NFC Reader Antenna Design 4

Optimization & Debugging

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Session 04: Optimization & Debugging

17 March 2015

NFC Reader Antenna Design 4: Optimization & Debugging

- How can we guarantee proper functionality?
  - Measure the current consumption (ITVDD)
  - Measure field strength: ANT#5
  - Measure wave shapes: ANT#5
  - Measure & adjust the Rx level

Part of compliance tests

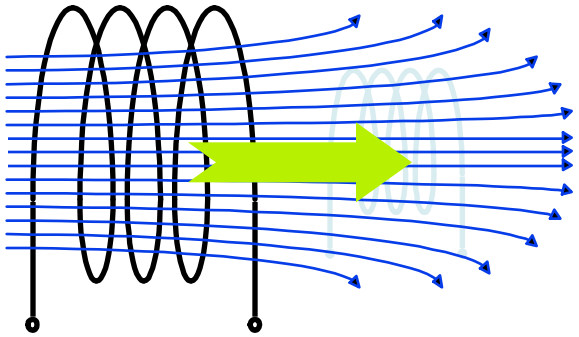
- How can we optimize performance?
  - Use a sniffer
  - Use test & debug signals
  - Test receiver signals to optimize register settings
  - Show “good” and “bad” signals

Example

- Q&A

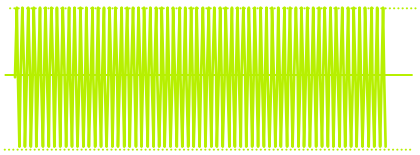
What must be tested?

Power

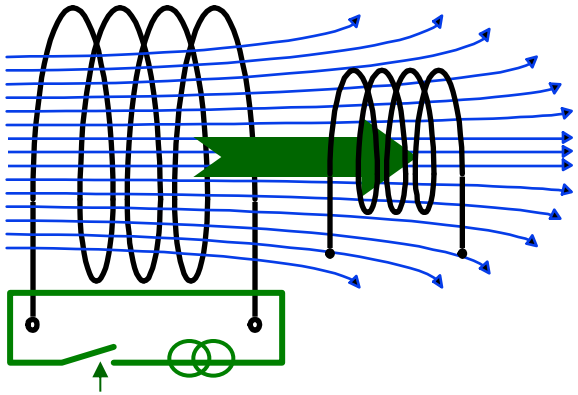


PCD → PICC

13.56 MHz Carrier

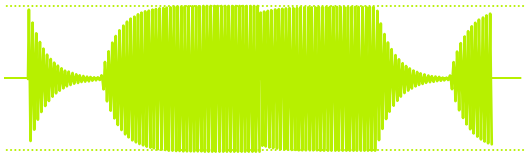


Transmit Data

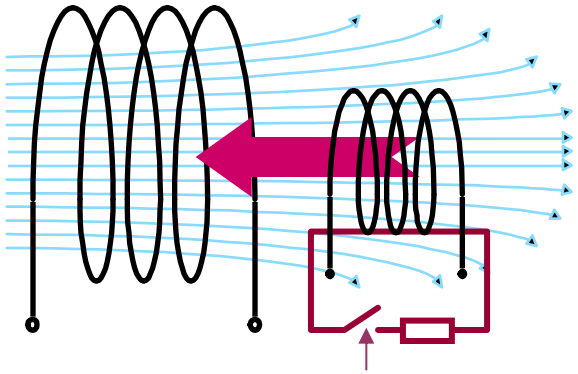


PCD → PICC

MILLER coded DATA

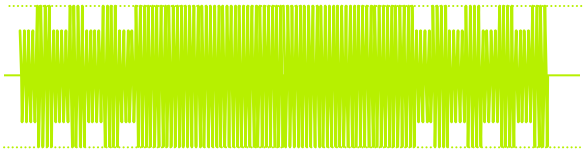


Receive Data



PCD ← PICC

LOAD modulated DATA



PCD: Proximity Coupling Device (“reader“)
PICC: Proximity Chip Card (“card“)

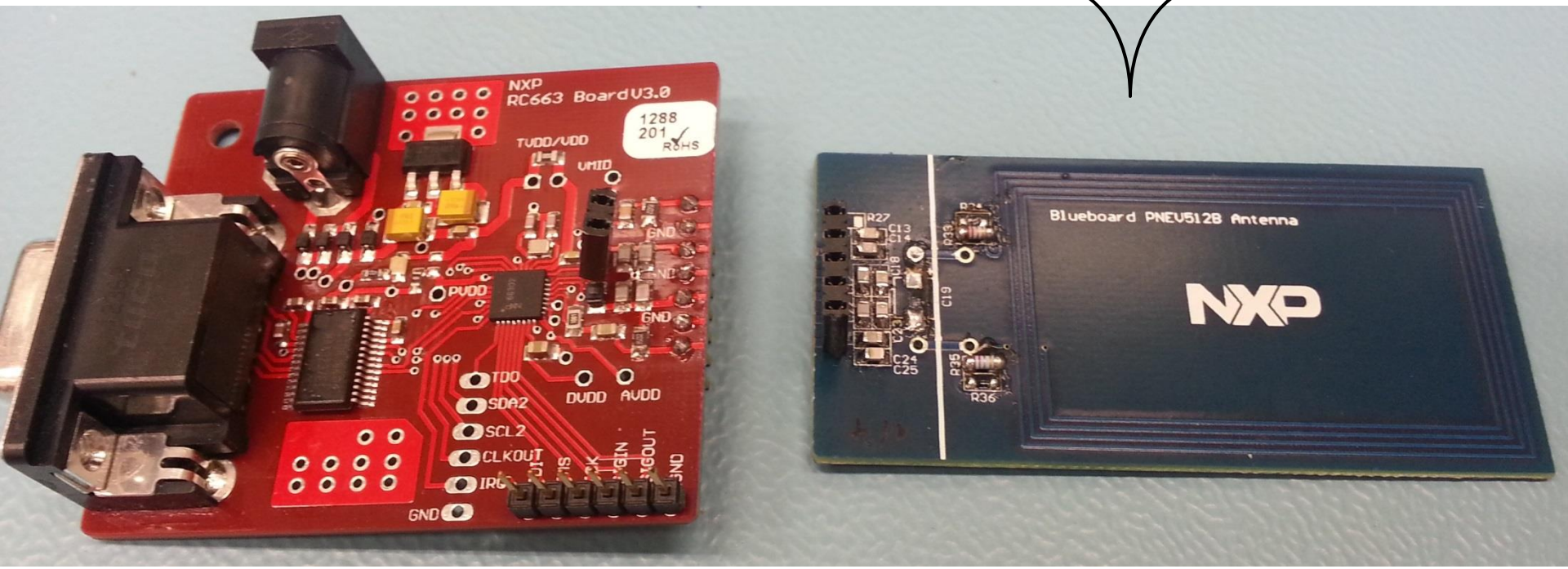
Hardware like in ANT#2 & ANT#3

CLRC663 “red board“

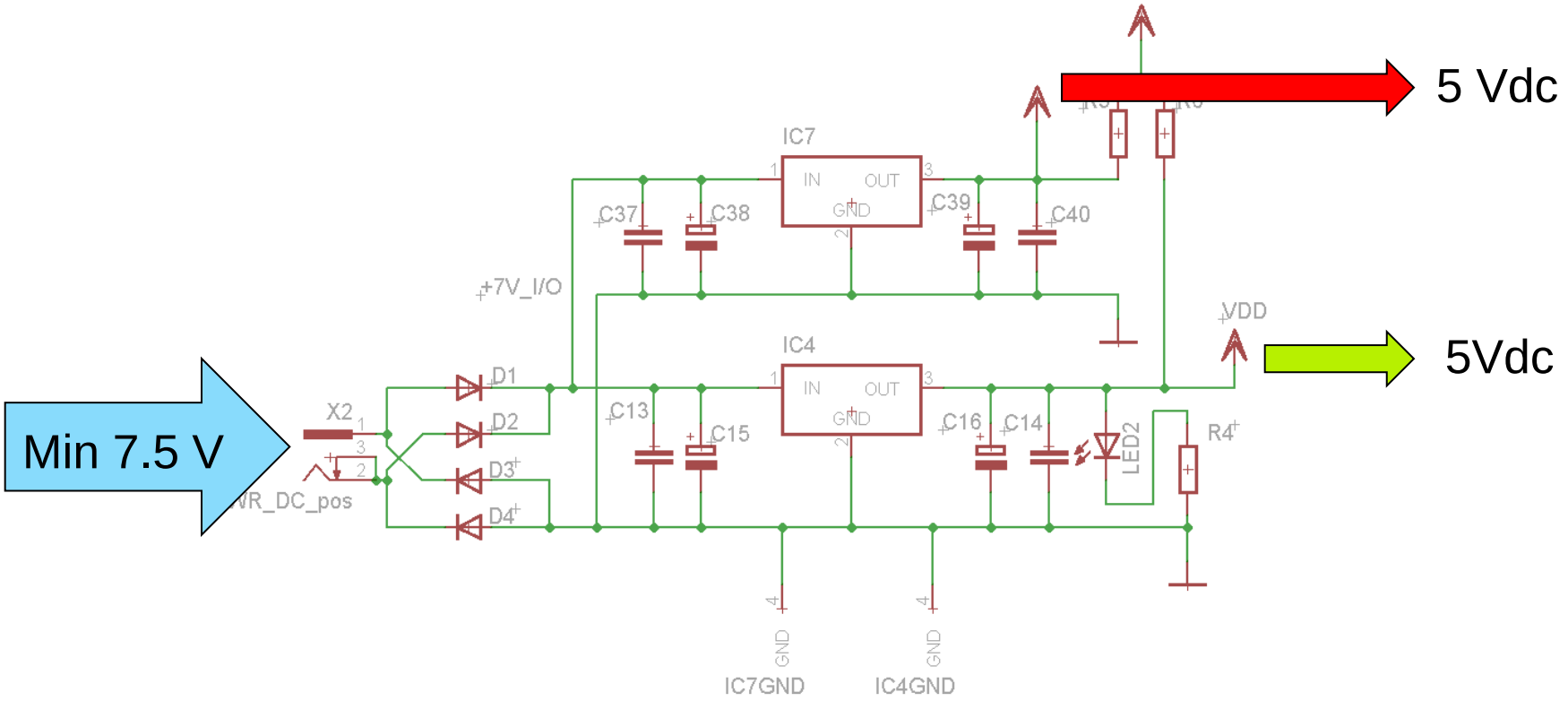
http://www.nxp.com/demoboard/CLEV663.html

PCB „antenna“ from PNEV512B (matched in ANT#2)

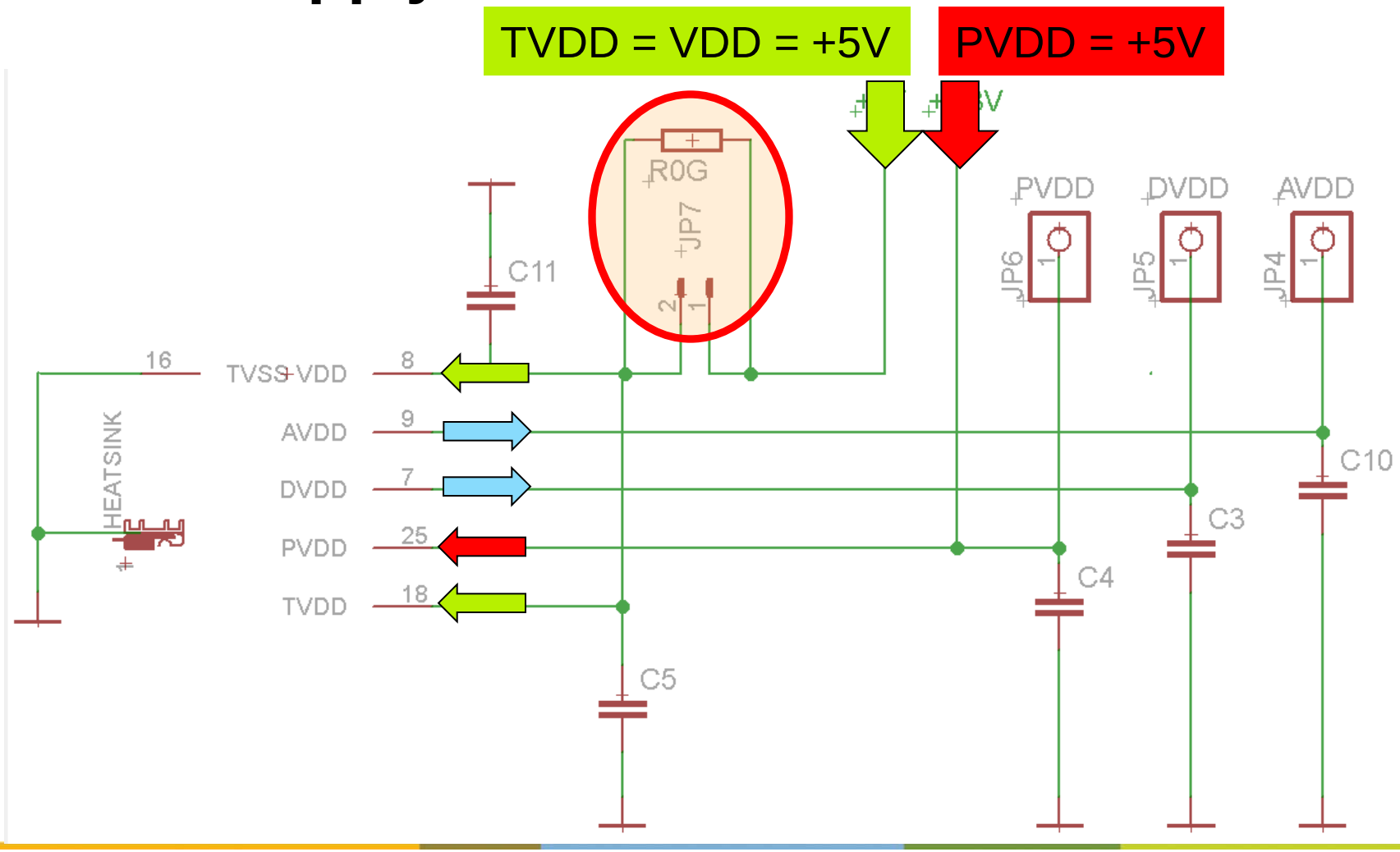
http://www.nxp.com/demoboard/PNEV512B.html



Step #1: Current measurement Power supply of Red Board



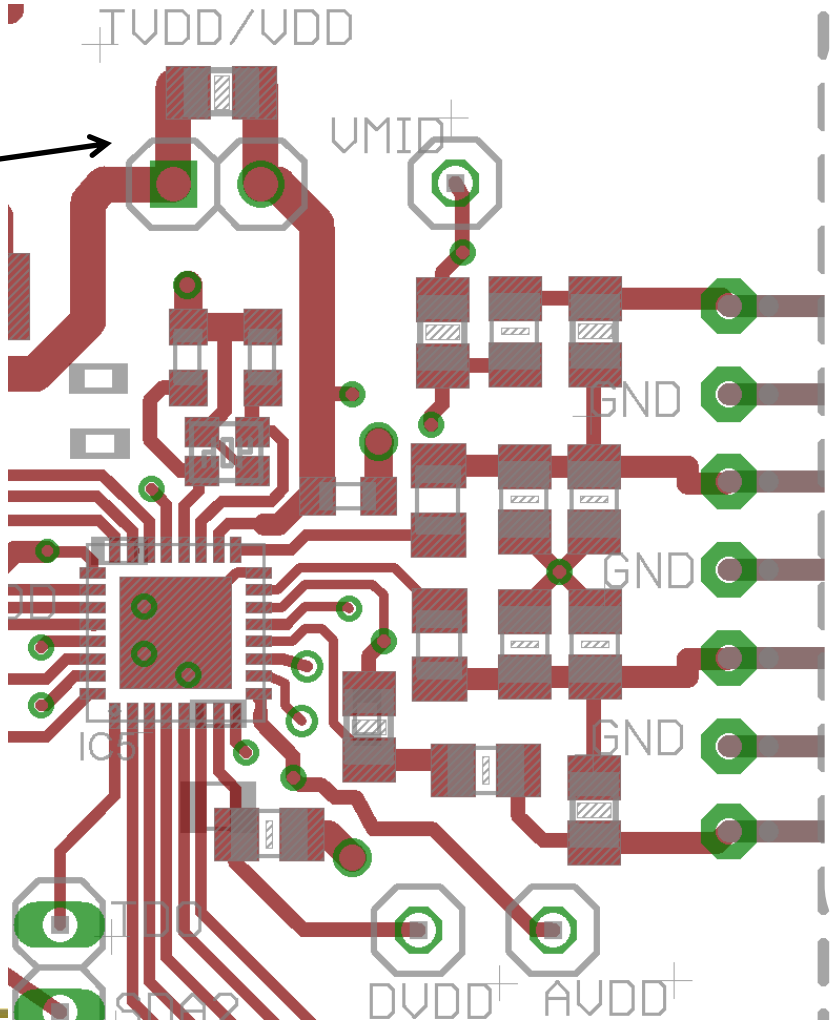
Step #1: Current measurement
Power supply of CLRC663



