AN02 Microsemi MMIC Amplifiers with On-Chip Power Detectors

Microsemi® designs and manufactures GaAs MMIC amplifiers, many of which have an on-chip differential diode power detector. This feature can be used with an external op-amp circuit, or a microprocessor with a lookup table, to enable real time output power detection.

Output power detector basics

The block diagram of the on-chip power detector is shown in *Figure 1*. The circuitry consists of two diodes, one with an RF signal and DC offset (V_{RF}) and the other with only a DC offset (V_{DC}). This topology allows for common mode cancellation of diode temperature drift and good log linearity versus power

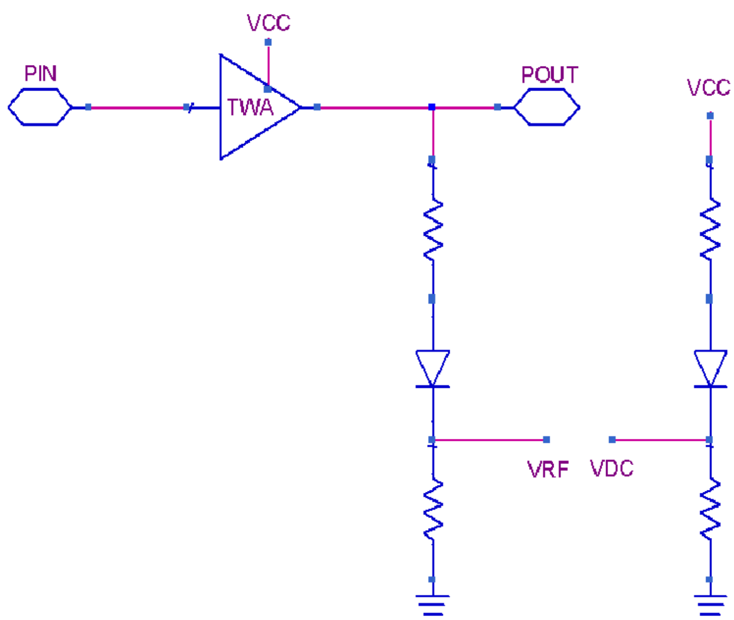

Figure 1. Simplified on-chip power detector

Most Microsemi MMIC amplifiers feature this power detector, but since the nominal DC bias of each amplifier varies, the DC offset voltage will be slightly different from family to family.

This application note details the power detector on the Microsemi MMA034AA, a 0.04-65GHz GaAs MMIC amplifier nominally biased with 8V, 250mA. However, the circuits recommended in this application note will work for all Microsemi TWA amplifiers.

Measurements of the power detector

Differential measurements of the MMA034AA power detector are shown in *Figure 2*. The graph shows the detector voltage (V_{RF}) with the reference voltage (V_{DC}) removed (V_{RF} - V_{DC}), which effectively eliminates the common mode diode temperature drift from the measurement. The difference voltage is plotted at frequencies from 2-40GHz, swept across a range of output power levels.

