PHILIPS	Fast / Easy Antenna Verification	**Authors:** Johannes Wroehlich **Date:** 20.03.2006 **Version:** 0.1

1 Introduction

For antenna dimensioning a network analyzer is normally needed. This approach shall show how to verify your antenna by use of "simple" oscilloscope equipment and in a second step by use of an active oscilloscope probe.

2 Approach by Use of Standard Oscilloscope

Measurement Equipment:

- Oscilloscope with a bandwidth of >50MHz e.g. MSO6032A Agilent Technologies 300MHz 2GSa/s used for this measurements
- Standard Oscilloscope Probe e.g. Agilent Technologies 10073C 1Mohm, 12pF used for this measurements
- Low Capacitance Oscillator Probe e.g. Agilent Technologies 1144A Active Probe 1Mohm, 2pF used for this measurements

- Some Card (Tag) e.g. Mifare® UL, Mifare® Standard 1k
- Software Tool which switches basic functionality of PN5xx device like RF-Field ON and SENSE_REQ in the second step, for this measurements the Mifare® Reader jcf for JoinerPCSerial is used

- PN5xx Board with Antenna, matching circuit done according to the AN100720 Antenna Design Guide, for this sample measurements the PN512 (v8.0) demo-board is taken.

Other software that can be used:

- NFC Basic Function Library (BFL)
- SCR-Tester (Mifare® Reader Example)
- JoinerPCSerial (e.g. Mifare® Reader jcf)

2.1 13,56MHz RF-Field - Basic Check

This is the very first basic check. Switch ON the RF field on measure the RF field (13,56MHz) by use of a field probe:

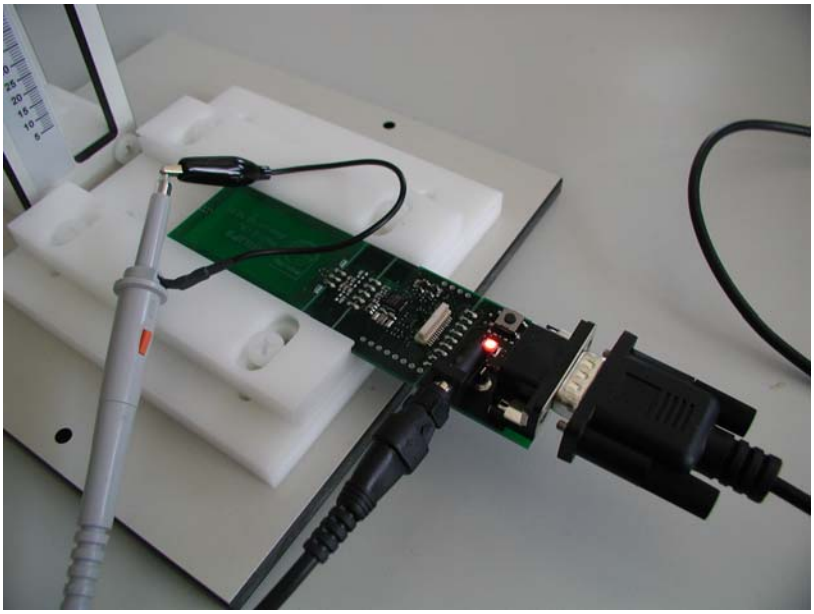

Figure 1: Basic Check with Field Probe

This shows how to establish the test setup with a field probe. It is the standard probe with 12pF capacitance. In case you use an ESD-mat or a desk which influences the magnetic field (iron inside or under the surface) please use some spacer for your measurements e.g. some card box of height 10cm. This should de-couple the desk's magnetic influence.

Start the MifareReader.jcf – An error is generated but the RF-Field is still running after finishing the script. The RF-Field is seen on the oscilloscope:

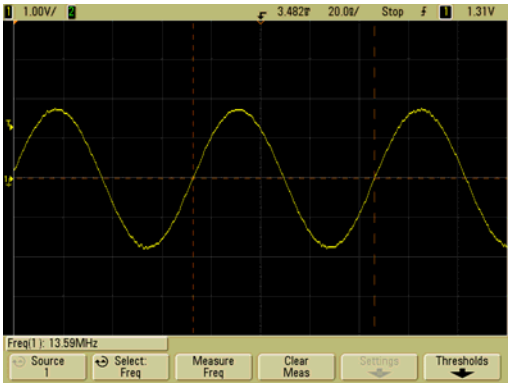

Figure 2: RF-Field Basic Check

Please take into account that the absolute amplitude may change due to the coupling factor achieved by the field probe. Of only interest is the existence of the 13,56MHz field.

