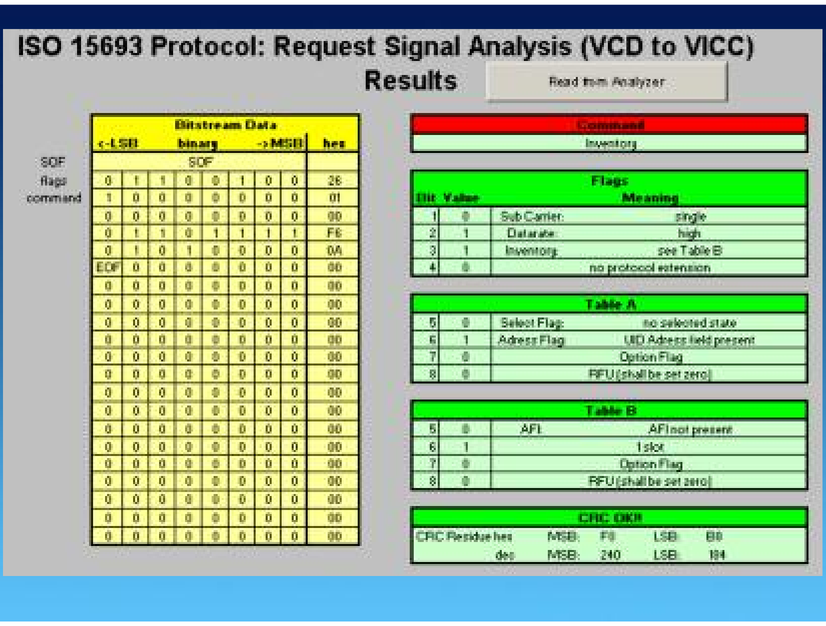


ISO 15693 Protocol: Request Signal Analysis (VCD to VICC)

Results

	Bitstream Data								
	<-LSB			binary				->MSB	hex
SOF	SOF								
flags	0	1	1	0	0	1	0	0	26
command	1	0	0	0	0	0	0	0	01
	0	0	0	0	0	0	0	0	00
	0	1	1	0	1	1	1	1	F6
	0	1	0	1	0	0	0	0	0A
	EOF	0	0	0	0	0	0	0	00
	0	0	0	0	0	0	0	0	00
	0	0	0	0	0	0	0	0	00
	0	0	0	0	0	0	0	0	00
	0	0	0	0	0	0	0	0	00
	0	0	0	0	0	0	0	0	00
	0	0	0	0	0	0	0	0	00
	0	0	0	0	0	0	0	0	00
	0	0	0	0	0	0	0	0	00
	0	0	0	0	0	0	0	0	00
	0	0	0	0	0	0	0	0	00
	0	0	0	0	0	0	0	0	00
	0	0	0	0	0	0	0	0	00
	0	0	0	0	0	0	0	0	00
	0	0	0	0	0	0	0	0	00
	0	0	0	0	0	0	0	0	00

Command
Inventory

Flags			
Bit	Value	Meaning	
1	0	Sub Carrier:	single
2	1	Datarate:	high
3	1	Inventory:	see Table B
4	0		no protocol extension

Table A			
5	0	Select Flag:	no selected state
6	1	Adress Flag	UID Adress field present
7	0		Option Flag
8	0		RFU (shall be set zero)

Table B			
5	0	AFI:	AFI not present
6	1		1 slot
7	0		Option Flag
8	0		RFU (shall be set zero)

CRC OK!!						
CRC Residue	hex	MSB:	F0	LSB:	B8	
	dec	MSB:	240	LSB:	184	

Products: R&S Signal Generator, R&S Signal Analyzer

Generation and Analysis of RFID Signals According to ISO 15693

Application Note

This application note describes how to generate test signals for 13.56 MHz RFID modules according to ISO 15693 with R&S®Signal Generators and analyze them with R&S®Signal Analyzers using software R&S®WinIQSIM™…

ROHDE&SCHWARZ

Contents

1. Overview

This paper details the generation and measurement of an RFID signal according to ISO standard ISO15693. This first chapter summarizes important PHY features of this signal. More information on the data coding is given in Appendix B. Please refer to the ISO15693 standard for more in-depth information. Tables and pictures are taken from the ISO15693 stadard.

In the following VCD (vicinity coupling device) refers to the reader/writer device and the VICC (vicinity integrated circuit card) refers to the RFID card or module.

1.1. Frequency

The frequency (f_c) of the RF operating field is 13,56 MHz ±7 kHz.

1.2. Power Transfer to VICC

Power transfer to the VICC is accomplished by radio frequency via coupling antennas in the VCD and in the VICC. The RF operating field that supplies power to the VICC from the VCD is modulated for communication. In order to power up the VICC, the CW RF operating field of the VCD is present before and after the communication.

1.3. Communication from VCD to VICC

1.3.1. Modulation Type

Modulation type is ASK (Amplitude Shift Keying). Possible Modulation Indices are 10% and 100%.

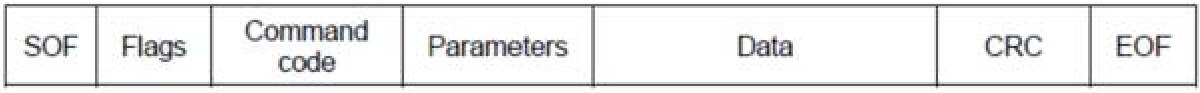
1.3.2. Data Coding

For a description of the data coding, please refer to the standard ISO15693. A summary is given in appendix B.

1.3.3. Data Frames

Communication data is organized in frames. A frame starts with a start-of-frame (SOF) sequence and ends with an end-of-frame (EOF) sequence.

The communication payload consists of flags, command codes, facultative parameters and data. A 16-bit CRC checksum is added to the payload.



SOF	Flags	Command code	Parameters	Data	CRC	EOF

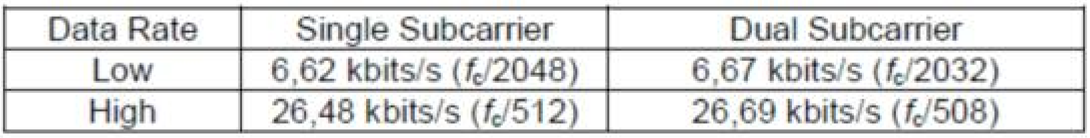
Figure 4 — General request format

1.4. Communication from VICC to VCD

1.4.1. Modulation Type

Modulation type is load modulation, i.e. the VICC generates one or two subcarriers to the RF operating field from the VCD. The number of subcarriers is defined by the request command. In the case of single carrier operation, the RF frequency of the subcarrier is (f_c+f_c/32) = 13.98375 MHz. In the case of two subcarriers, the additional subcarrier has the RF frequency of (f_c+f_c/28) = 14.044286 MHz.

Two datarates, low or high, are possible. The datarate is defined by the request command. The following table shows the possible datarates.



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)

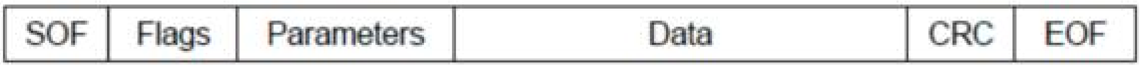
Table 1: Data rates

1.4.2. Data coding

Data coding is done by Manchester coding. For a description of the data coding, please refer to the standard ISO15693. A summary is given in appendix B.

1.4.3. VICC to VCD frames

The response from the VICC to the VCD consists of start of frame sequence, flags, facultative parameters and data (containing e.g. the UID). A 16 bit CRC checksum is appended to the data bits, followed by an end of frame sequence.



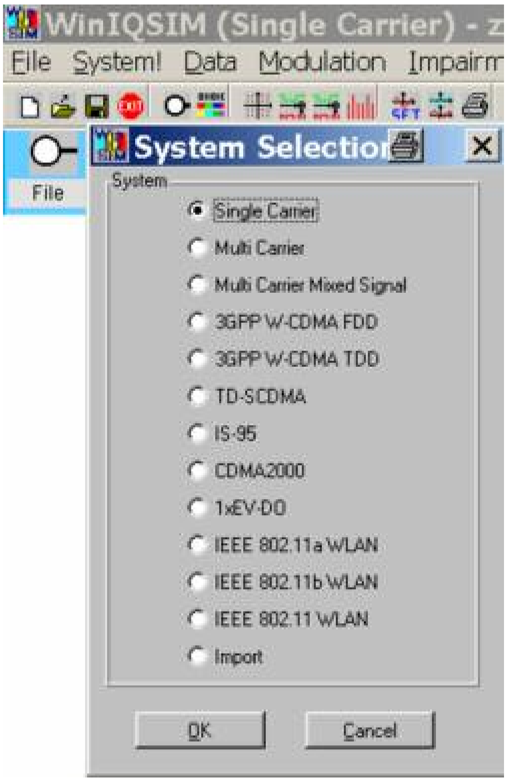
SOF	Flags	Parameters	Data	CRC	EOF

Figure 5 — General response format

2. Signal Generation

2.1. WinIQSIM™ Setup for VCD to VICC communication

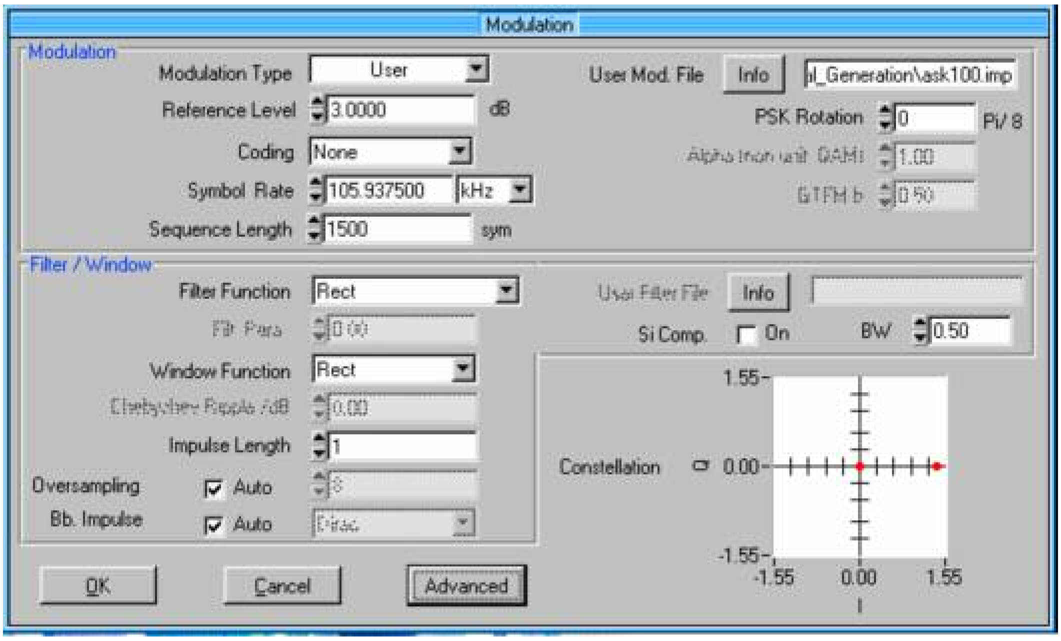
2.1.1. Setup WinIQSIM™ for Single Carrier Operation



System

- ● Single Carrier
- ○ Multi Carrier
- ○ Multi Carrier Mixed Signal
- ○ 3GPP W-CDMA FDD
- ○ 3GPP W-CDMA TDD
- ○ TD-SCDMA
- ○ IS-95
- ○ CDMA2000
- ○ 1xEV-DO
- ○ IEEE 802.11a WLAN
- ○ IEEE 802.11b WLAN
- ○ IEEE 802.11 WLAN
- ○ Import

2.1.2. Settings in the Modulation Panel



Modulation

Modulation Type: User

Reference Level: 3.0000 dB

Coding: None

Symbol Rate: 105.937500 kHz

Sequence Length: 1500 sym

User Mod. File: Info l_Generation\ask100.imp

PSK Rotation: 0 Pi/ 8

Alpha (non unit QAM): 1.00

GTFM b: 0.50

Filter / Window

Filter Function: Rect

Filt Para: 0.00

Window Function: Rect

Chebyshev Ripple /dB: 0.00

Impulse Length: 1

Oversampling ☑ Auto 8

Bb. Impulse ☑ Auto Dirac

User Filter File: Info

Si Comp. □ On

BW 0.50

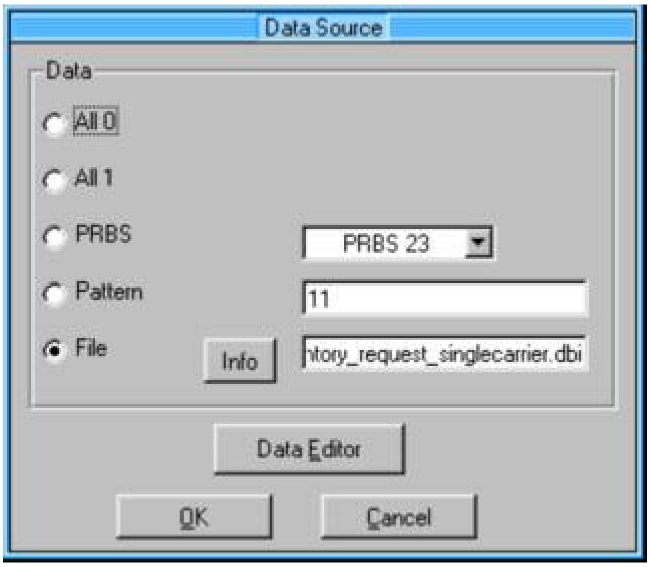
Modulation Type =ASK, either 100% or 10%. This modulation is not available as standard, but a user defined modulation can be used. Please refer to the annex (Chapter 8) for instructions on how to create user modulation files. The files for 100% ASK and 10% ASK are supplied with this application note.

Symbol Rate = 105.9375 kHz (this corresponds to the duration of the “off” period for the 1 out of 4 modulation type.

Sequence length is variable. If the data editor is used (see next chapter), then the sequence length is set automatically

Filter function = rectangle. The standard does not define any pulse shaping.

2.1.3. Settings in the Data Panel



Data Source

Data

○ All 0

○ All 1

○ PRBS PRBS 23

○ Pattern 11

● File ntory_request_singlecarrier.dbi

For a correctly framed operation, a datafile which contains the correct bit settings including the preamble information etc. has to be uploaded. Also, the datafile has to contain the information for the CW carrier before and after the payload information.

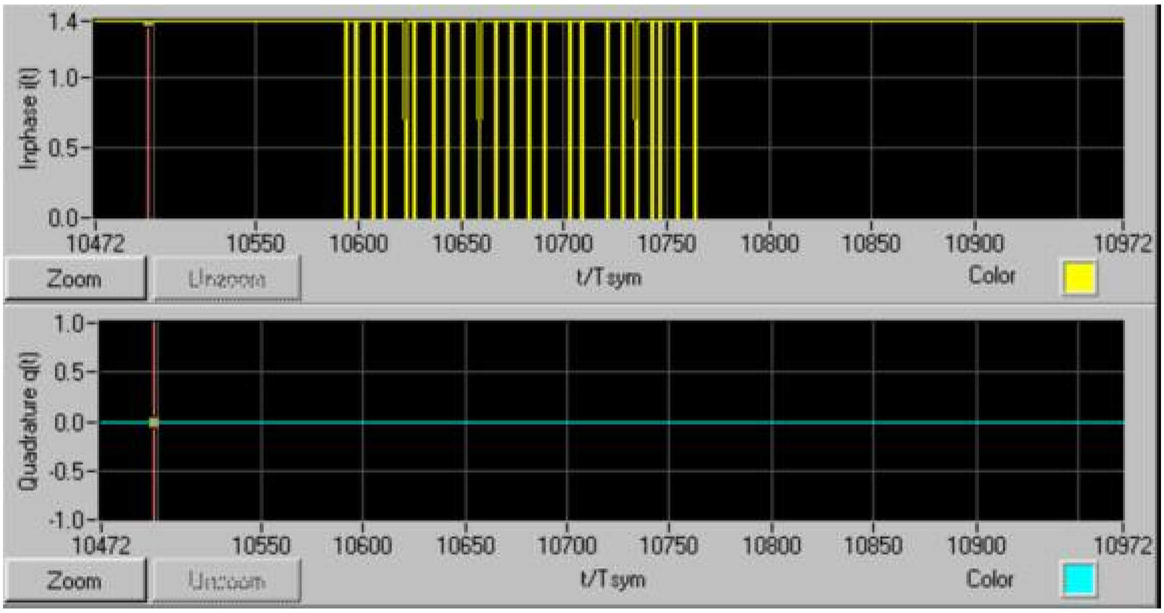
Check “File” and select a predefined datafile (*.dbi file). RFID Datafiles according to ISO15693 can be created with WinIQSIM™ using the Data Editor in the Data Panel. For a description please see Chapter 7.3.

The following screenshots show the inphase (I) and quadrature (Q) component of the created RFID signal.

It can be seen the that the quadrature component is non existent. The used ASK modulation only modulates the (real) amplitude with a constant phase. Only the inphase component carries the information.

