Down East Microwave Inc.

Design Note

DEMI

From: DEMI R&D Dept.

To: All DEM transverter and power amplifier product owners

DN#: 017

Date: March 22, 2005

Re: Retrofitting a RF power detection circuit

PROBLEM:

Since the release of our DEM RFPM, (bar graph display power meter) some of our customers have asked us for a simple design of a RF detection circuit. Since this circuit would need to be added to most products "Dead Bug" style, the problem arises when different interpretations of what is actual required to make this circuit operate in the correct fashion. The results could vary depending on the quality of components used and ones construction skills. This design note will act as an aid to assemble an effective circuit that once its construction is mastered, can be duplicated many times.

SOLUTION:

IF you are looking for dB for dB resolution, the use of any detector circuit with the RFPM or any other type of non-analog indicator is not for you. For resolution that requires that type of accuracy, directional couplers and calibrated power meters are the only way. However, if you are seeking a simple detection circuit to verify relative forward or reflective RF power with a voltage-measuring device such as our RFPM, read on.

DISCUSSION:

The main component of an effective diode detector circuit is of coarse the Schottky diode. A Schotky diode is easily excited in an intense RF field but requires a certain level of minimum energy to begin conduction. This does indeed put a limit on the dynamic range of the circuit. If you design the circuit to operate well with a few mW of power, the diode will most likely become saturated if more than a few watts are delivered and damaged if the saturation level is exceeded.

Schottky diodes are manufactured in different types of packages from glass leaded to microscopic surface mount that require wire bonding for connections. They are all designed and graded with different specifications either for mixers, frequency range, dynamic range, voltage output, linearity, and sensitivity. For this application, any version of diode that you can solder by hand will work. Yes the better linearity versions would work best and the lower sensitivity units would be preferred for low power circuits, but any general purpose Schotky diode will perform or may be made to perform to produce your requirements. Lets examine a simple diode detection circuit shown in Figure 1. It can be done with three components, D1, C1, and R1 but five is best. D1 is your Schotky diode of choice.

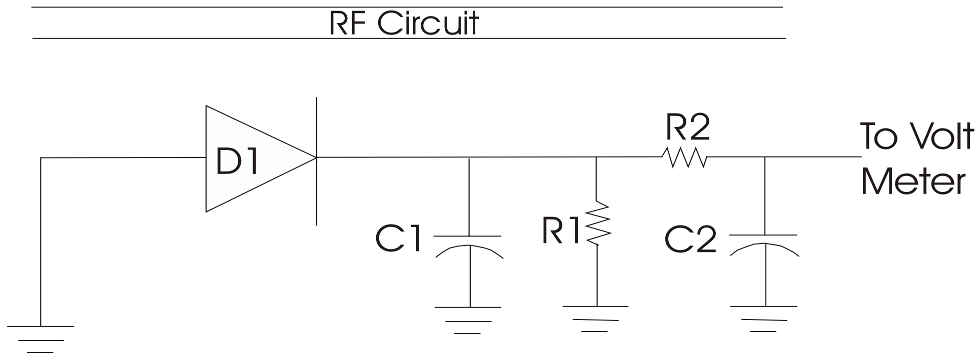

Figure 1

Up to the 100 watt level, we use a generic leaded glass package diode with a maximum voltage output of 50-70 VDC in any circuit under 3.5 GHz. C1 should be a RF bypass capacitor of good quality at the operating frequency of the transmitter. This will prevent most of the stray RF from migrating through the DC circuit. R1 is the diode's DC path to ground. Yes, there is a DC path to ground in the complete circuit with the RFPM or any voltmeter, but it is much higher impedance than desired. We prefer a direct lower impedance path as close to the diode as possible to minimize stray fields in the DC circuit and to eliminate potential ground loops. R1 is also a current limiter. This circuit can be used without R2 and C2 if the extra AC ripple is not a problem. R2 also provides additional limiting and C2 is a low frequency bypass.

The values of all of the components can be quite generic. Values for C1 at 144 MHz can be around 100-200 ρf. At 903/1296, 22 ρf will work as for 12 ρf at 2304. Try to use quality surface mount components for C1 but a short leaded cap for less than 450 MHz will work. It should be as close to the anode of the diode as possible. Depending on the Voltage and current rating of the diode, R1 should be between 470 - 1000 ohms. It should be mounted as close to C1 as possible. The lower the value of R1, the lower the voltage output but will increase the current passing through the diode. If you chose to use a diode with very little dissipation value, an additional current limiter can be installed between the cathode of the diode and ground. The value of R2 should be between 1K and 10K if using this detector with the DEM RFPM. The RFPM has a 10K pot to ground and the wiper adjusts the amount of voltage that is delivered to the voltage measuring circuit. C2 should be around .1μF. A larger value will start to dampen the response of the circuit and may be acceptable in some instances.