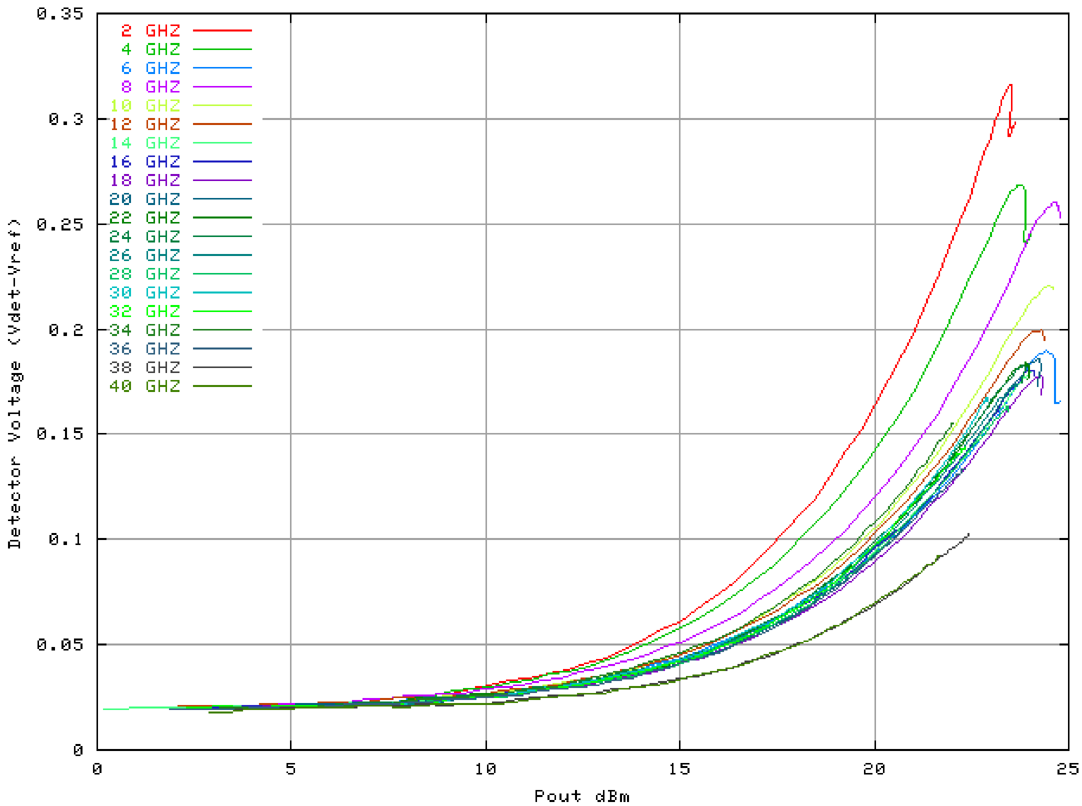

Figure 2. Differential detector output (logarithmic)

Note the 0.02V DC offset on the measurement. The DC offset can be removed with the same op-amp circuit that is used to generate the difference voltage, shown in *Figure 4*.

