Test Equipment

For Amateur Radio

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Guang-Hua Electronic Plaza

- The Electronics District in Taipei is a full city block of small and large electronics stores.
- This place is three underground floors with dozens of small shops selling a dazzling array of electronic parts and test equipment.
- The tiny test equipment shops always have interesting things, at unbelievably low prices, in their display cases…. but, are they useful?

Basic Test Equipment for the Ham Shack

- Multimeter
- Oscilloscope
- Frequency Counter
- RF Source
- Power Meter
- Antenna Analyzer
- Spectrum Analyzer
- Laboratory Standards

Multimeters

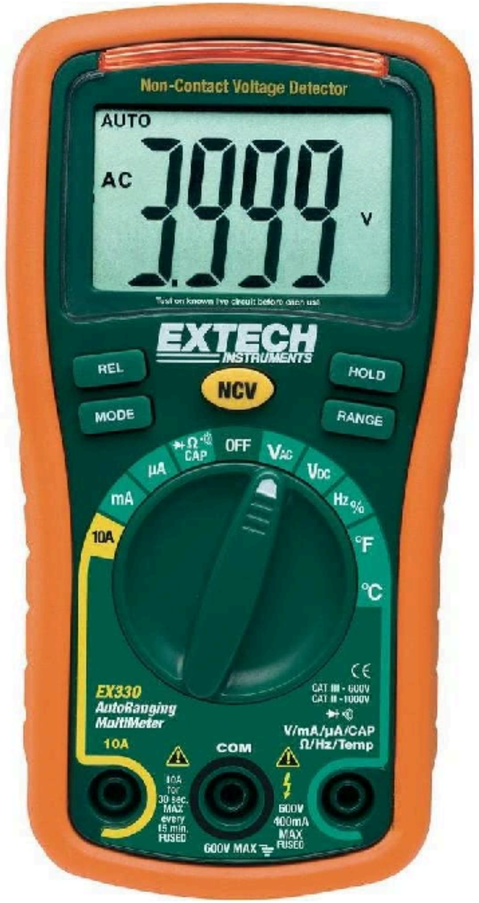
Fluke 115 and 179

- Fluke 115
- True RMS
- Autoranging
- One-handed operation
- $150, new

- Fluke 179
- Manual and automatic ranging
- Display Hold and Auto Hold
- Min/Max-Average recording
- Voltage measurements to 1000 V AC or DC
- Current measurements to 10 A AC/DC
- Resistance to 50 MΩ; capacitance to 10,000 µF, frequency to 100 kHz; temperature from -40 °C to 400 °C
- $325, new

Budget Meters

- Extech 330
- Not True RMS
- Autoranging
- AC Voltage Detector
- Capacitance & Frequency
- Thermometer
- $50, new on Amazon

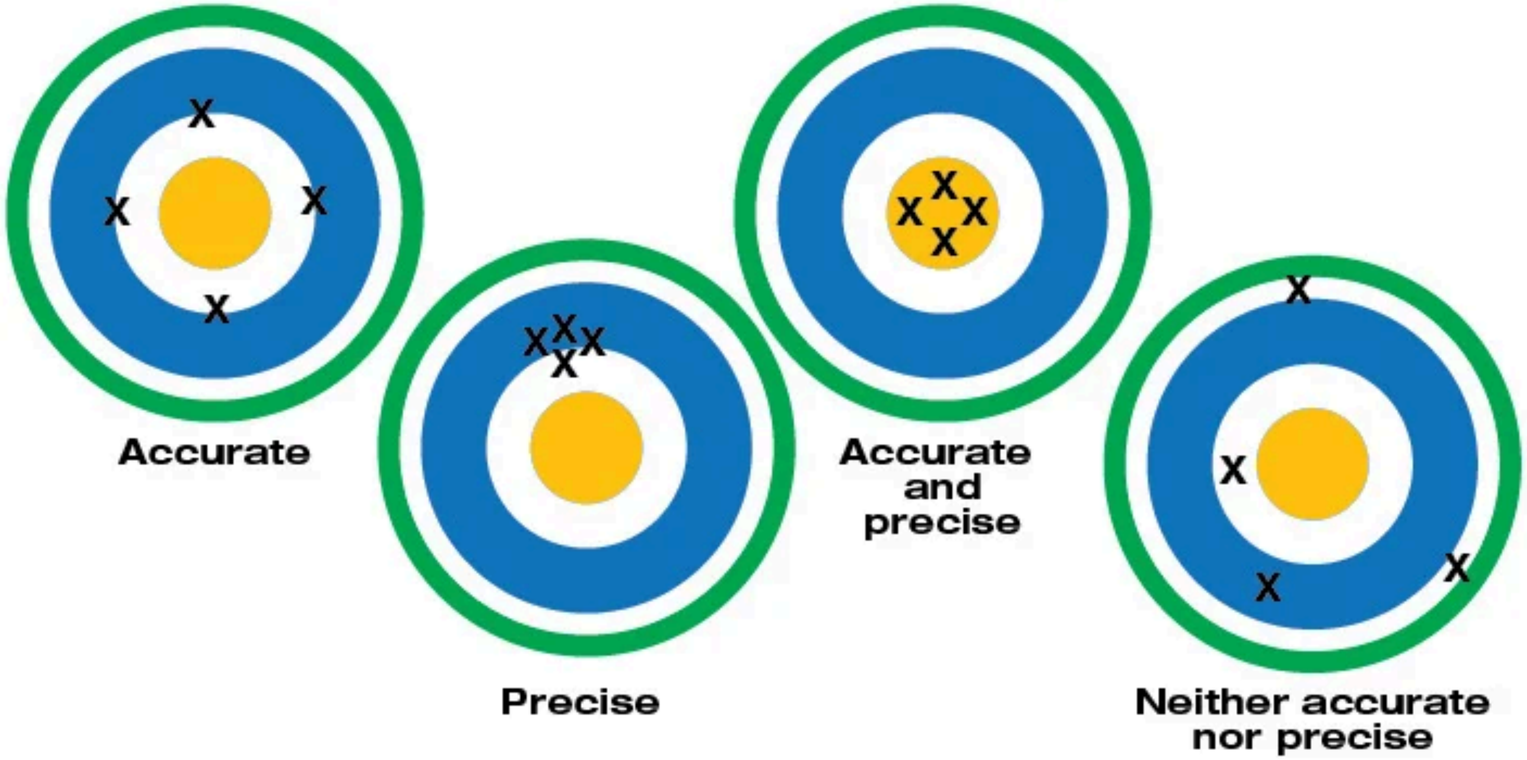


- WeePro Vpro850L
- Not True RMS
- Not Autoranging
- Transistor & diode tester
- $12, new on Amazon

