RSET frame has 2 optional bytes in order to provide the endpoint window size and capabilities. The number provided for the endpoint size shall be between 2 to 4 inclusive. In case this RSET frame is sent in response to a received RSET frame, the endpoint size value shall be lower than the previously provided value. The second optional byte may be sent after the window size by the endpoint in order to indicate support of optional endpoint capabilities. If it is absent, the default values apply.

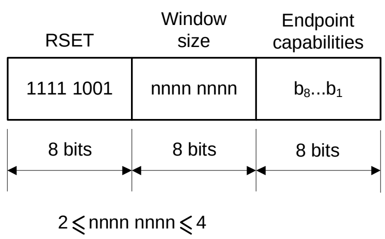


Figure 10.2: RSET frame payload

Table 10.4: Bit coding of optional endpoint capabilities

Bit	Default value	Description
1	0	Support of Selective Reject S-frame (SREJ) 0: Not supported (default) 1: Supported
2 to 8	000000	RFU

10.5.2 UA frame payload

The UA frame carries no payload.

10.6 SHDLC context

The SHDLC context is defined by constant values such as the timeouts and the sliding window size as well as a number of variables as defined below.

10.6.1 Constants

- **w**: Sliding window size. *w = 4* by default
  This value is not actually constant because it may be reduced at link establishment. However, up to the next reset of the SHDLC session, it never changes.

- **T1**: Acknowledge timeout. *,T1 = 5 ms*
  In context of streaming, the frames shall be acknowledged within T1 to avoid that the traffic stops. The T1 value is bound to the *w* value . The current value is computed for *w = 4*. If the value is reduced to *w"* then *T1* is changed to *T1" = T1* x *w" / w*.

- **T2**: Guarding/transmit timeout. *T2 > T1*. *T2 = 10 ms*
  If the frames are not acknowledged after a time period, a endpoint shall retransmit these frames. This value defines the minimal time to wait. *T2* is unaffected by modifications of *w*.

- **T3**: Connection timeout. *T3 = 5 ms*
  Used at link establishment, retry to setup link if the targeted end point did to not answer with an UA frame to a RSET frame. *T3* is unaffected by modifications of *w*.

10.6.2 Variables

These three variables are modulo 8 and hold sequence numbers.

- **N(S):** Sequence number for emission. Used in I Frames. Incremented after emission of the frame.

- **N(R):** Next sequence number for reception. Used in I and S type frames.
  During full duplex data transmission or by emission of a S type frame, all received frames with a sequence number lower than N(R) are acknowledged.

- **DN(R):** Lowest unacknowledged sequence number.
  Acknowledgements are outstanding for frames between DN(R) and N(S).

To know if a frame is in the window, sequence numbers are compared using modulo 8.
The definition used for $X <= Y < Z$ modulo 8 is as follows:

- If $X <= Z$ then the equation to calculate is: $X <= Y < Z$

- Otherwise the equation to calculate is: $Y >= X$ or $Y < Z$

10.6.3 Initial Reset State

The following initial states shall apply in every endpoint after successful link establishment:

- N(S) = N(R) = DN(R) = 0.

10.7 SHDLC sequence of frames

10.7.1 Nomenclature

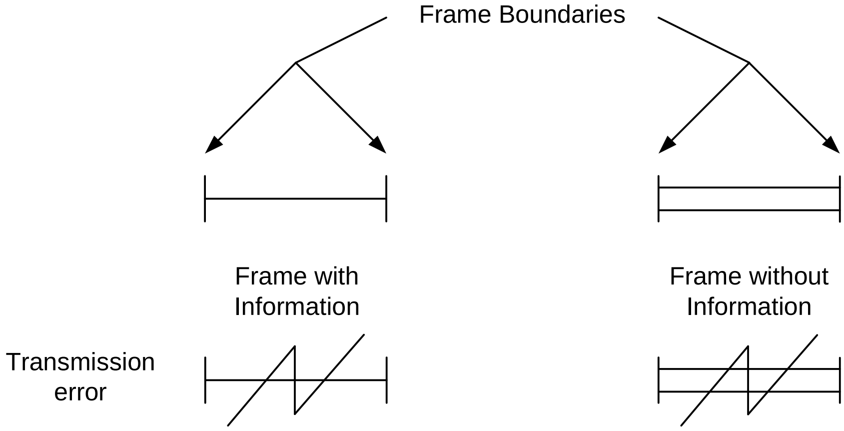


Figure 10.3: Frames representation

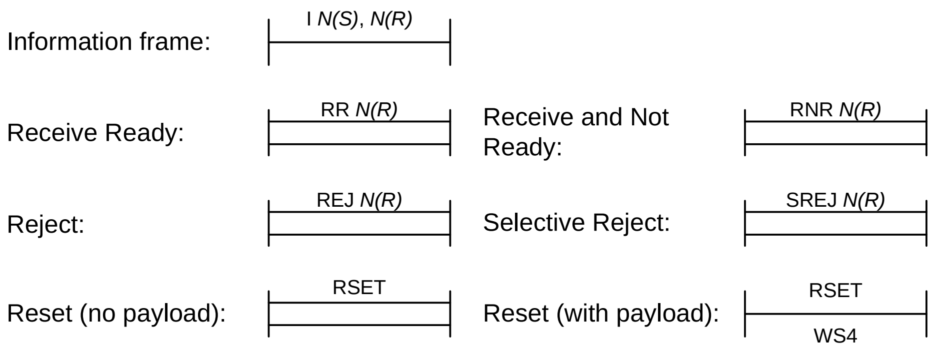


Figure 10.4: Frames type description

10.7.2 Link establishment with default sliding window size

An endpoint establishing a communication channel shall initiate the link by sending a RSET frame. If the target is ready, it shall answer with an UA frame. The link is established after receiving this acknowledgment. Before link establishment, all frames except RSET from other endpoint shall be discarded. The connection timeout is required in order to detect failure and restart the operation. In this example, both endpoints work with the default window size and the UICC does not send a RSET frame because it received a RSET frame first and agreed on the default window size.

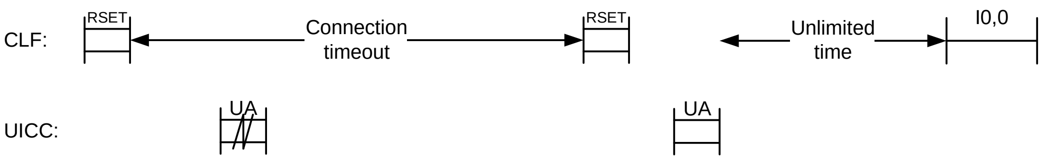


Figure 10.5: Link establishment restart after UA loss

Simultaneous resets are handled gracefully. After both endpoints send UA frames, link is established using the default window size.

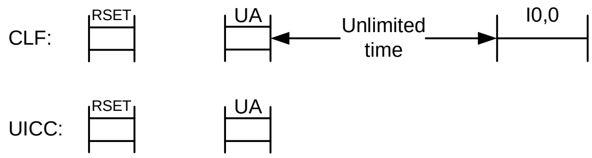


Figure 10.6: Link establishment with crossover RSET frames

10.7.3 Link establishment with custom sliding window size

If the UICC has a smaller window size than the CLF, it ignores the received RSET frame. The CLF sees the customized RSET frame, changes its window configuration to 2 and sends an UA frame to establish the link.

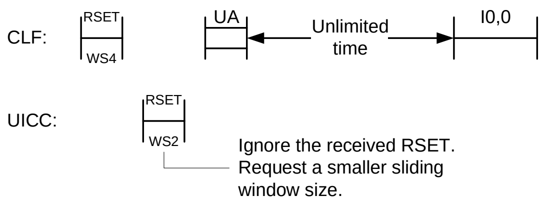


Figure 10.7: Link establishment with sliding window size of 2

In case of RSET frames crossover, the mechanism still works.

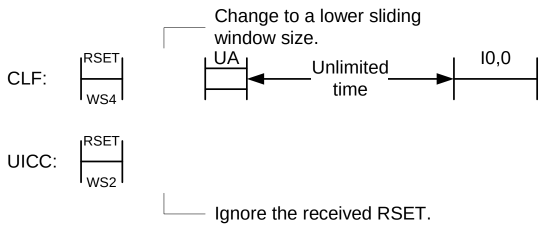


Figure 10.8: Link establishment with sliding window size of 2 and RSET frames crossover

In case of frame loss, the link establishment restarts and link configuration is finally completed.

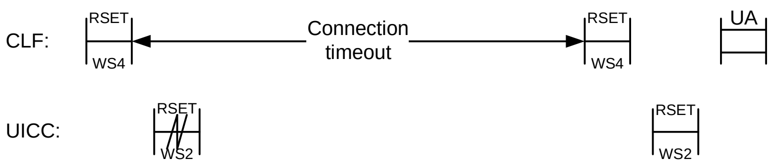


Figure 10.9: The RSET frame from the UICC is lost

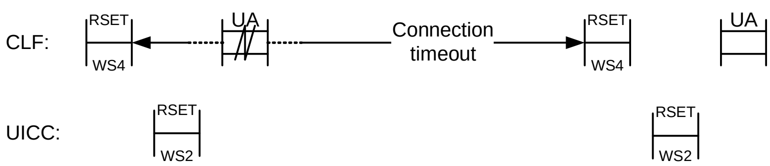


Figure 10.10: The UA from the CLF is lost and the connection timeout allows restarting the link configuration

10.7.4 Data flow

Once the link is established, both endpoints may exchange data.