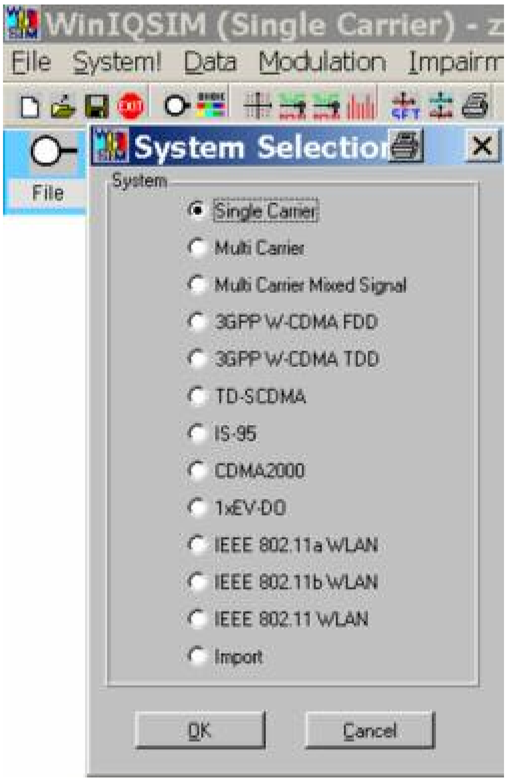
It can also be seen that before and after the payload information, the inphase component is a constant “high”. A high means that the carrier is transmitted at full amplitude, i.e. a CW carrier is transmitted.

The payload information shows an alternation between high (carrier on) and low (carrier off).



2.2. WinIQSIM™ Setup for VICC to VCD communication

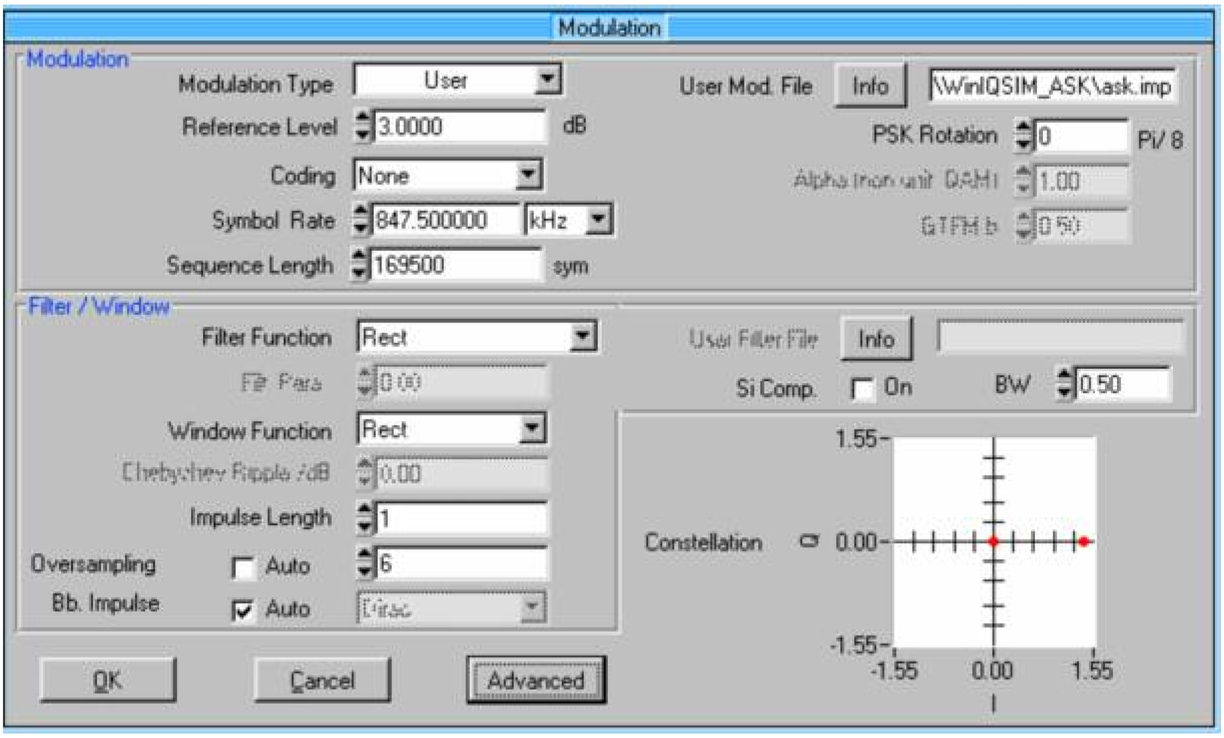
2.2.1. Setup WinIQSIM™ for Single Carrier Operation



System

- ● Single Carrier
- ○ Multi Carrier
- ○ Multi Carrier Mixed Signal
- ○ 3GPP W-CDMA FDD
- ○ 3GPP W-CDMA TDD
- ○ TD-SCDMA
- ○ IS-95
- ○ CDMA2000
- ○ 1xEV-DO
- ○ IEEE 802.11a WLAN
- ○ IEEE 802.11b WLAN
- ○ IEEE 802.11 WLAN
- ○ Import

2.2.2. Settings in the Modulation Panel



Modulation Type: User
Reference Level: 3.0000 dB
Coding: None
Symbol Rate: 847.500000 kHz
Sequence Length: 169500 sym
User Mod. File: Info \WinIQSIM_ASK\ask.imp
PSK Rotation: 0 Pi/ 8
Alpha (non unit QAM): 1.00
GTFM b: 0.50
Filter Function: Rect
Filt Para: 0.00
Window Function: Rect
Chebychev Ripple /dB: 0.00
Impulse Length: 1
Oversampling: □ Auto 6
Bb. Impulse: ☑ Auto Dirac
User Filter File: Info
Si Comp. □ On
BW: 0.50

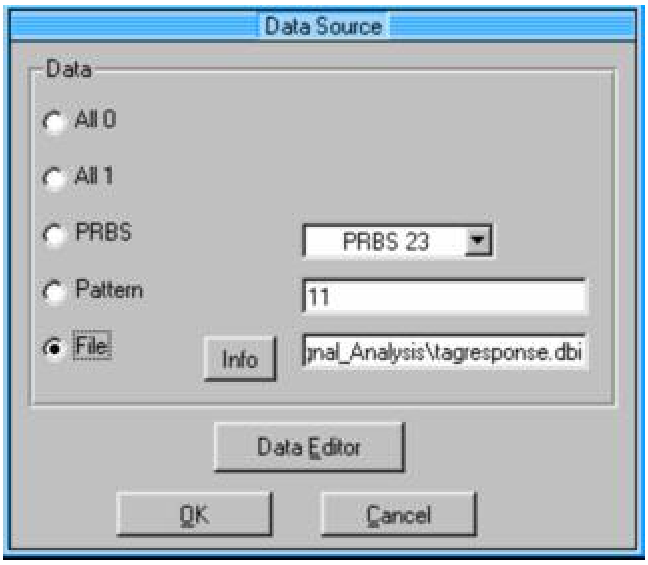
Modulation Type = ASK, either 100% or 10%. This modulation is not available as standard, but a user defined modulation can be used. Please refer to the annex (Chapter 8) for instructions on how to create user modulation files. The files for 100% ASK ans 10% ASK are supplied with this application note.

Symbol Rate = 847.5 kHz. This corresponds to one pulse during the response sequence. 32 such pulses form one response bit.

Sequence length is variable. If the data editor is used (see next chapter), then the sequence length is set automatically

Filter function = rectangle. The standard does not define any pulse shaping.

2.2.3. Settings in the Data Panel



Data Source

Data

○ All 0

○ All 1

○ PRBS PRBS 23

○ Pattern 11

● File gnal_Analysis\tagresponse.dbi

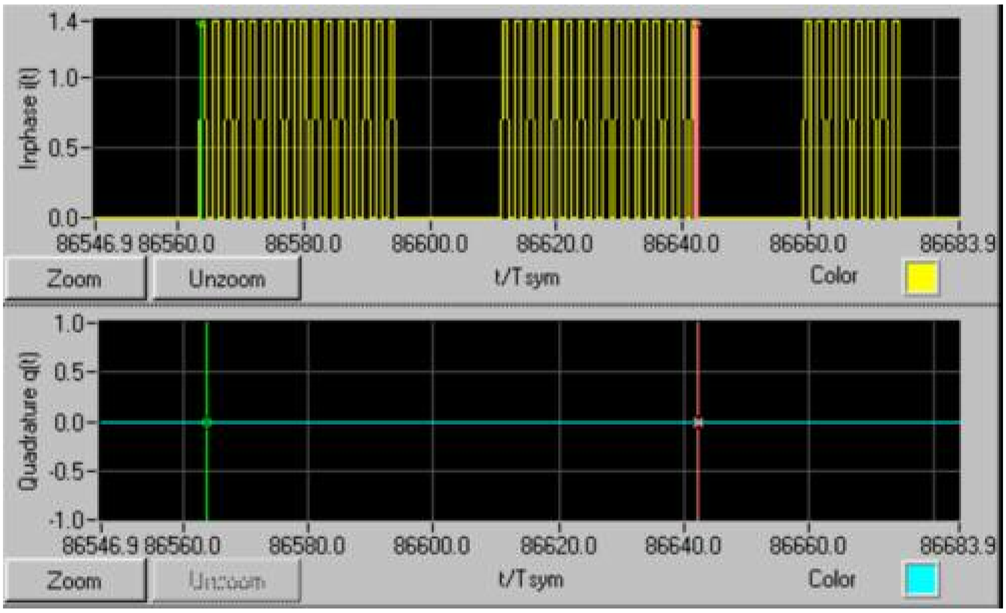
For a correctly framed operation, a datafile which contains the correct bit settings including the preamble information etc. has to be uploaded.

Check “File” and select a predefined datafile (*.dbi file). RFID Datafiles according to ISO15693 can be created with WinIQSIM™ using the Data Editor in the Data Panel. For a description please see chapter 7.4.

The following screenshots show the inphase (I) and quadrature (Q) component of the created RFID signal.

It can be seen the that the quadrature component is non existent. The used load modulation only modulates the (real) amplitude with a constant phase. Only the inphase component carries the information.

The payload information shows an alternation between high (carrier on) and low (carrier off). 8 consecutive pulses of total length 18.88 µs, followed by a blank of 18.88 µs show a databit “0”. A blank of 18.88 µs followed by 8 pulses of 18.88 µs show a databit “1”

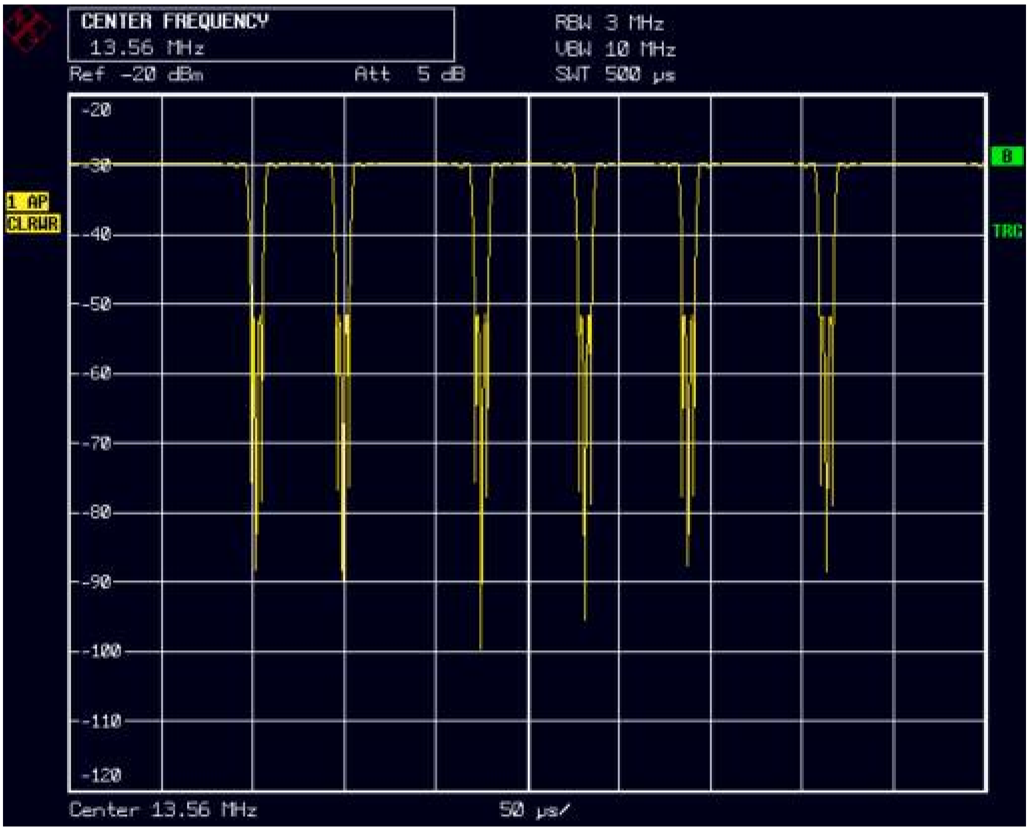


3. Signal Analysis

3.1. Analysis of Request Signal VCD to VICC

3.1.1. Analysis with Spectrum Analyzer in Zerospan

Connect the Signal Source, e.g. R&S SMJ100A, to the Spectrum Analyzer, e.g. R&S FSQ. If available, connect a Trigger Line from the Signal Source (Marker Out on SMJ100A) to the Analyzer (Trg In). Setup the center frequency to 13.56 MHz and analyze the signal in zerospan. You may need to setup a trigger delay in the analyzer because the RFID signal contains a CW signal part before the communication signal part. The length of the trigger delay is according to the length of the CW signal. The RFID request signal looks like this:



The beginning of the request burst can be seen in above picture. The signal has a constant CW part before the first off-keying starts the data communication. The screenshot above shows a correct start-of-frame sequence for “1 out of 4” data coding.

3.1.2. Analysis with Vector Signal Analyzer R&S FSQ-K70

Enter the vector signal analyzer (VSA) on FSQ by pressing the VSA button. Then setup the signal as follows:

- Set the trigger to external triggering

- Use an adequate trigger offset, e.g. 10 ms if the communication starts after 10 ms of CW. You get this value from the zerospan measurement in the previous chapter.

- Enter MODULATION SETTINGS

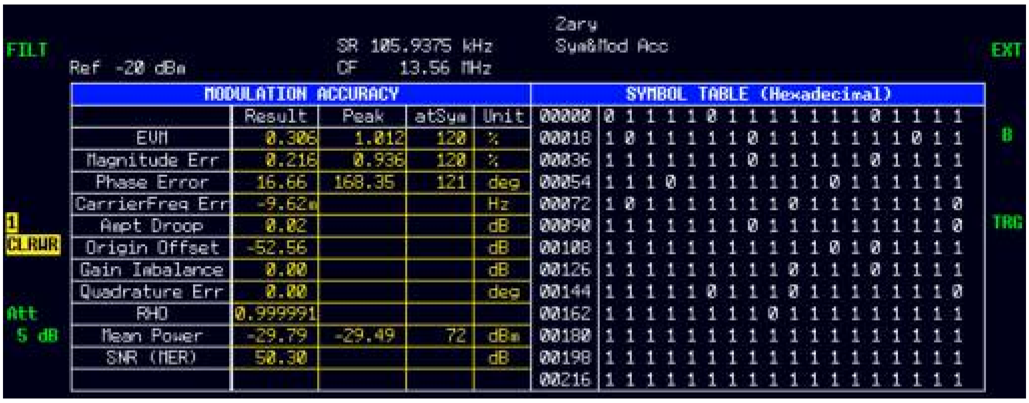
- SYMBOL RATE = 105.9375 kHz (= 13.56 MHz / 128)

- MODULATION FILTER = NONE. The standard does not specify any pulse filtering.

- MODULATION & MAPPING = On-Off-Keying.

