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High Isolation, Fixed Voltage, Fully Integrated Monolithic Microwave Amplifiers

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Introduction

Monolithic microwave amplifiers are widely used in the industry for signal amplification. Mini Circuits is introducing a series of amplifiers, which has very advantageous features for use in communication systems. These amplifiers have extremely high isolation, which makes them useful as active isolators. Some applications for high isolation amplifiers are reducing load pull of voltage controlled oscillators, providing a broadband interface at the input and output of filters that are reflective in their stop -bands, and any situation where mismatch could degrade a system.

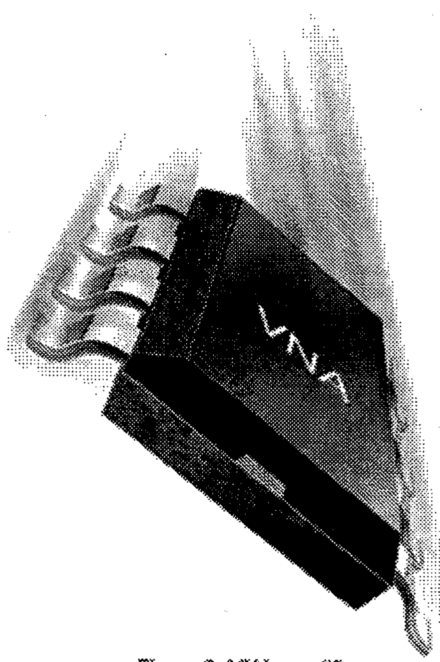

Figure 3: VNA amplifier

VNA-25 is a high isolation, fixed voltage, and fully integrated microwave amplifier introduced several years ago that has been very successful. Now, additional amplifiers are introduced to complement **VNA-25**. These amplifiers provide a choice of gains and power output levels. This article presents the performance and describes the advantages of the expanded series of amplifiers.

Biasing of Monolithic Microwave Amplifiers

The majority of commercially available amplifiers are specified to operate with fixed current. In the practical world of low voltage supplies, fixed current is difficult to realize. Normally, a constant-current source is approximated by a voltage source, RF choke and a resistor. In addition, DC blocking capacitors need to be added at the input and output of such amplifiers. All these external elements consume real estate on the user's PC board, and increase the component count, cost and complexity of the design.

Figure 1 shows the biasing circuit of most of the commercially available monolithic amplifiers. These amplifiers are designed for fixed current operation, and the DC bias current has to be applied at the RF output terminal. Therefore, it is important to ensure that the biasing circuit does not load the RF output (by proper selection of RFC and Rbias), and that the DC current does not go to the RF load (Cblock prevents it). The combined reactance of RFC and Rbias should be greater than 500 ohms to prevent reduction of gain and power output. The RFC should also have its resonant frequency higher than the intended frequency of operation. In addition, a DC blocking capacitor is needed at the input to prevent DC current flow back into the signal source. A minimum of 2 V drop across Rbias is required for proper operation.

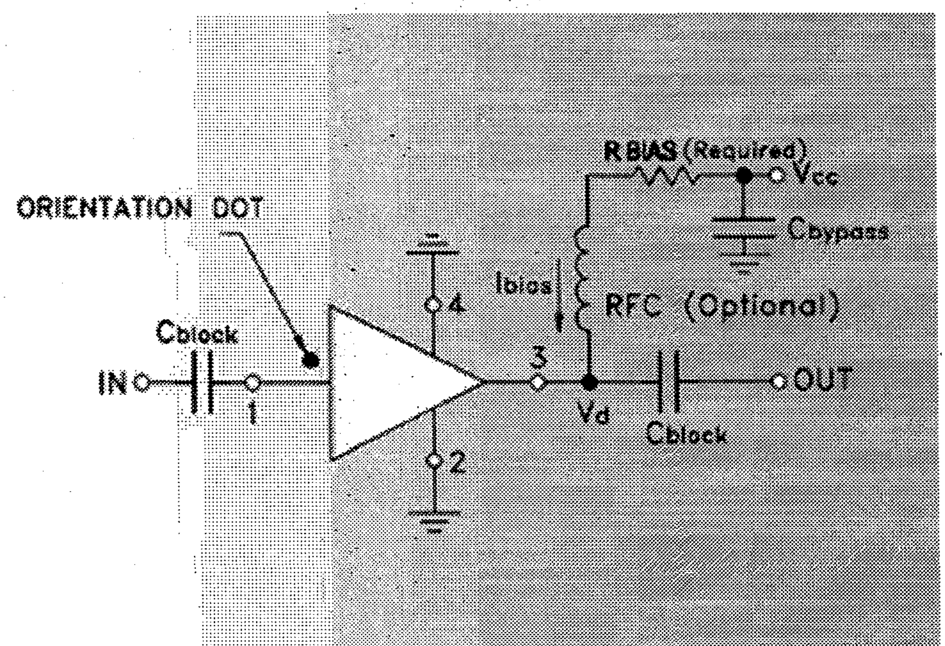

Figure 1: Biasing circuit of most monolithic microwave amplifiers

The new VNA monolithic microwave amplifiers that Mini-Circuits is introducing are well matched to 50 ohms; they are wide band and much simpler to apply. This makes them very user friendly. Unlike current-operated amplifiers, the new series has separate terminals for the RF output and DC supply. In addition, these new amplifiers are designed to operate with a fixed voltage source rather than a fixed current source. **Figure 2** shows the biasing circuit of the new amplifier series. Note that the only external component is a bypass capacitor for the DC supply, which provides an RF ground at the amplifier DC terminal. Cbypass should be in the range 100 pF to .01 mF; values toward the upper end of that range provide some filtering of noise from the power source.

