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# SIDE CHANNEL ANALYSIS FOR CHEAPSKATES

BLACKHAT PRESENTATION

COLIN O'FLYNN

**My Funding Provided By:**

OZ Optics
Global Leader In Fiber Optic Products Since 1985
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DALHOUSIE UNIVERSITY
*Inspiring Minds*

**Special Thanks:**

Dr. Zhizhang Chen

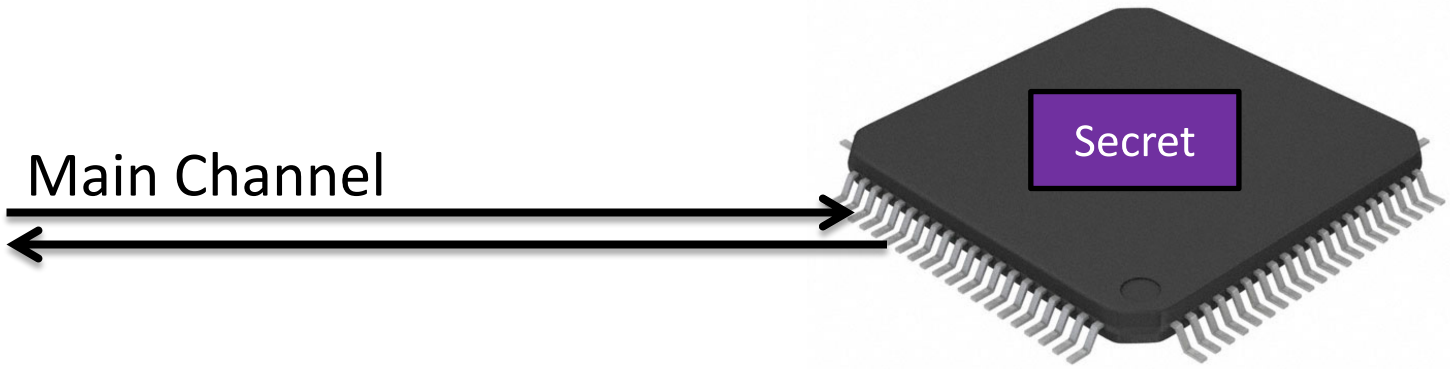
Cryptography Research Inc

# The Way Forward

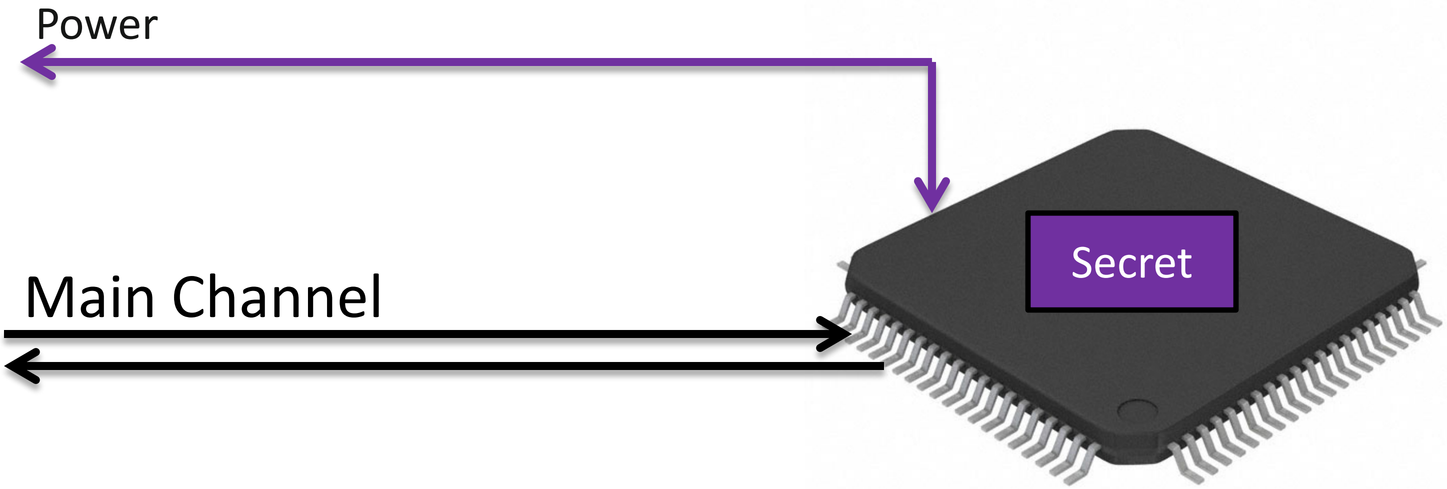
- What is Side Channel Analysis (SCA)
- Your First Attack!
- Waveform Acquisition
- Magnetic Field Probe
- Amplifiers/Front-End Stuff
- Measuring Current in Real Devices?
- Some Loose Ends

# The Side Channel

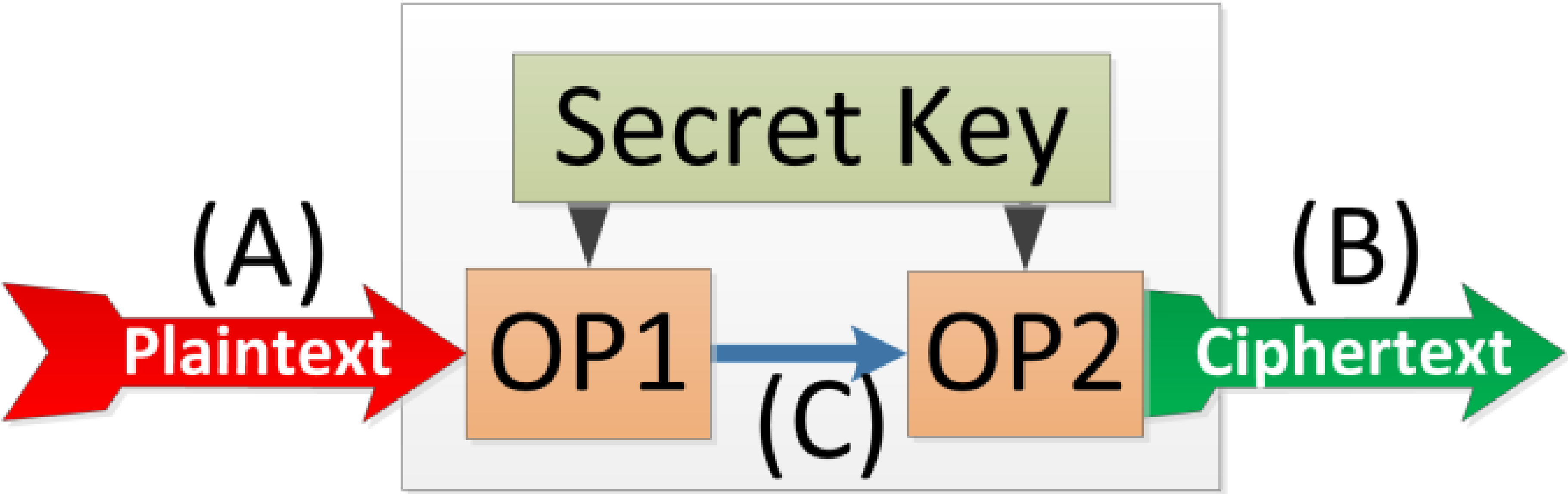
# Side Channel?



# Side Channel?



# Side Channel.



# 1. Capturing the Data

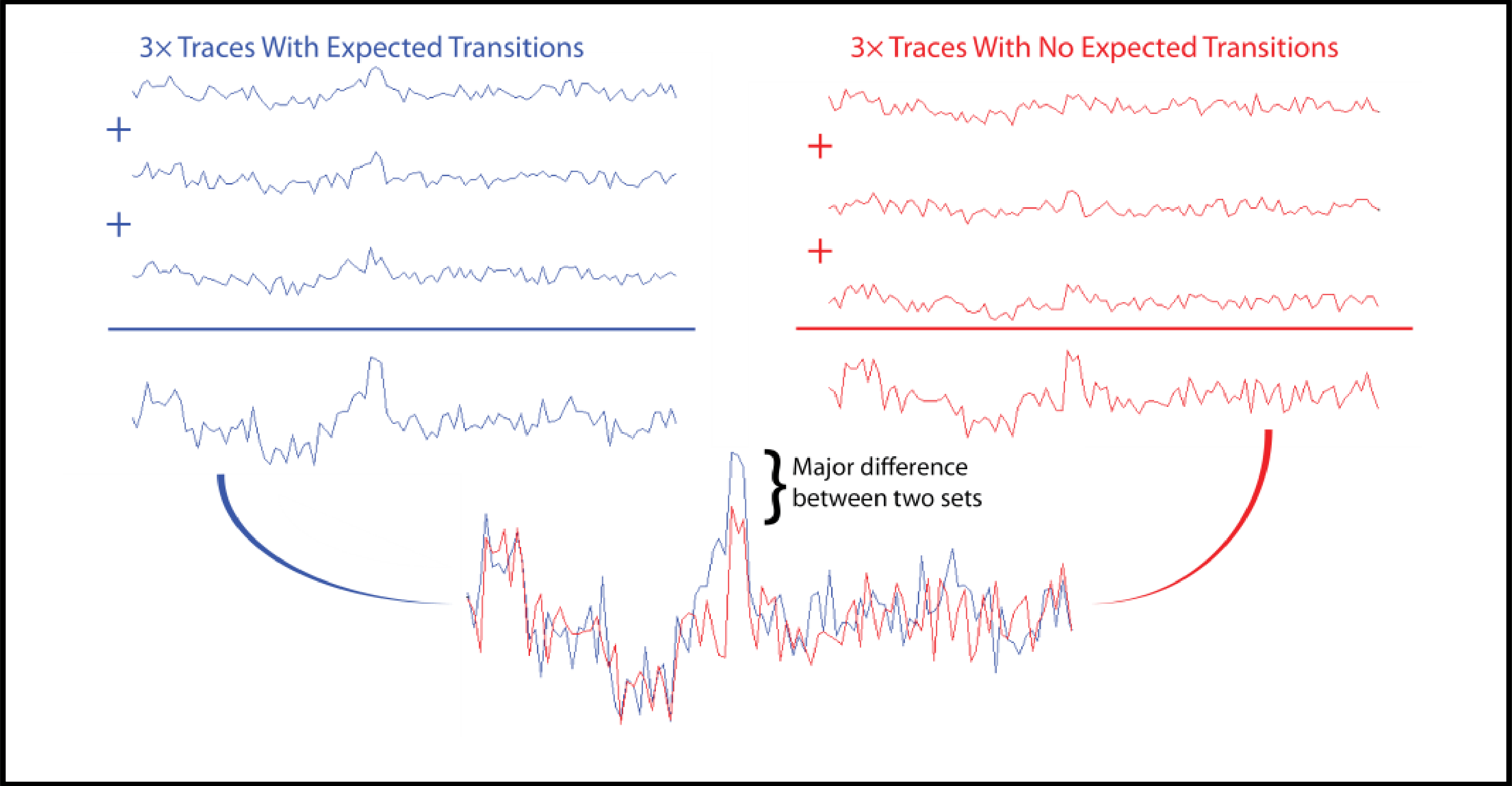
# 2. Modeling the Expected

# 3. Measure the Fit

# Differential Power Analysis

1. Input many plaintexts & measure power
2. Target a single bit in each byte.
3. Make a guess of what key byte is. For each power trace, is this bit now a 1 or 0?
4. Split traces into two groups based on that bit
5. Find mean of each group, subtract
6. If guess is correct, we should see a big peak
7. Repeat 3-6 for all 256 possible bytes

# Differential Power Analysis

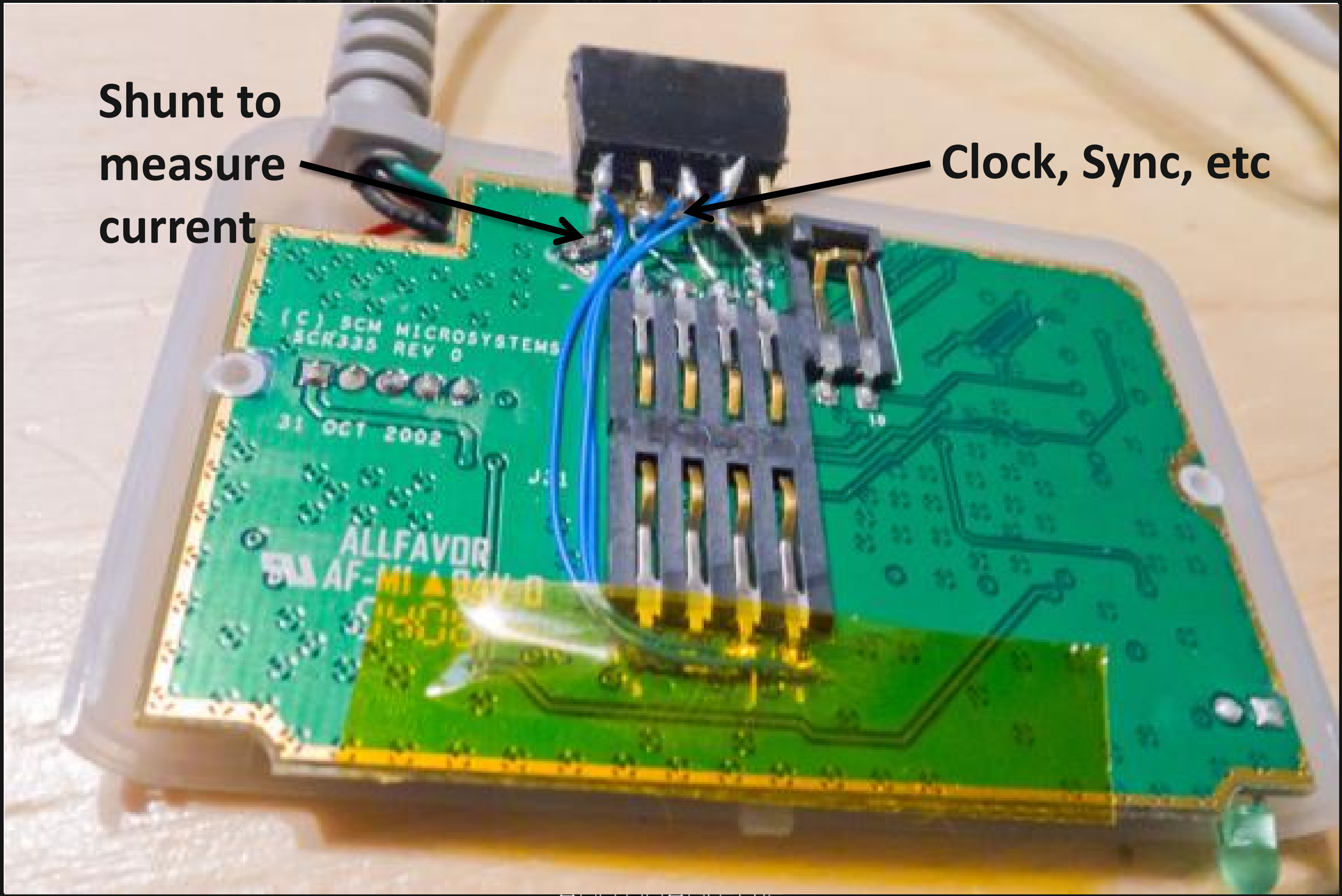

3x Traces With Expected Transitions
+
+
3x Traces With No Expected Transitions
+
+
Major difference
between two sets

```
#For all 16 bytes of key
for bnum in range(0, 16):
    diffs = [0]*256
    #For each 0..0xFF possible value of the key byte
    for key in range(0, 256):
        #Initialize arrays & variables to zero
        mean1 = numpy.zeros(len(traces[0,pointstart:pointend]))
        mean0 = numpy.zeros(len(traces[0,pointstart:pointend]))
        num1 = 0
        num0 = 0

        #For each trace, do the following
        for tnum in range(len(traces)):
            #Generate the output of the SBOX
            Hyp = SBOX[int(plaintexts[tnum, bnum], 16) ^ key]

            #Is target bit 1 or target bit 0?
            if (Hyp & (1 << targetbit)) != 0:
                #Bit is 1, so add this trace to the 1 partition
                mean1 = numpy.add(mean1, traces[tnum,pointstart:pointend])
                num1 = num1 + 1
            else:
                #Bit is 0, so add this trace to the 0 partition
                mean0 = numpy.add(mean0, traces[tnum,pointstart:pointend])
                num0 = num0 + 1

        #Average
        mean1 = mean1 / num1
        mean0 = mean0 / num0

        #Find the difference between the two means
        diff = numpy.subtract(mean1, mean0)
        #Find the biggest difference for this specific key & store
        diffs[key] = max(numpy.fabs(diff))
    #From all the key candidates, select the largest difference as most likely
    print "%2x "%diffs.index(max(diffs)),
```

# Your First Attack

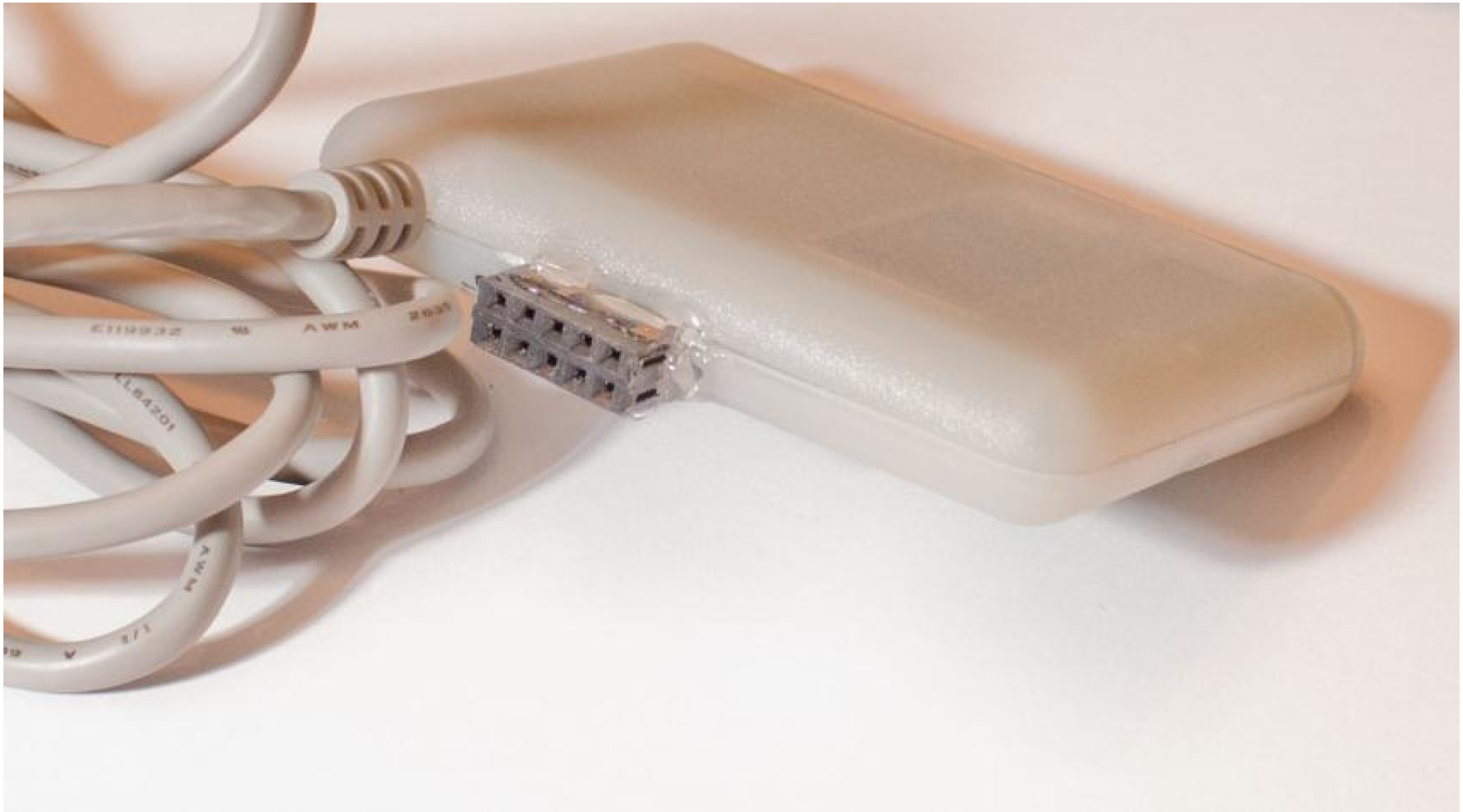
# Should I Attack a Smartcard?

# Attacks against Smart Card

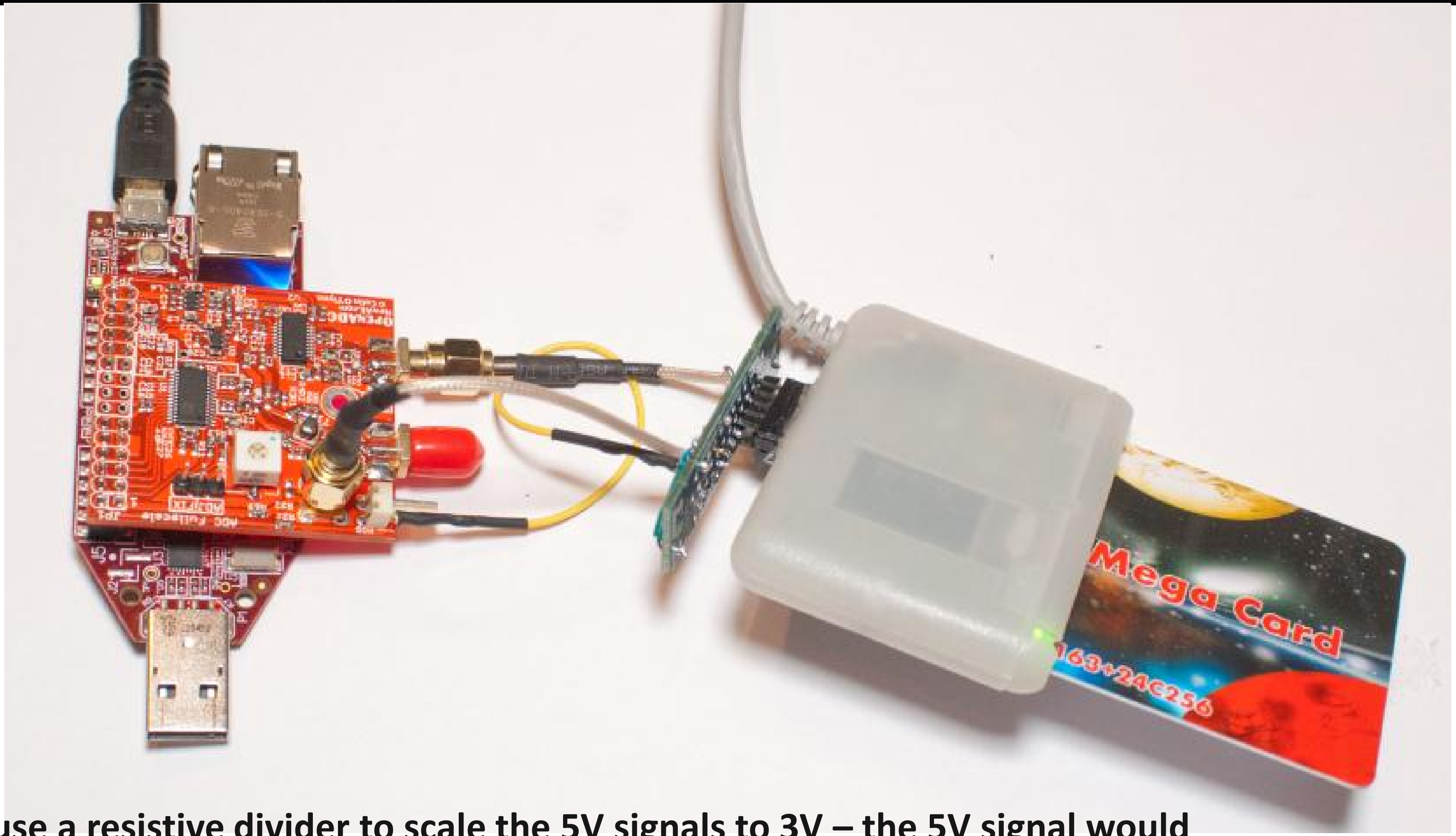


Shunt to measure current

Clock, Sync, etc

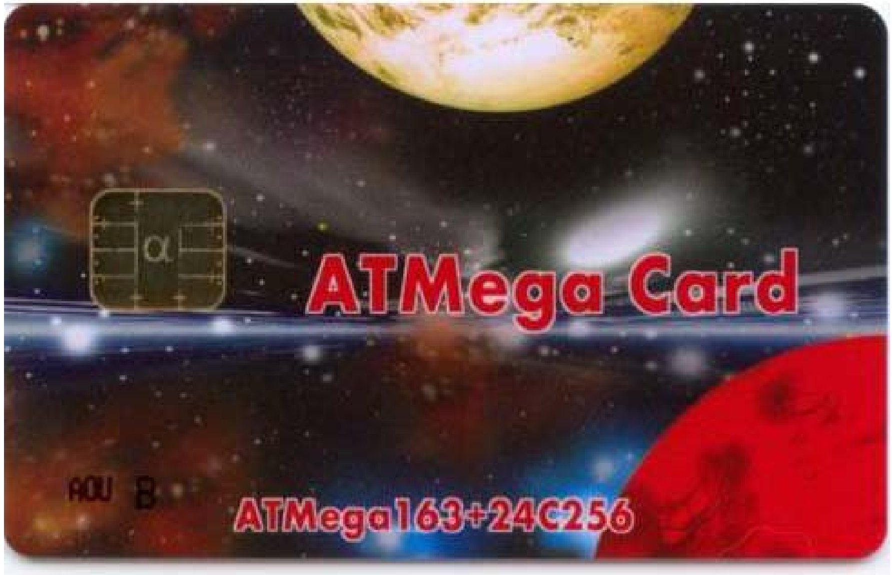

E119932
AWM
2835
LL84201
AWM
1/1

# SmartCard Capture



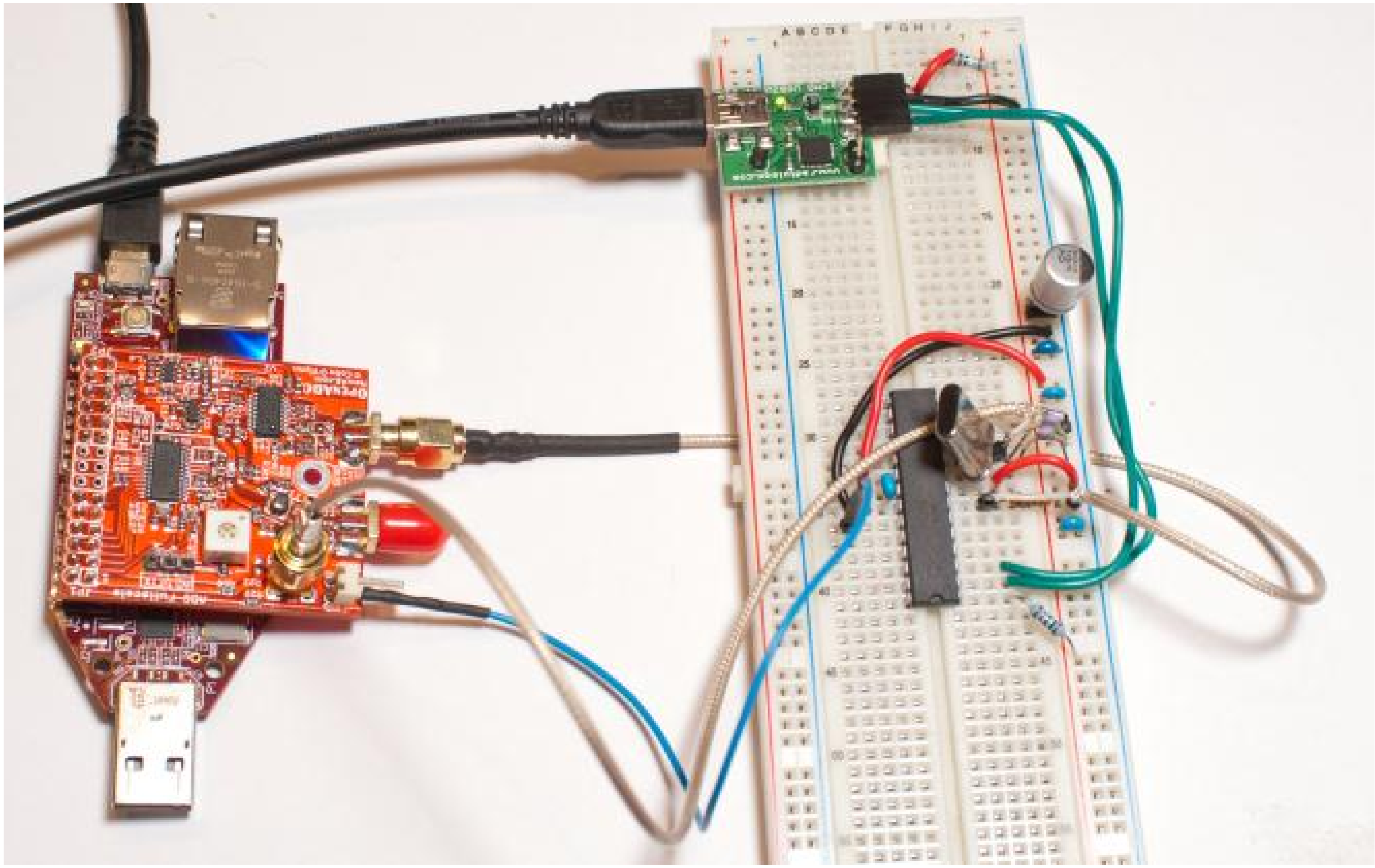
**Note we use a resistive divider to scale the 5V signals to 3V – the 5V signal would immediately destroy the FPGA board!**

# So What do you Do?

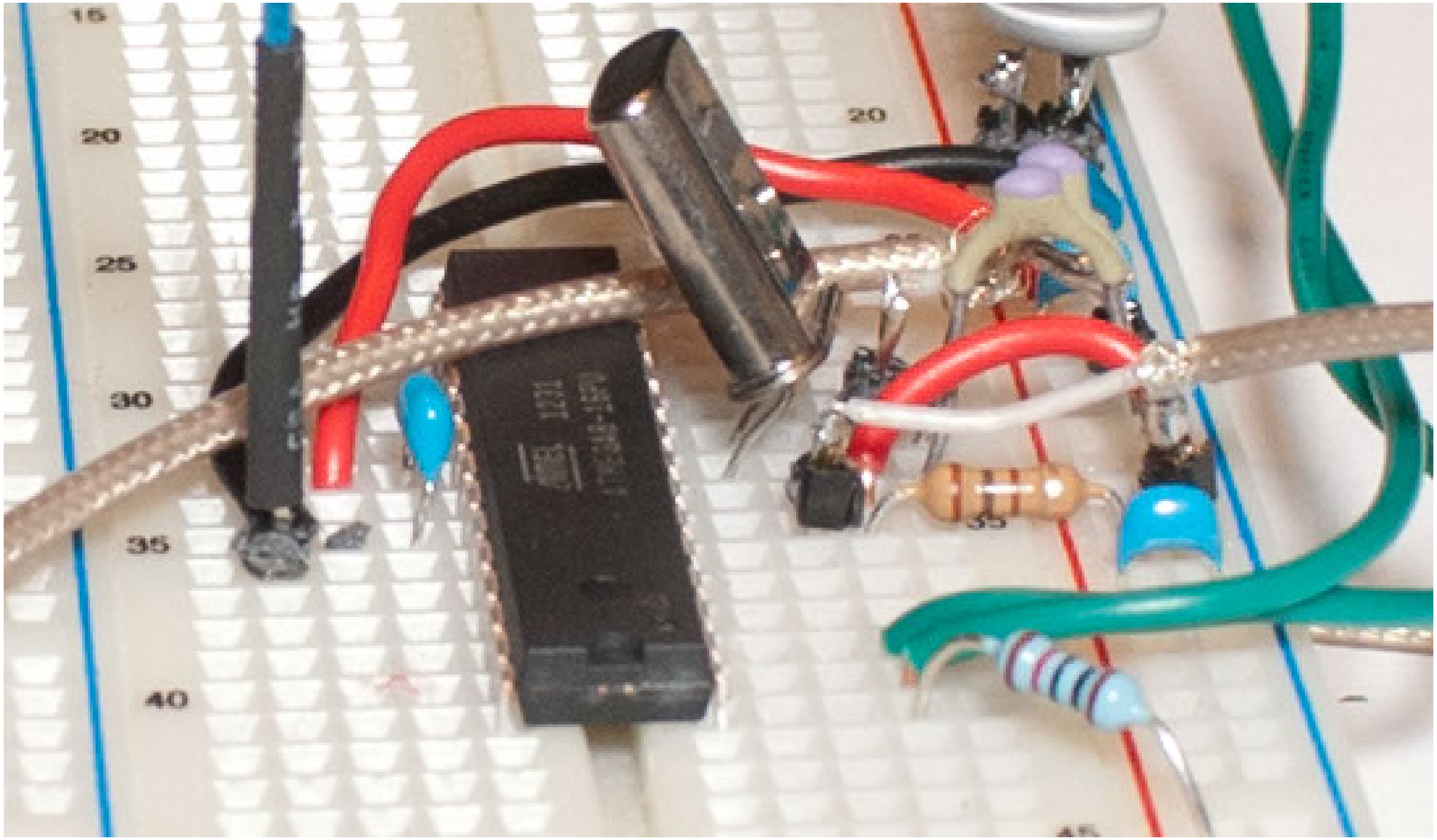


=

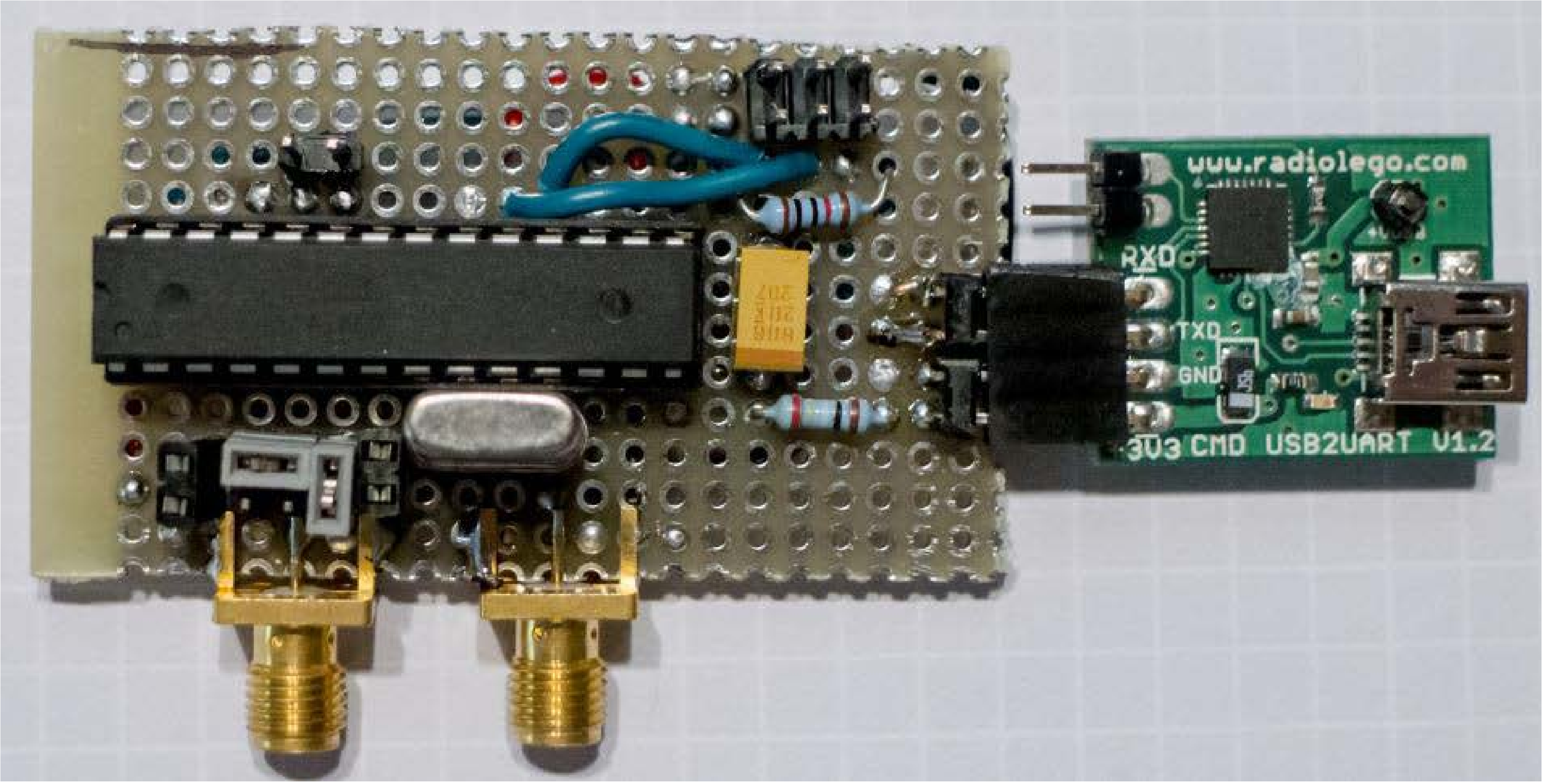
# What does this Look Like?



# What does this Look Like?



# A PCB Version



# Let’s Do This: Shopping List

- AtMega8-16PU
- 7.37 MHz Crystal
- 22pF Capacitors
- 100 ohm resistors
- 680uF (or bigger) capacitor
- 1uF Ceramic Capacitor
- 0.1uF Ceramic Capacitor
- Cables/Connectors
- Breadboard
- Capture HW
- Serial-USB Adapter
- Power?
- AVR Programmer

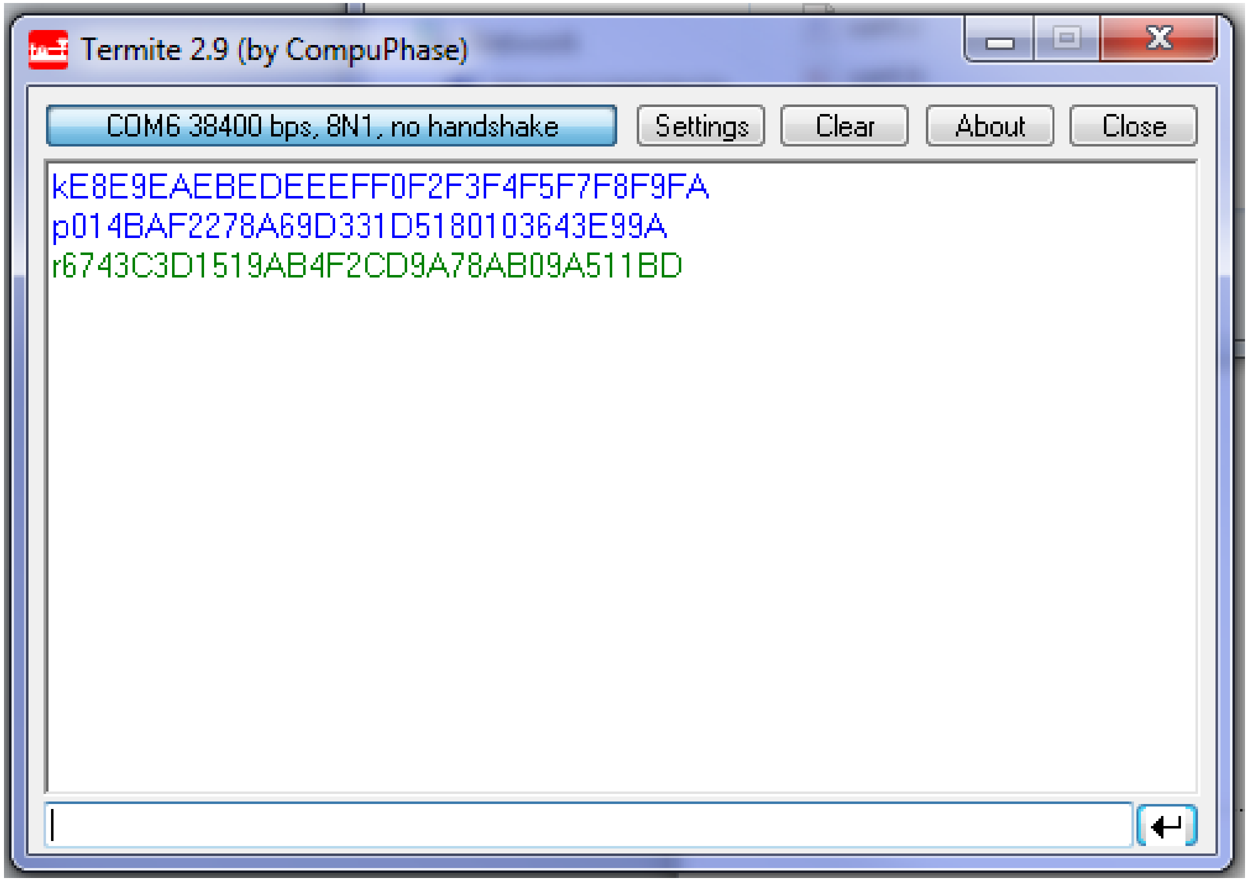
# Notes on Step 1

- Ideally Get ATMega8-16PU
- Crystal not 100% needed but makes life easier
- Example here uses Colorado Micro Devices USB2UART, many other manufactures of USB/Serial Cables
- Need Capture HW too – OpenADC used here, can use general purpose scope (Tiepie suggested as Differential versions, Picoscope popular too)

# Step 2: Build your Target HW

- See schematic in ref material
- Insert resistor in power line
- Need AVR programmer. Can use:
  - AVR-ISP MK-II
  - Arduino setup as programmer
  - Lots of other cheap AVR programmers (see EBay)

# Step 2: Continued (Testing)

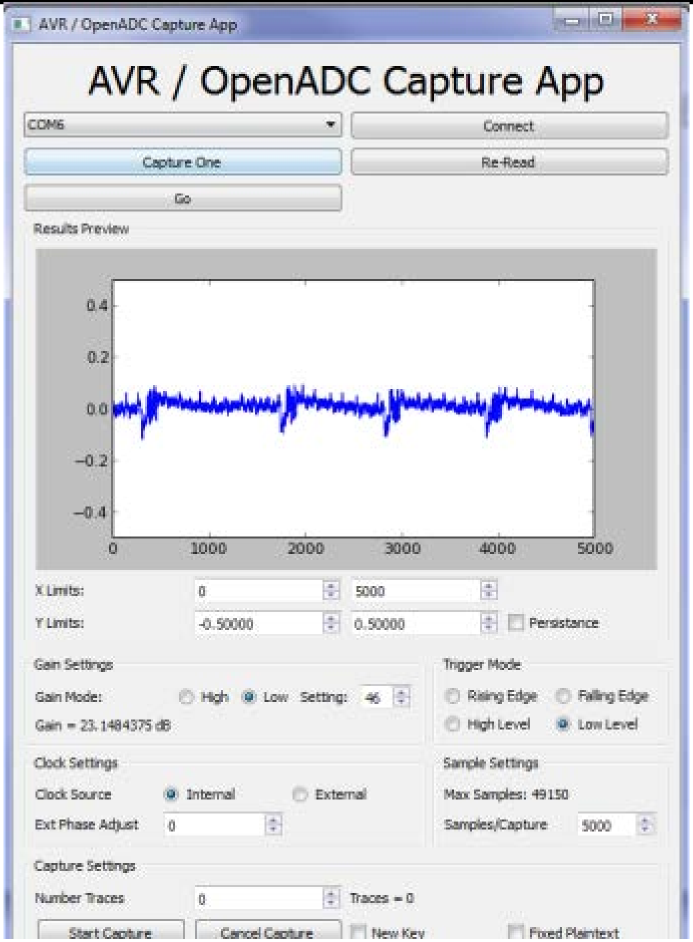


Termite 2.9 (by CompuPhase)
COM6 38400 bps, 8N1, no handshake
Settings
Clear
About
Close

```
kE8E9EAEBEDEEEFF0F2F3F4F5F7F8F9FA
p014BAF2278A69D331D5180103643E99A
r6743C3D1519AB4F2CD9A78AB09A511BD
```

Use serial port to confirm working

# Step 3: Characterize



COM6

X Limits: 0 5000

Y Limits: -0.50000 0.50000 □ Persistance

Gain Settings

Gain Mode: ○ High ● Low Setting: 46

Gain = 23.1484375 dB

Trigger Mode

○ Rising Edge ○ Falling Edge

○ High Level ● Low Level

Clock Settings

Clock Source ● Internal ○ External

Ext Phase Adjust 0

Sample Settings

Max Samples: 49150

Samples/Capture 5000

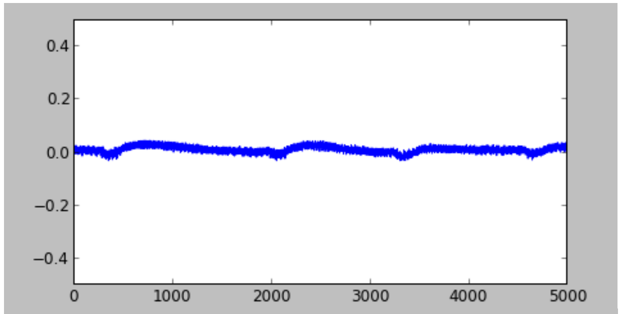
Capture Settings

Number Traces 0 Traces = 0

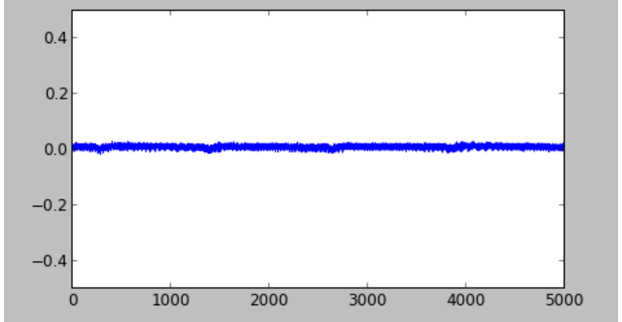
□ New Key □ Fixed Plaintext

- Probe connected to VCC rail, not across shunt

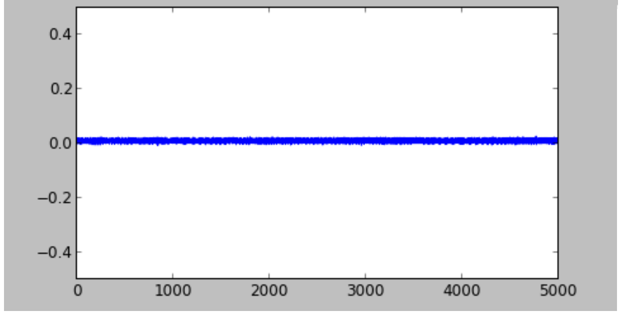
# Step 3: Characterize



2.2uF Ceramic Capacitor

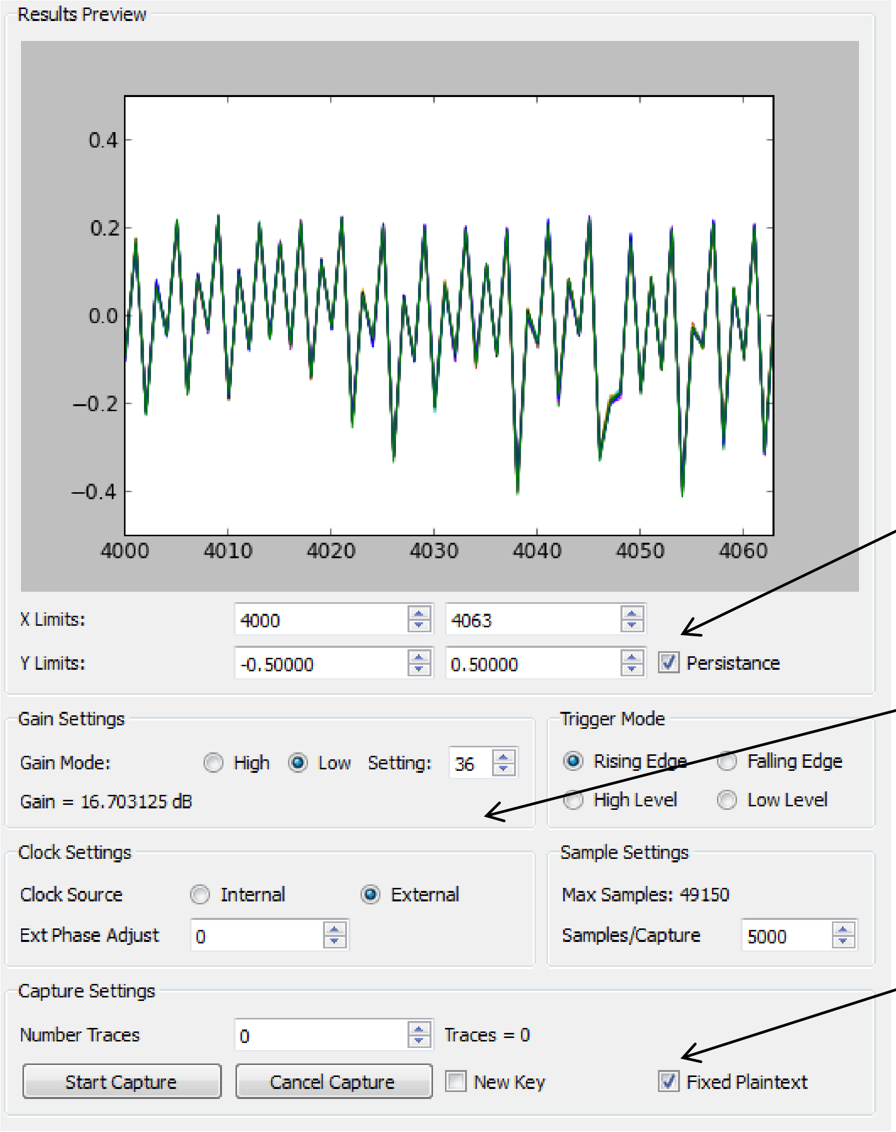


+680uF Electrolyctic



+100 ohm series resistor

# Step 3: Characterization Cont'd



Results Preview

X Limits: 4000 4063

Y Limits: -0.50000 0.50000 ☑ Persistance

Gain Settings

Gain Mode: ○ High ● Low Setting: 36

Gain = 16.703125 dB

Trigger Mode

● Rising Edge ○ Falling Edge

○ High Level ○ Low Level

Clock Settings

Clock Source ○ Internal ● External

Ext Phase Adjust 0

Sample Settings

Max Samples: 49150

Samples/Capture 5000

Capture Settings

Number Traces 0 Traces = 0

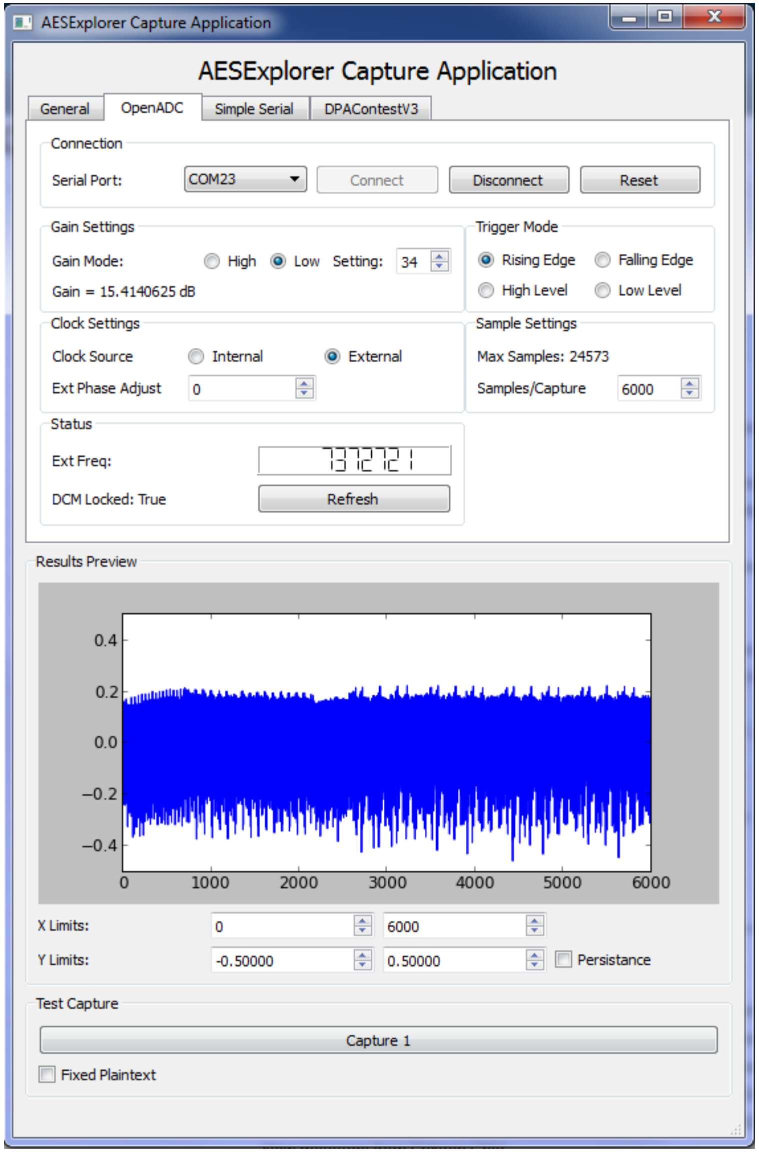
☐ New Key ☑ Fixed Plaintext

Persistence Mode in Scope

Adjust gain, trigger, etc to get reliable signal

Fixed Plaintext

# Step 4: Acquire



AESExplorer Capture Application

Connection

Serial Port: COM23

Gain Settings

Gain Mode: ○ High ● Low Setting: 34

Gain = 15.4140625 dB

Trigger Mode

● Rising Edge ○ Falling Edge

○ High Level ○ Low Level

Clock Settings

Clock Source ○ Internal ● External

Ext Phase Adjust 0

Sample Settings

Max Samples: 24573

Samples/Capture 6000

Status

Ext Freq: 7372721

DCM Locked: True

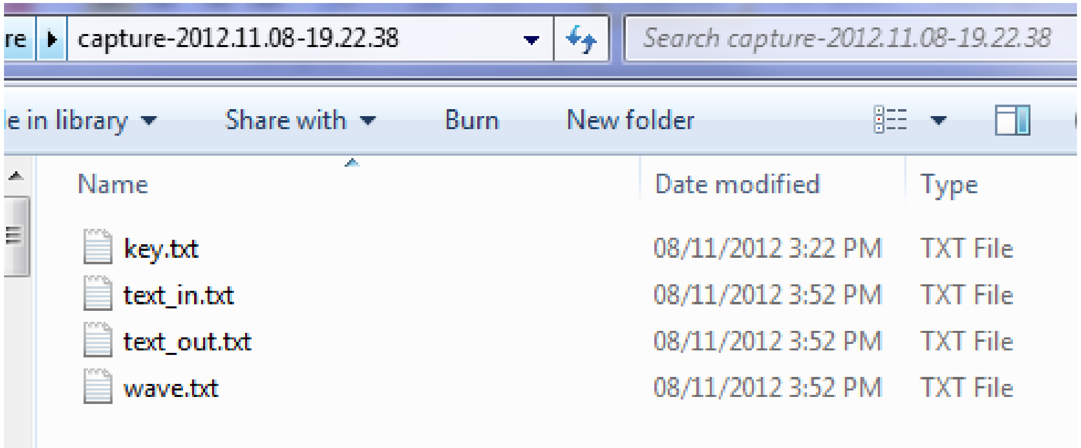
X Limits: 0 6000

Y Limits: -0.50000 0.50000 □ Persistance

□ Fixed Plaintext

- Use AESExplorer ‘Capture’ application, written in Python with PySide
  - Included on Blackhat CD
- Capture ~2500 traces, 6000 samples/capture

# Step 4: Acquire

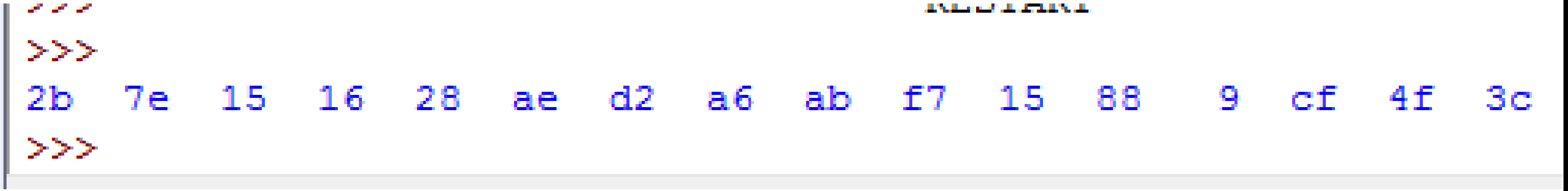

re
capture-2012.11.08-19.22.38
Search capture-2012.11.08-19.22.38
e in library
Share with
Burn
New folder

| Name | Date modified | Type |
|---|---|---|
| key.txt | 08/11/2012 3:22 PM | TXT File |
| text_in.txt | 08/11/2012 3:52 PM | TXT File |
| text_out.txt | 08/11/2012 3:52 PM | TXT File |
| wave.txt | 08/11/2012 3:52 PM | TXT File |

text_in.txt & wave.txt are the needed files

# Step 5: Break It

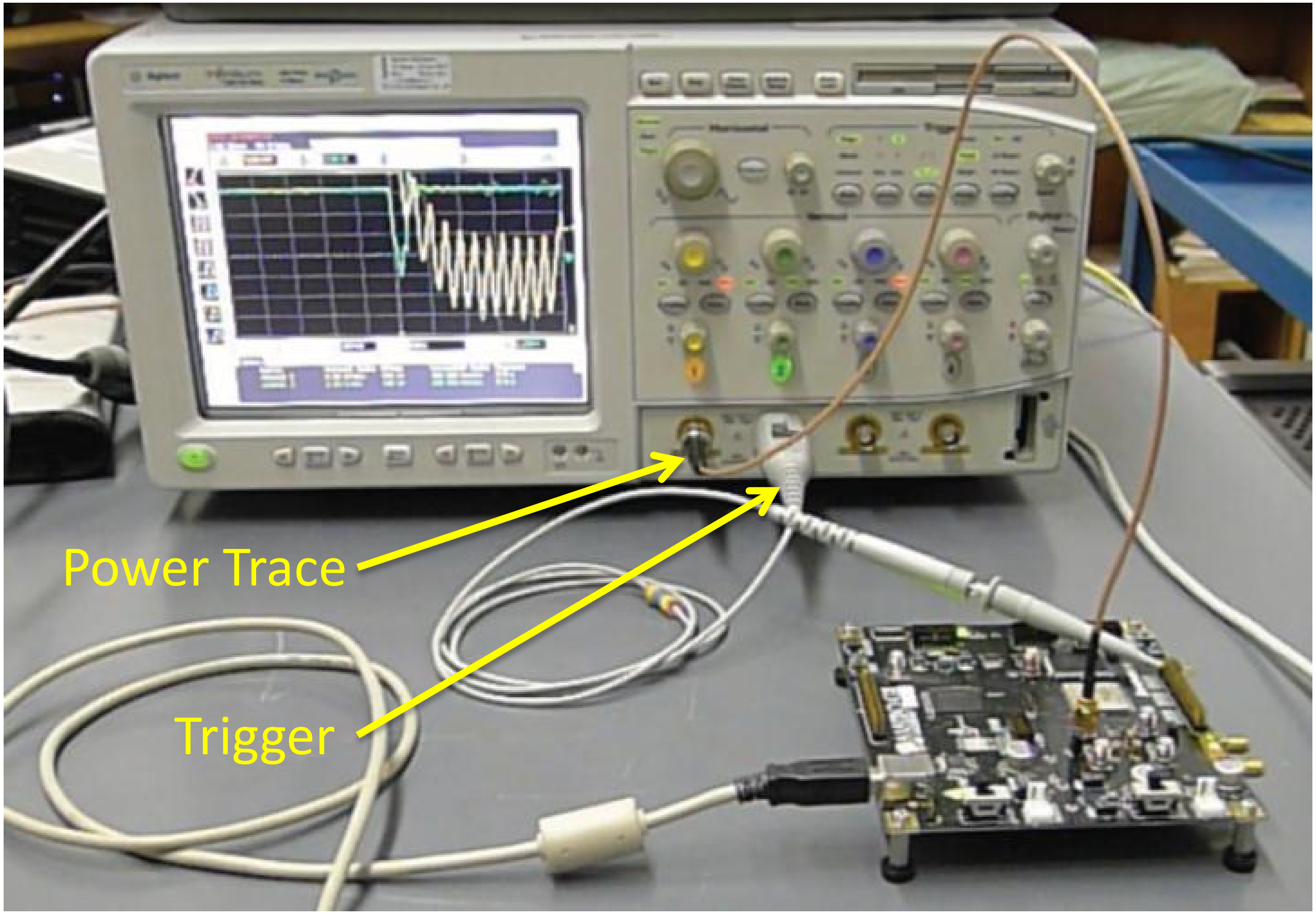
Copy wave.txt & text_in.txt to same directory as dpa_attack.py, run:



```
>>>                                         RESTART
>>>
2b   7e   15   16   28   ae   d2   a6   ab   f7   15   88    9   cf   4f   3c
>>>
```

# Waveform Acquisition & Low-Cost Alternatives

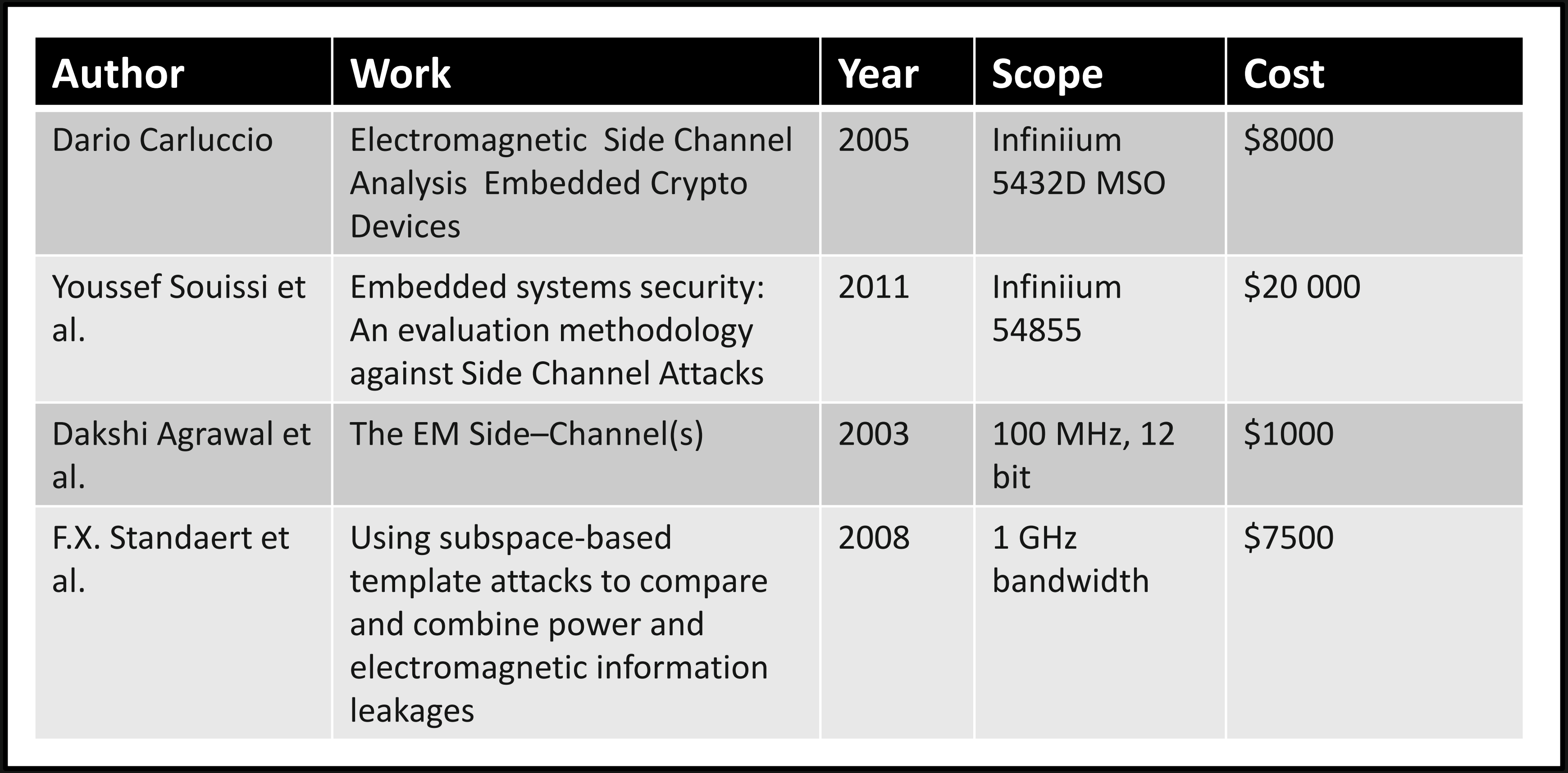
# What's a 'Normal' Setup look like?



Power Trace

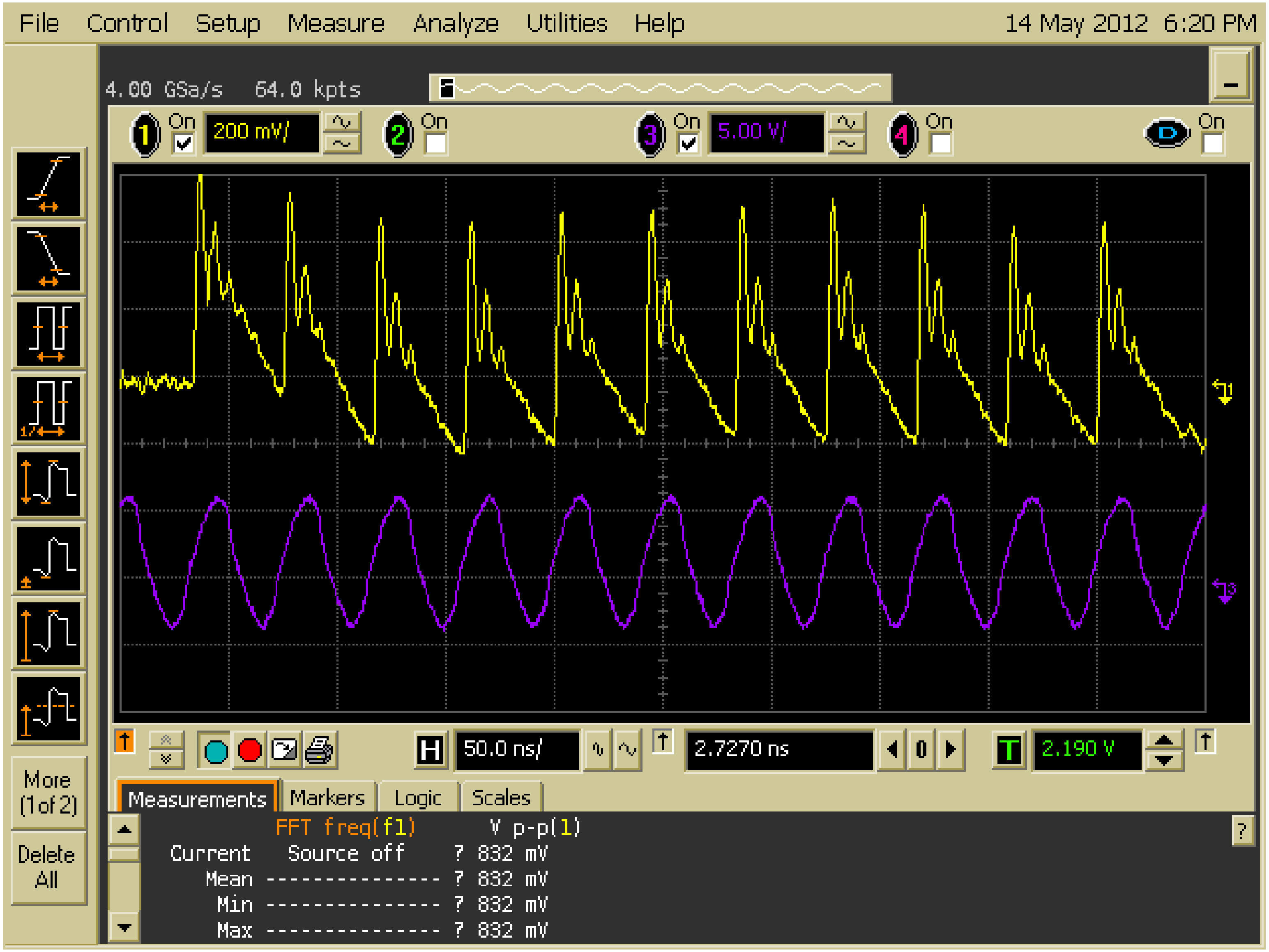
Trigger

# Is this Really Typical?



| Author | Work | Year | Scope | Cost |
|---|---|---|---|---|
| Dario Carluccio | Electromagnetic Side Channel Analysis Embedded Crypto Devices | 2005 | Infiniium 5432D MSO | $8000 |
| Youssef Souissi et al. | Embedded systems security: An evaluation methodology against Side Channel Attacks | 2011 | Infiniium 54855 | $20 000 |
| Dakshi Agrawal et al. | The EM Side–Channel(s) | 2003 | 100 MHz, 12 bit | $1000 |
| F.X. Standaert et al. | Using subspace-based template attacks to compare and combine power and electromagnetic information leakages | 2008 | 1 GHz bandwidth | $7500 |

# Can We Do Better?



14 May 2012 6:20 PM

4.00 GSa/s 64.0 kpts

200 mV/

5.00 V/

50.0 ns/

2.7270 ns

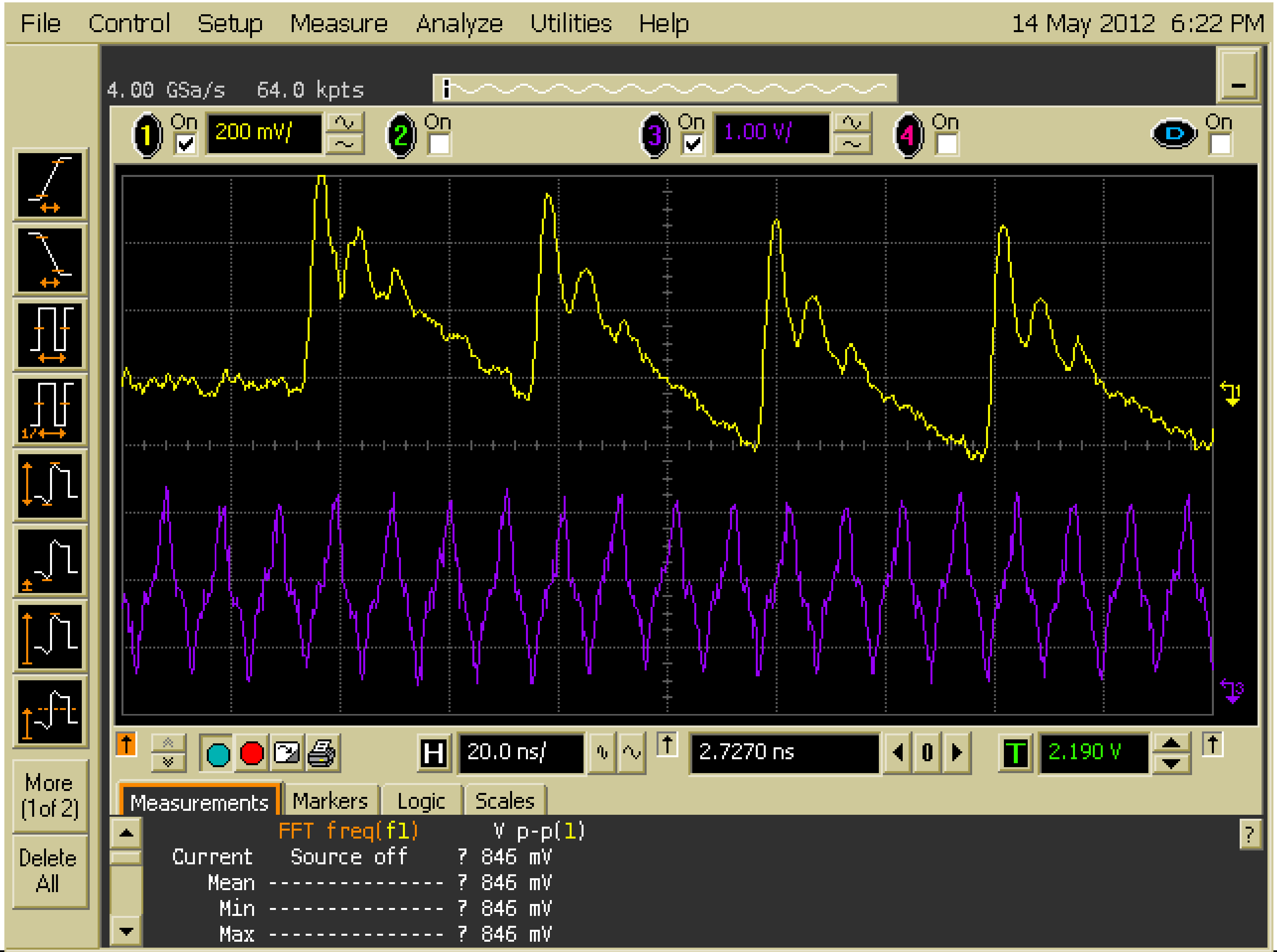
2.190 V

```
        FFT freq(f1)       V p-p(1)
Current  Source off     ? 832 mV
   Mean ---------------  ? 832 mV
    Min ---------------  ? 832 mV
    Max ---------------  ? 832 mV
```

Power

Clock

# Using 4x Source Clock

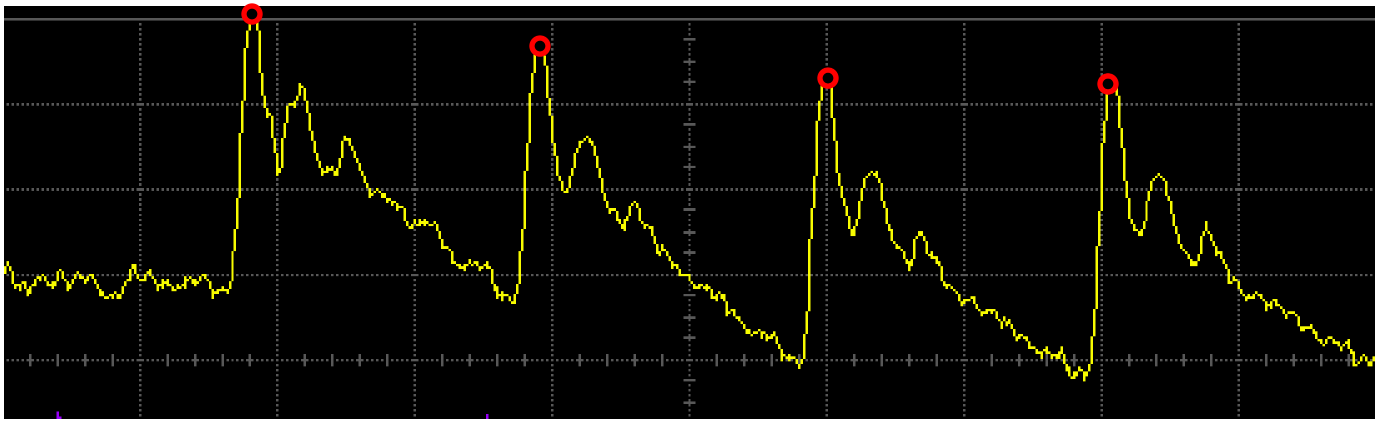


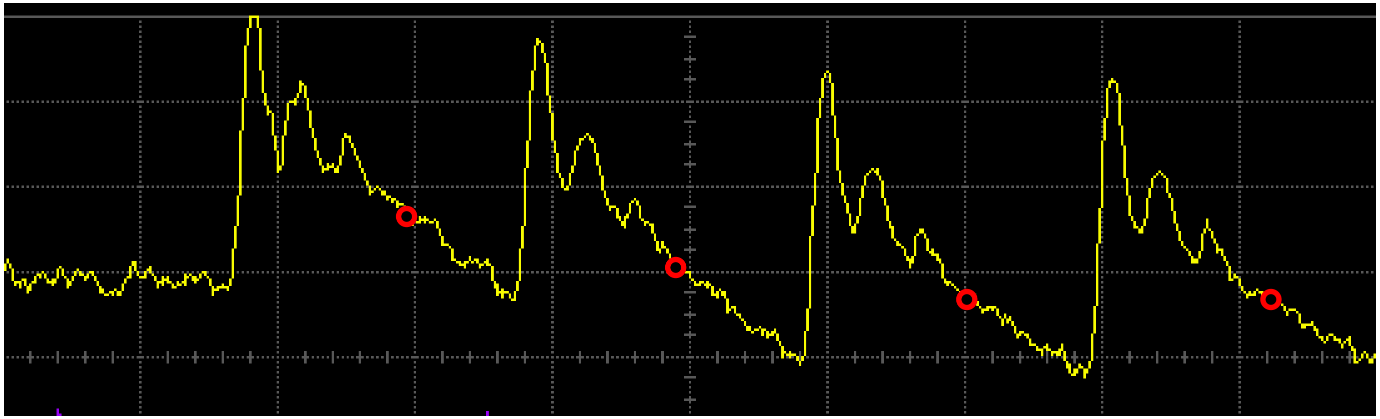
```
          FFT freq(f1)       V p-p(1)
Current   Source off       ? 846 mV
   Mean ---------------- ? 846 mV
    Min ---------------- ? 846 mV
    Max ---------------- ? 846 mV
```

Power

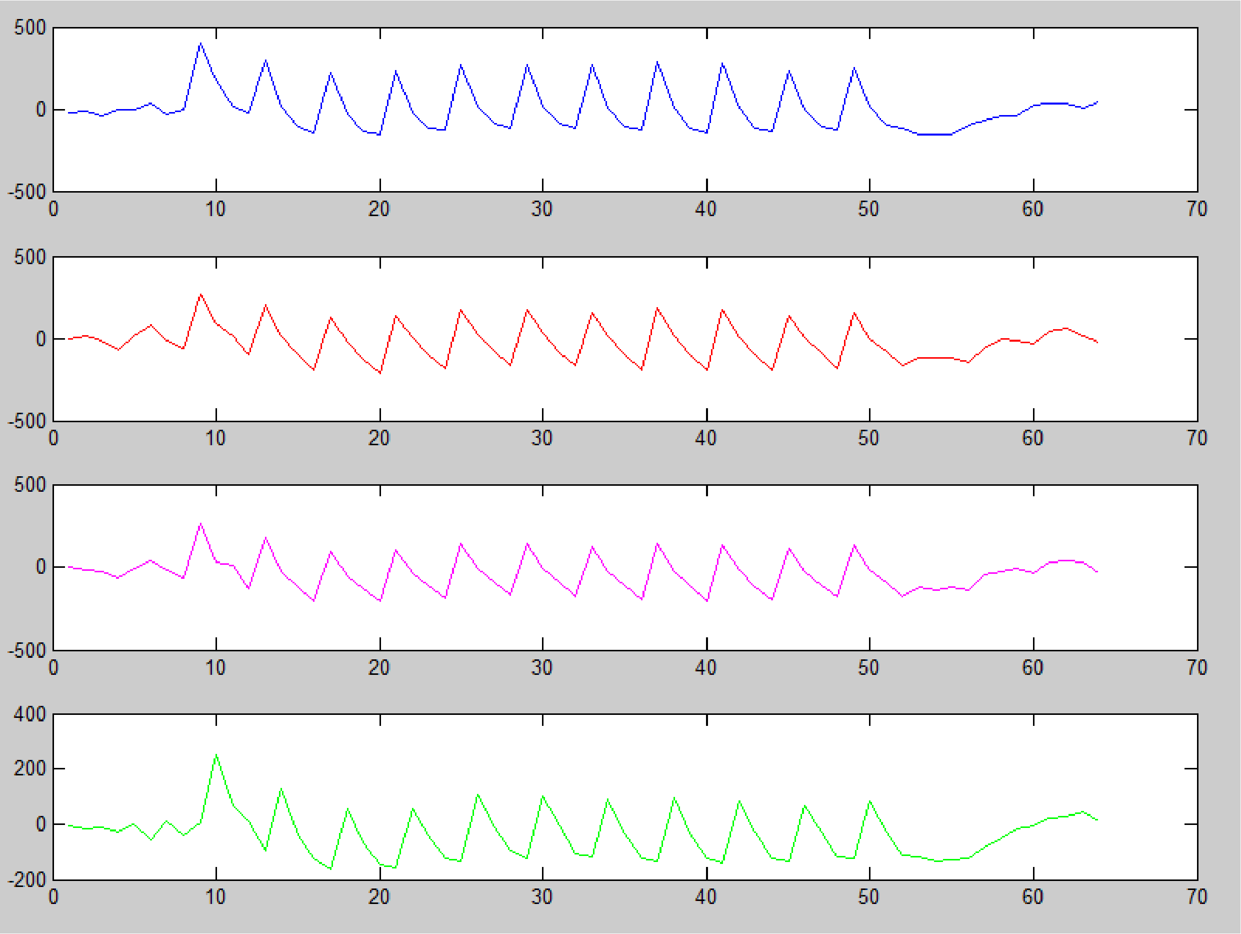
Clock

# What about Phase Shift?

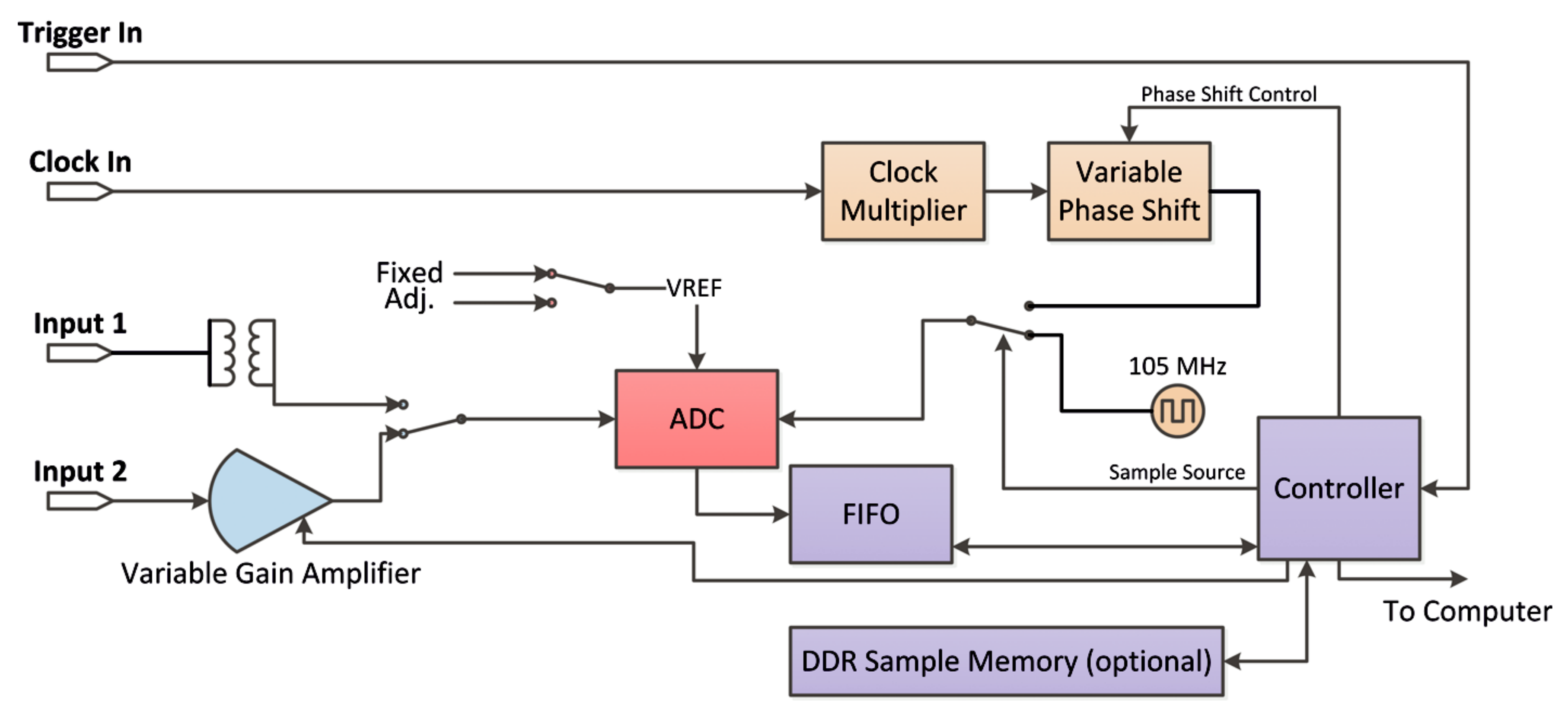




# 4x Sample Clock with Different Phases

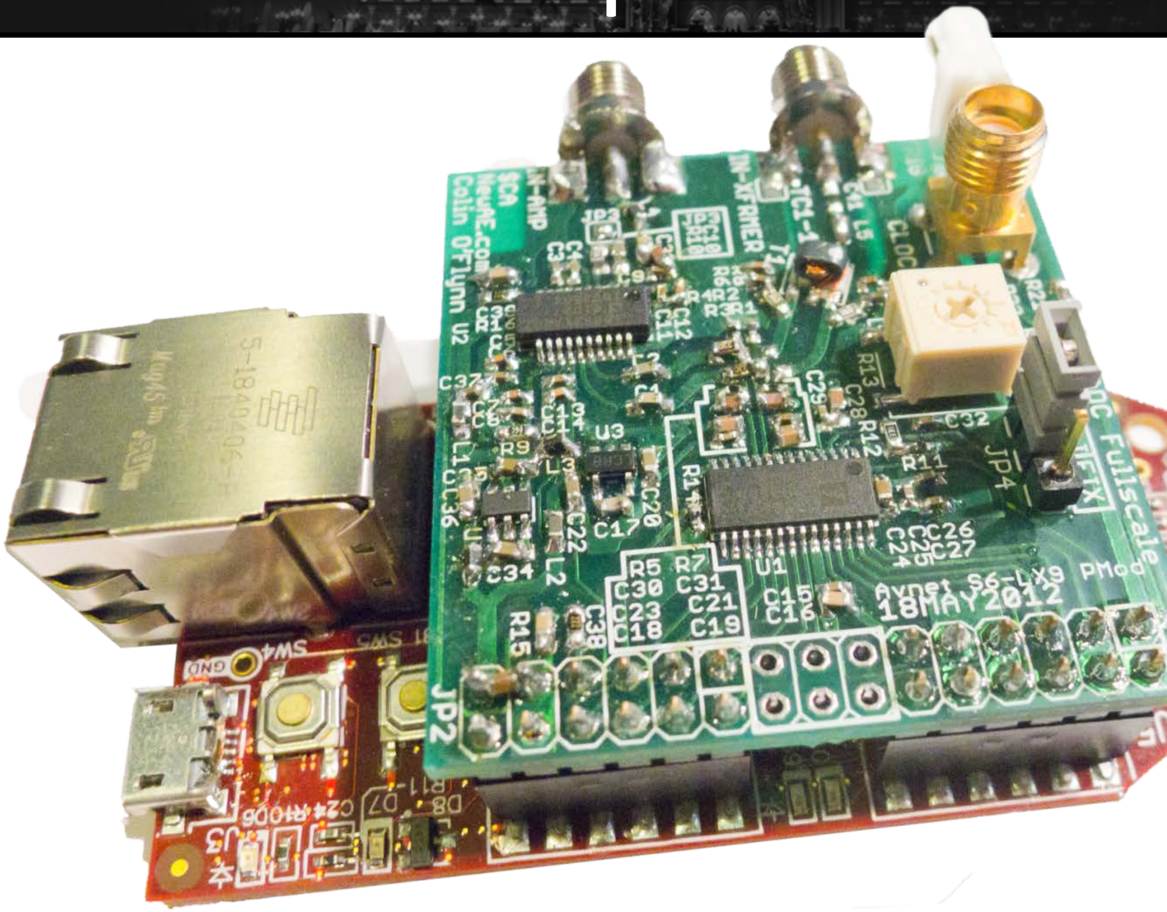


# Desired Capture HW



See "*A Case Study of Side-Channel Analysis using Decoupling Capacitor Power Measurement with the OpenADC*" by Colin O'Flynn & Zhizhen Chen

# OpenADC

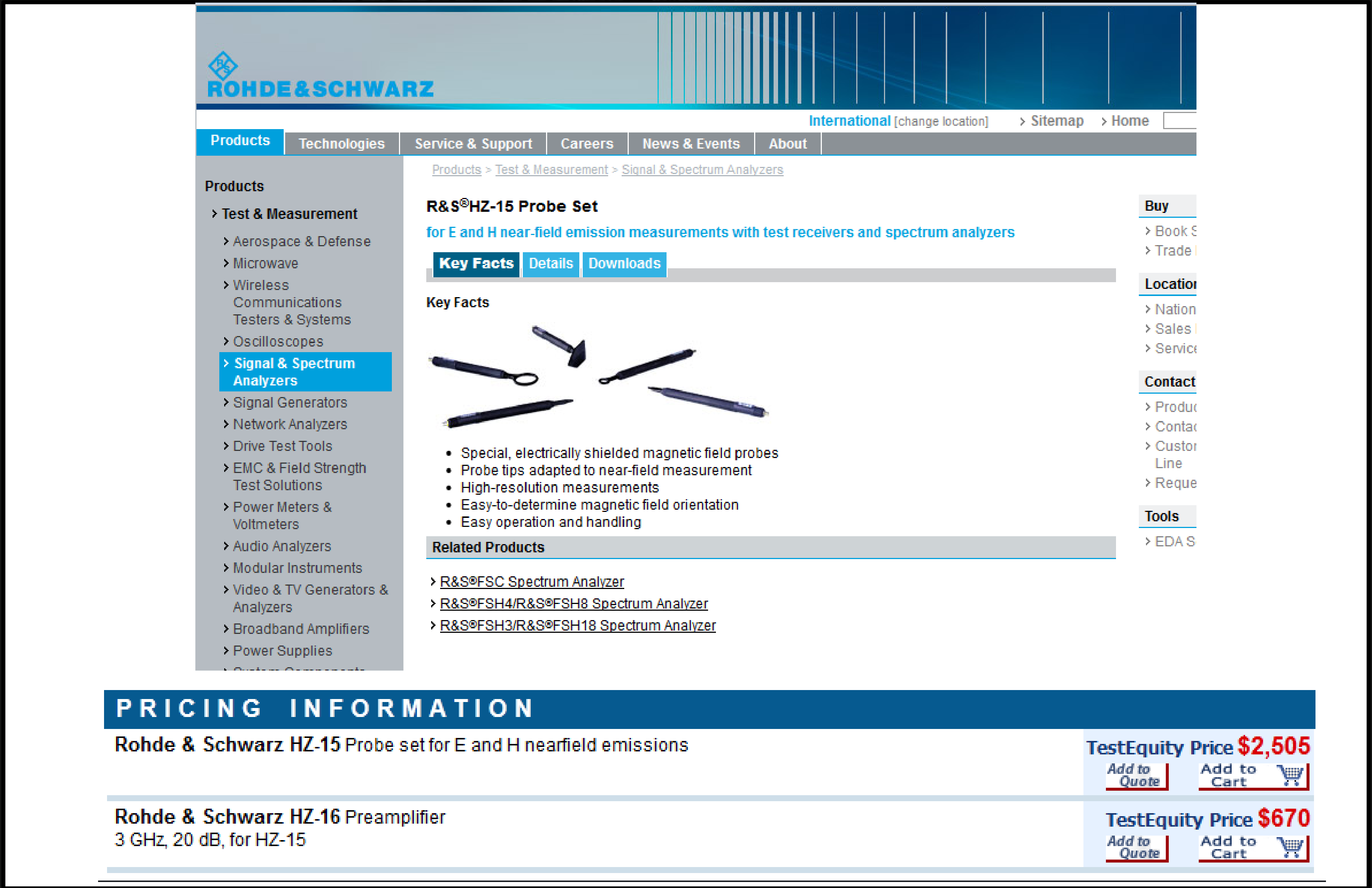

SCA
NewAE.com
Colin O'Flynn
Avnet S6-LX9 PMod
18MAY2012
ADC Fullscale
JP2
JP4
U1
U3

# OpenADC

- Can use up to 105 MSPS in oscilloscope-like mode
- Supports synchronizing to sample clock of device, so can attack high-speed targets well even!
- Built-in amplifier
- Open Source design!

# Magnetic Field Probes

# Rohde & Schwarz



Products > Test & Measurement > Signal & Spectrum Analyzers

R&S®HZ-15 Probe Set

for E and H near-field emission measurements with test receivers and spectrum analyzers

Key Facts

- Special, electrically shielded magnetic field probes
- Probe tips adapted to near-field measurement
- High-resolution measurements
- Easy-to-determine magnetic field orientation
- Easy operation and handling

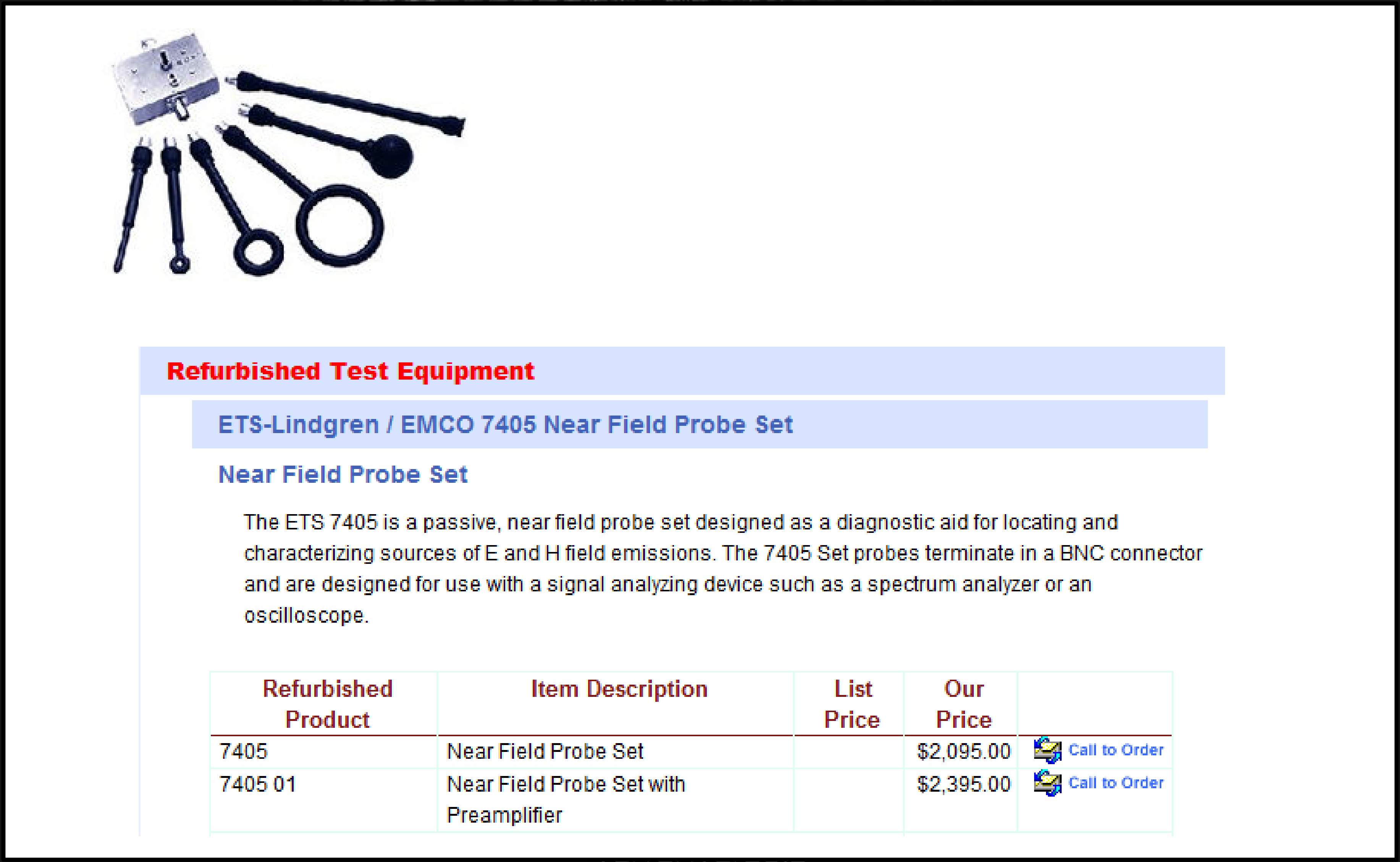
Related Products

- R&S®FSC Spectrum Analyzer
- R&S®FSH4/R&S®FSH8 Spectrum Analyzer
- R&S®FSH3/R&S®FSH18 Spectrum Analyzer

PRICING INFORMATION

| | |
|---|---|
| **Rohde & Schwarz HZ-15** Probe set for E and H nearfield emissions | TestEquity Price $2,505 |
| **Rohde & Schwarz HZ-16** Preamplifier<br>3 GHz, 20 dB, for HZ-15 | TestEquity Price $670 |

# ETS-Lindgren



**Refurbished Test Equipment**

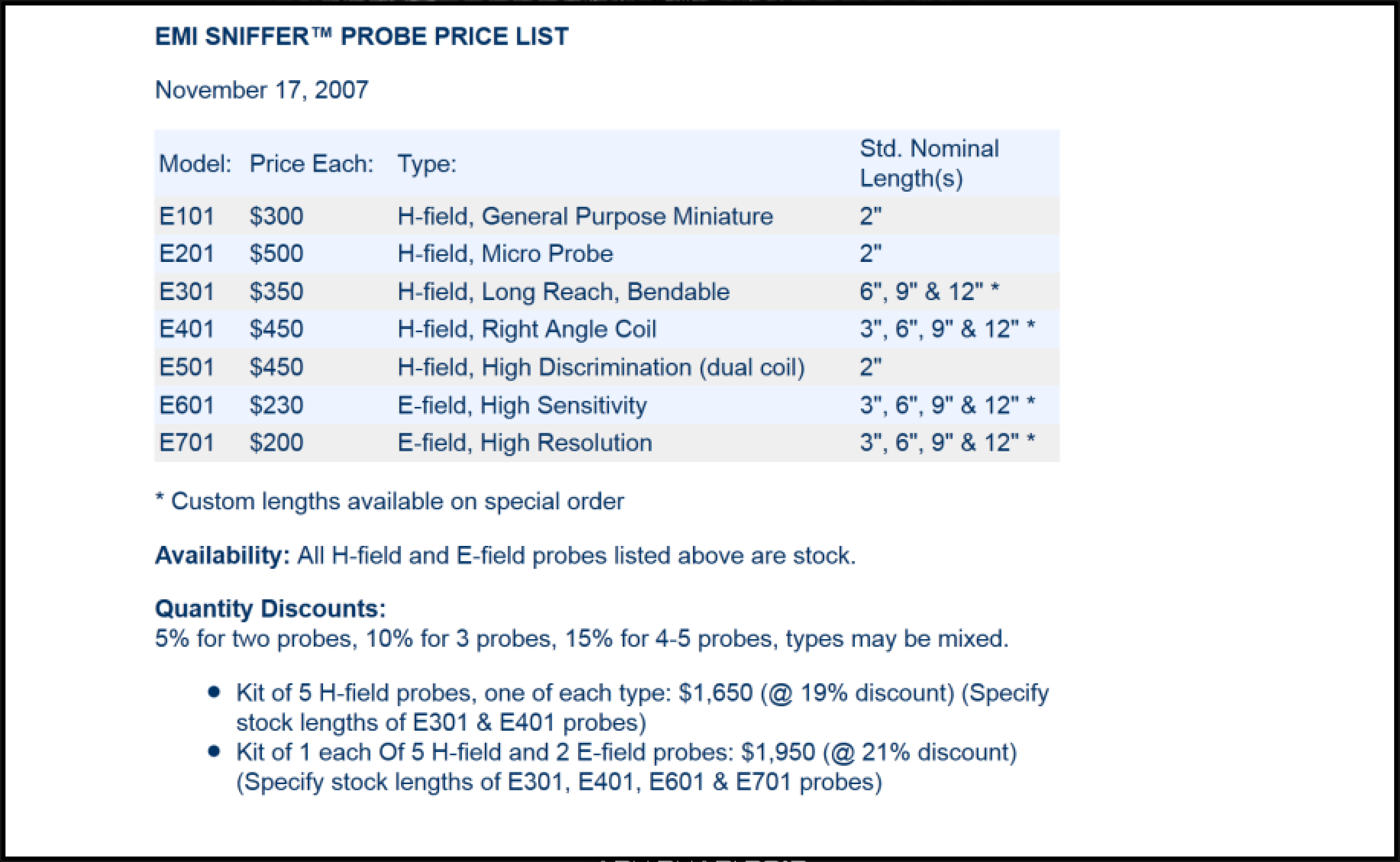
## ETS-Lindgren / EMCO 7405 Near Field Probe Set

### Near Field Probe Set

The ETS 7405 is a passive, near field probe set designed as a diagnostic aid for locating and characterizing sources of E and H field emissions. The 7405 Set probes terminate in a BNC connector and are designed for use with a signal analyzing device such as a spectrum analyzer or an oscilloscope.

| Refurbished Product | Item Description | List Price | Our Price | |
|---|---|---|---|---|
| 7405 | Near Field Probe Set | | $2,095.00 | Call to Order |
| 7405 01 | Near Field Probe Set with Preamplifier | | $2,395.00 | Call to Order |

# Bruce Carsten Associates, Inc.



## EMI SNIFFER™ PROBE PRICE LIST

November 17, 2007

| Model: | Price Each: | Type: | Std. Nominal Length(s) |
|---|---|---|---|
| E101 | $300 | H-field, General Purpose Miniature | 2" |
| E201 | $500 | H-field, Micro Probe | 2" |
| E301 | $350 | H-field, Long Reach, Bendable | 6", 9" & 12" * |
| E401 | $450 | H-field, Right Angle Coil | 3", 6", 9" & 12" * |
| E501 | $450 | H-field, High Discrimination (dual coil) | 2" |
| E601 | $230 | E-field, High Sensitivity | 3", 6", 9" & 12" * |
| E701 | $200 | E-field, High Resolution | 3", 6", 9" & 12" * |

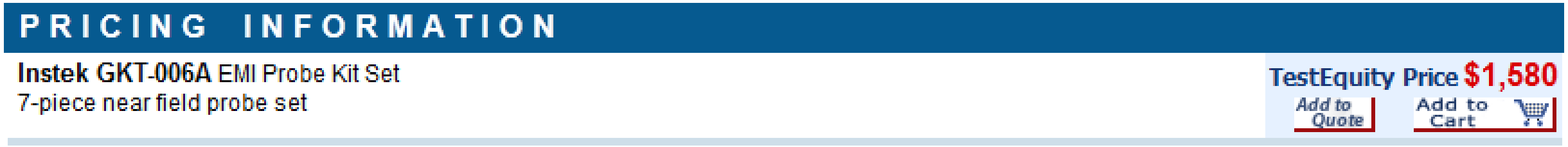
* Custom lengths available on special order

**Availability:** All H-field and E-field probes listed above are stock.

**Quantity Discounts:**
5% for two probes, 10% for 3 probes, 15% for 4-5 probes, types may be mixed.

- Kit of 5 H-field probes, one of each type: $1,650 (@ 19% discount) (Specify stock lengths of E301 & E401 probes)
- Kit of 1 each Of 5 H-field and 2 E-field probes: $1,950 (@ 21% discount) (Specify stock lengths of E301, E401, E601 & E701 probes)

# Instek



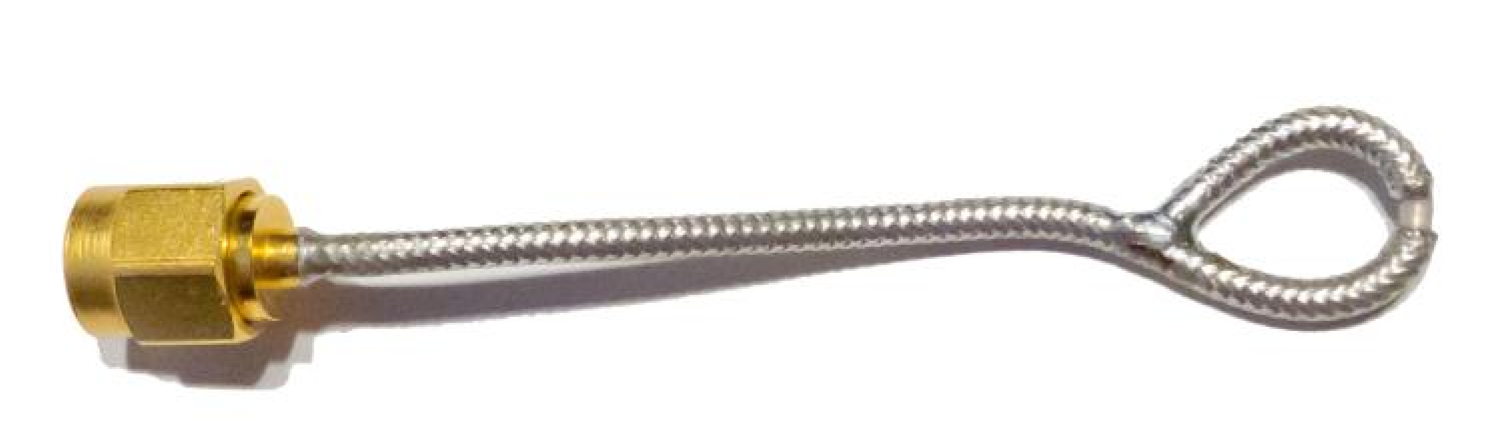
PRICING INFORMATION

**Instek GKT-006A** EMI Probe Kit Set
7-piece near field probe set

TestEquity Price $1,580

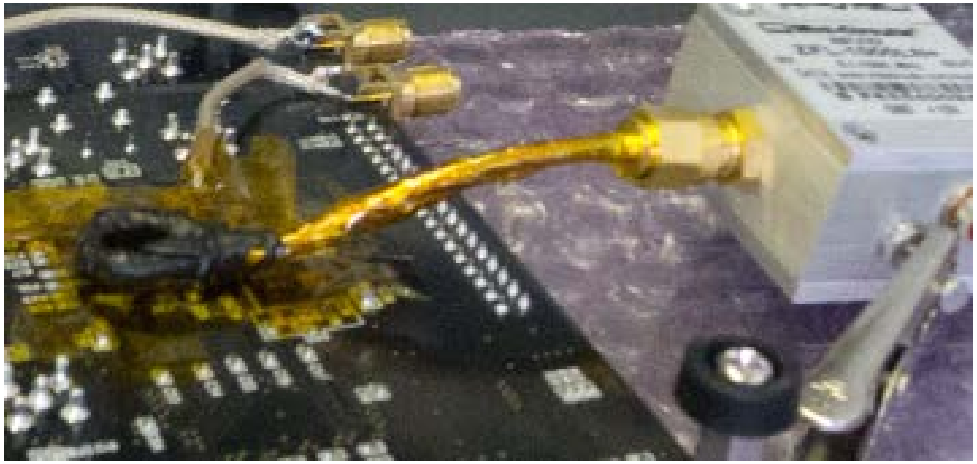
# DIY: Example

Length of Semi-Rigid cable with SMA Connectors ($3 surplus) can be turned into a simple magnetic loop:

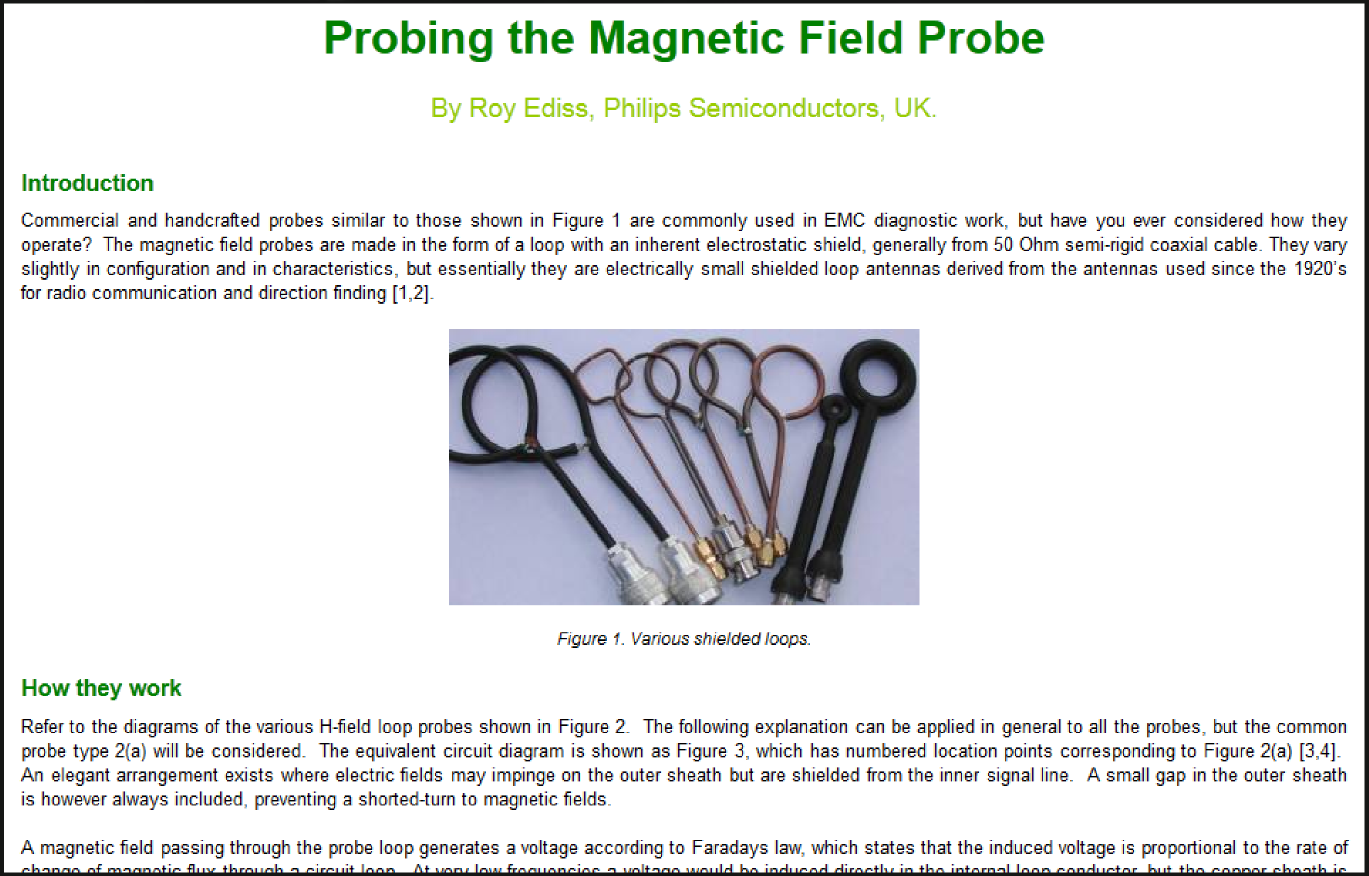


# DIY: Example

Wrap entire thing in non-conductive tape (here I used self-fusing + polyimide) to avoid shorting out anything:



# DIY: Some Useful References



## Probing the Magnetic Field Probe

By Roy Ediss, Philips Semiconductors, UK.

### Introduction

Commercial and handcrafted probes similar to those shown in Figure 1 are commonly used in EMC diagnostic work, but have you ever considered how they operate? The magnetic field probes are made in the form of a loop with an inherent electrostatic shield, generally from 50 Ohm semi-rigid coaxial cable. They vary slightly in configuration and in characteristics, but essentially they are electrically small shielded loop antennas derived from the antennas used since the 1920's for radio communication and direction finding [1,2].

*Figure 1. Various shielded loops.*

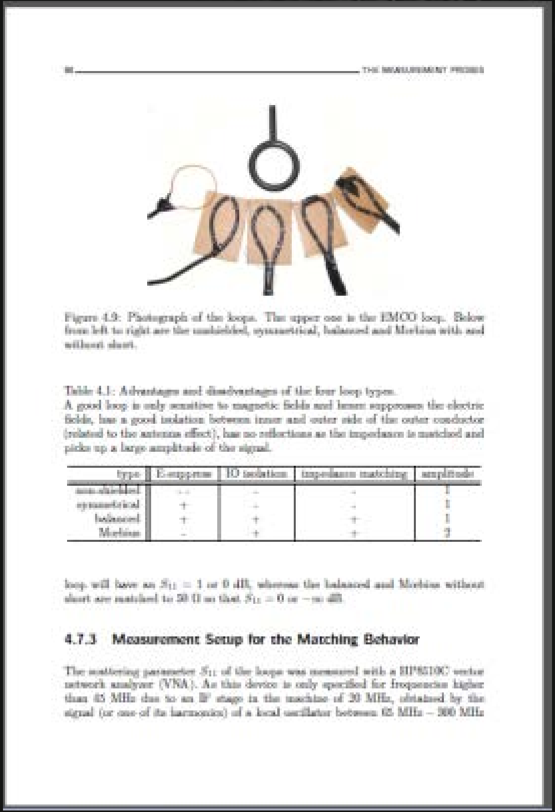
### How they work

Refer to the diagrams of the various H-field loop probes shown in Figure 2. The following explanation can be applied in general to all the probes, but the common probe type 2(a) will be considered. The equivalent circuit diagram is shown as Figure 3, which has numbered location points corresponding to Figure 2(a) [3,4]. An elegant arrangement exists where electric fields may impinge on the outer sheath but are shielded from the inner signal line. A small gap in the outer sheath is however always included, preventing a shorted-turn to magnetic fields.

A magnetic field passing through the probe loop generates a voltage according to Faradays law, which states that the induced voltage is proportional to the rate of change of magnetic flux through a circuit loop. At very low frequencies a voltage would be induced directly in the internal loop conductor, but the copper sheath is

http://www.compliance-club.com/archive/old_archive/030718.htm

# DIY: Some Useful References



86 THE MEASUREMENT PROBES

Figure 4.9: Photograph of the loops. The upper one is the EMCO loop. Below from left to right are the unshielded, symmetrical, balanced and Moebius with and without short.

Table 4.1: Advantages and disadvantages of the four loop types.
A good loop is only sensitive to magnetic fields and hence suppresses the electric fields, has a good isolation between inner and outer side of the outer conductor (related to the antenna effect), has no reflections as the impedance is matched and picks up a large amplitude of the signal.

| type | E-suppress | IO isolation | impedance matching | amplitude |
|---|---|---|---|---|
| non-shielded | - - | - | - | 1 |
| symmetrical | + | - | - | 1 |
| balanced | + | + | + | 1 |
| Moebius | - | + | + | 2 |

loop will have an $S_{11} = 1$ or 0 dB, whereas the balanced and Moebius without short are matched to 50 Ω so that $S_{11} = 0$ or $-\infty$ dB.

### 4.7.3 Measurement Setup for the Matching Behavior

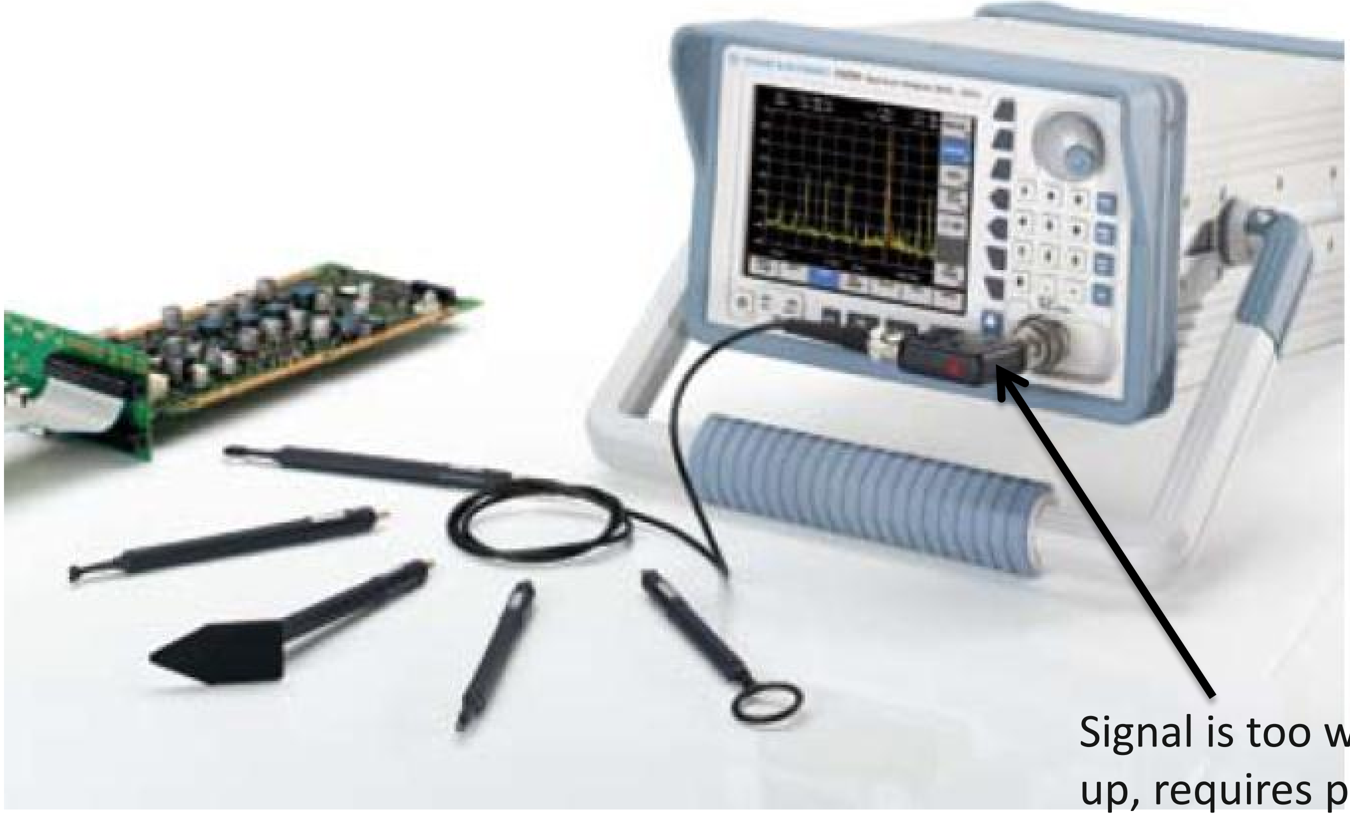
The scattering parameter $S_{11}$ of the loops was measured with a HP8510C vector network analyzer (VNA). As this device is only specified for frequencies higher than 45 MHz due to an IF stage in the machine of 20 MHz, obtained by the signal (or one of its harmonics) of a local oscillator between 65 MHz – 300 MHz

**Elke De Mulder: Electromagnetic Techniques and Probes for Side-Channel Analysis on Cryptographic Devices**

http://www.cosic.esat.kuleuven.be/publications/thesis-182.pdf

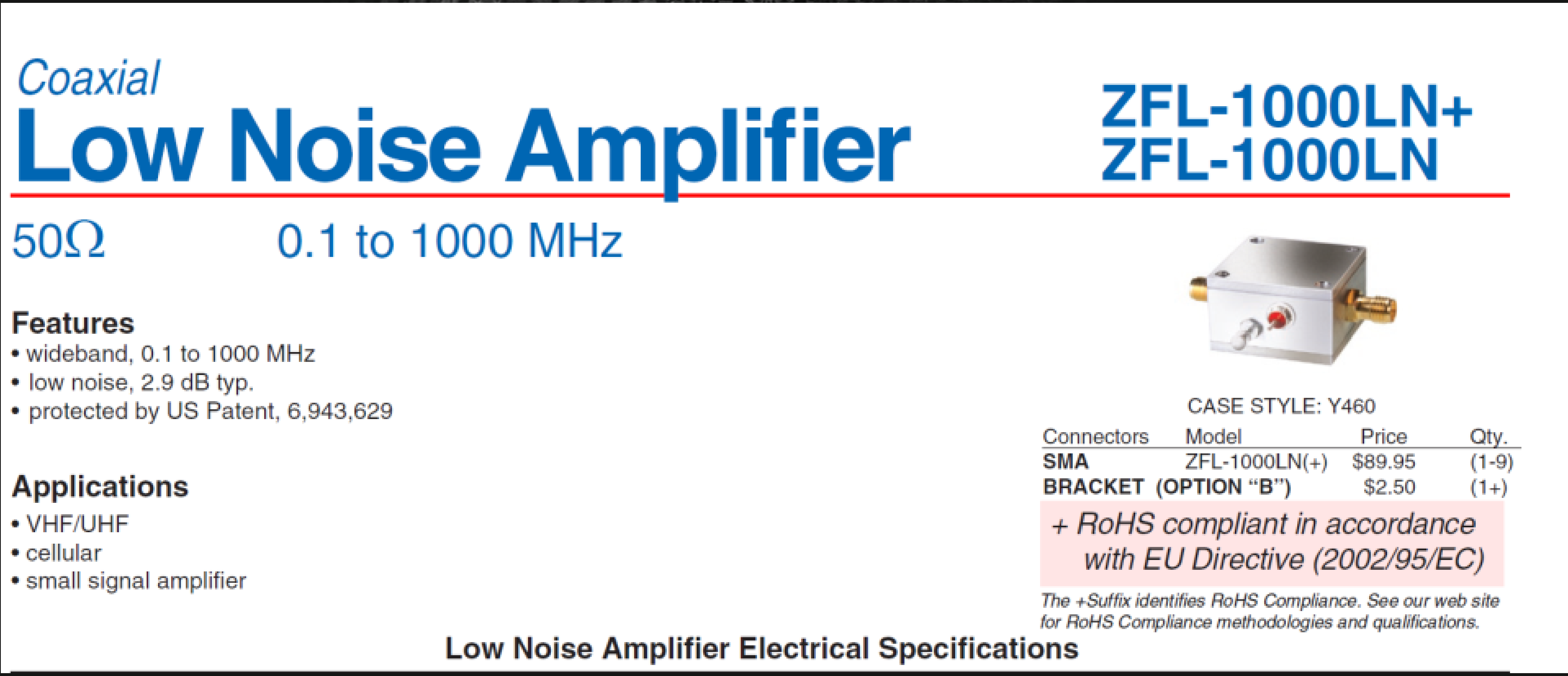
# Pre-Amplifier (Probe or Other)

# Pre-amplifier



Signal is too weak to be picked up, requires pre-amplifier in addition to probe.

# Pre-amplifier: Buying One



*Coaxial*

## Low Noise Amplifier

## ZFL-1000LN+
## ZFL-1000LN

50Ω 0.1 to 1000 MHz

### Features

- wideband, 0.1 to 1000 MHz
- low noise, 2.9 dB typ.
- protected by US Patent, 6,943,629

### Applications

- VHF/UHF
- cellular
- small signal amplifier

CASE STYLE: Y460

| Connectors | Model | Price | Qty. |
|---|---|---|---|
| **SMA** | ZFL-1000LN(+) | $89.95 | (1-9) |
| **BRACKET (OPTION "B")** | | $2.50 | (1+) |

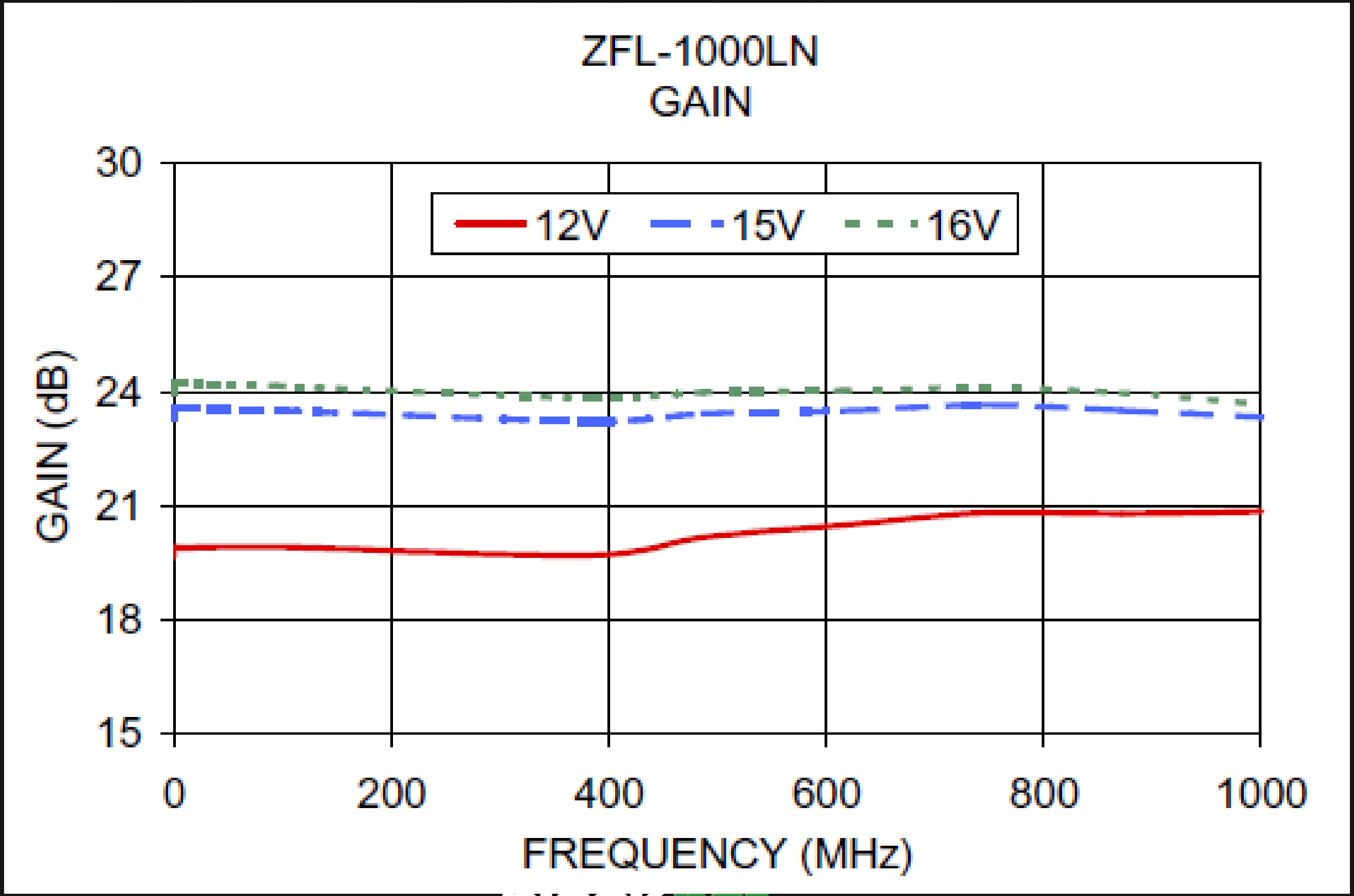
*+ RoHS compliant in accordance with EU Directive (2002/95/EC)*

*The +Suffix identifies RoHS Compliance. See our web site for RoHS Compliance methodologies and qualifications.*

**Low Noise Amplifier Electrical Specifications**

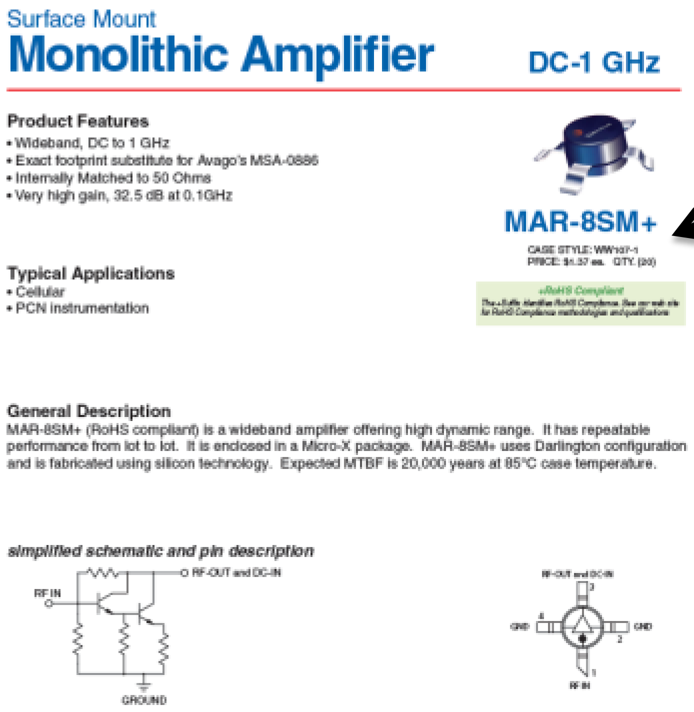
Assuming we are making a probe, there is no need to purchase the expensive pre-amplifier offered by that manufacture. Here is a 20 dB amplifier for $90, it was shown being used in another photo.

