Application Note No. 098

Broadband Amplifier MMICs for TV Tuner Applications

RF & Protection Devices

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Page	Subjects (major changes since last revision)
7	Bill of Matrials updated

1 Broadband Amplifier MMICs in TV Tuner Applications

Over the last few years there has been a clear trend in television to move from the classical TV-set out to more mobile platforms like notebooks, cell phones and PDAs. Especially the introduction of digital terrestrial television in many countries and the more and more evolving hand-held television standards like DVB-H and T-DMB support this evolution.

With television going mobile the antennas are getting smaller, resulting in a loss in antenna gain. It requires an additional LNA with low noise figure to keep up a good reception of the TV signal, no matter if the TV tuner's RF frontend uses the classical three-band tuner (**Figure 1**) or the more space saving silicon tuner (also called double conversion tuner or up-down converter, **Figure 2**). Particularly the silicon tuner has the need for and external LNA as tuner ICs in general tend to have high noise figures and the silicon tuner approach doesn't implement any pre-stages including an RF MOSFET.

LNAs for TV tuner applications have to fulfill challenging requirements. They have to cover a very wide frequency range and need to handle both extremely high and low signal levels at the amplifiers input. These different signal levels require an LNA that offers both a good noise figure as well as a high linearity.

Broadband design, low noise figure and high linearity make Infineon's Darlington broadband amplifier family the LNAs of choice for TV tuner applications.
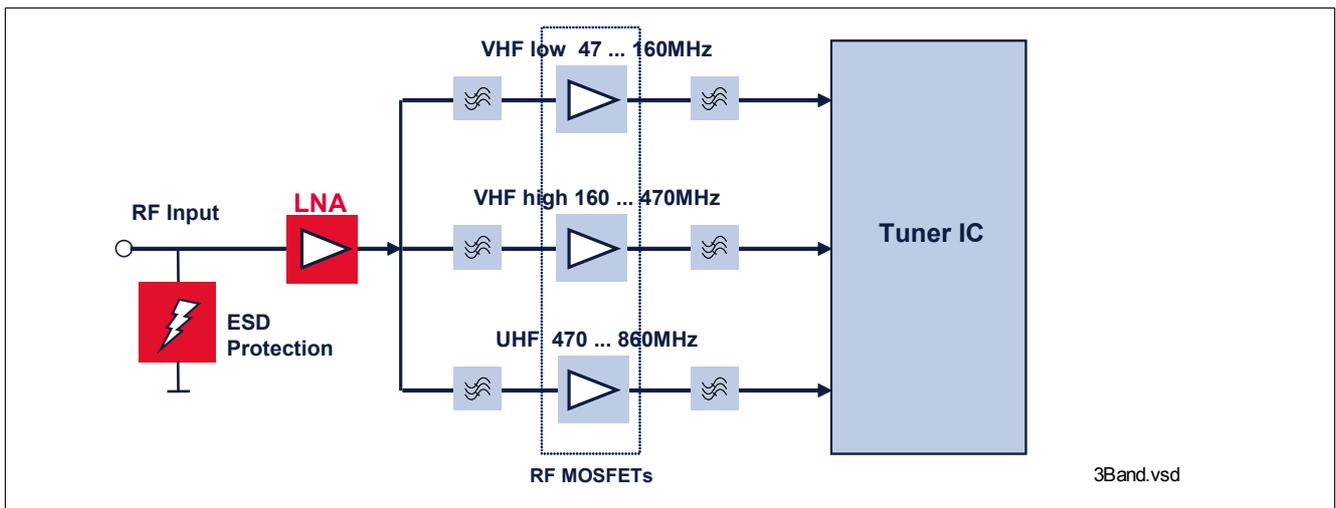