The CLF sends a stream of data. The UICC has no data to send. So, the piggyback mechanism is not used (Frames are acknowledged using information frames going in the opposite way). The UICC shall acknowledge frame reception regularly in order to avoid traffic stop. An acknowledge timeout is used in order to send RR frames to the CLF. The timeout starts at the first received packet after the previous acknowledgement (other RR frame or piggybacking). If the UICC sends information frames (not shows here), the acknowledge timeout shall be stopped as piggybacking will acknowledge received frames.

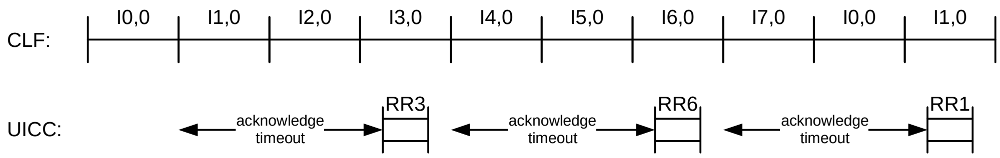


Figure 10.11: One way data flow with RR frames acknowledgement

The acknowledge timeout shall not be too long to avoid throughput degradation. Otherwise, the sending endpoint will be waiting for the destination to become ready. This diagram shows what happens with a sliding window size of 4 and a timeout value that is too large.

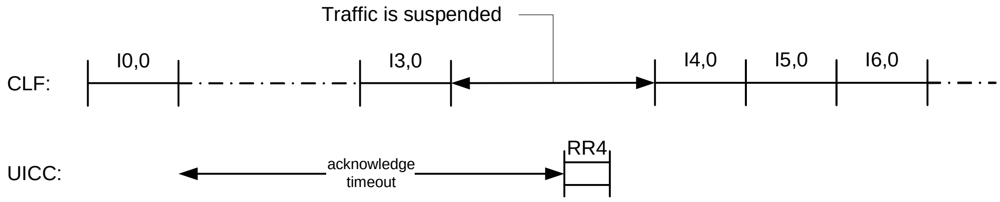


Figure 10.12: One way data flow with too long a time for acknowledgement

In this example, I-Frames flow in both ways. Piggybacking is used to acknowledge received frames during I-Frames crossover. Because of last packets crossover, both endpoints use acknowledge timeout to detect when to send a RR frame after traffic ends.

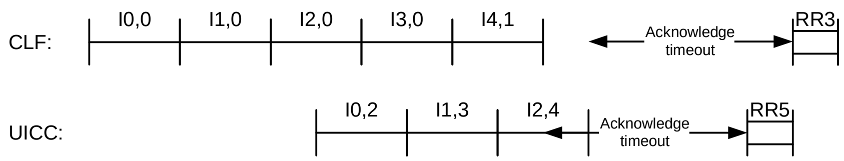


Figure 10.13: Piggybacking and timed acknowledgement

10.7.5 Reject (go N back)

When a frame gets lost in the stream, the destination (here the UICC) will see a gap in the received frame numbers. If SREJ is not supported or if several frames got lost, the destination shall send a REJ frame as soon as possible in order to restart the stream at the first missing frame.

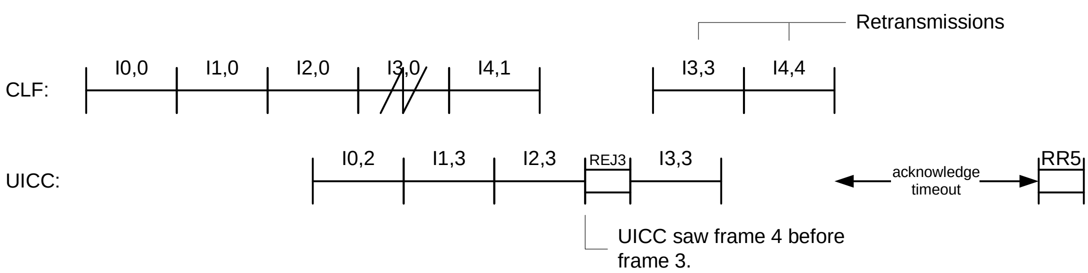


Figure 10.14: Piggybacking with reject frame after mismatching sequence number

10.7.6 Last Frame loss

Each frame shall have a guarding/transmit timeout in order to retransmit frames if the destination does not notice a loss. When the last frame is lost, the destination endpoint will not be able to detect it. A RR frame shall be sent to acknowledge the last frame but a lost frame will never be requested for retransmission by the destination endpoint by using a reject mechanism.

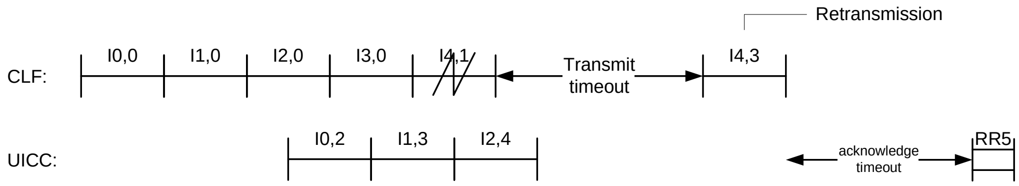


Figure 10.15: Last frame loss in piggybacking situation

Figure 10.16 shows the same behaviour when the destination endpoint do not send any traffic (i.e. no piggybacking).

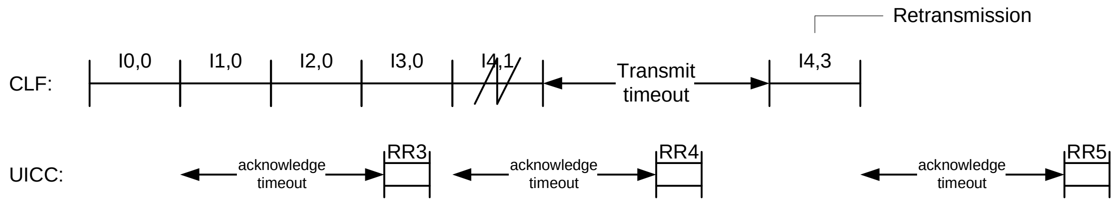


Figure 10.16: Last frame loss in one way data flow

10.7.7 Receive and not ready

Receive-not-ready (RNR) acknowledges an I-frame, as with RR, but also asks the peer endpoint to suspend transmission of I-frames.

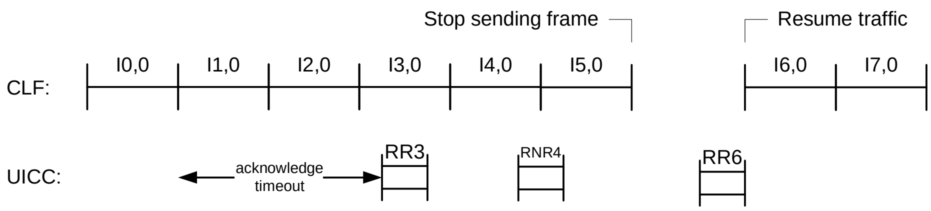


Figure 10.17: Stop and resume traffic at UICC request

10.7.8 Selective reject

Selective reject (SREJ) is used to request retransmission of just a single frame.

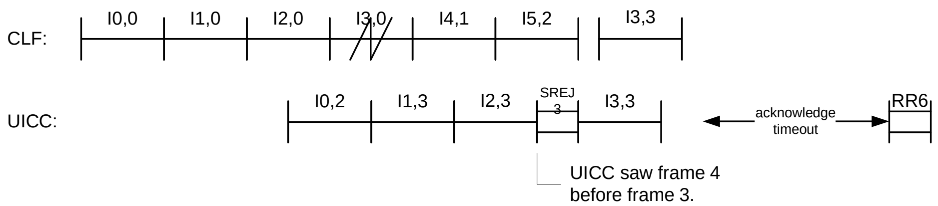


Figure 10.18: One frame loss in stream

10.8 Implementation model

All calculations on sequence numbers in this clause are done modulo 8.