This is a user modulation which is not supplied as standard with the FSQ-K70, but it can be generated e.g. with the tool R&S MAPWIZ. This application note comes with an appropriate ASK modulation definition file called *OOK.vam*

You will get the following result in the general result display:



Ref -20 dBm

SR 105.9375 kHz
CF 13.56 MHz

2ary
Sym&Mod Acc

MODULATION ACCURACY

	Result	Peak	atSym	Unit
EVM	0.306	1.012	120	%
Magnitude Err	0.216	0.936	120	%
Phase Error	16.66	168.35	121	deg
CarrierFreq Err	-9.62m			Hz
Ampt Droop	0.02			dB
Origin Offset	-52.56			dB
Gain Imbalance	0.00			dB
Quadrature Err	0.00			deg
RHO	0.999991			
Mean Power	-29.79	-29.49	72	dBm
SNR (MER)	50.30			dB

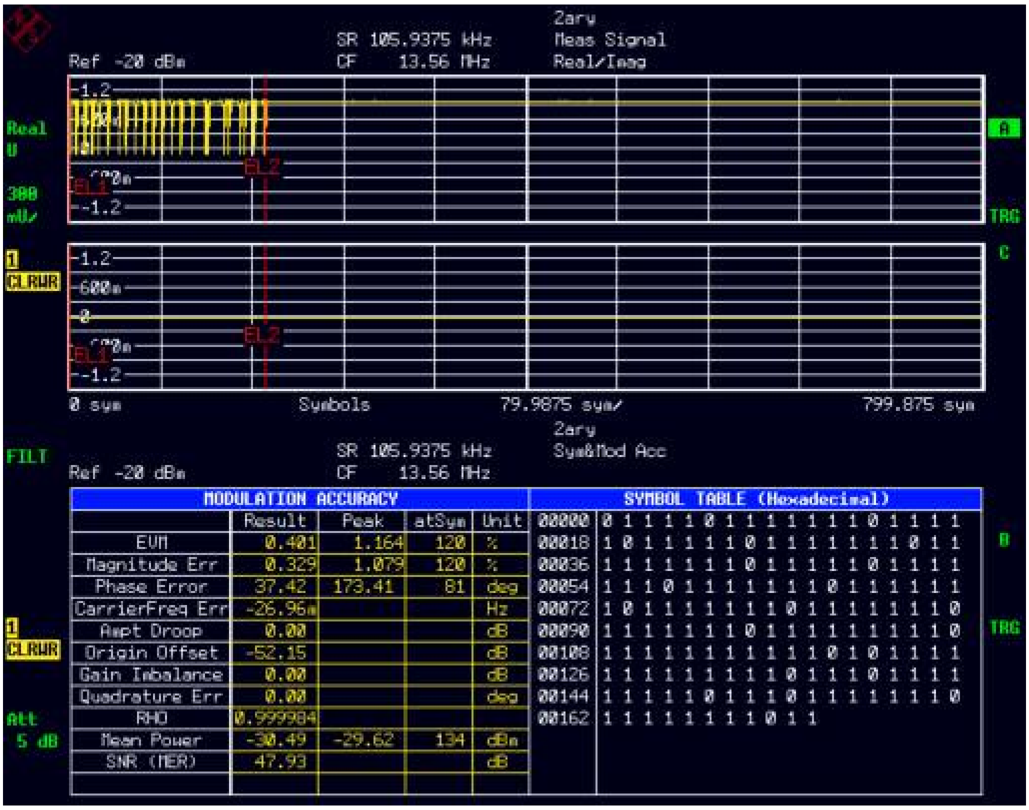
SYMBOL TABLE (Hexadecimal)

```
00000 0 1 1 1 1 0 1 1 1 1 1 1 1 0 1 1 1 1
00018 1 0 1 1 1 1 1 0 1 1 1 1 1 1 1 0 1 1
00036 1 1 1 1 1 1 1 0 1 1 1 1 1 0 1 1 1 1
00054 1 1 1 0 1 1 1 1 1 1 1 0 1 1 1 1 1 1
00072 1 0 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 0
00090 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 0
00108 1 1 1 1 1 1 1 1 1 1 1 0 1 0 1 1 1 1
00126 1 1 1 1 1 1 1 1 1 0 1 1 1 0 1 1 1 1
00144 1 1 1 1 1 0 1 1 1 0 1 1 1 1 1 1 1 0
00162 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1
00180 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
00198 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
00216 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
```

This result view shows various modulation accuracy parameters like magnitude error, frequency error, gain imbalance and others. The result for "Phase Error" must be disregarded, because an ASK modulation does not convey phase information, only amplitude information.

The Error Vector Magnitude EVM shows the overall modulation error of the constellation. The EVM result in the above general result view is calculated over the whole VSA capture buffer. Standard size is 800 symbols.

In order to get an appropriate reading for the EVM only for the duration of the request communication sequence, it is possible to place evaluation lines accordingly. The following screenshot shows a split-screen for the I/Q signal and the general results with added evaluation lines for the communication sequence (in red):

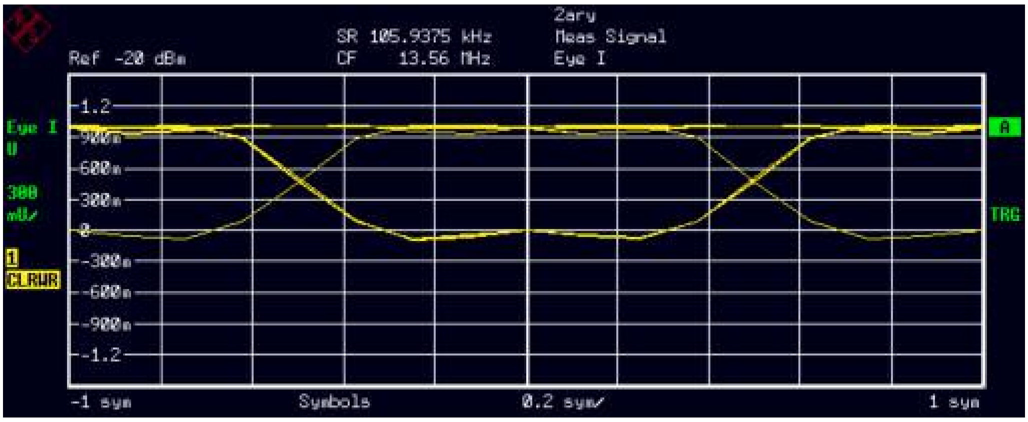


Ref -20 dBm
SR 105.9375 kHz
CF 13.56 MHz
2ary
Sym&Mod Acc

MODULATION ACCURACY	Result	Peak	atSym	Unit
EVM	0.401	1.164	120	%
Magnitude Err	0.329	1.079	120	%
Phase Error	37.42	173.41	81	deg
CarrierFreq Err	-26.96m			Hz
Ampt Droop	0.00			dB
Origin Offset	-52.15			dB
Gain Imbalance	0.00			dB
Quadrature Err	0.00			deg
RHO	0.999984			
Mean Power	-30.49	-29.62	134	dBm
SNR (MER)	47.93			dB

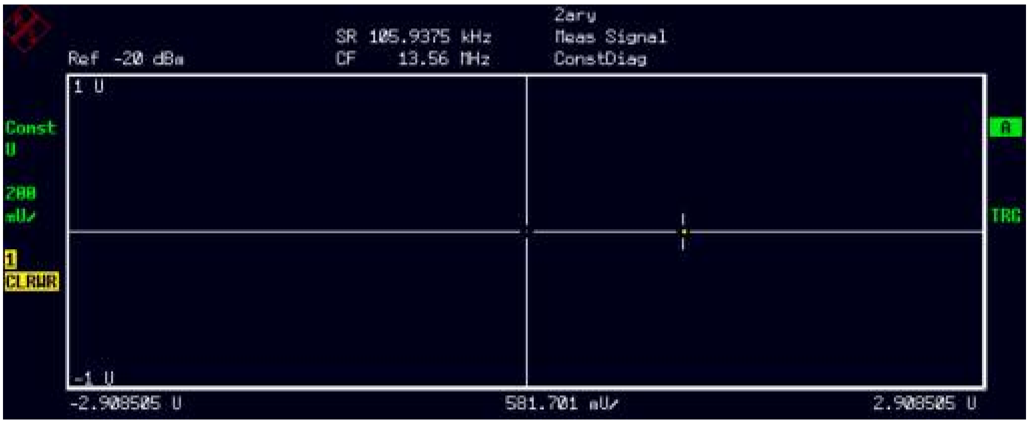
```
SYMBOL TABLE (Hexadecimal)
00000 0 1 1 1 1 0 1 1 1 1 1 1 1 0 1 1 1 1
00018 1 0 1 1 1 1 1 0 1 1 1 1 1 1 1 0 1 1
00036 1 1 1 1 1 1 1 0 1 1 1 1 1 0 1 1 1 1
00054 1 1 1 0 1 1 1 1 1 1 1 0 1 1 1 1 1 1
00072 1 0 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 0
00090 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 0
00108 1 1 1 1 1 1 1 1 1 1 1 0 1 0 1 1 1 1
00126 1 1 1 1 1 1 1 1 1 0 1 1 1 0 1 1 1 1
00144 1 1 1 1 1 0 1 1 1 0 1 1 1 1 1 1 1 0
00162 1 1 1 1 1 1 1 1 0 1 1
```

The eye diagram of a ISO15693 request signal shows the characteristic shape as in the following picture:



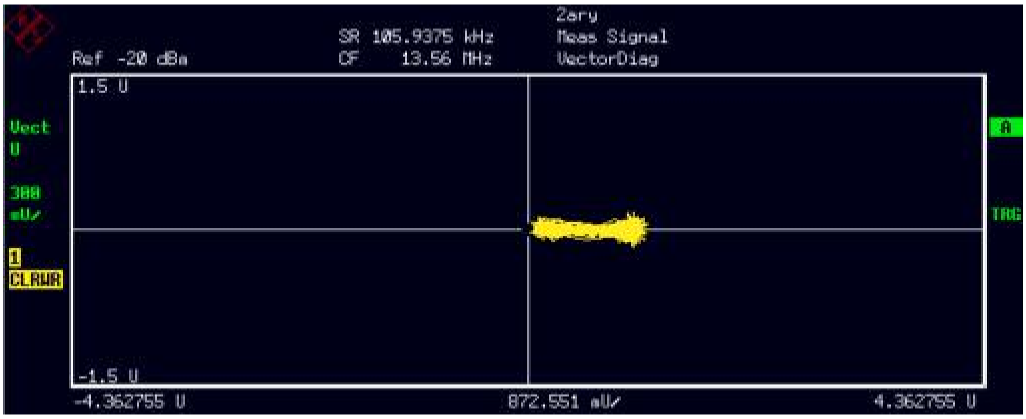
It can be seen that a “low” level of the carrier is always preceded and followed by a high level. There is no transition from low level to low level. If during signal analysis a low-low transition shows up, this is an indication of an improper timing of the signal and/or bit errors. Such Timing errors occur when the “low” level is expanded over one symbol period.

The following picture shows the constellation diagram of a near-ideal ISO15693 request signal. Two states can be distinguished: One in the origin of the constellation diagram, meaning no signal amplitude (carrier off), the second with a full signal amplitude (normalized to 1.0) on the real axis with phase = 0 degrees. This is due to the nature of a 100% ASK modulation. A 90% ASK modulation, which is also specified in the ISO15693 standard, would show two constellation points on the real axis at 0.9 and 1.0 normalized amplitude.



Ref -20 dBm
SR 105.9375 kHz
CF 13.56 MHz
2ary
Meas Signal
ConstDiag

The next picture shows the result of the vector diagram with additional white gaussian noise. A vector diagram shows the constellation points and also the traces of the transitions between the samples. The carrier-to-noise ratio C/N was 15 dB in the below example. An ideal vector diagram would show a straight line on the real axis between the two constellation points. The effect of noise on both the constellation points and also the transient behaviour can clearly be seen. This analysis is helpful in evaluating the quality of an ISO15693 transmitter.



Ref -20 dBm
SR 105.9375 kHz
CF 13.56 MHz
2ary
Meas Signal
VectorDiag

3.1.3. Analysis with Spectrum Analyzers without VSA Software, e.g. with R&S FSL

The previous chapter showed the demodulation of the RFID signal with the help of the vector signal analyzer (VSA) on FSQ. It enables digital demodulation and detailed analysis of modulation quality as well as demodulated data.

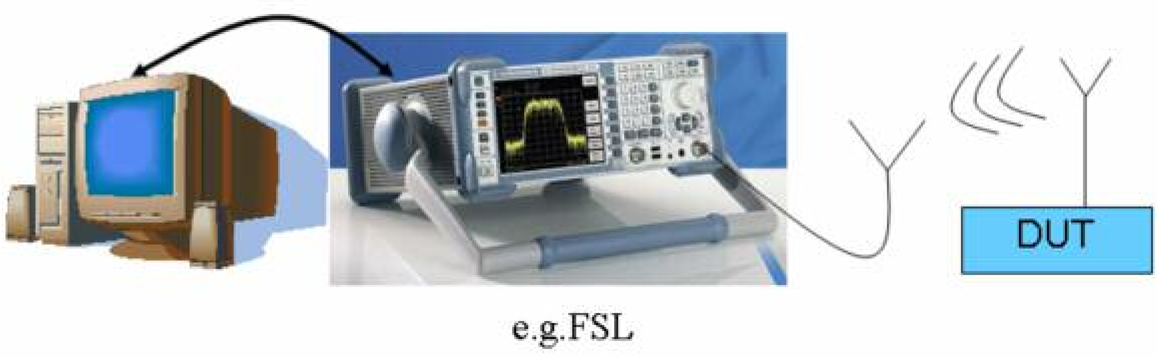
In some cases, it might be sufficient to just check the demodulated data without calculating all detailed modulation quality parameters like EVM, IQ offset etc.

For example, if the demodulated bitstream is available, it is possible to calculate CRC checksum and determine bit errors. Moreover, it is possible to see which exact message has been tranmitted.

If it is sufficient to look at the demodulated bitstream, there is no need to use a high-end expensive VSA. This measurement can be done even with a simple spectrum analyzer, provided that it offers access to the demodulated RF signal.

The R&S spectrum analyzers FSL, FSP, FSU and FSQ all offer the possibility of demodulating the RF signal to an I/Q baseband data (capture memory). The samplerate and capture length as well as other demodulation parameters can be adjusted individually.

The following example shows how to use an R&S FSL analyzer for demodulating an RFID signal. In the process, the transmitted RF will be demodulated, decoded and a CRC error correction will be performed. The result will be the digital data.



The signal from the RFID DUT is captured with an FSL spectrum analyzer. Then a PC software downloades the demodulated IQ waveform from the FSL to the PC. Finally the PC software decodes the waveform to information bits, performs the CRC and displays the result.

3.1.3.1. Setup of the FSL

In order to get the capture data, the FSL has to be set to Zerospan mode.

An appropriate Resolution bandwidth filter has to be used so that the signal is not affected by the bandwidth setting. For the symbol rate of 105.9 kHz, a minimum RBW of 200 kHz is recommended. FSL offers RBW settings up to 20 MHz.

Next, the FSL hast to be set to the appropriate RF frequency 13.56 MHz.

A signal trigger can be used in order to get a defined start of the capture buffer. Depending on setup, an external trigger or an IF or video trigger is recommended. A short negative trigger offset allows a reliable measurement of the complete first signal transition.

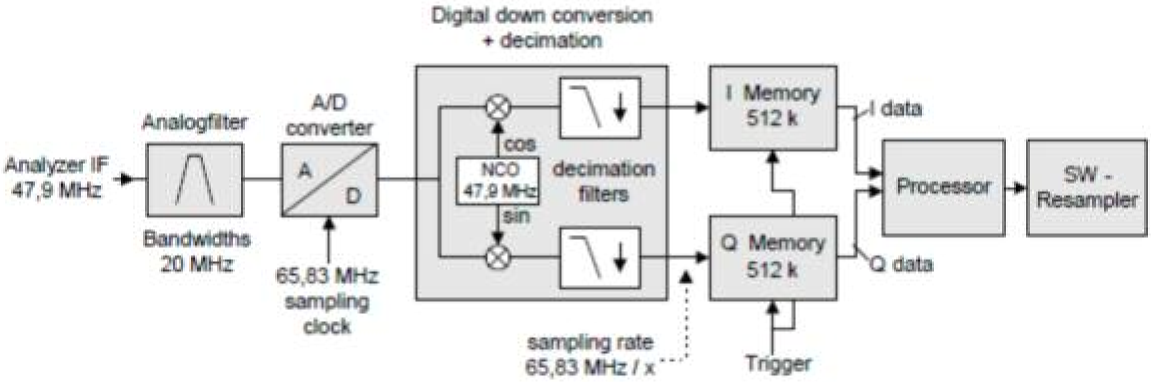
It is also possible to capture in free-run mode, however this requires subsequent detection of the signal start by analyzing the capture buffer.

3.1.3.2. IQ subsystem of R&S FSL

The remote control commands of this subsystem are used for collection and output of measured IQ data. A special memory is therefore available in the instrument with 512k words for the I and Q data. The measurement is always performed in zero span at the selected center frequency. The number of samples to be collected and the sample rate can be set. Prior to being stored in memory or output via GPIB, the measurement data is corrected in terms of frequency response.

The block diagram below shows the analyzer hardware from the IF section to the processor. The A/D converter samples the IF signal (47.9 MHz) at a rate of 65.83 MHz. The digital signal is down–converted to the complex baseband, lowpass–filtered, and the sampling rate is reduced. The output sampling rate is set between 10 kHz and 65.83 MHz. The continuously adjustable sampling rates are realized using an optimal decimation filter and subsequent resampling on the set sampling rate.

The I/Q data are written to separate memories of 512 k words each. The memories are hardware–triggered. 512 samples are designated as buffer for triggering, which leads to a max. recording length of (512k – 512) samples.



The trigger sources EXT (external trigger) and IFP (IF Power Trigger) can be used for triggering and additionally IMM (Free Run). The number of test points to be recorded prior to the trigger point can be selected for all available trigger sources, except for FREE RUN.

The output of the measurement results comesin the form of a list, with the Q values following immediately after the list of I values in the output buffer. The FORMAT command can be used to select between binary output (32 bit IEEE 754 floating–point values) and output in ASCII format.