Step #1: Current measurement
Connect Ampere meter

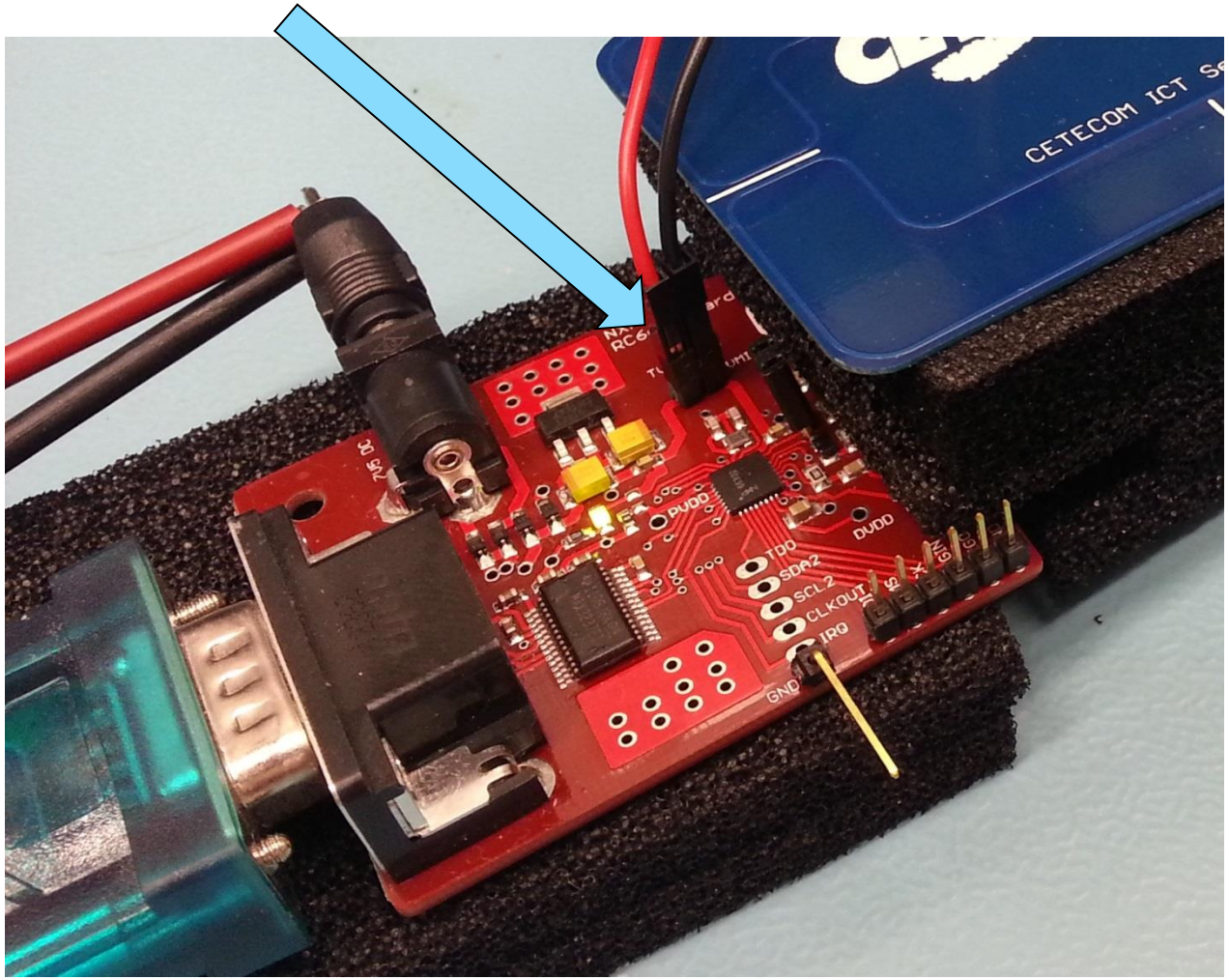
TVDD-Jumper

- Remove 0 Ω jumper
- Assemble 2 pins
- Connect ampere meter



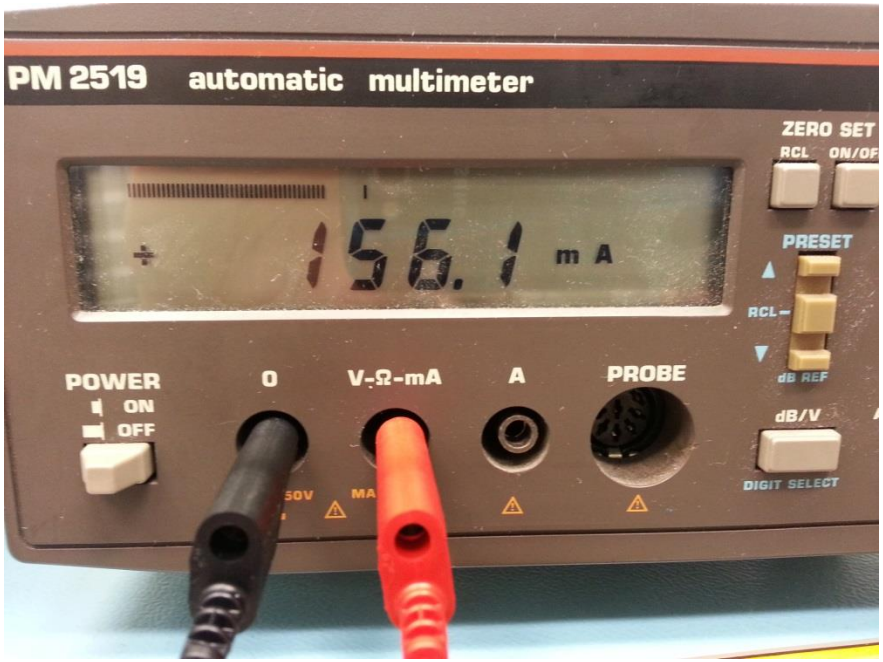
CL RC663
Red Board
Top view

Step #1: Current measurement
Connect Ampere meter



Step #1: Current measurement
Connect Ampere meter

Tx On (no modulation)



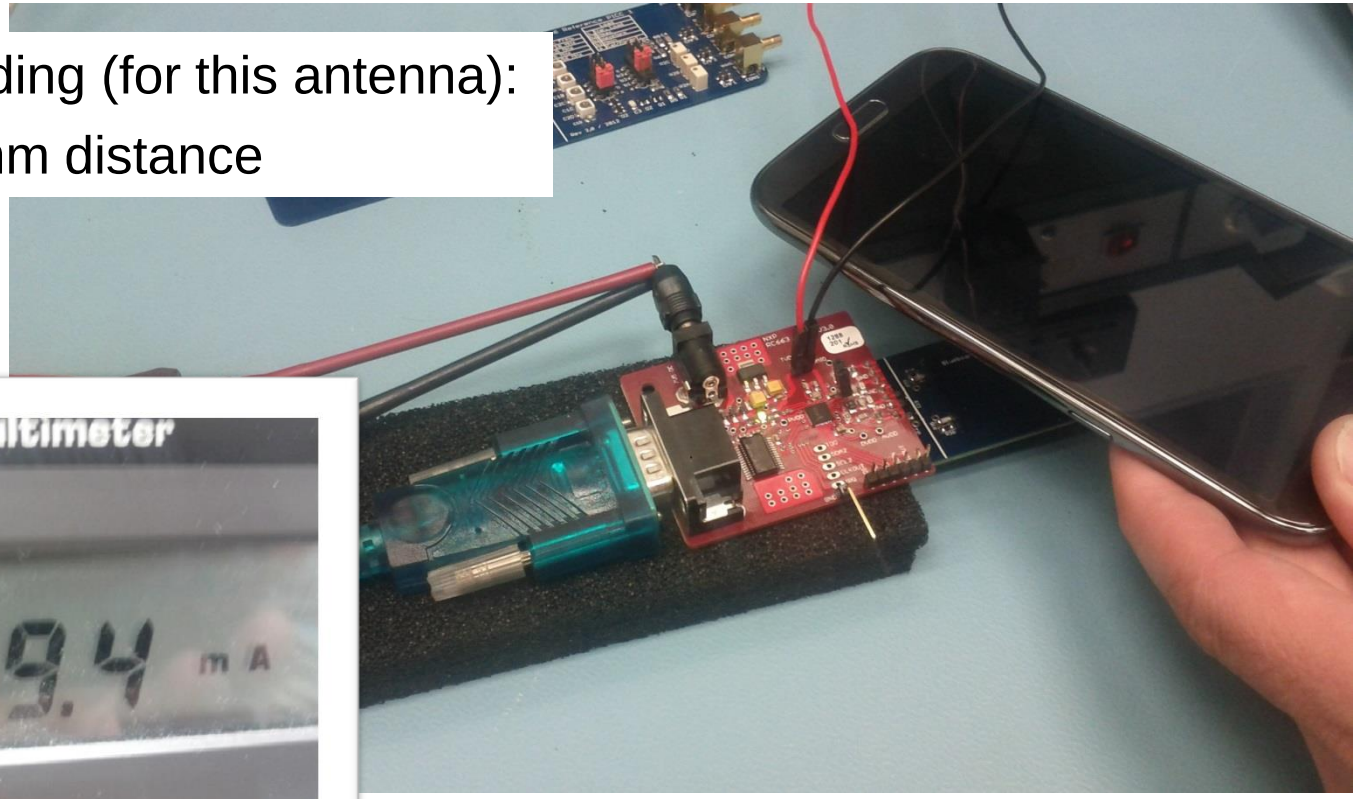
Tx Off (no carrier)

Check under all possible loading conditions!

Step #1: Current measurement
ITVDD under loading condition (phone)

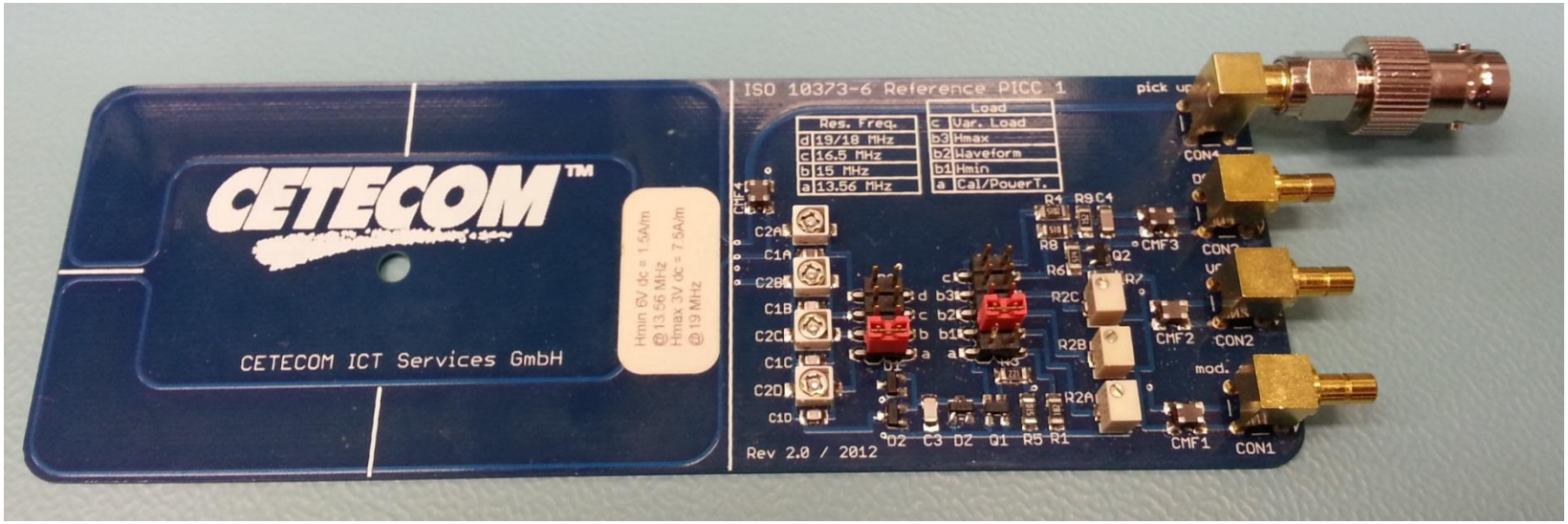
Worst case loading (for this antenna):

- Phone in 5mm distance



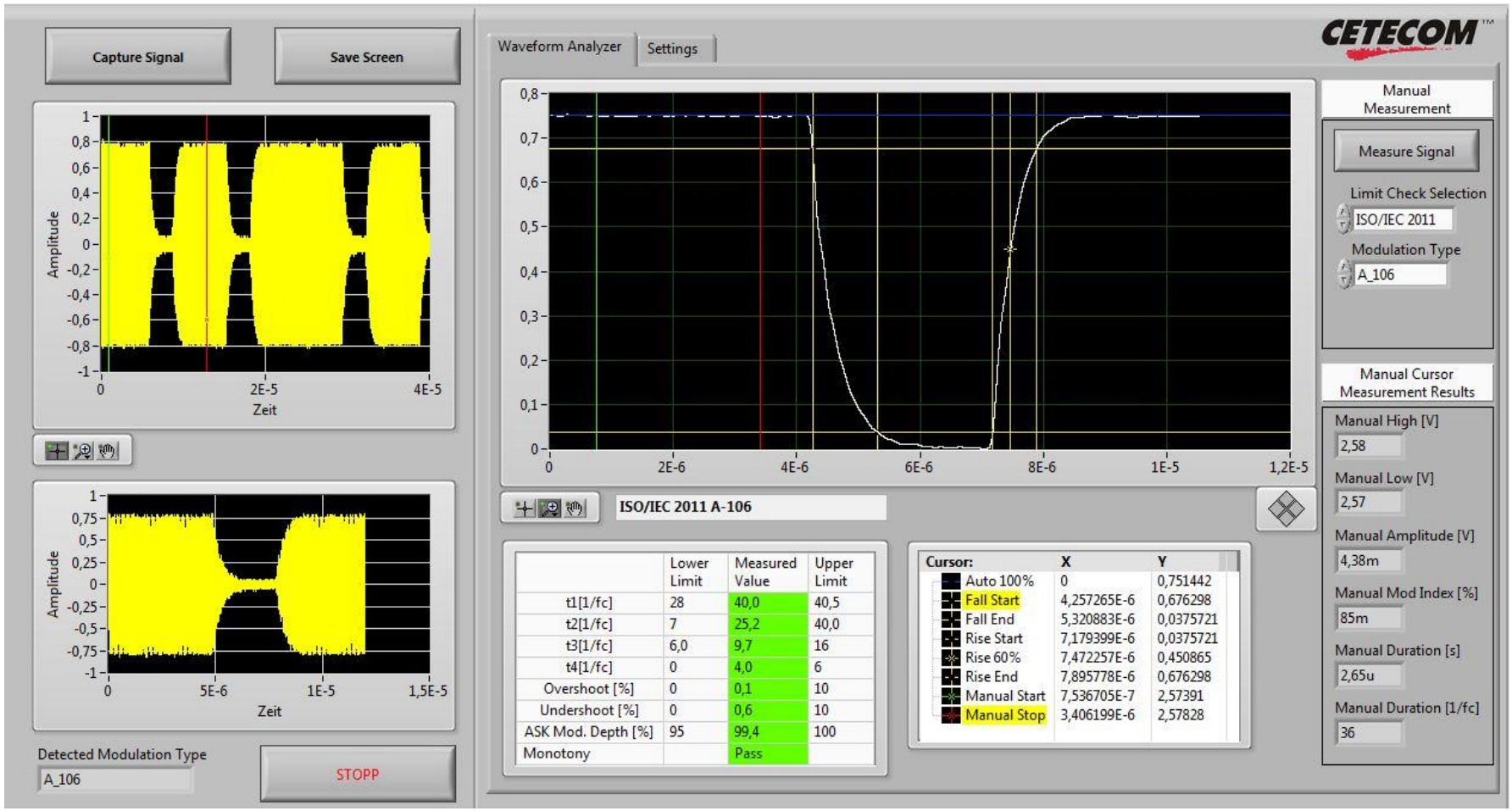
ITVDD = 180mA ≤ 200mA !

