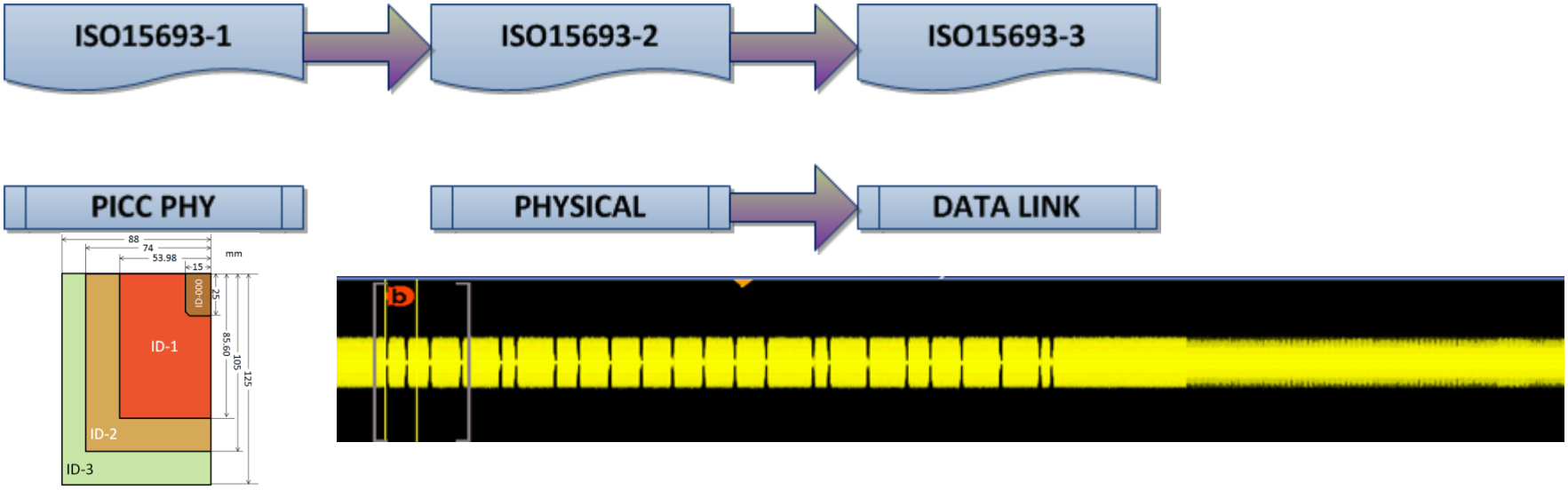
ISO15693

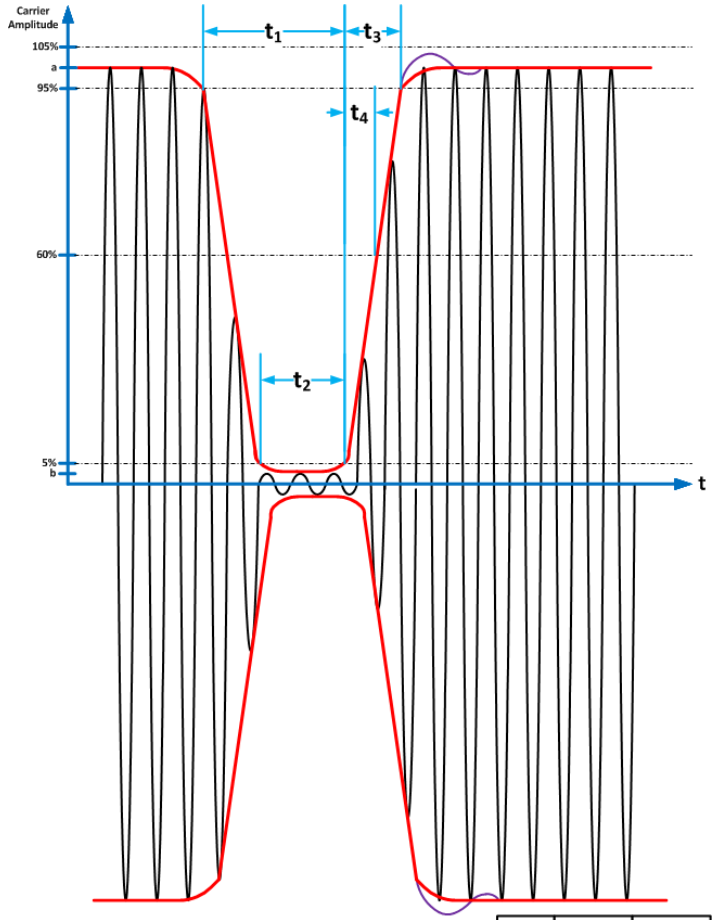
HF RFID ISO Standards Overview (cont.)

- **ISO/IEC 15693** is primarily used for **V**icinity Applications
  - Access Control, Asset Tracking, Portable Data Storage, etc.
  - ISO15693 is logically divided into 3 parts
    - ISO15693-1 : Physical Characteristics of Cards (**V**ICCs)
    - ISO15693-2 : Air Interface and Initialization
    - ISO15693-3 : Anti-Collision and Transmission Protocol
  - **NOTE**: ISO/IEC 18000-3 is medical application version of ISO15693



ISO15693-2

- **Air Interface Protocol – Downlink**
  - Uses either 100% or 10-30% Amplitude Shift Key (ASK) for PCD to PICC (downlink)