10.8.1 Information Frame emission

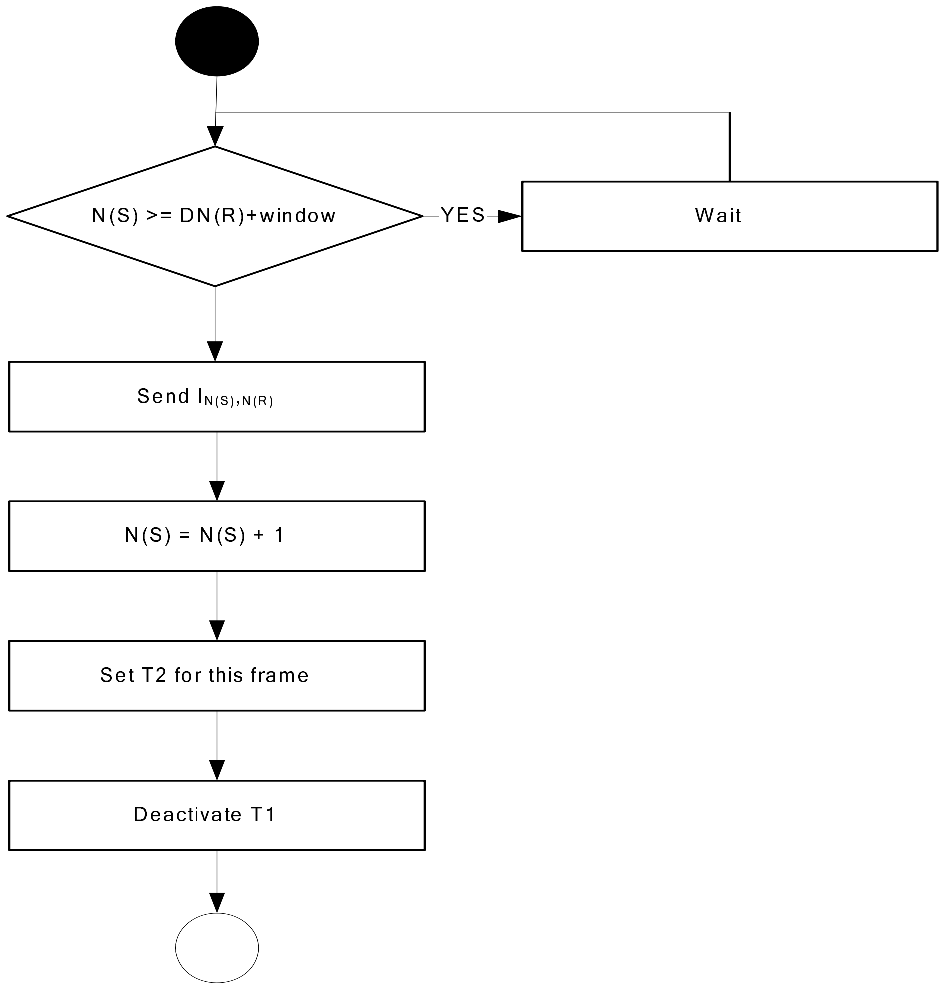


Figure 10.19: Information frame emission.