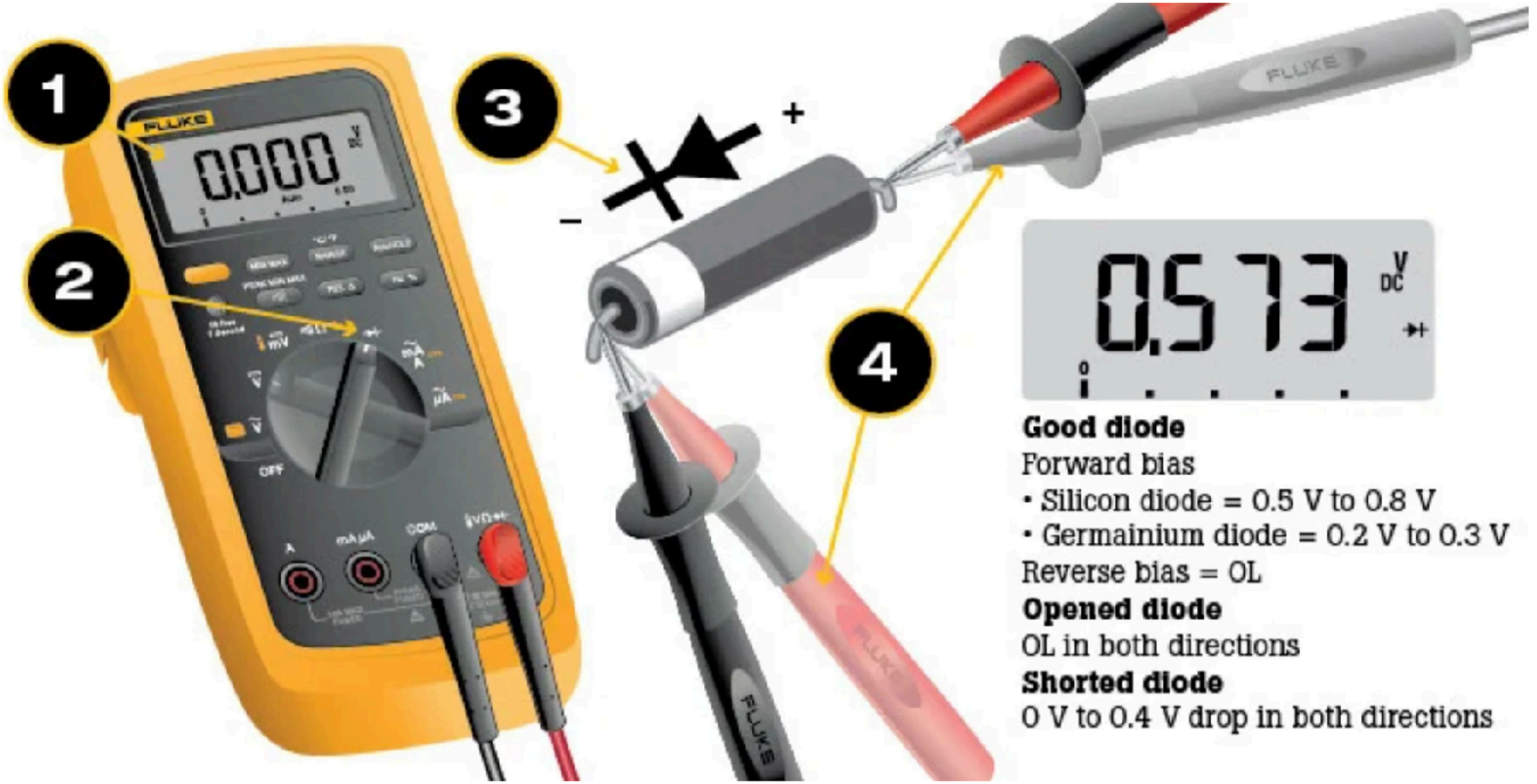
Fluke 8840A Bench DMM

- Reads to 0.001 ohm
- $75, used

Accuracy and Precision



How to test Diodes



Good diode
Forward bias
- Silicon diode = 0.5 V to 0.8 V
- Germainium diode = 0.2 V to 0.3 V