3.1.3.3. Setup of FSL for IQ data capture

Prior to the download of the IQ data, the FSL has to be set to the correct capture parameters by the remote control command

TRACE:IQ:SET

This command allows setting the bandwidth of the analog filters in front of the A/D converter as well as setting the sample rate, trigger conditions and the record length. The following parameters can be set:

Parameters

1. <filter type> can be omitted
2. <rbw> can be omitted
3. <sample rate> Sampling rate for the data acquisition.
   Value range: 10 kHz to 65.83 MHz, continuously adjustable
4. <trigger mode> Selection of the trigger source used for the measurement.
   Values: IMMediate | EXTernal | IFPower
5. <trigger slope> Used trigger slope.
   Values: POSitive
6. <pretrigger samples> Number of measurement values to be recorded before the trigger point.
   Negative values correspond to a trigger delay.
7. <# of samples> Number of measurement values to record.
   Value range:1 ... 523776

Example

:TRACe1:IQ:SET NORM,3MHz,1MHz,EXT,POS,10,2000

Sets the FSL for a zerospan Measurement with a RBW=3 MHz and normal filter shape. The measurement shall be triggered at the positive edge of an external trigger signal.

The sample rate is set at 1 MHz and 2000 sample values shall be read. This corresponds to a capture time of 2000/1 MHz=2 ms

The pretrigger samples are set to 10, which means at a sample rate of 1 MHz, that the measurement starts at 10 / 1 MHz = 10 μs before the trigger point.

Actually for an ISO15693 signal, the symbol rate is 105.9375 kHz. However, if the signal is sampled at this symbol rate, the result would be only one sample per symbol. Since FSL and DUT are not synchronized in time, it is advisable to do an oversampling and decode the data later.

The FSL offers the possibility of a arbitrary sample rate from 10 kHz to 65.83 MHz, adjustable in 1 Hz steps. For an oversampling of 10, the sample rate for an ISO15693 signal would be 1.059763 MHz. With this sample rate, one RFID data symbol has a fixed integer number of 10 samples.

Some other spectrum analyzers offer only fixed sample rates. For example R&S FSP only offers sample rates at 32 MHz/n (32 MHz, 16 MHz, 8 MHz, 4 MHz, 2 MHz, 1 MHz, 500 kHz, and so on). With these analyzers, it is not possible to set an arbitrary sample rate like 1.059763 MHz. However, it is still possible to use these analyzers for sampling any RFID signal. In this case, after oversampling the data decoding must be adjusted (no fixed integer number of samples per symbol)

The sample rate of 1 MHz in the example above provides an oversampling of 9.44 samples/symbol. This sample rate can be used by both FSL and FSP analyzers.

Following the ***TRACE:IQ:SET*** command, the IQ subsystem can be activated with the command ***TRACE:IQ:STATE ON***.

3.1.3.4. Download of Capture data to PC

After the FSL has been set up with RF frequency, zerospan and after the IQ subsystem has been configured and switched on, it is possible to download the captured IQ data with the command:

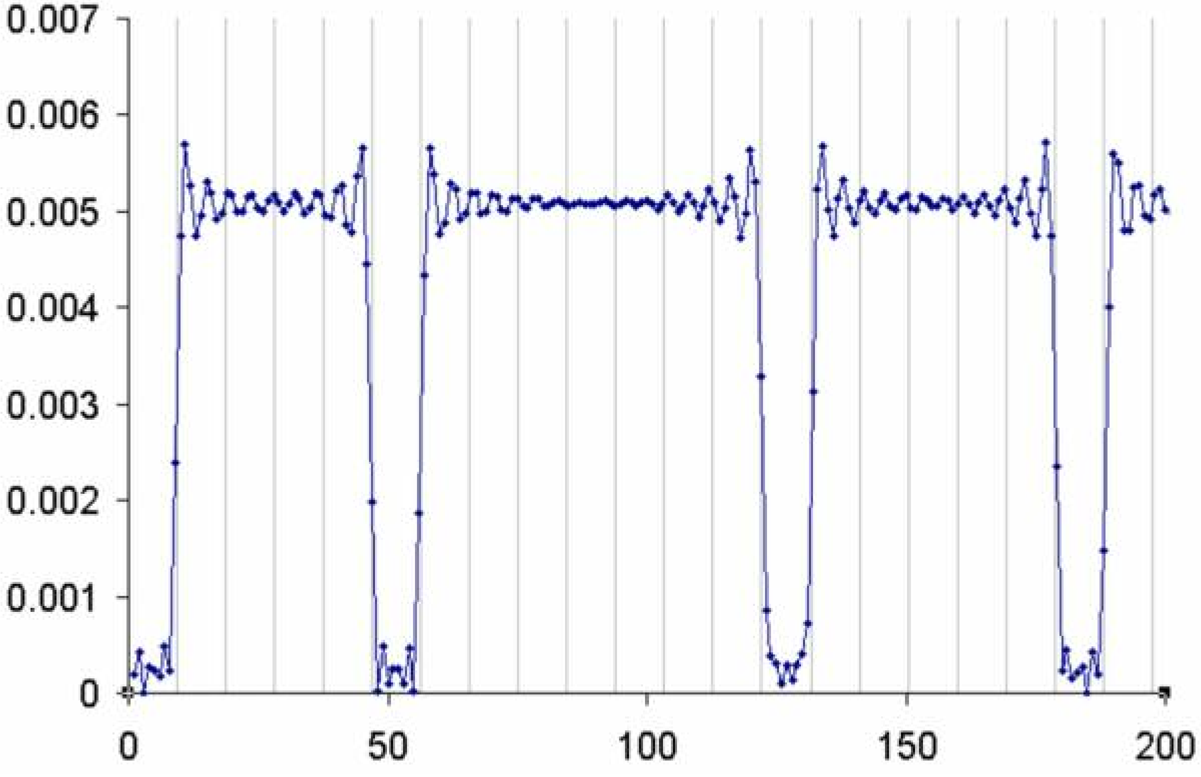
:TRACE:IQ:DATA?

This command starts a measurement and returns the list of measurement results immediately after they are corrected in terms of frequency response. The number of measurement results depends on the settings defined with TRACe:IQ:SET, the output format depends on the settings of the FORMat subsystem.

The result values are scaled linear in unit *Volt* and correspond to the voltage at the RF input of the instrument. In ASCII format, the number of the returned values is 2 * the number of samples. The first set contains the I–data, the second the Q–data. In binary format, the number of I– and Q–data can be calculated as follows: *# of I _ Data = # of Q _ Data = # of DataBytes/8*

The result are two waveforms in voltage vs. samples, which equals voltage vs. time. One waveform is the demodulated I-signal, the other the demodulated Q-signal.
For an ASK modulation, the Q-Signal will always be zero. The subsequent analysis only considers the I-signal.

The following diagram shows an example waveform of the I-signal of a ISO15693 request signal. It can be seen that the signal stays at high voltage (= RF on) for most of the time, except for short intervals where the voltage is zero (=RF off). It can also be seen that the signal-off duration is 10 samples. This corresponds to an oversampling factor of 10.



(Please note that the vertical gridlines are spaced every 9.44 samples!)

3.1.3.5. Decoding the captured data

After the ampliude waveform for the I-signal is available, the only remaining task is to decode this waveform into data symbols.

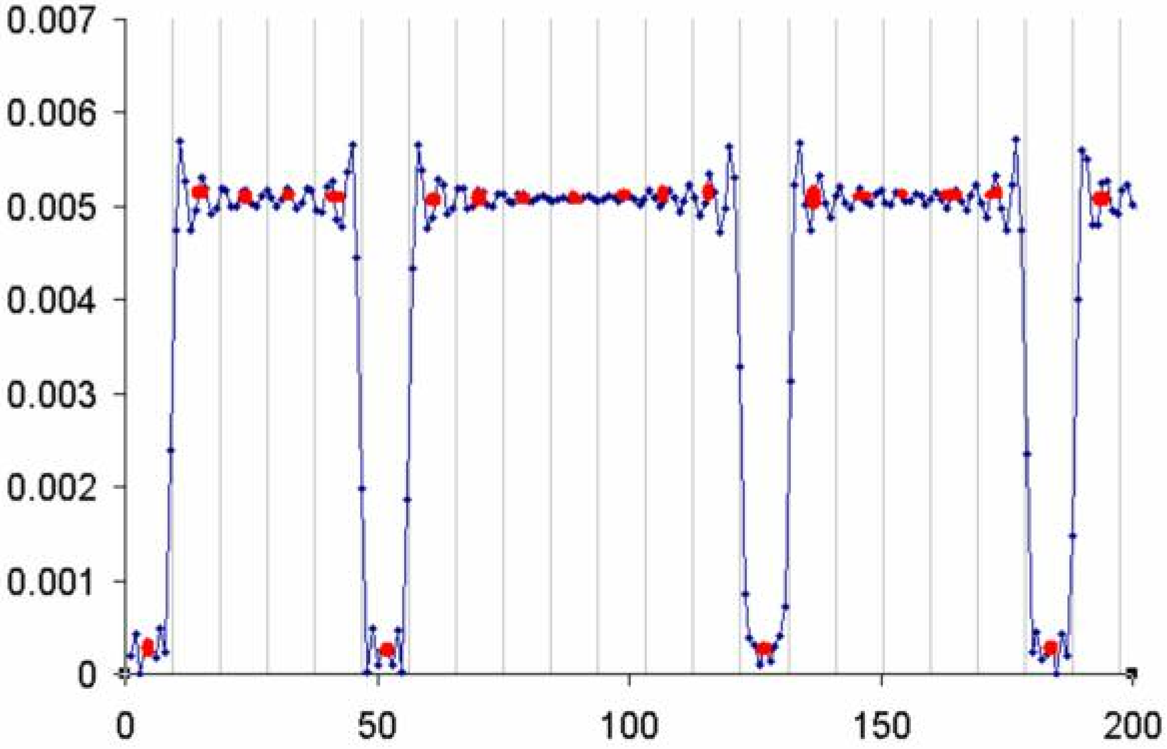
First step is to remove the oversampling and do a resampling with the correct RFID symbol rate. The resampling can be done in a variety of ways, e.g. with or without clock recovery.

The easiest way is to detect the first symbol where the RF amplitude is zero. This is the zero in the "Start of Frame delimiter" SOF (see also 7.3.4). In case of a request signal (VCD to VICC) with 1-out-of-4 method, the SOF consists of the sequence

"01111011" at the sample rate of 105.9375 kHz

After the first "0" has been detected, a fixed resampling starting with this symbol and with the new sampling rate of 105.9375 kHz is applied.

The following picture show the resampling points with the sample rate of 105.9375 kHz (red points).

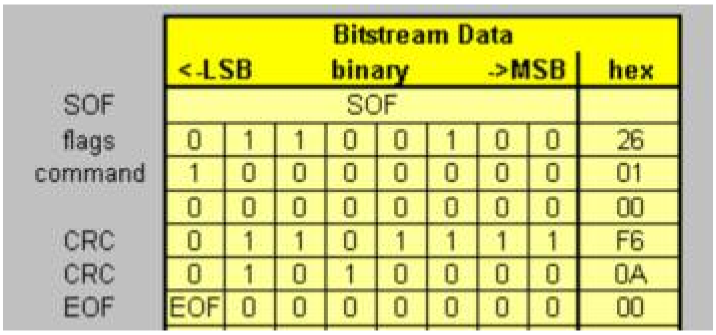


Now it is easy to decode the sample points into symbols:

0111 1011 1111 1011 1110 1 ……..

The first eight symbols show "0111 1011" which is exactly the SOF sequence according to the standard (see 7.3.4). Also the following data symbols are decoded in the same way, taking into consideration the mapping of symbols to data (see also data coding, 7.3.2)

As a result, the decoded bitstream data of the RFID signal can be obtained. For an "inventory request" signal, the result will look like this:



	Bitstream Data								
	<-LSB			binary				->MSB	hex
SOF	SOF								
flags	0	1	1	0	0	1	0	0	26
command	1	0	0	0	0	0	0	0	01
	0	0	0	0	0	0	0	0	00
CRC	0	1	1	0	1	1	1	1	F6
CRC	0	1	0	1	0	0	0	0	0A
EOF	EOF	0	0	0	0	0	0	0	00

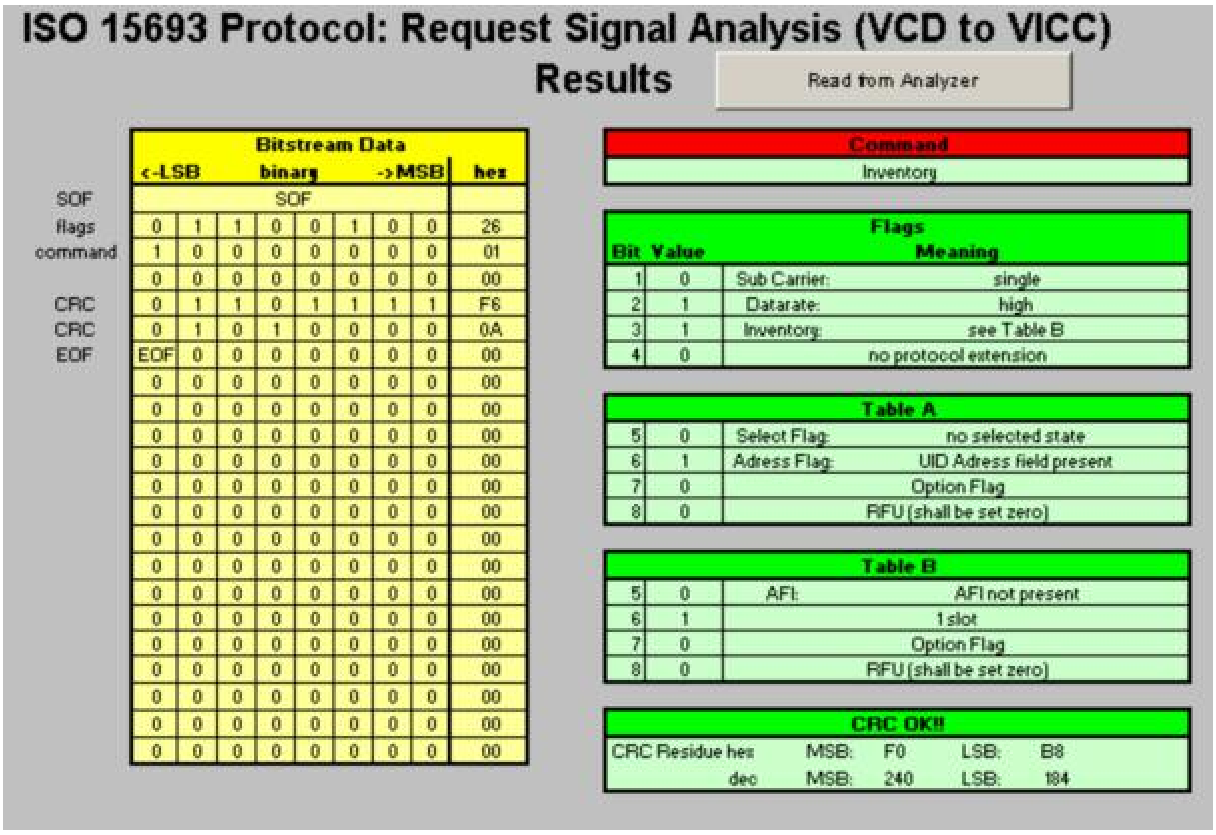
3.1.3.6. Software for automated capturing and decoding

This application note comes with a demonstration software to give an example how to measure a VCD-to-VICC signal.

The software is capturing the data with R&S FSL, followed by decoding inside the software. The CRC is checked and all results displayed.