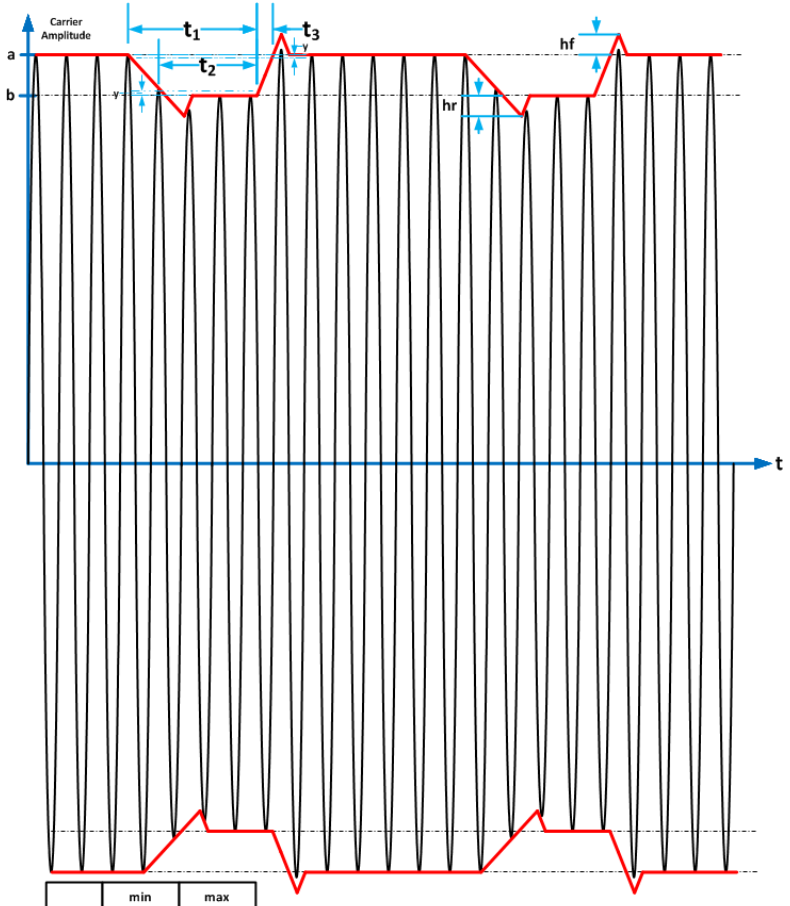


The clock recovery must be operational after t_4 max

NOTE: CARRIER WAVE IS ACTUALLY 13.56MHz, REPRESENTED HERE JUST AS SINE WAVE TO SHOW TYPE OF SIGNAL

	min (uSec)	max (uSec)
t_1	6.0	9.44
t_2	2.1	t_1
t_3	0	4.5
t_4	0	0.8

Figure 1 – Modulation of the carrier for 100% ASK



	min	max
t_1	6.0 uSec	9.44 uSec
t_2	3.0 uSec	t_1
t_3	0	4.5 uSec
MOD INDEX	10%	30%

γ	0.05 (a – b)
hf, hr	0.1 (a – b) max

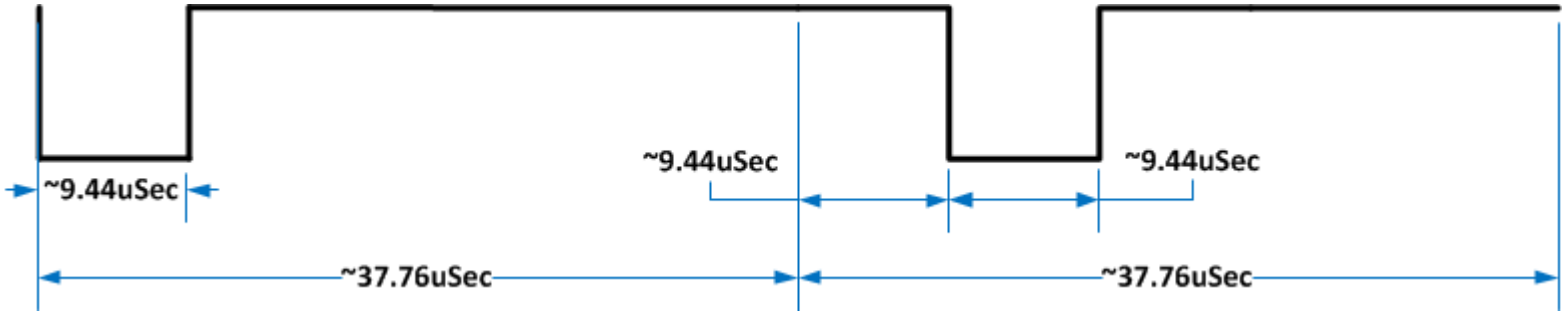
NOTE: CARRIER WAVE IS ACTUALLY 13.56MHz, REPRESENTED HERE JUST AS SINE WAVE TO SHOW TYPE OF SIGNAL

The VICC shall be operational for any value of modulation index between 10% and 30%

Figure 2 – Modulation of the carrier for 10% ASK

ISO15693-2
Important Timings (Downlink)