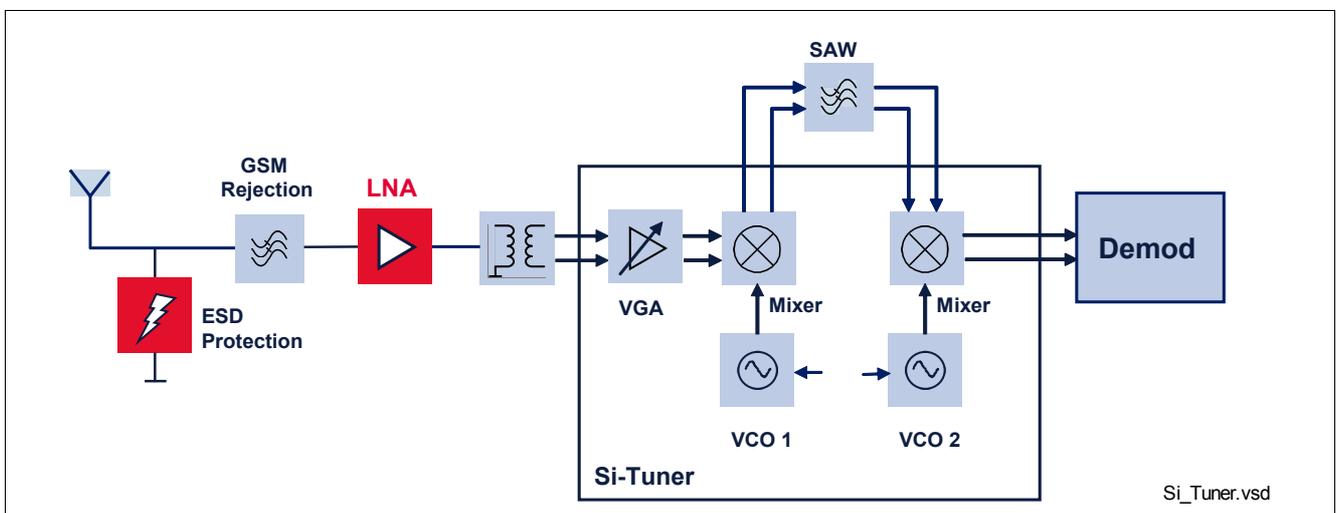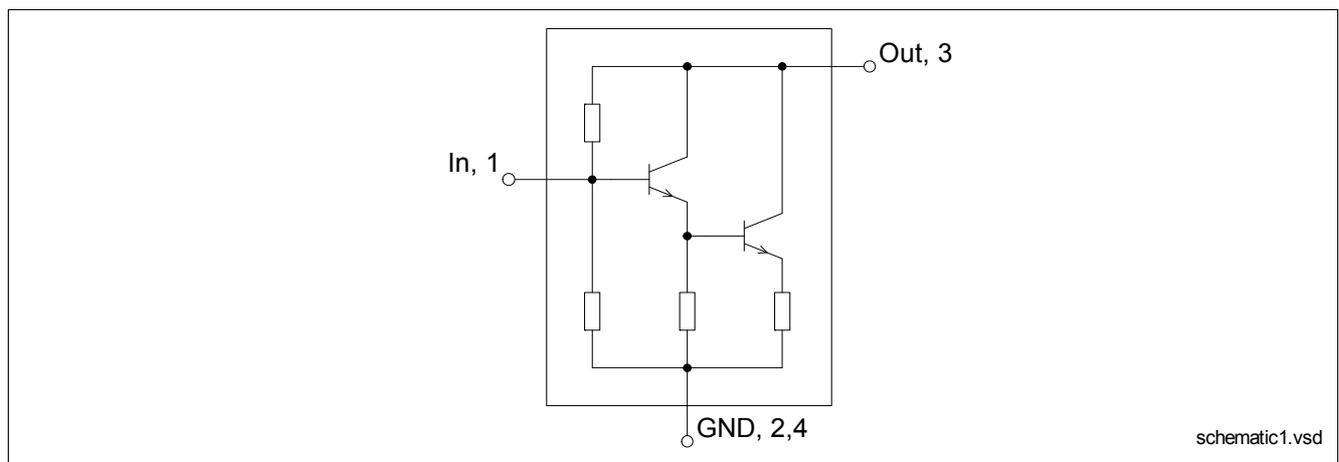**Figure 1   Classical Three-Band Tuner**

Figure 2   Silicon Tuner

2 Infineon's Darlington Broadband Amplifier Family

2.1 Description of the Devices

Infineon's Darlington amplifier family consists of three different LNAs:

- BGA612
- BGA614
- BGA616

Figure 3   Equivalent Circuit of the Broadband LNAs

These types are matched, general purpose broadband MMIC amplifiers in Darlington configuration. They are implemented in Infineon's high f_t, low noise B7HF Silicon Germanium technology.