2.2 13,56MHz RF-Field – ASK Check

Second step is to verify the correct pulse shaping of the Reader/ Writer Device. The 100%ASK of the SENSE_REQ is used for this measurement. By adjusting the trigger to Pulse-Width this can easily be observed. Just start the MifareReader.jcf again:

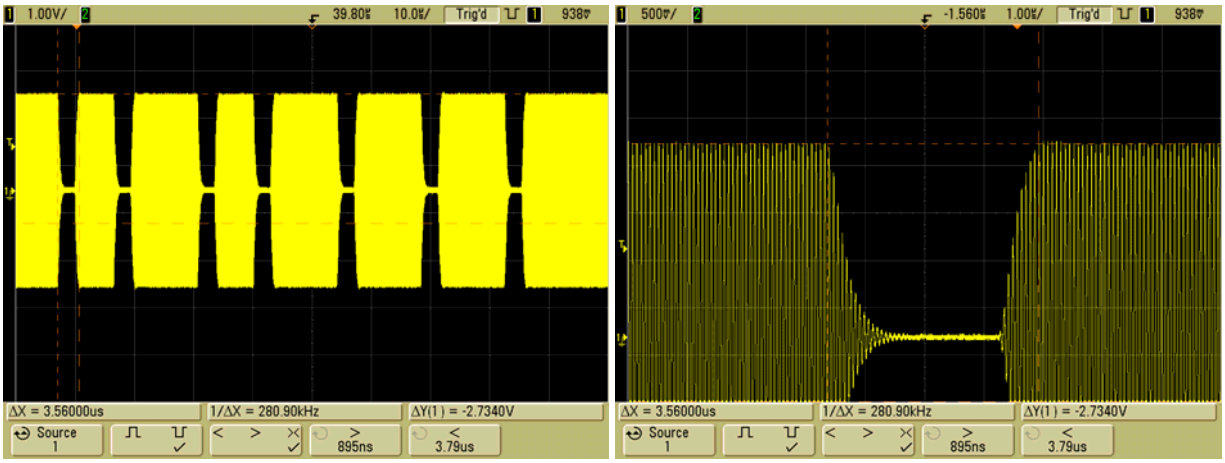

Figure 3: ASK Verification

From the oscilloscope shots one may take the basic oscilloscope settings. For comparison with ISO18092-envelope shaping some more detailed measurements might help.

This is the Pulse-Shaping given in the ISO18092 page 8. Of special interest are the given values of Rise/ Fall Time and Over/Undershoots. If the times are not OK the Q-factor of the antenna might be to High / Low as it controls mainly the rise time and the resulting overshoot.