Reverse bias = OL

Opened diode
OL in both directions

Shorted diode
0 V to 0.4 V drop in both directions

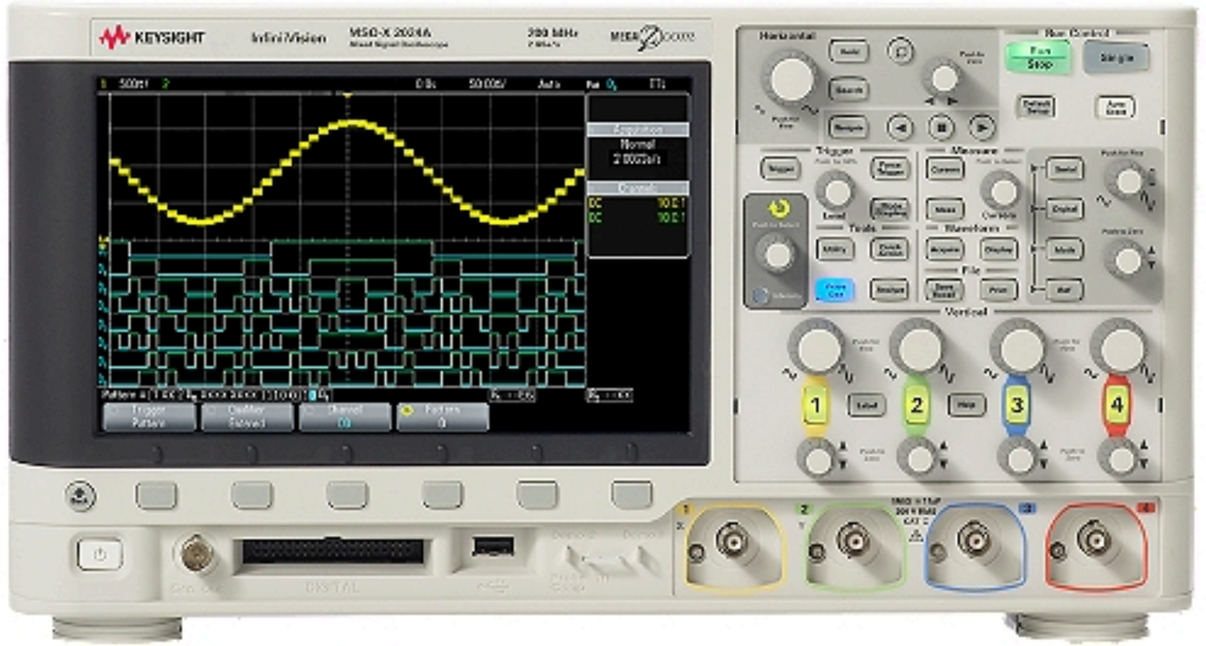
Oscilloscopes

Tektronix 465 Oscilloscope

- Introduced in 1972 (465B in 1980)
- 100 MHz
- 2 Channels
- CRT display, 18.5 kV
- $150-$250 on eBay

Keysight MSOX2024A Mixed Signal Oscilloscope

- 200 MHz
- 4 analog plus 8 digital channels
- Sample rate: 2 GSa/S
- $4103
- Upgrades:
  - $183 Embedded Analysis
  - $535 Function Generator



Siglent SDS-1202X-E

- 200 Mhz
- 2 Channels
- 1 GSa/S
- $379 at Amazon

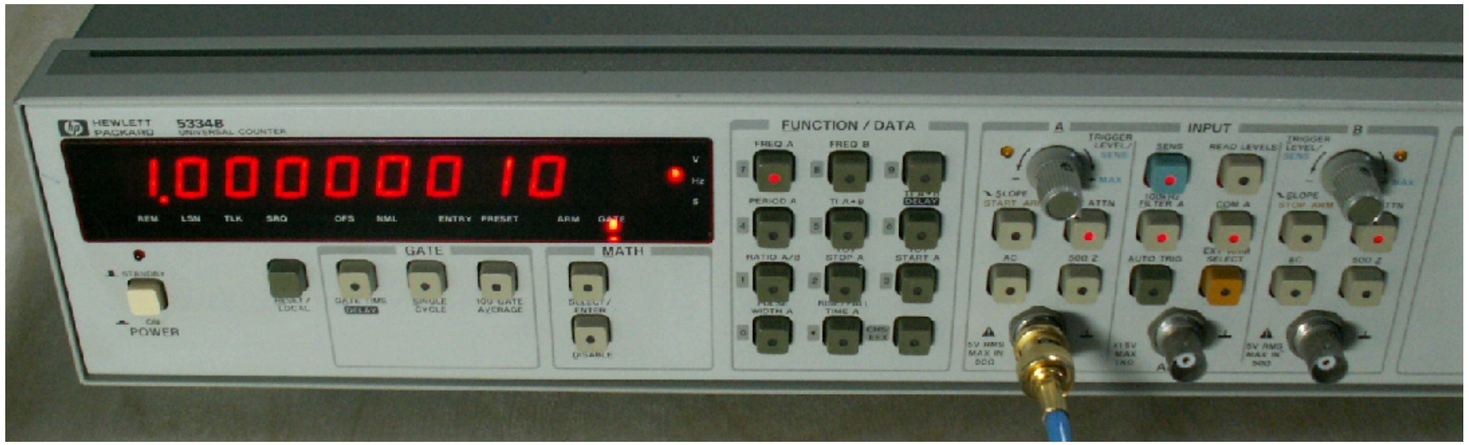
YEAPOOK ADS5012h Handheld Digital Portable Oscilloscope

- 100 Mhz
- 1 Channel
- Triggered
- Waveform Storage
- $82 at Amazon

Frequency Counters

HP5334B Frequency Counter

- 1300 MHz
- $250 on eBay



Logic Analyzer: Buying Guide

- New, Low-cost
- Oscilloscope added feature
- Used: HP, Tektronix

Logic Analyzer Demo: Raspberry Pi

- Logic Analyzer

FA-2 Precision Frequency Counter

- 13 Digits
- 0-6GHz
- $127 on eBay

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RF Sources

Elecraft XG3 Signal Generator

- Frequency Range: 1.5-200 MHz range, with a typical resolution of 1-24 Hz. (Up to 1400MHz via harmonics)
- Frequency Stability: ±50 ppm, maximum.
- Signal Characteristics: Highly stable RF square wave; phase noise -105 dBc/Hz
- Preset Frequencies: 12 frequencies preset at the factory - one in each Amateur band from 160 through 2 meters. Frequencies may be changed using a personal computer.
- Sweep Mode: Two frequency ranges preset. The sweep speed and the frequency increment for each step may be programmed using a personal computer.
- Computer Interface: RS-232 or USB: Allows changing the preset frequencies and operating the XG3 from a personal computer using the XG3 Utility program available free from Elecraft.
- Selectable Output Levels: Four levels, calibrated from 1.5 through 200 MHz: 0 dBm (± 3 dB), -33 dBm, -73 dBm, - 107 dBm (± 1 dB typ).
- Output Impedance: 50 ohms.
- $270 from Elecraft
- https://elecraft.com/products/xg3