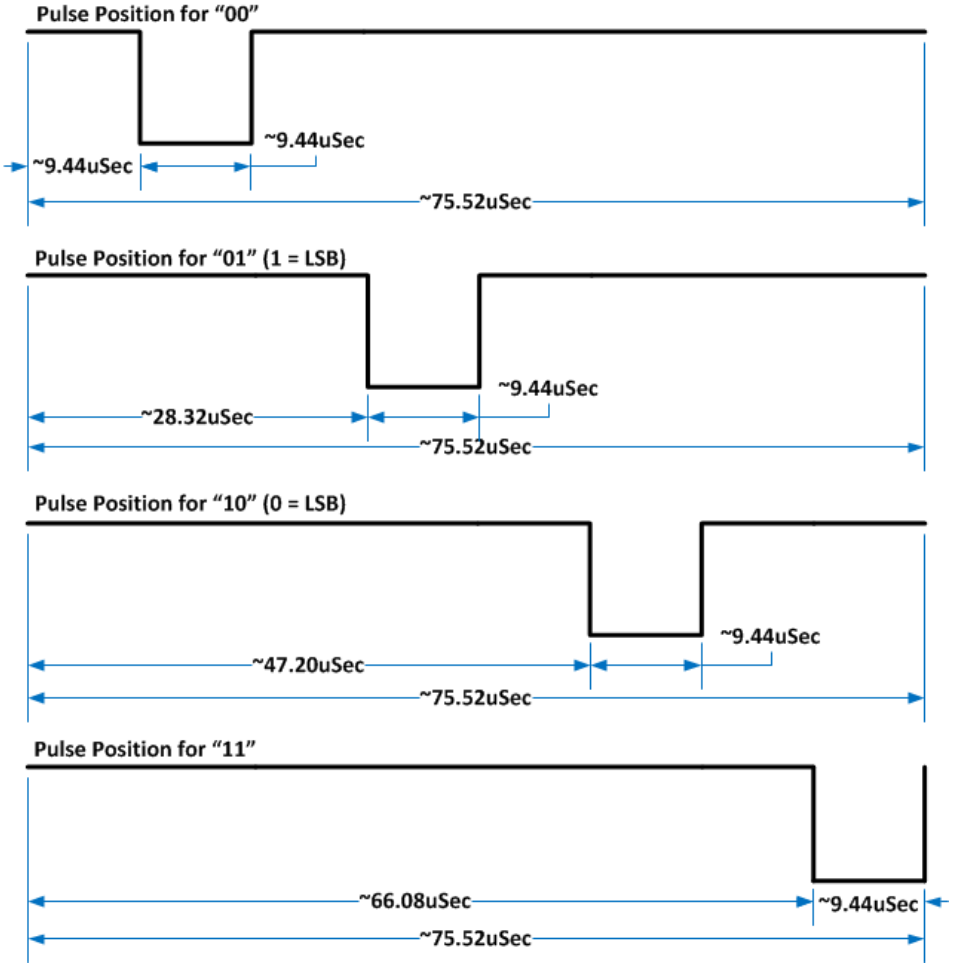
- Start of Frame (SOF)



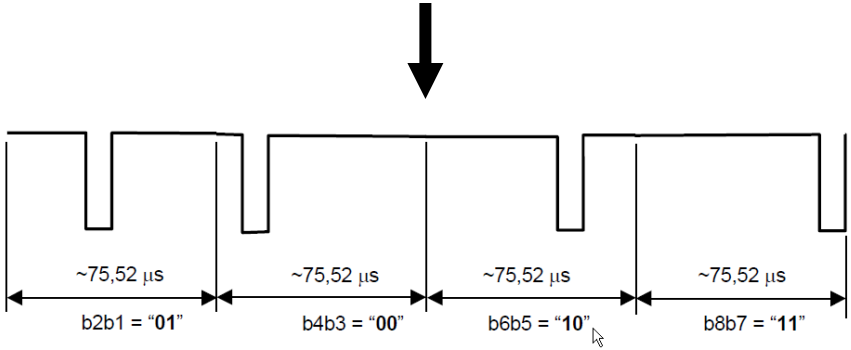
- End of Frame (EOF)

ISO15693-2
Important Downlink Timings (cont.)

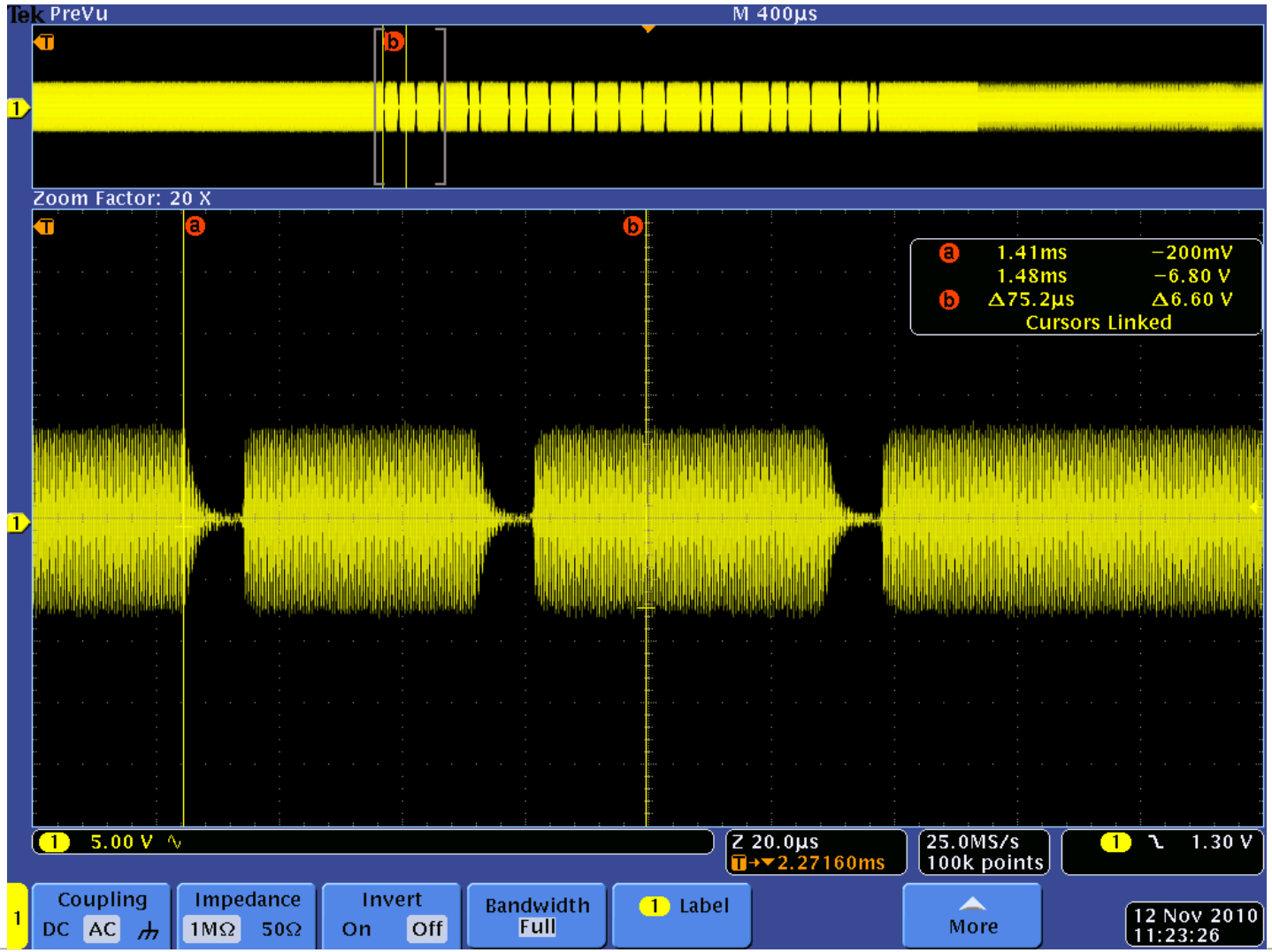
- **Symbols 00, 01, 10, 11**
  - Pulse Position Modulation Technique is used here, where the position determines two bits at a time.