# Pre-amplifier: Buying One



# Pre-Amplifier: Making One

But we can get cheaper. We can make a pre-amplifier with similar characteristics for even less!



Surface Mount

**Monolithic Amplifier** DC-1 GHz

**Product Features**

- Wideband, DC to 1 GHz
- Exact footprint substitute for Avago's MSA-0886
- Internally Matched to 50 Ohms
- Very high gain, 32.5 dB at 0.1GHz

**Typical Applications**

- Cellular
- PCN instrumentation

**MAR-8SM+**

CASE STYLE: WW107-1
PRICE: $1.37 ea. QTY. (20)

+RoHS Compliant
The +Suffix identifies RoHS Compliance. See our web site for RoHS Compliance methodologies and qualifications

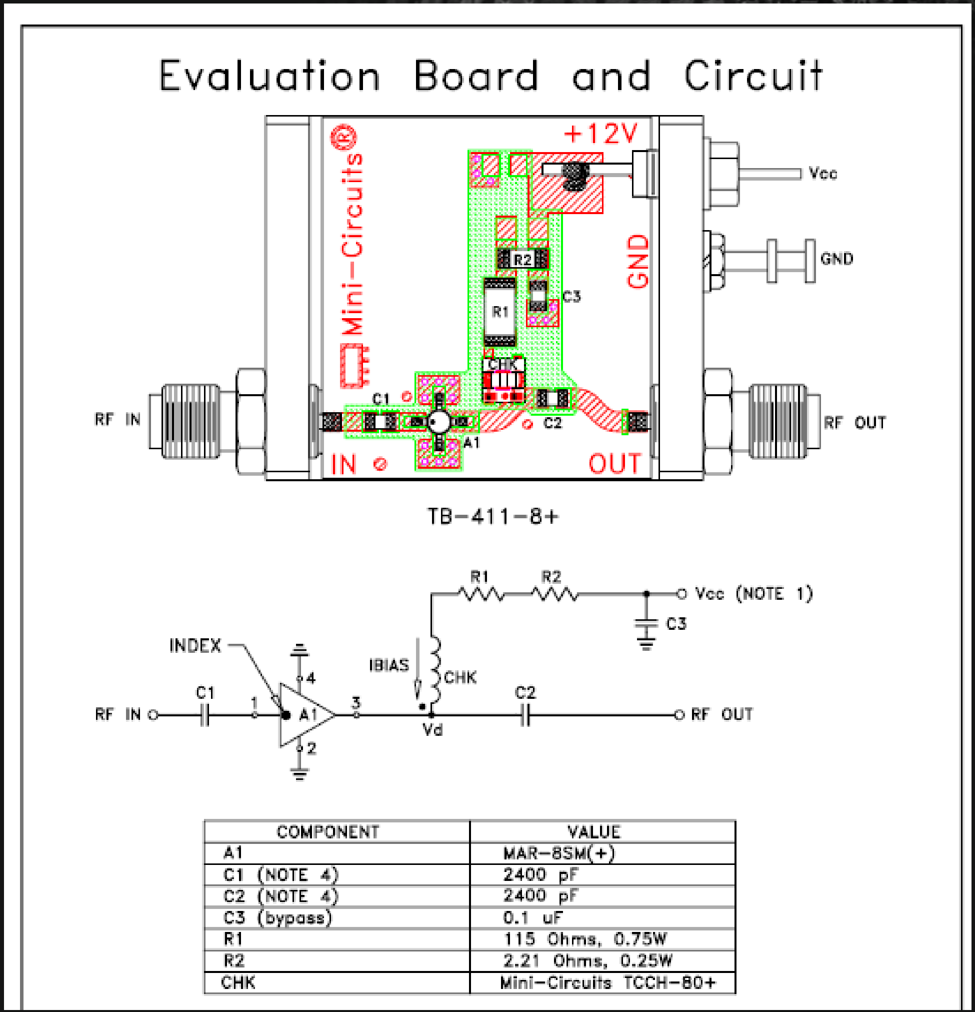
**General Description**

MAR-8SM+ (RoHS compliant) is a wideband amplifier offering high dynamic range. It has repeatable performance from lot to lot. It is enclosed in a Micro-X package. MAR-8SM+ uses Darlington configuration and is fabricated using silicon technology. Expected MTBF is 20,000 years at 85°C case temperature.

*simplified schematic and pin description*

Amplifier chip costs $2! Just needs a little support circuitry.

# Pre-amplifier: Making One



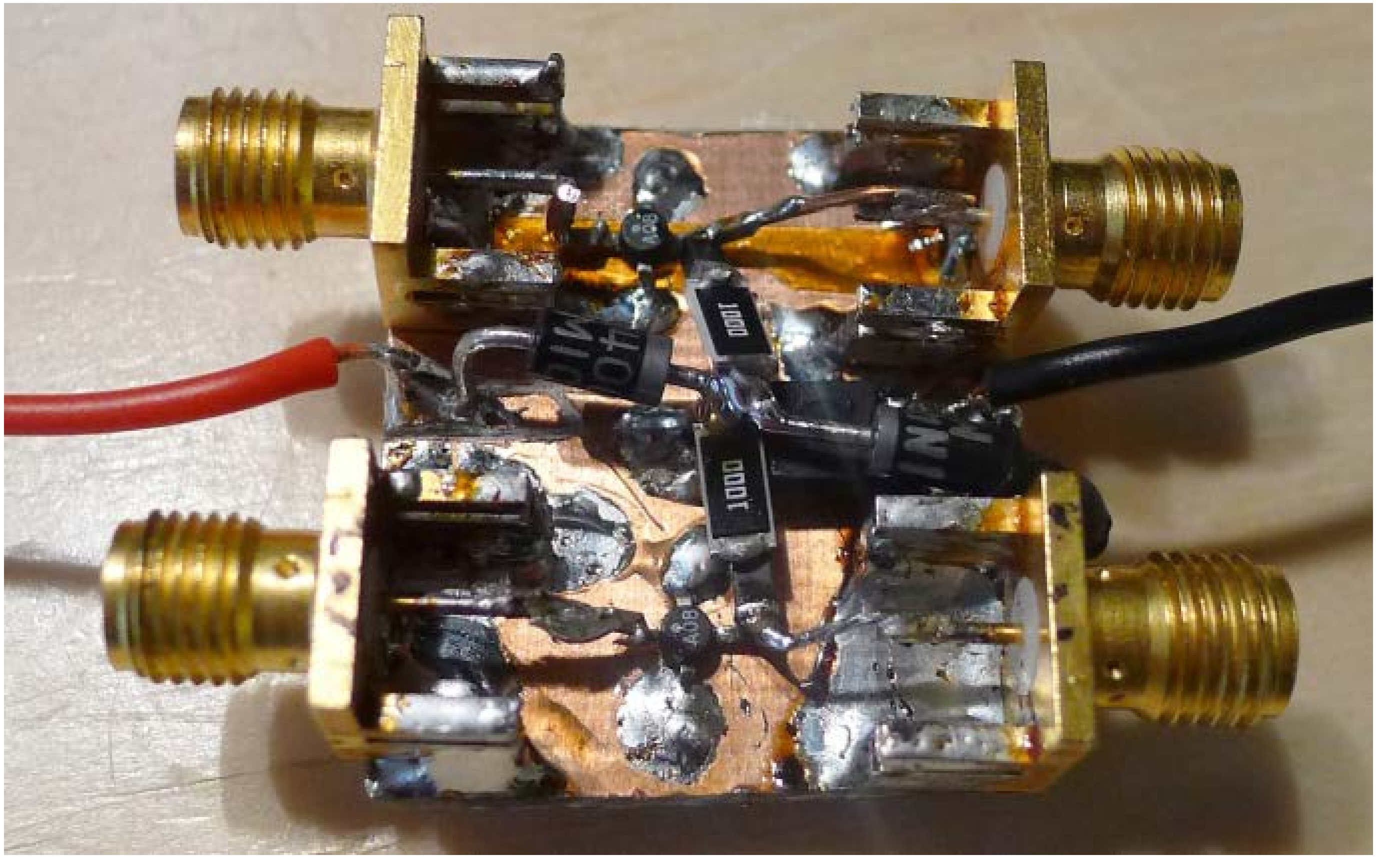
Evaluation Board and Circuit

| COMPONENT | VALUE |
|---|---|
| A1 | MAR–8SM(+) |
| C1 (NOTE 4) | 2400 pF |
| C2 (NOTE 4) | 2400 pF |
| C3 (bypass) | 0.1 uF |
| R1 | 115 Ohms, 0.75W |
| R2 | 2.21 Ohms, 0.25W |
| CHK | Mini–Circuits TCCH–80+ |

http://www.minicircuits.com/pcb/WTB-411-8+_P02.pdf

MiniCircuits lists full details of the required additional components

# Building One: Even Cheaper

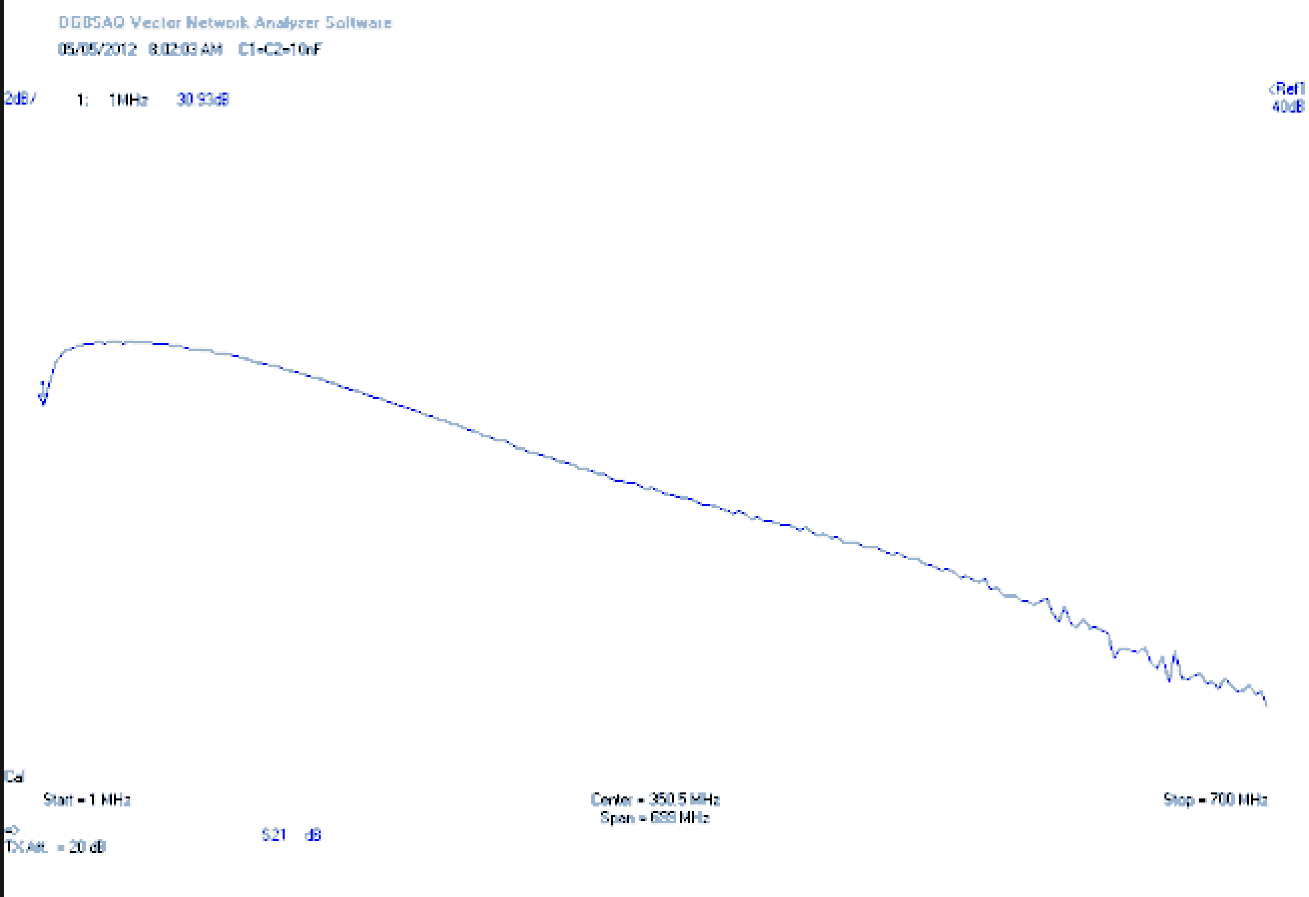


Here is an even cheaper version! Built on a piece of PCB, and has two channels to amplify different probes. This version has a voltage regulator on the bottom & protection diodes too, making it more robust than the basic schematic given.

# Building One: Even Cheaper

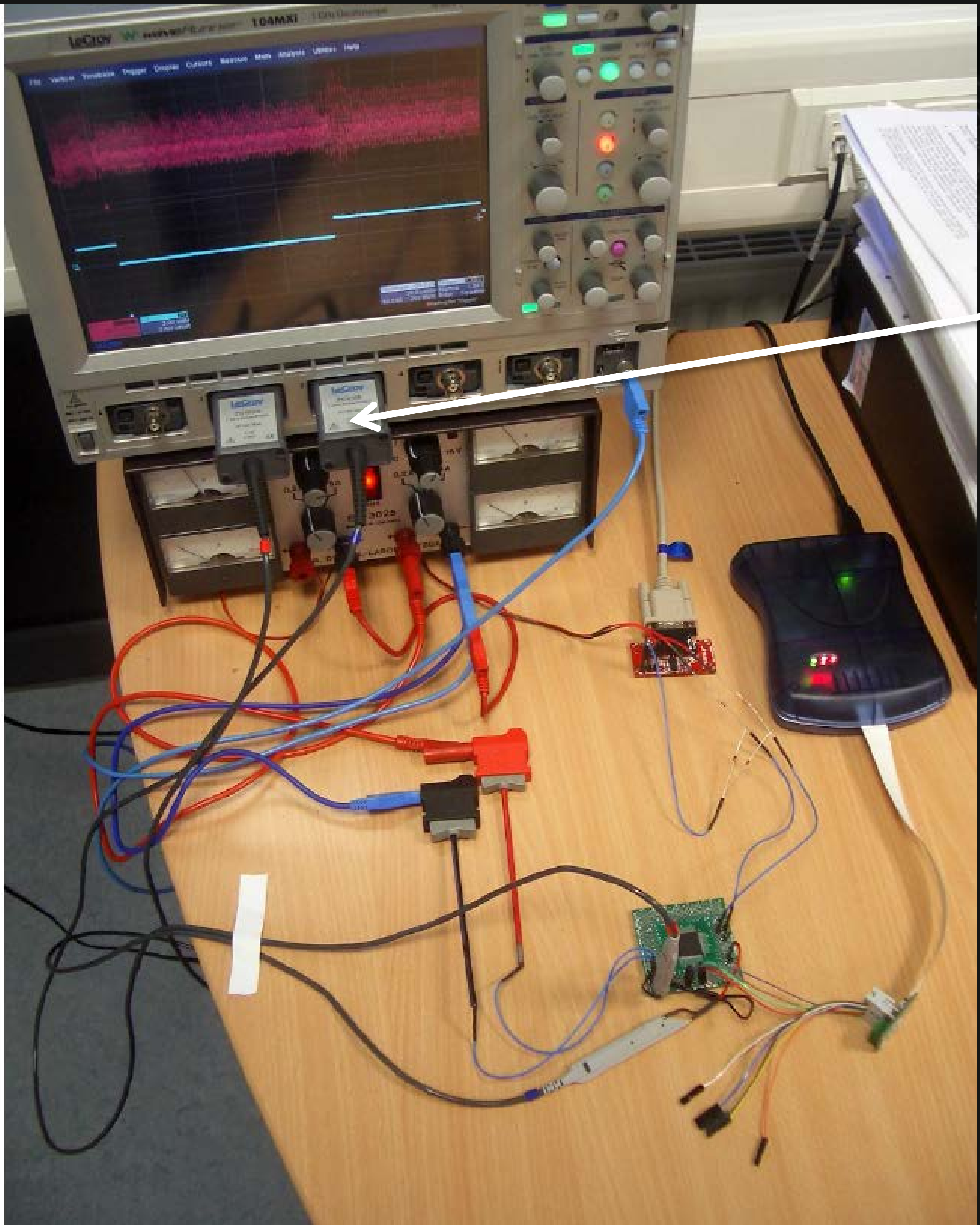
A PCB piece on top, some copper tape, and a final covering of non-conductive polyimide tape complete the amplifier. As a quick comparison to commercial ones let’s look at performance:

# Building One: Results



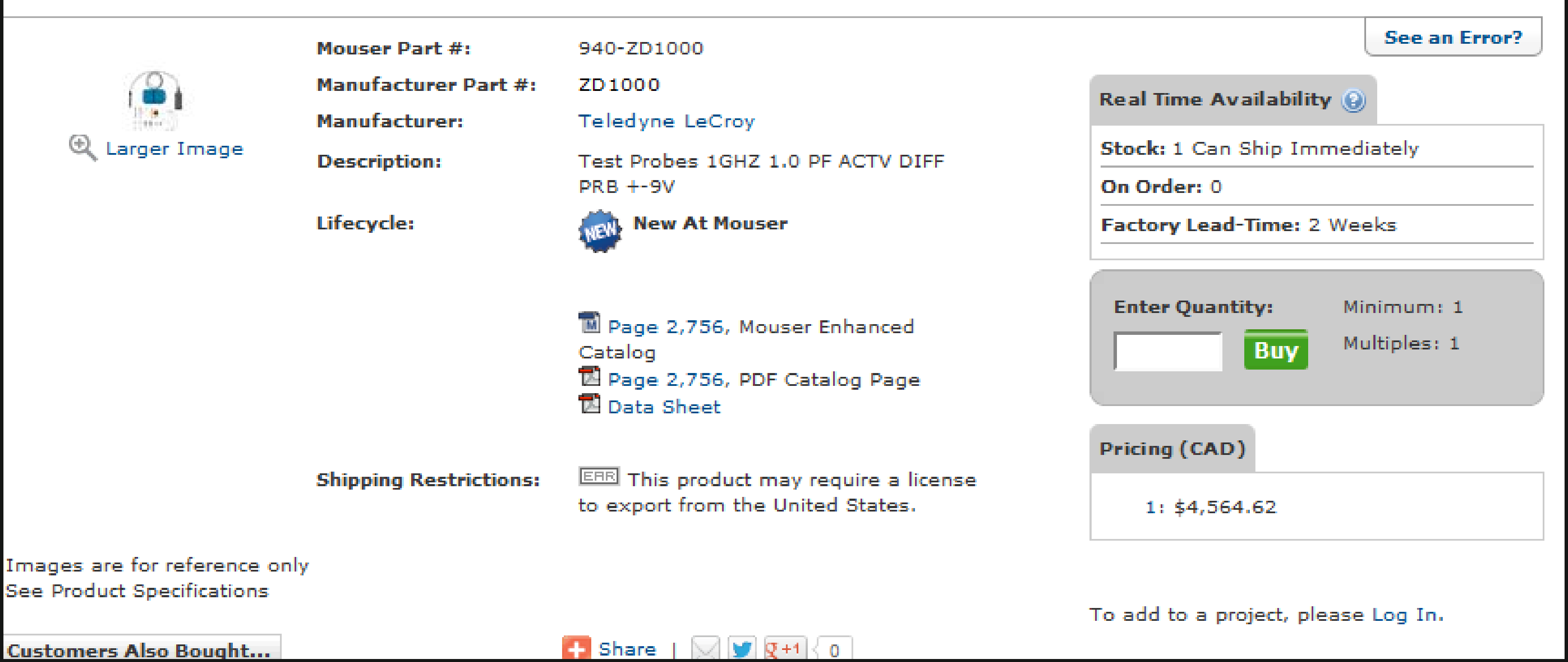
Here is the S21 measurement, showing amplifier gain. Gain varies from about 20-32 dB depending on frequency. The Noise Figure is below 3dB for this entire range.