The devices' 3 dB bandwidth covers DC up to 2.7 GHz, **Table 1** shows a collection of the most important electrical parameters of the three amplifiers. This data is an excerpt of the devices' data sheets and does not contain any external losses.

Table 1   Comparison of Key Parameters[1]

Parameter	BGA612	BGA614	BGA616	Unit
Typ. operating current	20	40	60	mA
Gain	17.0	18.5	18.5	dB
Noise Figure	2.25	2.2	2.8	dB
Input 1dB Compression Point	-9	-6	0	dBm
Input 3rd Order Intercept Point	0	6	11	dBm
Return Loss	>15	>15	>15	dB

1) Measured at 1 GHz

This exceptional performance, enabled by Infineon's 70 GHz B7HF Silicon Germanium process, combined with reduced external component count and ease of use, make these broadband amplifiers an ideal choice for a wide variety of RF applications up to 2.5 GHz. The high linearity make them especially useful for TV applications.

The Darlingtons' simplicity, flexibility and ease of use streamlines the RF design process and allows for shorter design cycles and fast time-to-market in today's fast-paced competitive business environment

2.2 TV Amplifier Design using BGA614

This chapter describes the design of a general purpose broadband amplifier for the frequency band between 50 MHz and 1 GHz using BGA614 as an example. Designing an amplifier with BGA612 or BGA616 is almost exactly the same procedure, they require only different bias resistors.

Implementing an amplifier circuit using BGA614 is a simple straightforward task. As both input and output are matched and BGA614 is an unconditionally stable device, there is no need to work on the RF portion of the amplifier design, leaving only DC biasing issues to contend with. The broadband 50 Ω match also eases and speeds integration of the MMIC with any external filters used.

Figure 5 and **Table 2** show the typical schematic and bill of material when using one of the three MMICs as an LNA in TV tuner applications.

Device Current $I_D = f(V_{CC})$
R_{Bias} = parameter in Ω
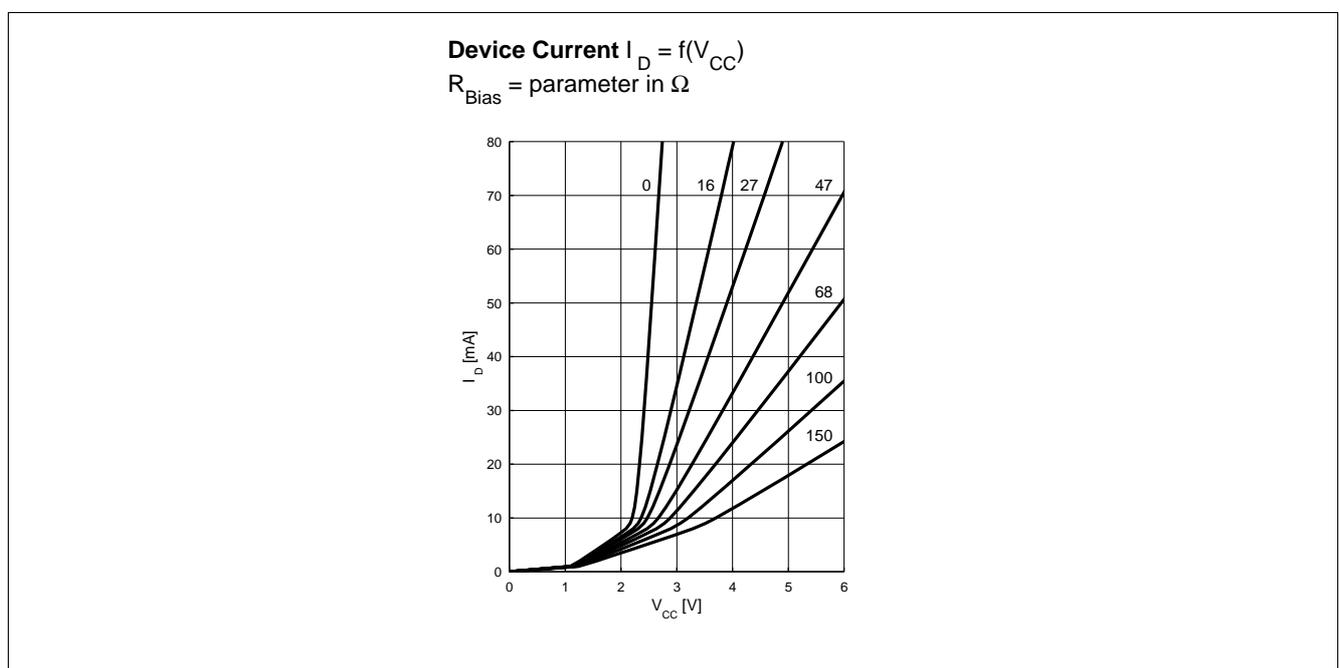
Figure 4   Device Current vs. Supply Voltage, Parameter is R1