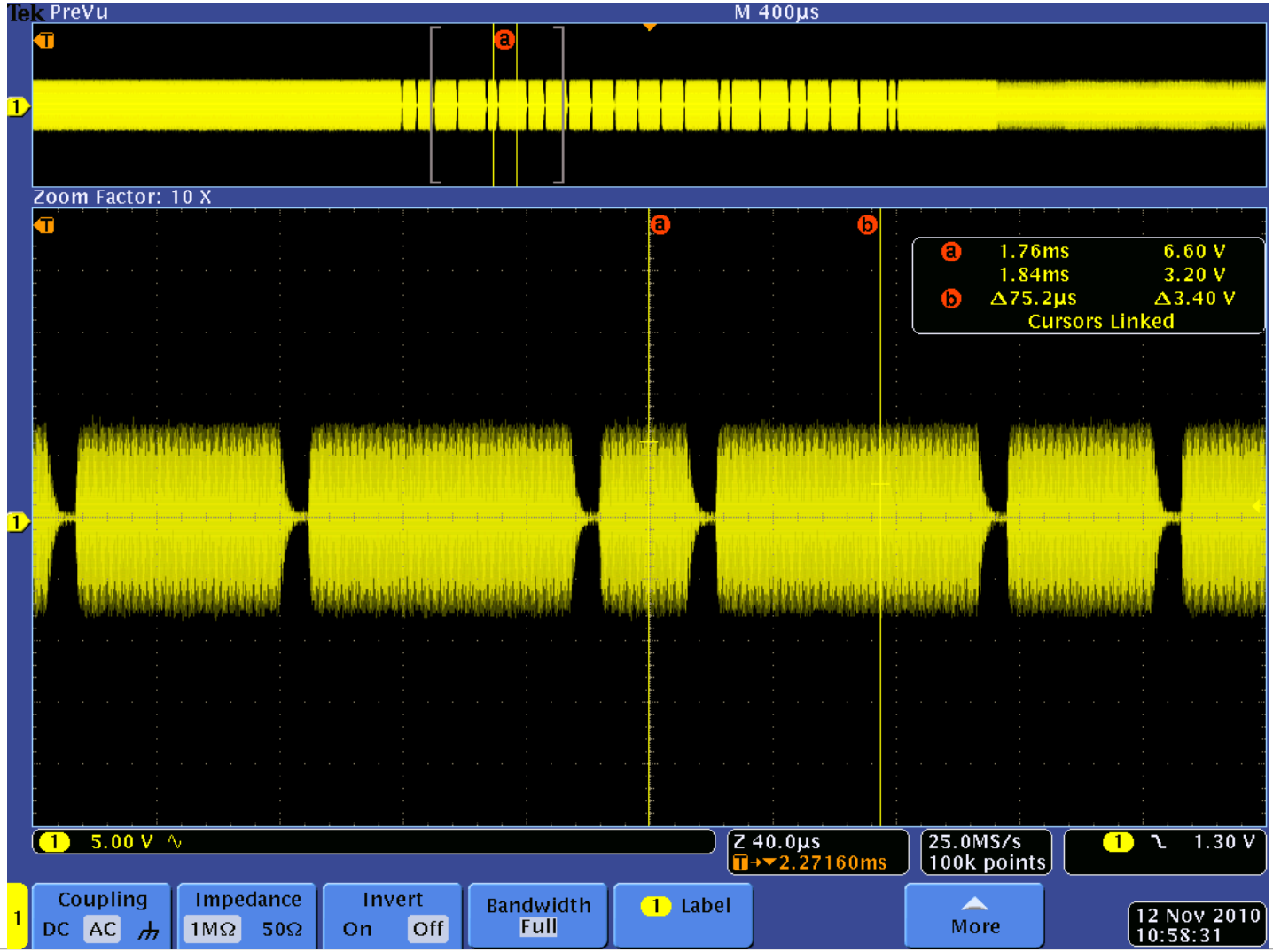
This is showing one complete byte (0xE1) for transmission