Step #2 & 3: Field strenght & Wave shapes ISO / IEC 10373-6 Reference PICC



Details will follow in ANT5 “Test & Qualification”

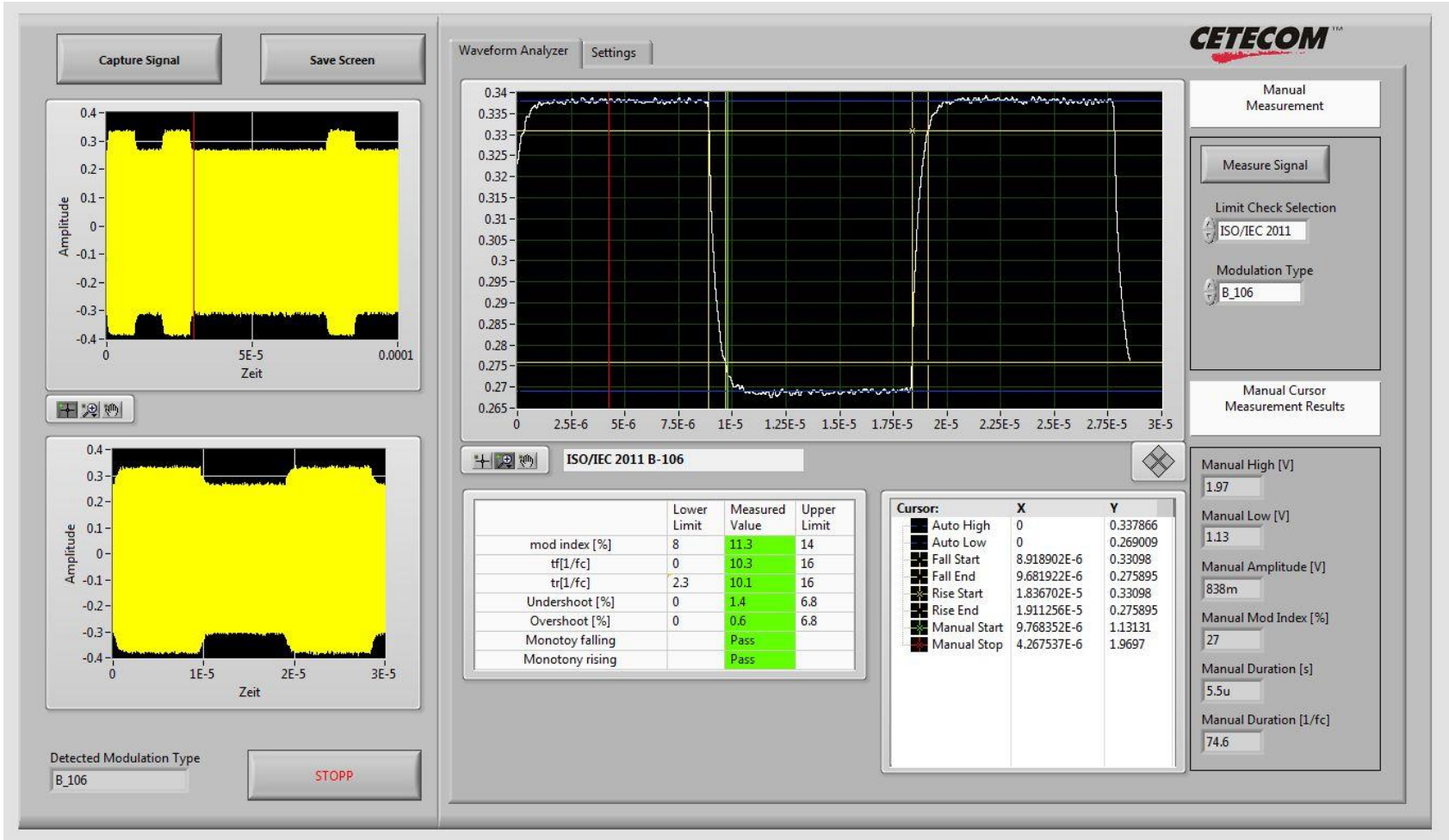
Step #3: Wave shapes
Type A @ 106 kbit/s in 35mm



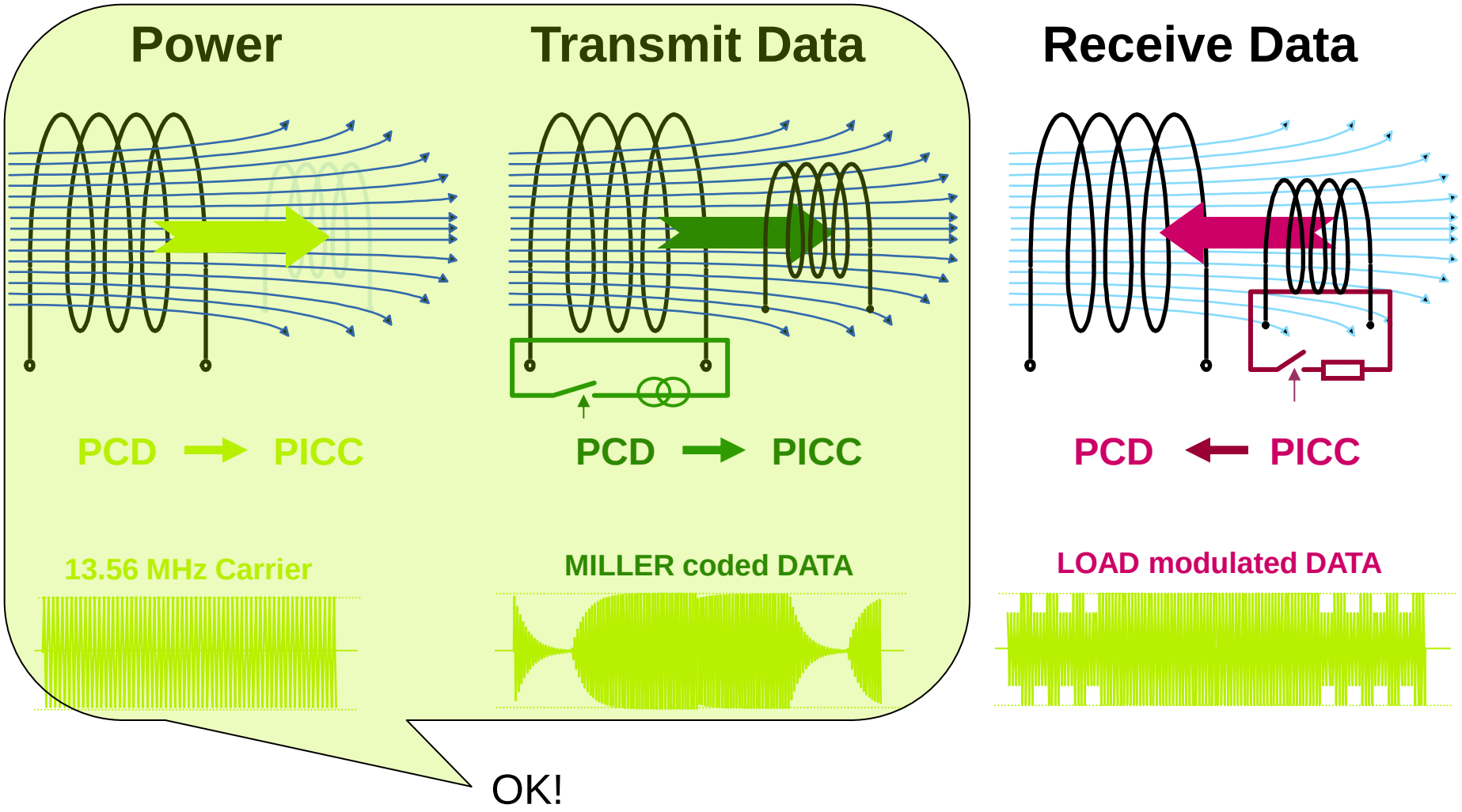
	Lower Limit	Measured Value	Upper Limit
t1[1/fc]	28	40,0	40,5
t2[1/fc]	7	25,2	40,0
t3[1/fc]	6,0	9,7	16
t4[1/fc]	0	4,0	6
Overshoot [%]	0	0,1	10
Undershoot [%]	0	0,6	10
ASK Mod. Depth [%]	95	99,4	100
Monotony		Pass	

Cursor:	X	Y
Auto 100%	0	0,751442
Fall Start	4,257265E-6	0,676298
Fall End	5,320883E-6	0,0375721
Rise Start	7,179399E-6	0,0375721
Rise 60%	7,472257E-6	0,450865
Rise End	7,895778E-6	0,676298
Manual Start	7,536705E-7	2,57391
Manual Stop	3,406199E-6	2,57828

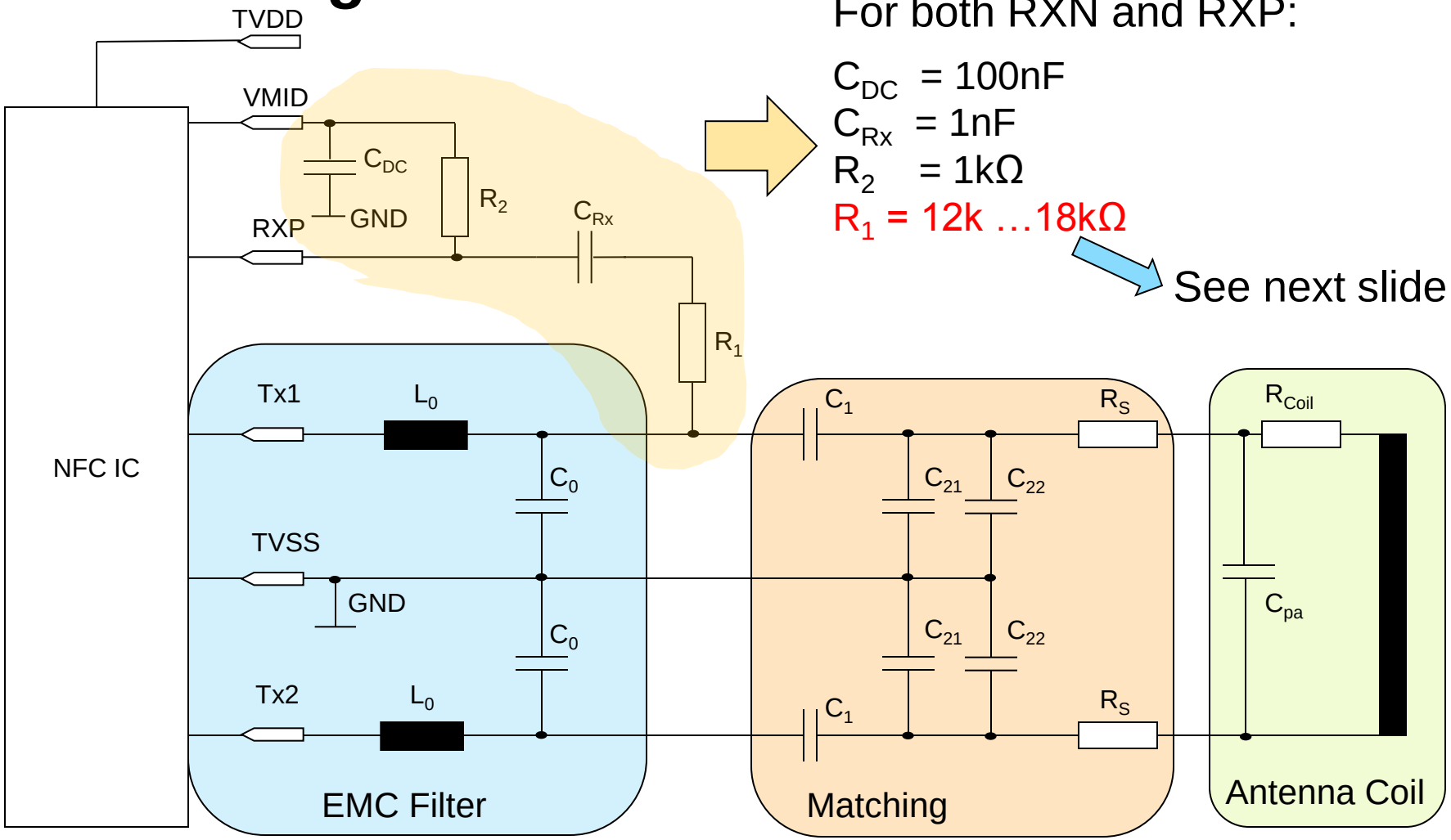
Step #3: Wave shapes
Type B @ 106 kbit/s in 35mm



What must be tested?



Step #4: Adjust the Receiver
Connecting the Rx



For both RXN and RXP:

C_{DC} = 100nF
C_{Rx} = 1nF
R_2 = 1kΩ
R_1 = 12k …18kΩ

See next slide

Step #4: Adjust the Receiver
Adjust the Rx level

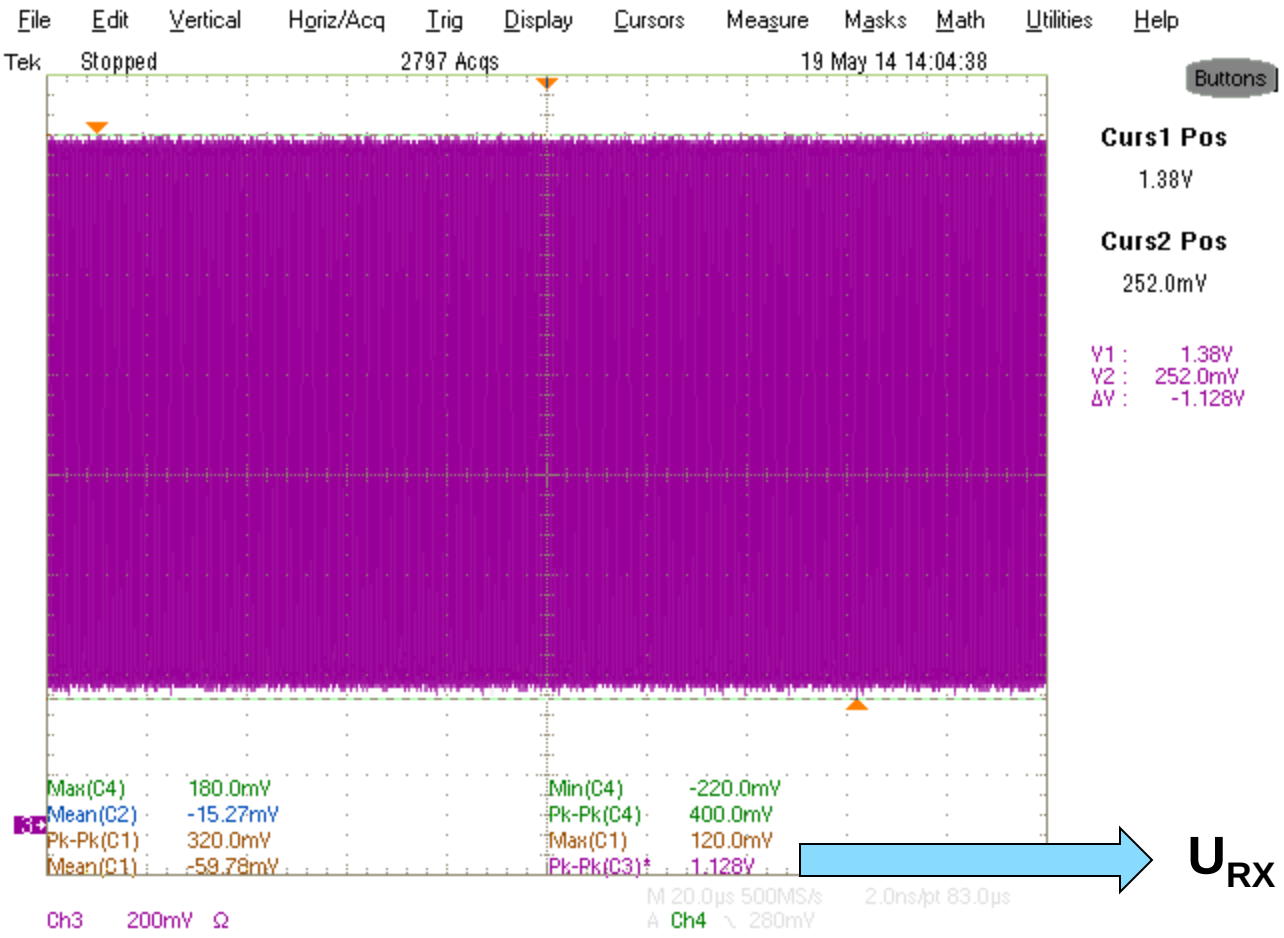
$U_{RX} \leq 1.7Vpp$ (RC663)

- Switch on the Tx (continious carrier)
- Measure U_{RX} on RXN pin with a low capacitance probe (< 2 pF)

- If $U_{RX} > 1.6Vpp$ -> Increase R_1
- If $U_{RX} < 1.0Vpp$ -> Decrease R_1

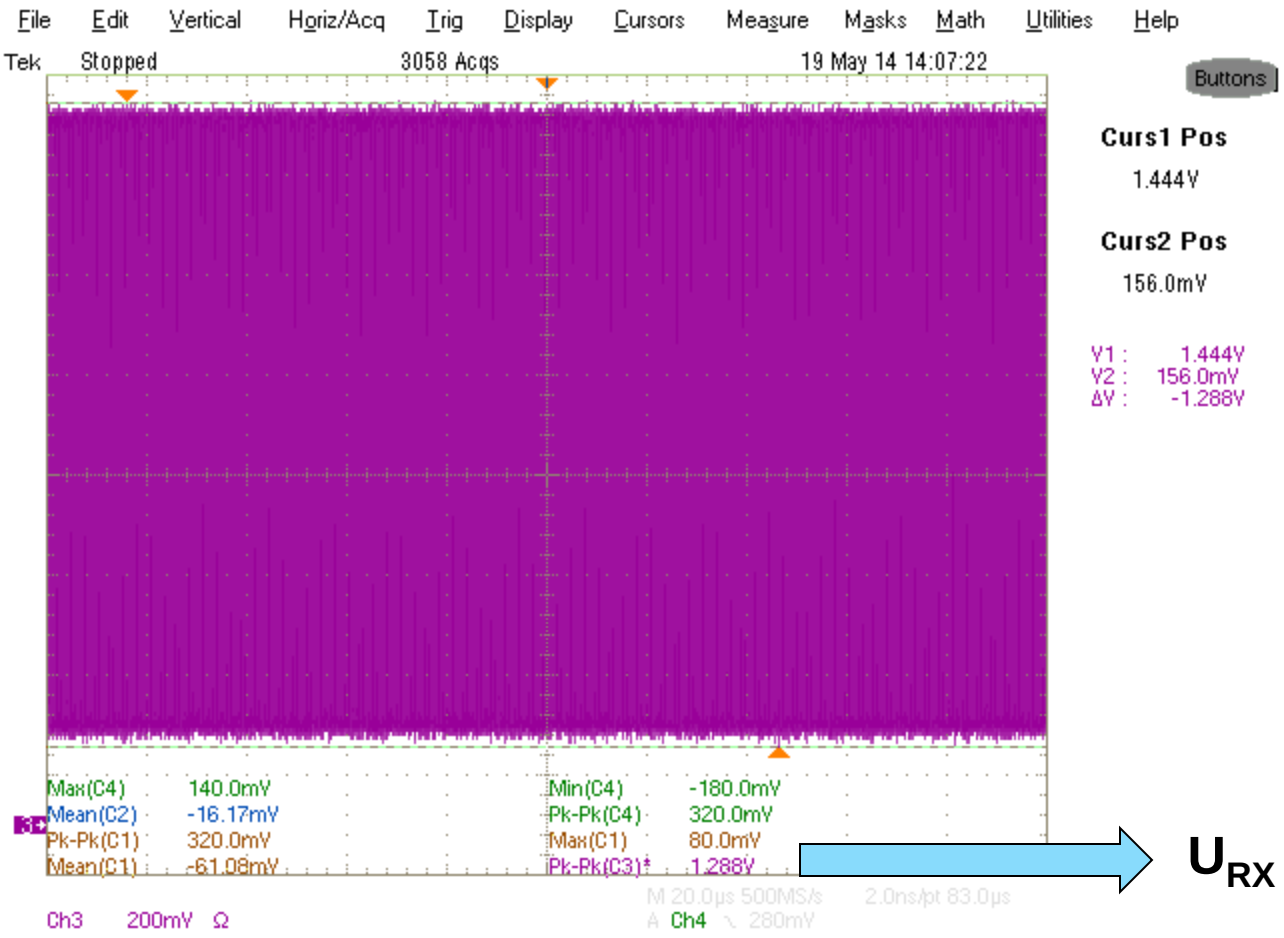
Check under all loading conditions!
- ReferencePICC,
- Phone,
- different cards,
- etc.

Step #4: Adjust the Receiver Measure Rx with Load 1



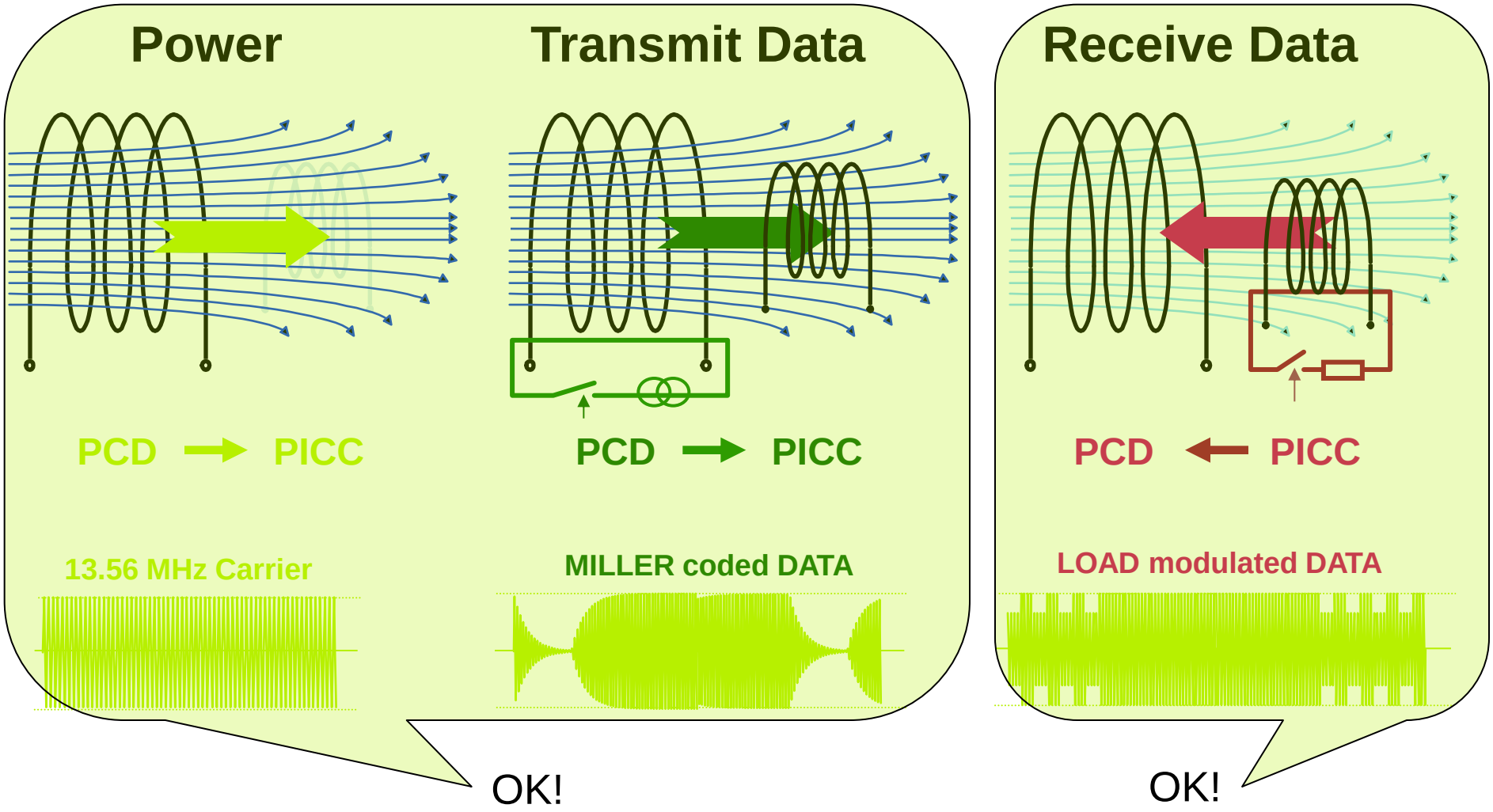
U_{RX} = 1.13Vpp

Step #4: Adjust the Receiver
Measure Rx without Load



U_{RX} = 1.29Vpp

What must be tested?

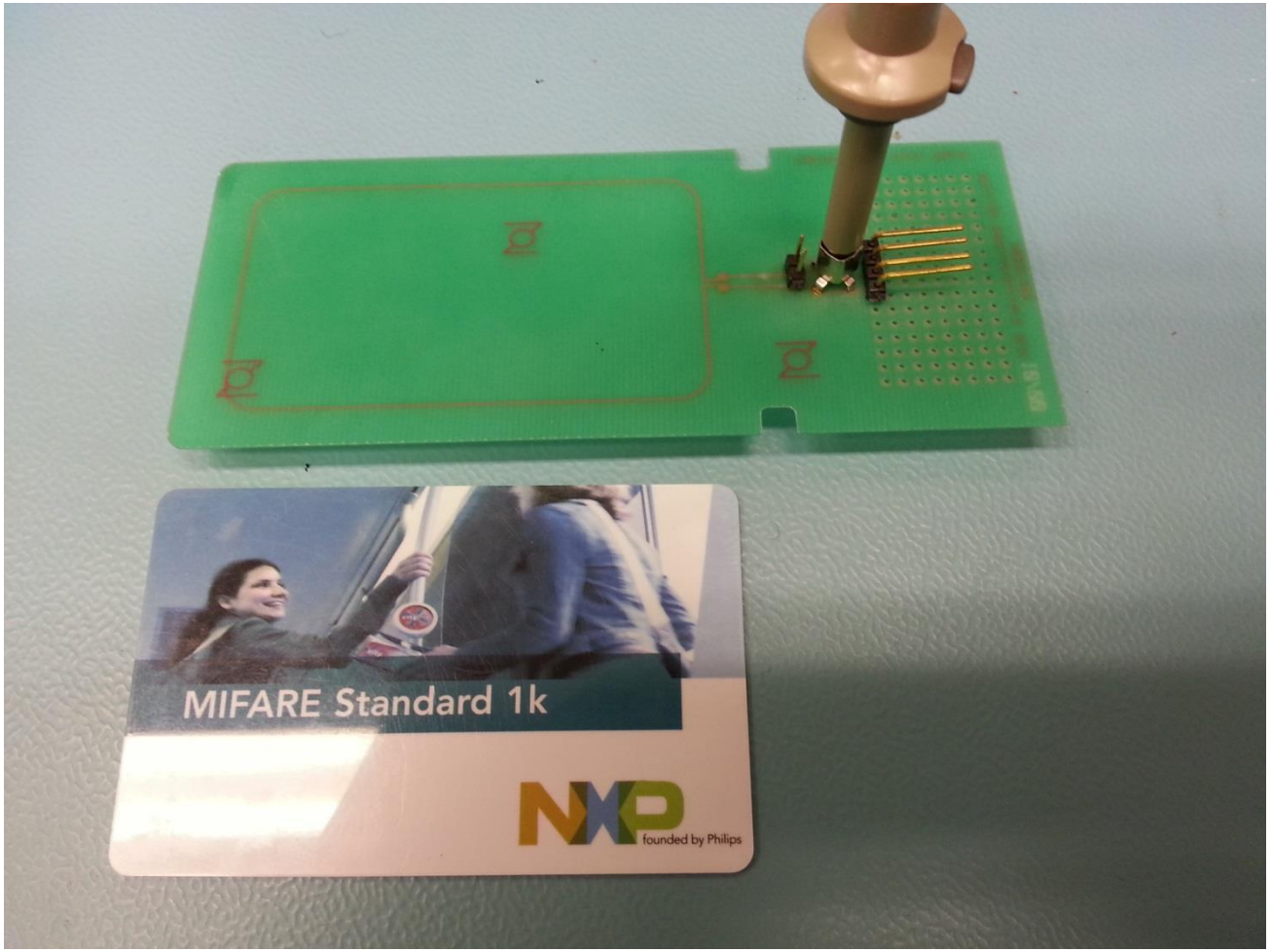


Done?

- What, if the Reader does not properly read a card?
- How do we know that we have the optimum performance?
- What are the best register settings?

- We need to look into debug and test signals!

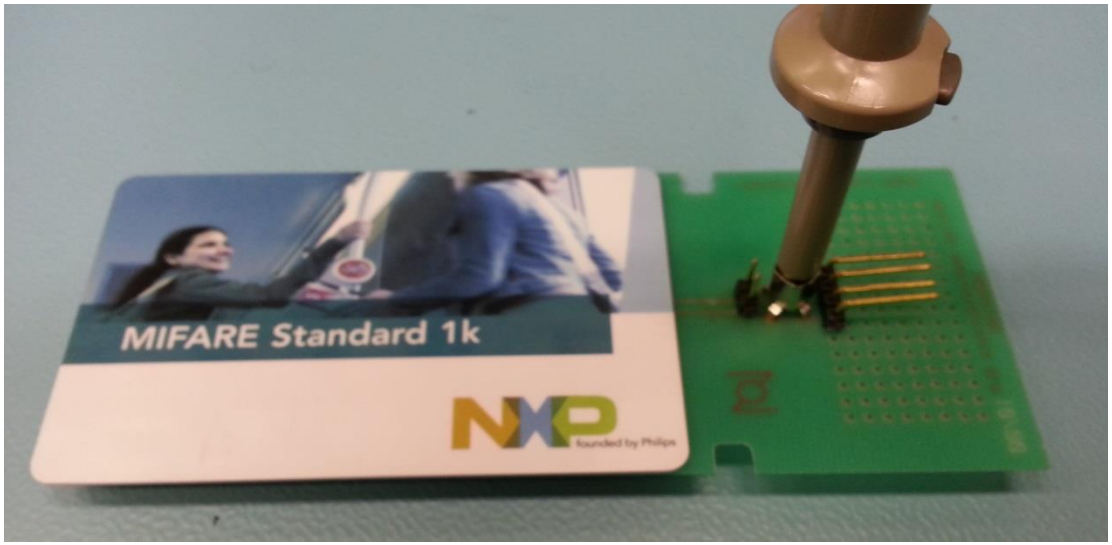
Step #5a: Debug a problem Sniffer



Single turn coil, connected to high impedance scope probe

e.g. ISO/IEC 10373-6 Calibration coil

Step #5a: Debug a problem
Sniffer with card



Sniffer does not load the reader (much).

Sniffer picks up the field (“unloaded“), i.e. U = k · H.

Coupling between sniffer and card is high, i.e. we “see” the card response.

Step #5a: Debug a problem Alternative Sniffer with card

Low cost sniffer:

Shortcut the probe.
Place the loop on the card.

Step #5b: Debug a problem
Unlock the CL RC663

Execute unlock sequence to enable test signals:

- Write ADR 0x66, 0x80
- Read ADR 0x66
- Write ADR 0x66, 0xC0
- Write ADR 0x66, 0xE0
- Read ADR 0x66
- Write ADR 0x66, 0xD0
- Read ADR 0x66
- Write ADR 0x66, 0xC3
- Read ADR 0x66

Step #5b: Debug a problem
Configure AUX pins

Route the RC663 internal testbus to the AUX1 and AUX2:

- Write ADR 0x6C, 0x09
- Write ADR 0x6D, 0x09
- Write ADR 0x65, **0xXY**

X	AUX1	Y	AUX2
1	Q-Channel	1	Q-Channel
2	I-Channel	2	I-Channel
3	Filtered Q-Channel	3	Filtered Q-Channel
4	Filtered I-Channel	4	Filtered I-Channel
9	dpresent_sum	9	dpresent_sum
A	BPSK_sum	A	BPSK_sum

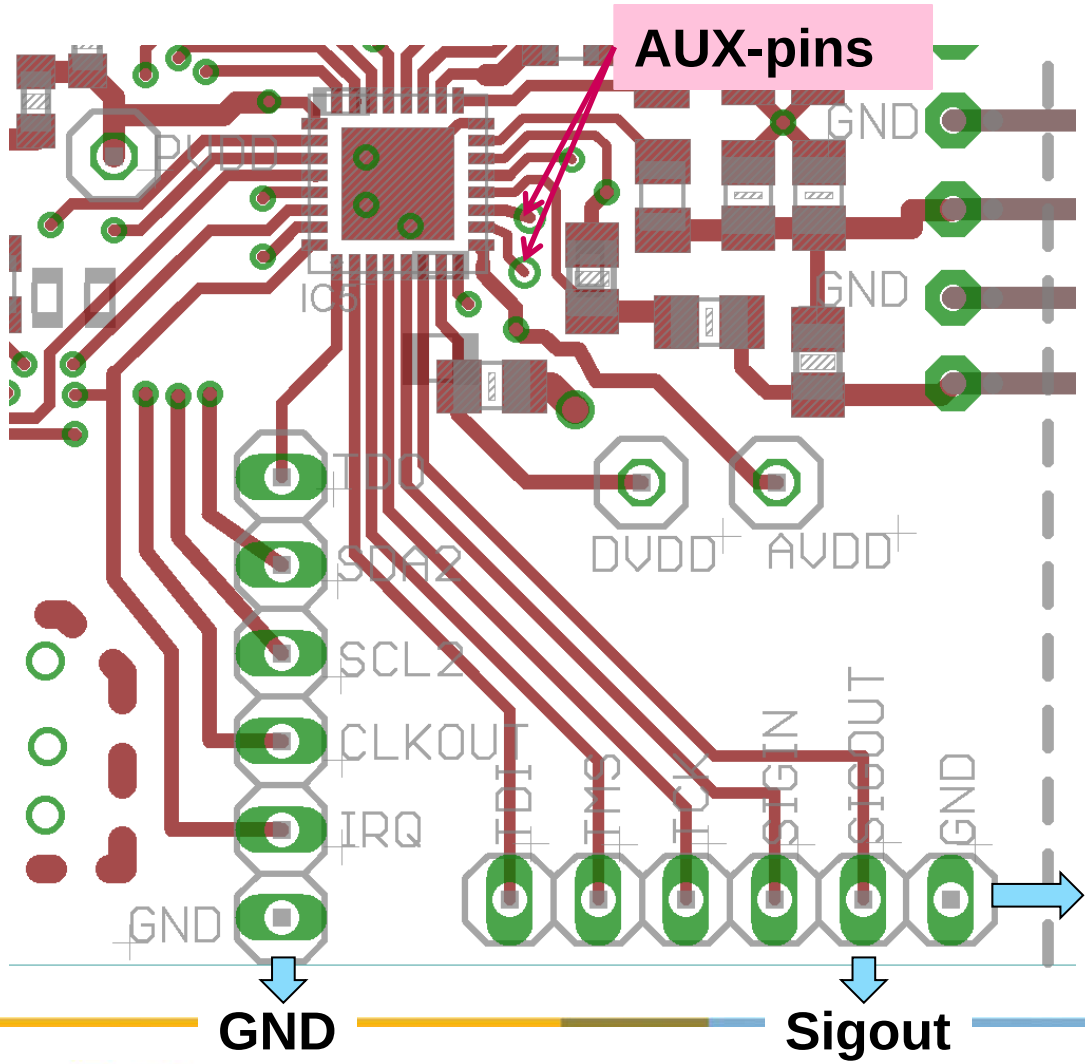
Step #5b: Debug a problem
Configure AUX pins: Script example

- //> --------unlock procedure
- SR 66 80
- GR 66
- SR 66 C0
- SR 66 E0
- GR 66
- SR 66 D0
- GR 66
- SR 66 C3
- GR 66

- SR 6C 09 // route test bus AUX1
- SR 6D 09 // route test bus AUX2
- SR 65 12 // set Aux1/2 to I/Q

- SR 47 05 // set SIGOUT register: route Tx active signal to SIGOUT pin

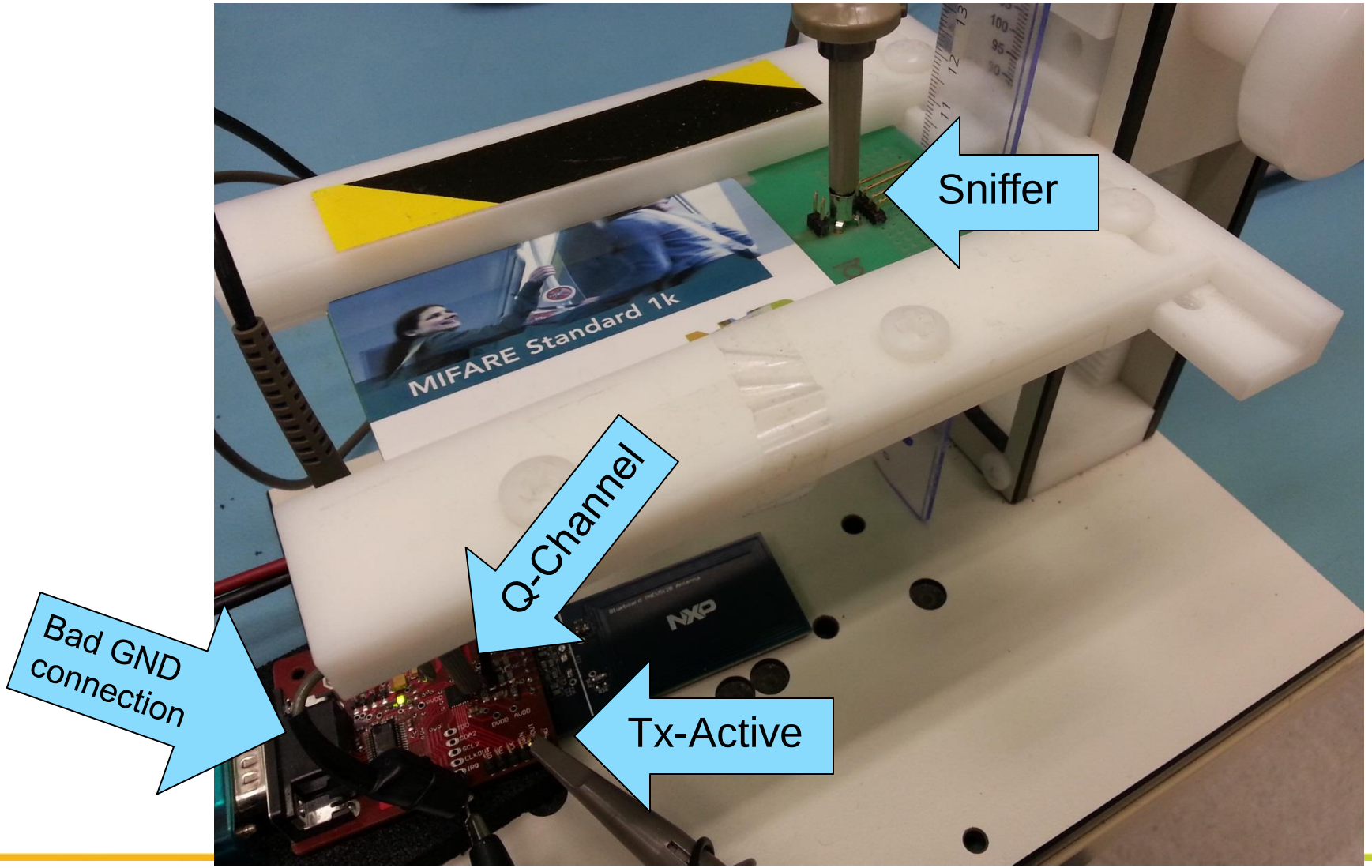
Step #5c: Debug a problem
Connect Testsignals



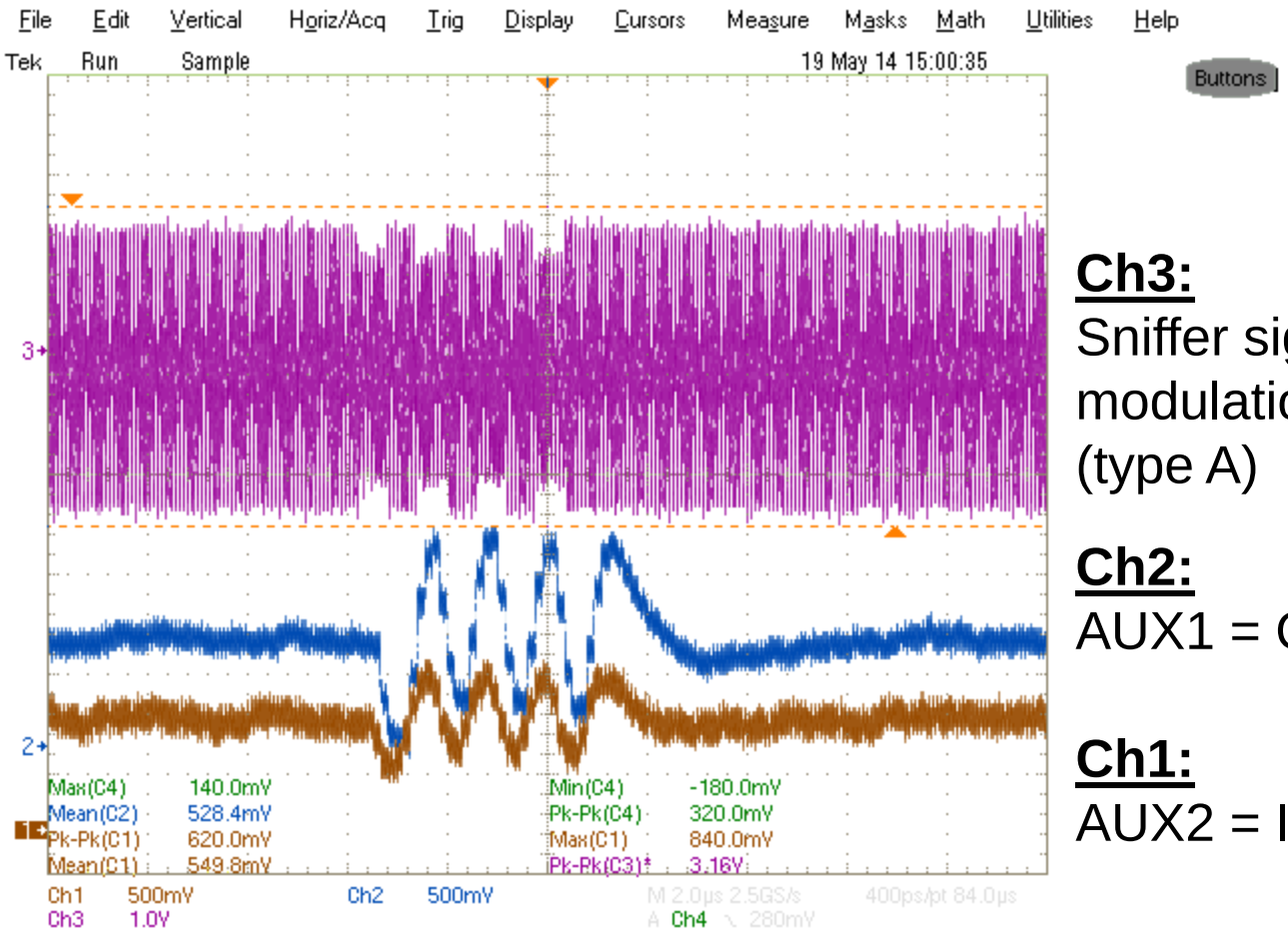
AUX1 and AUX 2
- Analog signal
- for debugging purpose
- very short traces
- configuration via registers

SigOut
- Digital Signal
- for debugging purpose
- for triggering a scope
- configuration via registers

Step #5: Debug a problem: Debug setup



Step #5: Debug a problem: Type A debug signal 1

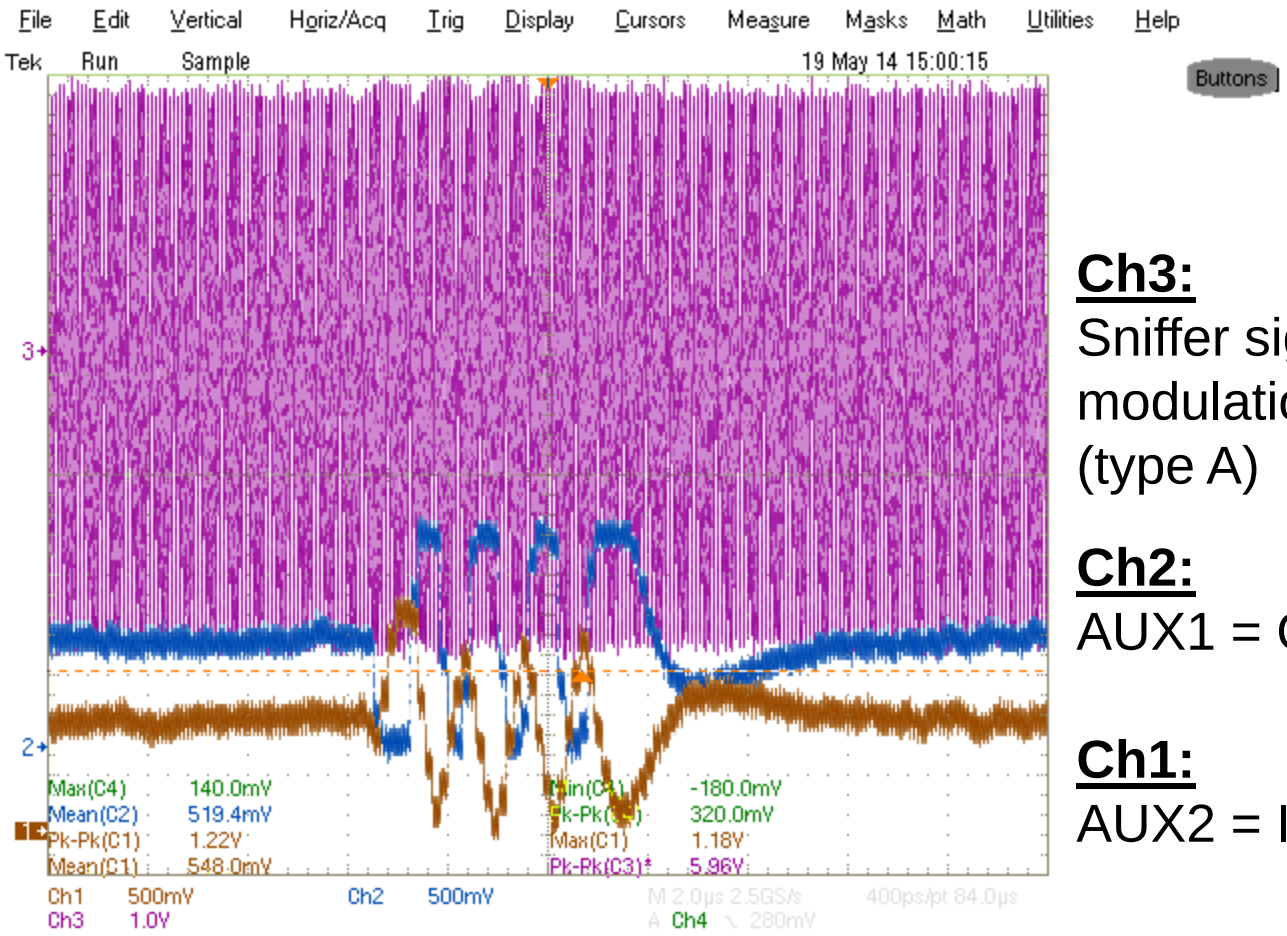


Ch3:
Sniffer signal showing Load modulation of a MIFARE card (type A)

Ch2:
AUX1 = Q-Channel

Ch1:
AUX2 = I-Channel

Step #5: Debug a problem: Type A debug signal at close distance

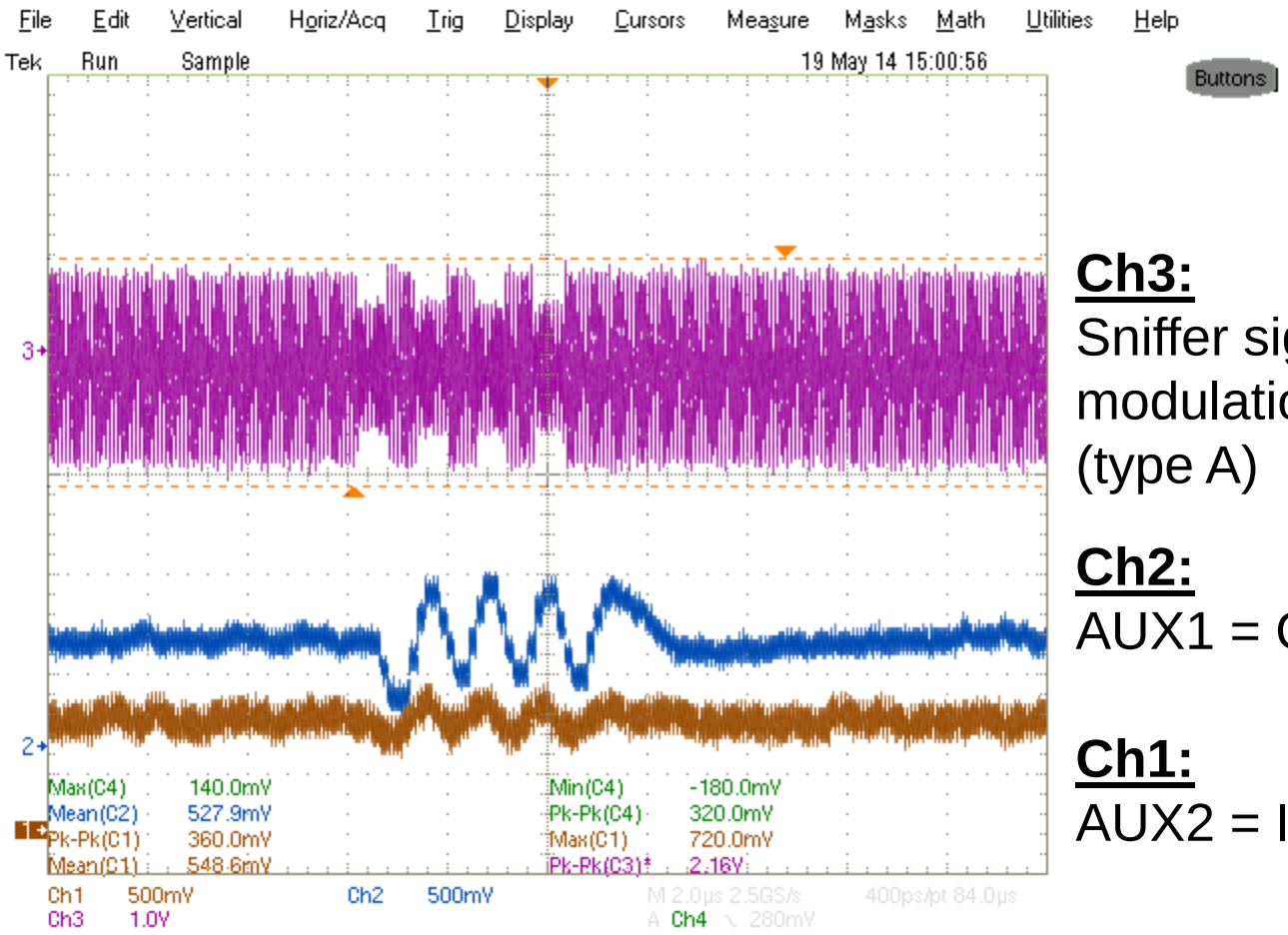


Ch3:
Sniffer signal showing Load modulation of a MIFARE card (type A)

Ch2:
AUX1 = Q-Channel

Ch1:
AUX2 = I-Channel

Step #5: Debug a problem: Type A debug signal at medium distance

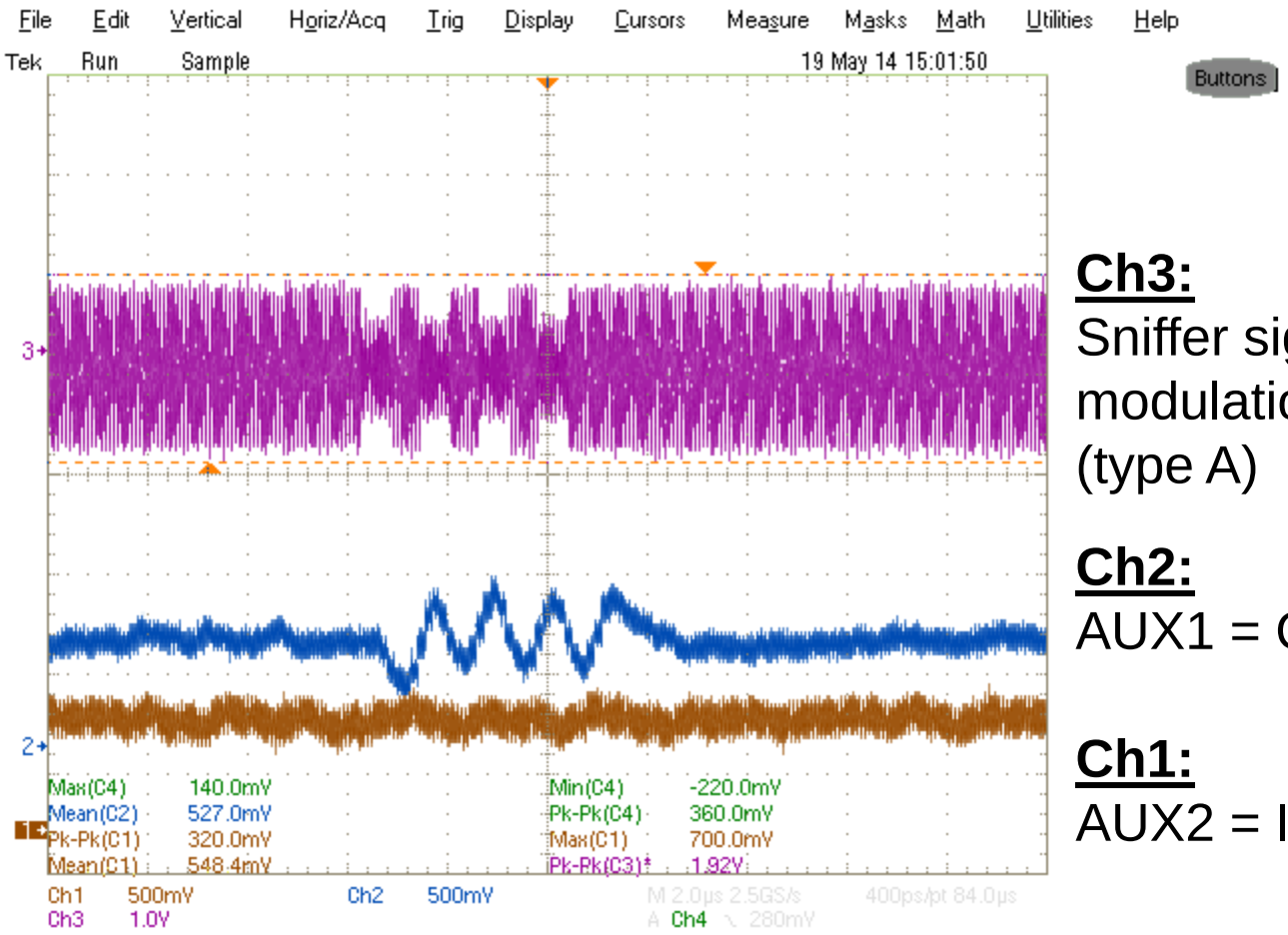


Ch3:
Sniffer signal showing Load modulation of a MIFARE card (type A)

Ch2:
AUX1 = Q-Channel

Ch1:
AUX2 = I-Channel

Step #5: Debug a problem: Type A debug signal, I-Channel = 0

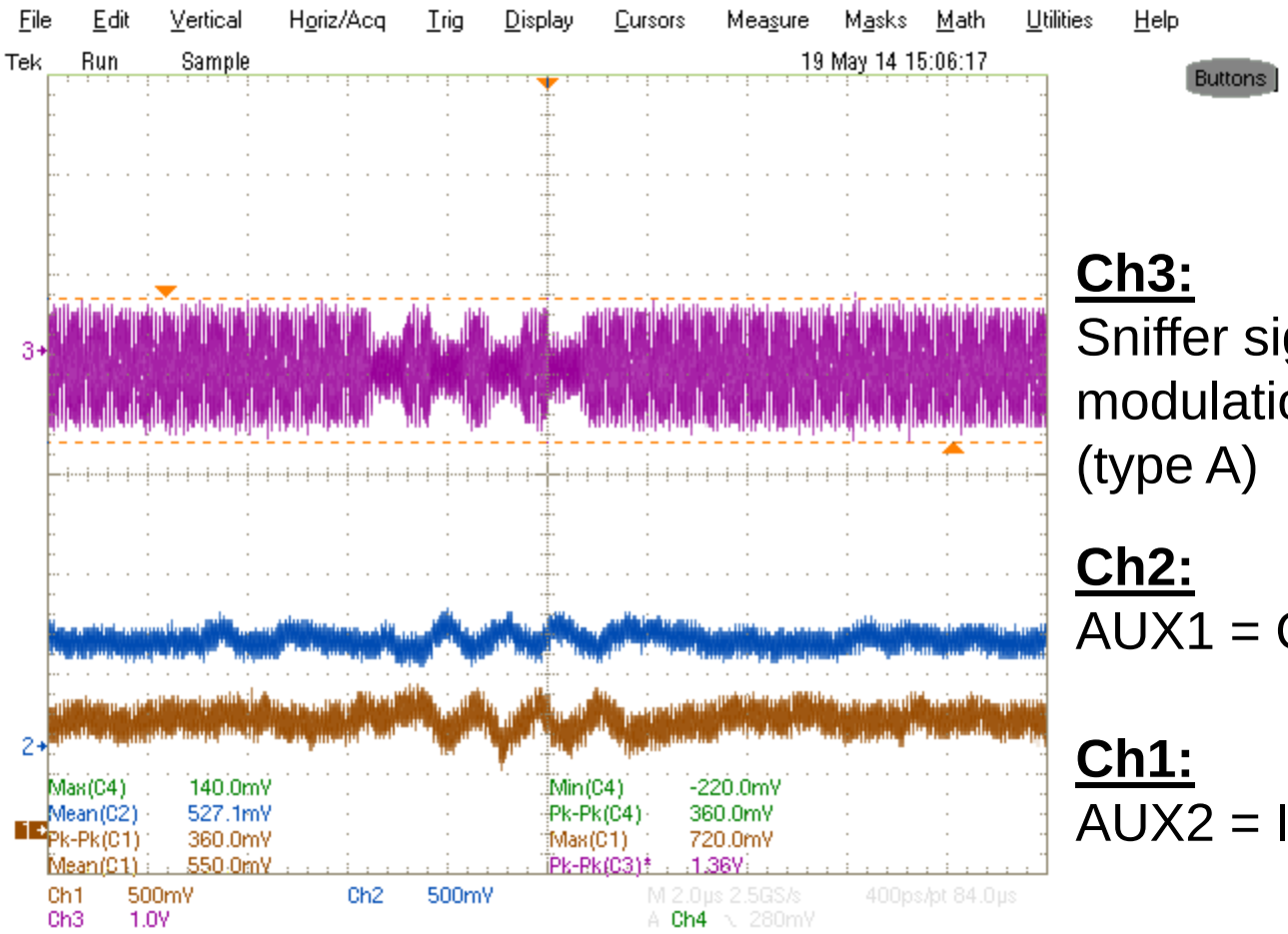


Ch3:
Sniffer signal showing Load modulation of a MIFARE card (type A)

Ch2:
AUX1 = Q-Channel

Ch1:
AUX2 = I-Channel

Step #5: Debug a problem: Type A debug signal at large distance

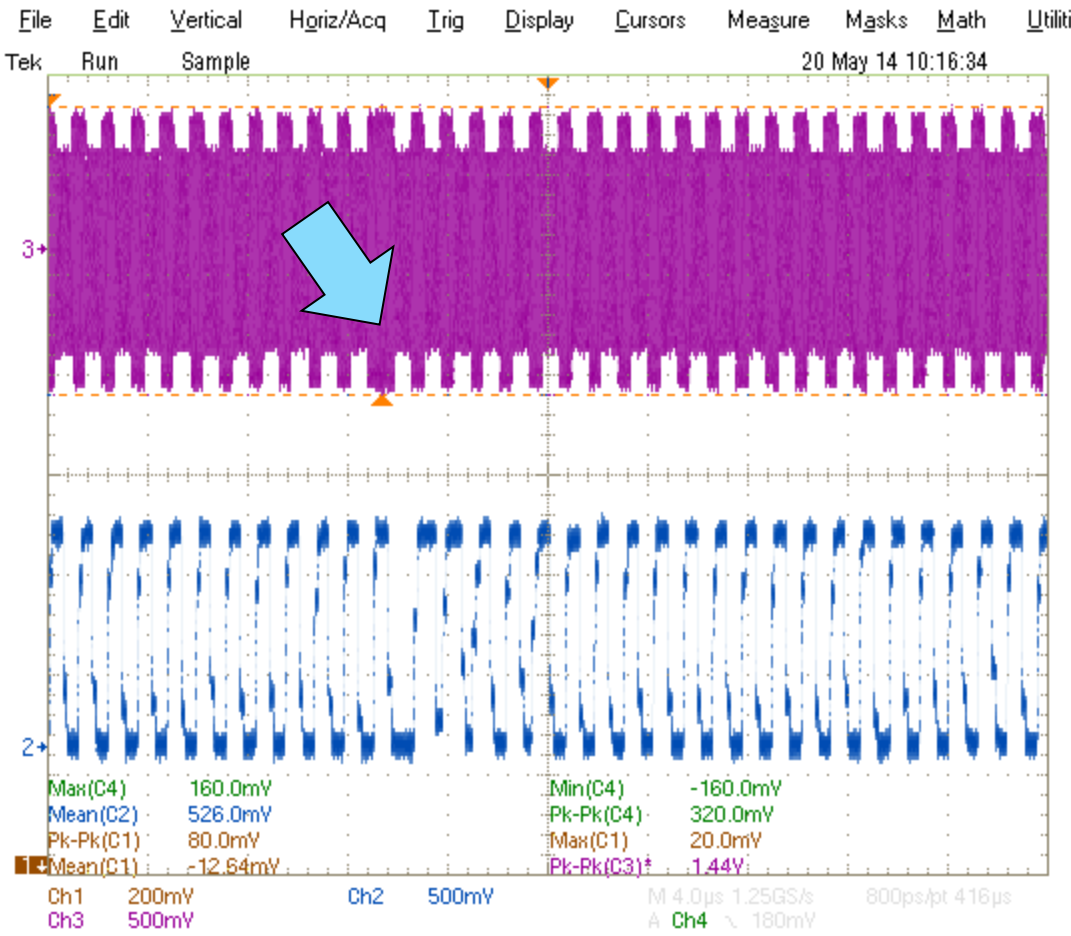


Ch3:
Sniffer signal showing Load modulation of a MIFARE card (type A)

Ch2:
AUX1 = Q-Channel

Ch1:
AUX2 = I-Channel

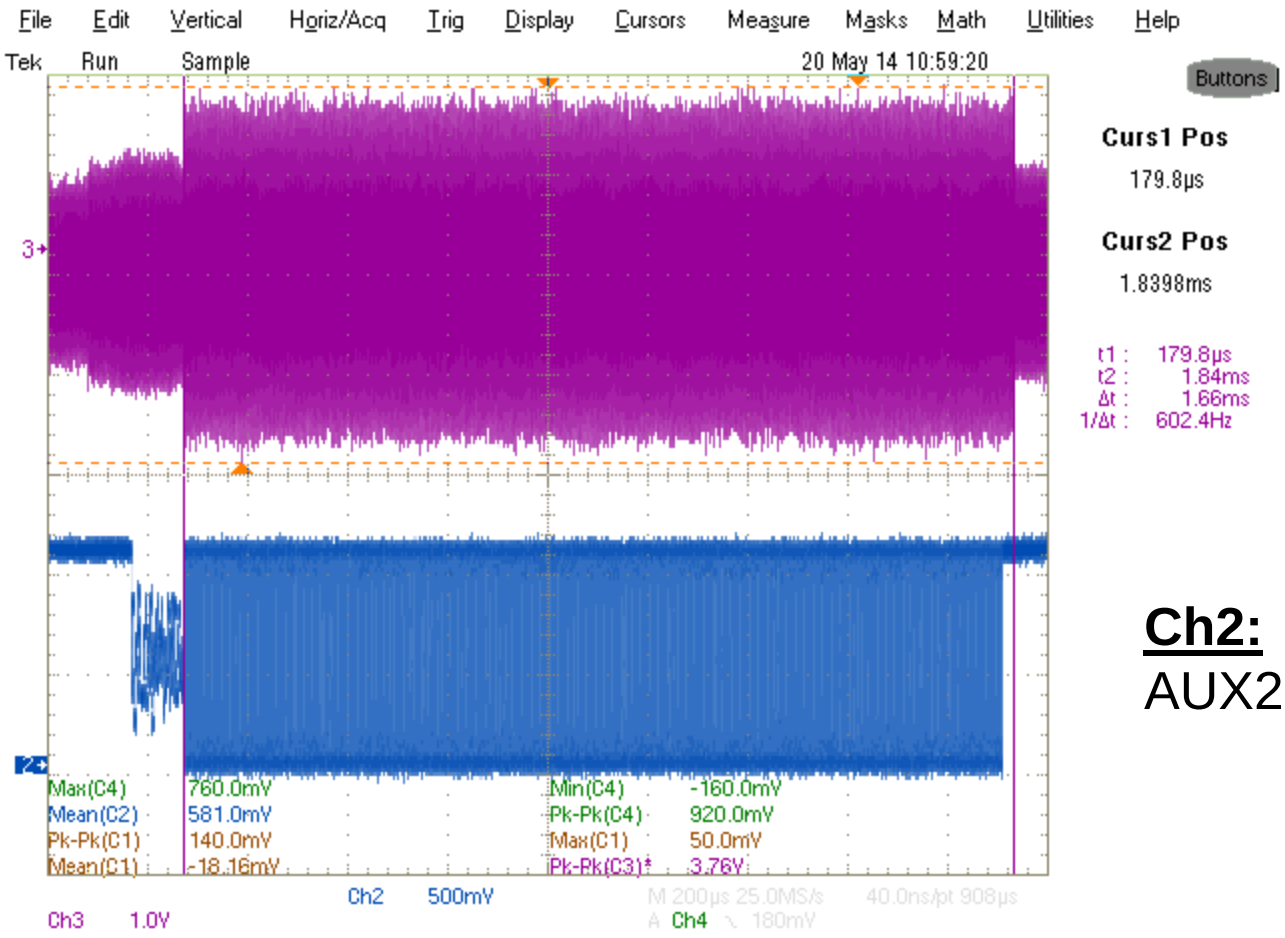
Step #5: Debug a problem: Type B debug signal at small distance



Ch3:
Sniffer signal showing Load modulation of a type B card

Ch2:
AUX1 = Q-Channel

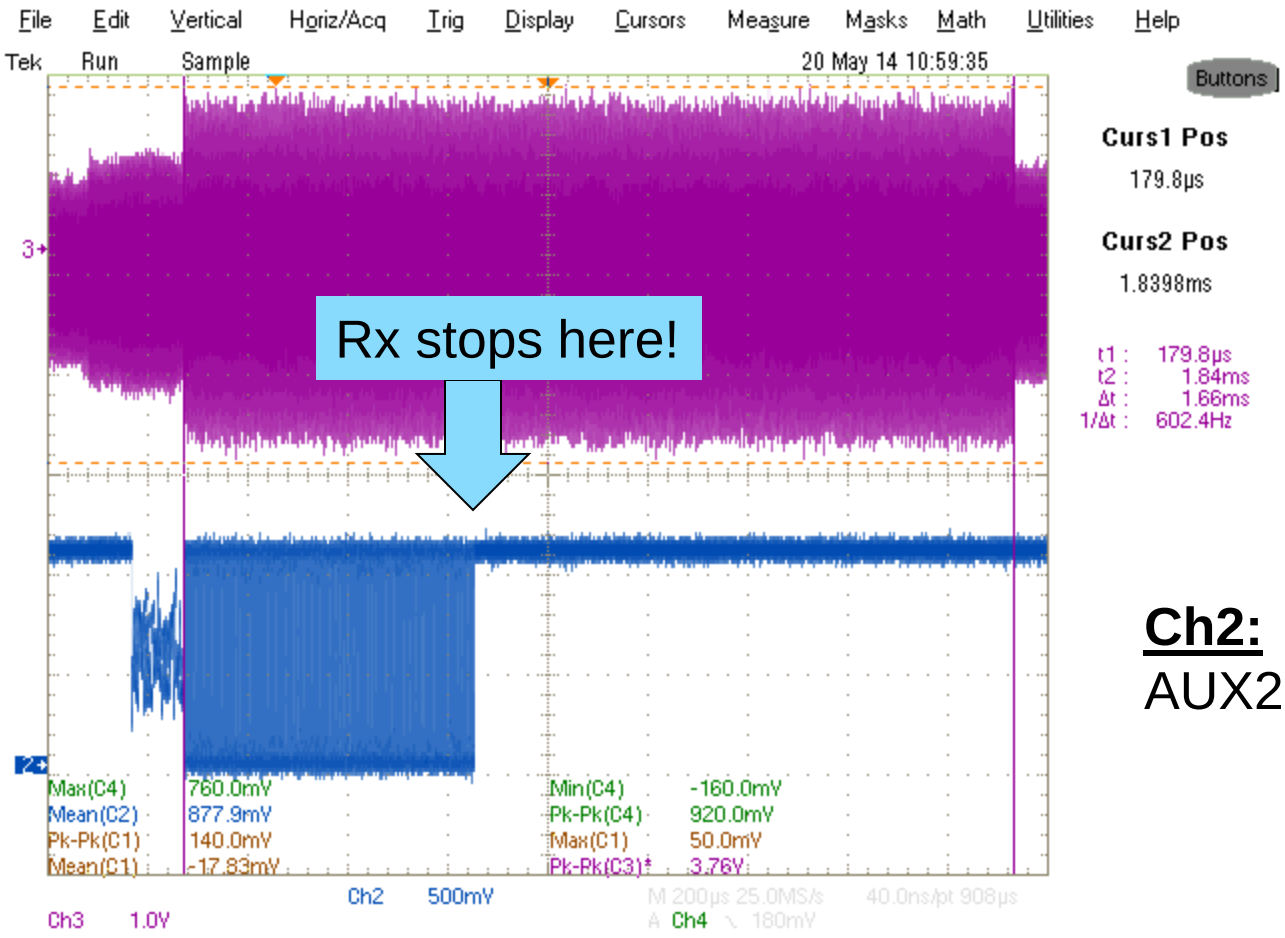
Step #5: Debug a problem: “Good” type B debug signal



Ch3:
Sniffer signal showing Load modulation of a type B card

Ch2:
AUX2 = filtered Q-Channel

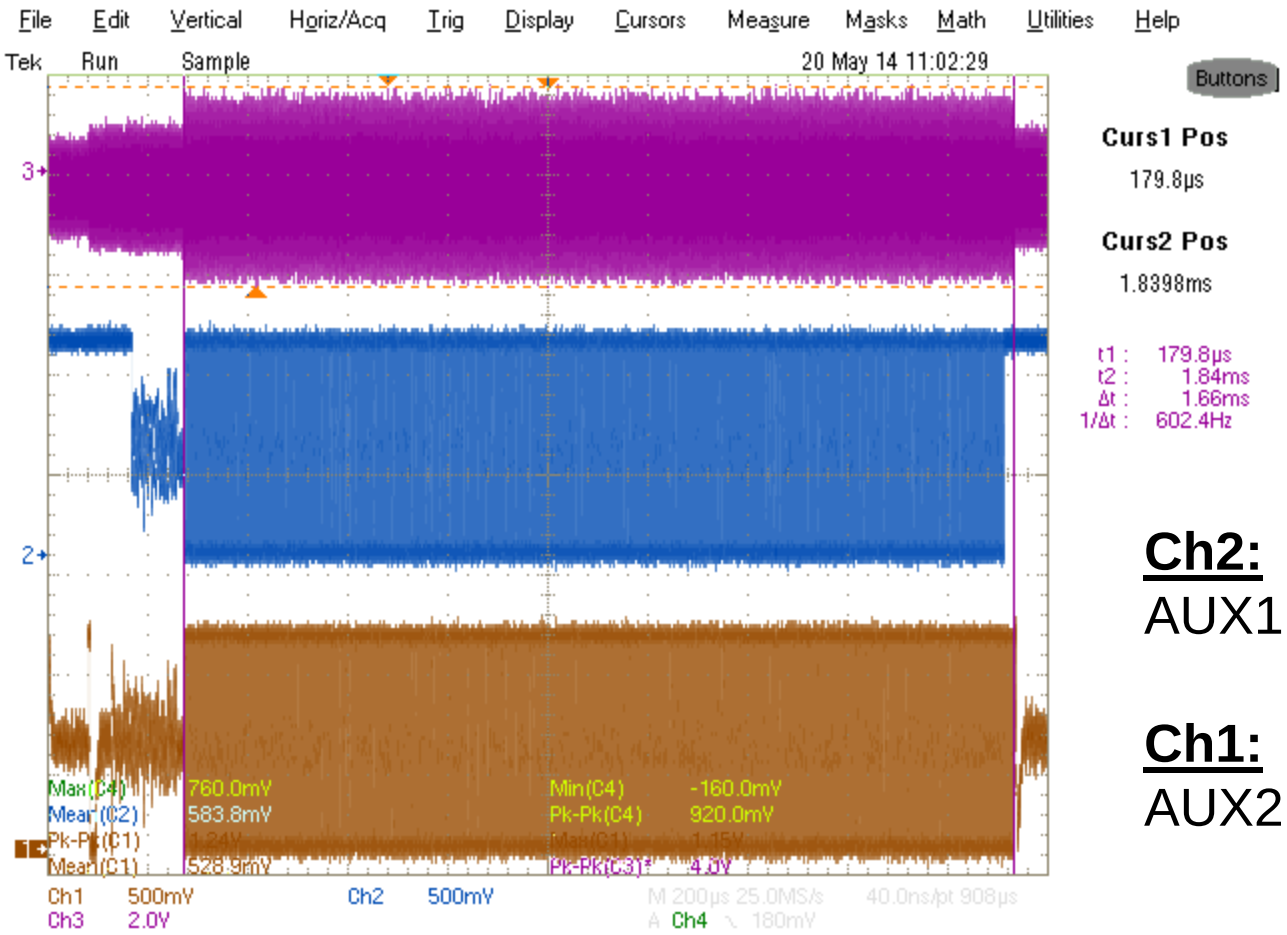
Step #5: Debug a problem: “Bad” type B debug signal



Ch3:
Sniffer signal showing Load modulation of a type B card

Ch2:
AUX2 = filtered Q-Channel

Step #5: Debug a problem: “Good” type B debug signal

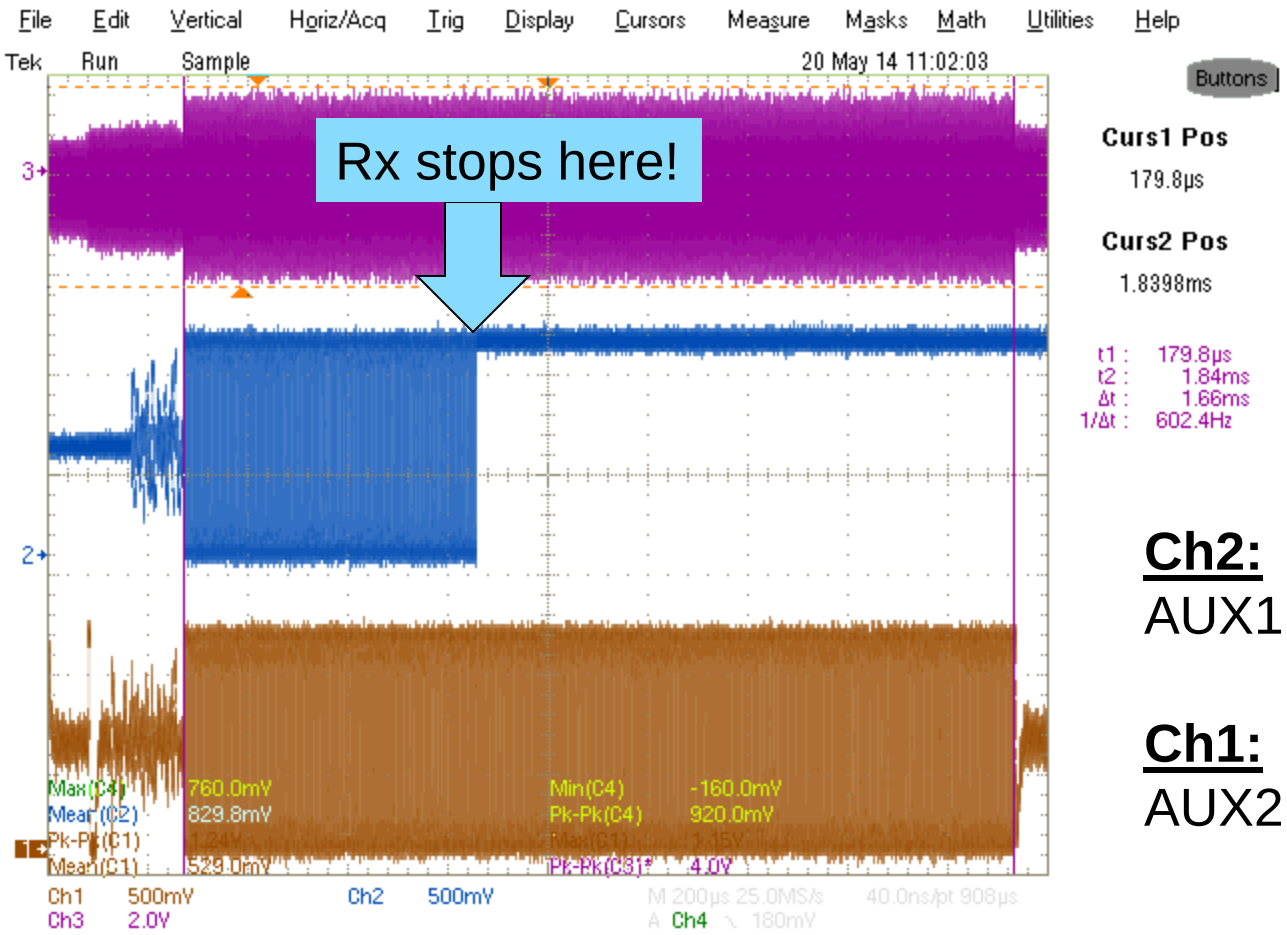


Ch3:
Sniffer signal showing Load modulation of a type B card

Ch2:
AUX1 = filtered Q-Channel

Ch1:
AUX2 = Q-Channel

Step #5: Debug a problem: “Bad” type B debug signal

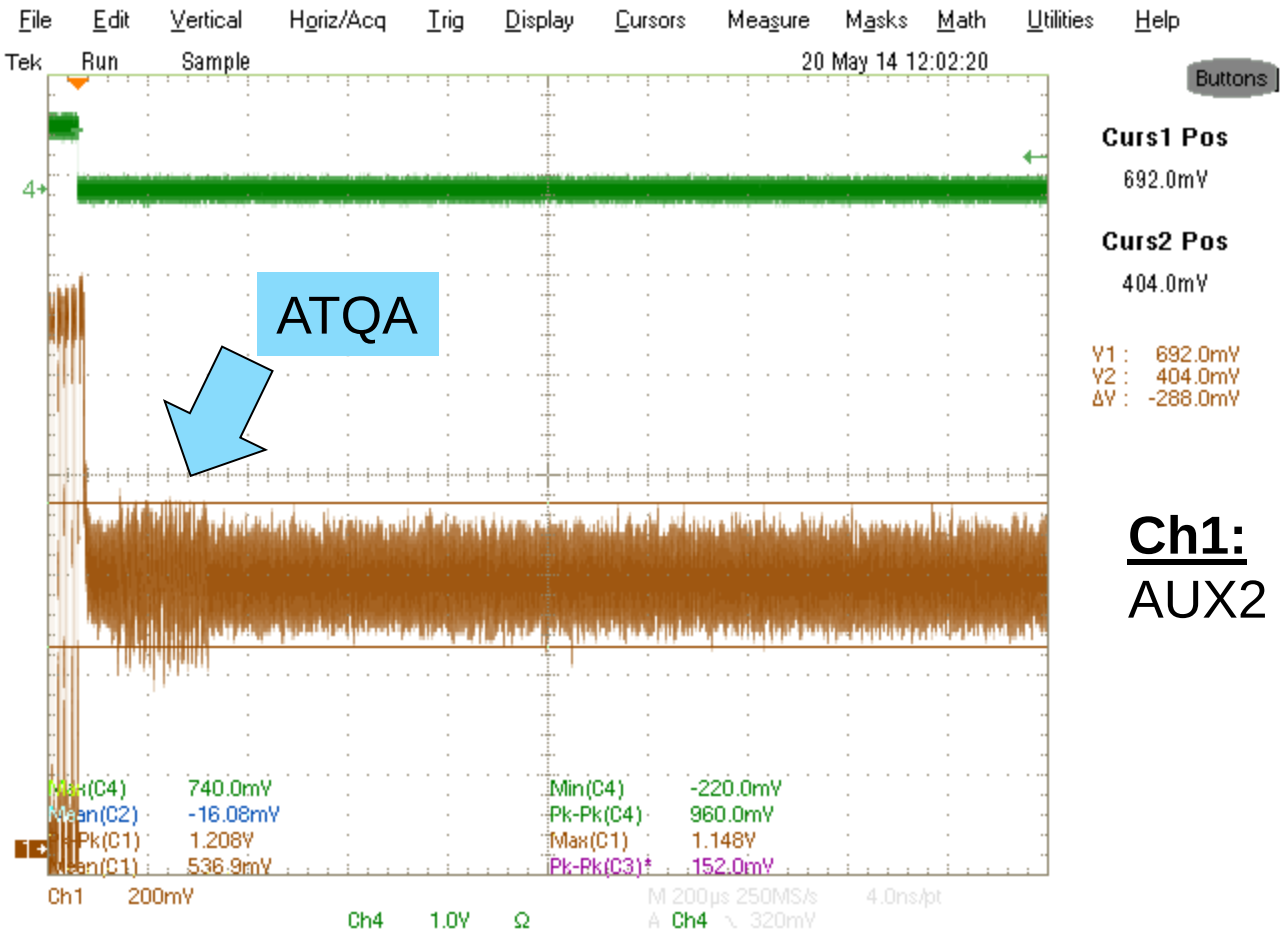


Ch3:
Sniffer signal showing Load modulation of a type B card

Ch2:
AUX1 = filtered Q-Channel

Ch1:
AUX2 = Q-Channel

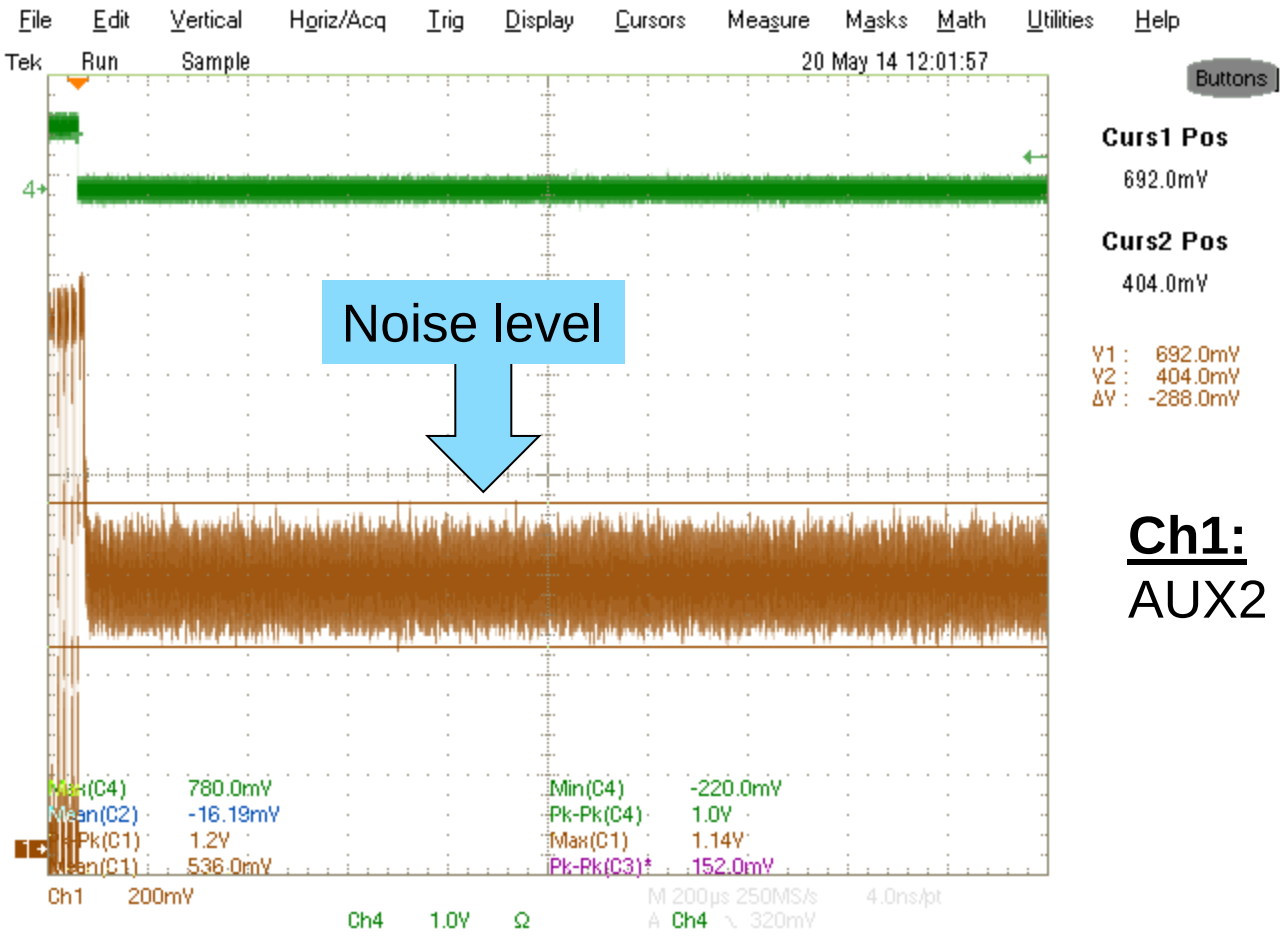
Step #5: Debug a problem: Small type A response, “clean” reader



Ch4:
Tx Active = trigger signal

Ch1:
AUX2 = Q-Channel

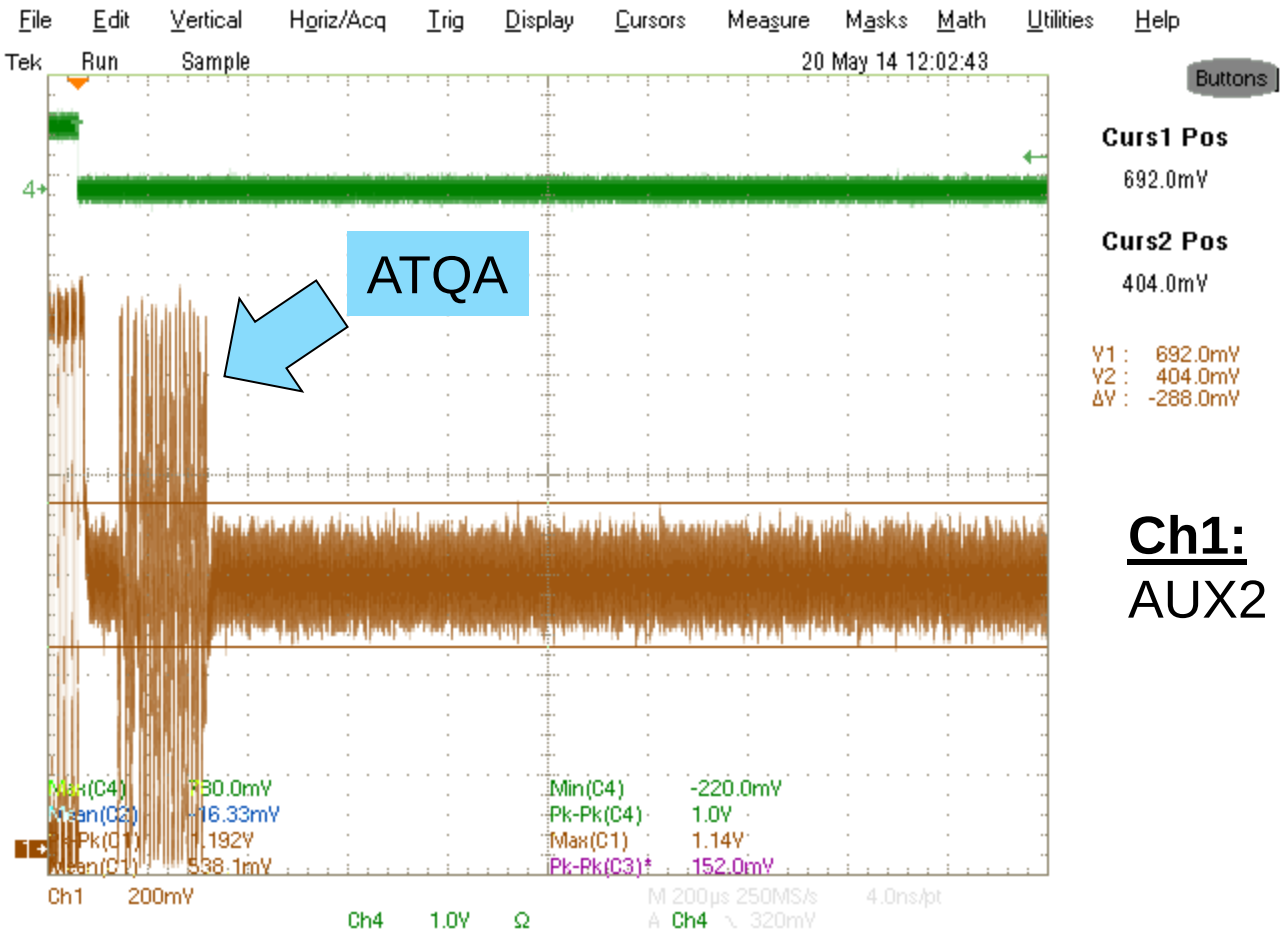
Step #5: Debug a problem: no response, “clean” reader



Ch4:
Tx Active = trigger signal

Ch1:
AUX2 = Q-Channel

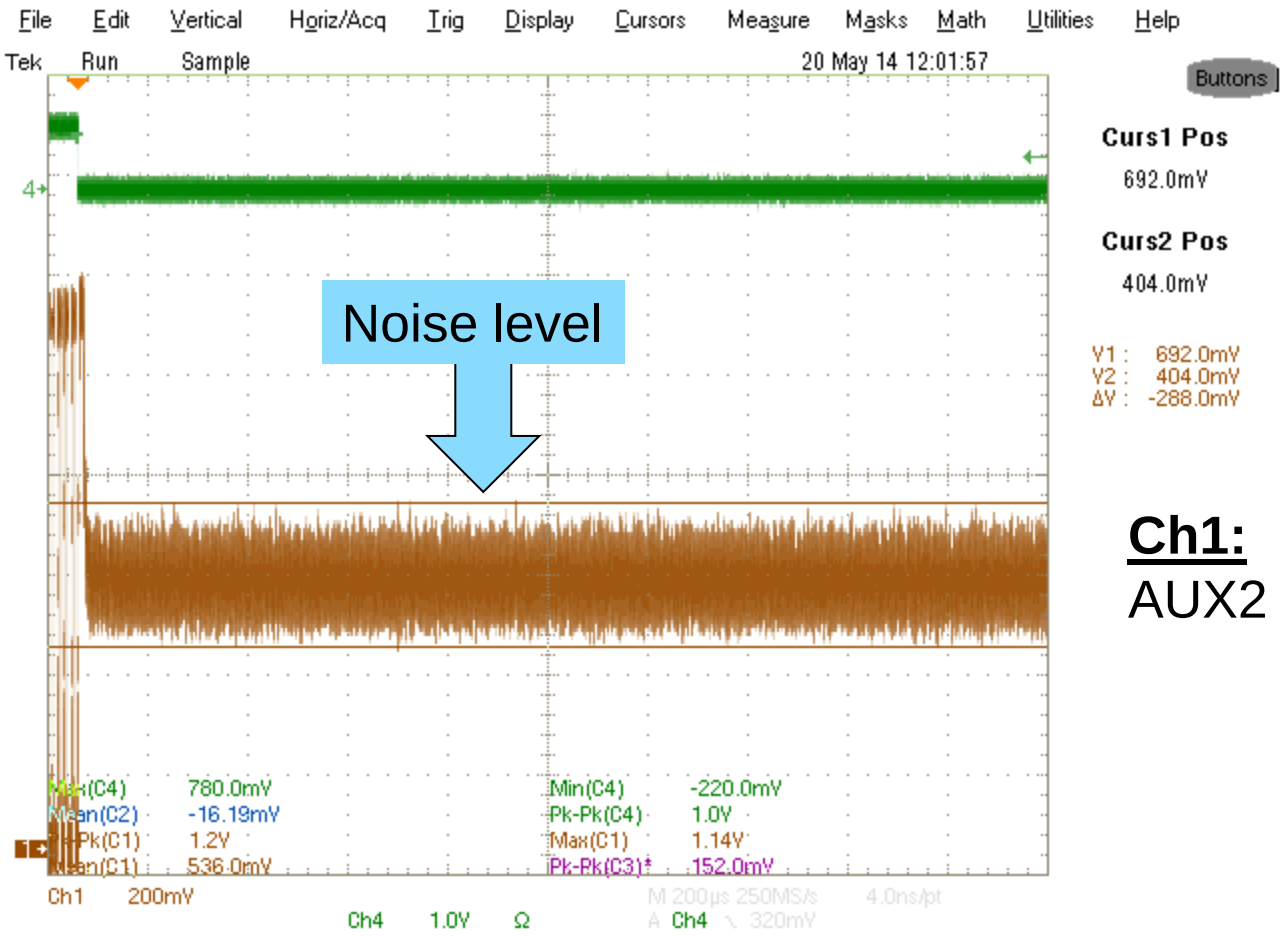
Step #5: Debug a problem: Strong type A response, “clean” reader



Ch4:
Tx Active = trigger signal

Ch1:
AUX2 = Q-Channel

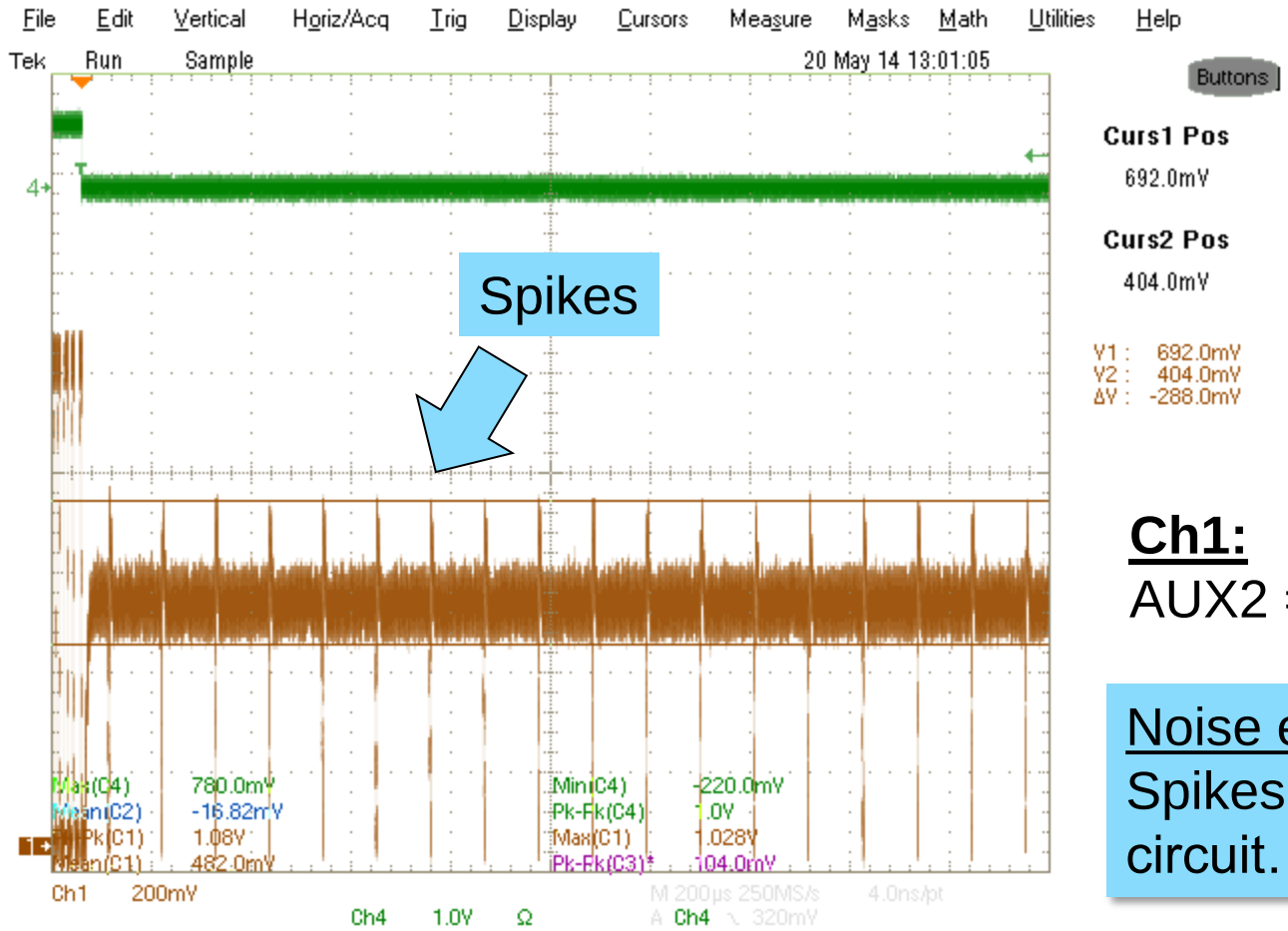
Step #5: Debug a problem: no response, “clean” reader



Ch4:
Tx Active = trigger signal

Ch1:
AUX2 = Q-Channel

Step #5: Debug a problem: no response, “noisy” reader

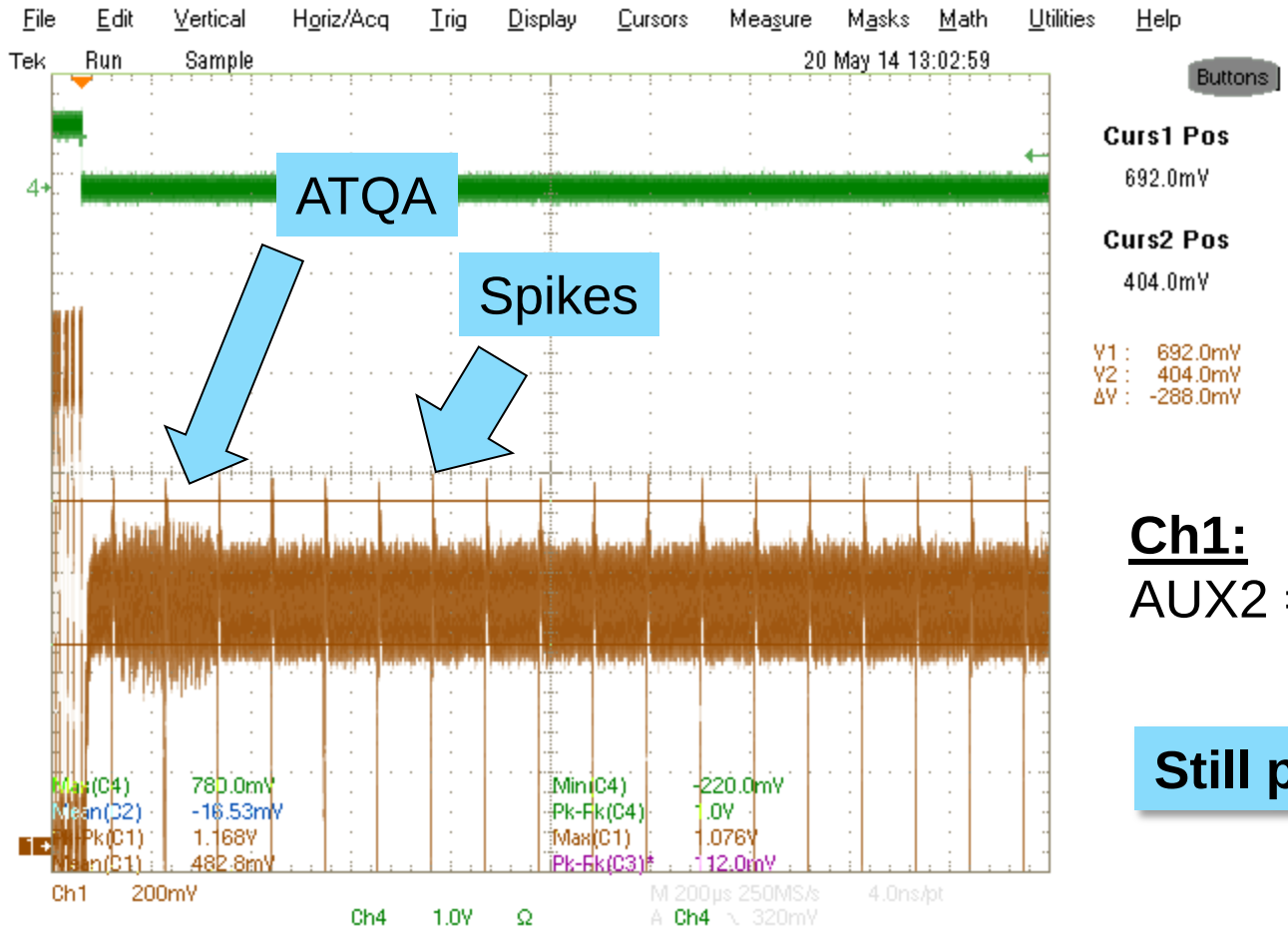


Ch4:
Tx Active = trigger signal

Ch1:
AUX2 = Q-Channel

Noise example:
Spikes from external UART circuit…

Step #5: Debug a problem: Small type A response, “noisy” reader

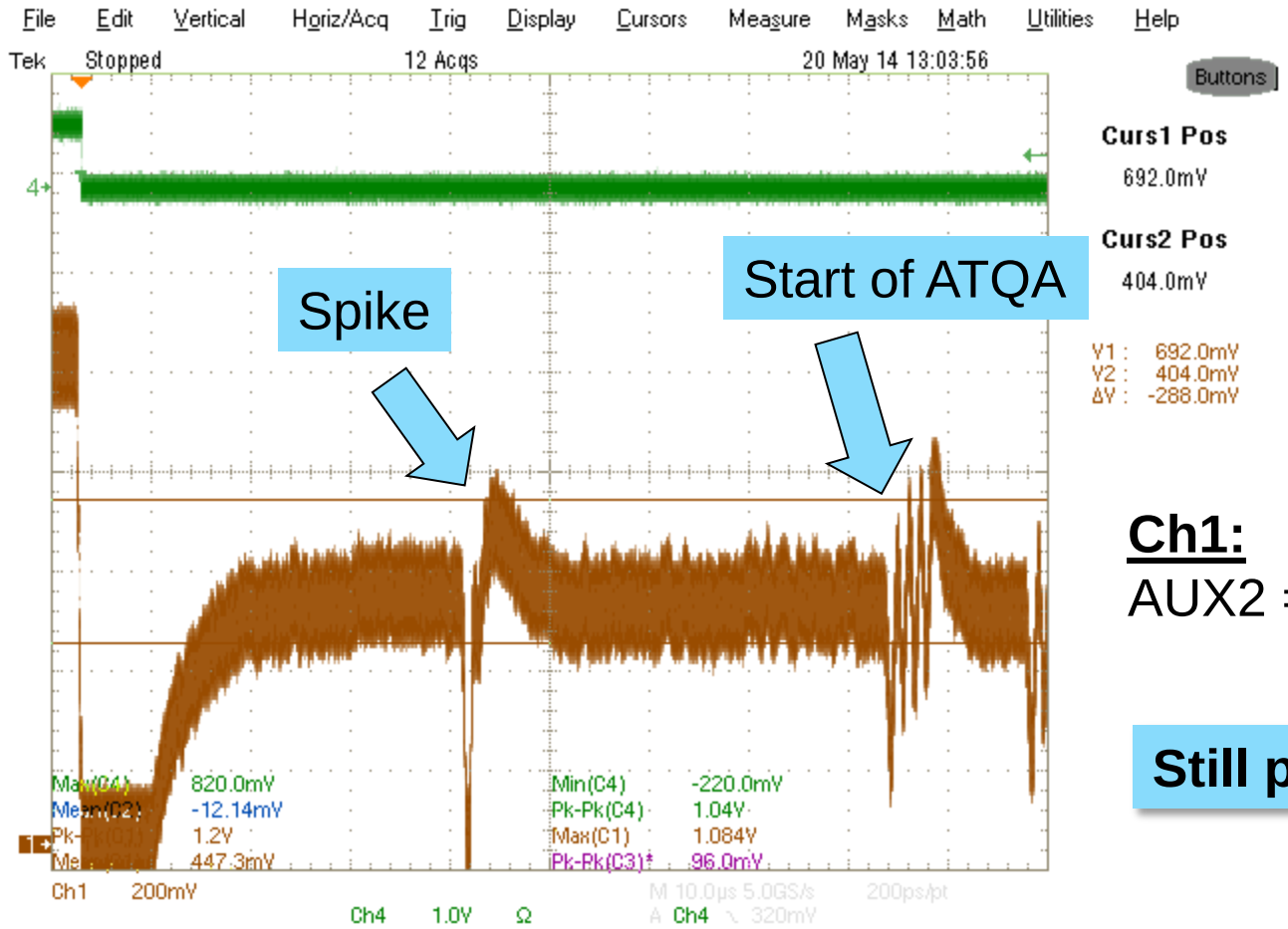


Ch4:
Tx Active = trigger signal

Ch1:
AUX2 = Q-Channel

Still proper Rx function!

Step #5: Debug a problem: Small type A response, “noisy” reader



Ch4:
Tx Active = trigger signal

Ch1:
AUX2 = Q-Channel

Still proper Rx function!

Conclusion

- Check ITVDD
  - Under all loading conditions
- Power & Data transfer to the PICC
  - Field strength: ANT#5
  - Pulse shapes & modulation index: ANT#5

Part of compliance tests

- Data transfer from the PICC
  - Adjust the Rx Level (Low capacitance probe!)
  - Test and reduce noise level
  - Optimize receiver settings
    - Use a sniffer to control the RF
    - Unlock test bus & route test signal to test pins
    - Check the relevant test signals & optimize registers

Anything else?

Please do not hesitate to contact NXP.

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Thank you!