Boonton 952001 RF Probe - 10KHz to 1.2GHz with 1.5pF loading:

Below is the schematic diagram of my probe serial number 10091. Please see the last section of this web page for more info about the special diodes, and do email me with your successes and failures. Please also help me identify the mysterious factory selected diodes as to manufacturer and part number.

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I have measured the unmarked diodes (custom manufactured by ITT) in this older revision probe, to expose the following characteristics:

```
<table>
<thead>
<tr>
<th>If</th>
<th>Vf</th>
<th>Measured at</th>
<th>Ir</th>
<th>Vr</th>
</tr>
</thead>
<tbody>
<tr>
<td>10uA</td>
<td>140mV</td>
<td>20 degrees</td>
<td>10uA</td>
<td>41.5V</td>
</tr>
<tr>
<td>100uA</td>
<td>210mV</td>
<td>Celsius</td>
<td>1uA</td>
<td>15.5V</td>
</tr>
<tr>
<td>1mA</td>
<td>320mV</td>
<td>100K ohm</td>
<td>0.4V</td>
<td></td>
</tr>
</tbody>
</table>
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Pictured below are some of the innards I pulled out of the probe. Notice the thin chip capacitor soldered between he two diodes and the probe tip header. The secretive diodes have no markings. No I did not destroy my probe, but would you like to buy it on eBay now that I've autopsied it a few times? Just kidding.

Older Boonton probes such as the 91-12A shown below, were designed to work with vacuum tube meters and so use 10K resistors at the output and have a slightly different mechanical construction, but are otherwise the same. This one belongs to Mark P.
Later revisions of the Boonton 952001 probe use 1KΩ resistors at the output, and the resistors at the diodes are selected during manufacturing to match individual diode characteristics. The resistor values and picture for probe serial number 18364 shown below are courtesy of Ray M.

THE UPDATED REV.B BOONTON PROBE CONTAINS:  
Detector Diodes: Infineon BAT62  
First resistors: 180 Ohm (200 Ohm)  
Second resistors: 150 Ohm (180 Ohm)  
Tip capacitor: 150pF 1000V RF  
Filter capacitors: 330pF 50V
Boonton 51013 (aka 4E) RF Power Sensor - 100KHz to 18GHz with built in 50 ohm termination:

Note diodes are wrapped in copper foil and casing is stuffed with 1/4" RF absorbing foam behind a teflon insulating disk.

Below is the schematic diagram of my sensor serial number 51013. The thin rectangular 750pF chip capacitor is soldered directly to the N connector center post, between the two red termination resistors. The white 160 ohm RF resistors are soldered directly in series with each diode. The termination is adjustable by loosening the screws and rotating the brass disks. Please see the last section of this web page for more info about the special diodes, and do email me with your successes and failures. Please also help me identify the mysterious factory selected diodes as to manufacturer and part number.

The unmarked diodes are almost certainly Low Barrier Silicon Schottky Detector Diodes, but they might be GaAs. Below is a sample probe characteristic.
Ballantine Labs 3440A Standard RF Probe - 10KHz to 1.2GHz with 2.5pF loading:

Below is schematic diagram of the probe circuit. Please see the last section of this web page for more info about the special diodes, and do email me with your successes and failures. The unmarked diodes are likely germanium hot carrier diodes as evidenced by the thermal stabilization circuit, consisting of the 2N4921 power transistor which heats the diodes to a constant temperature in order to prevent drift. Please email me if you have specific information regarding the diodes.

Ballantine Labs 3440A3 Precision RF Probe - 10KHz to 1.2GHz with 2.5pF loading:

Below is schematic diagram of the probe circuit. Please see the last section of this web page for more info about the special diodes, and do email me with your successes and failures. The unmarked diodes are likely germanium hot carrier diodes as evidenced by the thermal stabilization circuit, consisting of the 2N4921 power transistor which heats the diodes to a constant temperature in order to prevent drift. Please email me if you have specific information regarding the diodes.