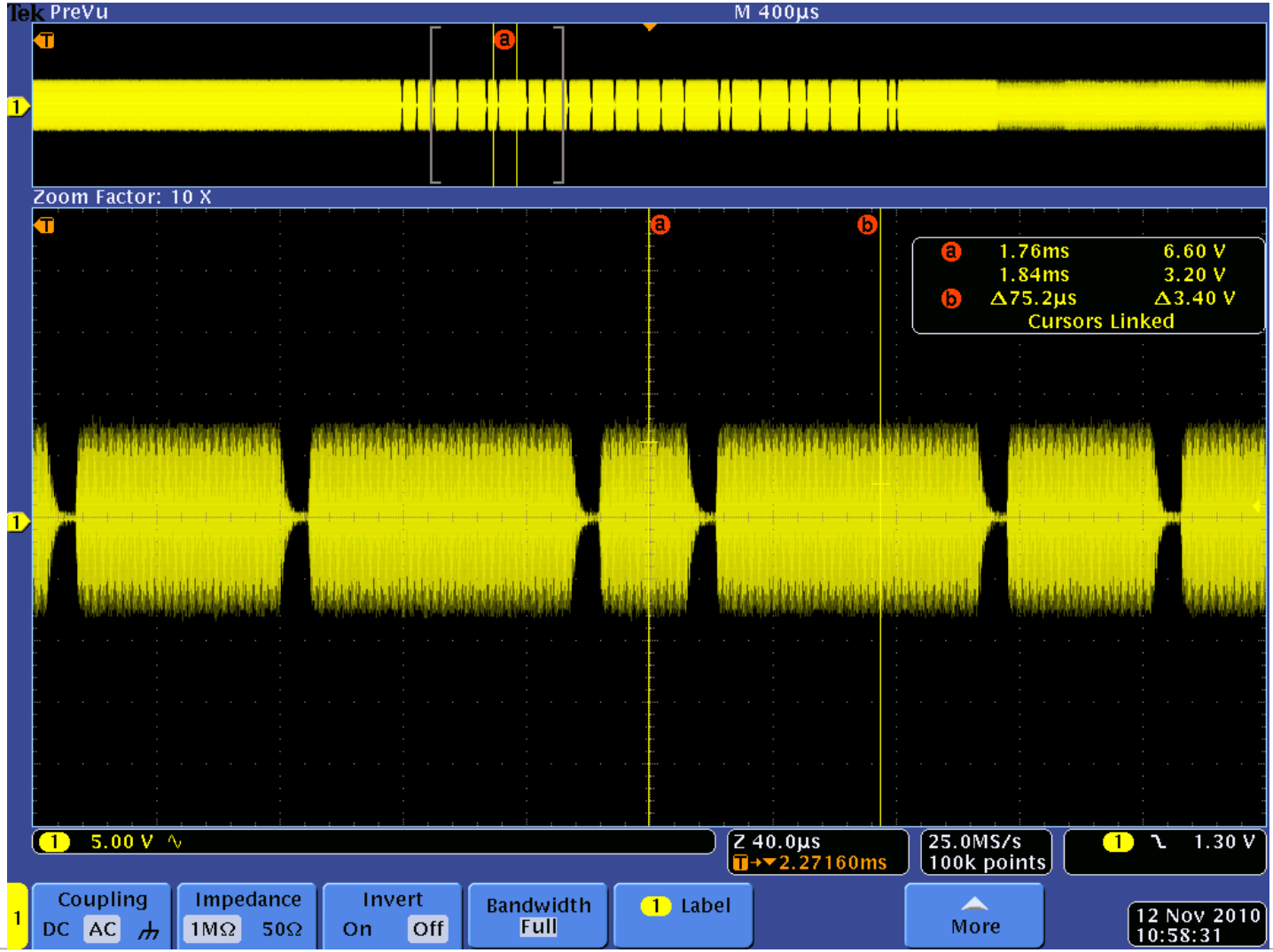
ISO15693 Downlink Start of Frame (SOF)