# Differential Probe



From “**Side Channel Analysis of AVR XMEGA Crypto Engine**” by Ilya Kizhvatov

# What was that?



| | |
|---|---|
| **Mouser Part #:** | 940-ZD1000 |
| **Manufacturer Part #:** | ZD1000 |
| **Manufacturer:** | Teledyne LeCroy |
| **Description:** | Test Probes 1GHZ 1.0 PF ACTV DIFF PRB +-9V |
| **Lifecycle:** | NEW **New At Mouser** |
| | Page 2,756, Mouser Enhanced Catalog<br>Page 2,756, PDF Catalog Page<br>Data Sheet |
| **Shipping Restrictions:** | EAR This product may require a license to export from the United States. |

Images are for reference only
See Product Specifications

**Real Time Availability**

**Stock:** 1 Can Ship Immediately

**On Order:** 0

**Factory Lead-Time:** 2 Weeks

**Enter Quantity:** Minimum: 1 Multiples: 1

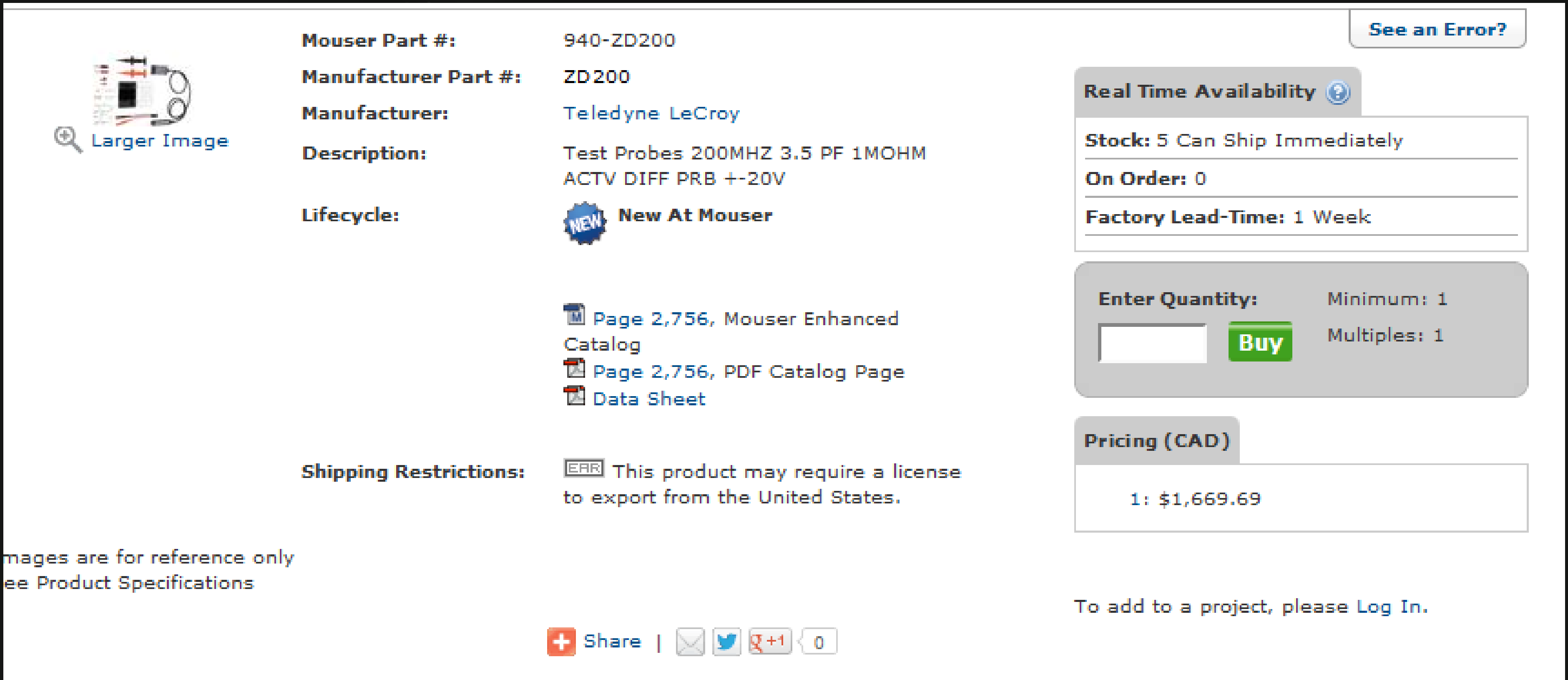
**Pricing (CAD)**

1: $4,564.62

To add to a project, please Log In.

**Customers Also Bought...**

# We don’t need 1000 MHz..



See an Error?

Larger Image

| | |
|---|---|
| **Mouser Part #:** | 940-ZD200 |
| **Manufacturer Part #:** | ZD200 |
| **Manufacturer:** | Teledyne LeCroy |
| **Description:** | Test Probes 200MHZ 3.5 PF 1MOHM ACTV DIFF PRB +-20V |
| **Lifecycle:** | NEW **New At Mouser** |

Page 2,756, Mouser Enhanced Catalog

Page 2,756, PDF Catalog Page

Data Sheet

**Shipping Restrictions:** EAR This product may require a license to export from the United States.

mages are for reference only
ee Product Specifications

Share | +1 0

**Real Time Availability**

**Stock:** 5 Can Ship Immediately

**On Order:** 0

**Factory Lead-Time:** 1 Week

**Enter Quantity:** Buy

Minimum: 1

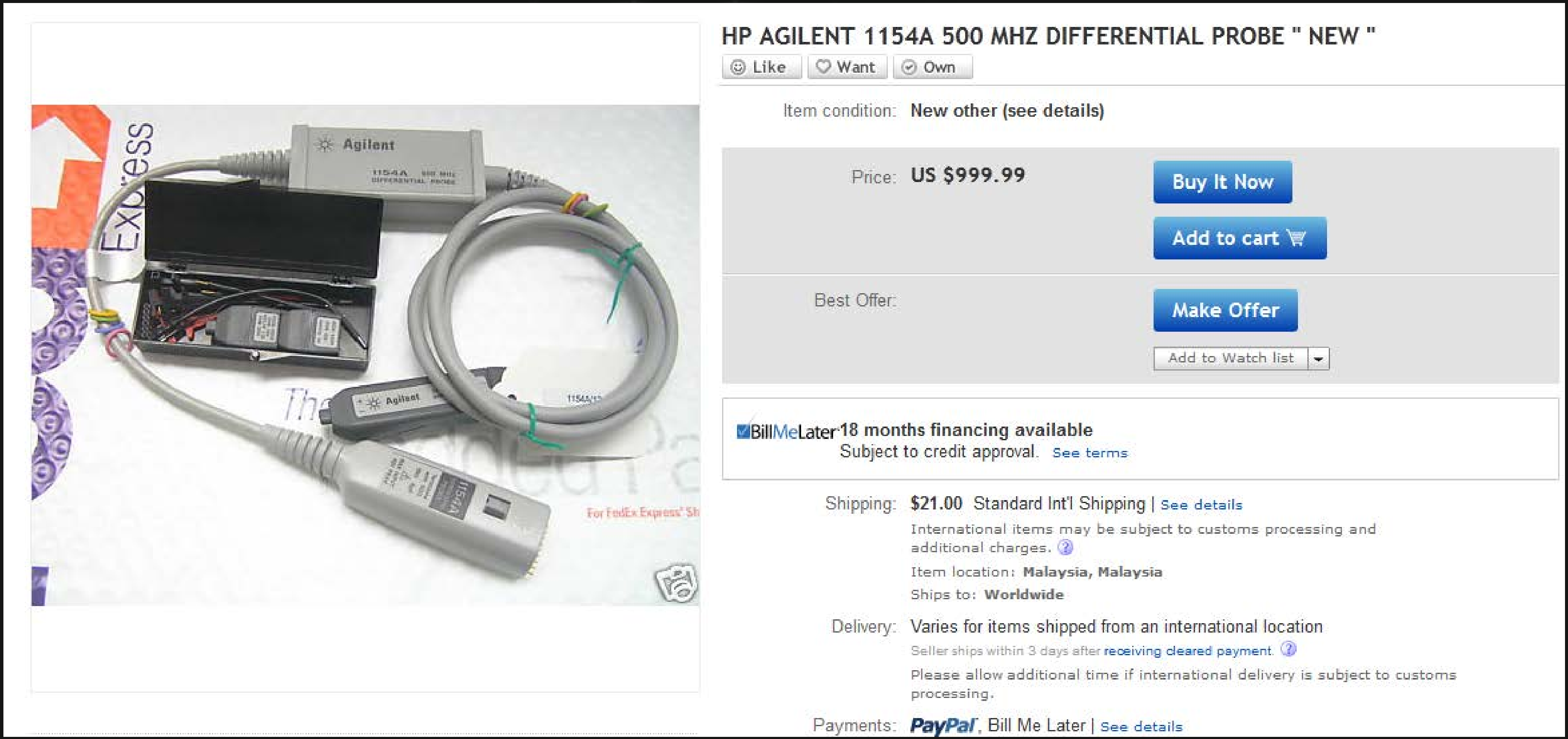
Multiples: 1

**Pricing (CAD)**

1: $1,669.69

To add to a project, please Log In.

# Uh what about E-Bay?



HP AGILENT 1154A 500 MHZ DIFFERENTIAL PROBE " NEW "

Item condition: **New other (see details)**

Price: **US $999.99**

Best Offer:

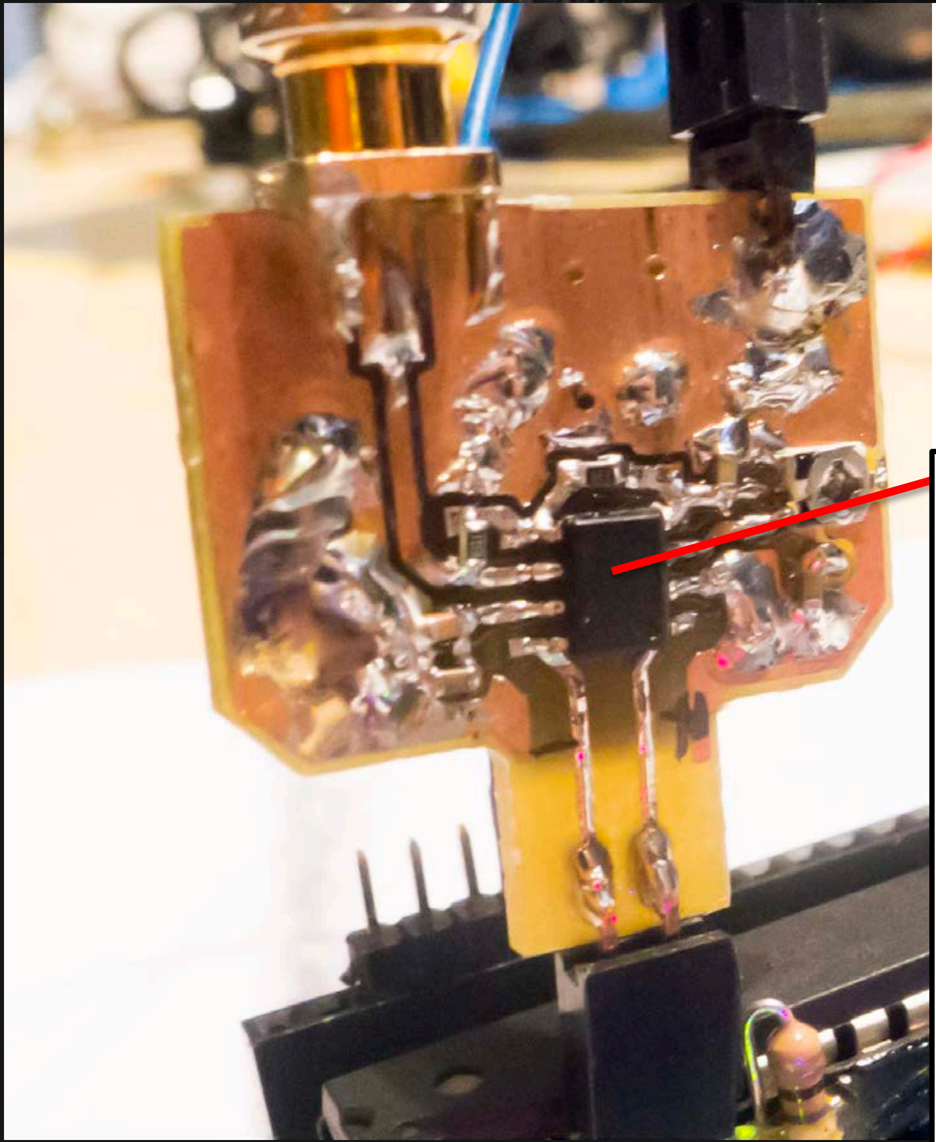
☑ BillMeLater **18 months financing available**
Subject to credit approval. See terms

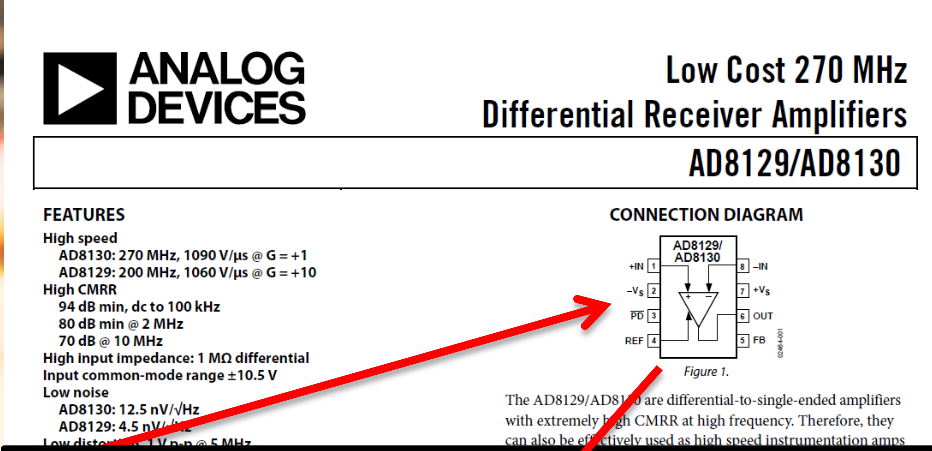
Shipping: $21.00 Standard Int'l Shipping | See details
International items may be subject to customs processing and additional charges. ?
Item location: **Malaysia, Malaysia**
Ships to: **Worldwide**

Delivery: Varies for items shipped from an international location
Seller ships within 3 days after receiving cleared payment. ?
Please allow additional time if international delivery is subject to customs processing.

Payments: PayPal, Bill Me Later | See details

# How Cheap are you?





ANALOG DEVICES

Low Cost 270 MHz Differential Receiver Amplifiers

AD8129/AD8130

FEATURES

High speed
  AD8130: 270 MHz, 1090 V/μs @ G = +1
  AD8129: 200 MHz, 1060 V/μs @ G = +10
High CMRR
  94 dB min, dc to 100 kHz
  80 dB min @ 2 MHz
  70 dB @ 10 MHz
High input impedance: 1 MΩ differential
Input common-mode range ±10.5 V
Low noise
  AD8130: 12.5 nV/√Hz
  AD8129: 4.5 nV/√Hz
Low distortion: 1 V p-p @ 5 MHz

CONNECTION DIAGRAM

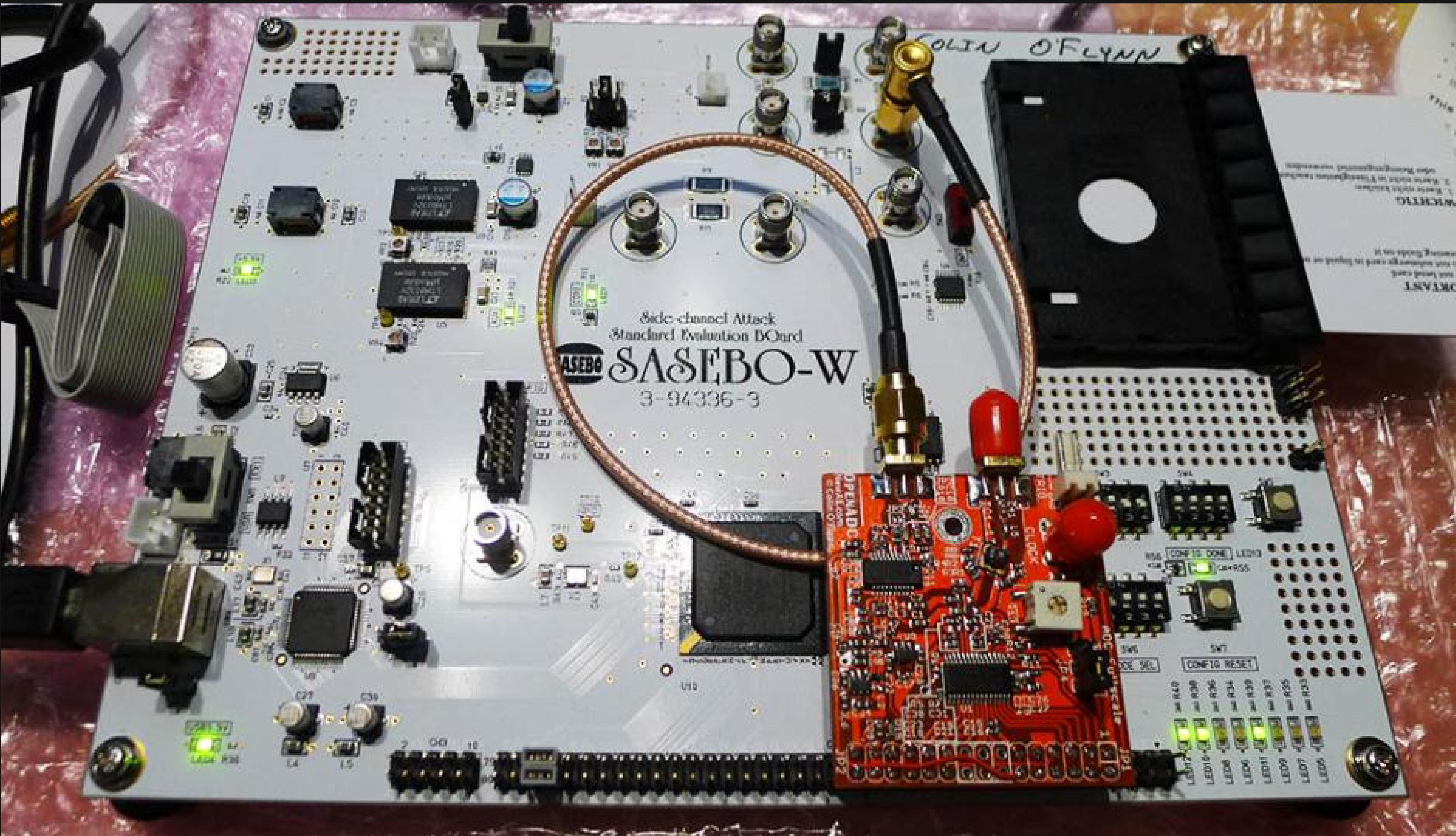
*Figure 1.*

The AD8129/AD8130 are differential-to-single-ended amplifiers with extremely high CMRR at high frequency. Therefore, they can also be effectively used as high speed instrumentation amps

This chip is < $5 in single-unit quantities! Add a voltage supply & a few resistors/capacitors and you've got a pretty good probe.

# Other Targets of Interest

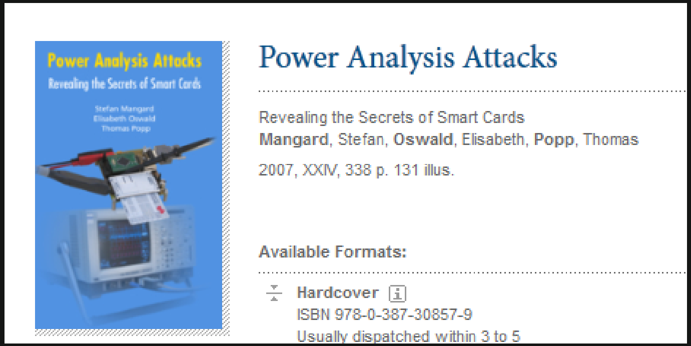
# SASEBO-W Board



# Where to Go from Here?

# Actions You Can Take

- Read the White Paper for more details including a ‘Buying Guide’ to start playing around – be SURE to check for updates to it on newae.com/blackhat
- There is a good book that covers a LOT:



Power Analysis Attacks

Revealing the Secrets of Smart Cards
**Mangard**, Stefan, **Oswald**, Elisabeth, **Popp**, Thomas

2007, XXIV, 338 p. 131 illus.

**Available Formats:**

**Hardcover**
ISBN 978-0-387-30857-9
Usually dispatched within 3 to 5

- Read original DPA Paper by Kocher, look at CHES & COSADE Proceedings
- Hint: Local universities often have access to these, so use a computer on their network (e.g. from library)

# Questions Etc.

Visit me on interweb: newae.com/blackhat

E-mail me: coflynn@newae.com

Please complete the Speaker Feedback Surveys!