Application Note for Voltage Variable Attenuator, VVA-MCM-1.9G-a

Introduction:

Merrimac's voltage variable attenuator, VVA-MCM-1.9G-a is a continuously variable, electronically controlled two-stage attenuator, ideal for amplitude control. A significant reduction in size is accomplished through the use of Merrimac's Pico products. Two quadrature hybrids (QHD-2Z-1.9G) are used in the configuration shown in Figure 1. This hybrid-based approach enables flat attenuation to be achieved with minimal phase shift variations. It also has the advantage of maintaining a good impedance match at the input and output independent of bias. The attenuation flatness is a direct function of, and hence limited to the passband characteristics of the quadrature hybrid.
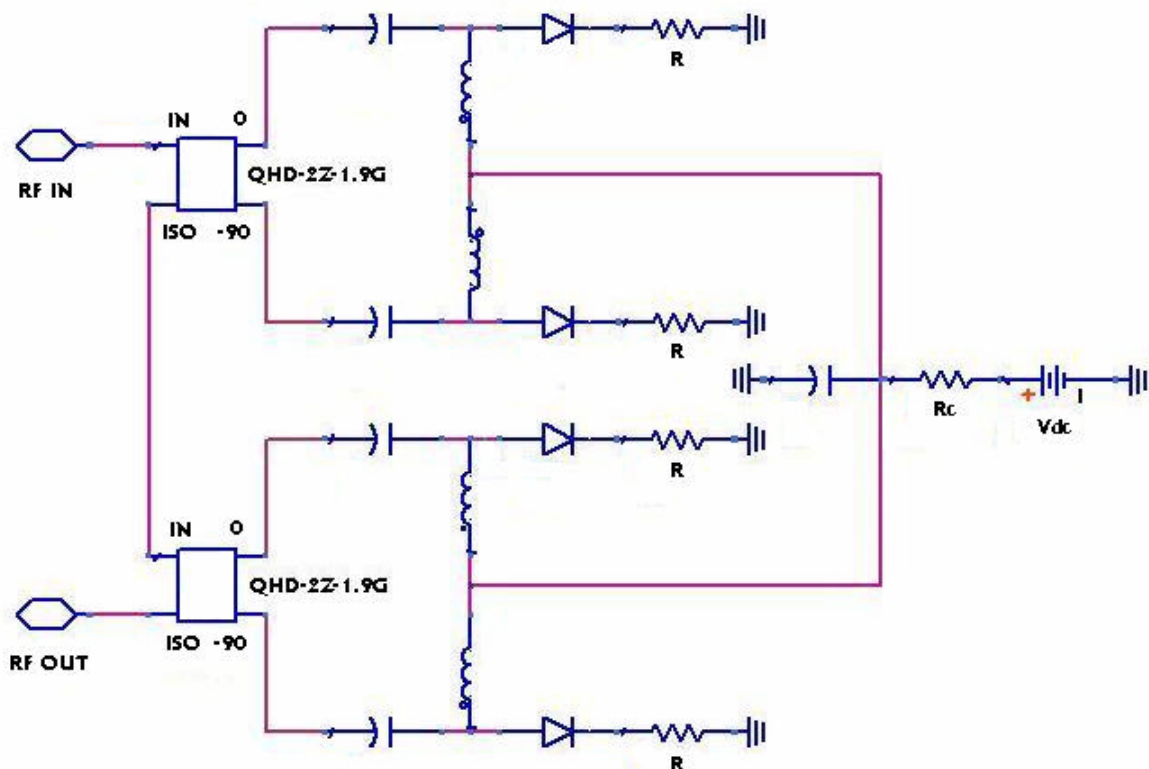

Figure 1: Schematic of the Circuit

Theory of Operation:

A detailed schematic of a single-stage attenuator is shown in Figure 2 for analysis. The sum of the diode resistance R_{diode} and series resistor $R = 50\,\Omega$ is shown as a lumped value Z.
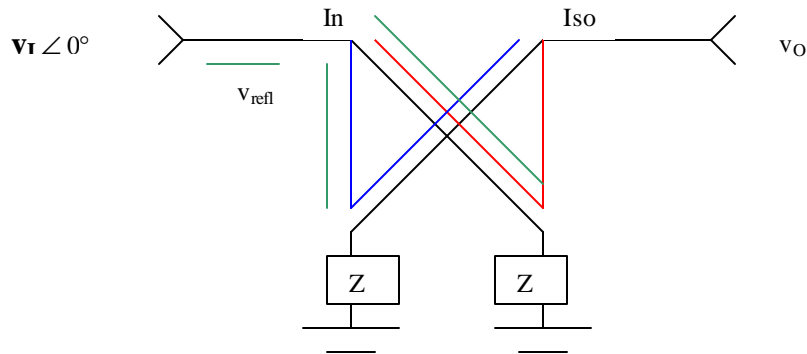