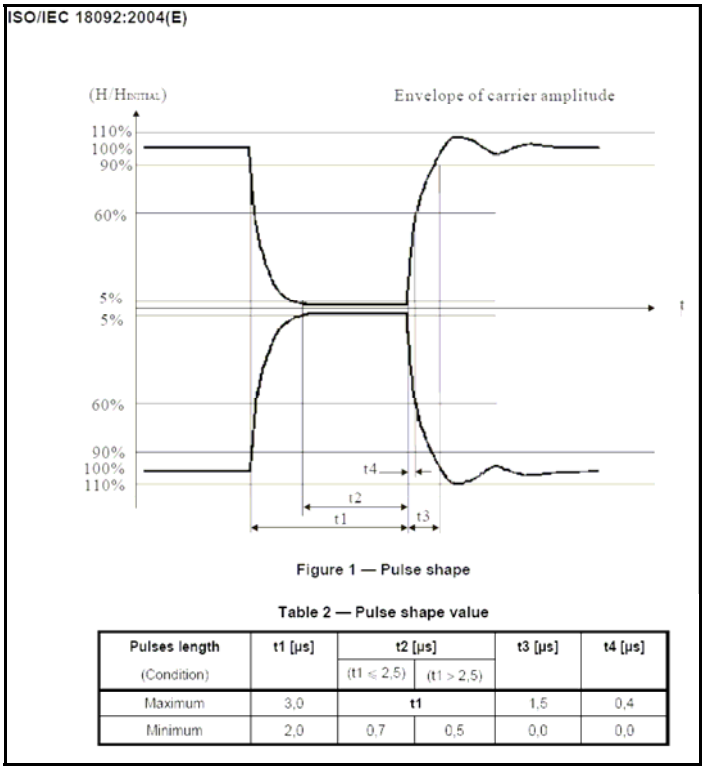

Figure 1 — Pulse shape

Table 2 — Pulse shape value

Pulses length (Condition)	t1 [µs]	t2 [µs]		t3 [µs]	t4 [µs]
		(t1 ≤ 2,5)	(t1 > 2,5)		
Maximum	3,0	t1		1,5	0,4
Minimum	2,0	0,7	0,5	0,0	0,0

Figure 4: ISO18092 Envelope Check

If the shaping is OK we move on to the next step and have a look on the antenna tuning.

2.3 13,56MHz RF-Field – TX1 - TX2 Check

Within this measurement the tuning of the antenna can be verified. For this measurement the standard as the low-capacitance probes are used. In principle the measurement can be done on TX1 or TX2.
This is the setup for the measurement, for measurements close to the antenna try to avoid magnetic coupling influences by good ground connection which is close to the test-point (TP1, TP2).

IMPORTANT

Always perform these tests in the final application surroundings e.g. Battery-Pack in close distance, underlying PCB etc.

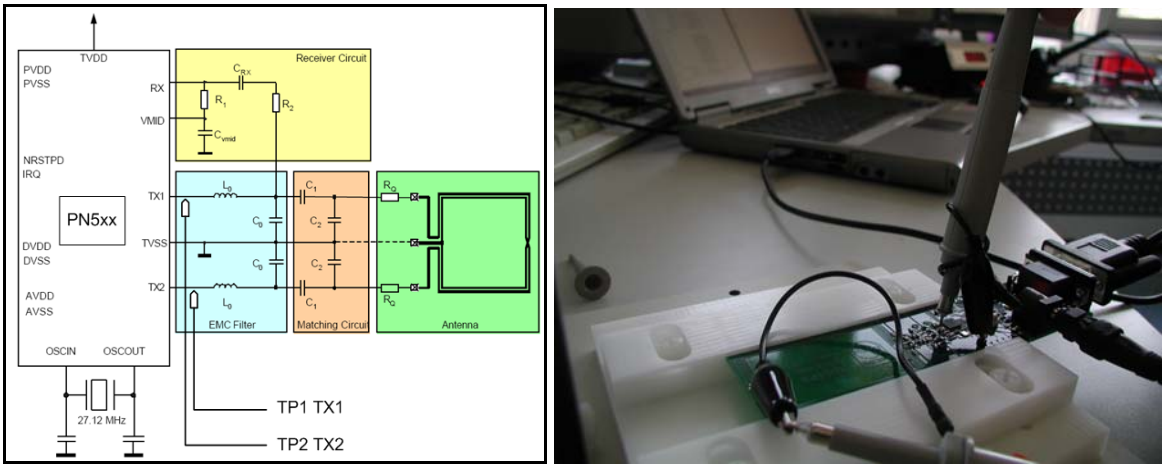

Figure 5: TX Measurement Setup

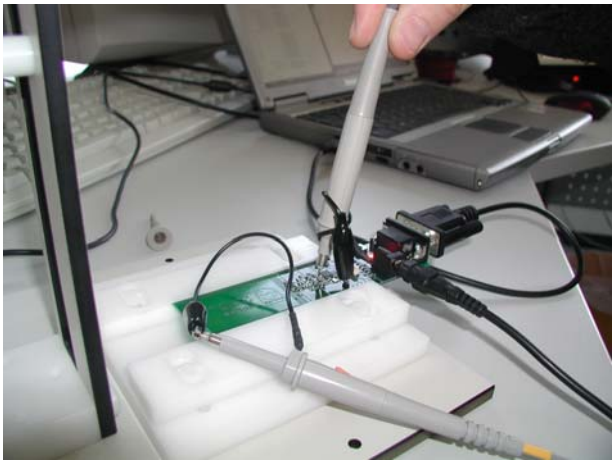

Figure 6: TX Measurement Setup 2

This measurement is taken with the low-capacitance probe:

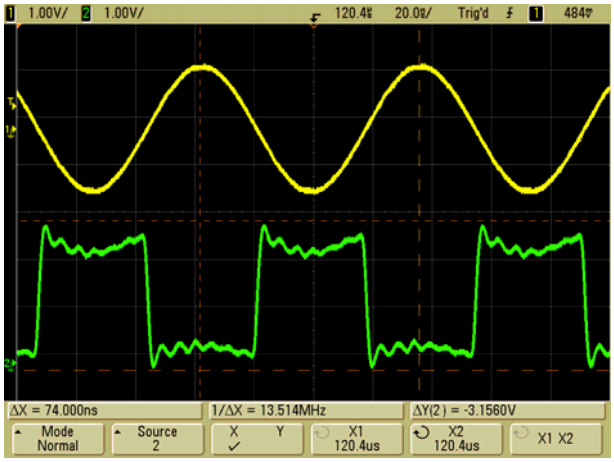

Figure 7: TX1 Verification Low Capacitance Probe

From this picture we take the information that the antenna tuning is done in a perfect way. The shaping of the digital signal is very nice – we will see in comparison to the following pictures given.

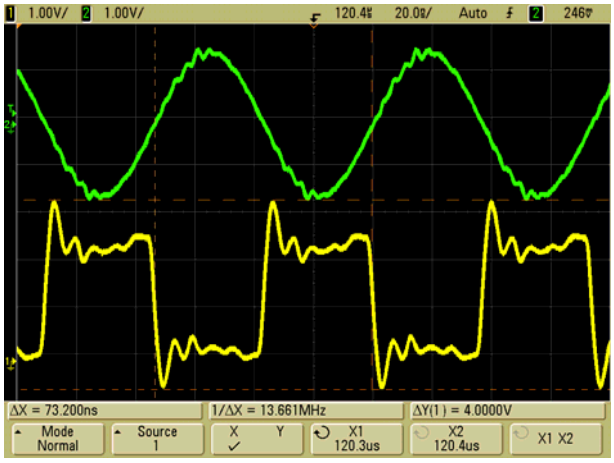

Figure 8: TX1 Verification using the Standard Probe

It is still a quite nice signal but some difference to the low capacitance setup can be seen. This picture shall just demonstrate the impact of the measurement equipment.

2.3.1 TX1 Measurement with a Non-Perfect Antenna

Again the low capacitance probe is used. A picture like this would need a deeper investigation on root cause.

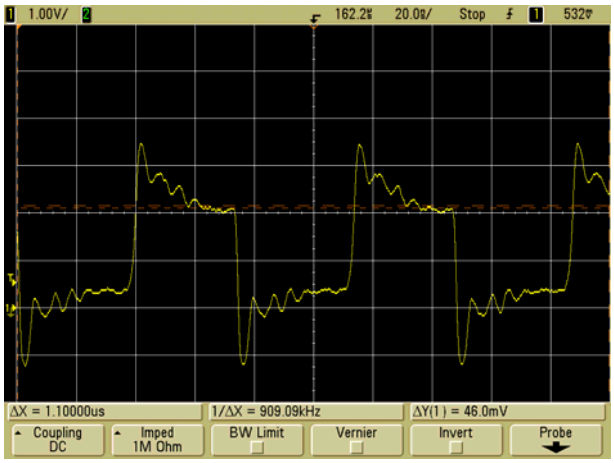

Figure 9: TX Voltage with a De-Tuned Antenna

To show the effect a Smith Diagram by use of a Network Analyzer is taken. For information on how to set-up this measurement please refer to the Antenna Design Guide AN100720.

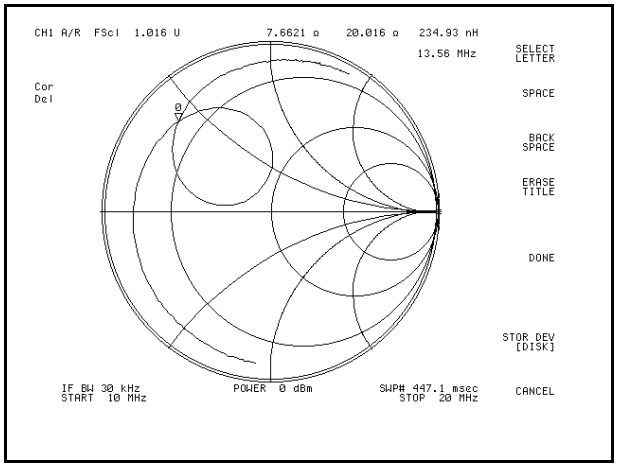

Figure 10: Smith Diagram of Bad-Tuned Antenna

We clearly see some strong inductive behavior. The 13.56MHz resonance point is far from the 50Ohm tuning point. For this antenna bad communication distance and communication errors are expected. Also the antenna current will exceed 100mA if the tuning as in this example is in the area <20Ohm. De-tuning due to a Tag in the field will even worsen performance and current consumption.