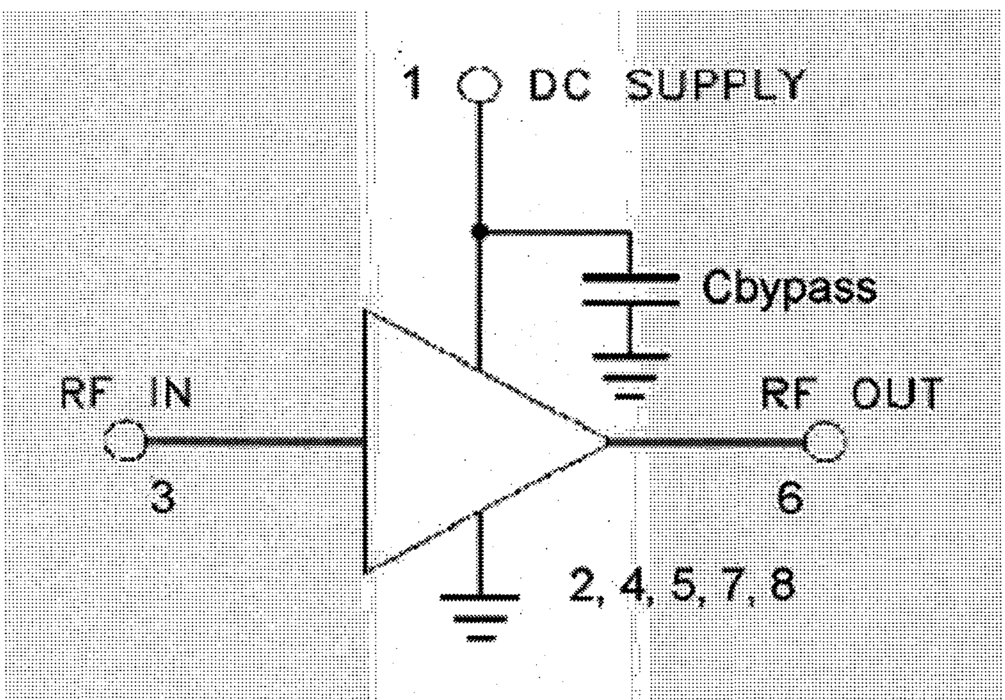

Figure 2: Biasing circuit of new monolithic amplifier

These amplifiers are packaged in a standard SOIC 8 lead package. The leads can easily be soldered by automated and manual assembly methods. **Figure 3** illustrates the VNA amplifier.

Electrical Performance

Table 1 lists the typical specifications of these amplifiers. The reverse isolation is in the range of 30 to 40dB across the band. This is equivalent to an active directivity of 13 to about 30dB, which enables these amplifiers to be used as low cost active isolators. One significant feature is that they can be operated over a wide voltage range, 2.8 to 5V. This makes them useable in battery powered applications.

SUPPLY VOLTAGE AT 5V									
MODEL	Freq. (GHz)	Gain (dB)	1 dB Comp (dBm)	Noise Figure	IP3 (dBm)	Reverse Isolation (dB)	I-DC (mA) typ.	Thermal Resistance (°C/W)	Junction temp (°C) at 85°C ambient*
VNA-21	0.5-2.5	12	8	6.4	18	35	23	105	112
VNA-22	0.5-2.5	19	18	5.7	27	30	80	102	136
VNA-23	0.5-2.5	18	10	4.7	28	33	22	110	113
VNA-25	0.5-2.5	16	18	5.5	27	30	85	125	148
VNA-28	0.5-2.5	20	9	3.7	19	40	35	125	117

*Allowing for typical 10°C rise of the user's PC board above ambient.

Table 1: Specifications of VNA series amplifiers

The VNA series offers a choice of gains and power output levels to aid the circuit designer. Detailed specifications of these amplifiers can be found at the Mini-Circuits web site: http://www.minicircuits.com

As an example of the VNA series, **Figures 4 - 8** show typical performance of Model VNA-28. Each graph includes two curves: one for operation with a 2.8 V supply, and one for 5 V. Gain, in **Figure 4**, is nearly flat from 750 to 2000 MHz and tapers off by about 4 dB at 500 and 2500 MHz. Directivity, shown in **Figure 5**, is in the range 15 to 20 dB. Compression, in **Figure 6**, is the characteristic most affected by the choice of supply voltage; there is 1.5 to 2 dB difference across the band. Input VSWR, shown in **Figure 7**, is in the range 1.4:1 to 2:1 from 750 to 2500 MHz. **Figure 8** shows that Output VSWR remains low over the entire band.