Figure 2: Simplified schematic for analysis

$$\Gamma = g\angle q \quad , \quad g = \frac{|Z - 50|}{(Z + 50)}$$

$Z > 50$ Ohms, then $\Gamma = \mathbf{g}\angle 0°$

$$\mathbf{v_O} = (2 * \mathbf{v_I}(0.707 * \mathbf{g} * 0.707))\angle(-90°) = (\mathbf{v_I} * \mathbf{g})\angle(-90°)$$
$$\mathbf{v_{refl}} = (\mathbf{v_I} * (0.707 * \mathbf{g} * 0.707)) * (1\angle 0° + 1\angle 180°) = 0$$

Implementation:

The VVA-MCM-1.9G-a was assembled using coplanar lines on Rogers 4003 material, 0.060" thick. The overall board dimensions are (0.8 x 0.8) inches. An outline and photograph is shown in Figure 3. The module may be surface mounted or connectorized to suit one's requirements.
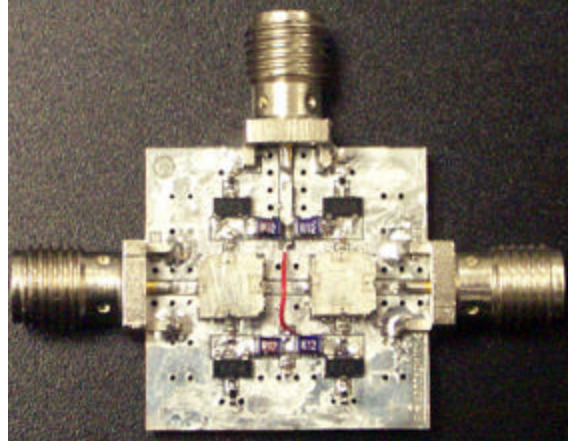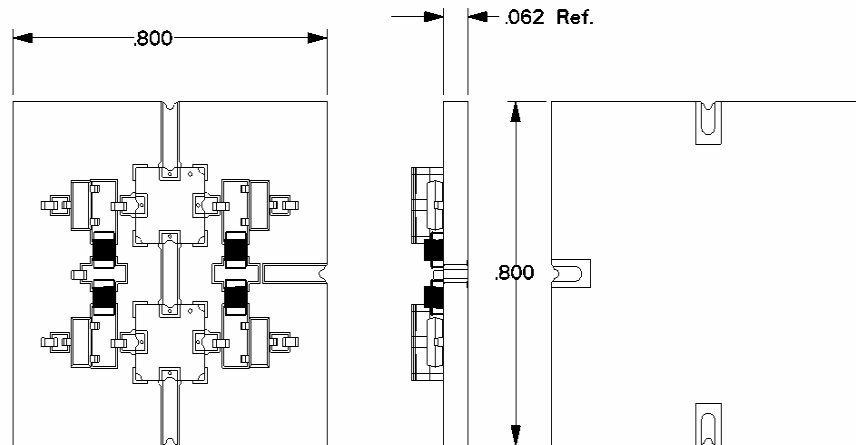

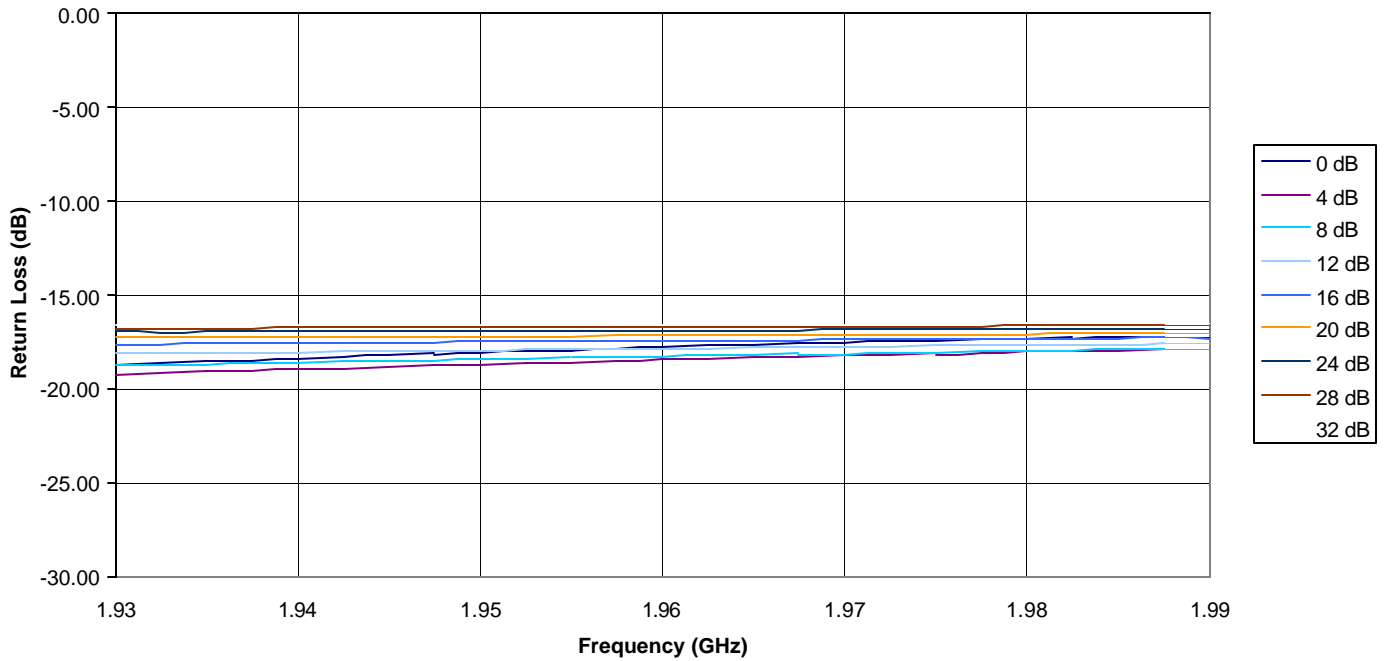**Figure 3: Outline drawing and photograph of the assembly**