WB-SG1 Signal Generator

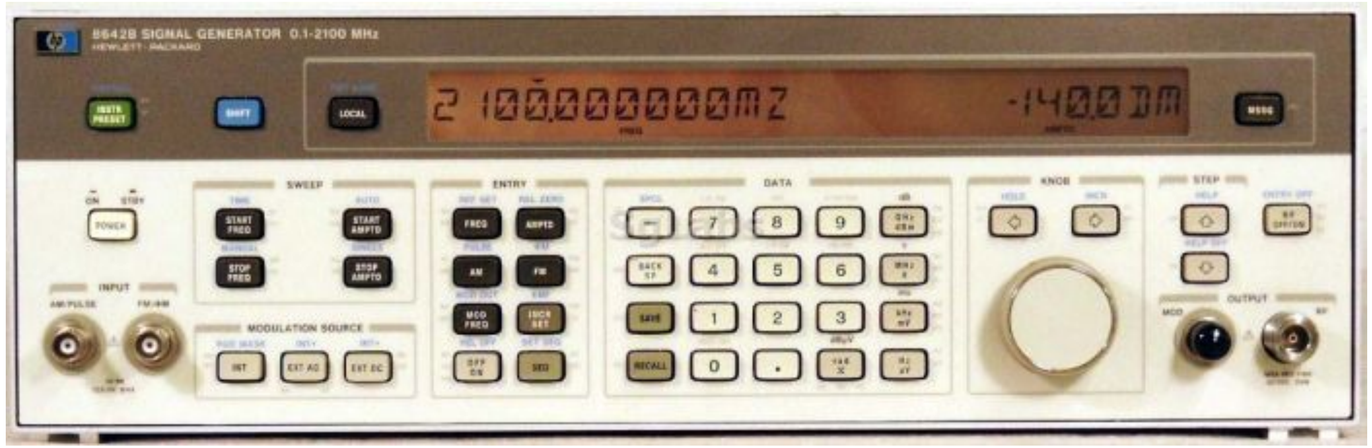
- CH1 Frequency Range: 1Hz-200MHz
  Steps: 1Hz: 1Hz-19.9MHz, 10 Hz: 20MHz-200MHz
- CH1 Output Amplitude: 3.3 Vpp
- CH2 Frequency Range: 10MHz-20GHz (10Hz steps)
- Internal Reference Frequency: 10MHz
- Internal Reference Type: constant temperature crystal (TCXO?)
- Internal Base Year Aging: 0.5Hz
- 10MHz reference output power: 5dBm
- External reference input power range: 0dBm to +20dBm
- https://www.thanksbuyer.com/wideband-rf-signal-generator-power-regulation-broadband-support-external-reference-wb-sg1-1hz-20g-64635
- $329 at thanksbuyer.com

GPS-Disciplined Oscillator (GPSDO)

- Leo Bodnar Electronics
- Outputs low-jitter reference clock frequency-locked to GPS signal.
- Long term stability of output signal is defined by high accuracy of GPS Cesium references and approaches $1x10^{-12}$.
- Short term signal quality is defined by internal TCXO clock source providing high-quality, low phase noise clock signal with sub-picosecond RMS jitter.
- Digital PLL allows main output reference frequency to have almost any value between 400Hz and 810MHz.
- Output signal is a square wave at 3.3V CMOS levels with 50 Ohm characteristic impedance. Output drive level can be adjusted.

HP8642A Signal Generator

- 100 kHz — 2100 MHz
- < -134 dBc/Hz SSB phase noise
- ±1 dB absolute output level accuracy down to -127 dBm
- Up to +20 dBm output level reduces the need for external amplifiers
- AM, FM, phase and pulse modulation
- Up to 100 kHz modulation rates with low-distortion internal oscillator
- $2000, eBay



Power Meters

MFJ-874 Peak-reading SWR/Wattmeter

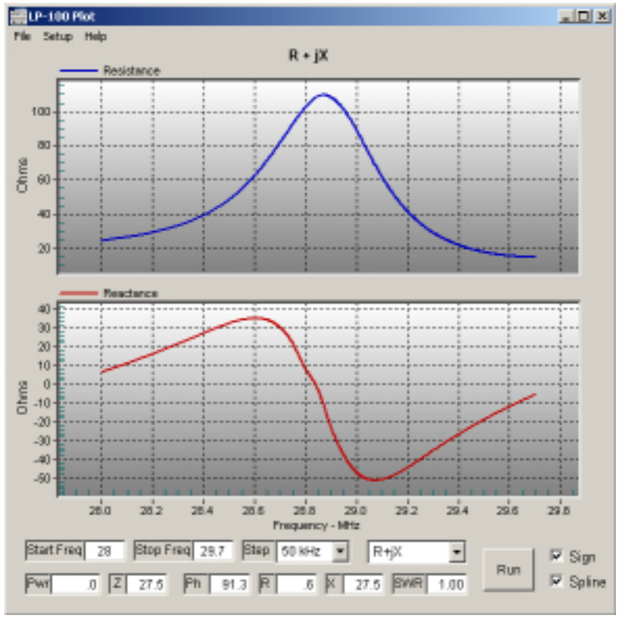
- Seven ranges per element
- 5% accuracy
- $300 with elements

Bird 4410A

- Seven ranges per element
- 5% accuracy
- $300 with elements

Telepost LP100A Digital Vector Wattmeter

- Coupler options:
  - 0.10W to 3KW,1.8 to 54 MHz
  - 0.10W to 5KW, 1.8 to 30 MHz
  - 0.10W to 5KW,1.8 to 54 MHz
  - 0.20W to 10KW, 1.8 to 30 MHz
- $475 with 3kW coupler
- http://www.telepostinc.com/lp100.html

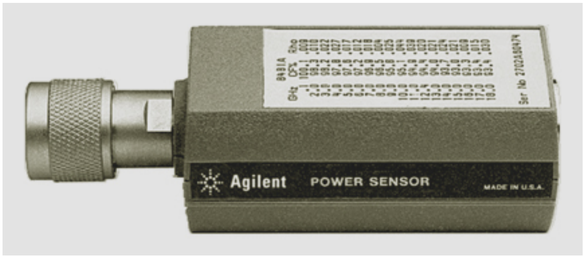


HP 432A, 435B, 436A

- $99, eBay (without sensor)

- $30, eBay (without sensor)

- $95, used (without sensor)