The detector output shows good log linearity, as shown in *Figure 3.*

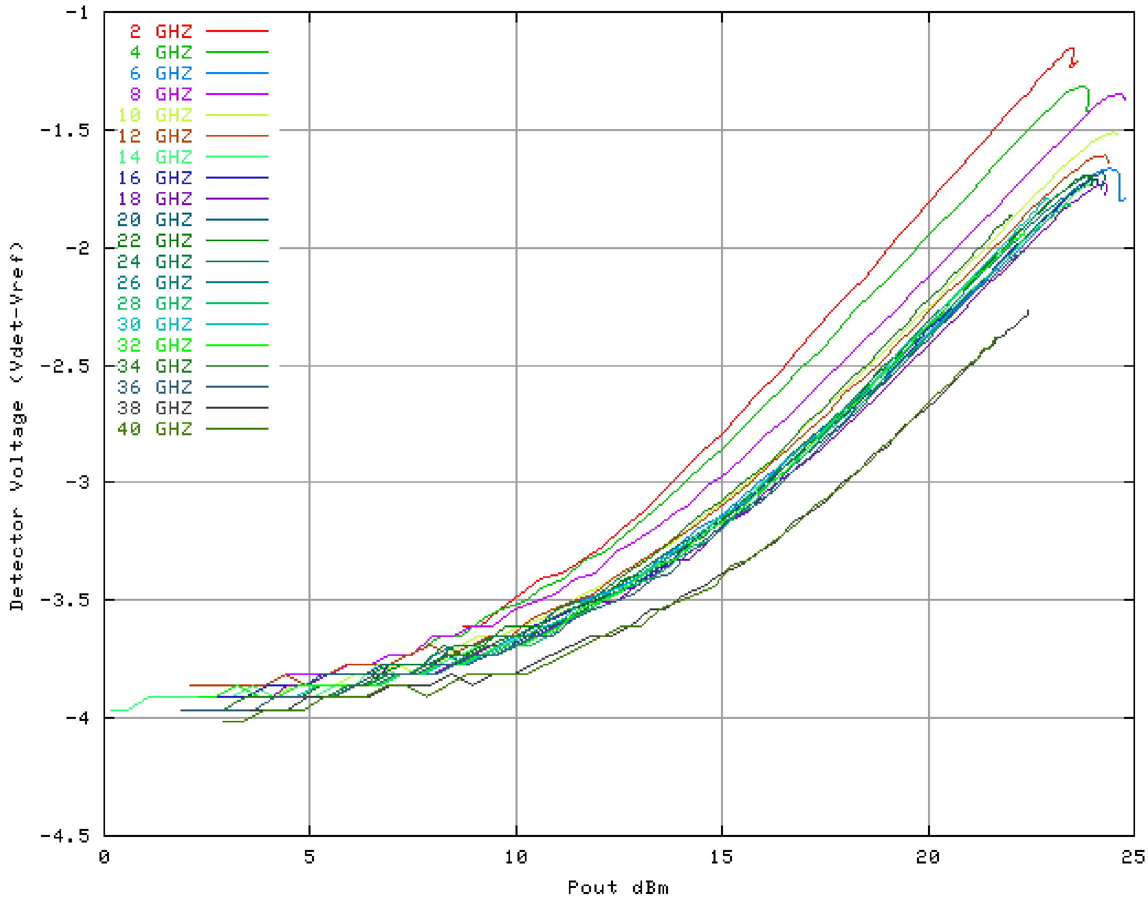

Figure 3. Differential detector output (logarithmic)

However, much improved log linearity can be achieved by removing the DC offset from the difference voltage, as discussed in the next section. Removing the small DC offset enables the full dynamic range of the detector.

Power detector measurements with offset adjustment

To obtain the full dynamic range of the device, the DC offset voltage must be removed from the difference voltage. This improves the low power noise floor and the log linearity as shown in *Figure 6*.

An example opamp circuit to determine the difference voltage, with DC offset removed, is shown in *Figure 4*; this circuit is designed for unity gain (the 50kΩ feedback resistor can be increased for higher voltage output).

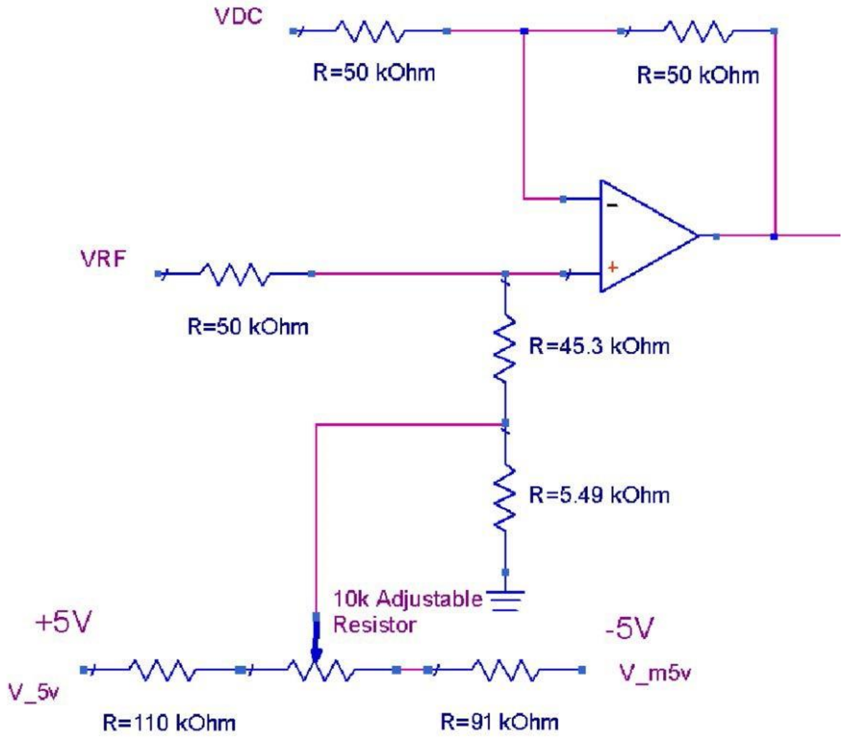

Figure 4. Op-amp circuit to remove the DC offset voltage

The DC offset can be removed by adjusting the 10kΩ resistor in the divider network connected to the V_{RF} op-amp input.

Removing the DC offset decreases the lower range of the detector from +13dBm to +5dBm, illustrated by comparing *Figure 3* and *Figure 6*. This effectively increases the dynamic range of the power detector by 8dB.

Figure 5 shows the linear output voltage with the DC offset removed as per the op-amp circuit shown above. *Figure 6* shows the same corrected output voltage plotted on a logarithmic scale. The linearity is excellent from +5dBm to the maximum range of the detector.