The software is written in Visual Basic for Applications (VBA) and runs inside Microsoft Excel. It uses a library of remote control routines from R&S called "VIF"

The main screen of the software is shown in the following screenshot:



ISO 15693 Protocol: Request Signal Analysis (VCD to VICC)

Results

	Bitstream Data								
	<-LSB			binary				->MSB	hex
SOF	SOF								
flags	0	1	1	0	0	1	0	0	26
command	1	0	0	0	0	0	0	0	01
	0	0	0	0	0	0	0	0	00
CRC	0	1	1	0	1	1	1	1	F6
CRC	0	1	0	1	0	0	0	0	0A
EOF	EOF	0	0	0	0	0	0	0	00
	0	0	0	0	0	0	0	0	00
	0	0	0	0	0	0	0	0	00
	0	0	0	0	0	0	0	0	00
	0	0	0	0	0	0	0	0	00
	0	0	0	0	0	0	0	0	00
	0	0	0	0	0	0	0	0	00
	0	0	0	0	0	0	0	0	00
	0	0	0	0	0	0	0	0	00
	0	0	0	0	0	0	0	0	00
	0	0	0	0	0	0	0	0	00
	0	0	0	0	0	0	0	0	00
	0	0	0	0	0	0	0	0	00
	0	0	0	0	0	0	0	0	00
	0	0	0	0	0	0	0	0	00
	0	0	0	0	0	0	0	0	00

Command
Inventory

Flags			
Bit	Value	Meaning	
1	0	Sub Carrier:	single
2	1	Datarate:	high
3	1	Inventory:	see Table B
4	0	no protocol extension	

Table A			
5	0	Select Flag:	no selected state
6	1	Adress Flag:	UID Adress field present
7	0	Option Flag	
8	0	RFU (shall be set zero)	

Table B			
5	0	AFI:	AFI not present
6	1	1 slot	
7	0	Option Flag	
8	0	RFU (shall be set zero)	

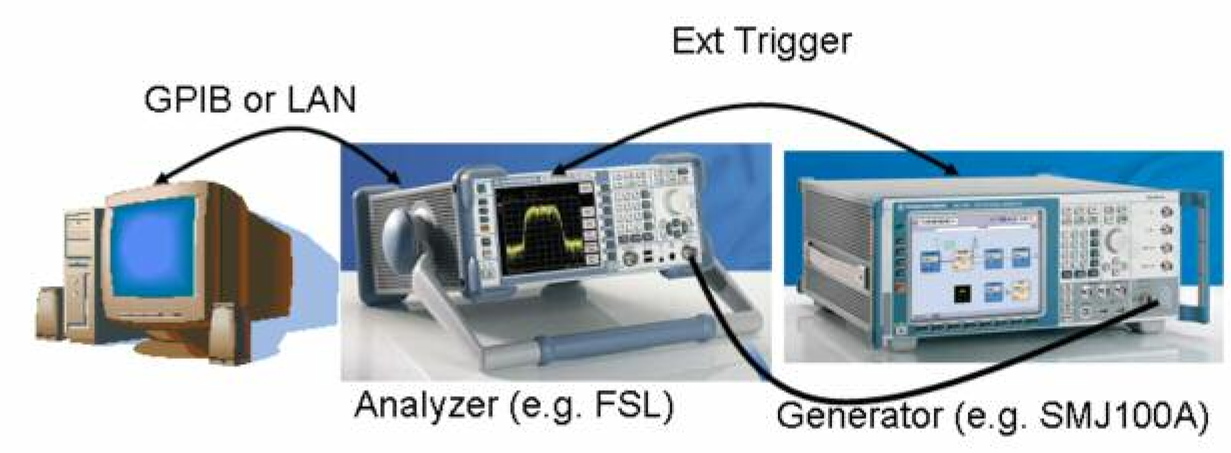
CRC OK!!					
CRC Residue hex	MSB:	F0	LSB:	B8
dec	MSB:	240	LSB:	184

After pressing the button “Read from Analyzer”, the results become immediately visible. Result views contain the bitstream data in binary and hexadecimal, the content and description of the individual flags, the command name as well as the result of the CRC checksum test.

3.1.3.7. Operation of the software

As demo setup, connect a signal generator (e.g. R&S SMJ100A) with the FSL. The signal generator should be setup to generate a VCD-to-VICC request signal. As demo file, for example the arbitrary waveform files provided with this application note can be used (inventory_request_singlecarrier.wv).

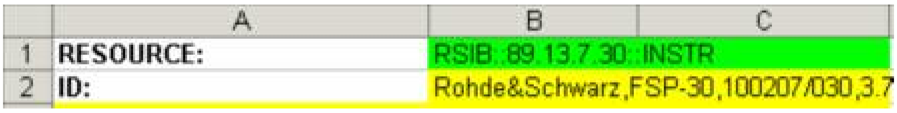
Connect an external trigger line between the generator and the FSL analyzer. The control PC can be connected either by LAN or by GPIB bus to the FSL analyzer.



Next step is to setup the software. The operating PC must have either an LAN connection or a GPIB interface with installed VISA library.

The software comes with a DLL called “MATHDLL.DLL”. This DLL must either be installed in the same directory as the Excel-File or it can be installed in the Windows System Directory.

Next, start the Excel file and setup the instrument in the control software. This can be done in the spreasheet “FSL_Data” inside the provided MS Excel file. Edit the string in the cell “B2” to the correct values.



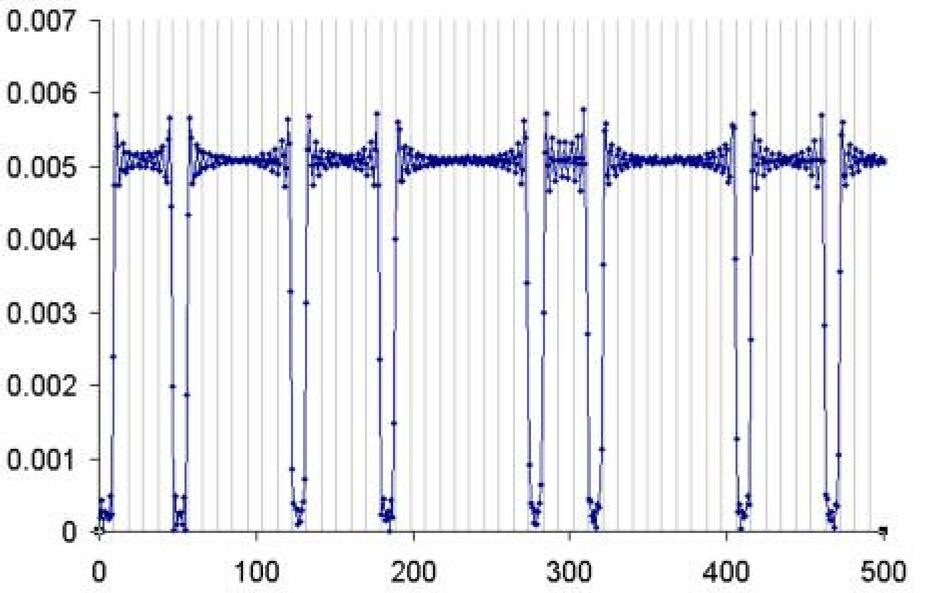
	A	B	C
1	RESOURCE:	RSIB::89.13.7.30::INSTR	
2	ID:	Rohde&Schwarz,FSP-30,100207/030,3.7	

In the case of GPIB connection, the string should look like this: “gpib0::20::instr” where “20” is the GPIB address. In the case of LAN connection, the control string reads “RSIB::89.13.1.241::INSTR”. The correct IP number of the FSL analyzer has to be entered.

Next, change to the “Bitstream” spreadsheet inside the Excel file. You can start the measurement now by pressing the button

Now the measured and decoded bitstream immediately becomes visible.

It is possible to look at the Waveform of the demodulated data by changing to the “Amplitude Display” view:



The other spreadsheets in the Excel file show intermediate results:

- “Amplitude Data” shows digital sample amplitudes which are still not resampled digital values

- “Amp Demod” shows the resampled symbols before they are decoded according to the 1-out-of-4 scheme (see 7.3.2)

4. Appendix A - filenames

Convention of used filenames:

*.iqs WinIQSIM™ Setup file. This file contains the settings of the WinIQSIM™ Workbench

*.imp WinIQSIM™ Modulation definition file. This file contains a user-specific modulation, for example a amplitude shiftkeying (ask.imp)

*.ded Data Editor setup file. This file contains the definitions of data fields, slots and frames

*.dbi Data file. This file contains the formatted data including header information etc. as defined in the data editor.

*.wv Waveform file. Contains an analog waveform as a series of samples. Can be uploaded and played by R&S generators like e.g. SMU or SMJ

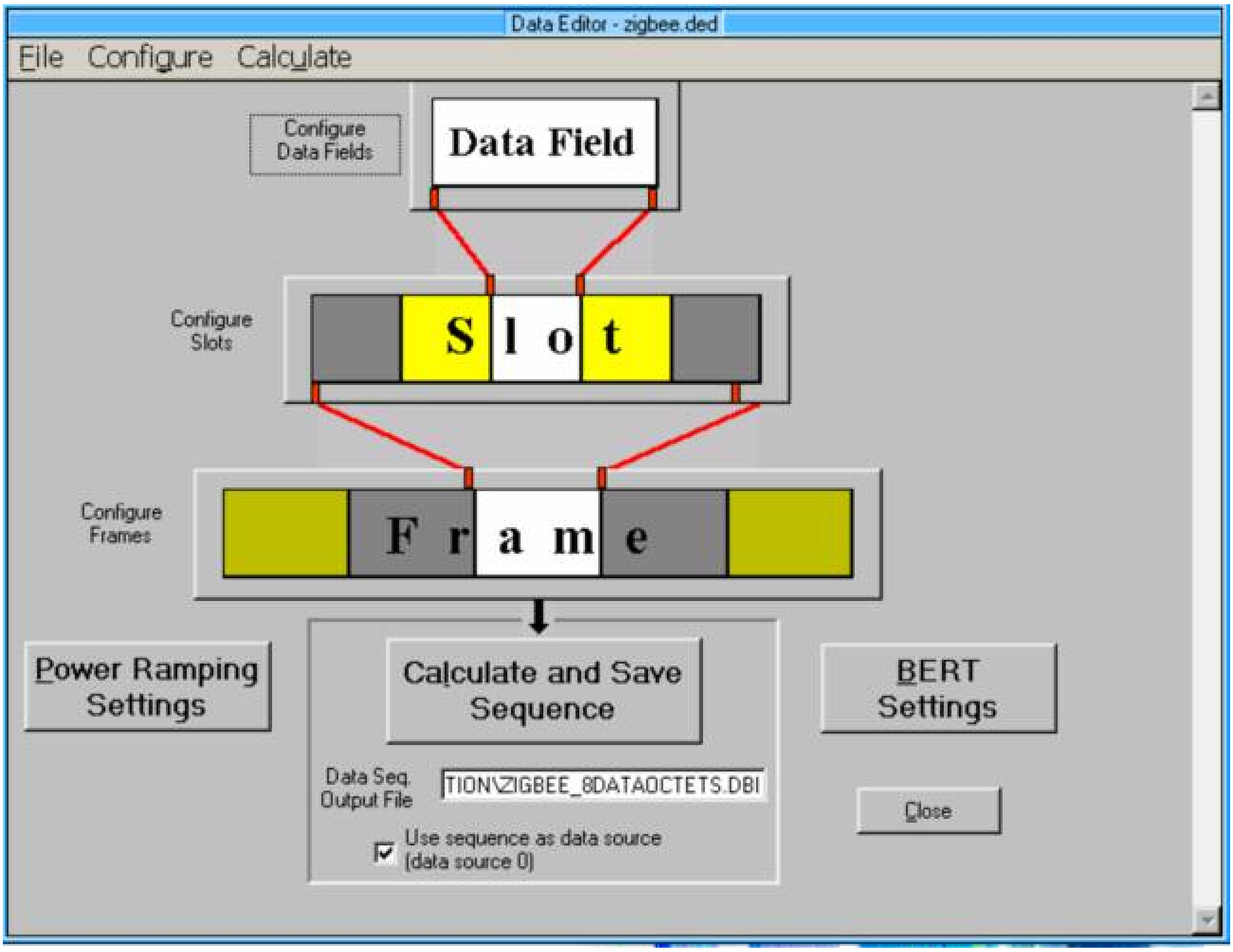
*.vam Modulation and mapping definition file for Signal Analyzer R&S FSQ with option FSQ-K70

*.dll Dynamic link library. Library file with software routines to be used by any Windows software

5. Appendix B - RFID Request Frame Structure with WinIQSIM™

The frame structure of ISO15693 can be implemented into WinIQSIM™ and test frames can be generated. A frame structure can be saved into a datafile with the ending "*.dbi". This file can then be uploaded into the data panel to be used for transmission.

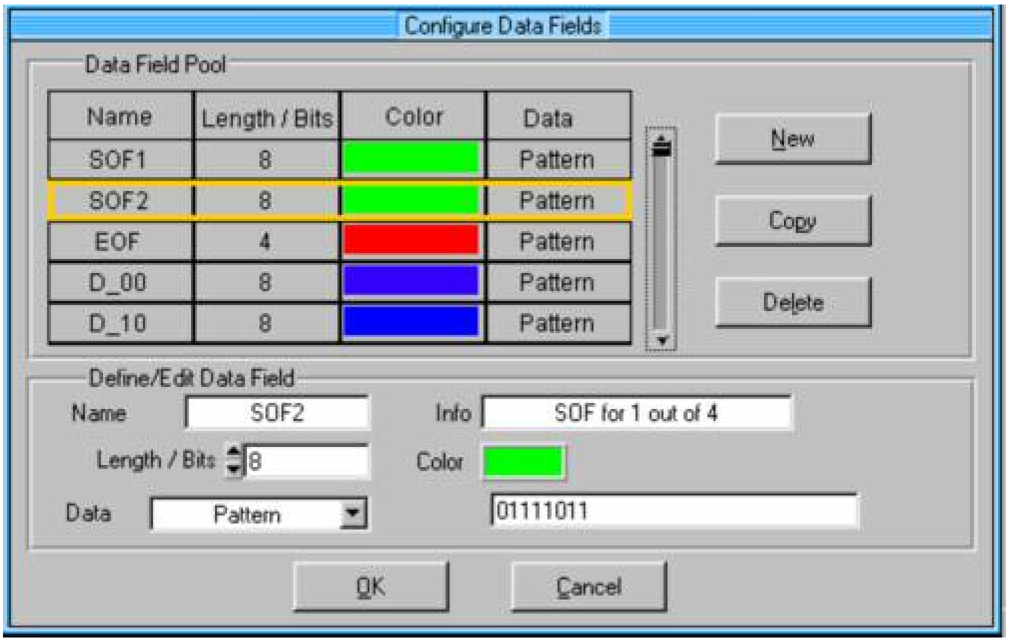
To setup the frame structure, enter the Data Panel and select "Data Editor".



Data Seq. Output File: TION\ZIGBEE_8DATAOCTETS.DBI

☑ Use sequence as data source (data source 0)

Data fields contain a sequence of data which can be used in higher levels of the frame structure. For ISO15693, it is suitable to define the start-of-frame sequence (SOF), the end-of-frame sequence (EOF) and the four dibits as "data fields".



Data Field Pool

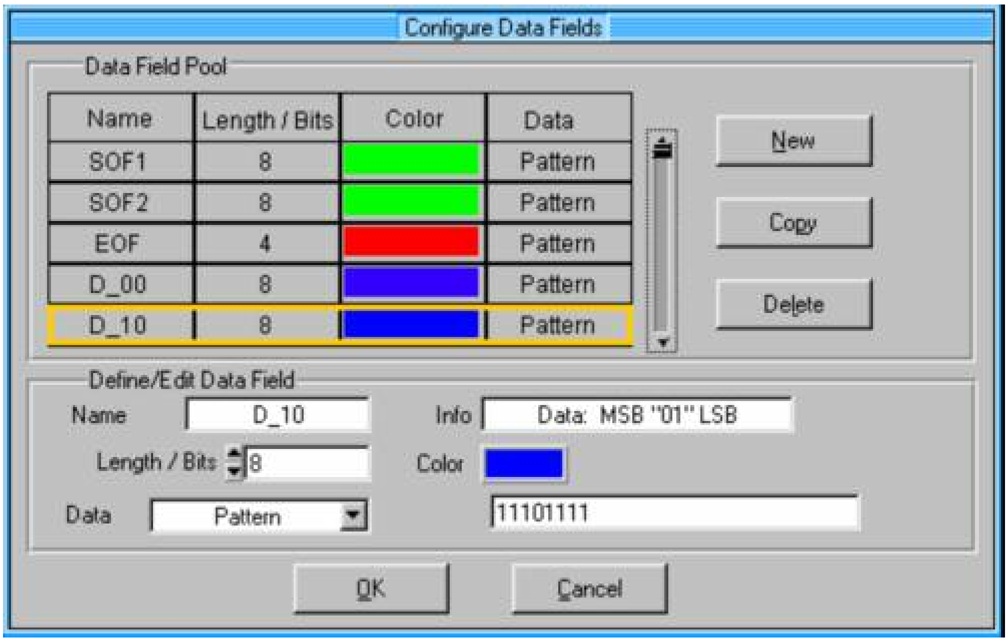
Name	Length / Bits	Color	Data
SOF1	8	🟩	Pattern
SOF2	8	🟩	Pattern
EOF	4	🟥	Pattern
D_00	8	🟦	Pattern
D_10	8	🟦	Pattern

Define/Edit Data Field

Name: SOF2
Info: SOF for 1 out of 4
Length / Bits: 8
Color: 🟩
Data: Pattern
01111011

In the above dialog, you can see for example the definition of data field “SOF2”, which corresponds to the start-of-frame sequence for “1 out of 4” code (see standard 15693-2, page 7). One bit has the length 9.44 µs, therefore the bit sequence for SOF2 is “01111011”

Similarly, the bit sequences for SOF1 and EOF are created. The “1 out of 4” code specifies also sequences for four dibits, here called “D_00”, “D_01”, “D_10” and D_11”. One dibit represents two databits of the payload to be tranmitted.