Ballantine & Boonton 100:1 probe tip screw on voltage divider:

These are calibrated to each probe by means of thin plastic shims which have a very low dissipation factor at GHz frequencies. Squishy teflon and brittle polystyrene comes to mind. They are capacitive dividers containing no resistors.
Connecting cable for Sensors and Probes - Shielding arrangement:

The cable consists of two individually insulated coaxial shielded wires in a twisted pair configuration which is additionally shielded by an outer braid. The two inner shields and the outer braid attach to the connector shell/GND at the meter side, but at the probe/sensor side only the outer braid connects to the housing/GND leaving the inner shields totally unconnected. Be mindful that the cable carries a small DC voltage proportional to the amplitude of the RF signal, and that impedances rise extremely high when measuring microvolt or nanowatt levels, making the cable susceptible to leakage and movement. Below is an example Boonton cable; the Ballantine contains some extra wires for running the probe heater.

Square Law Detector Diodes - Details and general information:

A diode detector continues to produces a DC output even when the AC input falls orders of magnitude below the diode junction threshold voltage. This is called square-law region operation and here the DC output voltage is proportional to the square root of the peak AC input voltage. For the full-wave square-law diode detectors discussed here, we have $V_{out} = (V_{in}/5.8)^{1/2}$ where $V_{in}$ is in mV RMS and $V_{out}$ is in mV DC. Ordinary PN junction silicon diodes and ordinary Schottky hot carrier diodes have an extremely high video resistance when biased to mere microvolt levels, making it difficult to separate a meaningful DC output signal from the noise. Such diodes typically also have too much junction capacitance and this leads down the signal source at megahertz or higher frequencies. Therefore you must use one of the special types of hot carrier diodes listed below, many of which are already configured as back to back matched pairs in a single SMD package. In any case you will need to recalibrate your millivoltmeter in order to obtain correct readings with your choice of diodes. For more details simply Google for "square law diode" or "square law diode" or "zero bias Schottky" but be sure to include the quotes to ensure relevant results.

1) Zero Bias Silicon Schottky Detector Diodes. These have a reverse breakdown voltage of only around 3V so they are only good for measuring signals of 1 volt or less, but they work fantastically well in the microvolt and nanowatt ranges, and they exceed the 1.2GHz upper limit original spec of the Boonton probes.

   www.infineon.com  BAT32
   www.agilent.com  HSMS-2852
   www.nicrometrics.com  M2600B
   www.calmtech.com  CMS-825X
   www.skyworksinc.com  SMS7630
   www.mpulsemw.com  MP20xx

2) Zero Bias GaAs Schottky Detector Diodes. These have a reverse breakdown voltage around 10V and are good to about 100GHz but they are expensive and a bit hard to find. They also don't come as back to back connected matched pairs within a single package. This is your only option if you want to maintain or exceed the original 18GHz spec of your Boonton power sensor.

   www.agilent.com  HSCH-9161

3) Low Barrier Silicon Schottky Detector Diode: These have a reverse breakdown voltage of 7V so you will need to use them if you intend to measure at the upper end of the 3V range on your boonton millivoltmeter. Unfortunately they don't turn on enough to measure well in the low microvolt and nanowatt ranges.

   www.agilent.com  HSMS-2862
   www.infineon.com  BAT62
   www.skyworksinc.com  SMS7621

4) Old Germanium Point Contact Microwave Detector or Mixer Diode: These are obsolete, large, thermally unstable, mechanically fragile, and electrically fragile, but their junction capacitance is low enough that they can be used at UHF and beyond.

   1N23 or 1N23 microwave diodes.

5) Common old Germanium Point Contact Detector or Mixer Diode: These are obsolete, thermally unstable, and have high parasitic capacitance, but you can easily find these in old gear or in old UHF TV tuners. It's the poor mans solution, and definitely at the bottom of the list.