- HP81841A Power Sensor
- -30dBm to +20dBm
- $550, used

MFJ-874 Peak-reading SWR/Wattmeter

Model	MFJ-872	MFJ-873	MFJ-874
Frequency Range	1.8 - 200 MHz	125 - 525 MHz	1.8 - 525 MHz
Power Range	1W to 200W		
Power Scale	5W, 20W, 200W		
Maximum Power	200W		
Accuracy 5W Range	+/- 10% (AVG)		
	+/- 15% (PEP)		
20W-200W Range	+/- 5% (AVG)		
	+/- 10% (PEP)		
VSWR	Min Power required = 1 Watt for F.S.D.		
Input/Output Impedance	50 Ohms		
Input/Output Connectors	SO-239		
Dimensions (W/H/D) in	7.5 X 3.35 X 5.3		
Weight (lbs)	1.76		
Accessories	Instruction Manual & Lead wire with DC Plug		

- $129.95

RF-Power8000 OLED RF Power Meter

- Measuring power range: -45 ~ + 5 dBm (external RF attenuator can be extended to 100dBm)
- Measurement resolution: 0.1 dBm
- Measurement frequency range: 1MHz-8000MHz
- Measured power: 1nW ~ 2W
- $38 from Banggood

Antenna Analyzers

MFJ-223

- 1-60 MHz
- Measures SWR, R, X, and Z
- +5dBm Output
- Battery-powered
- $340

Rig Expert AA-55 ZOOM

- 60 kHz - 55 MHz
- Measures SWR, Return Loss, R, X, and Z
- +13dBm Output
- Battery-powered
- $265 at GigaParts
- AA-1500 ZOOM (1.5GHz) $900

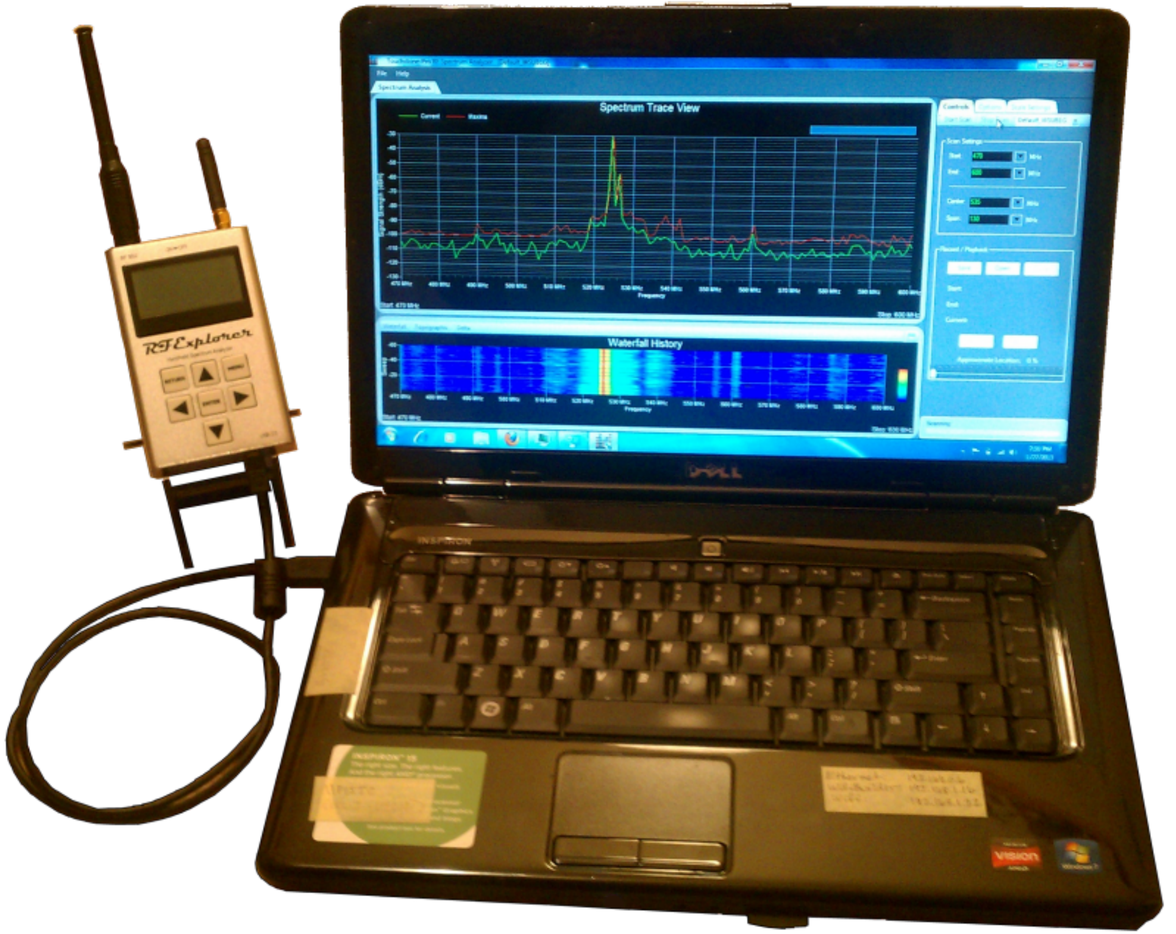
NanoVNA

- 10 kHz - 1.5 GHz
- RF Power output:) dBm
- Measures complete S11 and S12 Parameters
- Time-domain Reflectometer (TDR) Function
- $70 at GigaParts
- https://nanovna.com/

