Do-It-Yourself Diodes

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Coming Attractions

Radio Rocks

EZ Curve Tracer

Radio Circuit Model

Mineral Diodes & Thingies

Rust Never Sleeps

Why Diodes Matter

In The Beginning

- Before integrated circuits...
- Before transistors...
- Before vacuum tubes...
- Before *electronics*...
- ... there were radios!
  - Modern radio by VE6AB

The Simplest Possible Radio

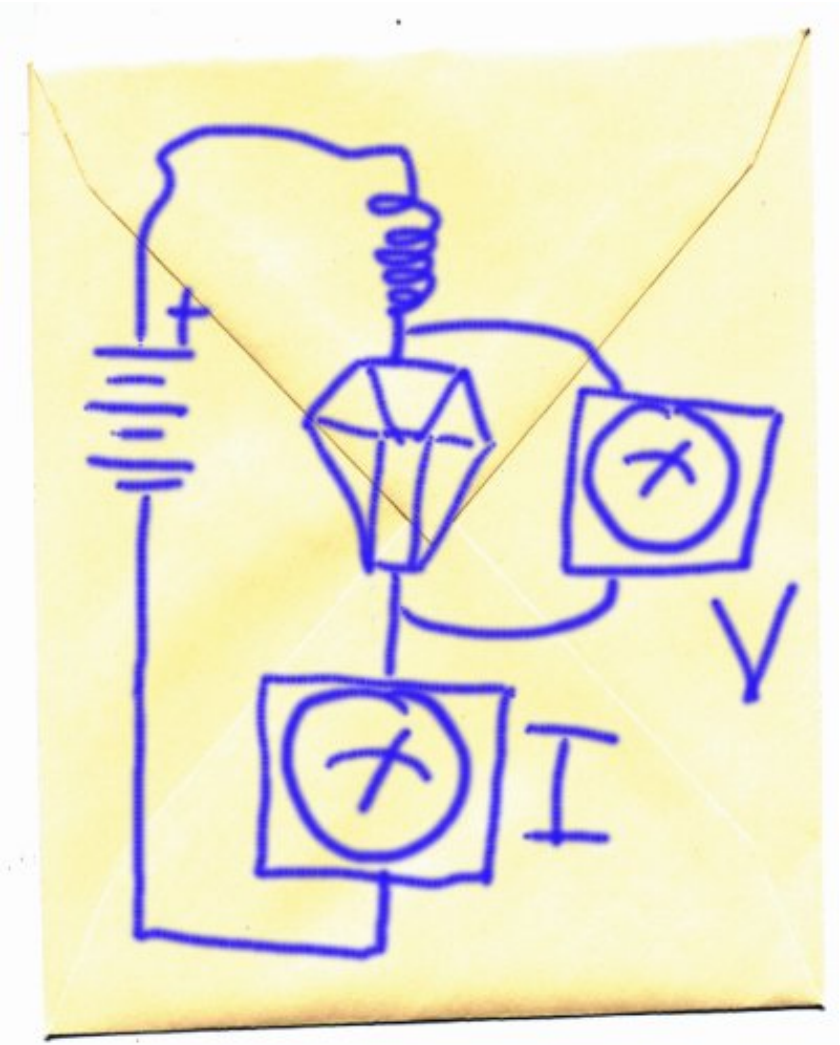
- Antenna
- Ground
- Earphone
- Detector
  - AM demodulator (huh?)
  - A rock on a hard place
  - Crystal diode!
- Tuning? Hah!

Mineral Samples

- Who knew?
  - Nobody!
  - Conflicting stories
- Try all combinations
  - Most don’t work at all
  - How can you tell?
- Instrumentation!

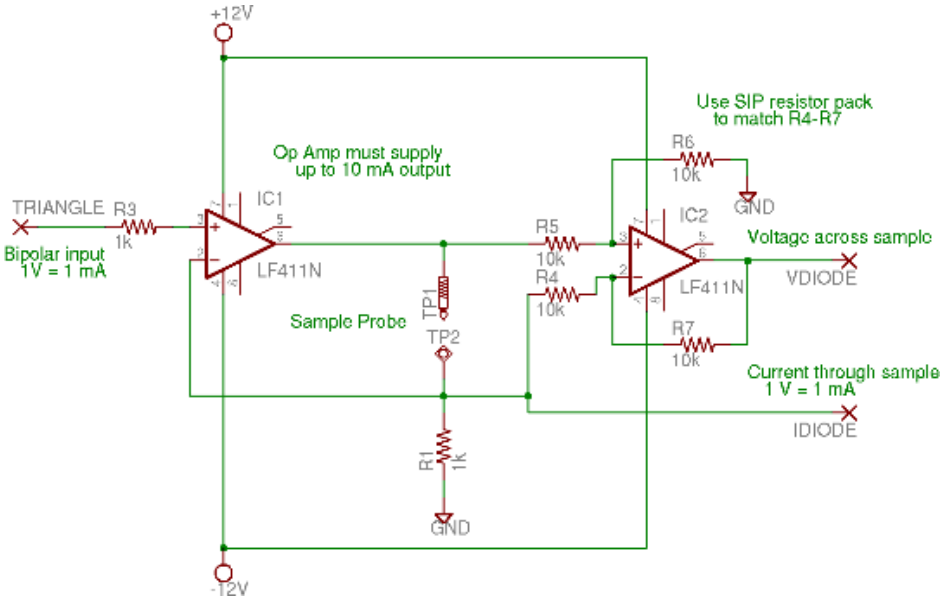
The Big Idea

- Jam current (I) in
  - How much?
  - Polarity?
- Measure volts (V) across
  - Range?
- Plot results: curves!
  - It can be done manually
  - More fun automatically
  - Oscilloscope screen shots