ISO15693 Downlink Symbol 00

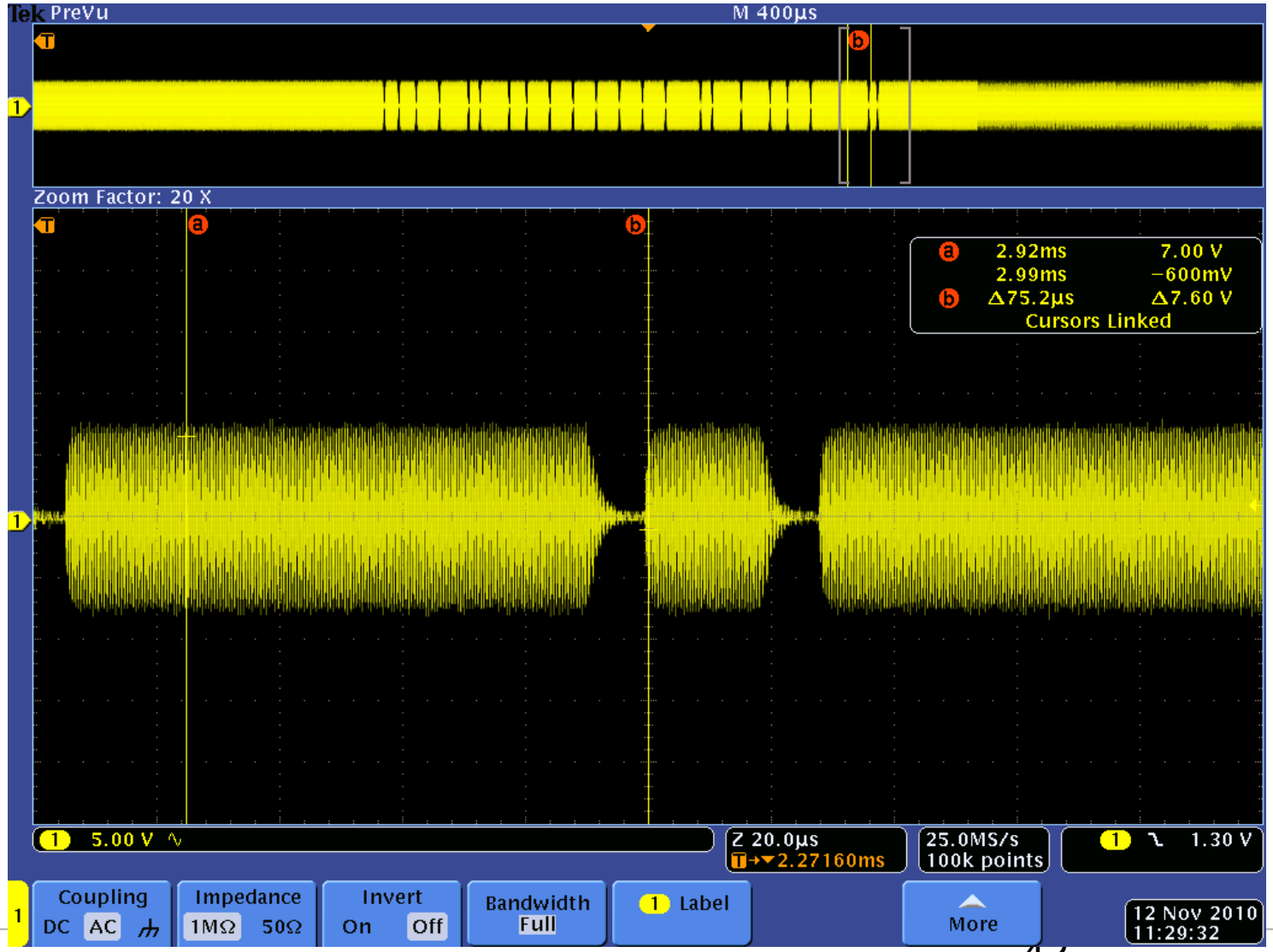


ISO15693 Downlink Symbol 01

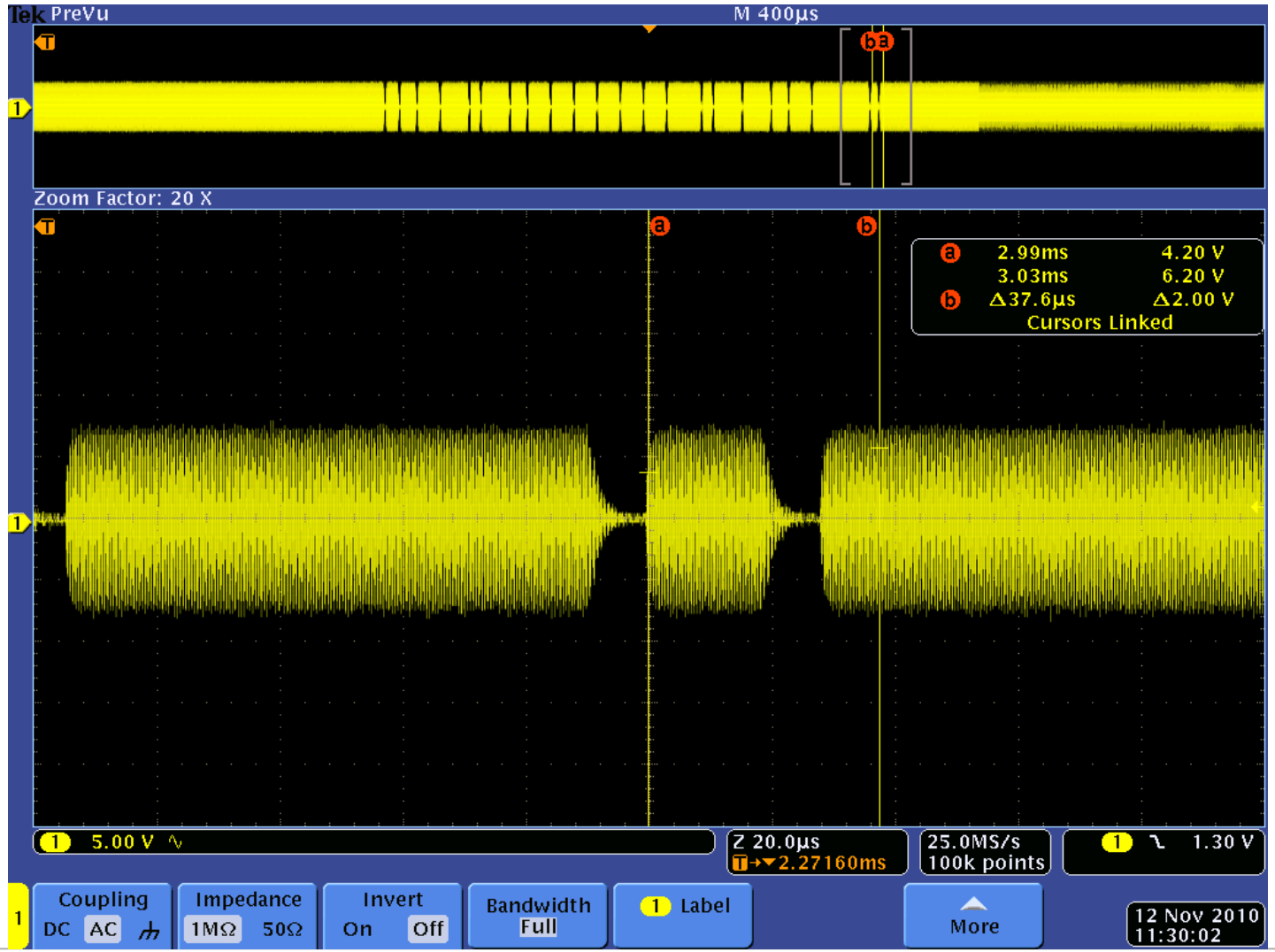


ISO15693 Downlink Symbol 10

ISO15693 Downlink Symbol 11



ISO15693 Downlink End of Frame (EOF)



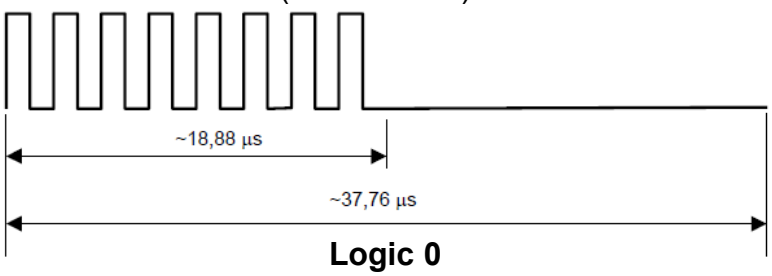
ISO15693-2

- **Air Interface Protocol –**
  - PICC to PCD communications uses load modulation and one or two subcarriers may be used as selected by the VCD using the first bit in the protocol header as defined in ISO/IEC 15693-3. The VICC shall support both modes.
- When one subcarrier is used, the frequency of the subcarrier load modulation will be *fc*/32 (423.75kHz).
- When two subcarriers are used, the frequency f_1 shall be *fc*/32 (423.75kHz), and the frequency f_2 shall be *fc*/28 (484.28kHz).
- If two subcarriers are present there shall be a continuous phase relationship between them.
- **Data rates –**
  - A low or high data rate may be used. The selection of the data rate shall be made by the VCD using the second bit in the protocol header as defined in ISO/IEC 15693-3. The VICC shall support the data rates shown below.

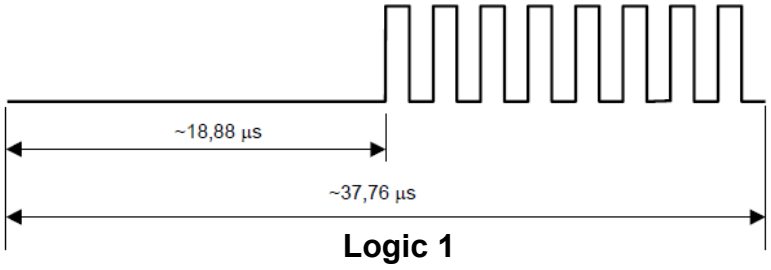
Data Rate	Single Subcarrier	Dual Subcarrier
Low	6,62 kbits/s (f_c/2048)	6,67 kbits/s (f_c/2032)