Spectrum Analyzers

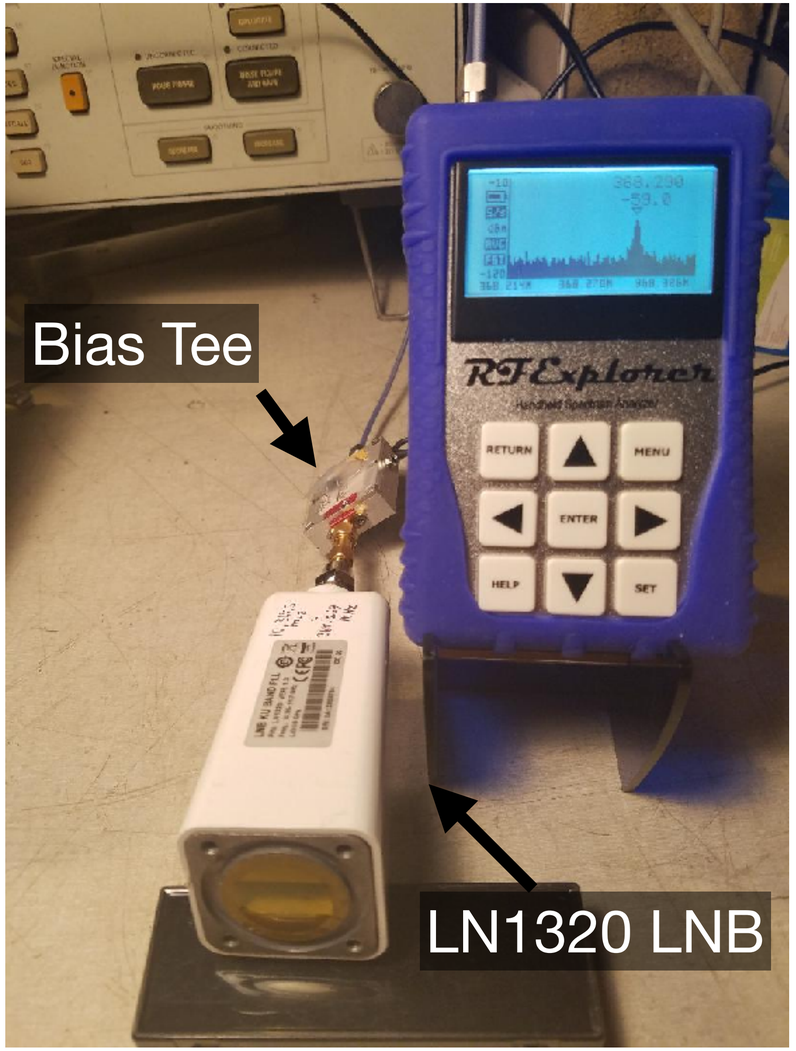
RF Explorer WSUB1G+

- 50 kHz — 960 MHz
- PC-hosted application software
- $200, Amazon
- http://j3.rf-explorer.com/



RF Explorer 10 GHz Spectrum Analyzer

- Fujitsu LN1320 Low-Noise Block Converter (LNB)
- 15-24 VDC via bias tee
- $20, used



K6JEY

Anritsu MT8212B Cell Master

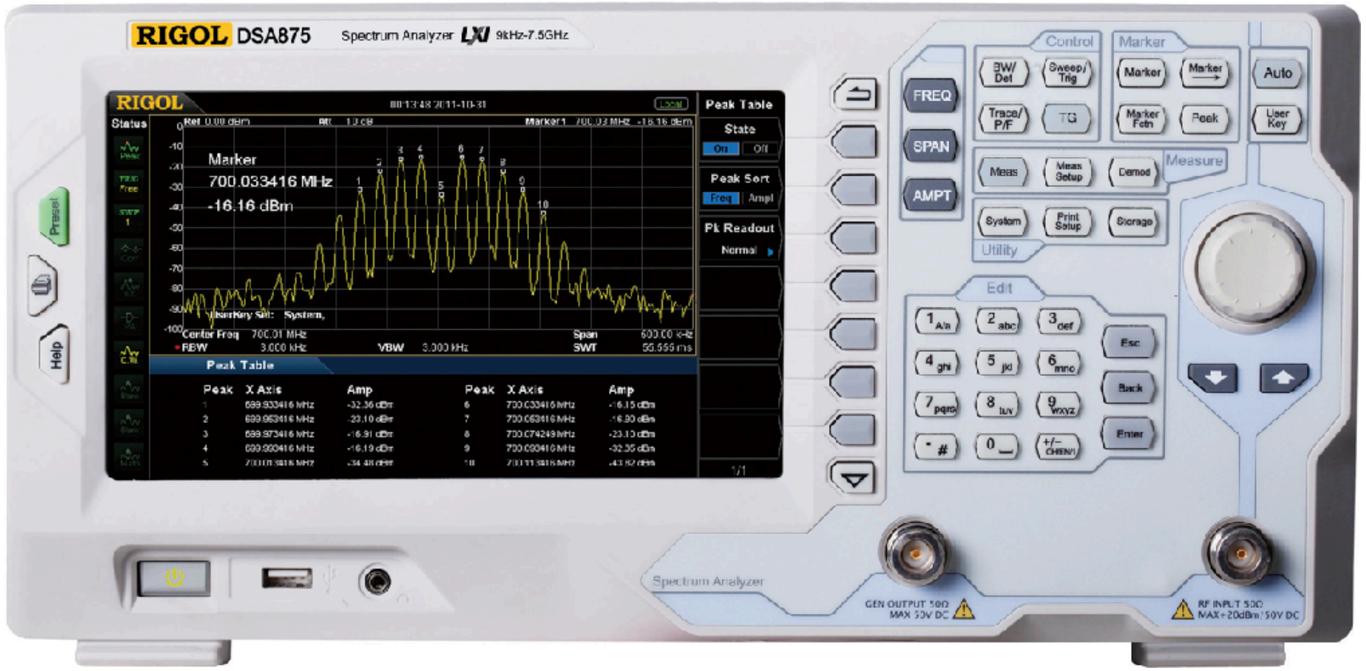
- 9 kHz — 3 GHz
- $800+ depending upon options, eBay

Anritsu MS2712E Spectrum Master

- 9 kHz — 4 GHz
- Measurements: Occupied Bandwidth, Channel Power, ACPR, C/I, Spectral Emission Mask, PIM Hunting
- Interference Analyzer: Spectrogram, Signal Strength, RSSI, Signal ID, Interference Mapping
- Battery-operated
- $1800—4500 depending upon options and condition, eBay