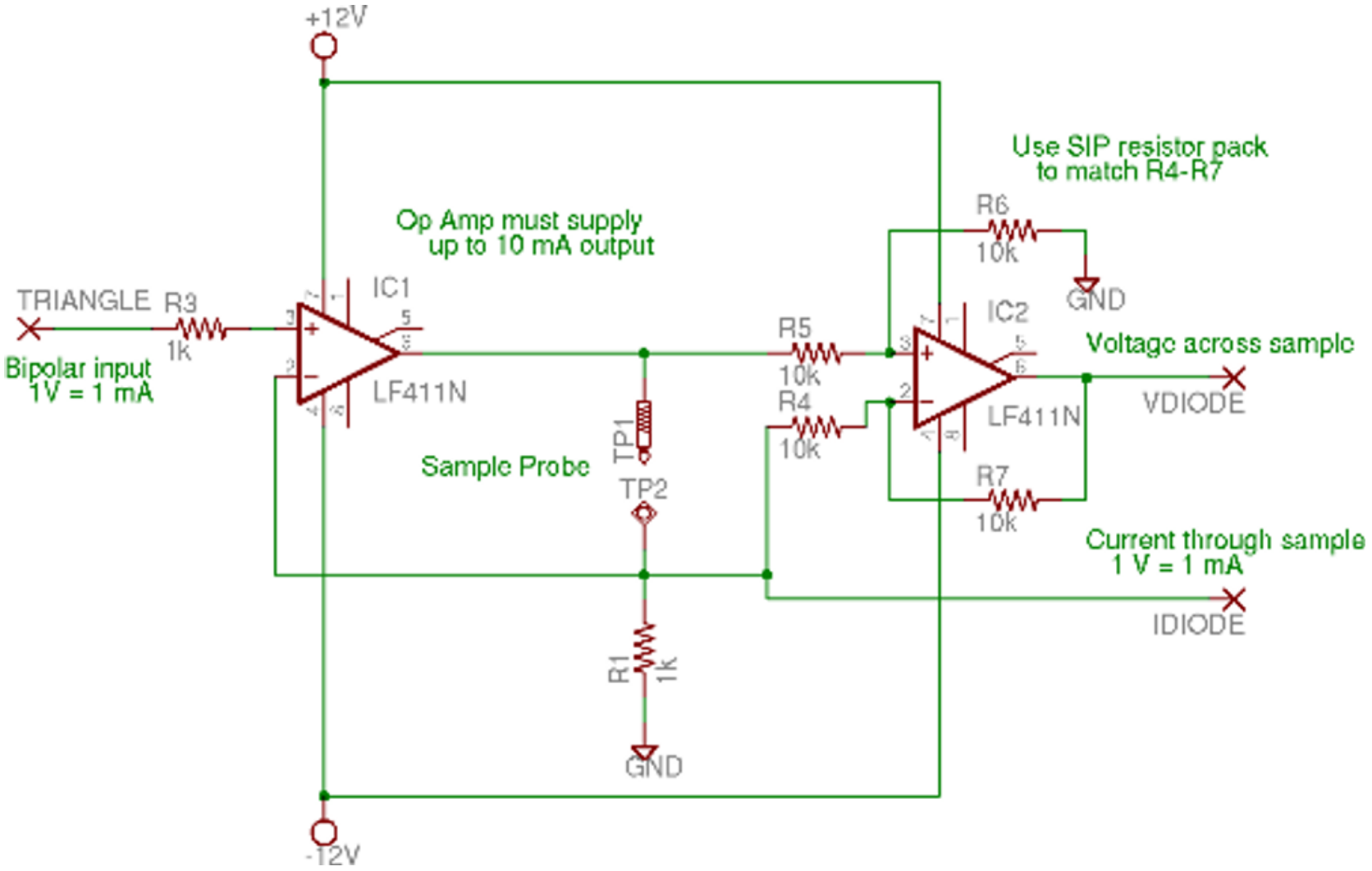


The Little Details

- Triangle wave input
  - 200 Hz, 8 V peak
  - Voltage to Current
  - Oscilloscope X axis
- Measure V at sample
  - Differential to single
  - Oscilloscope Y axis
- ±10 mA and ±10 V
  - Still makes sparks…



Enlarged to Show Texture

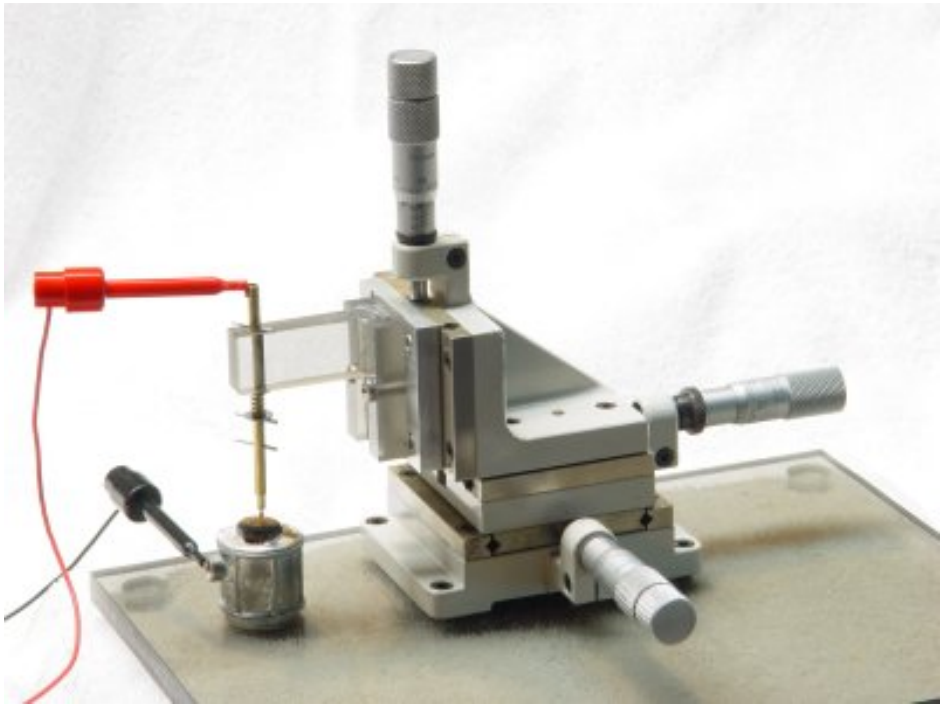


Cat's Whisker Probe

- Mineral in metal pot
- Wire pin-point probe
  - Steel? Bronze? Carbon?
- 3-axis ball slide mount
- Springy thing
- Patience

He Who Dies With The Most Stuff...

- 3-axis positioner
  - 0.001” resolution
  - 0.5” accessible cube
  - Zero backlash
- Black-belt dweebdom



Probe and Sample Holder

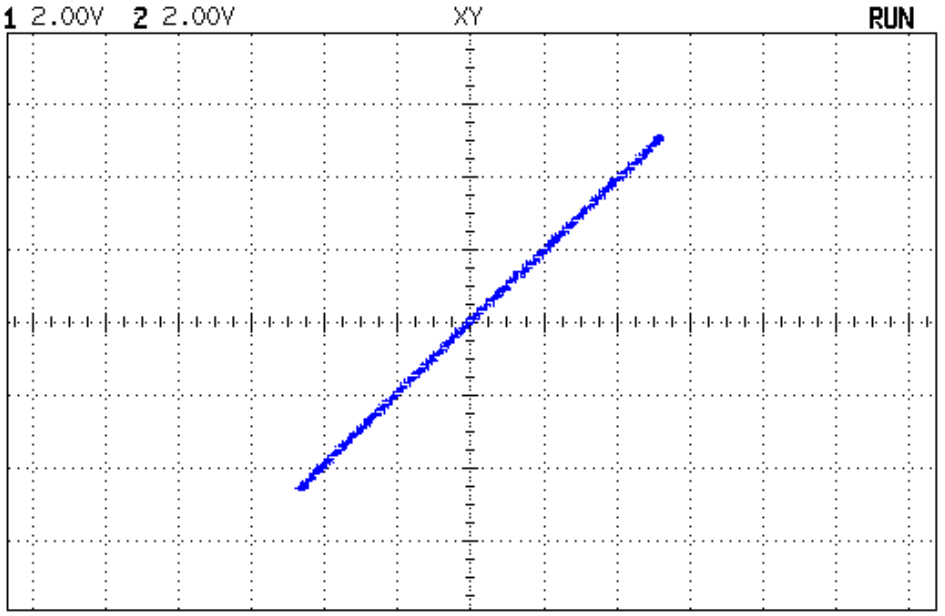
- Telescoping brass tubes
- Tapered clock pins
- Springy thing
- EMT fitting
- Gratuitous CNC
- Low frequency = clips

Sample Holder

- Wood's Metal
  - Makes solid contact
  - But: **Pb**+**Cd**+Bi+Sn
  - But: melts at 160° F
  - Use Field's Metal?
- Friction-fit probe tips
  - Steel, bronze, carbon
  - Small differences?

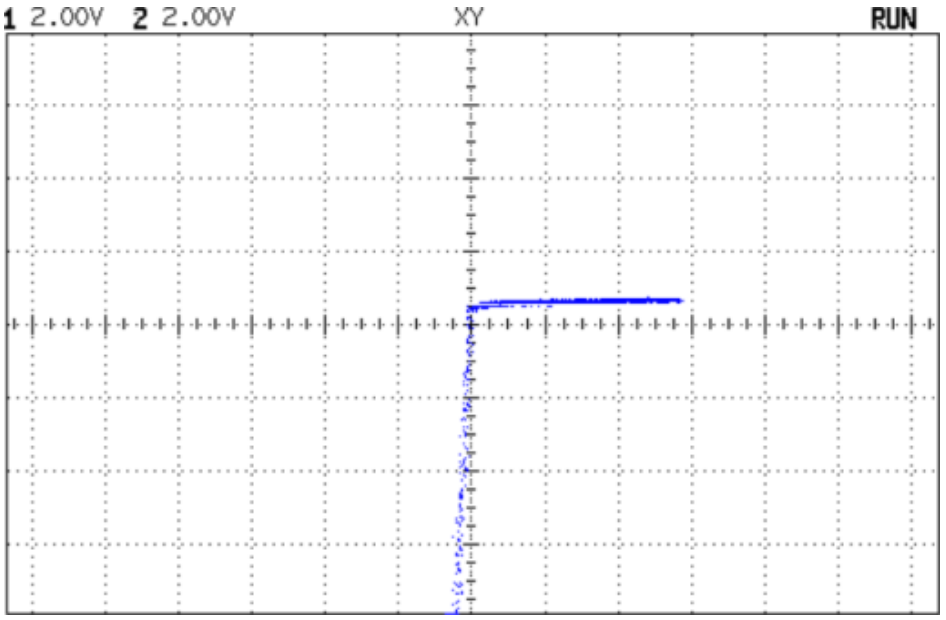
Calibration – 1 kΩ Resistor

- 1 V input = 1 mA
- Scope Axes
  - X = current (2 mA/div)
  - Y = voltage (2 V/div)
- Linear!
  - Whew…
- Set DC offset = 0