The Darlingtons are biased via their RF output pin (pin 3). **Figure 4** shows the dependence of BGA614's current consumption on the supply voltage for different values of the bias Resistor R1. R1 stabilizes the supply current by using voltage feedback. For BGA612 and BGA616 exist similar plots which can be found in the devices' data sheets.

In principle it is possible to bias BGA614 without an additional resistor. However, omitting R1 will lead to increased unit-to-unit variation in operating current due to the usual variation in the DC Beta (h_{FE}) of the internal transistor cells. It is therefore recommended that R1 be used in all cases.

The inductor L1 in series with resistor R1 is necessary for RF blocking. C3 and C4 serve as RF bypass at the voltage supply.

The capacitors C1 and C2 are DC blocks as there is DC voltage present on pin 1 and pin 3. These capacitors are needed only if there is no DC open circuit on the input and output of the amplifier. For example, if a filter that presents a DC open circuit is used ahead of or after the BGA614, the corresponding DC blocking capacitor may be omitted.
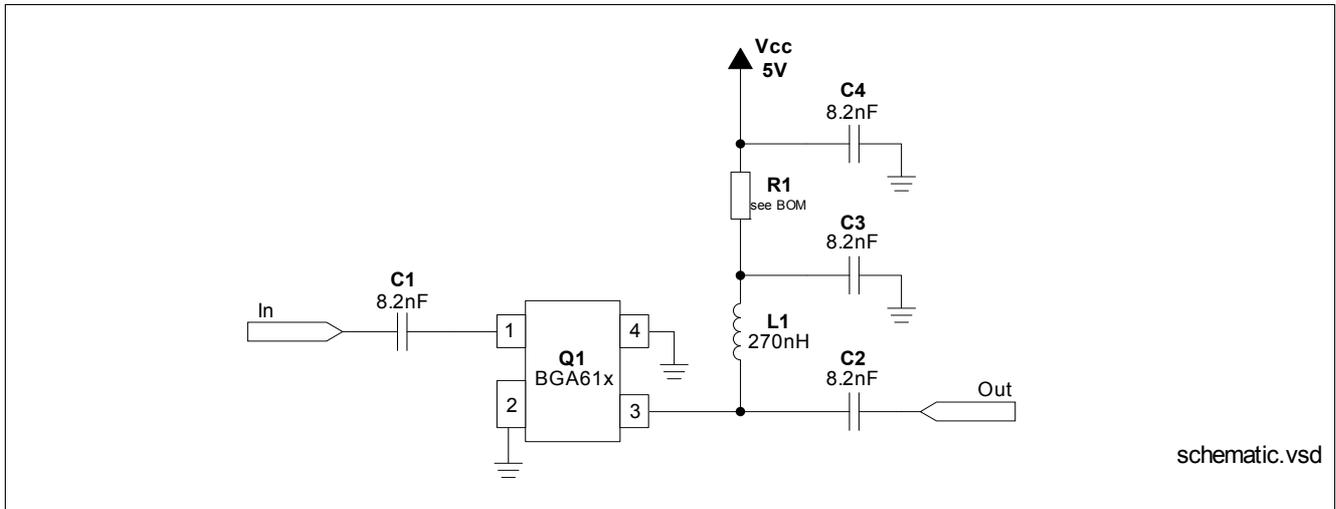
Figure 5   Typical Schematic