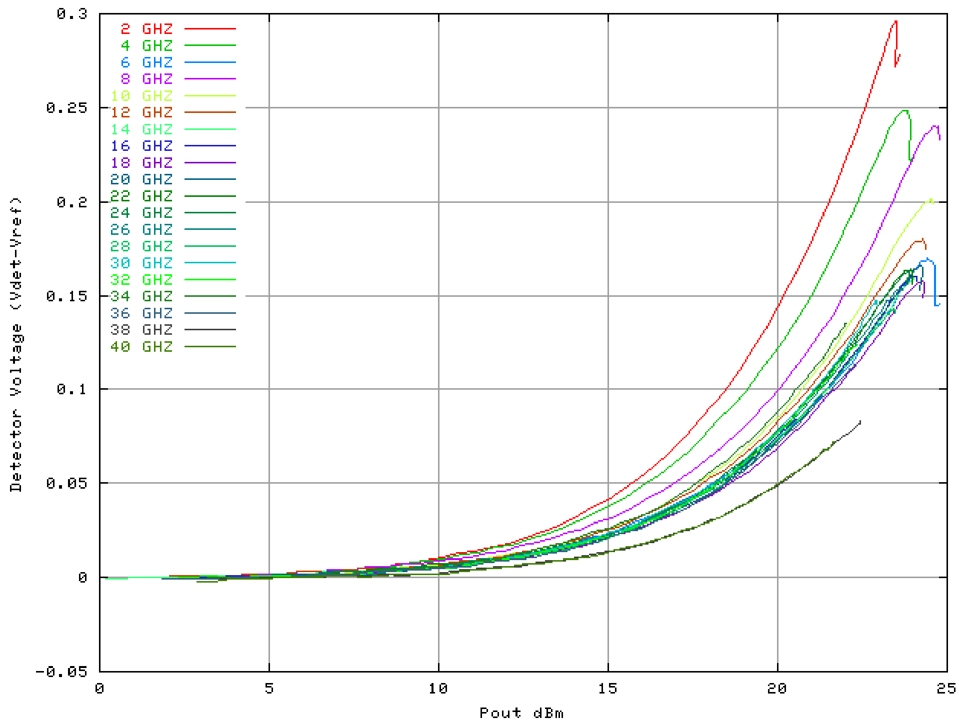

Figure 5. Offset-removed detector output (linear)

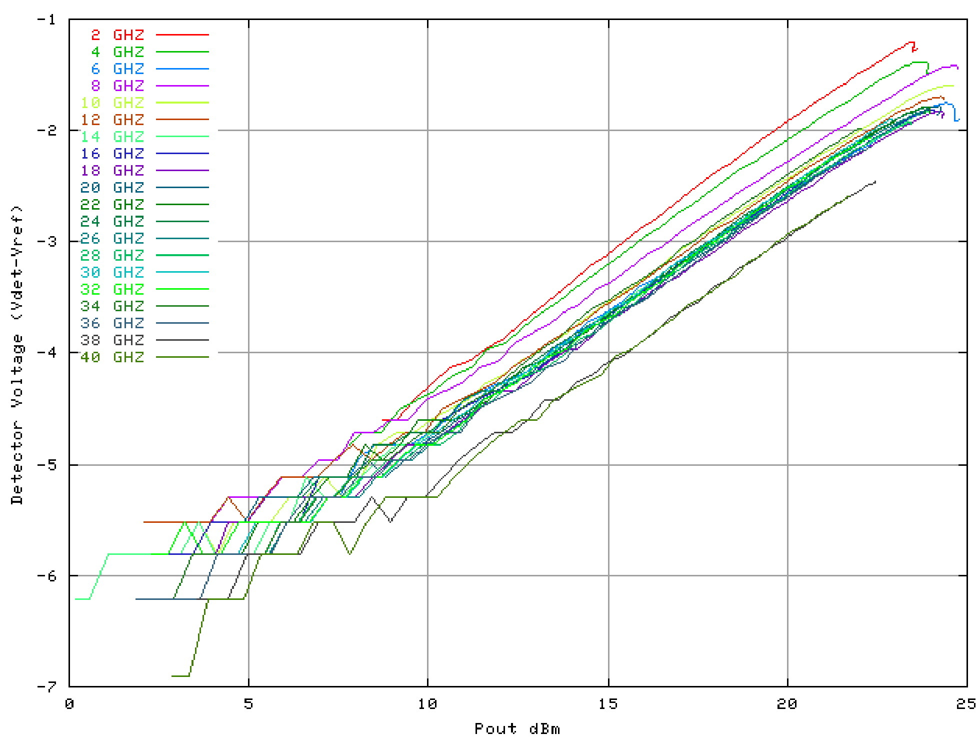

Figure 6. Offset-removed detector output (logarithmic)

The power detector difference voltage is also very stable across a wide temperature range, as shown in *Figure 7*.