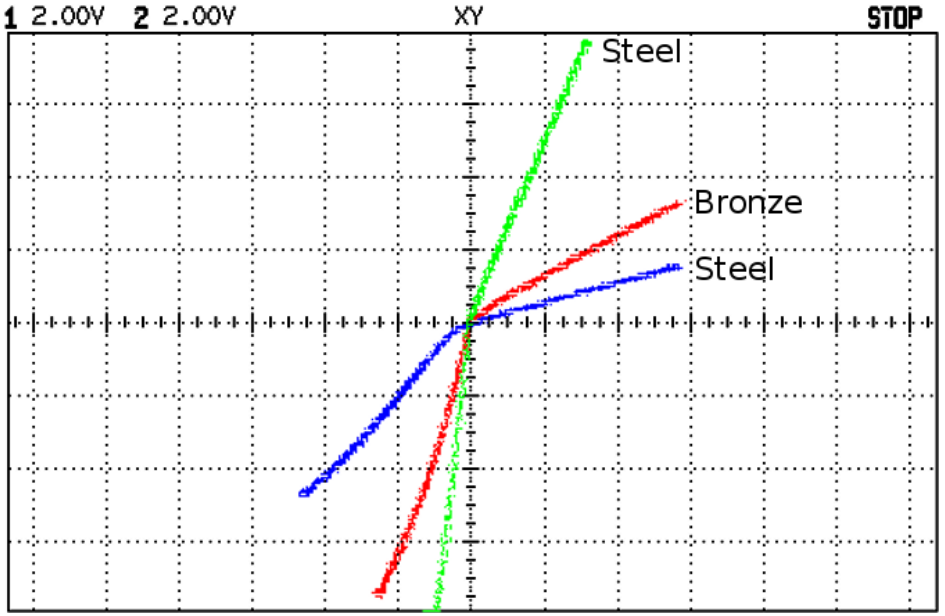
Calibration – 1N914

- Jellybean Si diode
- V_{fwd} = 0.5 V
  - Pretty close
- I_{rev} = zilch
  - Limited by diff amp's input resistance



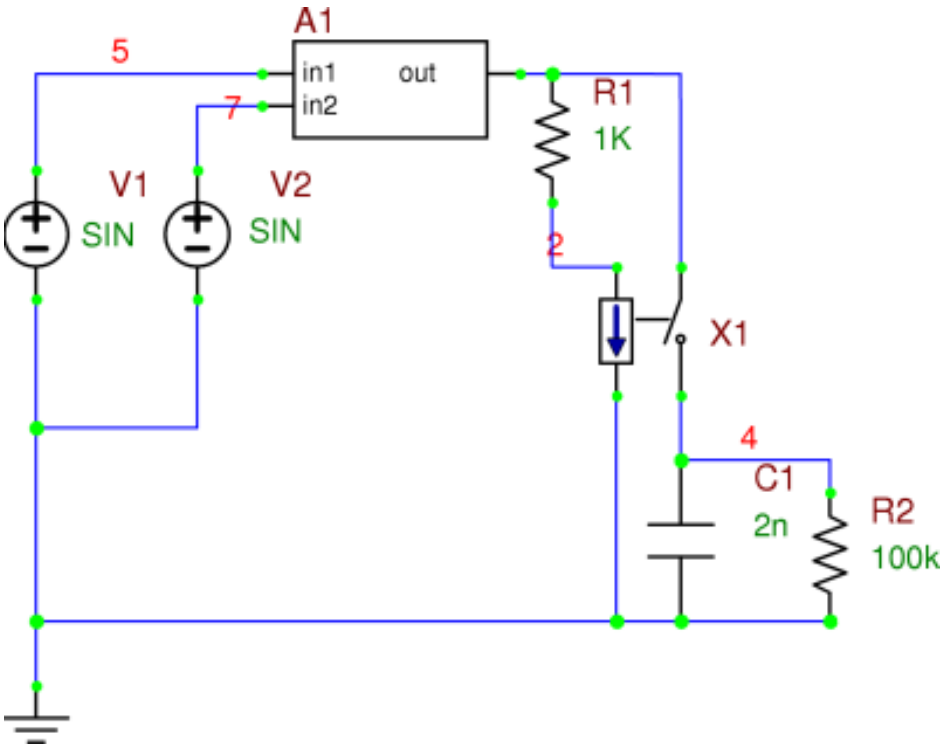
Iron Pyrite

- Green trace
  - Nearly a resistor
- Red trace
  - More like a diode
- Blue trace
  - Both better & worse
- Same lump!
- Probe material?



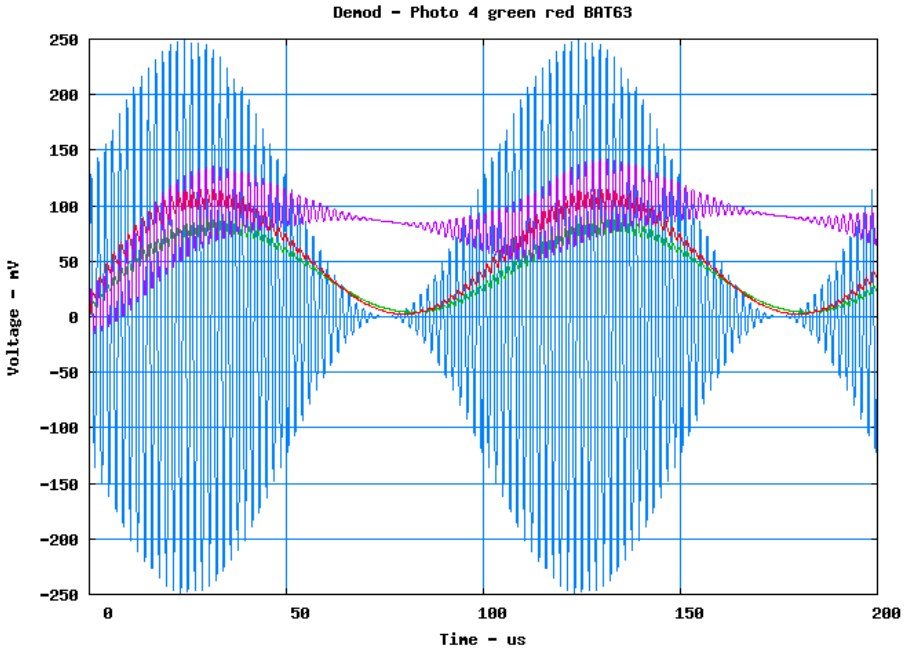
Spice Circuit Model

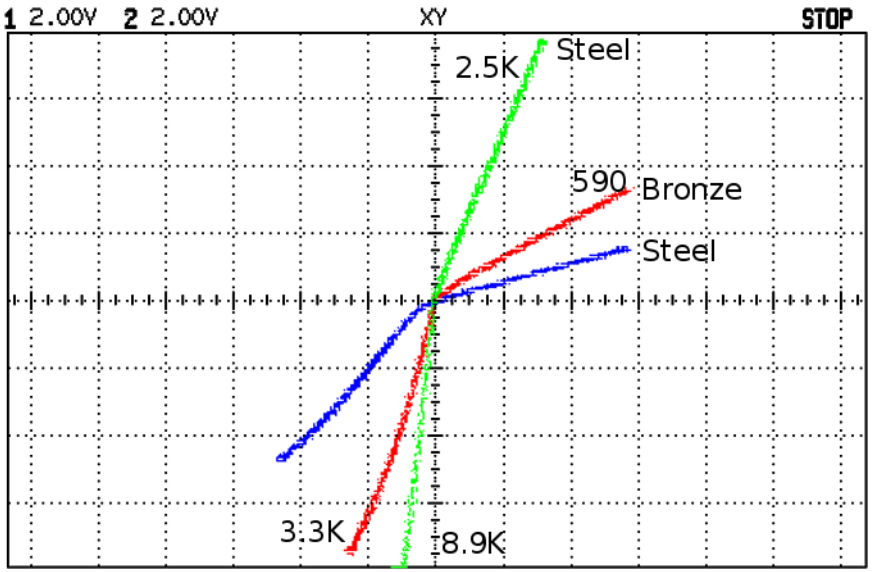
- Diode = switch
  - Voltage controlled
  - Maybe a lousy switch
- Resistance from plots
  - R = ΔV /Δ I = slope
- C1 & R2 ≈ earphone
  - High impedance
- V1*V2 = AM signal!