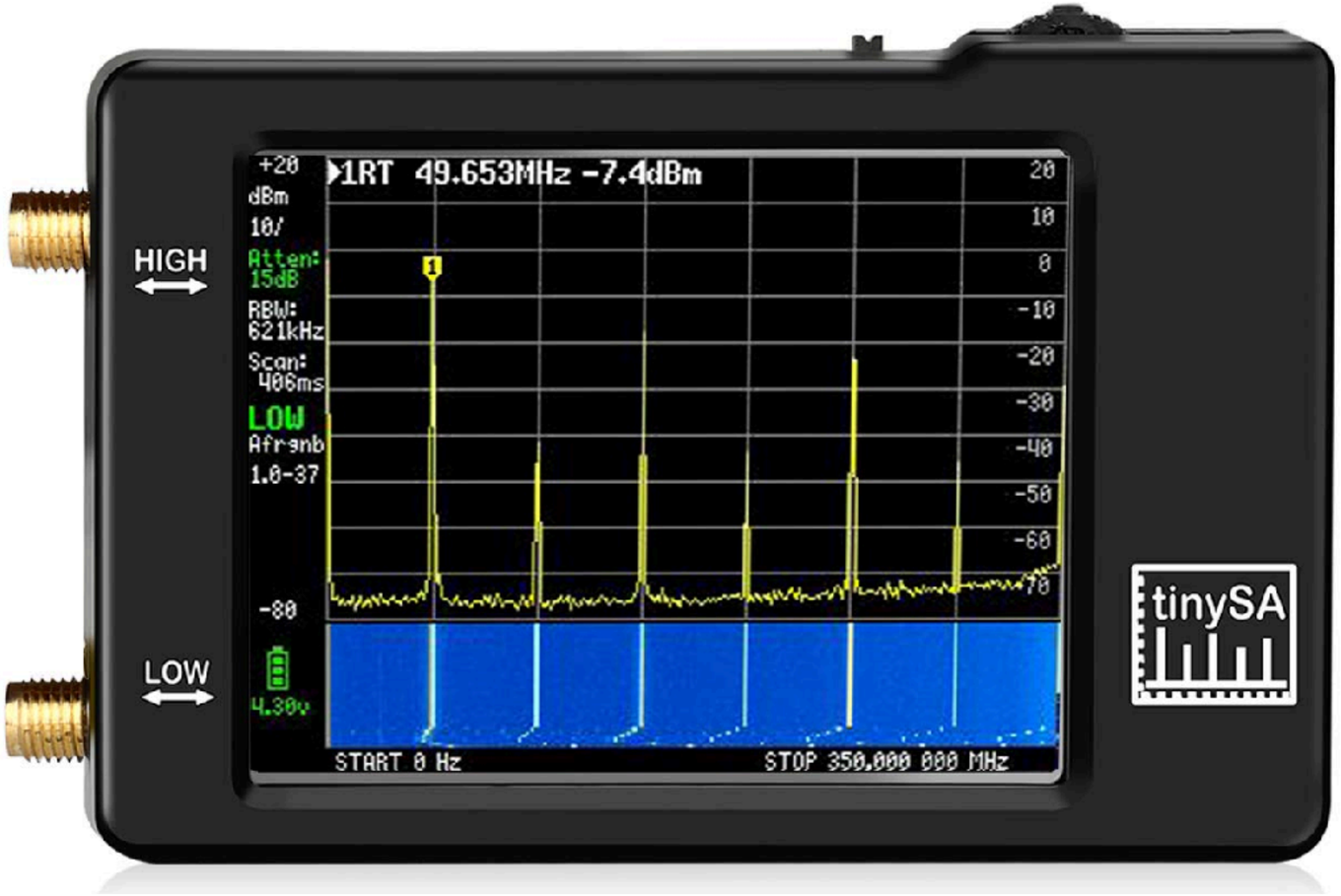
Rigol DSA-815TG

- 9 kHz — 1.5 GHz
- Tracking generator
- Typical -135 dBm displayed average noise level (DANL)
- 100 Hz minimum resolution bandwidth (RBW)
- Damage Level: +20dBm
- $999, Amazon Prime
- https://www.rigolna.com/products/spectrum-analyzers/dsa800/



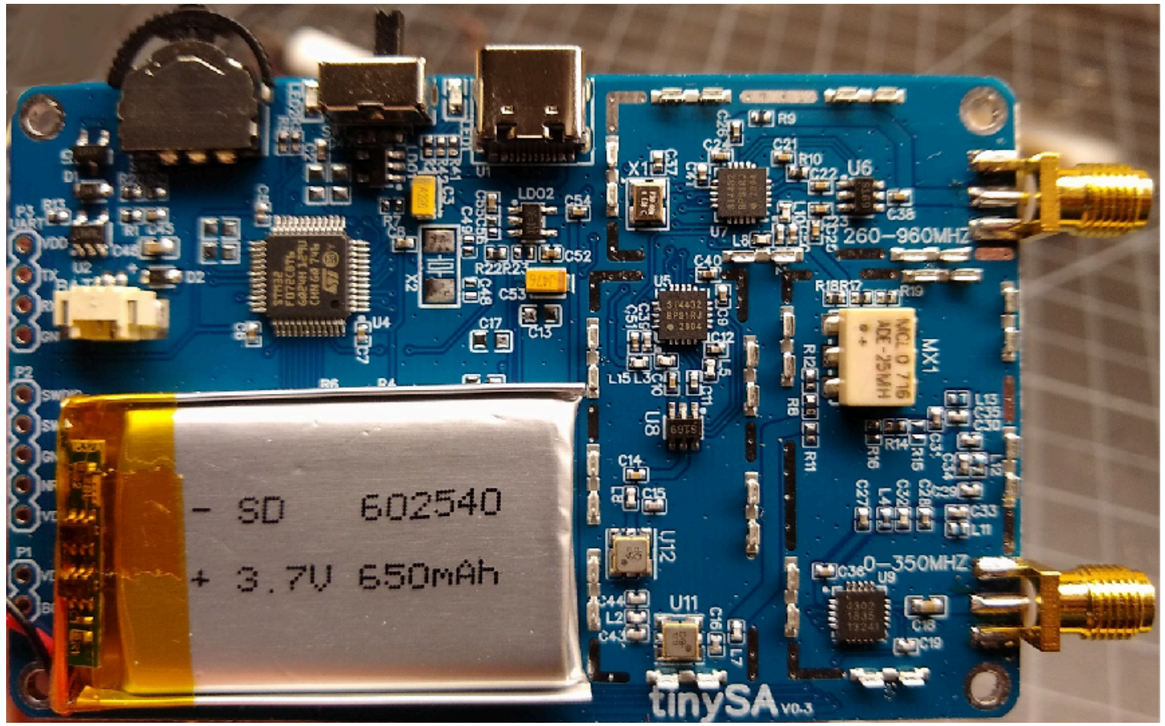
tinySA

- Frequency Range: 0.1MHZ-350MHz, lesser quality UHF input for 240MHz-960MHz
- Switchable resolution bandpass filters for both ranges between 2.6kHz and 640kHz
- Connected to a PC via USB it becomes a PC controlled Spectrum Analyzer
- Battery-operated
- $60-90
- https://tinysa.org/wiki/pmwiki.php?n=Main.HomePage



tinySA

- Maximum input signal level: +10dBm
- Signals below -30dBm should not generate spurs in low input mode
- The noise level with an Resolution Bandwidth (RBW) of 10kHz is about -105dBm
- Uses a resolution filter that is used to isolate the input power in a small frequency range.
- 350MHz with an RBW of 10kHz takes about 2 minutes.
- Limitations:
  - The internal phase noise sets a clear lower limit for phase noise measurements.
  - The minimum resolution bandwidth of 2.4kHz makes it impossible to see more spectral detail