Results:

Frequency Range:	1.93 – 1.99 GHz
Attenuation Range:	0 – 30 dB min
Attenuation Flatness:	0.5 dB
Insertion Loss:	3 dB max.
VSWR:	1.5:1 max.
Impedance:	50 Ohms
Control Current:	0 to + 22 mA
Control Voltage (Rc=680Ω):	0 to + 15 V
Input 1-dB Compression Point:	+ 31 dBm
Input Intercept Point (2 Tone, 3rd Order):	+ 41 dBm
Switching Speed:	10 μs
Operating Temperature:	-55°C to 85°C

VVA-MCM-1.9G-a
Return Loss - RF Input
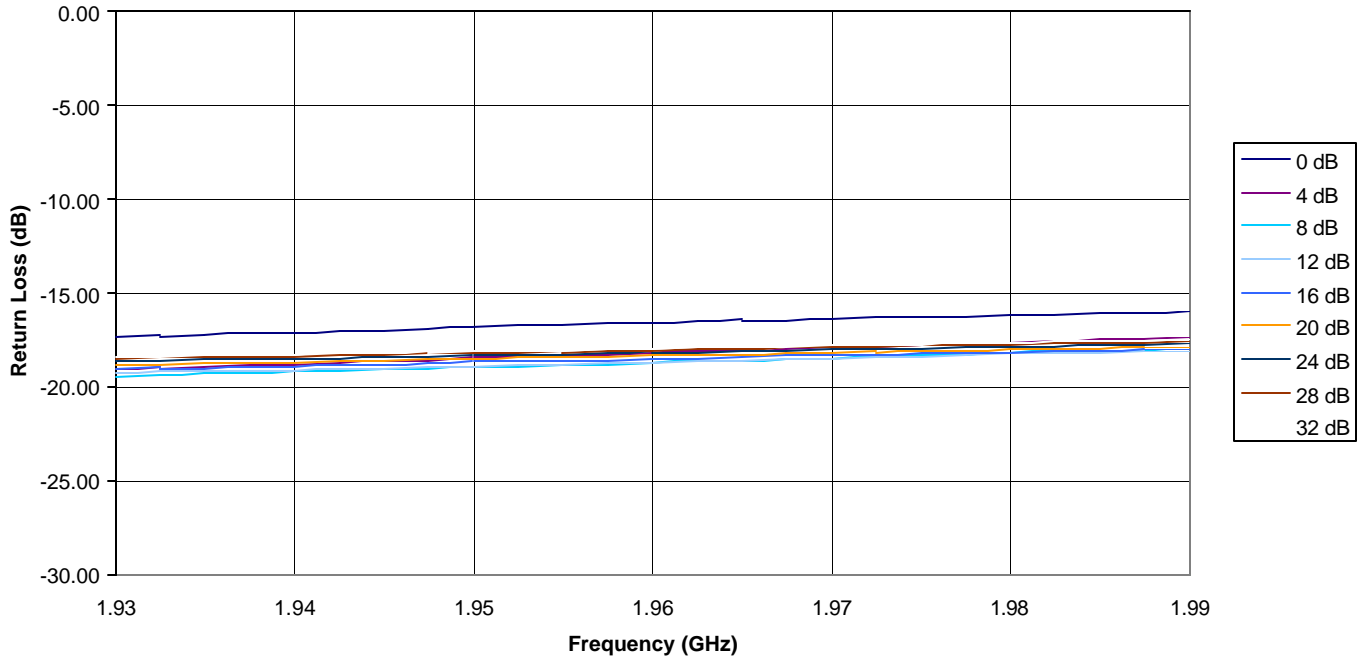
VVA-MCM-1.9G-a
Return Loss - RF Output

VVA-MCM-1.9G-a
Relative Attenuation

Legend:
- 0 dB
- 4 dB
- 8 dB
- 12 dB
- 16 dB
- 20 dB
- 24 dB
- 28 dB
- 32 dB

Y-axis: Relative Attenuation (dB)
X-axis: Frequency (GHz)