Table 2   Bill of Materials

Name	Value	Unit	Manufacturer	Function
C1	8.2	nF	Various	DC block
C2	8.2	nF	Various	DC block
C3	8.2	nF	Various	RF bypass
C4	8.2	nF	Various	RF bypass
L1	270	nH	Various	RF choke
R1	120 @ BGA612 68 @ BGA614 15 @ BGA616	Ω	Various	Biasing
Q1	BGA612 BGA614 BGA616		Infineon Technologies	Broadband SiGe MMIC

3 Measurement Results

Please note that the data displayed in the following chapters includes connector losses as well as board losses. In other words, the reference planes of the measurements are the input and output connectors.
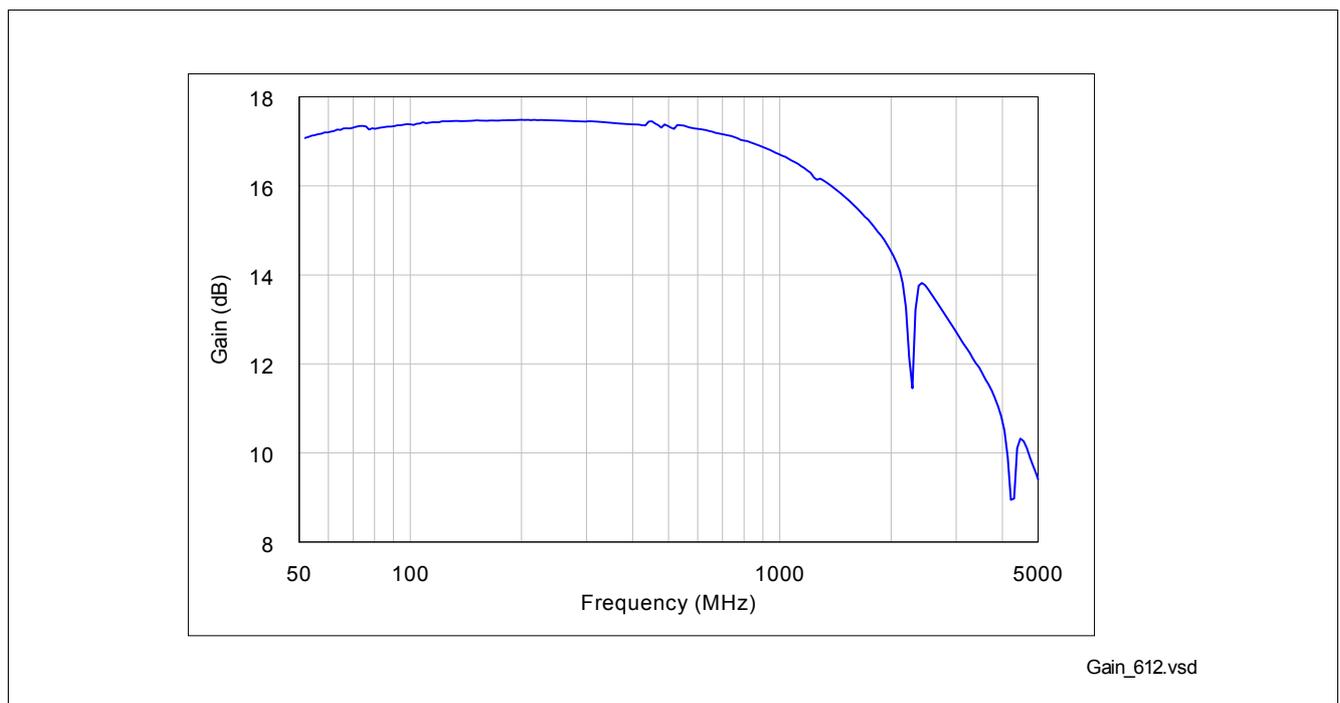
3.1 BGA612