   1N34A or 1N48 or 0A91 or 0A23 diodes

Additional Resources: (Right-click the image and select View Image or Save Picture)
SIEMENS

Silicon Schottky Diode

BAT 32

- RF detector
- Low-power mixer
- Zero bias
- Very low capacitance
- For frequencies up to 18 GHz
- HiRel/Mil-tested diodes available

ESD: Electrostatic discharge sensitive device, observe handling precautions!

<table>
<thead>
<tr>
<th>Type</th>
<th>Frequency band (GHz)</th>
<th>Marking</th>
<th>Ordering Code (tape and reel)</th>
<th>Pin Configuration</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAT 32</td>
<td>... 18 (X, Ku)</td>
<td>32</td>
<td>Q62702-A826</td>
<td>2</td>
<td>Cerc-C-X</td>
</tr>
</tbody>
</table>

**Maximum Ratings**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Values</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reverse voltage</td>
<td>( V_r )</td>
<td>6.5</td>
<td>V</td>
</tr>
<tr>
<td>Forward current</td>
<td>( I_r )</td>
<td>50</td>
<td>mA</td>
</tr>
<tr>
<td>Junction temperature</td>
<td>( T_J )</td>
<td>150</td>
<td>°C</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>( T_{stg} )</td>
<td>−55 ... +150</td>
<td>°C</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>( T_{op} )</td>
<td>−55 ... +150</td>
<td>°C</td>
</tr>
</tbody>
</table>

**Electrical Characteristics** at \( T_a = 25 \, ^\circ\text{C} \), unless otherwise specified.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Values</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breakdown voltage ( I_b = 1 , \text{mA} )</td>
<td>( V_{br} )</td>
<td>6.5</td>
<td>V</td>
</tr>
<tr>
<td>Forward voltage ( I_b = 1 , \text{mA} )</td>
<td>( V_f )</td>
<td>0.2</td>
<td>V</td>
</tr>
<tr>
<td>Diode capacitance ( f = 1 , \text{MHz} )</td>
<td>( C )</td>
<td>0.20</td>
<td>pF</td>
</tr>
<tr>
<td>Differential resistance</td>
<td>( R_d )</td>
<td>15</td>
<td>kΩ</td>
</tr>
</tbody>
</table>

BOONTON CALIBRATOR

DC Range Calibrator
Model 2500

- Accurate, convenient, and self contained.
- Designed for calibrating the Model 4200 and 9200 series instruments.

**Description**

The Model 2500 is a precise, highly stable DC range calibrator that provides the voltage levels and source resistances that are necessary to calibrate the Model 4200 and 9200 series instruments.

**Specifications**

Ranges and Outputs:

<table>
<thead>
<tr>
<th>Range</th>
<th>Output Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0 V</td>
</tr>
<tr>
<td>1</td>
<td>900 μV</td>
</tr>
<tr>
<td>2</td>
<td>900 mV</td>
</tr>
<tr>
<td>3</td>
<td>900 mV</td>
</tr>
<tr>
<td>4</td>
<td>900 mV</td>
</tr>
<tr>
<td>5</td>
<td>900 mV</td>
</tr>
<tr>
<td>6A</td>
<td>1.8 V</td>
</tr>
<tr>
<td>6B</td>
<td>4.5 V</td>
</tr>
</tbody>
</table>

Accuracy: ±0.15%, all ranges.

Source Resistance:

Low: 100 ohms to 1000 ohms.
300 ohms, ±2%.
900 ohms, ±2%.

Temperature Influence:

Operating: ±2°C to ±5°C.
Non-operating: ±20°C to 75°C.

Power Consumption: 7 VA, 100, 120, 208, 240 V ±10%, 50 to 400 Hz.

Dimensions: 5.2 in (13.2 cm) high, 8.3 in (21.1 cm) wide, and 11.5 in (29.2 cm) deep.

Weight: 5.9 lbs (2.7 kg).

I do not guarantee the accuracy or safety of any information herein.
Do not experiment with or build any of the above circuits.