2.4 Verification on Tag-Response

We go on with our investigations in case the TX1 behavior is within the limits. To the setup we now add some tag – in this case a Mifare® Standard 1k card. The setup looks like this:

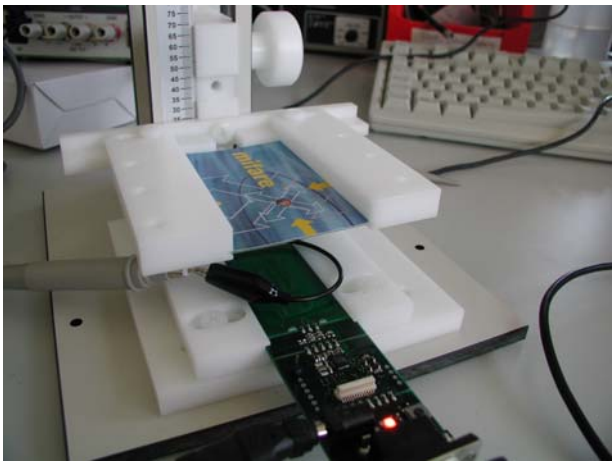

Figure 11: Verification on Tag Response

With the previously done measurement we shall be able to power up the card and send a SENSE_REQ. What we would like to see is the card's response. If this can be observed we know two things:

1. We are able to power up the Tag
2. We are able to send a command which is demodulated and understood by the card correctly (even if the response is some error code)

We try to find the 848kbps modulated carrier response of the tag:

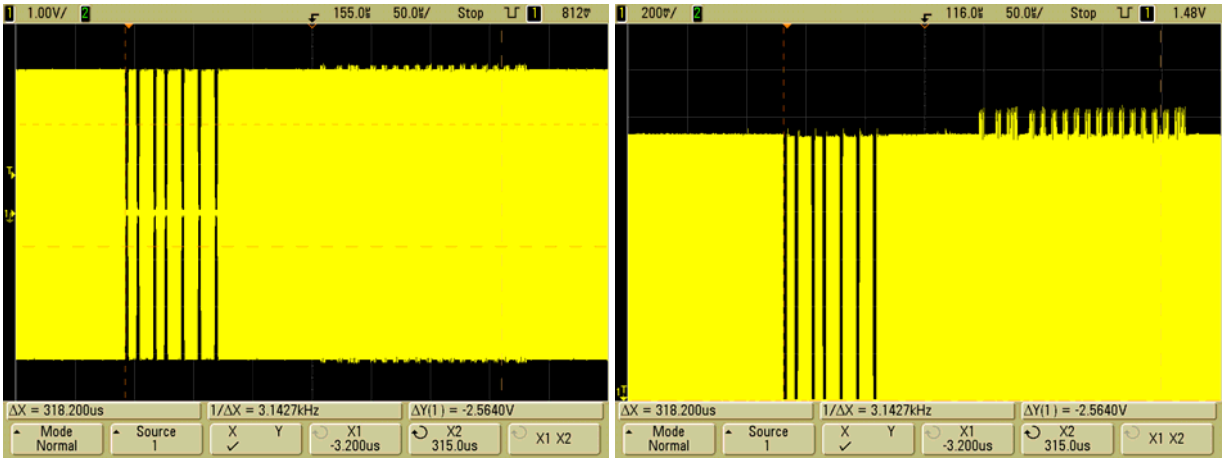

Figure 12: Tag Response Part 1

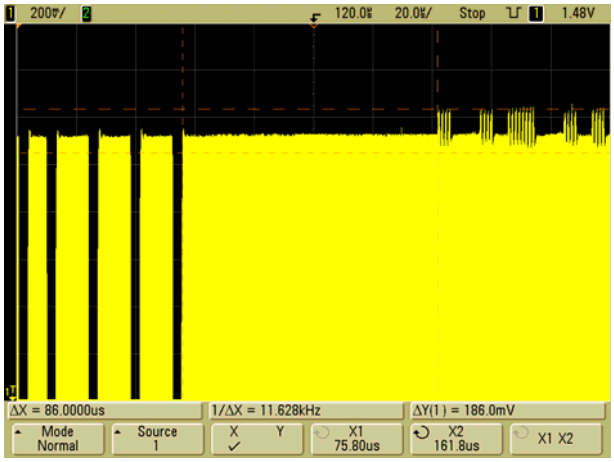

Figure 13: Tag Response Part 2

The pictures show all the same Request / Response only the zoom factor is different. We can conclude that the card is powered correctly, the Request command could be decoded correctly – thus we see some response from the target.