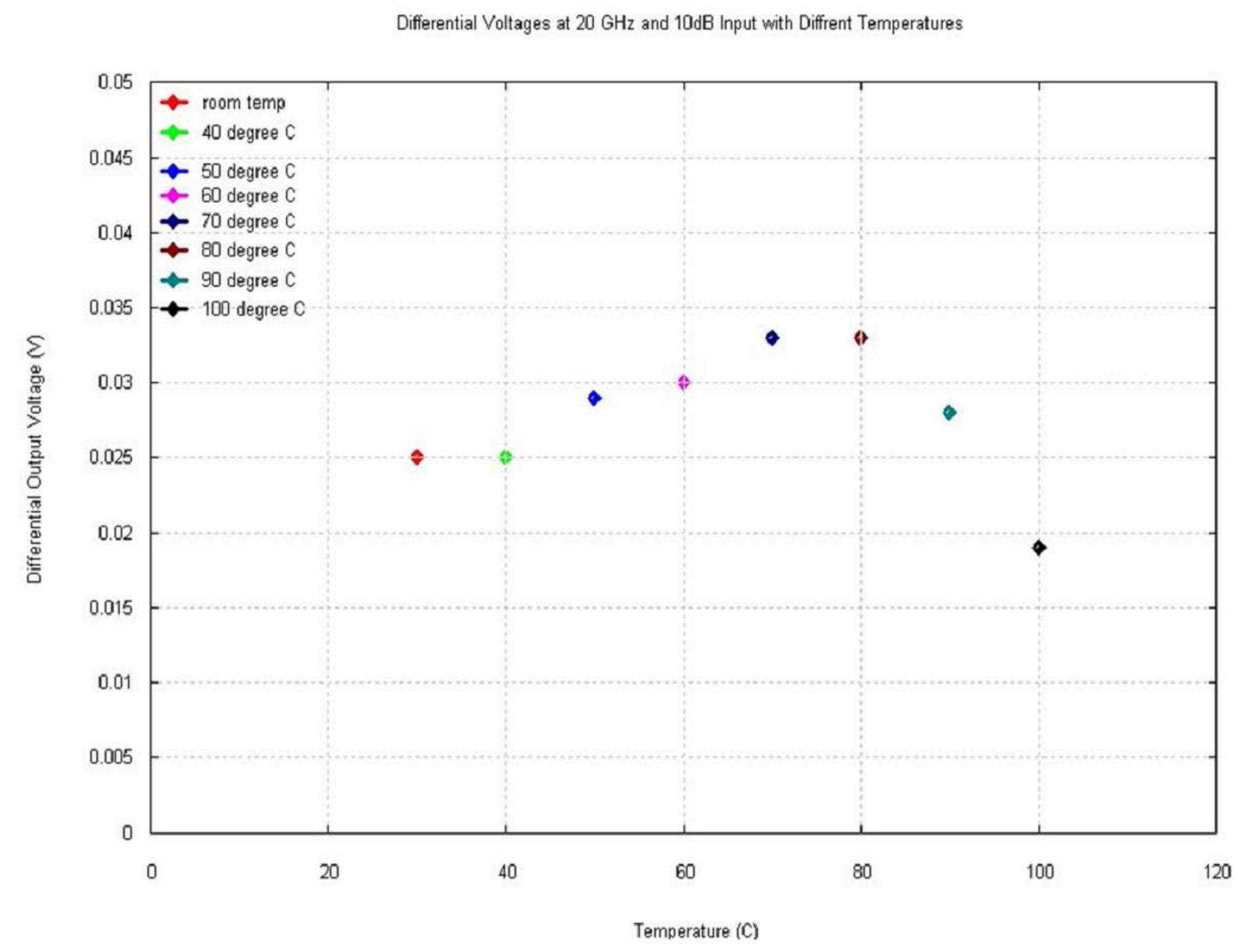

Figure 7. Op-amp circuit to remove the DC offset voltage

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