Data Field Pool

Name	Length / Bits	Color	Data
SOF1	8	🟩	Pattern
SOF2	8	🟩	Pattern
EOF	4	🟥	Pattern
D_00	8	🟦	Pattern
D_10	8	🟦	Pattern

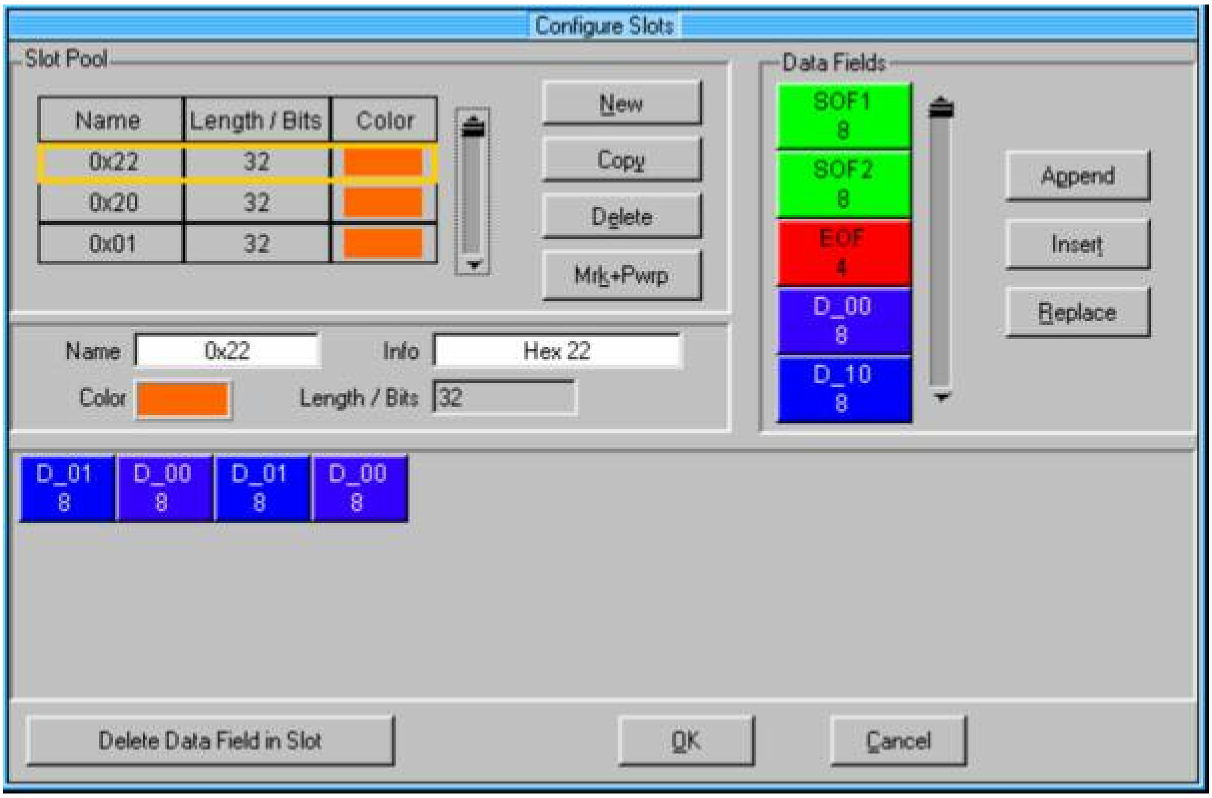
Define/Edit Data Field

Name: D_10
Info: Data: MSB "01" LSB
Length / Bits: 8
Color: 🟦
Data: Pattern
11101111

The above screenshots show the definition of the sequence for Dibit “D_10”. It is important to note that the dibit is sent “LSB first”. Therefore the dibit “D_10” means that the MSB of the dibit is “0” and the LSB of the dibit is “1”.

All four dibits are defined in a similar way.

In the next steps, the predefined datafields can be used to create so-called slots:



Configure Slots

Slot Pool

Name	Length / Bits	Color
0x22	32	🟧
0x20	32	🟧
0x01	32	🟧

Name 0x22

Info Hex 22

Color 🟧

Length / Bits 32

Data Fields

SOF1 8
SOF2 8
EOF 4
D_00 8
D_10 8

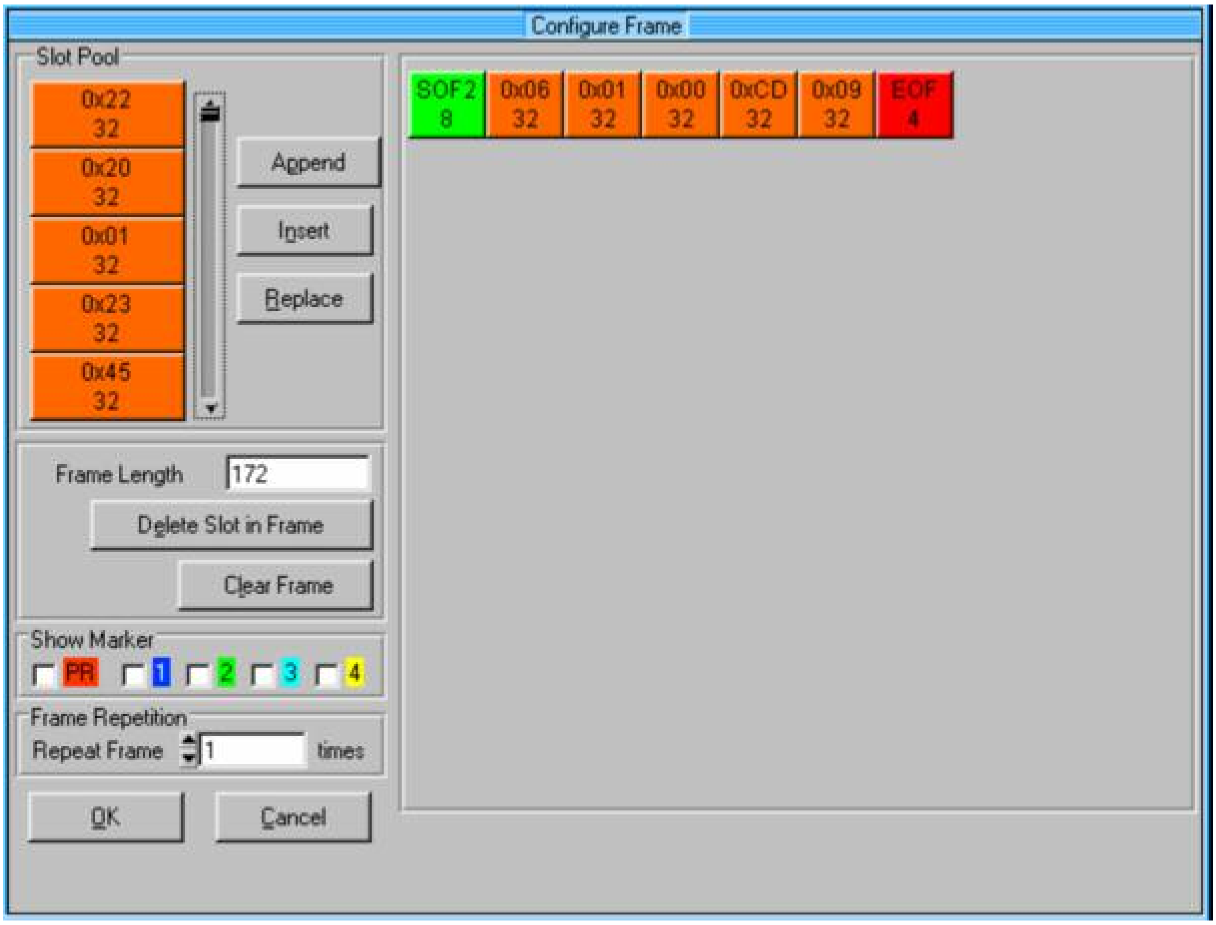
D_01 8 | D_00 8 | D_01 8 | D_00 8

A slot is a concatenation of several datafields. In the above example, you can see several slots for hexadecimal bytes (e.g. 0x22, 0x20, 0x01). In case of the slot 0x22, the contents of the slot are composed of Data Fields “D_01”, “D_00”, “D_01” and “D_00”. This corresponds to data bits “01000100”.

Care must be taken regarding the “LSB first” rule in ISO15693. The above example for 0x22 transmits the LSB first. This means the real data byte value is the mirror of the above data bits: “00100010” = 0x22 in hexamdecimal.

Any other databyte can be configured in a similar way. Databytes are stored in the slot pool.

In a final step, slots are arranged to compose a frame:



Frame Length 172

Repeat Frame 1 times

SOF2	0x06	0x01	0x00	0xCD	0x09	EOF
8	32	32	32	32	32	4

In this example, the frame consists of a start of frame SOF2 (8 chips at 9.44 µs), followed by 5 databytes (each byte consisting of 32 chips at 9.44 µs), followd by an end of frame EOF (4 chips at 9.44 µs).

The above example shows the frame for an “inventory request” signal.

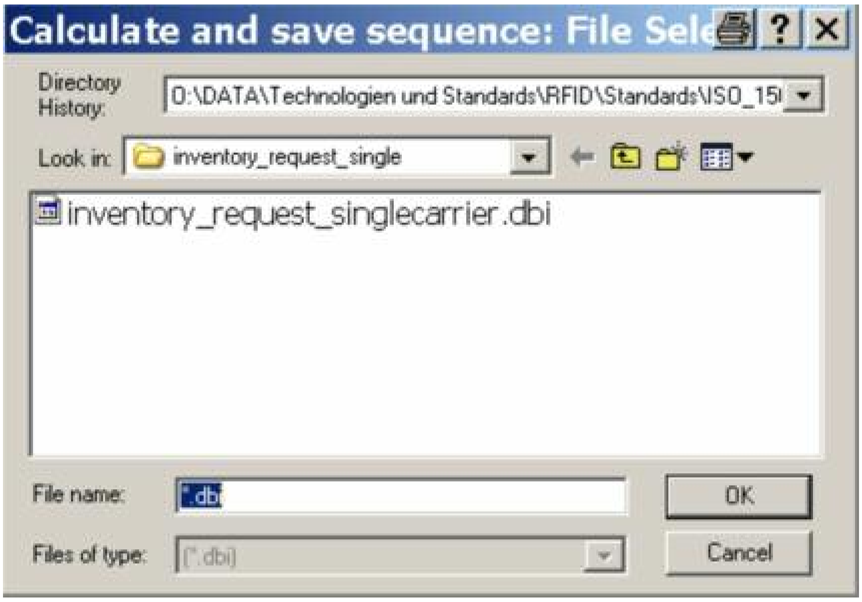
The first byte contains the request flags: 0x06 means single carrier transmission, high datarate.

The second byte contains the command: 0x01 means “inventory request”

The third byte denotes the mask length: 0x00 means no mask is specified.

The remaining 2 bytes are created from the preceding bytes by means of a CRC16 algorithm. This application note comes with an Excel VBA macro (CRC.xls) which enables the calculation of CRC16 codes according to ISO15693. For the given frame, the CRC16 yields “0x09CD”. LSB is transmitted first.

When the frame is setup, you can save your settings to a data editor definition file (ending *.ded)



O:\DATA\Technologien und Standards\RFID\Standards\ISO_15

inventory_request_single

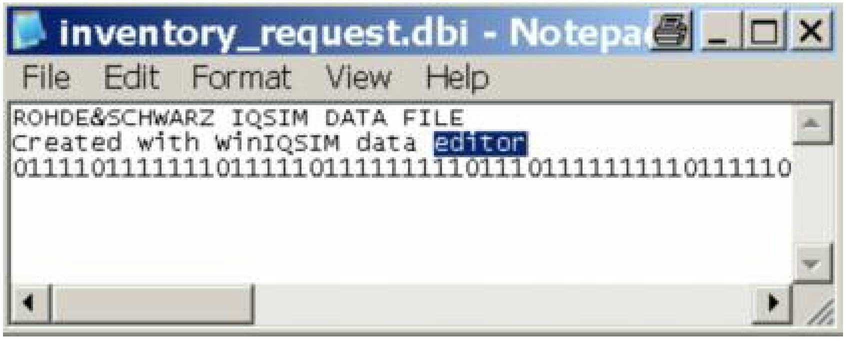
inventory_request_singlecarrier.dbi

*.dbi

(*.dbi)

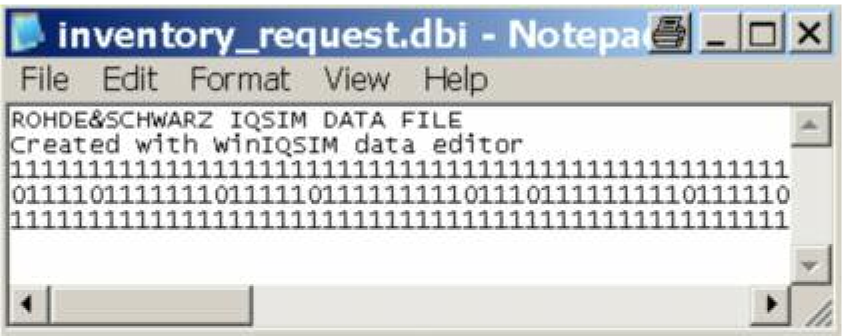
As a next step, the frame has to be calculated. Enter the name of the wanted datafile (*.dbi) in the filed an press “calculate and save sequence”

The created .dbi file contains only the payload information (request signal), not the CW section before and after the request signal:



```
ROHDE&SCHWARZ IQSIM DATA FILE
Created with WinIQSIM data editor
0111101111111011111011111111110111011111111110111110
```

The CW section can easily added by inserting a sequence of “1”s before and after the request signal. Each “1” has a duration of 9.44us. For example, in order to add 1 ms of CW signal before and after the request signal, a series of 106 x “1” has to be added. You can do this easily with a text editor, for example “Notepad” in MS Windows environments.

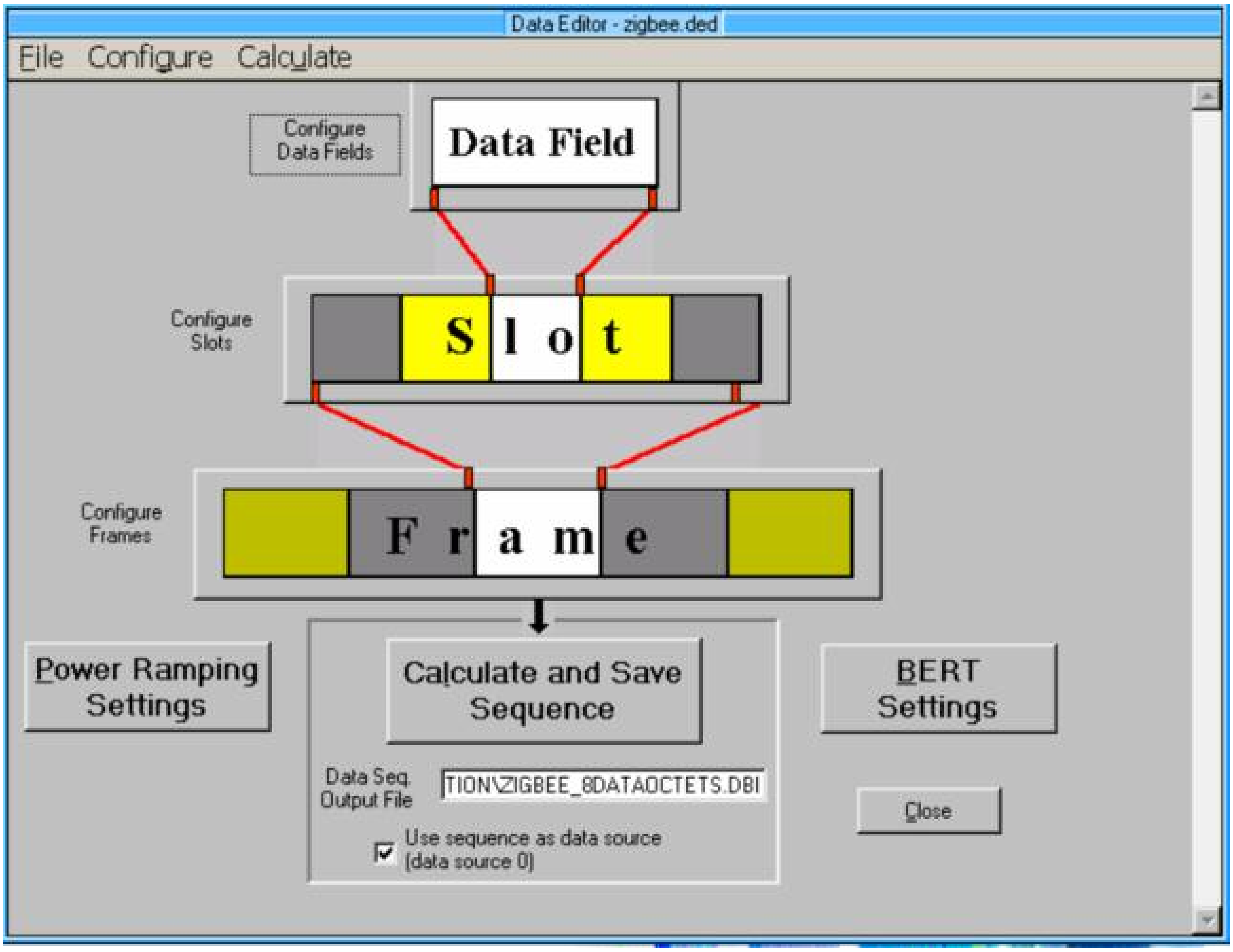


```
ROHDE&SCHWARZ IQSIM DATA FILE
Created with winIQSIM data editor
1111111111111111111111111111111111111111111111111111111111
0111101111111011111111101111111110111011101111111110111110
1111111111111111111111111111111111111111111111111111111111
```

6. Appendix C - RFID Response Frame Structure with WinIQSIM™

The frame structure of ISO15693 can be implemented into WinIQSIM™ and test frames can be generated. A frame structure can be saved into a datafile with the ending “*.dbi”. This file can then be uploaded into the data panel to be used for transmission.