To see the response nicely a good coupling factor is needed. For this measurement the distance between Reader / Writer and Mifare® card was about 1cm. The rest is as shown on the setup picture.

2.5 Verification of RX-Path

The last thing we now are going to check if the response is seen on the RX Path, too. For this we use some probe on the RX pin of the PN5xx chip.

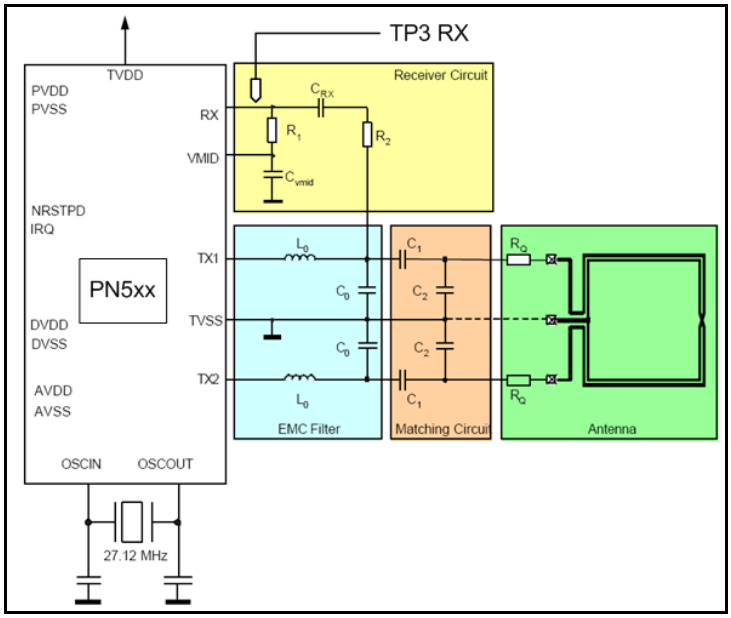

Figure 14: Setup RX Path Verification

First we use the active probe:

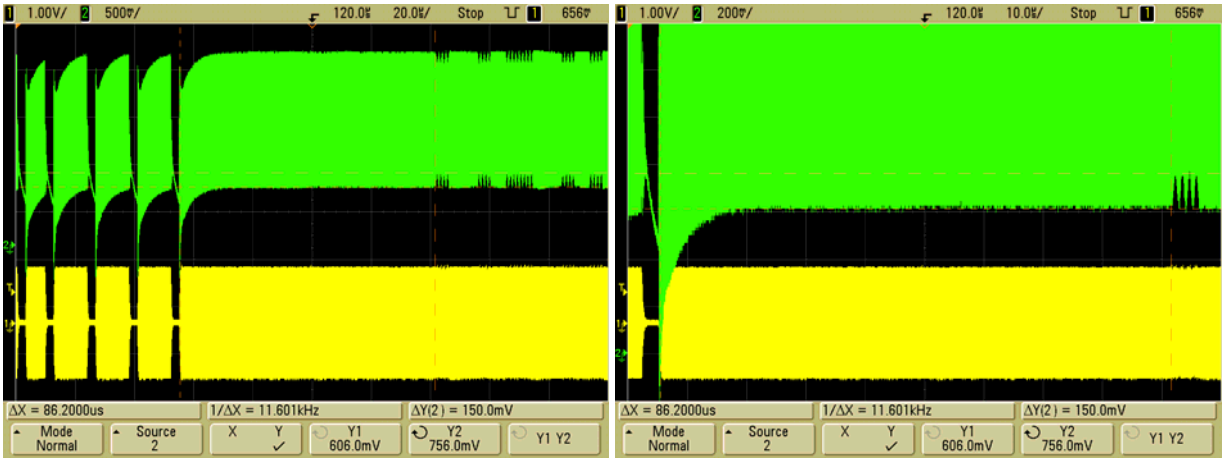

Figure 15: RX Response Verification Low Capacitance Probe

We clearly see the response (around 150mV)– If the software is set correctly we should find data in the FIFO.