10.8.2 Information Frame reception

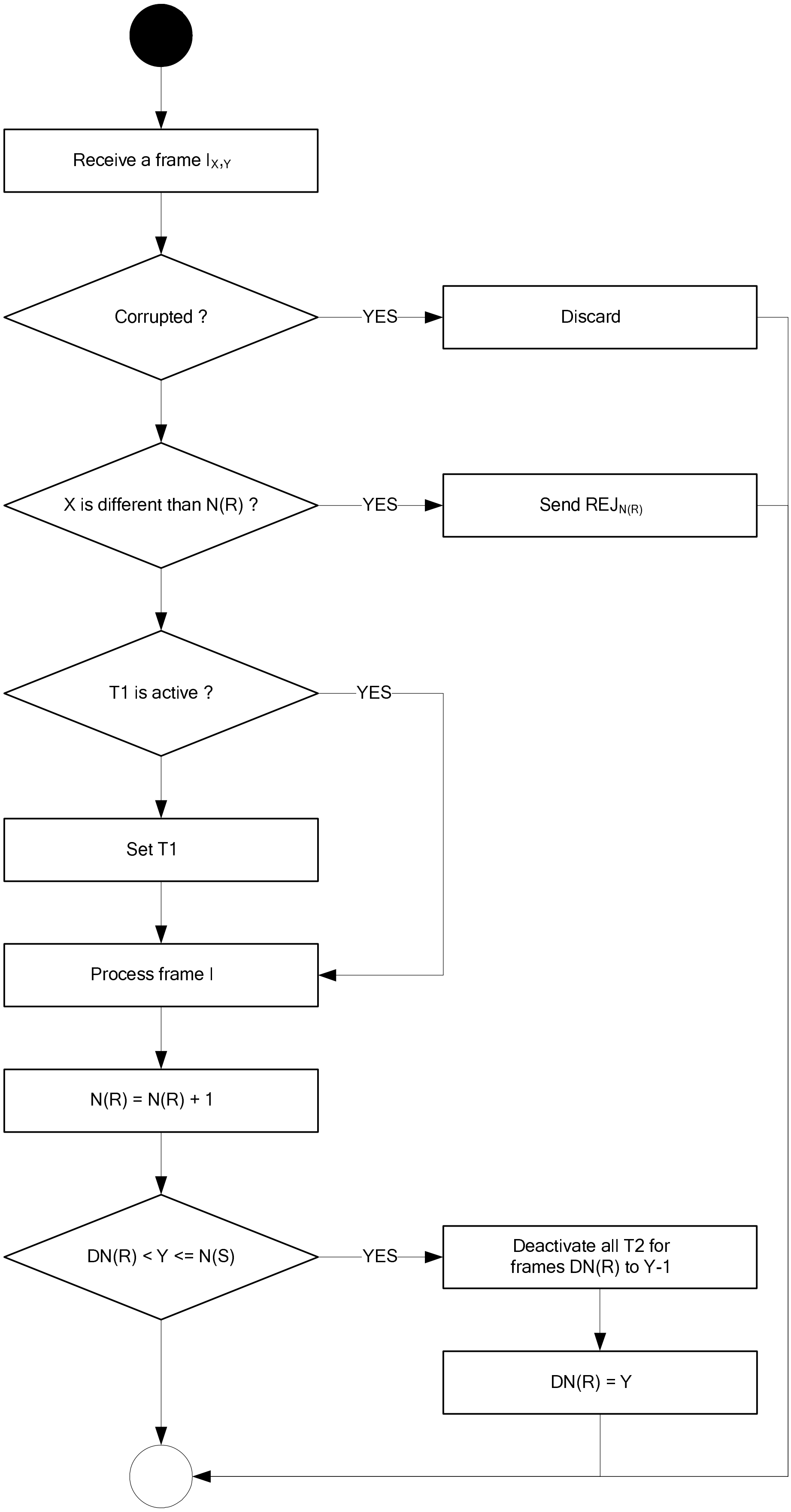


Figure 10.20: Information frame reception

10.8.3 Reception Ready Frame reception

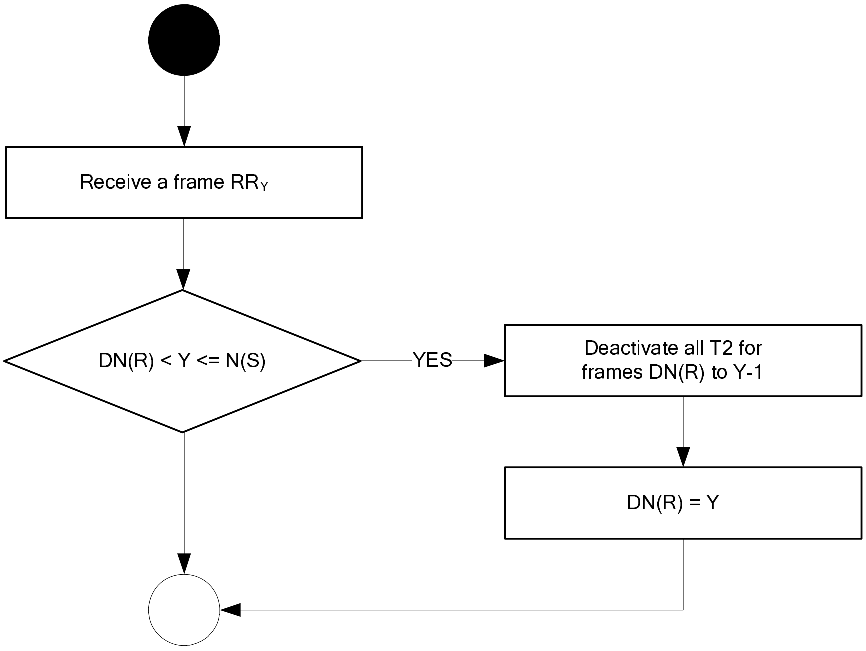


Figure 10.21: RR frame reception

10.8.4 Reject Frame reception

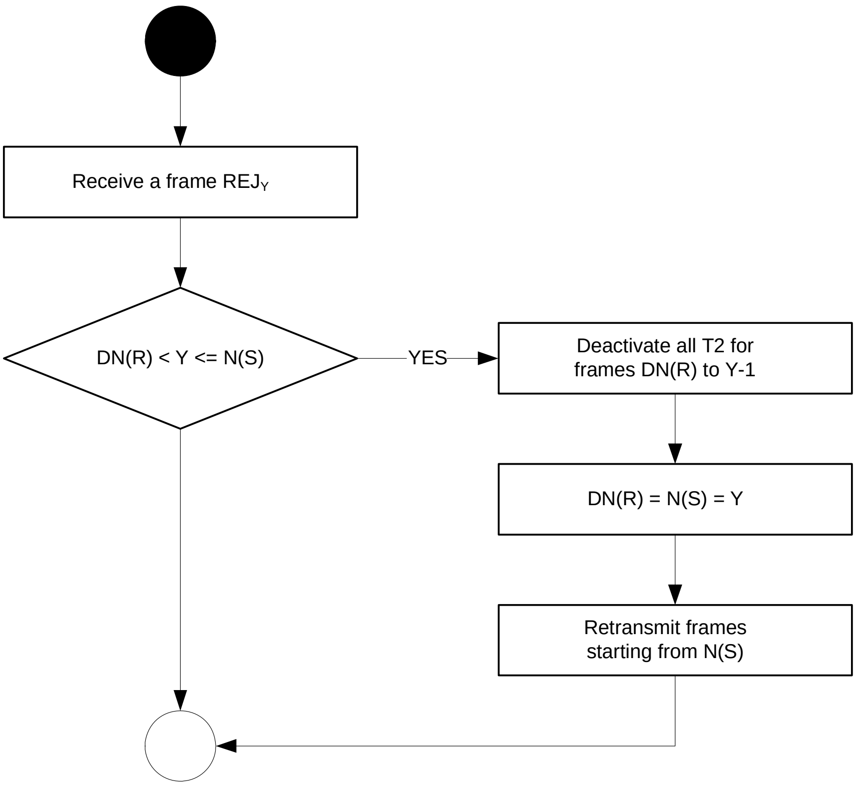


Figure 10.22: REJ frame reception

10.8.5 Selective Reject Frame reception

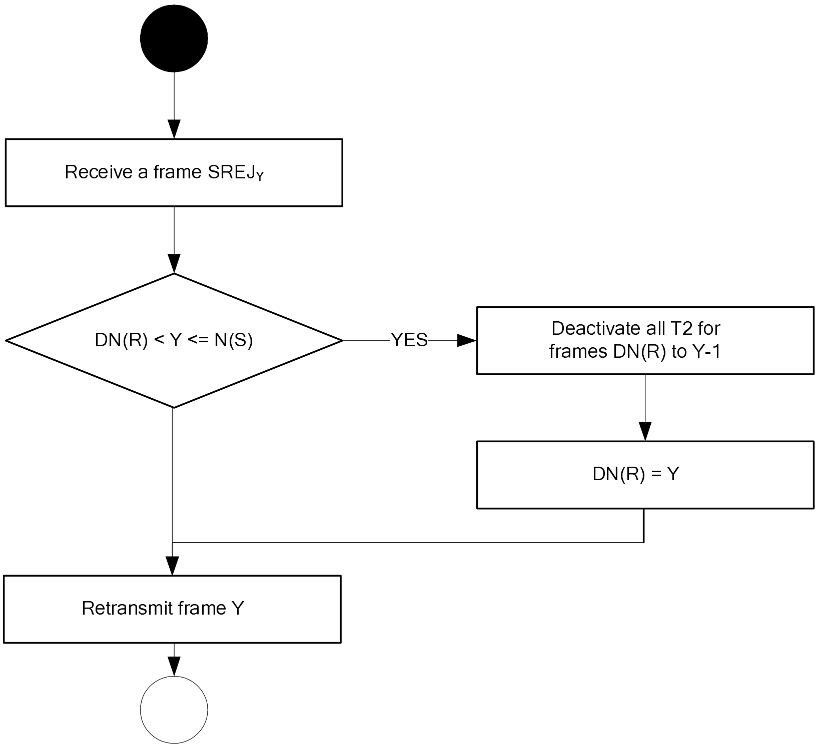


Figure 10.23: SREJ frame reception

10.8.6 Acknowledge timeout

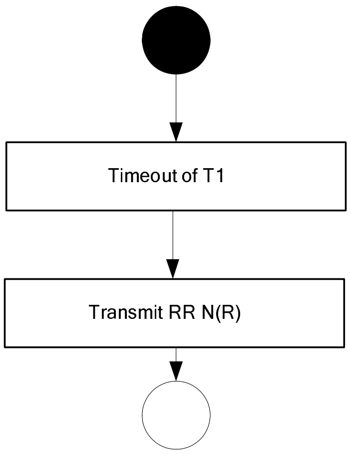


Figure 10.24: Acknowledge timeout

10.8.7 Guarding/transmit timeout

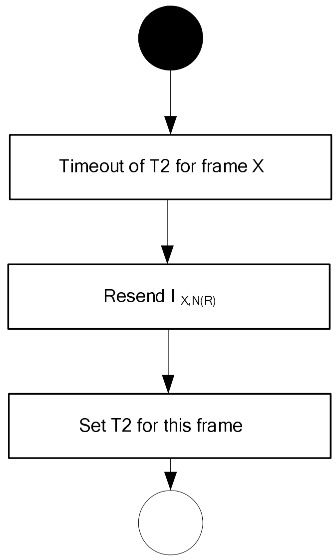


Figure 10.25: Guarding/transmit timeout

11 CLT LLC definition

11.1 System Assumptions

The following system assumptions are made as the basis for the CL-Tunnelling protocol specification:

- System partitioning:
  - For ISO/IEC 14443-2 [2] and ISO/IEC 14443-3 [3] Type A proprietary protocols, initialization (anticollision and selection) of RF protocols is performed by the CLF without UICC involvement. The CLF possesses all information necessary.
  - For ISO/IEC 18092 [8] 212 /424 kbps passive mode based proprietary protocols as used in existing infrastructure, the UICC performs anticollision.
    - CLT mode is not required in order to support ISO/IEC 18092 [8] NFCIP-1 mode for P2P communication.
  - The necessary protocol translation (from RF level to CLT and vice versa) is performed by the CLF.
- Supported NFC operating modes:
  - "NFC Card Emulation", where proprietary RF protocols are processed by the UICC.
  - Other NFC use cases are currently out of scope.
- Supported RF protocols
  - ISO/IEC 14443-2 [2] and ISO/IEC 14443-3 [3] Type A based proprietary RF protocols within legacy widespread infrastructures.
  - ISO/IEC 18092 [8] 212 kbps/424 kbps passive mode based proprietary RF protocols within legacy widespread infrastructures.

- In the current document, alternative RF protocols are not specified in detail, but are not excluded from being operated via CLT, as there are (e.g.) ISO/IEC 14443 [2,3] Type B based proprietary schemes, as long as the maximum RF frame length (including EDC) of the supported RF protocol does not exceed the transport capability of a single CLT frame and the CLF supports the proper RF protocol initialization.

11.2 Overview

The CLT protocol is used to exchange data based on SWP physical layer between the CLF and the UICC. The CLF acts as a bridge, which composes/removes the type specific RF-frame encapsulation, but keeps the type-specific error detection code, which is managed by the UICC.

A minimum set of administrative commands is implemented as well.

A CLT session is defined as the sequence of data exchange based on CLT starting from the first CLT frame issued by the CLF until an SHDLC frame is issued by the CLF or the UICC, or a reset condition, whatever occurs first.

In a CLT session, frames are typically exchanged in an half-duplex manner.

11.3 CLT Frame Format

According to table 10.1, one of the coding possibilities for the LLC header is used as CLT frame indicator. The coding coexists with the coding of SHDLC and ACT LLC.

Based on this frame header, the following basic CLT LPDU format is defined:

Byte 1 (CLT_HEADER)				Byte 2-N (default 30)
0	1	0	CLT_CMD[4:0]	CLT_PAYLOAD

The resulting frame is:

SOF	0	1	0	CLT_CMD	CLT_PAYLOAD	CRC16	EOF

The CLT_HEADER is one byte in length and includes the frame type indication 01 in bits 7 and 6 and the CLT_CMD field.

The CLT_PAYLOAD may have the length 0 bytes and shall not exceed the value stated in this specification. It may contain data transferred from or to RF side of the CLF, furthermore referenced as "DATA_FIELD".

The CLT_CMD shall indicate the type of data in the CLT_PAYLOAD and may include additional administrative commands exchanged between the CLF and the UICC, furthermore referenced as "ADMIN_FIELD". The interpretation of the data in the ADMIN_FIELD is linked to the entity which has submitted the CLT frame (either the UICC or the CLF).

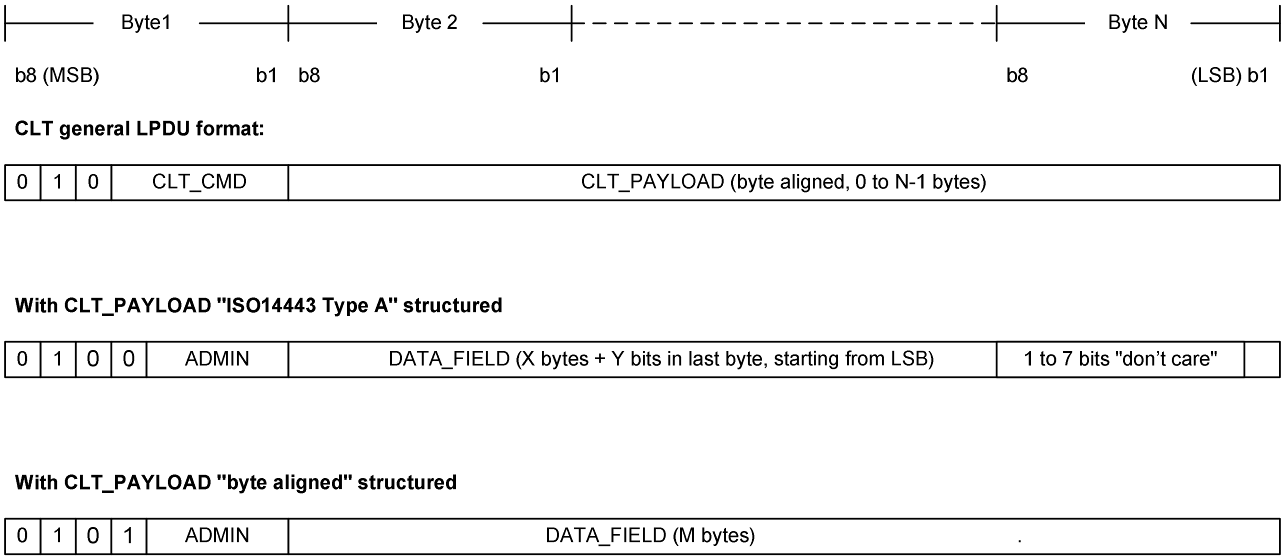


Figure 11.1: Typical examples for CLT frames

11.4 CLT Command Set

Table 11.1 gives the coding of the CLT_CMD field.