High	26,48 kbits/s (f_c/512)	26,69 kbits/s (f_c/508)

ISO15693-2

- **Data Encoding –**
  - Data shall be encoded using Manchester coding, according to the following schemes. All timings shown refer to the high data rate from the VICC to the VCD.
    - When using one subcarrier:
      - » A logic 0 starts with 8 pulses of *fc*/32 (~423.75kHz) followed by an unmodulated time of 256/*fc* (~18.88µSec)
      - » A logic 1 starts with an unmodulated time of 256/*fc* (~18.88µs) followed by 8 pulses of *fc*/32 (~423.75kHz)

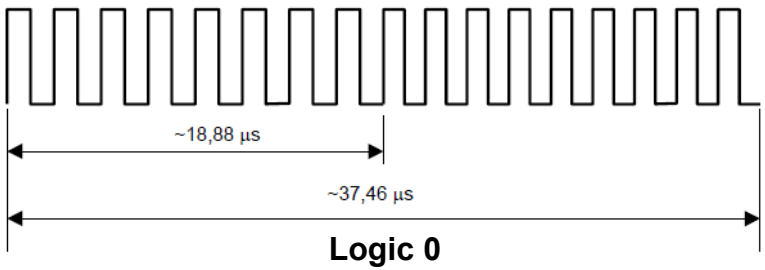


Logic 0

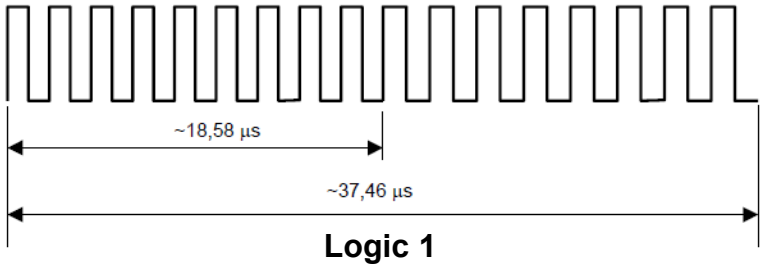


Logic 1

    - When using two subcarriers:
      - » A logic 0 starts with 8 pulses of *fc*/32 (~423.75kHz) followed by 9 pulses of *fc*/28 (~484.28kHz)
      - » A logic 1 starts with 9 pulses of *fc*/28 (~484.28kHz) followed by 8 pulses of *fc*/32 (~423.75kHz)



Logic 0



Logic 1

ISO15693-3

- **ISO15693 General Command Request Format:**

SOF	Flags	Command code	Parameters	Data	CRC	EOF

- The Request Flags are just as important as the command codes in ISO15693-3. The Request Flags are defined in Tables 3, 4 and 5 of the ISO15693-3 standard. Anyone who is using this standard will need to become familiar / friendly with these tables!