AM Demodulation

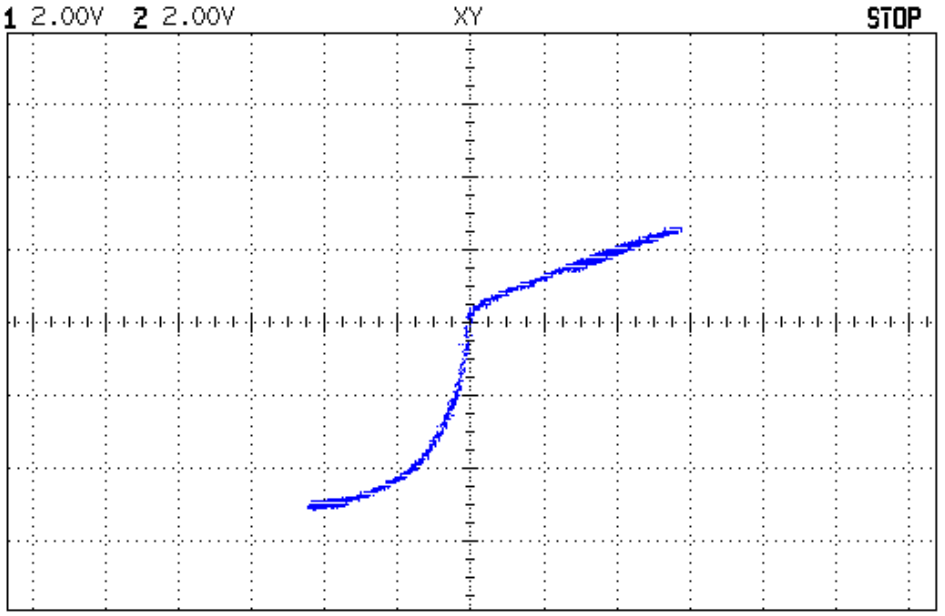
- Low voltage RF
  - This is before tubes!
- Poor diodes are OK
  - Green ≈ 3.6 / 1 (rev/fwd)
  - Red ≈ 5.6 / 1
- Modern diodes are NG
  - Purple = Schottky ≈ ∞ / 1
  - But V_{fwd} still too high





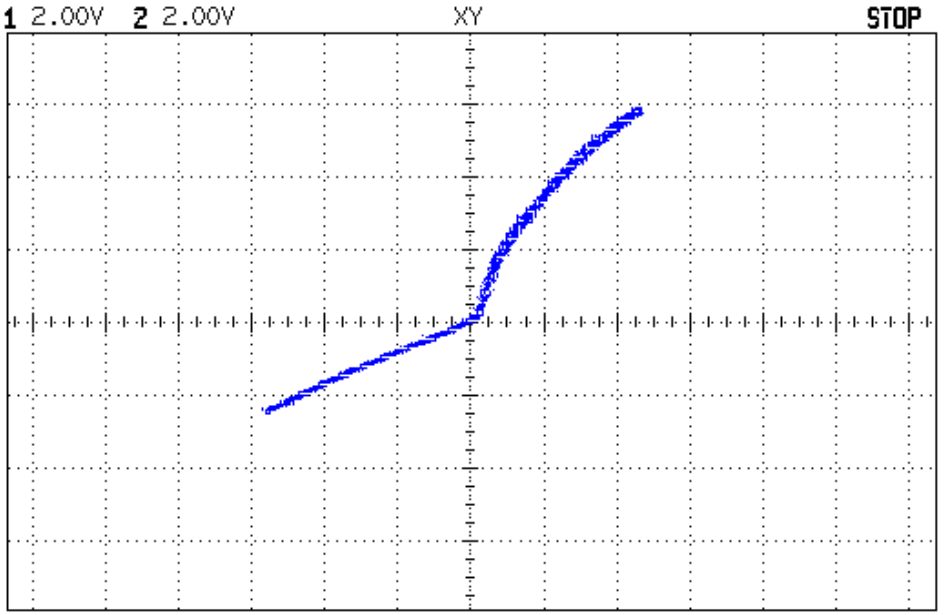
Iron Pyrite

- Huh?
  - Sorta Zener-ish
- Marginal diode
  - For low I & V, anyway



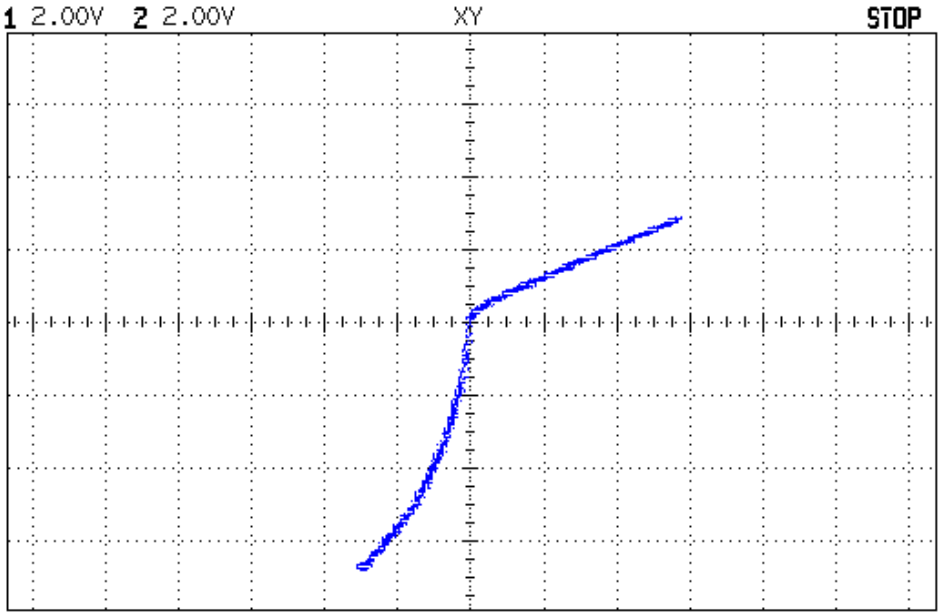
Lead - Galena?

- Backwards polarity
  - Whatever that means
- Low V_{fwd}
- Bronze probe
- Best of a bad sample
  - Who knew?
  - Maybe it's just lead?



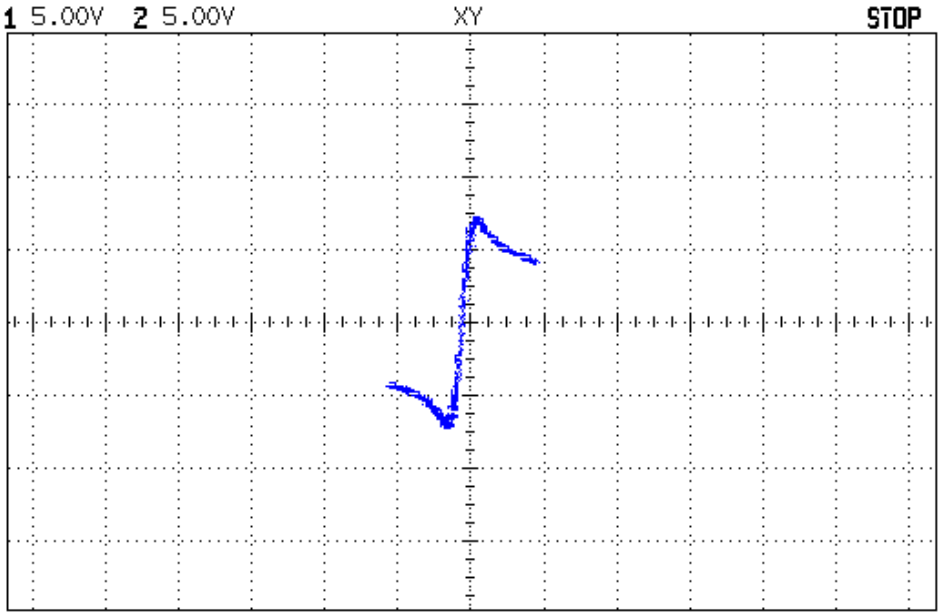
Chalcopyrite

- Say kal'•keh•pie'•right
- Looks diode-ish
  - If you squint
- Low V_{fwd}
- But wait...