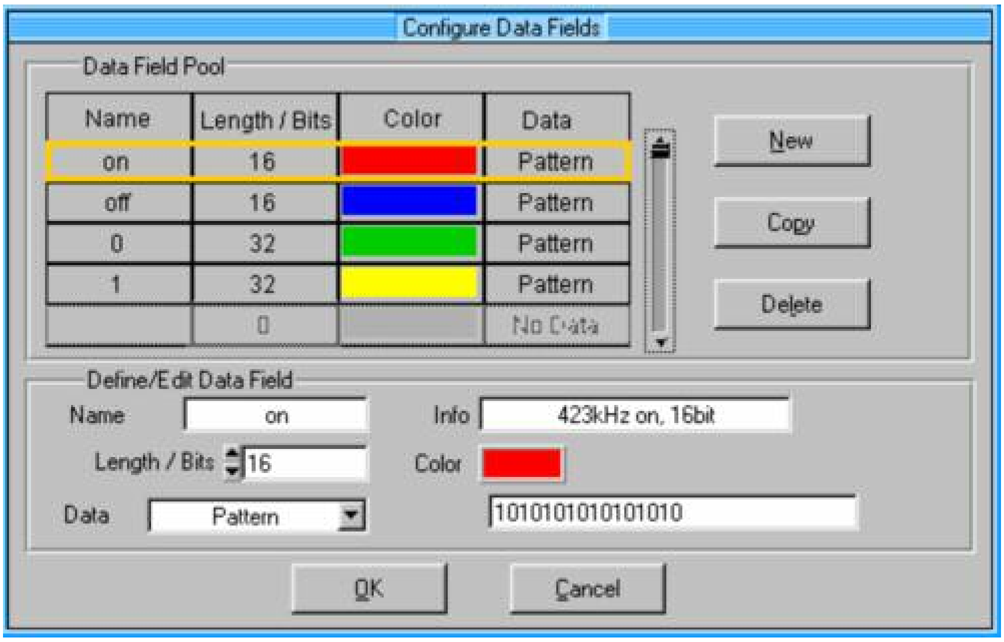
To setup the frame structure, enter the Data Panel and select “Data Editor”.



Data Seq. Output File: TION\ZIGBEE_8DATAOCTETS.DBI

☑ Use sequence as data source (data source 0)

Data fields contain a sequence of data which can be used in higher levels of the frame structure. For ISO15693 response signals, it is suitable to define the sequence of 8 pulses as one data field “on” and the off-period of same length as “off”.



Name	Length / Bits	Color	Data
on	16	🟥	Pattern
off	16	🟦	Pattern
0	32	🟩	Pattern
1	32	🟨	Pattern
	0		No Data

Name: on

Info: 423kHz on, 16bit

Length / Bits: 16

Color: 🟥

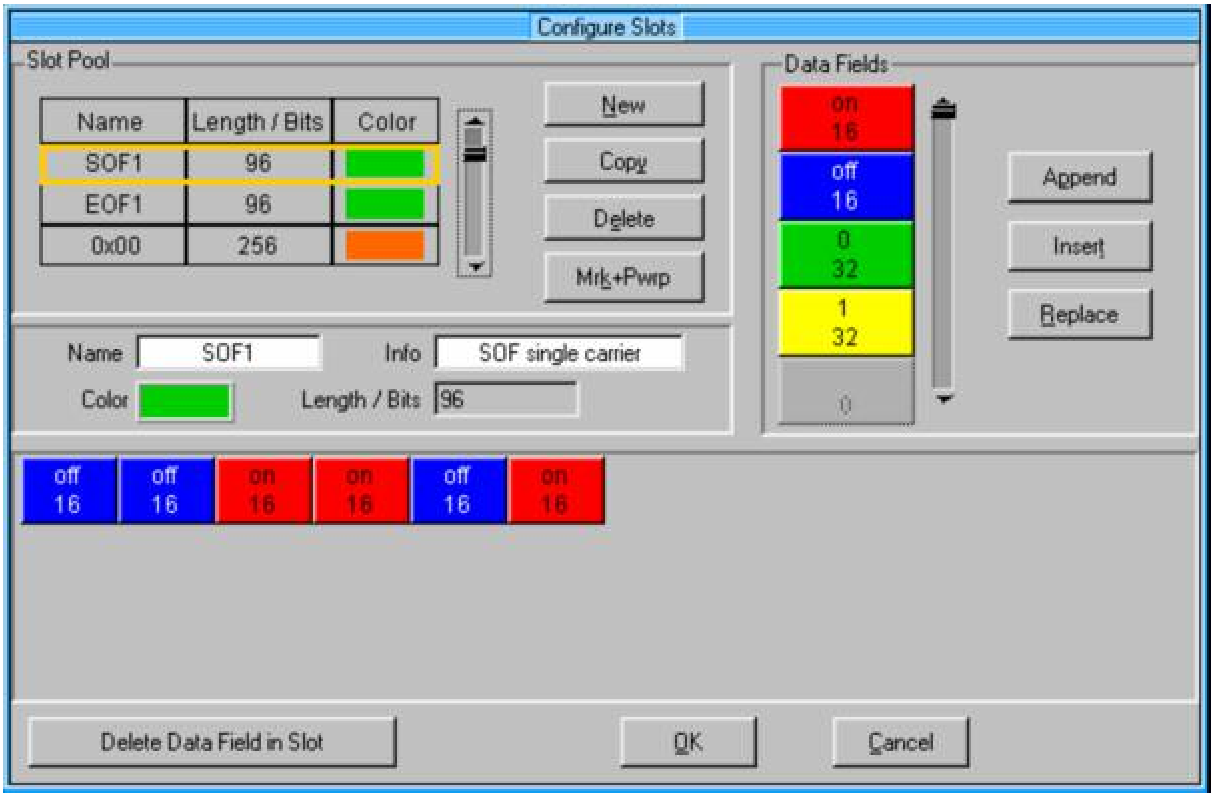
Data: Pattern

1010101010101010

In the above dialog, you can see for example the definition of data field “on”, which corresponds to 8 pulses of 1.18 µs separated by 1.18 µs off-periods. The total length is 18.88 µs.

Similarly, the datafield “off” is a signal-off period of 18.88 µs.

In the next steps, the predefined datafields can be used to create so-called slots:



Name	Length / Bits	Color
SOF1	96	🟩
EOF1	96	🟩
0x00	256	🟧

Name: SOF1 Info: SOF single carrier

Color: 🟩 Length / Bits: 96

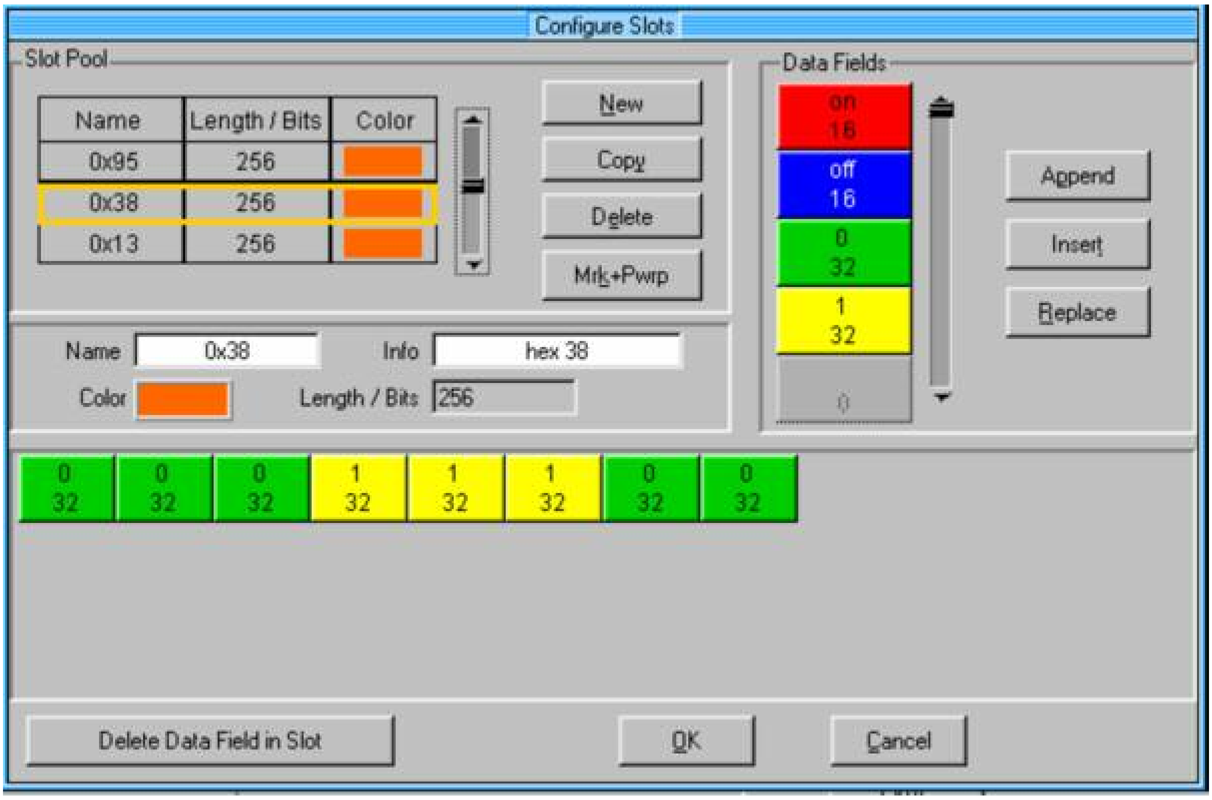
Data Fields:

on	16
off	16
0	32
1	32
0	

off	off	on	on	off	on
16	16	16	16	16	16

A slot is a concatenation of several datafields. In the above example, you can see several slots for SOF, EOF and for hexadecimal bytes (e.g. 0x00, 0x20, 0x01). In case of the slot “SOF1”, the contents of the slot are composed of Data Fields “off” and “on” in order to give the specified sequence for the start of frame sequence.

The following screenshot shows the definition of one databye (example: 0x38). It is composed of eight 32-chip data-fields “0” and “1”. Total length of one databyte is 256 chips.



Configure Slots

Slot Pool

Name	Length / Bits	Color
0x95	256	🟧
0x38	256	🟧
0x13	256	🟧

Name: 0x38 Info: hex 38

Color: 🟧 Length / Bits: 256

Data Fields

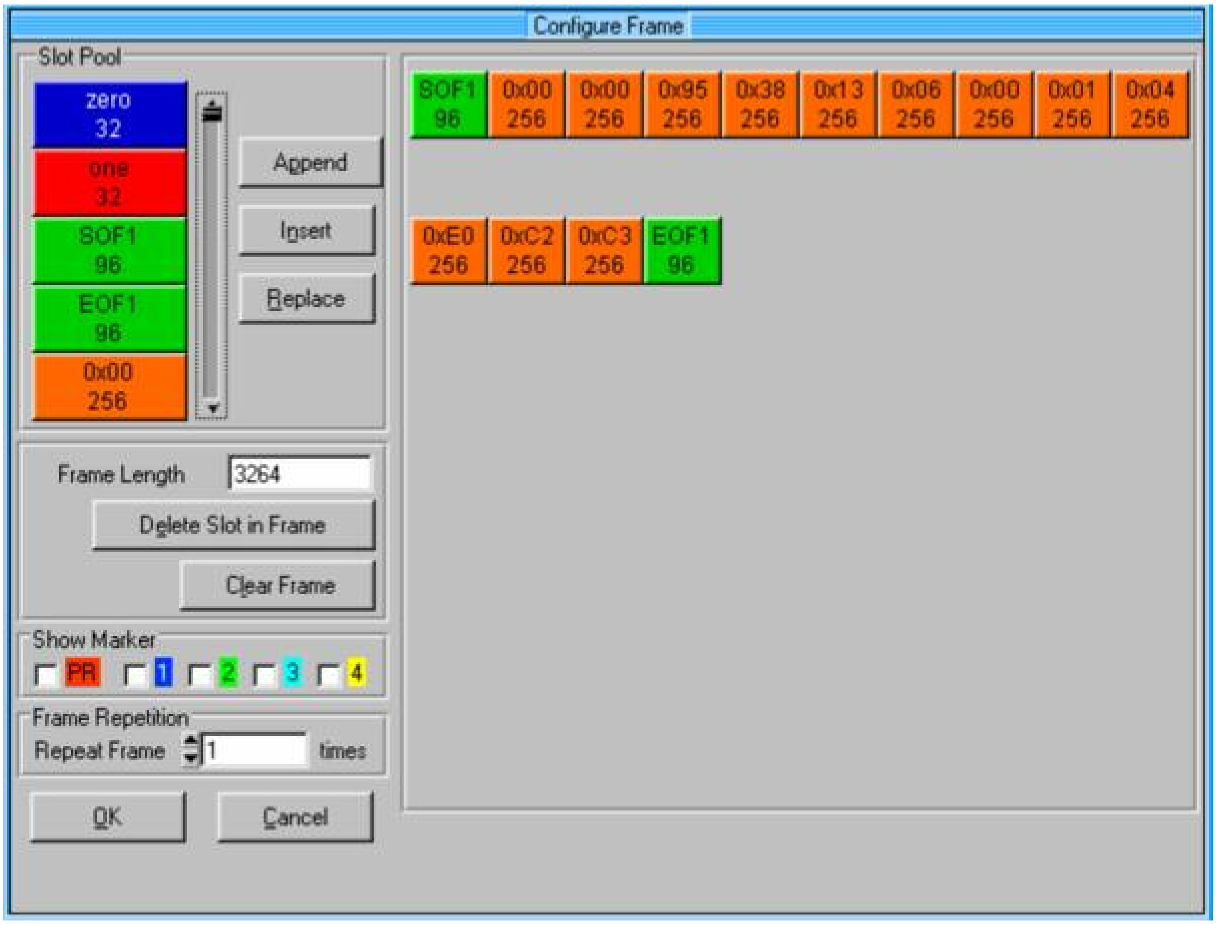
on	16
off	16
0	32
1	32

0	0	0	1	1	1	0	0
32	32	32	32	32	32	32	32

Care must be taken regarding the “LSB first” rule in ISO15693. The above example for 0x38 transmits the LSB first. This means the real data byte value is the mirror of above data bits: “00111000” = 0x38 in hexamdecimal.

Any other databyte can be configured in a similar way. Databytes are stored in the slot pool.

In a final step, slots are arranged to compose a frame:



Frame Length 3264

Repeat Frame 1 times

SOF1	0x00	0x00	0x95	0x38	0x13	0x06	0x00	0x01	0x04
96	256	256	256	256	256	256	256	256	256

0xE0	0xC2	0xC3	EOF1
256	256	256	96

In this example, the Frame consists of a start of frame SOF1, followed by 12 databytes, followd by an end of frame EOF.

The above example shows the frame for a response to an “inventory request” signal.

The first byte contains the response flags: 0x00 means that no error was detected.

The second byte contains the parameters: 0x00 does not specify parameters in this case

The following eight bytes show the UID: “0xE0 04 01 00 06 13 38 95” (please note that LSB is sent first)

The remaining 2 bytes are created from the preceding bytes by means of a CRC16 algorithm. This application note comes with an Excel VBA macro (CRC.xls) which enables the calculation of CRC16 codes according to ISO15693. For the given frame, the CRC16 yields “0xC3C2”. LSB is transmitted first.

When the frame is setup, you can save your settings to a data editor definition file (ending *.ded)

As a next step, the frame has to be calculated. Enter the name of the wanted datafile (*.dbi) in the filed an press “calculate and save sequence”

7. Appendix D – ISO15693 standard

7.1. Frequency

The frequency (f_c) of the RF operating field is 13,56 MHz ±7 kHz.

7.2. Power Transfer to VICC

Power transfer to the VICC is accomplished by radio frequency via coupling antennas in the VCD and in the VICC. The RF operating field that supplies power to the VICC from the VCD is modulated for communication.

7.3. Communication from VCD to VICC

7.3.1. Modulation Type

Modulation type is ASK (Amplitude Shift Keying). Possible Modulation Indexes are 10% and 100%.

7.3.2. Data Coding

Data Coding is done by pulse position modulation. Two different data coding methods are possible: 1 out of 256 and 1 out of 4.