Table 3

Bit	Flag name	Value	Description
b1	Sub-carrier_flag	0	A single sub-carrier frequency shall be used by the VICC
		1	Two sub-carriers shall be used by the VICC
b2	Data_rate_flag	0	Low data rate shall be used
		1	High data rate shall be used
b3	Inventory_flag	0	Flags 5 to 8 meaning is according to table 4
		1	Flags 5 to 8 meaning is according to table 5
b4	Protocol Extension_flag	0	No protocol format extension
		1	Protocol format is extended. Reserved for future use

Table 4

Bit	Flag name	Value	Description
b5	Select_flag	0	Request shall be executed by any VICC according to the setting of Address_flag
		1	Request shall be executed only by VICC in selected state. The Address_flag shall be set to 0 and the UID field shall not be included in the request.
b6	Address_flag	0	Request is not addressed. UID field is not included. It shall be executed by any VICC.
		1	Request is addressed. UID field is included. It shall be executed only by the VICC whose UID matches the UID specified in the request.
b7	Option_flag	0	Meaning is defined by the command description. It shall be set to 0 if not otherwise defined by the command.
		1	Meaning is defined by the command description.
b8	RFU	0	

Table 5

Bit	Flag name	Value	Description
b5	AFI_flag	0	AFI field is not present
		1	AFI field is present
b6	Nb_slots_flag	0	16 slots
		1	1 slot
b7	Option_flag	0	Meaning is defined by the command description. It shall be set to 0 if not otherwise defined by the command.
		1	Meaning is defined by the command description.
b8	RFU	0	

ISO15693-3

- **ISO15693 Command Set**:

Command code	Type	Function
'01'	Mandatory	Inventory
'02'	Mandatory	Stay quiet
'03' – '1F'	Mandatory	RFU
'20'	Optional	Read single block
'21'	Optional	Write single block
'22'	Optional	Lock block
'23'	Optional	Read multiple blocks
'24'	Optional	Write multiple blocks
'25'	Optional	Select
'26'	Optional	Reset to ready
'27'	Optional	Write AFI
'28'	Optional	Lock AFI
'29'	Optional	Write DSFID
'2A'	Optional	Lock DSFID
'2B'	Optional	Get system information
'2C'	Optional	Get multiple block security status
'2D' – '9F'	Optional	RFU
'A0' – 'DF'	Custom	IC Mfg dependent
'E0' – 'FF'	Proprietary	IC Mfg dependent

ISO15693-3

- **Formulating ISO15693 Command Examples with Request Flags detail**:
- Implementing the Inventory Command, which uses Tables 3 & 5

FLAGS	COMMAND CODE	PARAMETER
0x26	0x01	0x00
0010 0110	Inventory	MASK LENGTH

Table 5	Table 3
B5 = 0 (no AFI)	B1 = 0 (single subcarrier)
B6 = 1 (1 slot)	B2 = 1 (high tag DR)
B7 = 0 (no option)	B3 = 1 (Table 5)
B8 = 0 (RFU)	B4 = 0 (no protocol ext.)

- Implementing the Read Single Block Command, which uses Tables 3 & 4

FLAGS	COMMAND CODE	PARAMETER
0x02	0x20	0x00 : 0x3F
00000010	Read Single Block	Block #

Table 4	Table 3
B5 = 0 (not selected)	B1 = 0 (single subcarrier)
B6 = 0 (unaddressed)	B2 = 1 (high tag DR)
B7 = 0 (no option)	B3 = 0 (Table 4)
B8 = 0 (RFU)	B4 = 0 (no protocol ext.)

ISO15693-3 Anti-Collision

- **Explanation of an anti-collision sequence**:
- The following text and figure summarizes the main cases that can occur during a typical anti-collision sequence where the number of slots is 16. The different steps are:
  a) The VCD sends an inventory request, in a frame, terminated by an EOF. The number of slots is 16.
  b) VICC 1 transmits its response in slot 0. It is the only one to do so, therefore no collision occurs and its UID is received and registered by the VCD
  c) The VCD sends an EOF, meaning to switch to the next slot.
  d) In slot 1, two VICCs 2 and 3 transmits their response, this generates a collision. The VCD detects it and remembers that a collision was detected in slot 1.
  e) The VCD sends an EOF, meaning to switch to the next slot.
  f) In slot 2, no VICC transmits a response. Therefore the VCD does not detect a VICC SOF and decides to switch to the next slot by sending a EOF.
  g) In slot 3, there is another collision caused by responses from VICC 4 and 5
  h) The VCD then decides to send an addressed request (for instance a Read Block) to VICC 1, which UID was already correctly received.
  i) All VICCs detect a SOF and exit the anti-collision sequence. They process this request and since the request is addressed to VICC 1, only VICC1 transmit its response.
  j) All VICCs are ready to receive another request. If it is an inventory command, the slot numbering sequence restarts from 0.

  NOTE: The decision to interrupt the anti-collision sequence is up to the VCD. It could have continued to send EOF's till slot 15 and then send the request to VICC 1.

ISO15693-3 Anti-Collision

- **ISO15693 Anti-collision Flow**: