HITB KUL 2013

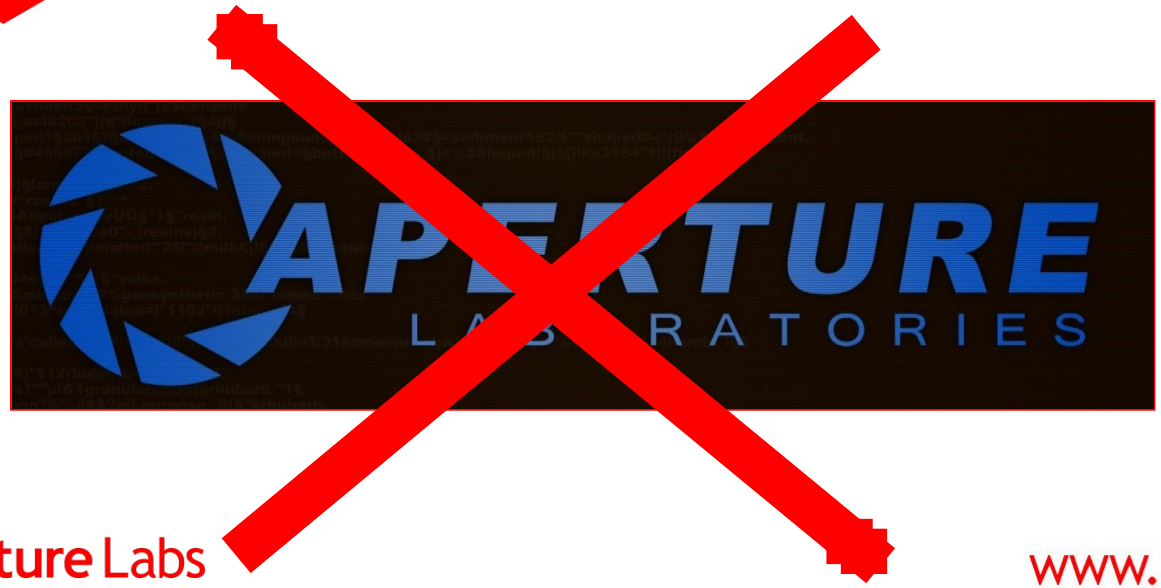
RFIDler
a Software Defined RFID tool

Adam Laurie

(Zac Franken)

Who are we?

- Aperture labs: www.aperturelabs.com



Fan Mail

April 1, 2013

Dear Aperture Laboratories

Do you make ~~or~~ Portal Guns?

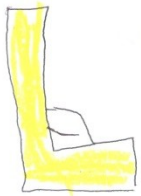
Do they work?

well I have a Idea for a portal Gun.

here is the picture

The portal colors are yellow and Rainbow

FROM Joshua



Who are we?

- Zac Franken
  - Chip Monkey
    - Scary Chemicals
    - Bad Smells

Who are we?

- Adam Laurie
  - Code Monkey
    - Convert scary analogue Magic Moonbeams to lovely Digital Bits & Bytes

What?

- RFIDler
  - Software Defined RFID

Why?

- Many systems totally insecure
  - Manufacturers know it
- Existing tools expensive / complicated
  - Proxmark3
    - Very good but 'fragile' & expensive
- Vendor specific dev kits
  - Locked in to one tag type
- Disrupt the market
  - Change threat landscape

Why?

- RFID is confusing
  - Proliferation of standards
  - Proprietary systems
  - Analogue
    - Inductive Coupling / NFC
      - Magic Moonbeams
    - Digital only after **ALL** decoding/demodulation

Software Defined Radio

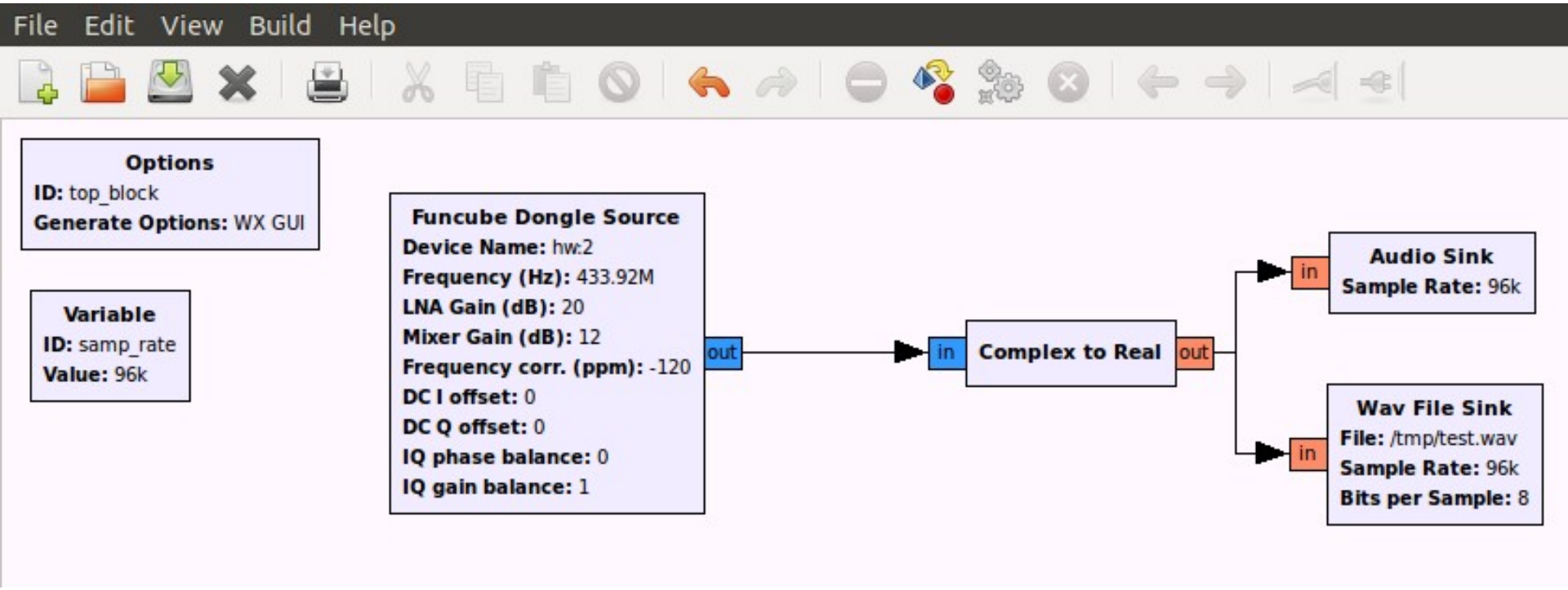
- RF front-end in hardware
- Everything else in software
  - Modulation
  - Filtering
  - Mixing
  - etc.

Software Defined Radio

- FUNcube Dongle
  - 150 kHz -> 1.9GHz

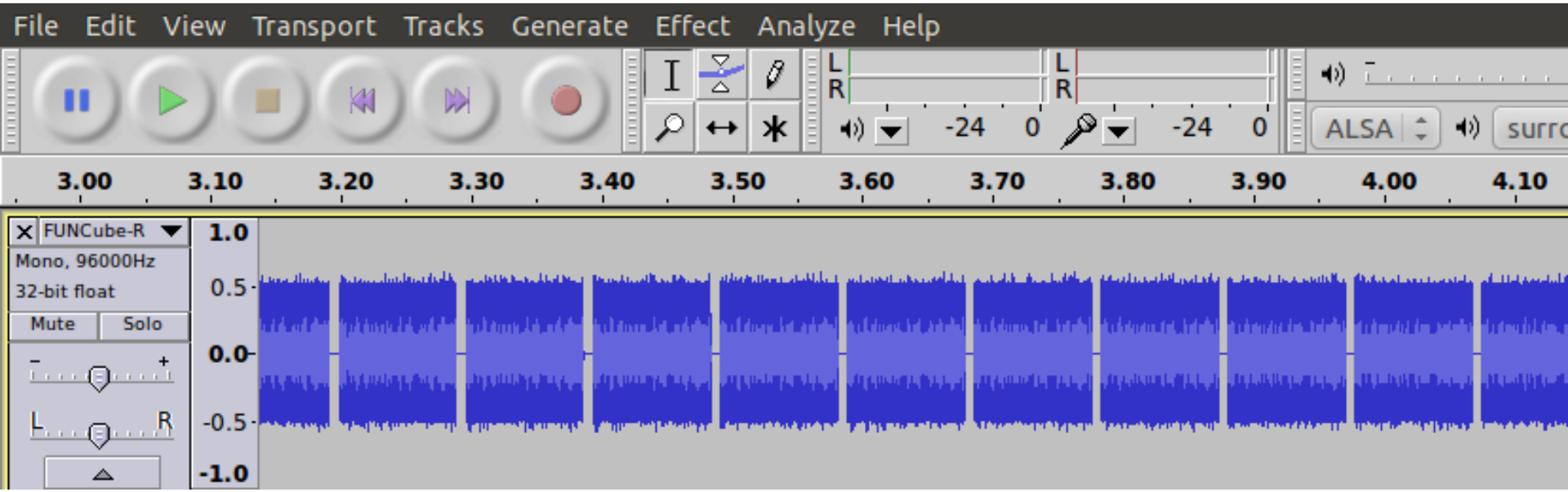
Software Defined Radio

- GNU Radio Companion
  - Works with any supported hardware
  - Creates python code to drive GNU Radio



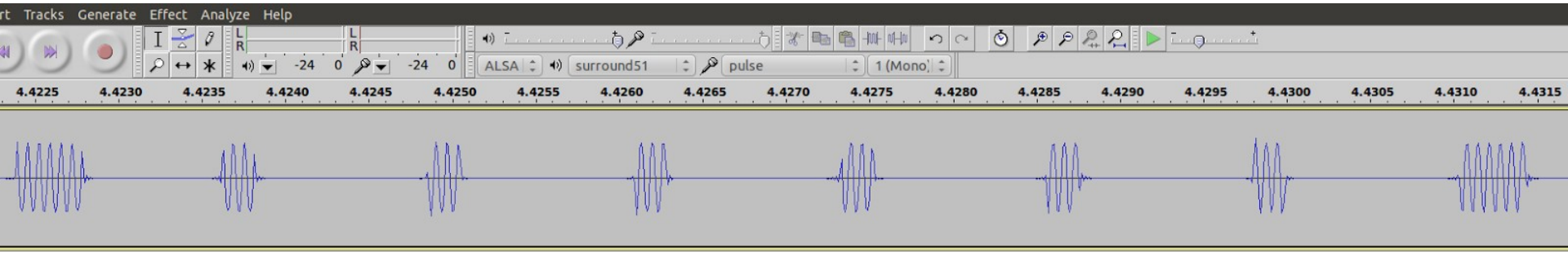
Software Defined Radio

- Raw data capture
  - Saved as WAV file



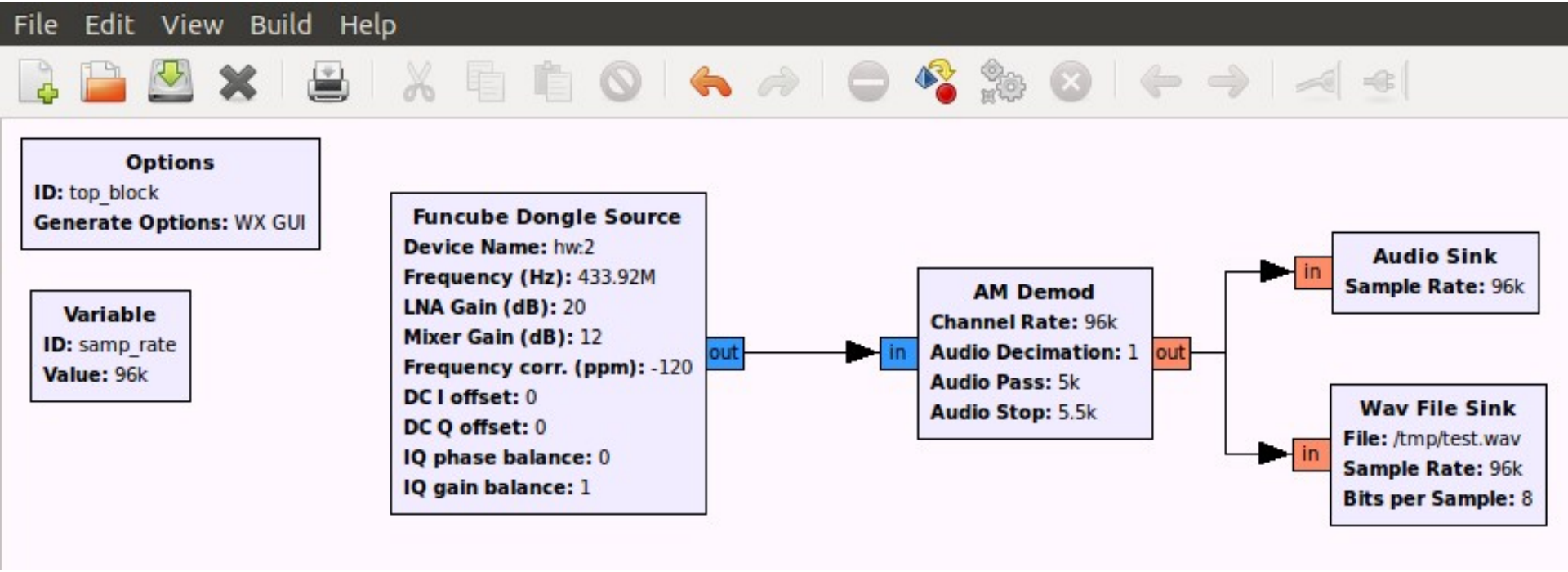
Software Defined Radio

- Raw data
  - AM - Amplitude Modulation
    - OOK – On / Off Keying



Software Defined Radio

- GNU Radio Companion
  - Pre-defined modulators / de-modulators
    - AM

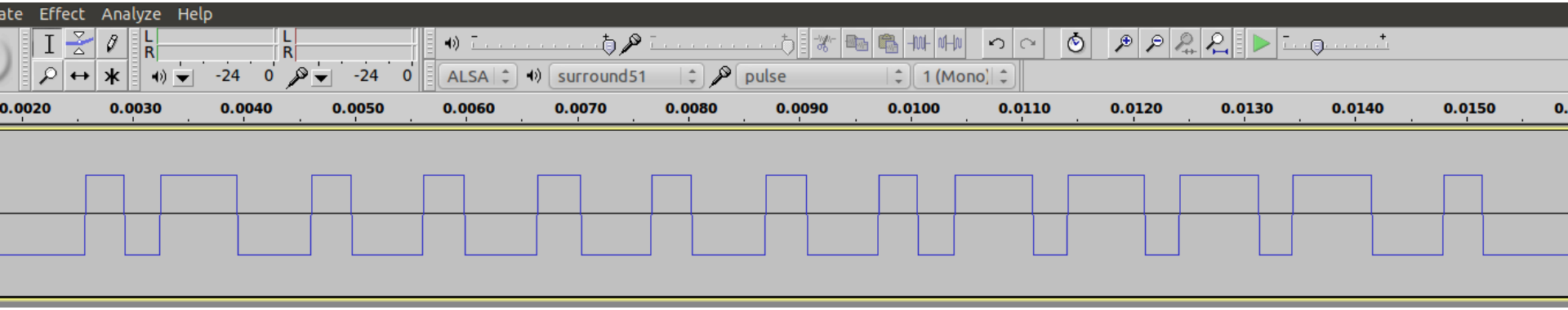


Software Defined Radio

- AM data capture
  - Saved as WAV file

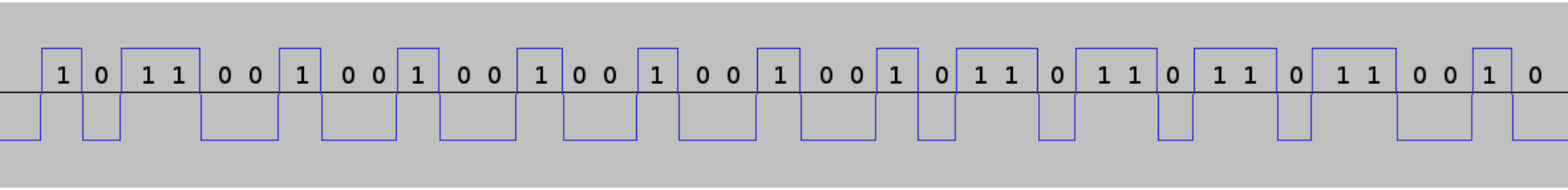
Software Defined Radio

- AM data capture
  - Convert to square wave



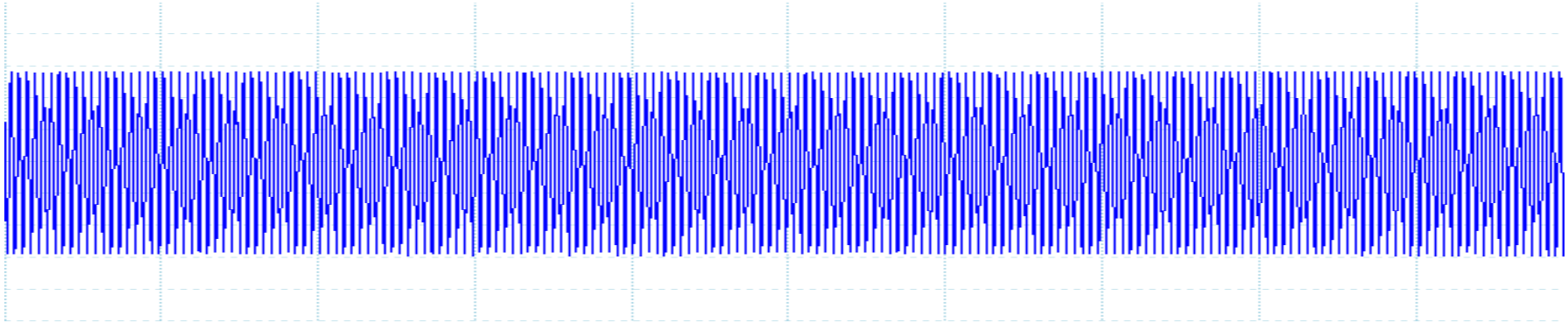
Software Defined Radio

- Decode to binary
  - HIGH is 1
  - LOW is 0
  - Smallest pulse is single bit length
  - 10110010010010010010010110110110110010



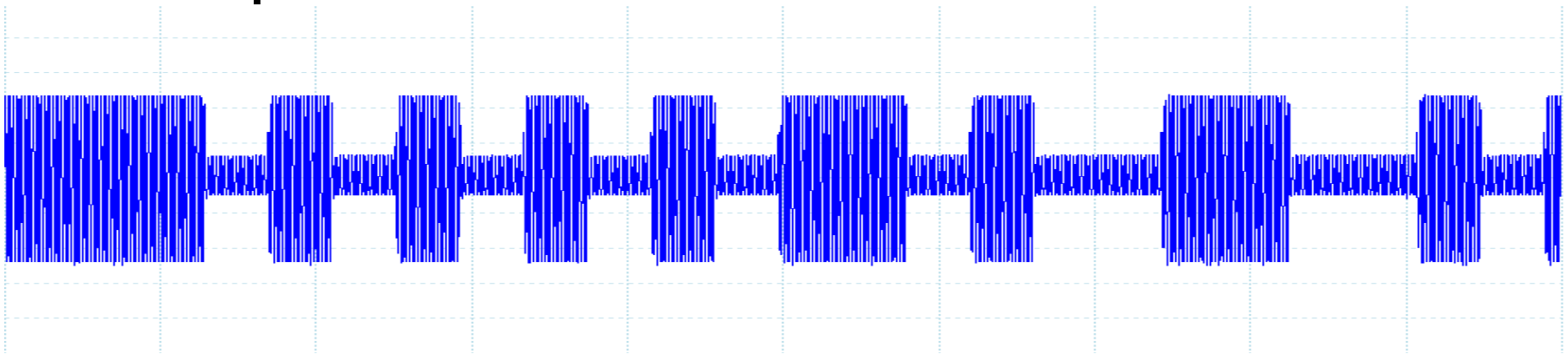
RFID Basics

- TAG and READER are inductively coupled
- READER generates CARRIER (in this case 125KHz) to energise TAG
- TAG takes power from its coil



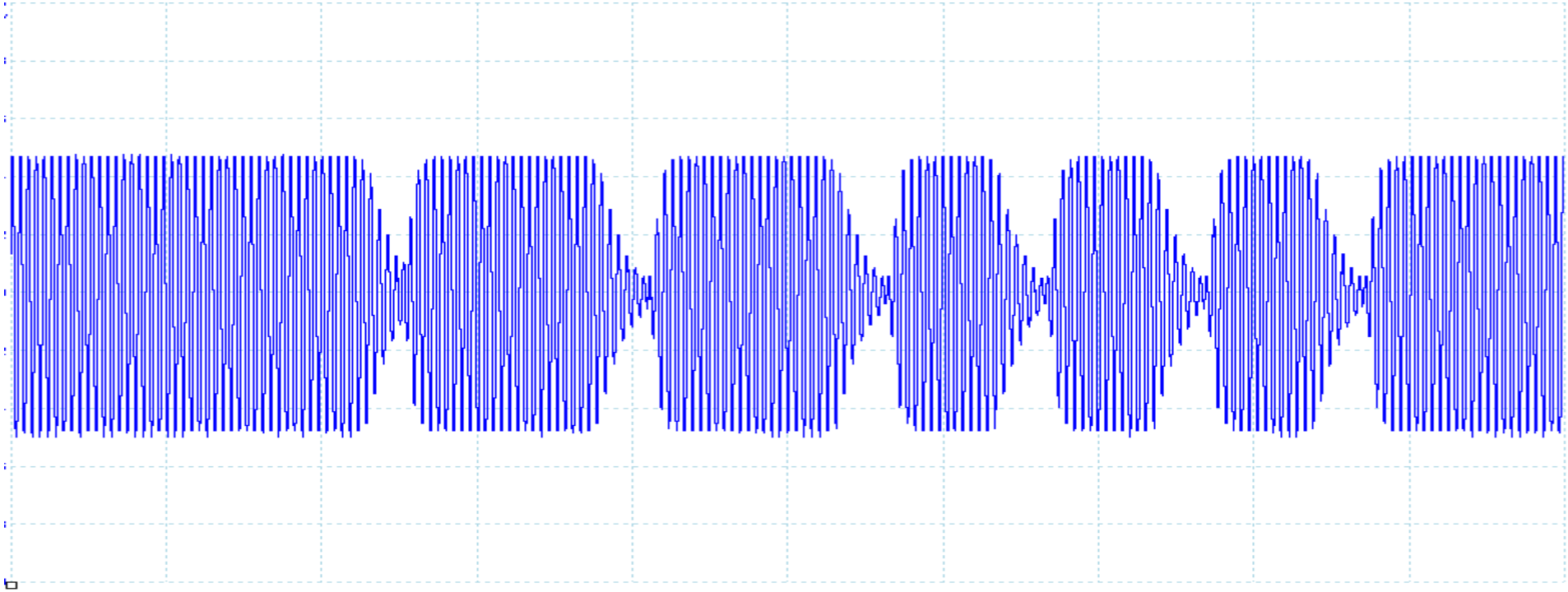
RFID Basics

- TAG communicates to READER by grounding its coil, thereby inducing a voltage drop in the inductively coupled READER coil



RFID Basics

- Reader communicates to TAG by interrupting the CARRIER



RFID Basics

- Modulation:
  - ASK – Amplitude Shift Keying
    - OOK – On / Off Keying

RFID Basics

- Modulation:
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    - OOK – On / Off Keying
      - READER ENERGISING coil
        - 'ON'
        - or not 'OFF'

RFID Basics

- Modulation:
  - ASK – Amplitude Shift Keying
    - OOK – On / Off Keying
      - READER ENERGISING coil
        - 'ON'
        - or not 'OFF'
      - TAG GROUNDING coil
        - 'ON'
        - or not 'OFF' (DAMPING)

RFID Basics

- Modulation **schemes**
  - ASK – Amplitude Shift Keying
    - OOK – On / Off Keying

RFID Basics

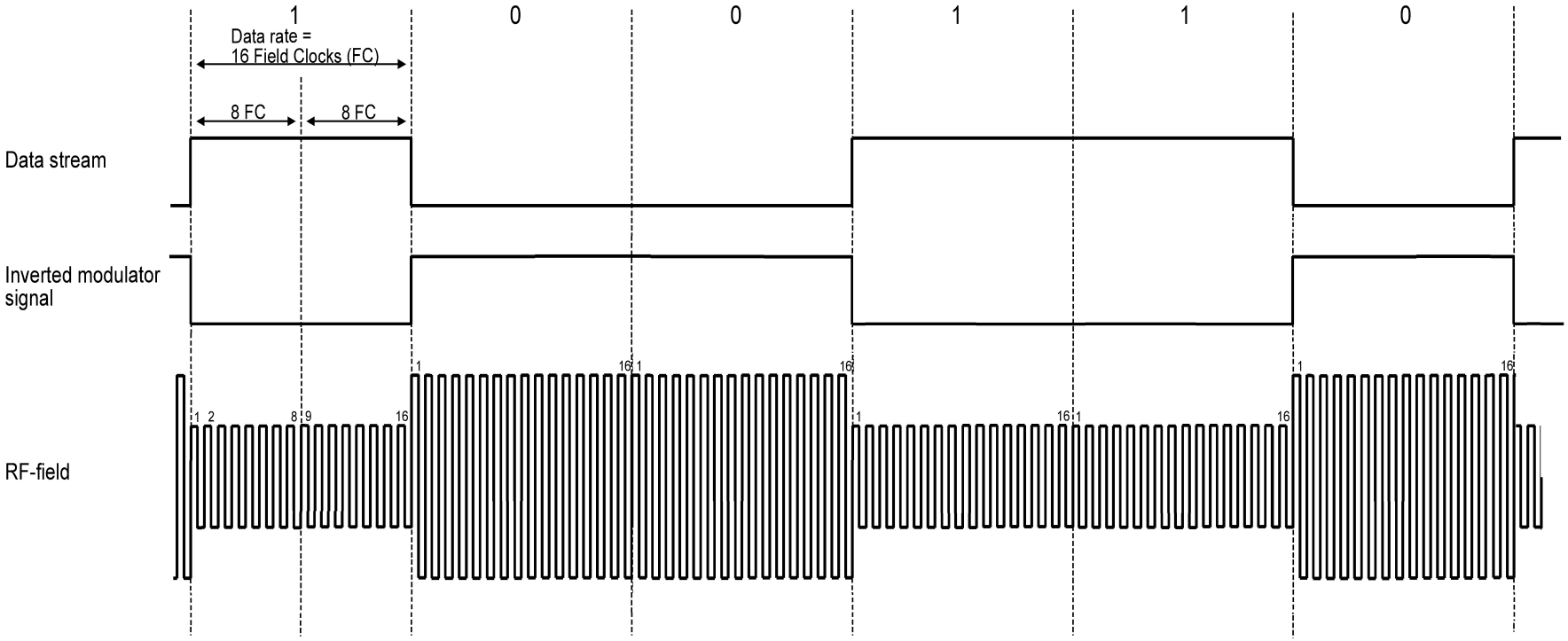
- Modulation **schemes**
  - ASK – Amplitude Shift Keying
    - OOK – On / Off Keying
  - That's all she wrote!

RFID Basics

- Modulation **schemes**
  - ASK – Amplitude Shift Keying
    - OOK – On / Off Keying
  - PWM – Pulse Width Modulation
  - FSK – Frequency Shift Keying
  - PSK – Phase Shift Keying
  - Manchester / BiPhase Encoding

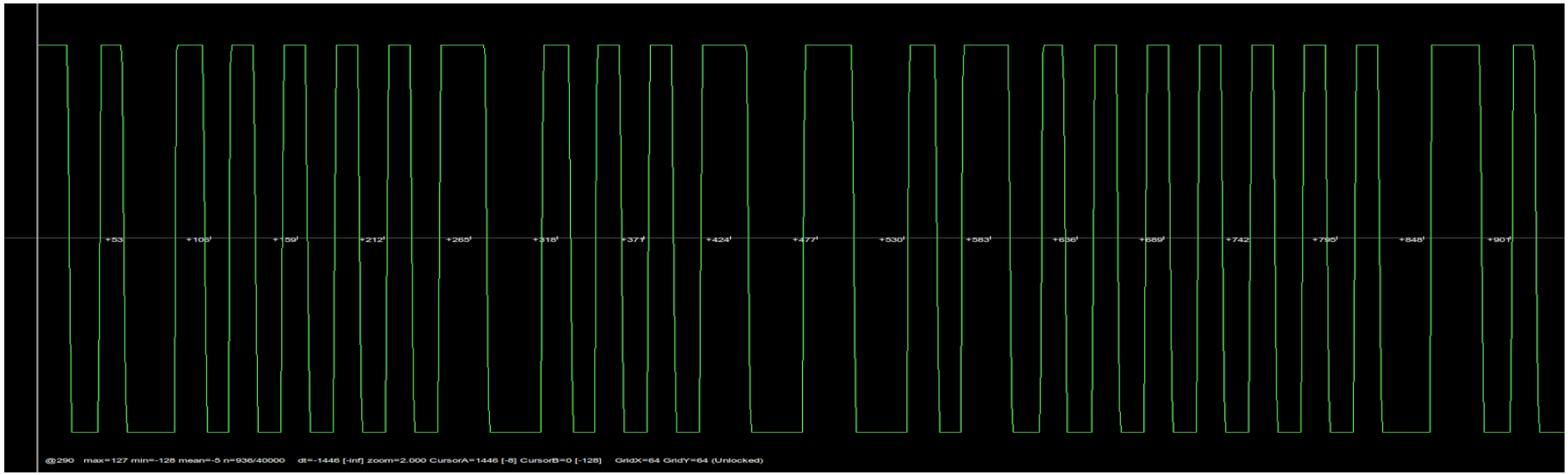
RFID Basics

- ASK / OOK



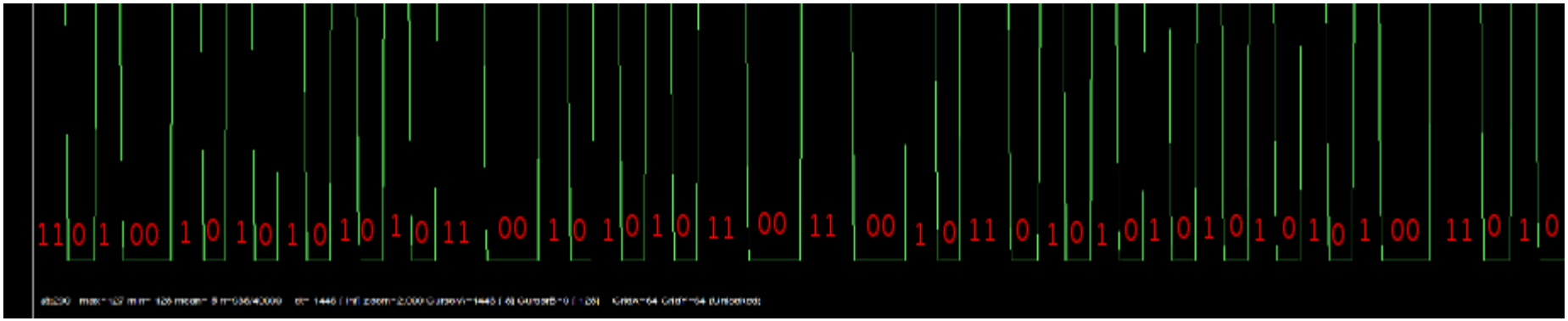
RFID Basics

- ASK / OOK
  - DAMPED for a 0
  - UN-DAMPED for a 1



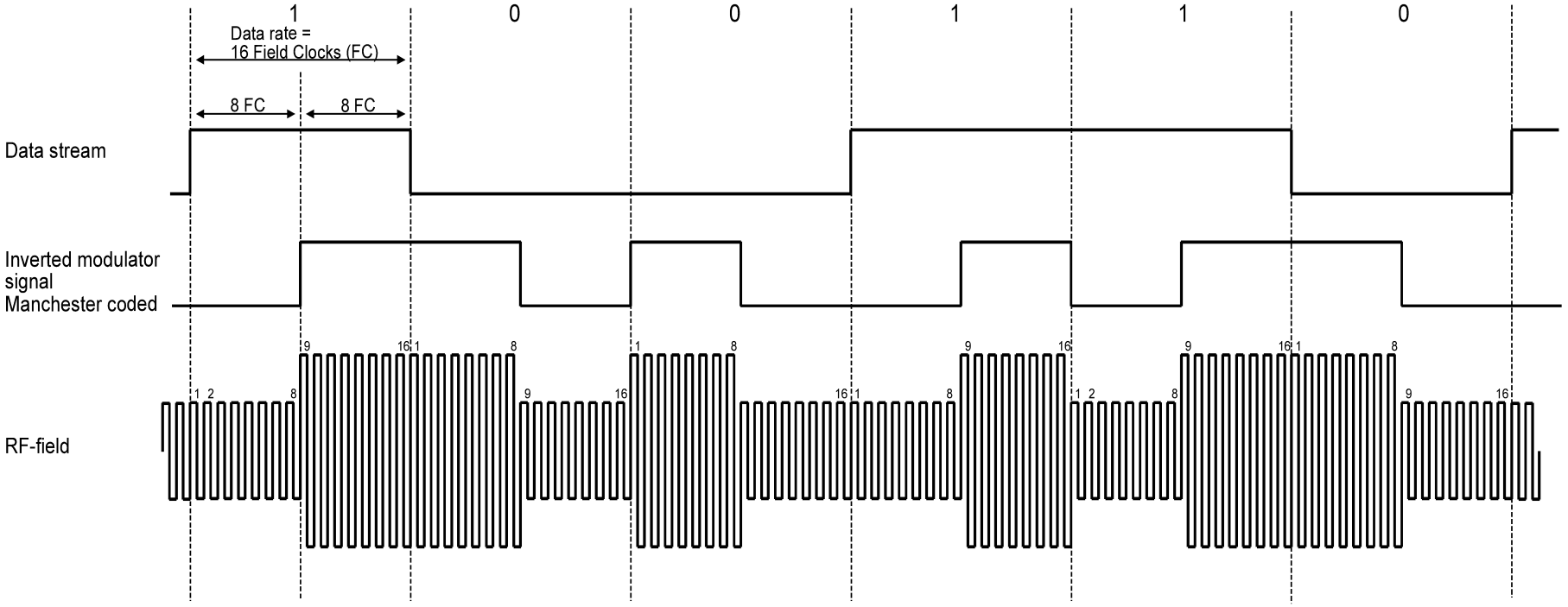
RFID Basics

- ASK – Amplitude Shift Keying
  - OOK – On / Off Keying
    - 1101001010101011001010101100110010110101010101010011010



RFID Basics

- Manchester encoding



RFID Basics

- Manchester encoding:
  - 1101001010101010110010101011001100101101010101010010011010
  - 10 = '1'
  - 01 = '0'
  - 11 = Invalid!
  - 00 = Invalid!

RFID Basics

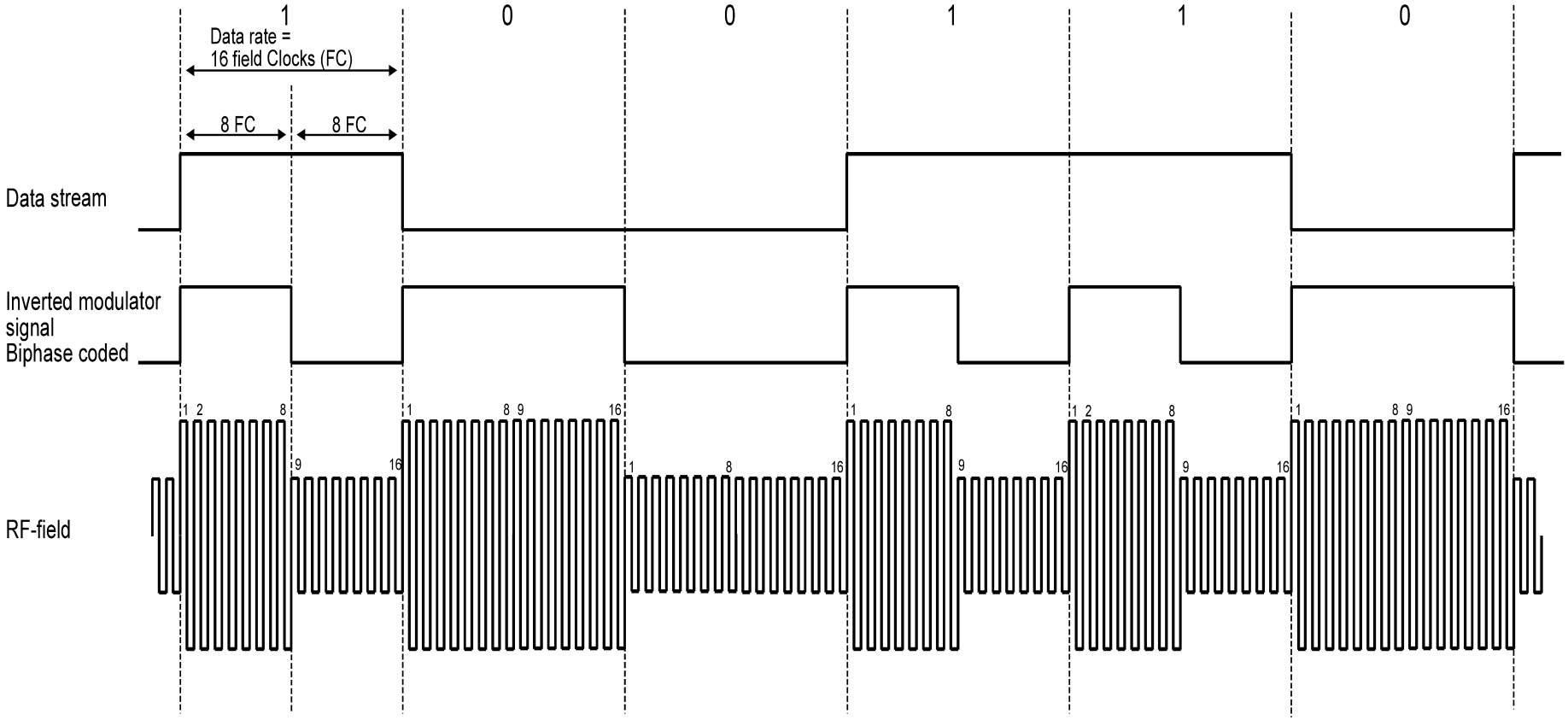
- Manchester encoding:
  - Two baseband pulse widths
    - '00' or '11' = long
    - '01' or '10' = 2 x short
  - Two pulse periods per bit
    - 11 01 00 10 10 10 10 10 11 00 10 10 10 11 00 11 00 10 11 01 01 01 01 01 01 0 10 10 01 10 10
  - Automatic error detection
    - 11 == Invalid!
  - Self clocking
    - Skip ½ bit:
    - 10 10 01 01 01 01 01 01 10 01 01 01 01 10 01 10 01 01 10 10 10 10 10 10 10 10 01 10 10
      - 1100000010000101001111111011

RFID Basics

- Manchester encoding:
  - Self-Clocking
  - Error-Detection
  - Ability to transmit ASK '0'
    - Distinguish from silence

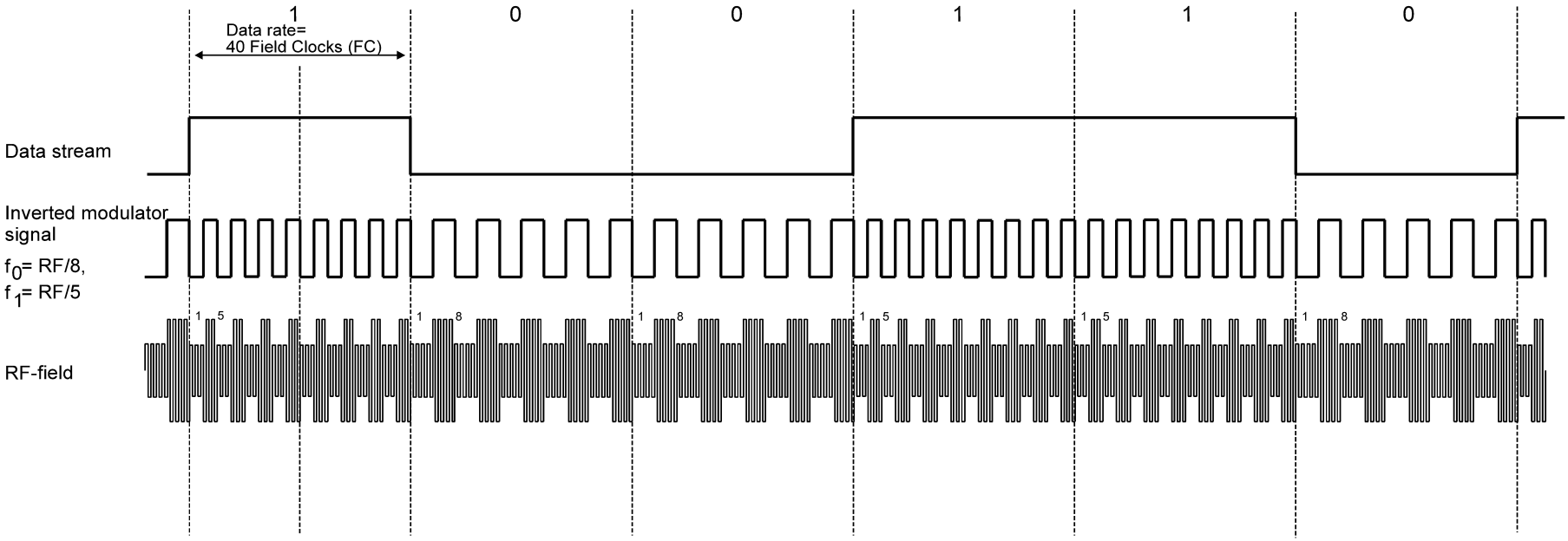
RFID Basics

- BiPhase encoding



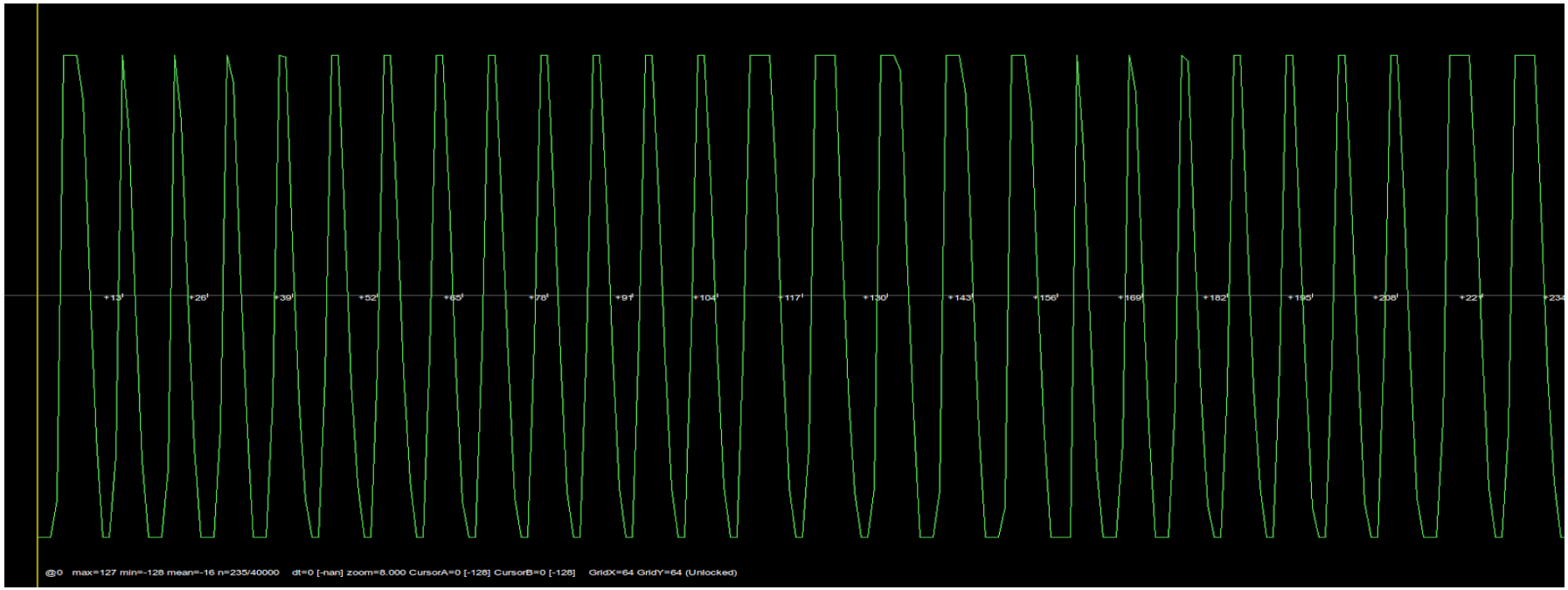
RFID Basics

- Modulation schemes
  - FSK – Frequency Shift Keying



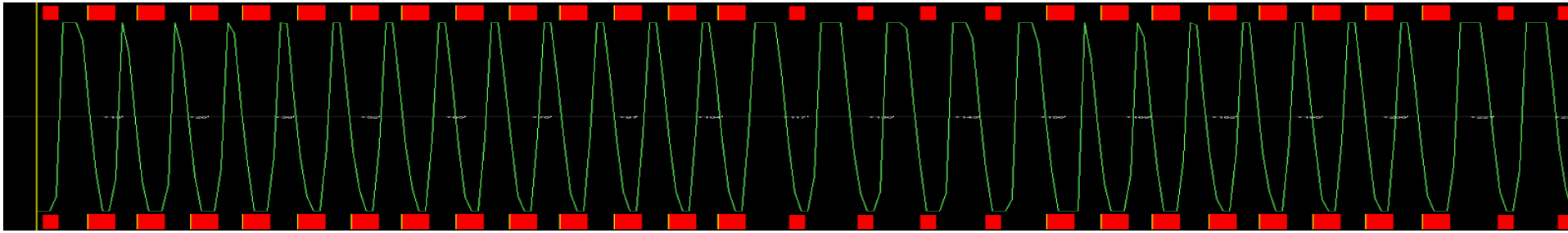
RFID Basics

- Modulation schemes
  - FSK – Frequency Shift Keying



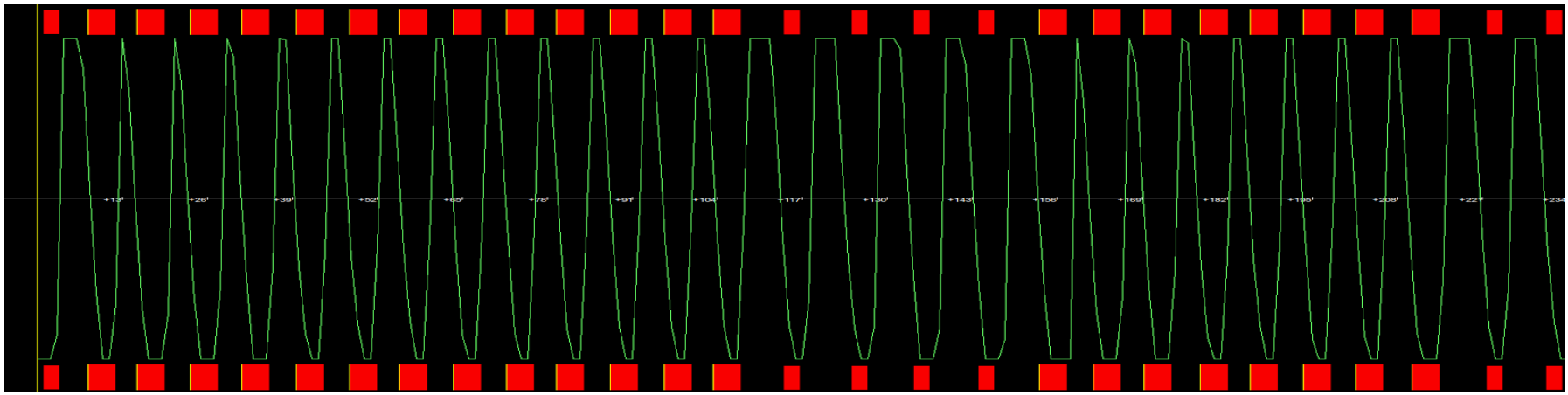
RFID Basics

- ASK / FSK – Frequency Shift Keying
  - DAMPING creates secondary pulses by allowing bursts of carrier
  - Frequency of pulses over fixed period determines '0' or '1'



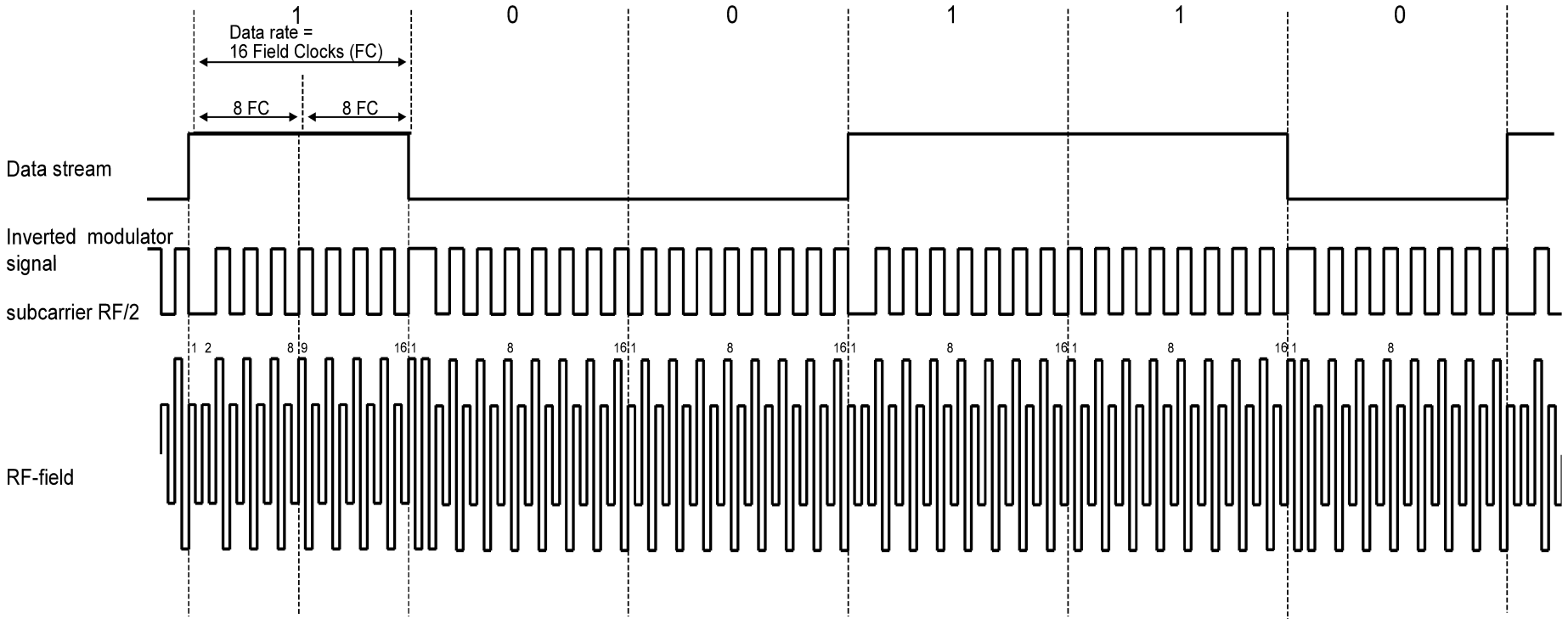
RFID Basics

- ASK / FSK – Frequency Shift Keying
  - 6 short = '0'
  - 5 long = '1'
  - This message: 100101



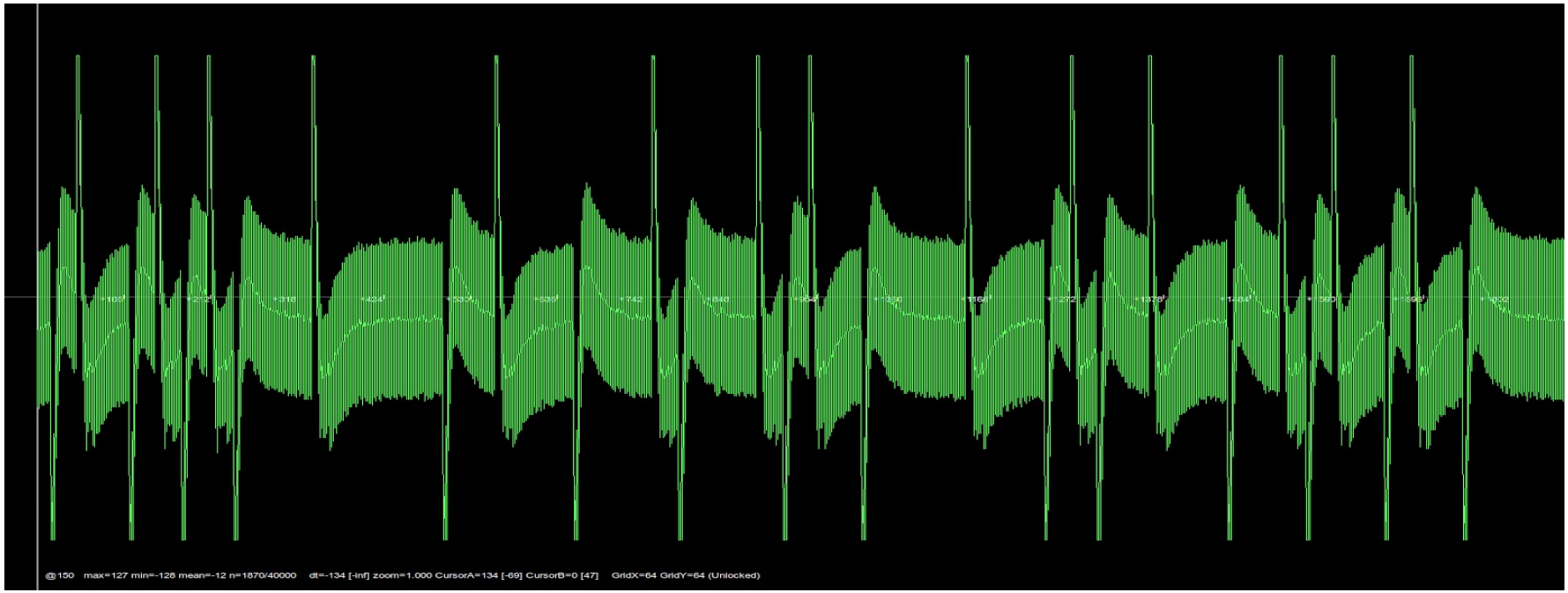
RFID Basics

- Modulation schemes
  - PSK – Phase Shift Keying



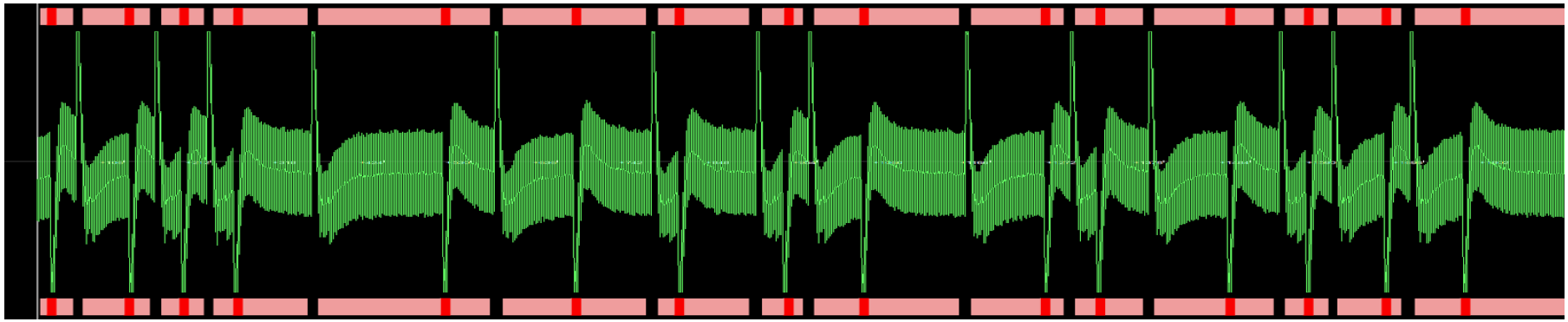
RFID Basics

- Modulation schemes
  - PSK – Phase Shift Keying



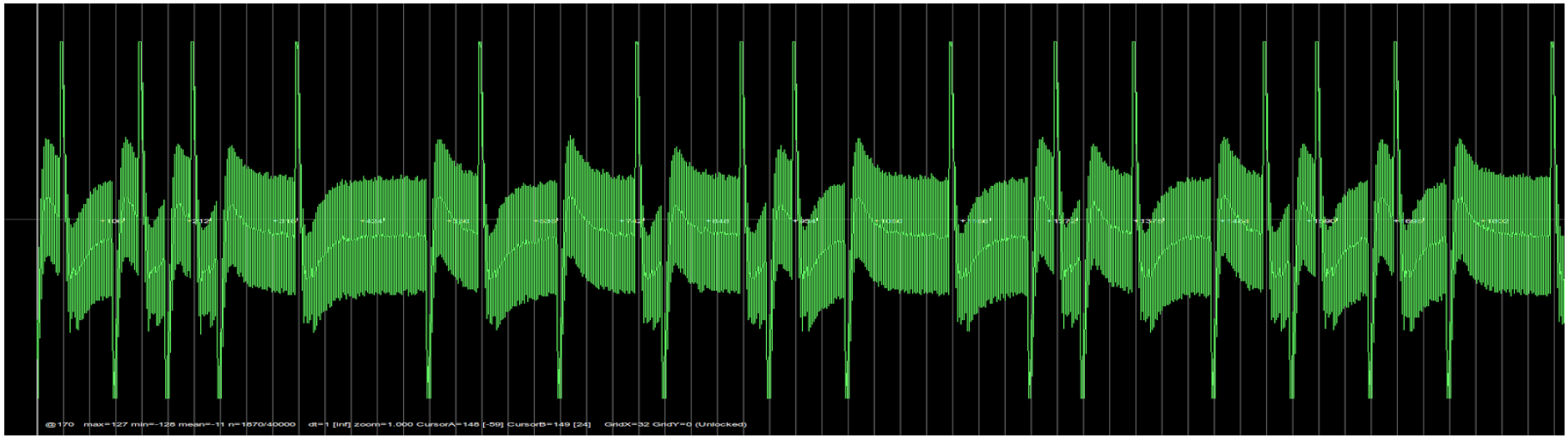
RFID Basics

- ASK / PSK – Phase Shift Keying
  - 50% DAMPING creates secondary CARRIER
  - Phase shift allows single burst of original CARRIER to break through
    - (2 x 50% = 100%)
    - High pulse is UN-DAMPED
    - Low pulse is DAMPED



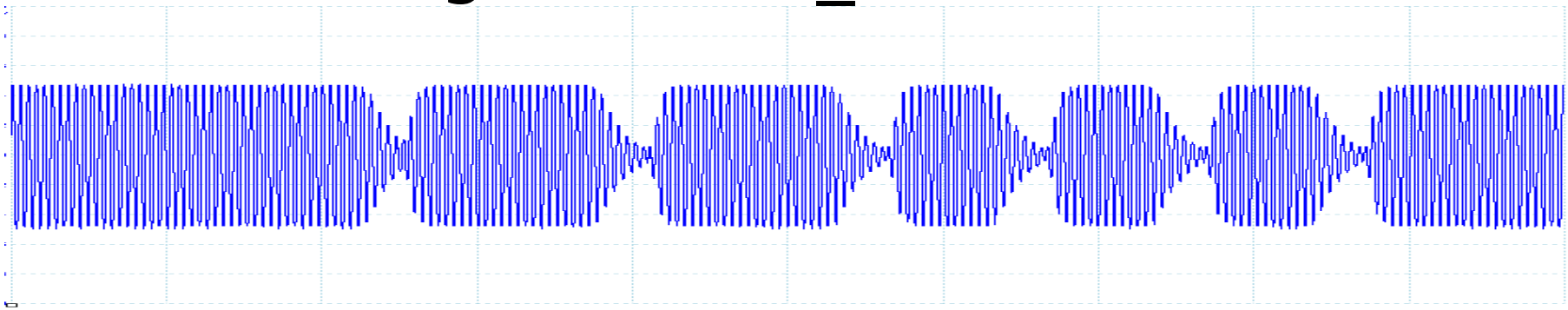
RFID Basics

- ASK / PSK – Phase Shift Keying
  - 1 bit per period
  - Phase change = value change
  - 0110101000111110011100010001011000011101001110 0101101100001



RFID Basics

- Modulation schemes
  - PWM – Pulse Width Modulation
  - '1' is a long pulse, '0' a short
  - This message is '11000'
    - Hitag2 'START_AUTH'



Passive TAGs

- One-way communication:
  - TAG → READER
  - Fixed ID
  - Plaintext
    - Even 'encrypted' is fixed – i.e. no session key
  - About as secure as a barcode!
    - EM4102
    - HID Prox (plaintext content)
    - Indala (encrypted content)

Active TAGs

- Two-way communication:
  - READER → TAG & TAG → READER
  - Fixed or Random ID
  - May be encrypted
    - Session key
    - Two-Way Authentication
  - As secure as underlying crypto
    - Hitag2 (broken)
    - DESFire (DES, 3DES, AES)

RFIDler LF (125/134 KHz)

- Very low cost
  - Standard: Full device with processor
    - USB / TTL CLI / API & GPIO
      - £30.00
  - Lite: RFID Coil & ASK mod/demod only
    - GPIO
      - £20
  - Kickstarter project

RFIDler LF (125/134 KHz)

- Utilise ANY modulation scheme, including bi-directional protocols
- Write data to tag
- Read data from tag
- Emulate tag
- Sniff conversations between external reader & tag
- Provide raw as well as decoded data
- Built-in antenna
- External antenna connection
- USB power and user interface
- TTL interface
- GPIO interface
- JTAG interface for programming
- USB Bootloader for easy firmware updating

RFIDler LF (125/134 KHz)

- EM4102 / Unique
- Hitag 1/2/S
- FDX-B (ISO 11784/5 Animal Standard)
- Q5
- T55xx
- Indala
- Noralsy
- HID Prox
- NXP PCF7931
- Texas Instruments
- VeriChip
- FlexPass

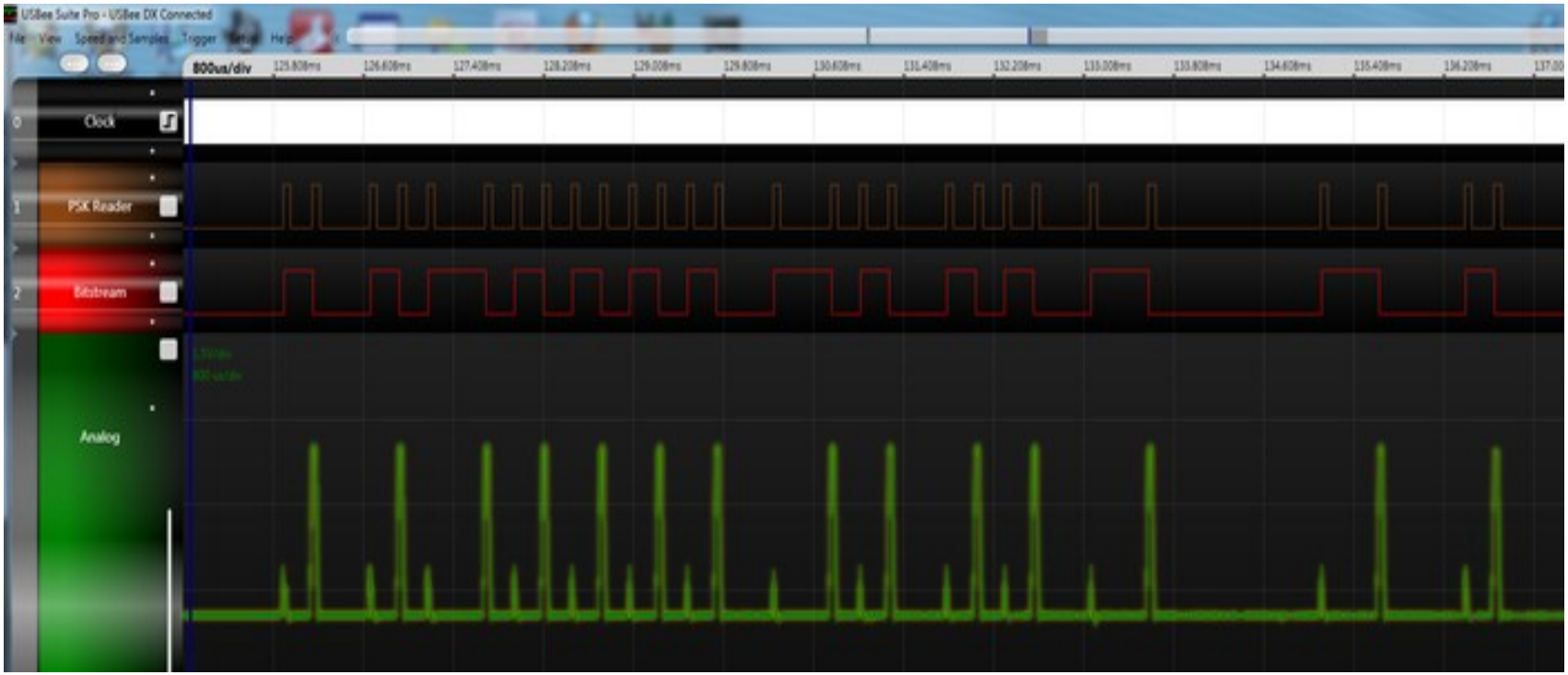
RFIDler LF (125/134 KHz)

How SD is it?

- Hardware Modulate / Demodulate:
  - ASK
- Software Modulate / Demodulate:
  - CARRIER
  - FSK / PSK
  - Manchester / BiPhase
  - PWM

RFIDler LF (125/134 KHz)

Reading PSK



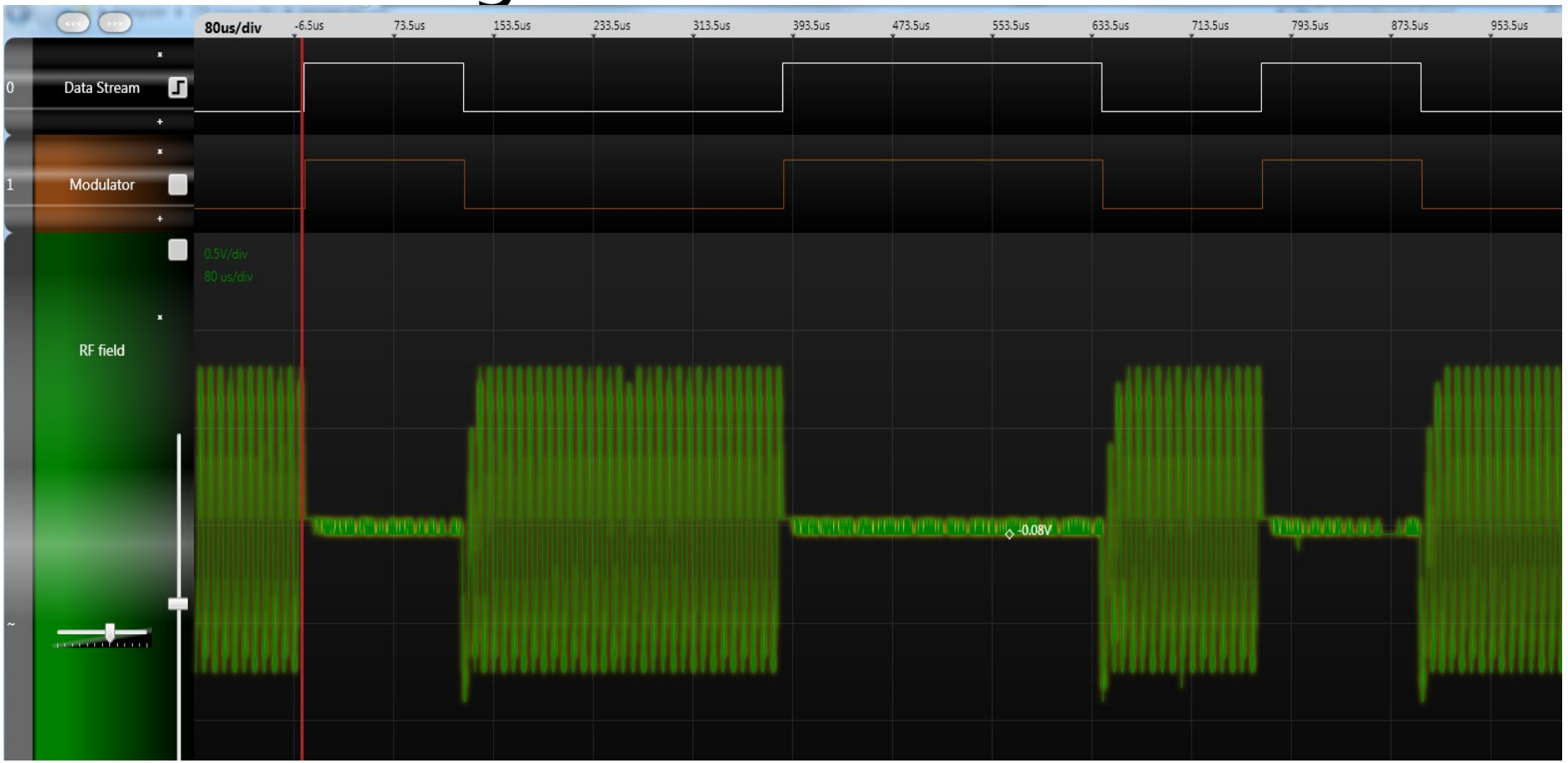
RFIDler LF (125/134 KHz)

Emulation / Commands

- Measure in Field Clocks
  - 1 second / Frequency == 1 Field Clock
    - e.g. 1 / 125KHz == 8 uS
  - Baseband timings from datasheets

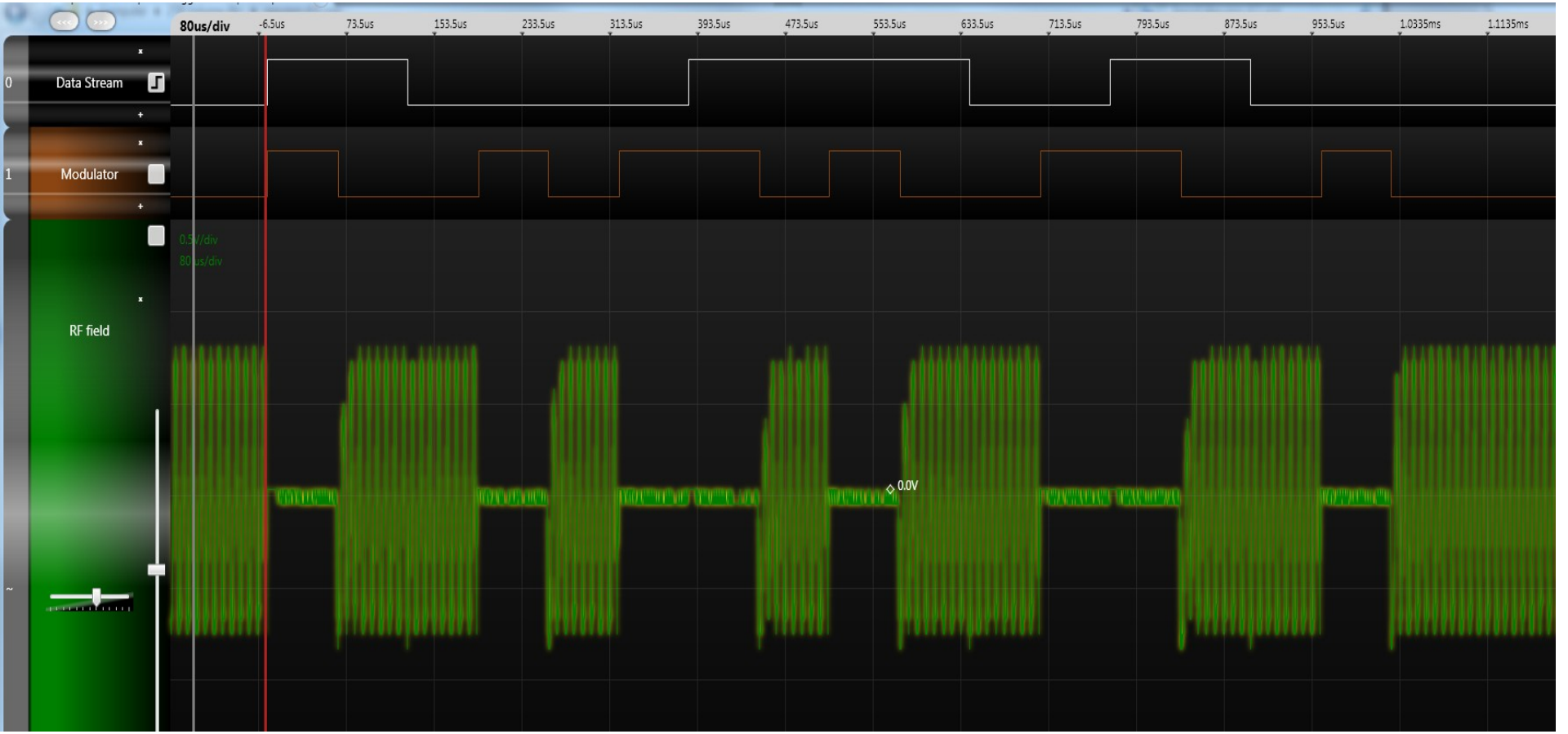
RFIDler LF (125/134 KHz)

Emulating ASK



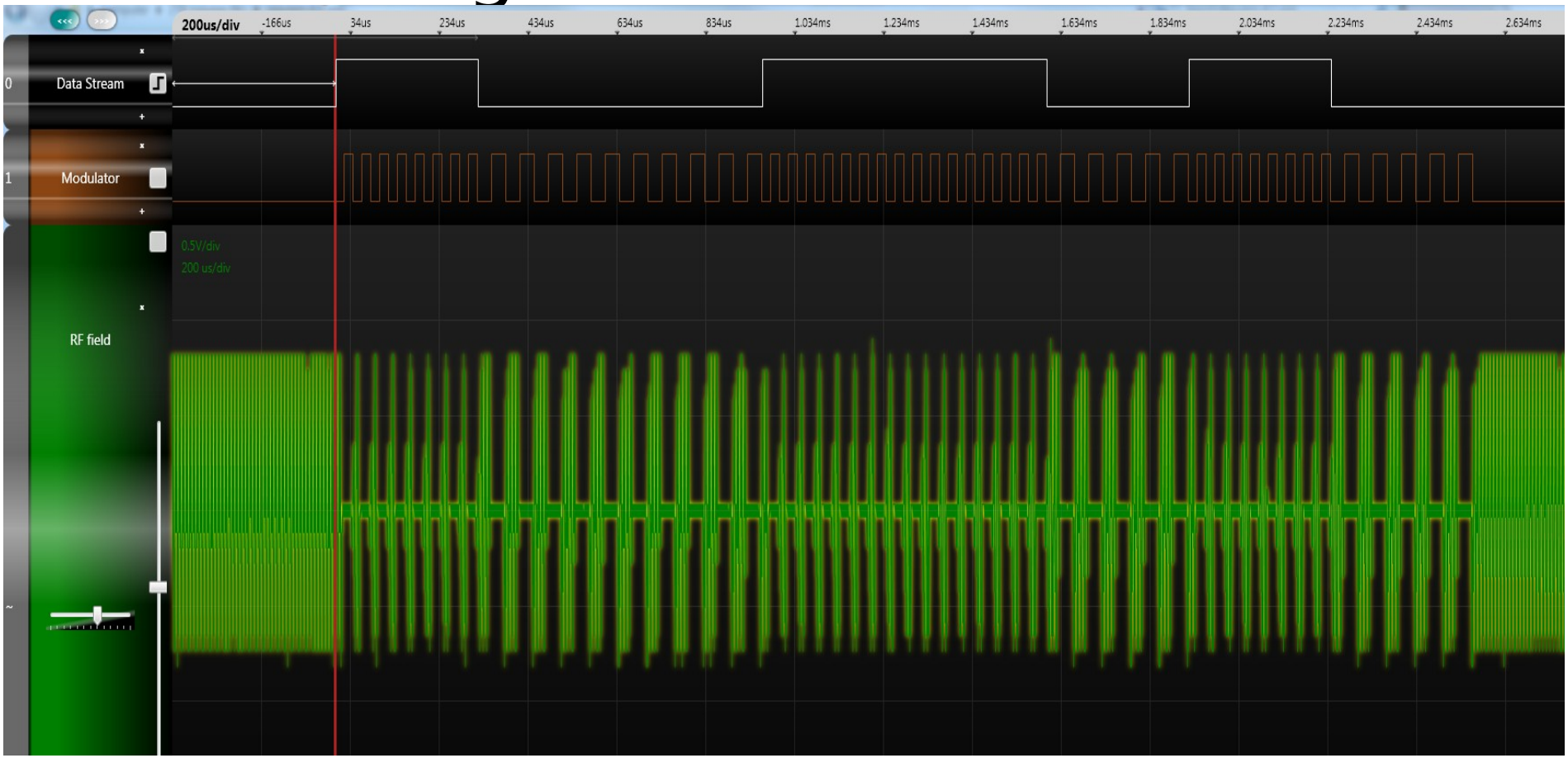
RFIDler LF (125/134 KHz)

Emulating Manchester



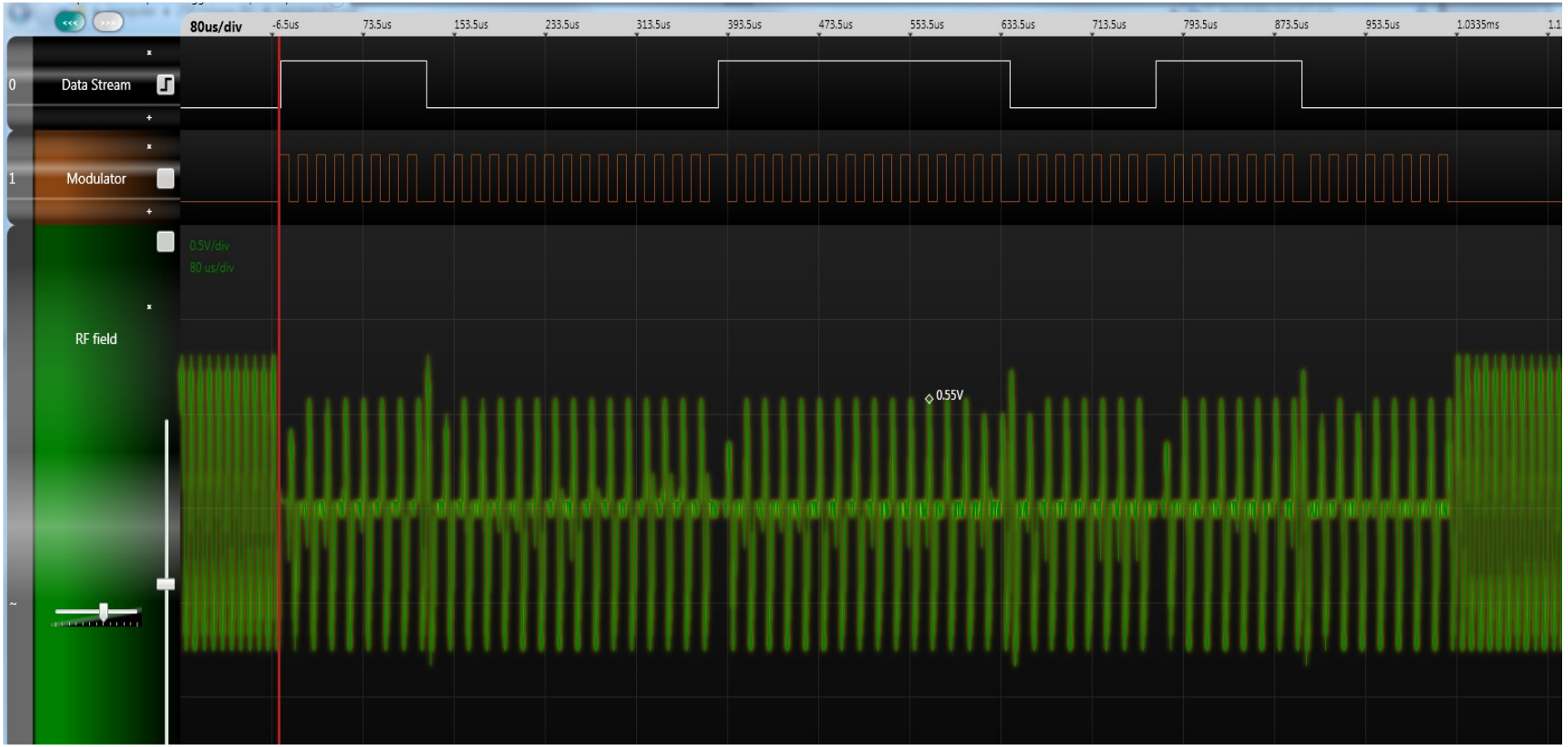
RFIDler LF (125/134 KHz)

Emulating FSK



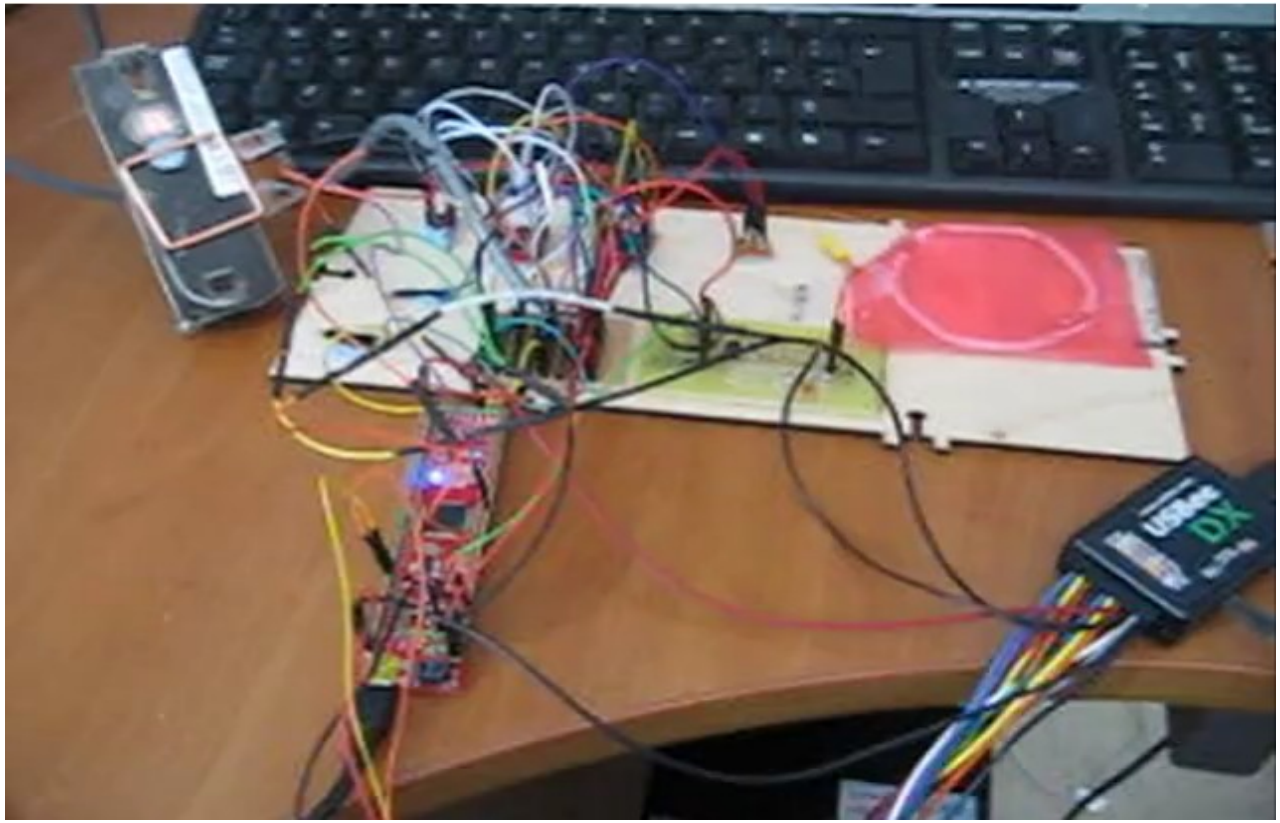
RFIDler LF (125/134 KHz)

Emulating PSK



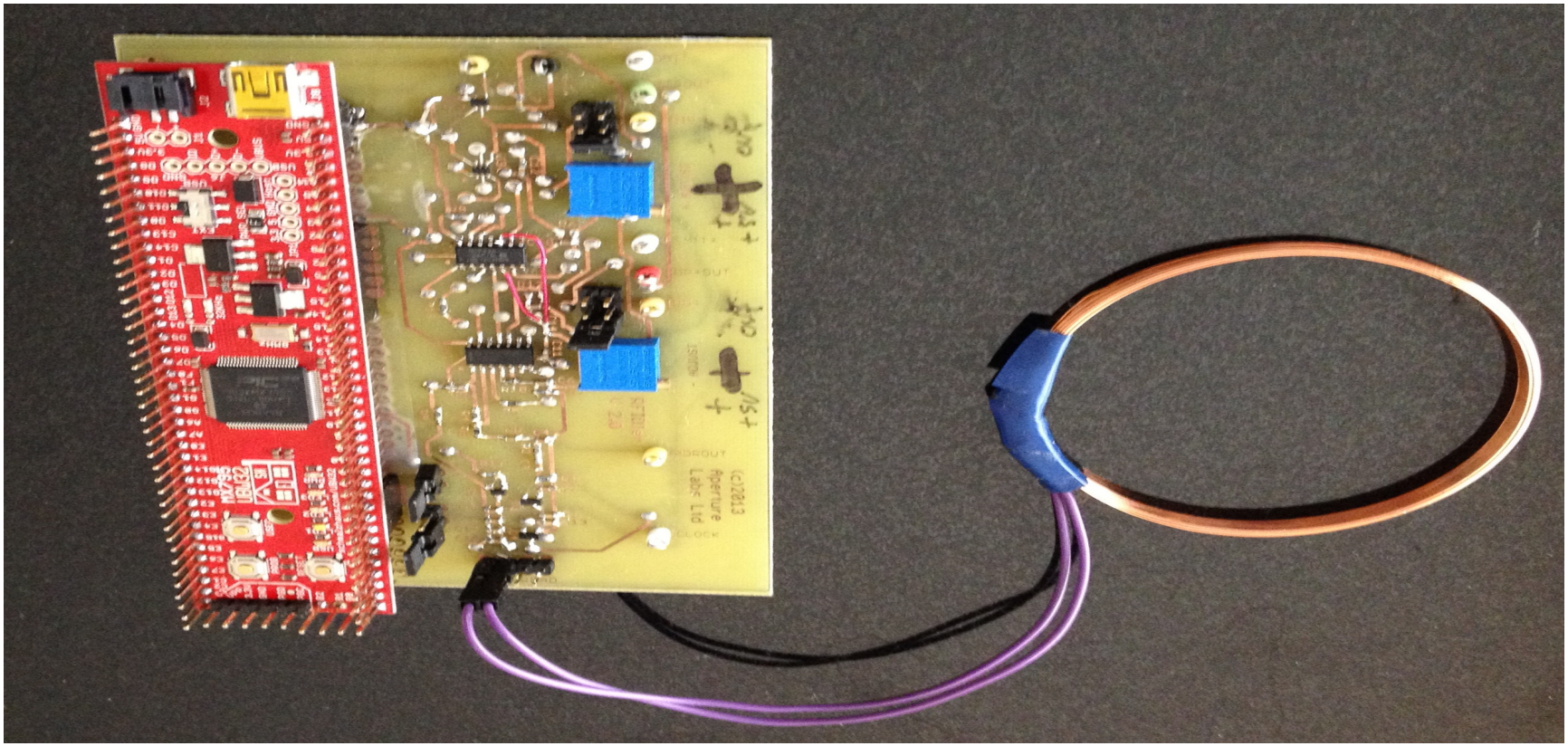
RFIDler LF (125/134 KHz)

Prototype 1



RFIDler LF (125/134 KHz)

Prototype 2



RFIDler LF (125/134 KHz)

DEMO

RFIDler LF (125/134 KHz)

Questions?

https://github.com/ApertureLabsLtd/RFIDler

http://www.kickstarter.com/projects/1708444109/rfidler-a-software-defined-rfid-reader-writer-emul