Table 11.1: Contents of CLT_CMD

Bit	Value	Meaning
4		Structure of DATA_FIELD in CLT_PAYLOAD
	0	Data structure retrieved from ISO/IEC 14443 Type A (see clause 11.5.1)
	1	Data structure is byte aligned
3:0		ADMIN_FIELD (see note)
		Interpretation of ADMIN_FIELD sent by the CLF to the UICC:
	0000	Payload contains data to be transmitted
	1000	CL_PROTO_INF(A): The CLF was selected in ISO/IEC 14443-2 [2] and ISO/IEC 14443-3 [3] Type A technology (see clause 11.5.3.1)
	1001	CL_PROTO_INF(F): The CLF forwards anticollision data according to ISO/IEC 18092 [8] 212 kbps/424 kbps passive mode (see clause 11.5.3.2)
	Other Values	Reserved for future use
		Interpretation of ADMIN_FIELD sent by the UICC to the CLF:
	0000	Payload contains data to be transmitted
	0001	CL_GOTO_INIT: Requests transition of the CLF to initial state of anticollision and selection sequence (ISO/IEC 14443-3 [3])
	0010	CL_GOTO_HALT: Requests transition of the CLF to 'HALT' state of anticollision and selection sequence (ISO/IEC 14443-3 [3])
	Other Values	Reserved for future use
NOTE: Valid for CLT frames with CLT_CMD bits 5:4 set to 00 or 01.		

11.5 CLT Data Field

11.5.1 Type A structured DATA_FIELD

For CLT frames with ISO/IEC 14443 Type A structured DATA_FIELD, the bit count shall be retrieved implicitly from the byte length of the CLT_PAYLOAD, where the interpretation rule depends on the direction the frame is transferred.

For CLT frames sent from the CLF to the UICC the following table shall apply.

Table 11.2: Bit length calculation of Type A structured frame (direction CLF to UICC)

Size [bytes] of CLT_PAYLOAD	Number of RF bits interpreted by the UICC	Remark
0	Treat as error	
1	7 (starting from LSB)	
2	9	1 RF byte + 1 parity bit
3	18	2 RF bytes + 2 parity bits
…4 to 8…	(continue similar way)	
9	72	8 RF bytes + 8 parity bits
10	Treated as error	
11	81	9 RF bytes + 9 parity bits
…12 to 17…	(continue similar way)	
18	144	16 RF bytes + 16 parity bits
19	Treated as error	
20	153	17 RF bytes + 17 parity bits
…21 to 26…	(continue similar way)	
27	216	24 RF bytes + 24 parity bits
28	Treated as error	
29	225	25 RF bytes + 25 parity bits

For CLT frames sent from the UICC to the CLF the following table shall apply.

Table 11.3: Bit length calculation of Type A structured frame (direction UICC to CLF)

Size [bytes] of CLT_PAYLOAD	Number of RF bits sent to PCD by the CLF	Remark
0	0	Interpretation rule see clause 11.5.2
1	4 (starting from LSB)	
2	9	1 RF byte + 1 parity bit
3	18	2 RF bytes + 2 parity bits
…4 to 28…	(continue similar way)	
29	225	25 RF bytes + 25 parity bits

Below, the CLT frame layout transporting 4 RF bytes + 4 parity bits is shown as an example.

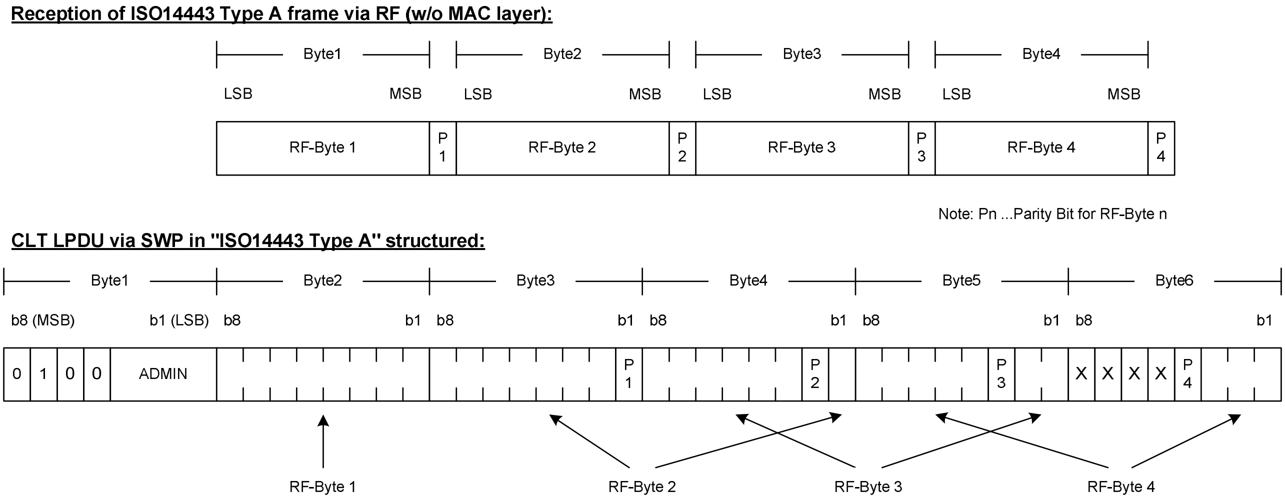


Figure 11.2: Examples for a "Type A structured" CLT frame

11.5.2 Handling of DATA_FIELD by the CLF

Due to the nature of RF protocols, the information exchange on RF side is half-duplex, where the PICC sends a command and the PICC sends normally a response, but also may not respond to erroneous frames (as per ISO/IEC 14443-3 [3]) or to certain commands when operating in proprietary RF schemes, but shall then be ready to receive further PICC commands.

In an architecture consisting of both a UICC and a CLF that operate in CLT, the response or the condition not to respond is evaluated by the UICC. This condition is reported to the CLF by means of an empty DATA_FIELD. The resulting flow is as follows:

- After the CLF has received a frame via RF, a CLT frame with DATA_FIELD is composed and sent to the UICC. Afterwards, the CLF continues listening to the SWP interface only but does not respond to RF activity, unless the RF field disappeared.
- After the reception of a CLT frame from the UICC, the CLF shall transmit the respective data via RF if the DATA_FIELD was not empty, if the DATA_FIELD was empty no data shall be transmitted via RF. In both cases, the CLF then shall enter immediately a state in which it is able to receive new commands from the RF interface as well as the SWP interface.

11.5.3 Handling of ADMIN_FIELD

11.5.3.1 CL_PROTO_INF(A)

With this ADMIN command, the CLF shall informs the UICC about the presence of a proprietary RF protocol according to ISO/IEC 14443-3 [3] Type A processed in CLT mode.

CL_PROTO_INF shall be sent by the CLF to the UICC after every successful RF protocol initialization requiring CLT mode processing.

Following actions shall be taken by the CLF for this ADMIN command:

- After anticollision and selection sequence (ISO/IEC 14443-3 [3] Type A: Received SAK), the next RF frame shall be received and its EDC verified. This frame is expected to be formatted according to the ISO/IEC 14443-3 [3] and ISO/IEC 14443-4 [4] response and may be the entry sequence of ISO/IEC 14443-3 [3] Type A based proprietary RF protocols.
- In case of an EDC error, no CLT frame shall be sent to the UICC and the CLF handles the error according to ISO/IEC 14443-3 [3] and ISO/IEC 14443-4 [4].

NOTE 1: For ISO/IEC 14443 Release 2001-2006, there is a misalignment between ISO/IEC 14443-3 [3] and ISO/IEC 14443-4 [4] for error handling at this state (ISO/IEC 14443-3 [3]: Return to IDLE/HALT, ISO/IEC 14443-4 [4]: Remain listening). With ISO/IEC 14443 Revision 2007, the ISO/IEC 14443-3 [3] condition also applies for ISO/IEC 14443-4 [4].

- If the RF frame was correctly received, the first byte shall be checked by the CLF.
- If the first byte is equal to 'E0' (command RATS, ISO/IEC 14443-4 [4]), then the CLF shall continue ISO/IEC 14443-4 [4] processing using a higher level protocol, no CLT command is sent to the UICC (assuming that ISO/IEC 14443-4 [4] compliancy was indicated in the SAK)

NOTE 2: For protocols according to ISO/IEC 18092 [8] 106 kbps passive mode, the command code 'D4' (ATR_REQ) recognized in the 1st byte is treated in a similar way.

NOTE 3: ISO/IEC 14443-3 [3] Type A permits the presence of both ISO/IEC 14443-4 [4] and proprietary RF protocols at one physical card. The type selection is done by the PCD evaluating the SAK byte sent from the PICC. As a future option, the ISO/IEC 14443-4 [4] processing may also take place on the UICC. In this case, the RATS command may be sent to the UICC encapsulated in the CL_PROTO_INF.

- If the first byte is not equal to one of the above mentioned values, then the CLF shall compose a CLT frame with "CL_PROTO_INF" (A) in the ADMIN_FIELD and attaches the received RF data as DATA_FIELD. The EDC may be included.
  - If the length of the RF data exceeds the DATA_FIELD, this shall be treated as an RF error and no CLT frame shall be sent to the UICC. The CLF shall handle the error according to ISO/IEC 14443-3 [3] and ISO/IEC 14443-4 [4].
- After having sent CL_PROTO_INF, the CLF shall keep listening to the SWIO and shall not respond to RF interface activity, unless the RF field disappeared.