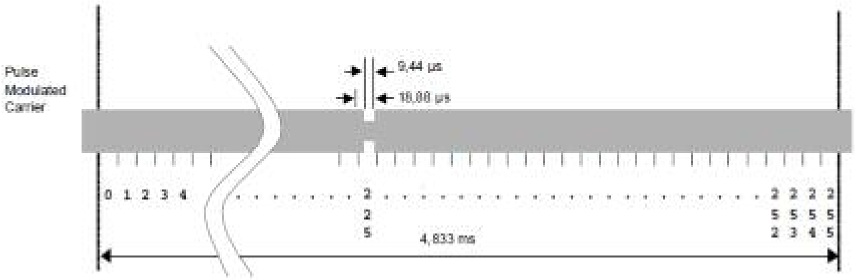


Figure 3: 1 out of 256 coding mode

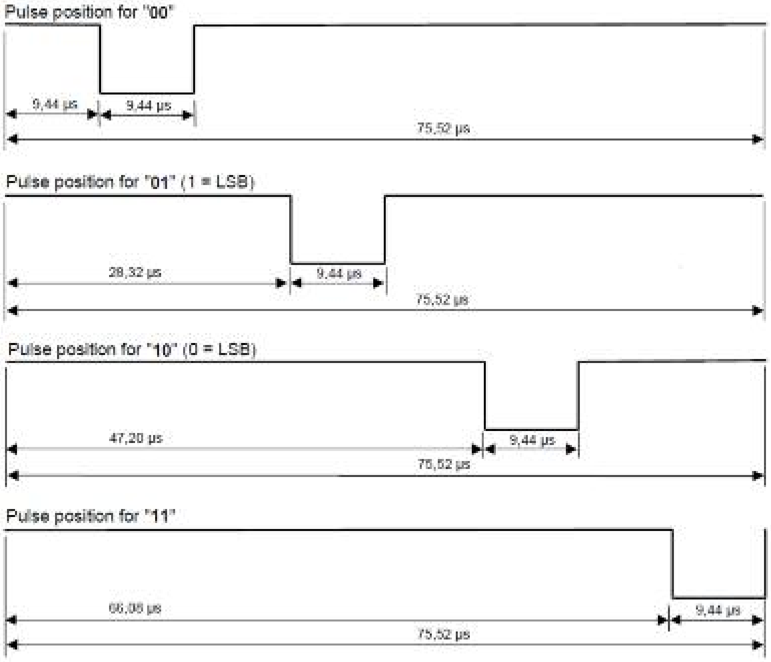


Figure 5: 1 out of 4 coding mode

7.3.3. Frames

Frames shall be delimited by a start of frame (SOF) and an end of frame (EOF) and are implemented using code violation

The VICC shall be ready to receive a frame from the VCD within 300 µs after having sent a frame to the VCD.

The VICC shall be ready to receive a frame within 1 ms of activation by the powering field.

7.3.4. Start of Frame (SOF)

There are two possible Start of Frame sequences, selecting either the 1 out of 256 mode or the 1 out of 4 mode.

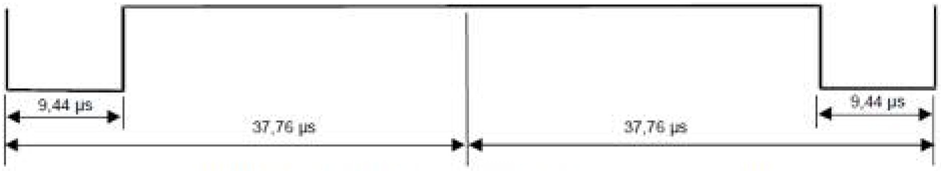


Figure 7: Start of frame of the 1 out of 256 mode

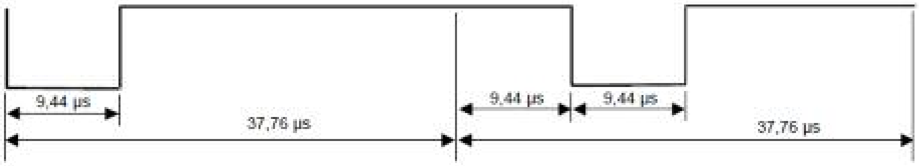
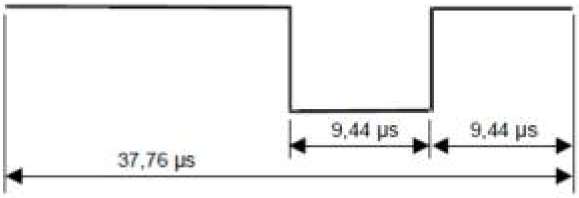


Figure 8: Start of frame of the 1 out of 4 mode

7.3.5. End of Frame (EOF)

The end of frame for either mode is as follows:



7.4. Communication from VICC to VCD

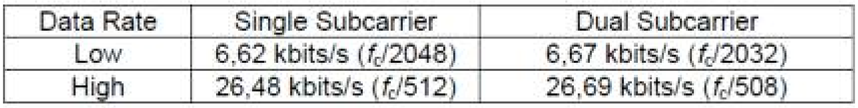
7.4.1. Frequencies

Communication from VICC to VCD can be done with one or with two subcarriers.

When one subcarrier is used, the frequency f_{s1} of the subcarrier load modulation shall be $f_c/32$ (423,75 kHz).

When two subcarriers are used, the frequency f_{s1} shall be $f_c/32$ (423,75 kHz), and the frequency f_{s2} shall be $f_c/28$ (484,28 kHz).

7.4.2. Datarate



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)

Table 1: Data rates

7.4.3. Modulation and coding

The communication from VICC to VCD shall be done by direct coding of the RF carrier wave.

Coding with one subcarrier

A logic 0 starts with 8 pulses of 423,75 kHz (f_c/32) followed by an unmodulated time of 18,88 µs (256/f_c). As shown in Figure 10.

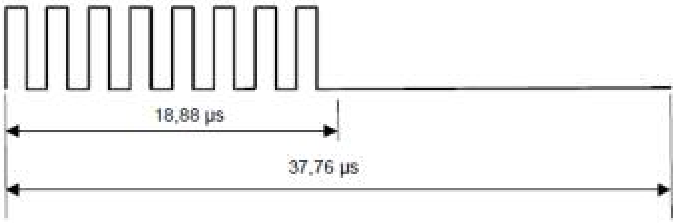


Figure 10: Logic 0

A logic 1 starts with an unmodulated time of 18,88 µs (256/f_c) followed by 8 pulses of 423,75 kHz (f_c/32). As shown in Figure 11.

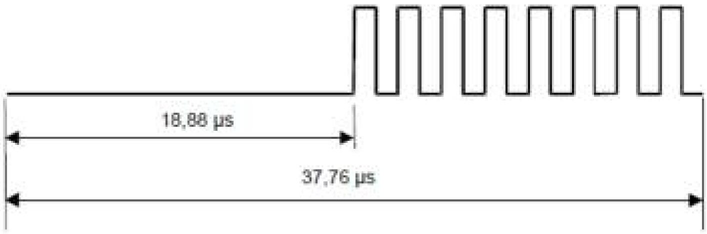


Figure 11: Logic 1

Coding with two subcarriers

A logic 0 starts with 8 pulses of 423,75 kHz (f_c/32) followed by 9 pulses of 484,28 kHz (f_c/28). As shown in Figure 12.

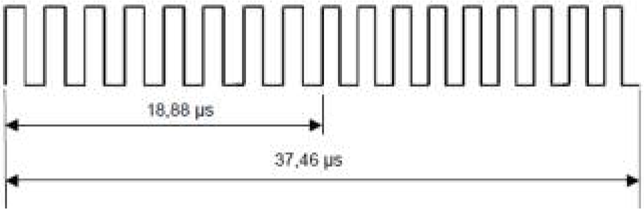


Figure 12: Logic 0

A logic 1 starts with 9 pulses of 484,28 kHz (fc/28) followed by 8 pulses of 423,75 kHz (fc/32). As shown in Figure 13.

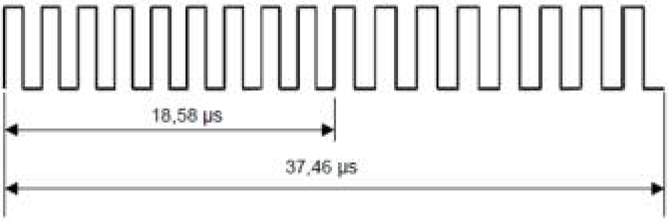


Figure 13: Logic 1

7.4.4. VICC to VCD frames

Frames are delimited by a Start of frame (SOF) and an End of frame (EOF) and are implemented using code violation.

The VCD shall be ready to receive a frame from the VICC within 300 µs after having sent a frame to the VICC.

Start of Frame (SOF) with one carrier

SOF comprises 3 parts:

- an unmodulated time of 56,64 µs (768/fc),
- 24 pulses of 423,75 kHz (fc/32),
- a logic 1 which starts with an unmodulated time of 18,88 µs. (256/fc) followed by 8 pulses of 423,75 kHz (fc/32).

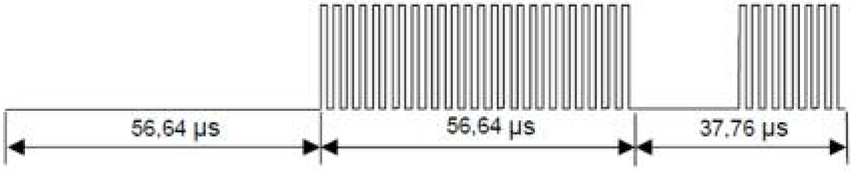


Figure 14: Start of frame when using one subcarrier

Start of Frame (SOF) with two carriers

SOF comprises 3 parts:

- 27 pulses of 484,28 kHz (fc/28),
- 24 pulses of 423,75 kHz (fc/32),
- a logic 1 which starts with 9 pulses of 484,28 kHz (fc/28) followed by 8 pulses of 423,75 kHz (fc/32).

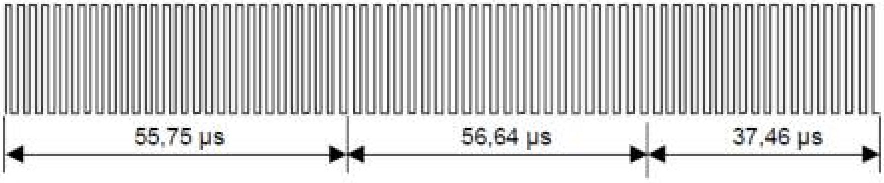


Figure 15: Start of frame when using two subcarriers

End of Frame (EOF) with one carrier

EOF comprises 3 parts:

- a logic 0 which starts with 8 pulses of 423,75 kHz (fc/32), followed by an unmodulated time of 18,88 µs (256/fc),
- 24 pulses of 423,75 kHz (fc/32),
- an unmodulated time of 56,64 µs (768/fc).

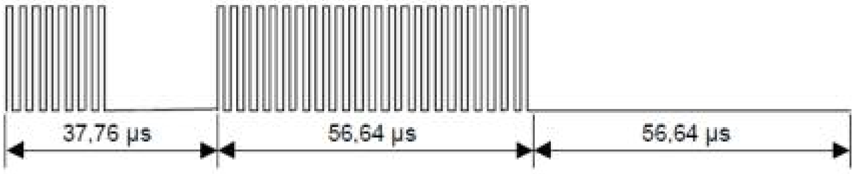


Figure 16: End of frame when using one subcarrier

End of Frame (EOF) with two carriers

EOF comprises 3 parts:

- a logic 0 which starts with 8 pulses of 423,75 kHz (fc/32) followed by 9 pulses of 484,28 kHz (fc/28),
- 24 pulses of 423,75 kHz (fc/32),
- 27 pulses of 484,28 kHz (fc/28).

Communication ***from VICC to VCD***

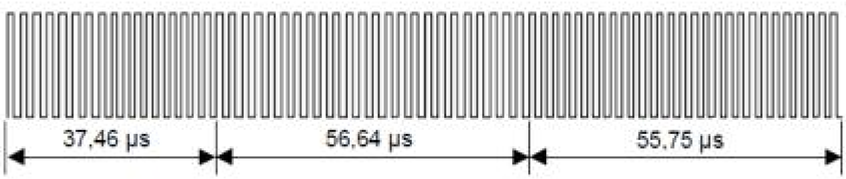
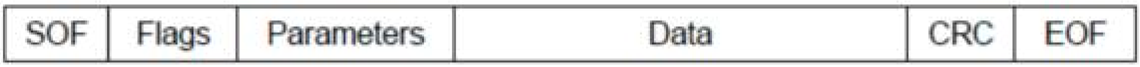


Figure 17: End of frame when using 2 subcarriers

Response format

The response from the VICC to the VCD consists of start of frame sequence, flags, facultative parameters and data (containing e.g. the UID). A 16 bit CRC checksum is appended to the data bits, followed by an end of frame sequence.



SOF	Flags	Parameters	Data	CRC	EOF

Figure 5 — General response format

8. Appendix A – User Modulation in WinIQSIM™

User modulation: To allow also new modulation types to be used that are not predefined by WinIQSIM™, a user-specific modulation type can be configured via a data file. When User Modulation is selected, a window is opened where a file with the extension *.IMP (IQSIM mapping file) can be selected. The user modulation file must be an ASCII file of the following format

Format of user modulation file

Line	Content
1	ROHDE&SCHWARZ IQSIM MAPPING FILE
2	Comment line with any kind of entries
3	PSK
4	0 (no offset of I/Q signal)
5	Number of modulation states
6	I value, Q value for data symbol 0
7	I value, Q value for data symbol 1
8	Cont'd for all modulation states

The first data line states the name ROHDE&SCHWARZ IQSIM MAPPING FILE to distinguish user files. Any number of comment lines can be written before the first line. They must all start with #. These lines are followed by a compulsory comment line (without #). Subsequently it has to be decided whether PSK, QAM or FSK modulation should then be defined. With PSK and QAM modulation, the following line determines whether an offset of the

Q signal should be used (1) or not (0) in bit 0 (weighting 1). Bit 2 (weighting 2) decides about differential coding.

It should be noted that the maximum amplitude of the vector defined by an I/Q pair should not exceed 1.

Example for 100%ASK Modulation File:

```
ROHDE&SCHWARZ IQSIM MAPPING FILE
special OOK (on-off-keying) or ASK amplitude shift keying
PSK
0
2
0.00001,        0.0
1.0,            0.0
```

9. Hardware and Software Requirements

9.1. PC Hardware Requirements

	Minimum	Recommended
CPU	Pentium 133 MHz	Pentium II 450 MHz or higher
RAM	32 MByte	128 MByte
Harddisc	10 MByte free space	50 MByte free harddisc space
Monitor	VGA monitor (640x480)	SVGA color monitor, resolution 800x600 or better
IEEE Bus		

9.2. PC Software Requirements

	Minimum	Recommended
OS	Windows 95 / 98 / NT 4.0 / 2000 / Me / XP	Windows 98 / 2000 / Me / XP
OS add-ons	---	Microsoft Internet Explorer 5.0 or above Microsoft Excel 2002 or above
IEEE Bus Driver	Version 1.70 (or above)	---
VISA		---

10. Literature

[1] ISO15693 standard document

11. Additional Information

This application note and the associated program are updated from time to time. Please visit the website **1MAxx** in order to download new versions. After installation, the latest program information can be found in the file *history.rtf* in the installation directory. You can access this file also from link *Programs / Field Strength Estimator / History* from your *Start Programs* folder.

Please send any comments or suggestions about this application note to **TM-Applications@rsd.rohde-schwarz.com**.

12. Ordering information

Signal Analyzers		
R&S® FSL3	9 kHz to 3 GHz	1300.2502.03
R&S® FSL6	9 kHz to 6 GHz	1300.2502.06
R&S® FSP3	9 kHz to 3 GHz	1093.4495.03
R&S® FSP7	9 kHz to 7 GHz	1093.4495.07
R&S® FSP13	9 kHz to 13 GHz	1093.4495.13
R&S® FSP30	9 kHz to 30 GHz	1093.4495.30
R&S® FSP40	9 kHz to 40 GHz	1093.4495.40
R&S® FSQ3	20 Hz to 3.6 GHz	1155.5001.03
R&S® FSQ8	20 Hz to 8 GHz	1155.5001.08
R&S® FSQ26	20 Hz to 26,5 GHz	1155.5001.26
R&S® FSQ-K70	Vector Signal Analyzer	1161.8038.02
R&S® FSU3	20 Hz to 3.6 GHz	1166.1660.03
R&S® FSU8	20 Hz to 8 GHz	1166.1660.08
R&S® FSU26	20 Hz to 26.5 GHz	1166.1660.26
R&S® FSU46	20 Hz to 46 GHz	1166.1660.46
Signal Generators		
R&S® SMJ100A		1403.4507.02
R&S® SMJ-B103	100 kHz to 3 GHz	1403.8502.02
R&S® SMJ-B106	100 kHz to 6 GHz	1403.8702.02
R&S® SMJ-B10	Baseband with ARB (64 Msamples)	1403.8902.02
R&S® SMJ-B11	Baseband with ARB (16 Msamples)	1403.9009.02
R&S® SMJ-B13	Baseband Main Module	1403.9109.02
R&S® SMU200A		1141.2005.02
R&S® SMU-B102	RF Path A: 100 kHz to 2.2 GHz	1141.8503.02
R&S® SMU-B103	RF Path A: 100 kHz to 3 GHz	1141.8603.02
R&S® SMU-B104	RF Path A: 100 kHz to 4 GHz	1141.8703.02
R&S® SMU-B106	RF Path A: 100 kHz to 6 GHz	1141.8803.02
R&S® SMU-B202	RF Path B: 100 kHz to 2.2 GHz	1141.9400.02
R&S® SMU-B203	RF Path B: 100 kHz to 3 GHz	1141.9500.02
R&S® SMU-B10	Baseband with ARB (64 Msamples)	1141.7007.02
R&S® SMU-B13	Baseband Main Module	1141.8003.02

Please note, that complete solutions for signal generation and signal analysis for various applications are available from Rohde & Schwarz.

For additional information about equipment, see the Rohde & Schwarz website www.rohde-schwarz.com.

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