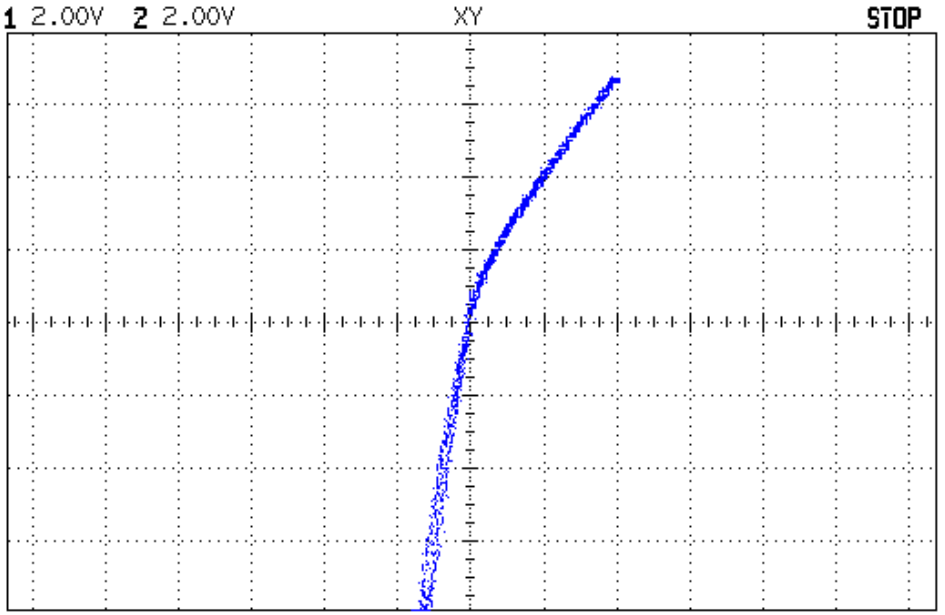
Chalcopyrite

- It's a Diac!
  - Bilateral trigger diode
- It's a resistor!
  - For *very* low I
- Negative resistance
  - Current ↑ = Voltage ↓
- Note scale change
  - 5 V and 5 mA / div

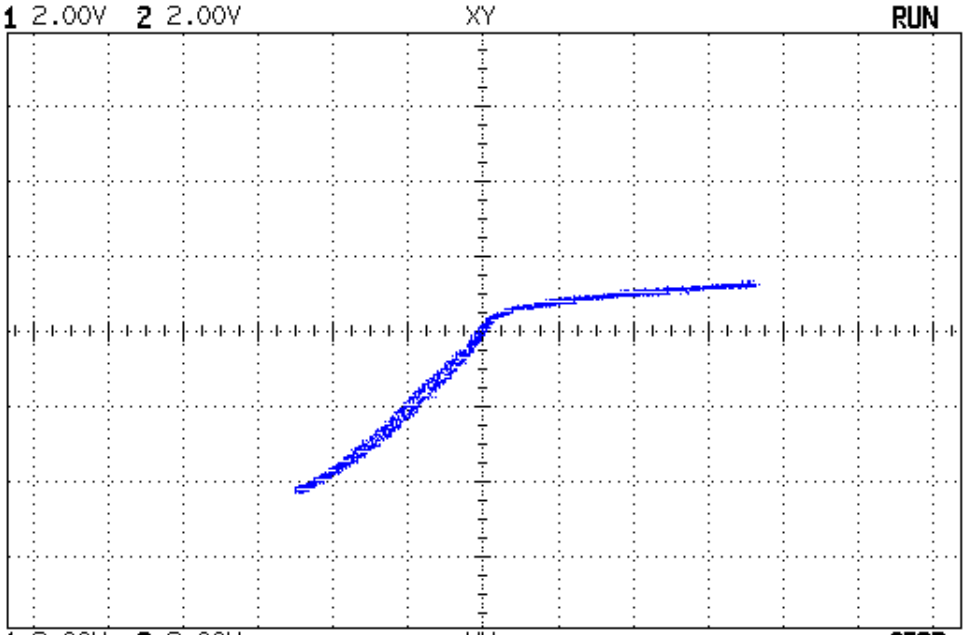


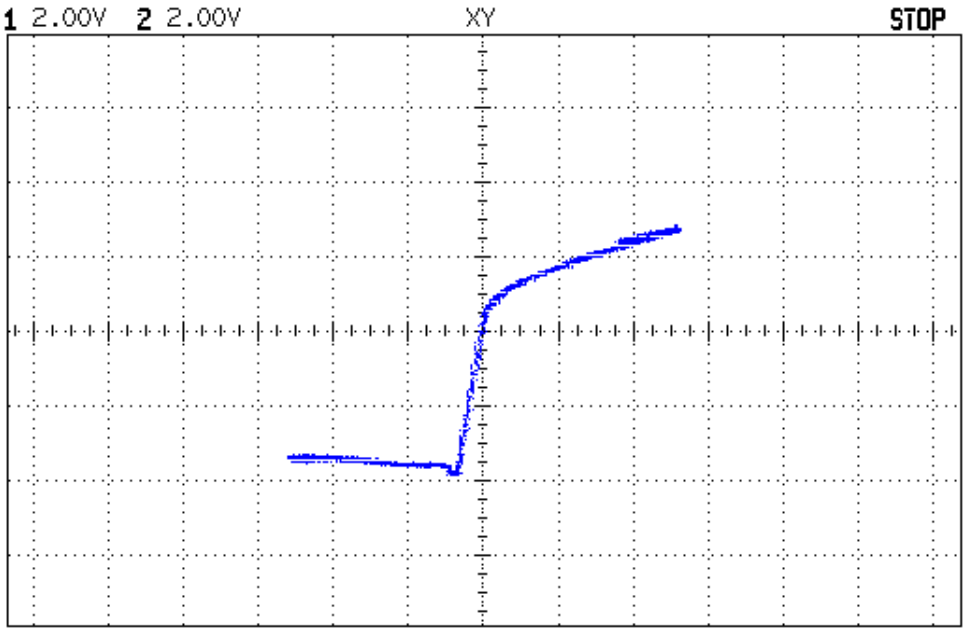
Galvanized Steel

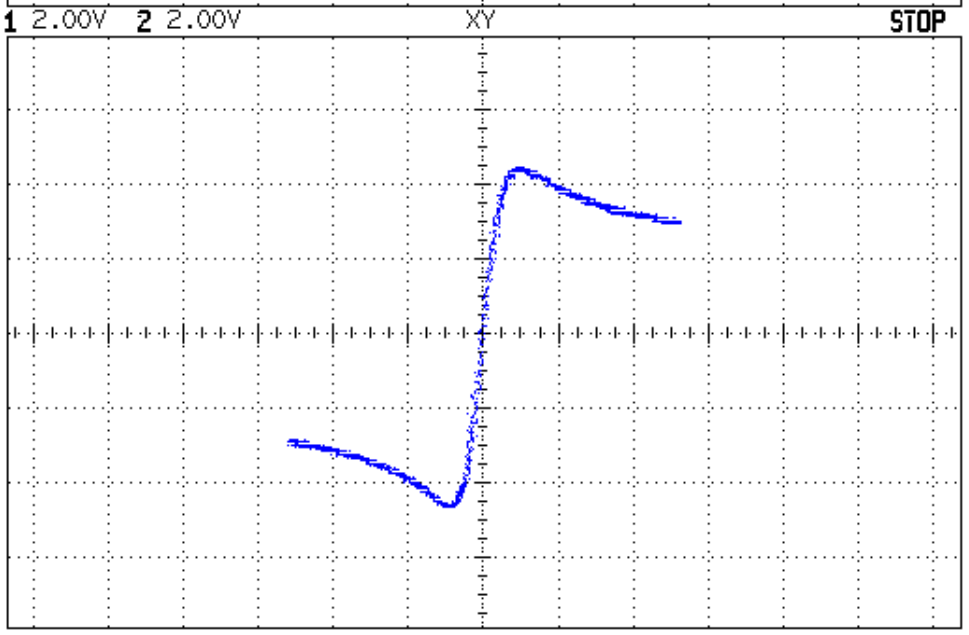
- Propane torch
  - Little black spots…
  - Do this outdoors!
- Iron-tin-zinc alloy?
  - Cadmium? *Ick!*
- Looks like high R
  - And not a diode
- But wait…