Following actions shall be taken by the UICC on receiving the CL_PROTO_INF(A) CLT frame:

- CL_PROTO_INF is the first frame of a CLT session. The UICC shall continue in CLT protocol operation.
- The contents of the DATA_FIELD shall be evaluated. If the RF data match with one of the RF protocols supported, the response shall be calculated and sent to the CLF. Otherwise, the CLF shall be triggered to treat it as an error by sending an appropriate CLT frame CL_GOTO_INIT.

11.5.3.2 CL_PROTO_INF(F)

With this ADMIN command, the CLF informs the UICC about the presence of a ISO/IEC 18092 [8] based RF protocol in 212 kbps/424 kbps passive mode, for which the anticollision is processed in the UICC. The anticollision commands shall be exchanged in CLT mode.

CL_PROTO_INF(F) shall be sent by the CLF to the UICC after every detection of a new RF field according to ISO/IEC 18092 [8] for 212/424kbps passive mode if the CLF is configured to do so. This information is retrieved from higher application layers.

Following actions shall be taken by the CLF for this ADMIN command:

- When the CLF has received the POLLING REQUEST command (Command Code '00'), it:
  - Shall start a timer in order to be able to align the response to the time grid;
  - Shall memorize the Time Slot Number (TSN, 5th byte of POLLING REQUEST payload); and
  - Shall forward the command to the UICC encapsulated as payload in the CL_PROTO_INF(F) CLT frame.
- The CLF shall send out the received POLLING RESPONSE according to the anticollision time grid as defined in ISO/IEC 18092 [8] for 212/424kbps passive mode. The CLF shall randomly select one of the available timeslot indicated as Time Slot Number within the previous POLLING_REQUEST.

NOTE: According to ISO/IEC 18092 [8], the POLLING RESPONSE is received by the Target after a waiting time of 2.417 ms (512 x 64 / 13,56 MHz) within one of the allowed time slot. Each time slot has a duration of 1.208 ms (256 x 64 / 13,56 MHz).

Following actions shall be taken by the UICC on receiving the CL_PROTO_INF(F) CLT frame:

- CL_PROTO_INF is the first frame of a CLT session. The UICC shall continue in CLT protocol operation.
- The contents of the DATA_FIELD shall be evaluated and the ISO/IEC 18092 [8] 212 kbps/424 kbps passive mode EDC and length (LEN byte) shall be verified.
  - In case the received command does not match with the applications available on the UICC, the UICC shall send a CLT frame with an empty DATA_FIELD to the CLF within 850 µs.
  - In case the command matches the application available on the UICC, the UICC shall respond with an CLT frame containing the ISO/IEC 18092 [8] 212 kbps/424 kbps passive mode POLLING RESPONSE in the DATA_FIELD within 850 µs.
  - In case an error with respect to ISO/IEC 18092 [8] 212 kbps/424 kbps passive mode is detected, the UICC shall send a CLT frame with an empty DATA_FIELD to the CLF within 850 µs.

Figure 11.3 shows a CLT frame containing an ISO/IEC 18092 [8] 212 kbps/424 kbps passive mode based frame.

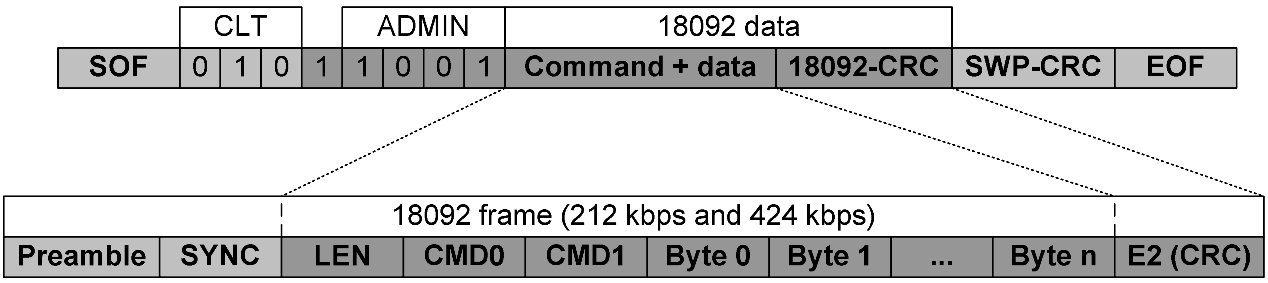


Figure 11.3: Type F structured CLT frame

Figure 11.4 shows the byte alignment of ISO/IEC 18092 [8] based frame data within a CLT LPDU.

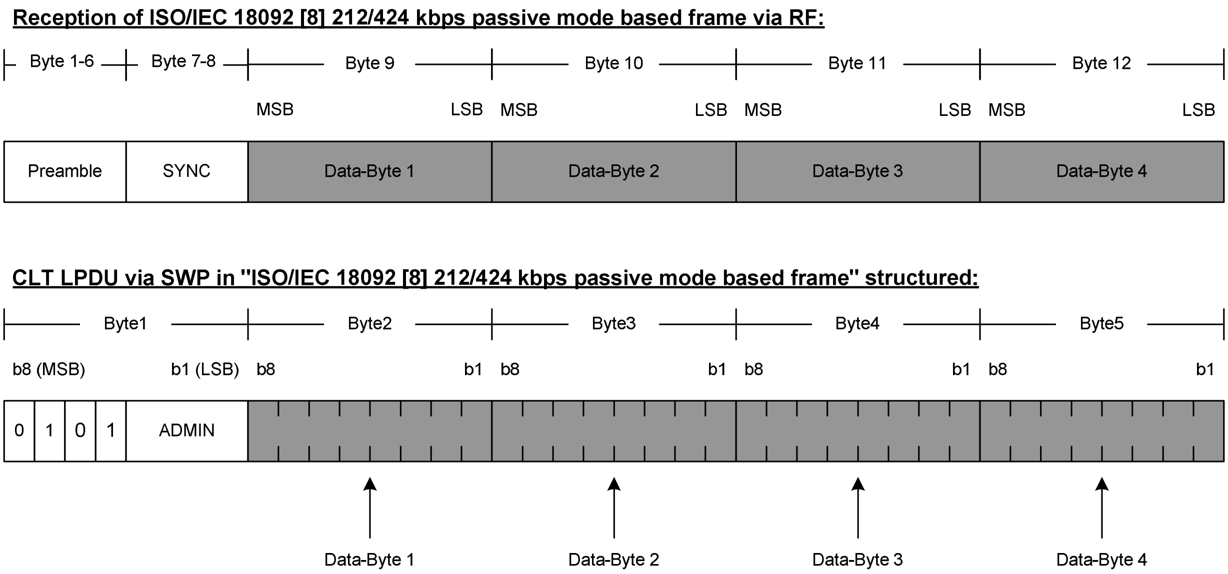


Figure 11.4: Type F byte alignment in CLT frame

11.5.3.3 CL_GOTO_INIT and CL_GOTO_HALT

With those ADMIN_FIELD contents, the UICC shall informs the CLF about a necessary transition to initialization state with respect to the initialization state diagram on RF side. This may occur either in case of an error or if a dedicated transition command (e.g. HLTA) was decoded by the UICC.

In ISO/IEC 14443-3 [3] Type A, the CLF has to support two initialization branches, the corresponding actions are outlined in table 11.4.

Table 11.4: Reasons and actions for CL_GOTO_INIT and CL_GOTO_HALT

	The CLF was selected from IDLE state (via "READY/ACTIVE" states)	**The CLF was selected from HALT state (via "READY*/ACTIVE*" states)**
The UICC decodes an error → send CL_GOTO_INIT	Transition of the CLF to ISO/IEC 14443-3 [3] "IDLE" state	Transition of the CLF to ISO/IEC 14443-3 [3] "HALT" state
The UICC decodes a HLTA command → send CL_GOTO_HALT	Transition of the CLF to ISO/IEC 14443-3 [3] "HALT" state	Transition of the CLF to ISO/IEC14443-3 [3] "HALT" state

11.6 CLT Protocol Rules

11.6.1 Rules for the CLF

The following rules apply for the CLF:

- The CLF shall not issue a CLT command as long as there is an SHDLC frame transfer pending.
- To open a CLT session, the CLF shall send a CLT frame with ADMIN_FIELD set to "CL_PROTO_INF".
- Any SHDLC command may be received at any time (which closes the CLT session inherently) and shall be processed as intended.
- During a CLT session, an incorrectly received SWP frame shall be ignored. To avoid a deadlock situation, the CLF shall enter the initial state of the RF anticollision and selection sequence and shall issue an appropriate higher layer command to the UICC or deactivate SWP after at least 10 ms. The same timeout mechanism shall apply in case the UICC has not responded to a CLT frame within 10 ms.

11.6.2 Rules for the UICC

The following rules apply for the UICC:

- The UICC shall not send a CLT response before having received a CLT command.
- Any valid CLT command shall be responded to with a valid CLT response.
- Any SHDLC command may be received any time (which closes the CLT session inherently) and shall be processed as intended.
- During a CLT session, an incorrectly received SWP frame (wrong CRC) or an unknown or erroneous CLT command shall be ignored.

12 Timing and performance

12.1 SHDLC Data transmission mode

When in SHDLC mode as defined in clause 10 the CLF shall be able to send multiple data frames over the SWP link to the UICC, the format and management of this data is out of the scope of this specification. The CLF shall transmit frames to the UICC in a timely fashion and shall ensure that the time from receipt of the last RF bit to the end of the transmission of the last SWP frame shall be less than $T_{CLF,shdlc}$ = 500 us.

Where:

the *last RF bit* is the end of the last pause transmitted by the PCD (see ISO/IEC 14443-3 [3], applies for Type A);

and

the *end of the transmission of the last SWP frame* is the end of the last bit of EOF on signal S1.

When receiving response data from the UICC the CLF shall be capable of concatenating multiple frames into a single RF transmission and shall ensure that the time between the first bit of the first frame over SWP to the start of the first bit of RF data shall be less than $T_{CLF,shdlc}$ = 500us.

Where:

the *first bit of the first frame over SWP* is the start of the first bit of the SOF on signal S2;

and

the *start of the first bit of RF data* is the first modulation edge within the start bit (see ISO/IEC 14443-3 [3], applies for Type A).

NOTE 1: The CLF and UICC must take care to ensure that no delays in SWP data cause a break in RF transmission.

NOTE 2: The above timings presume error free communications over SWP

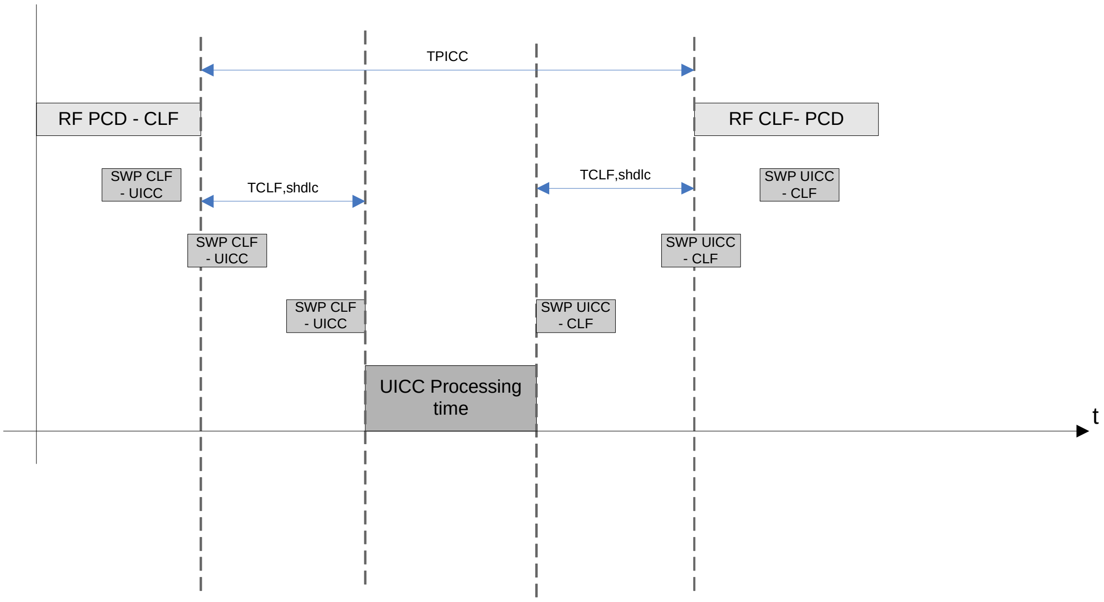


Figure 12.5: SHDLC transmission timings

12.2 CLT data transmission mode

12.2.1 CLF processing delay when receiving data from the PCD

The CLF receives RF data and sends data over SWP to the UICC. The processing delay by the CLF is defined as:

The time between receipt of the *last bit of the RF data block* and *last data bit sent over SWP* where:

> the *last bit of the RF data block* is the end of last pause transmitted by the PCD (see ISO/IEC 14443-3 [3], applies for Type A);

and

> the *last data bit sent over SWP* is the end of the last bit of EOF on signal S1.

This processing delay is designated as $T_{CLF,receive}$.

The CLF shall deliver the received RF data block as payload within exactly one CLT frame. In the case where the incoming RF data block exceeds the length limit of CLT, an error on the RF side or wrong RF protocol type shall be assumed and proper error handling shall be executed (see note 1).

NOTE 1: If the length of the incoming RF data exceeds the maximum length of the CLT payload, then the CLF may send to the UICC either an incorrect CRC or an incorrect EOF or an empty CLT frame.

NOTE 2: The CLF may start data transmission over SWP after having received a complete RF data block or may start data transmission over SWP while still receiving RF data (pipelining).

12.2.2 CLF processing delay when sending data to the PCD

The CLF receives data over SWP from the UICC and modulates it onto the RF. The processing delay by the CLF is defined as:

The time between the receipt of the *first bit sent over SWP* and the *first bit sent to the PCD.*

Where:

> the *first bit sent over SWP* is the start of the first bit of the SOF on signal S2;

and

> the *first bit sent to the PCD* is the first modulation edge within the start bit (see ISO/IEC 14443-3 [3], applies for Type A).

In the case where the RF protocol specifies that no response be sent to the PCD for a command, the processing delay by the CLF is defined as the time between the receipt of *first bit sent over SWP* from UICC to CLF and the time when the CLF shall be ready to receive the start bit of the next RF data block.

This processing delay is designated as $T_{CLF,transmit}$.

The UICC shall deliver the RF data block as payload within exactly one CLT frame. The CLF shall deliver the received CLT payload within exactly one RF data block.

The CLF shall check the ADMIN_FIELD for CL_GOTO_INIT, CL_GOTO_HALT, "Payload contains data" and "RFU" (as in the current document). The CLF shall then proceed as follows:

- if the CLF has detected an CL_GOTO_INIT or CL_GOTO_HALT, the CLF shall evaluate the CRC of the SWP frame and follow rules given in clause 11.6.1 (last bullet point);
- if the CLF has detected "Payload contains data" 0000, then the CLF may start sending data after having received a complete CLT frame or may start sending data to the PCD while still receiving data over SWP (pipelining). If the CRC is not correct, the CLF shall follow the rules given in clause 11.6.1 (last bullet point). In case of non-pipelining and if the CRC is not correct, the CLF shall not modulate the RF-field;

- if the CLF has detected an "RFU" value, the CLF shall behave according to the rules given in clause 11.6.1 (last bullet point).

12.2.3 Timing values for the CLF processing delay

The total processing delay in the CLF is given by:

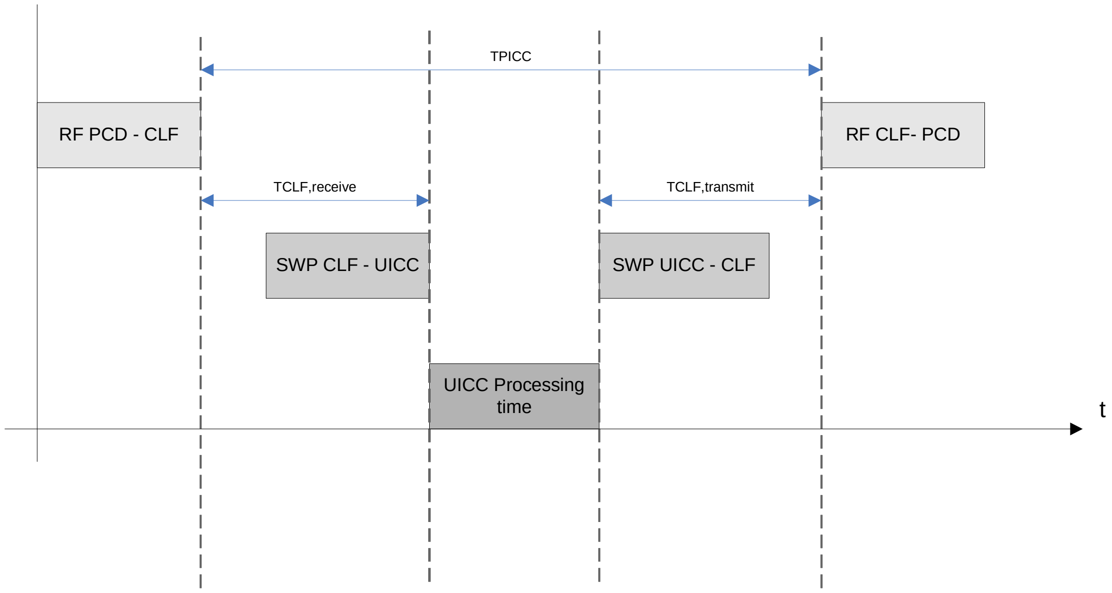
$$T_{CLF,delay} = T_{CLF,receive} + T_{CLF,transmit}$$

The maximum values for both $T_{CLF,receive}$ and $T_{CLF,transmit}$ are calculated as:

$$T_{CLF,receive} = 100\ \mu s + (15\ \mu s \text{ per byte of RF data})$$

$$T_{CLF,transmit} = 100\ \mu s + (15\ \mu s \text{ per byte of RF data})$$

This gives a maximum value of 100 + (29 x 15) μs = 535 μs.



NOTE: *SWP CLF-UICC* and *SWP UICC-CLF* represent the time taken to transmit the data over SWP and are included in the $T_{CLF,receive}$ and $T_{CLF,transmit}$ times.

Figure 12.6: CLF transmission timings

The CLF and UICC should take care to ensure that processing delays do not comprise overall transactions times of commands and ensure that response timeslots can be achieved.