This circuit can be assembled and tested without the RFPM connected. The placement of D1 determines the placement of the rest of the circuit. Pick a position on the circuit board as close to the output connection of the power amplifier or power amplifier section of the transverter as possible. Never install the detection circuit between a hybrid module and a filter because it will measure all power present. It may be mounted on the output connector on the enclosure, but the installation of ground lugs will be required and may not be worth the effort for the same achieved results.

After the circuit is installed, measure the voltage output with a VOM at the junction of R2 and C2. Transmit the minimum and maximum power levels into a good 50-ohm load and verify voltage swing. Then connect the DC detection circuit of choice to the RF detector. Cycle the transmitter, both high and low to set the range on the DC detection circuit. If the voltage is too high (cannot minimize the RFPM) or too low, (cannot maximize) try adjusting the position of the diode relative RF circuit. You can find a "Hot Spot" and you may find a direction the diode works best relative to the circuit. Now the only fault with this circuit will show itself if the power detector is used on an amplifier connected to a antenna system with a bad match. Since this is a detector circuit, it will measure both forward and reflected power indiscriminately. The circuit has near "ZERO" directivity. You may be able to adjust the position of D1 to increase the resistance to reflected power with a bit more "Tweaking".

On some higher frequency, lower power microwave circuits, it may be necessary to actually place the diode on the RF circuit to develop enough voltage to drive the RFPM. **CAUTION:** This may rob "dBs" of power from the circuit. Figure 2 shows the preferred method used on lower power (<1 watt) and higher frequency (> 3.5 GHz.) circuits. The circuit is the same except for the addition of C3 and L1.

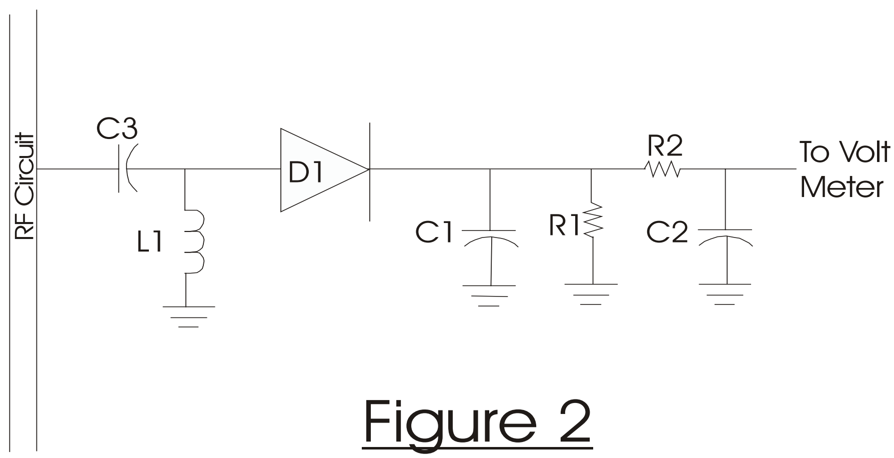

Figure 2

C3's value should be as small as possible to prevent overdriving the detector diode. If the value of C3 becomes to large, it will couple excessive energy from the RF circuit and rob your amplifier of as much as 3dB of energy. L1 should be a value that when placed in series with C3, it will not resonate at the RF frequency. If you find that you have excessive energy driving the diode D1, L1 could be replaced with a resistor. In all cases of 5 GHz and higher, a 1 ρf for C3 and 2-3 turn, 0.05" dia. for L1 will work. If the diode is overdriven, use a smaller C3 or install a resistor for L1 between 470 and 1000 ohms. If you do not have enough drive power, increase the value of C3 a value at a time. Rule of thumb: Twice the amount of capacitance, twice the amount of diode drive. However, remember, if the C is too large, the amplifiers output power will be decreased.

If you are using the DEMI RFPM, you may utilize the additional Op Amp in its circuit if you desire to measure very low power levels or cannot get a diode that is sensitive enough.

CONCLUSION: This circuit is proven to provide a low cost, low-tech alternative to using expensive test equipment to make common relative output power measurements. You will find that you will have additional confidence when someone asks you if you are transmitting or not if installed in your portable gear. It is a simple circuit that may be used with a remote transmitter or tower top installation. Once you install this circuit and use it, you will find many other instances within your station that will benefit from its use. Have fun building and experimenting!