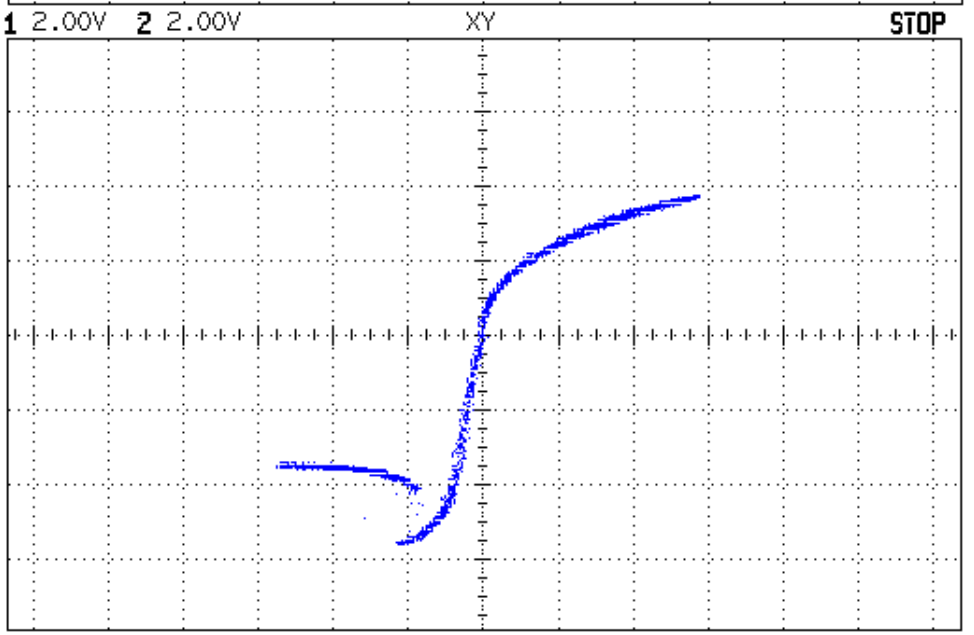


Galvanized Steel Bestiary







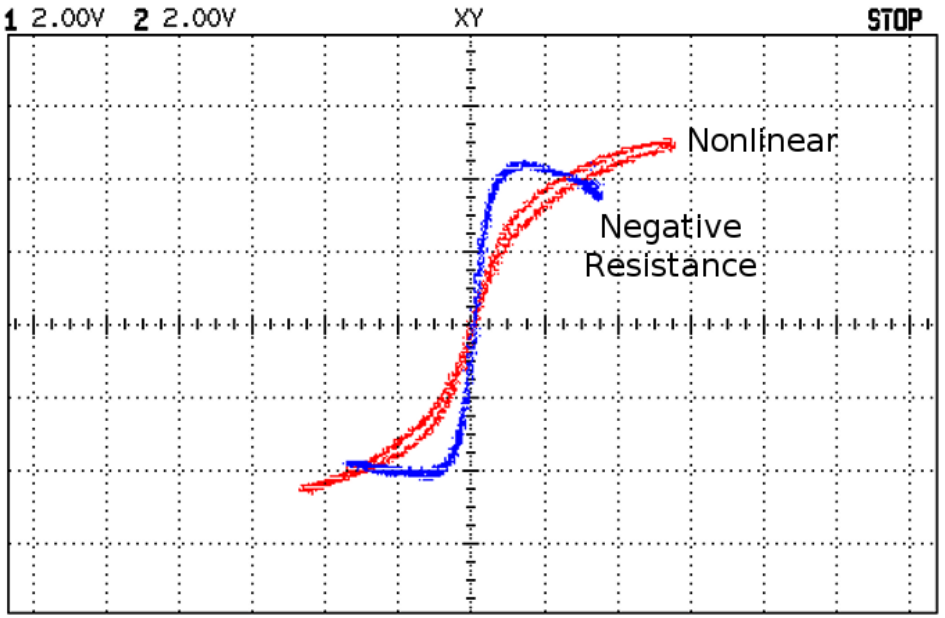


Rust Never Sleeps

- Ordinary steel bolt
- Salt + towel + copper
  - Cu + Fe = 650 mV
  - At *only* 1 mA
  - Slow and steady
- AA cell
  - 1500 mV & 10 mA
  - 4 hours later…

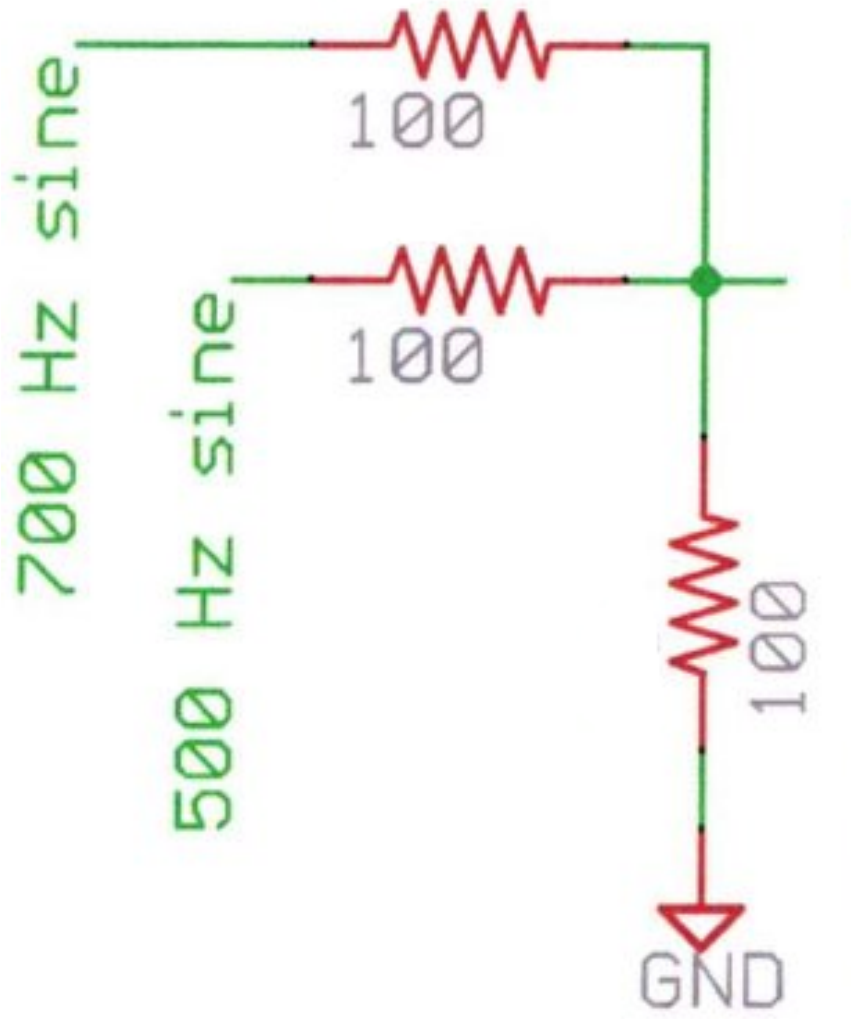
Steel Corrosion

- Nonlinear
- Symmetric
  - Sorta, kinda
- Negative resistance
  - Oscillator!
- No Battery Needed
  - Self-biasing circuitry
  - DC bias + small AC

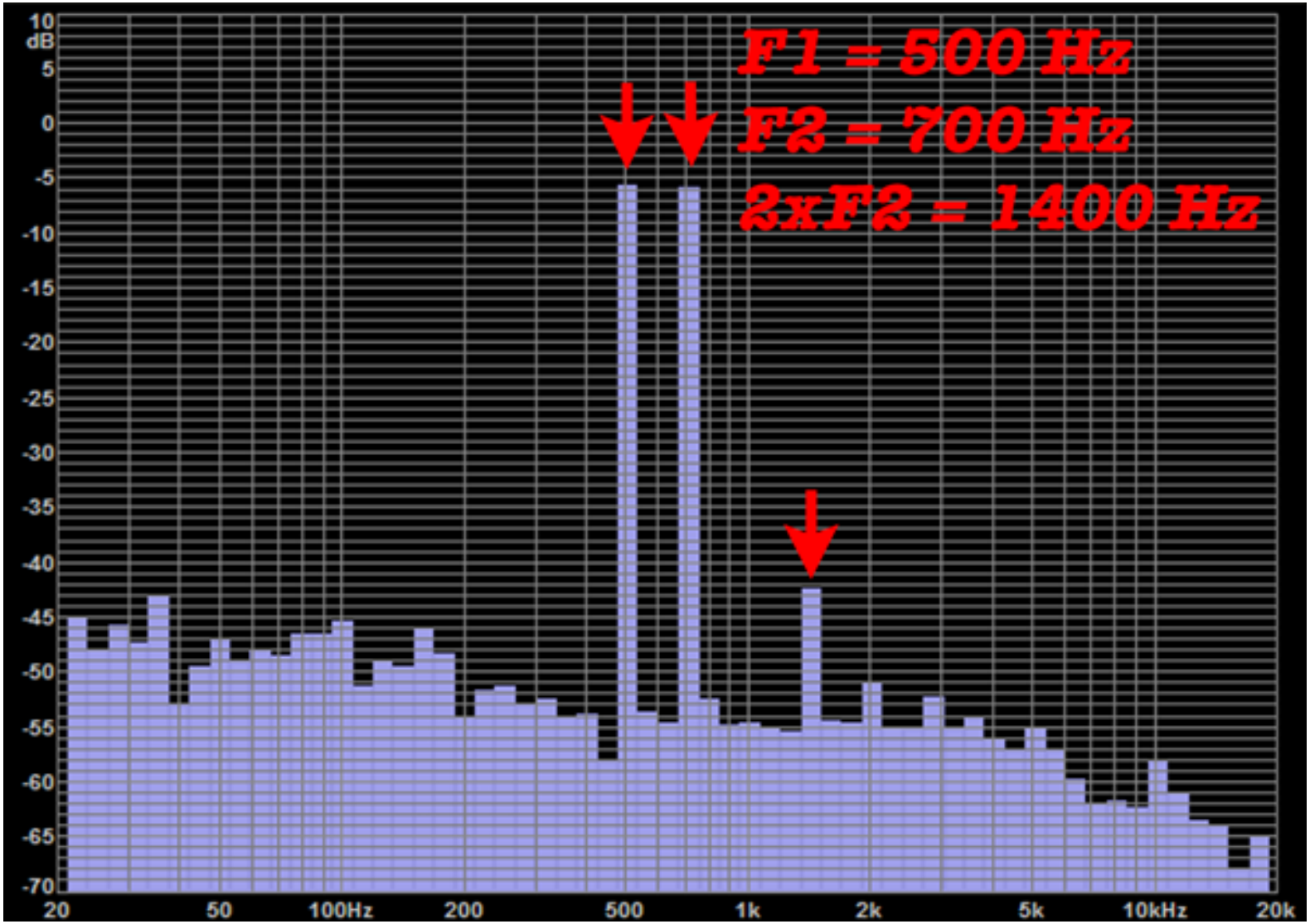


Linear Mixing Circuit

- Linear mixing
  - Only “resistors”
  - Sum of amplitudes
  - No surprises
  - Ohm’s Law, etc

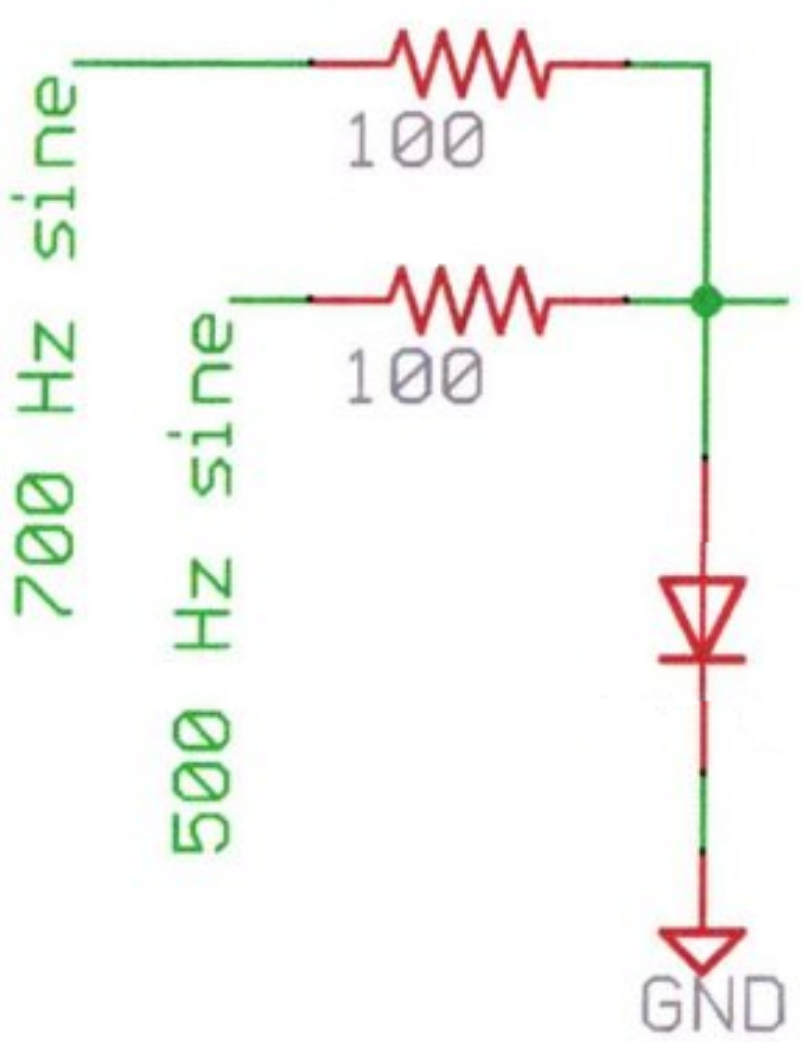


Linear Mixing Results

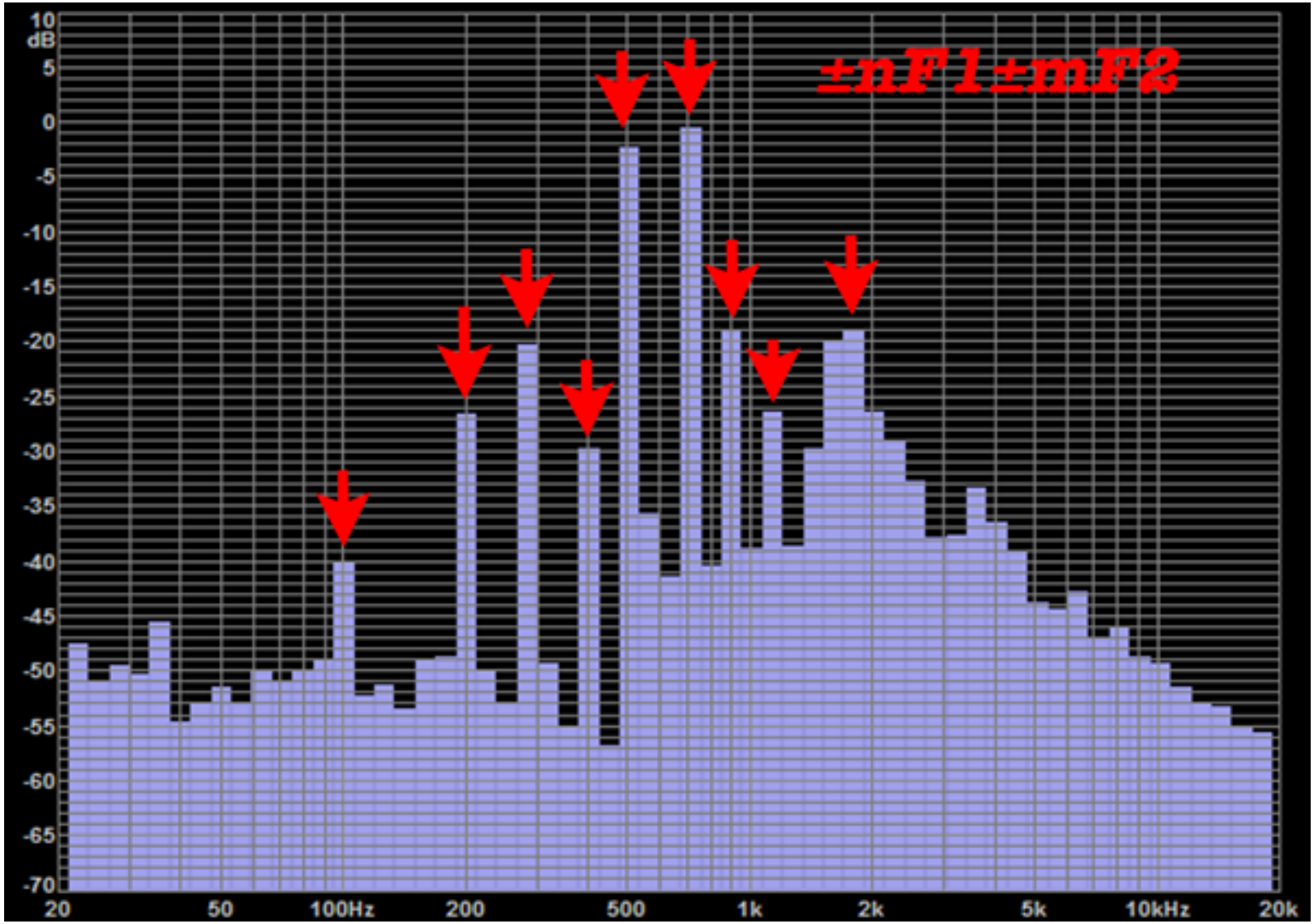


Nonlinear Mixing Circuit

- Nonlinear mixing
  - Usually a diode, but …
  - *Any* nonlinearity will do
  - $\pm nF_1 \pm mF_2$
  - Amplitudes? Hah!
  - No analytic equations
  - Simulation values?



Nonlinear Mixing Result



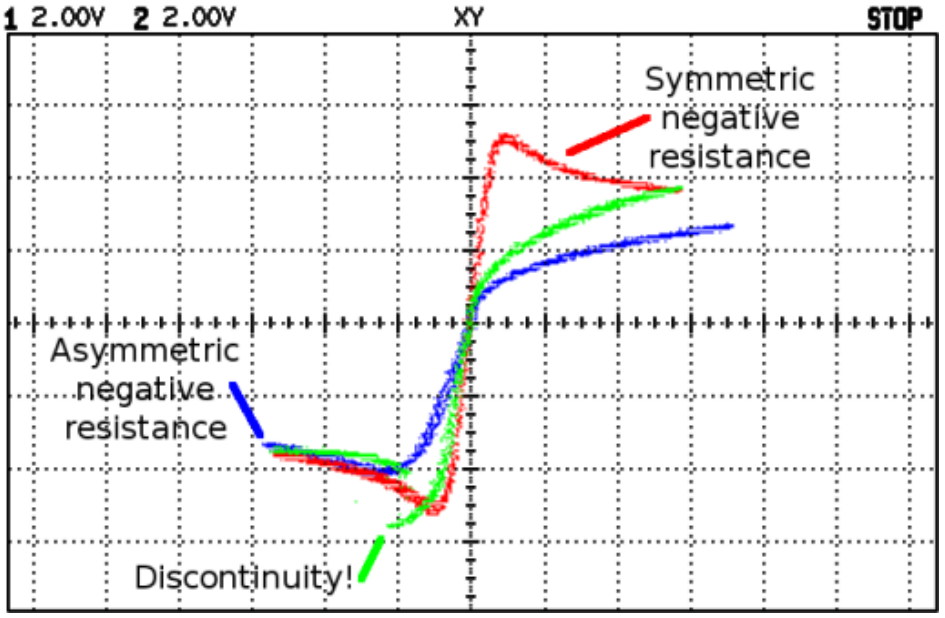
RF vs. The Rusty Bolt

- Mountaintop radio
  - *Many* transmitters
  - High RF field intensity
  - Sensitive receivers
  - Galvanized towers
  - Acid rain
- Corrosion
- Intermodulation!
  - $\pm nF_1 \pm mF_2 \pm pF_3 \pm \ldots$

Mt Beacon NY - Photo by WB2UWU

DIY Diodes

- They're everywhere
- They're cheap
  - OK, not that positioner
- They're easy, sorta
- You'll learn…
  - … about electronics
  - … about patience
- ***Demo: Sunday AM!!***



References

My column in Circuit Cellar magazine: www.circuitcellar.com
October 2006 is mostly this talk, has file of scripts, pictures, other stuff
February & April 2003 describe nonlinear frequency mixing

Semiconductor curve tracer using PC sound card: George Steber, WB9LVI
Circuit Cellar, Jan 2004
ARRL QEX, July 2006: http://www.arrl.org/qex/2006/07/qx7steber.pdf

Good overview of crystal-set parameters: http://www.oldradioworld.de/gollum/analysis.htm

Zinc negative resistance oscillators: http://home.earthlink.net/~lenyr/zincosc.htm

Galvanic Series table: http://www.ocean.udel.edu/seagrant/publications/corrosion.html

Wood's metal, springs, phosphor bronze sheet, tools from MicroMark: http://micromark.com/

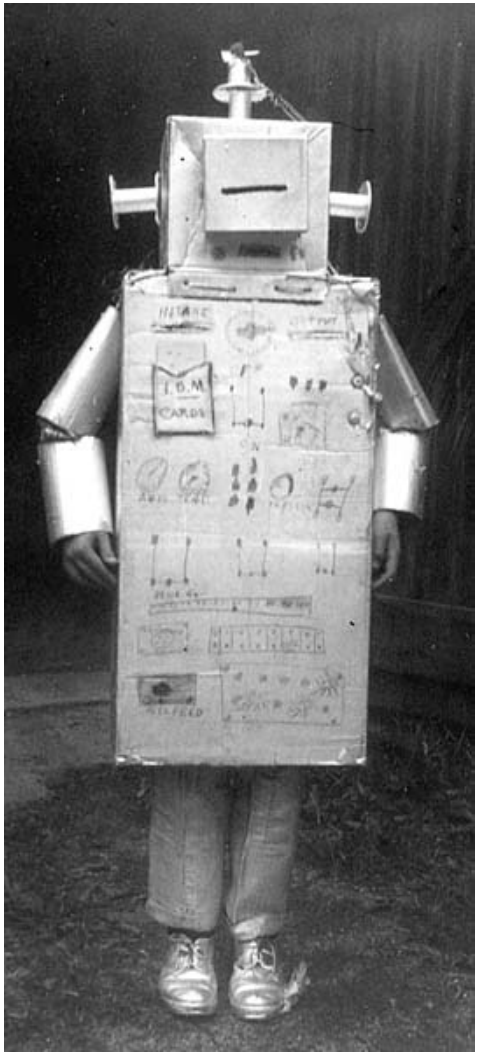
Taper pins and small parts from S. LaRose, Inc: http://www.slarose.com/ (dead on 18 Aug 06)

Capturing oscilloscope traces with Kermit: http://www.columbia.edu/kermit/index.html

Converting HPGL to bitmaps with hp2xx utility: http://www.gnu.org/software/hp2xx/

Who Am I?

- Ed Nisley
  - Say “NISS-lee”, even though my ancestors were half-essed
  - Engineer, author, tinker, family guy
  - Circuit Cellar: Above the Ground Plane - www.circuitcellar.com
    - Analog & RF stuff
  - Dr Dobb’s Journal: Nisley’s Notebook - www.ddj.com
    - Embedded systems & hardware stuff



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