Reliability

The junction temperature of these amplifiers at 85 °C ambient is calculated as follows:

$$T_j = (I \cdot V) \cdot \theta_{jc} + T_r + 85$$

where Tj = Junnction temperature, °C
I = Current
V = Voltage
θ_{jc} = Thermal resistance, junction-to-case, in °C/W
Tr = temperature rise of leads above ambient

The reference point for case temperature is the leads. When installed on a PC board the leads can rise 5° to 10°C above ambient temperature. As seen from **Table 1**, the junction temperature of low power devices in 85 °C ambient is in the range 112 to 117°C, for which **Figure 9** shows an MTTF of 6000 years. For the medium power devices, the junction temperature is in the range 136 to 148°C, and the MTTF is 500 years or better. Thermally related failure is therefore not a significant issue with these amplifiers.

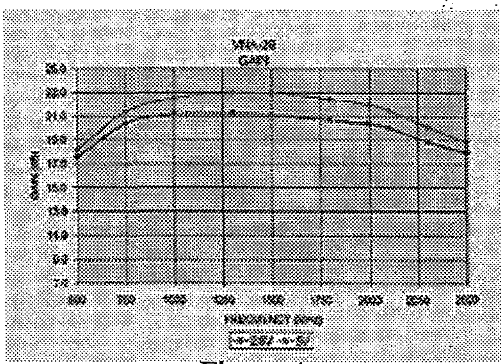

Figure 4

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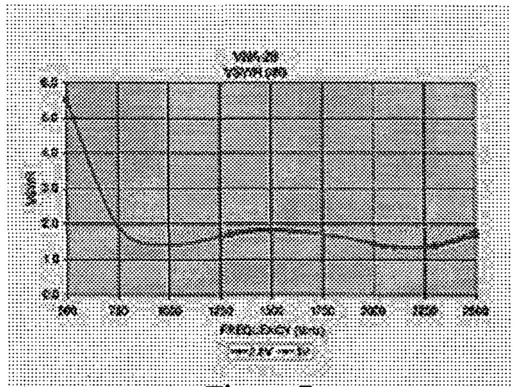

Figure 7

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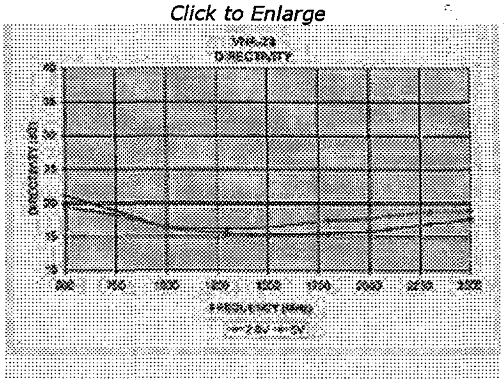

Figure 5

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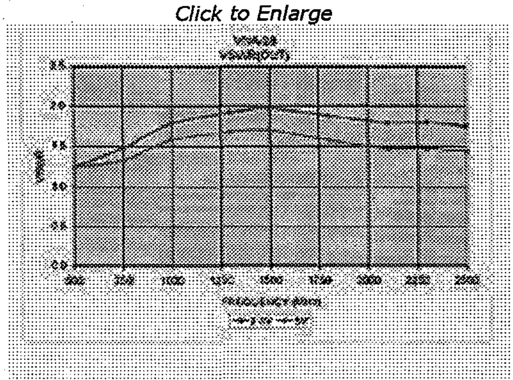

Figure 8

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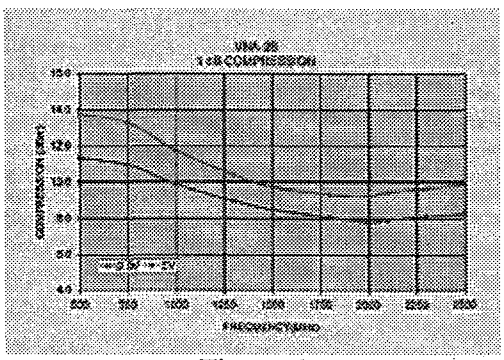

Figure 6

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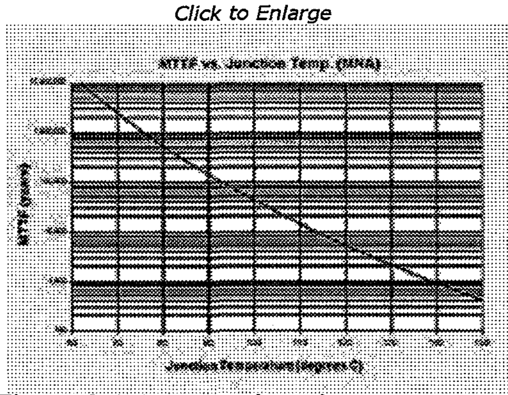

Figure 9: MTTF vs. junction temperature

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Conclusions

Mini-Circuits has introduced a series of new amplifiers to cover 0.5 to 2.5 GHz. These amplifiers have a separate terminal for DC, and require no external matching, biasing or DC blocking elements. They operate with fixed DC voltage and have very high reverse isolation.

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