NOTE: In the diagram above TPICC represents a time equivalent to the total processing time of a Contactless card and is used to demonstrate the relationship between a card emulated by a CLF/UICC pair and a real card.

Using the above diagram and the example of a typical ISO/IEC 14443 type A read command where the command from the PCD is 2 bytes long plus a CRC and the response is 16 bytes long plus a CRC then we would see:

$T_{CLF,receive} = 160\ \mu s$

$T_{CLF,transmit} = 370\ \mu s$

TPICC =160 μs + 370 μs = 530 μs plus the processing time of the UICC

12.2.4 Timing value for the CLF processing delay (Request Guard Time)

If the CLF receives from the PCD a REQA or WUPA, the Request Guard Time (ISO/IEC 14443-3 [3]) has to be respected. The maximum value for $T_{CLF,delay}$ is:

$$T(max)_{CLF,delay} = 180\mu s$$

NOTE: UICC and a CLF operating in CLT may be in the states ACTIVE or ACTIVE* (named as PICC states in ISO/IEC 14443-3 [3]). A REQA/WUPA sent by the PCD will force a transition to the PICC states IDLE or HALT (with no response from the CLF to the PCD). A subsequent REQA/WUPA will restart the collision resolution process. In some implementations, the PCD deliberately forces this error condition in order to exit the authenticated state of the PICC.

Annex A (informative): CLT Protocol Operation flowcharts

The followings flowcharts are given for typical Use Cases.

A.1 Example Flowchart for the UICC

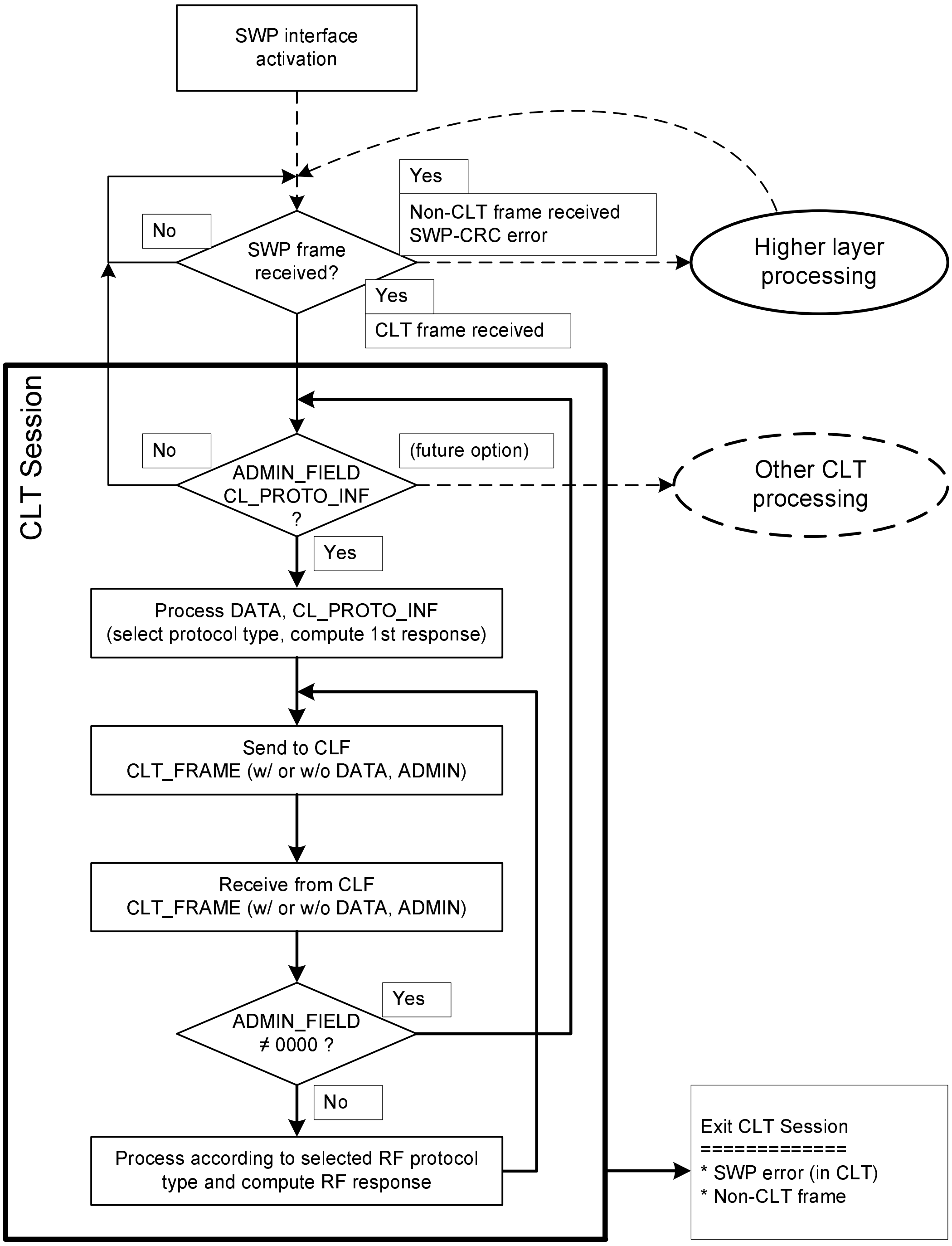


Figure A.1

A.2 Example Flowchart for the CLF

This example contains details for ISO/IEC 14443-3 [3] Type A based RF protocol initialization.

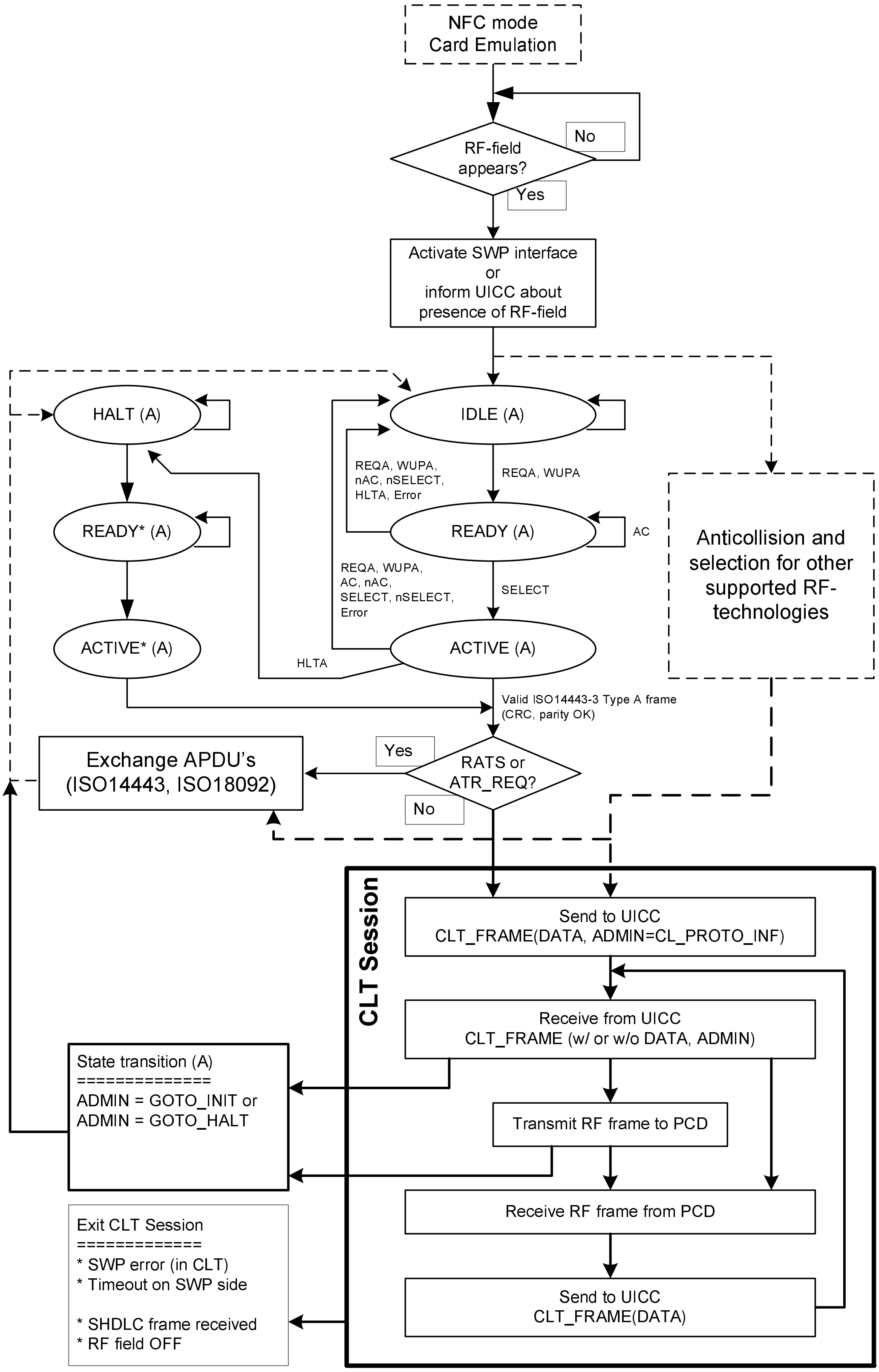


Figure A.2

History

Document history		
V7.0.0	November 2007	Publication