Laboratory Standards

Primary Resistance Standard

- Resistor bank from 1ohm-100K ohms
- Temperature controlled oven
- Julie Research Labs
- ~$400 used

K6JEY

Voltage and Frequency Standards

- Valhalla Scientific Model 2701A
  - Precision Voltage Reference 0-10 V
  - ~$500 Used
- Bodnar Electronics GPSDO
  - Frequency Reference
  - £199 ($260)

K6JEY

Calorimetric Wattmeter

- Bird Model 6091
  - 1.5% accuracy
  - 10-200W
  - 0-2,5 GHz
  - ~$1000 Used

K6JEY

Calorimetric Low-power Wattmeter

- PRD Electronics Type 680
  - Thermopile AC/DC Transfer Power Meter
  - 1%
  - 1W max at 1GHz

K6JEY

RF Calibrator

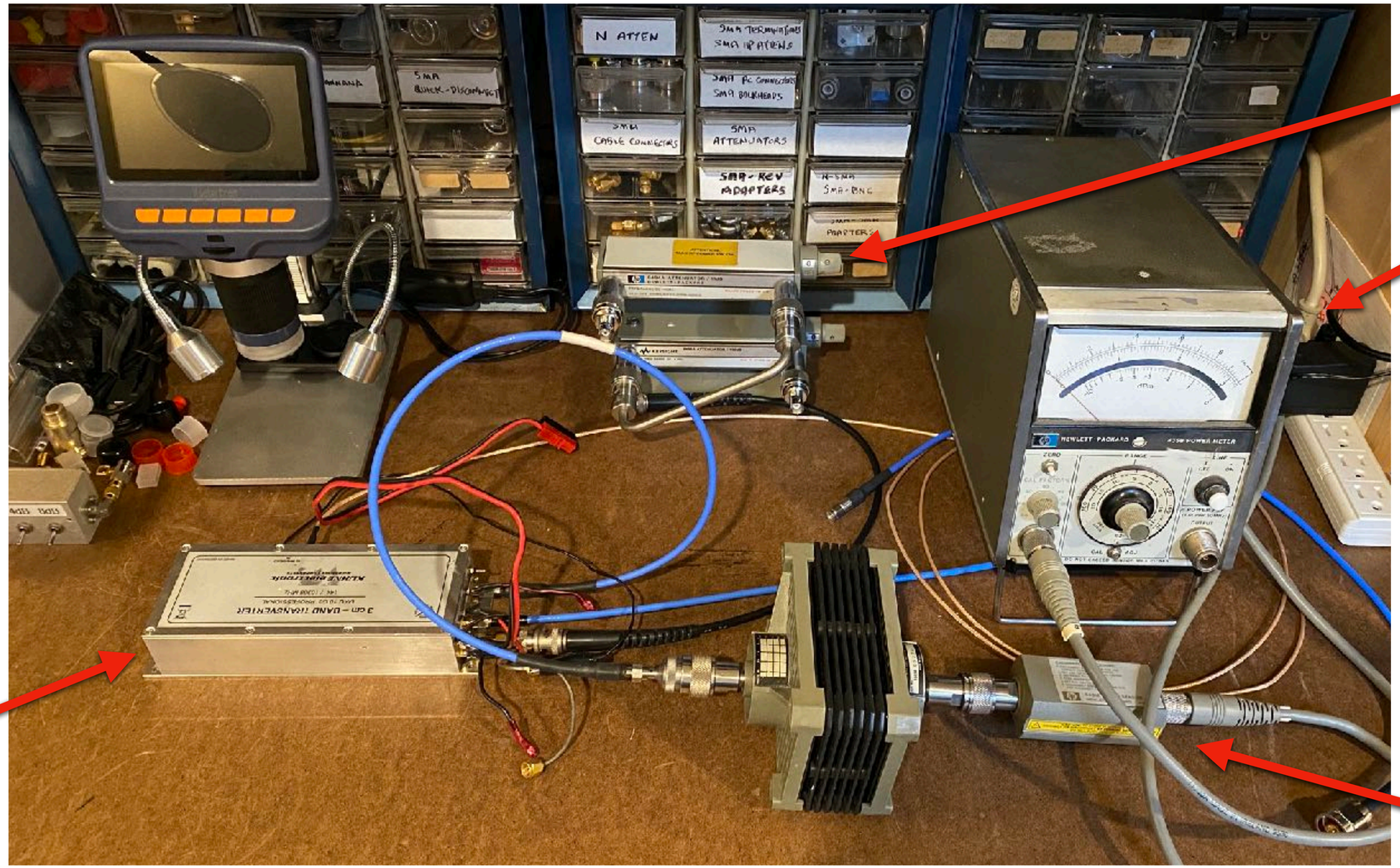
- Boonton 2520
  - Frequency: 30 MHz
  - -70 to +20 dBm in 0.1 dB steps
  - Frequency Accuracy: 0.1 %
  - $695, used on eBay

K6JEY

Examples

N6MN Test Bench

N6MN Project Bench



HP
HP8494A
Step Attenuator

HP
HP435B
Power Meter

DB6NT
10 GHz
Transverter

HP
HP-86818
Power Sensor

Thanks to:

- John Maxwell, W0VG
- Bill McNally, N6MN
- Dr. Doug Millar, K6JEY
- Rocky Mountain Ham Radio University Team!