Again to show the difference with respect to capacitance on the oscillator probe we take the same measurement with the 12pF probe:

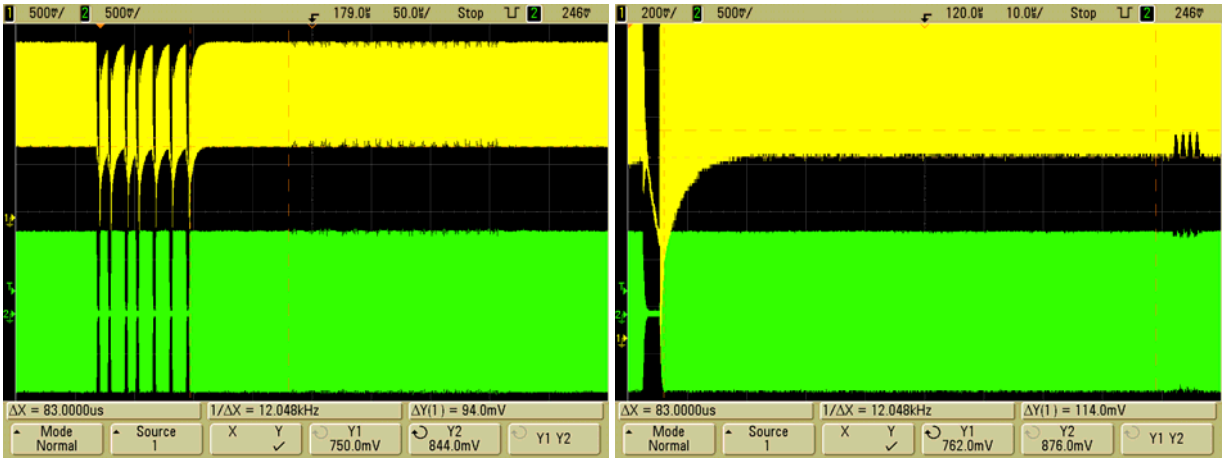

Figure 16: RX Response Verification Standard Probe

We expect some changes in response voltage due to coupling etc but no decrease from around 150mV to 100mV. We conclude that RX is quite sensitive to capacitive load. If the response is already at the boarder of demodulators capabilities (5mV) the Low Capacitive Probe could show some response while the standard probe does not. This comparison is just highlighting the effect of measurement equipment used.

3 Conclusion

This paper shows some straight forward way to verify the RF communication path. If all checks are done and the result is satisfying the system's needs we know that:

- The register settings of the output drivers are correct if we see some RF-Field
- Measuring the ASK pulse shape gives us knowledge on the Q-factor of the antenna and we can check ISO18092 compliancy
- By observing TX1 or TX2 pin we get some basic information on antenna tuning
- The response of some Target/ Tag on the RF Field shows three things:
  - We are able to power-up the device (Passive Tag communication)
  - We are able to send some RF-compliant command which can be demodulated by the target
  - The target is able to modulate its response to the initiator
- By checking the RX path we ensure that the response is at least arriving on RX pin of the demodulation circuit of the Initiator

In case all RF-requirements are met but no data is found in the FIFO checking of receiving path register settings might help.

If other communication speeds (212kbps, 424kbps) or types (e.g. active communication) have problems this report can be used to set-up some equivalent flow to find and eliminate its root cause. The activation and thus the software is different but with respect to RF-Verification the steps will be quite the same.

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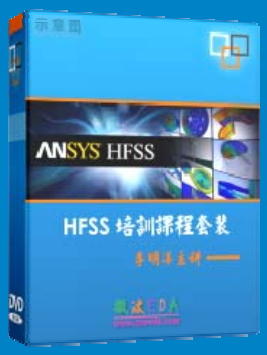

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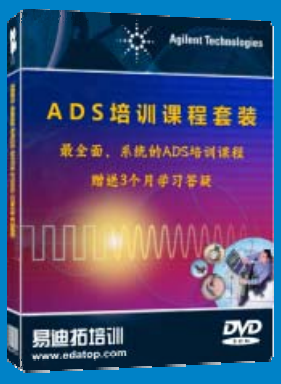

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