Table 3   Measured Electrical Performance on Evaluation Board[1]

| Parameter	50 MHz	500 MHz	1000 MHz	Unit
Supply Voltage		5		V
Biasing Resistor		120		Ω
DC current		20.8		mA
Gain	17.0	17.4	16.7	dB
Noise Figure	2.2	2.4	2.25	dB
Input 1dB Compression Point	-11	-10	-10	dBm
Input 3rd Order Intercept Point[2]	---[3]	2.5	1.5	dBm
Input Return Loss	11.3	17.1	14.3	dB
Output Return Loss	9.7	17.1	14.9	dB
Reverse Isolation	20.6	20.4	20.5	dB

1) Including all PCB losses
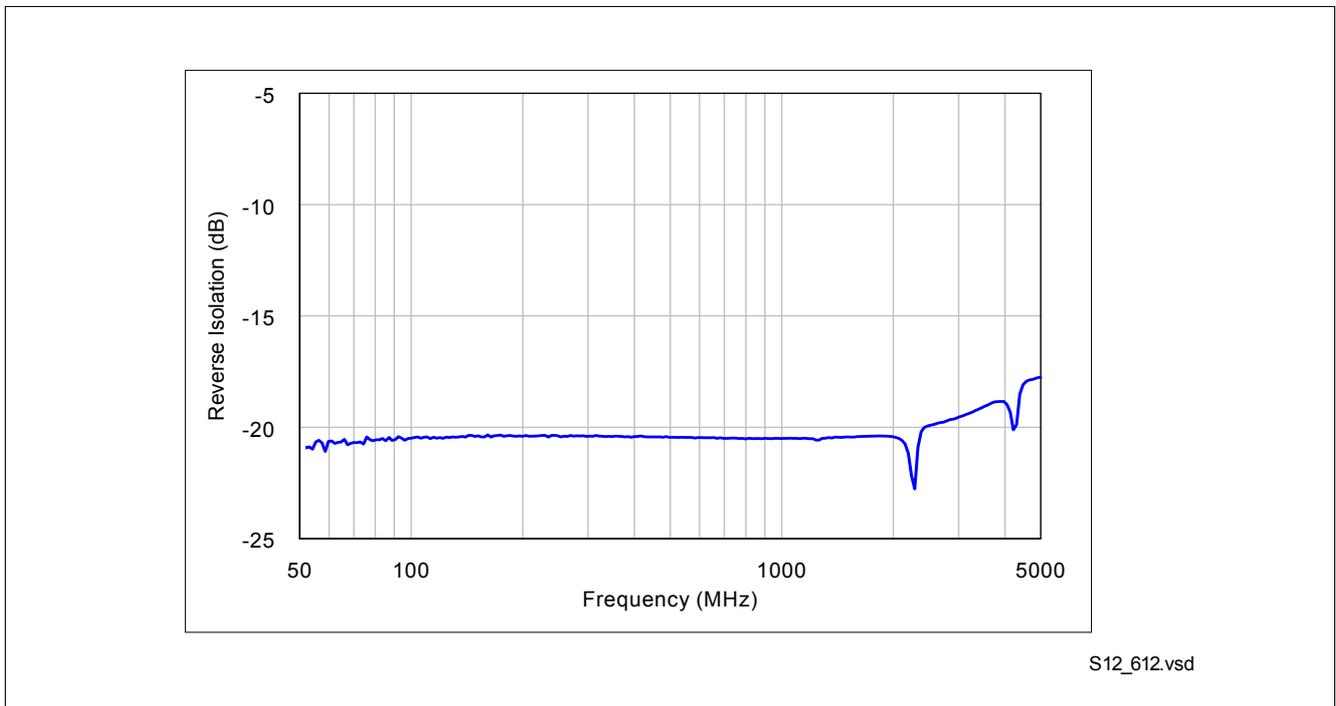
2) Input power -25 dBm / tone; Δf = 1 MHz

3) No power combiner for this frequency available in lab

Gain_612.vsd

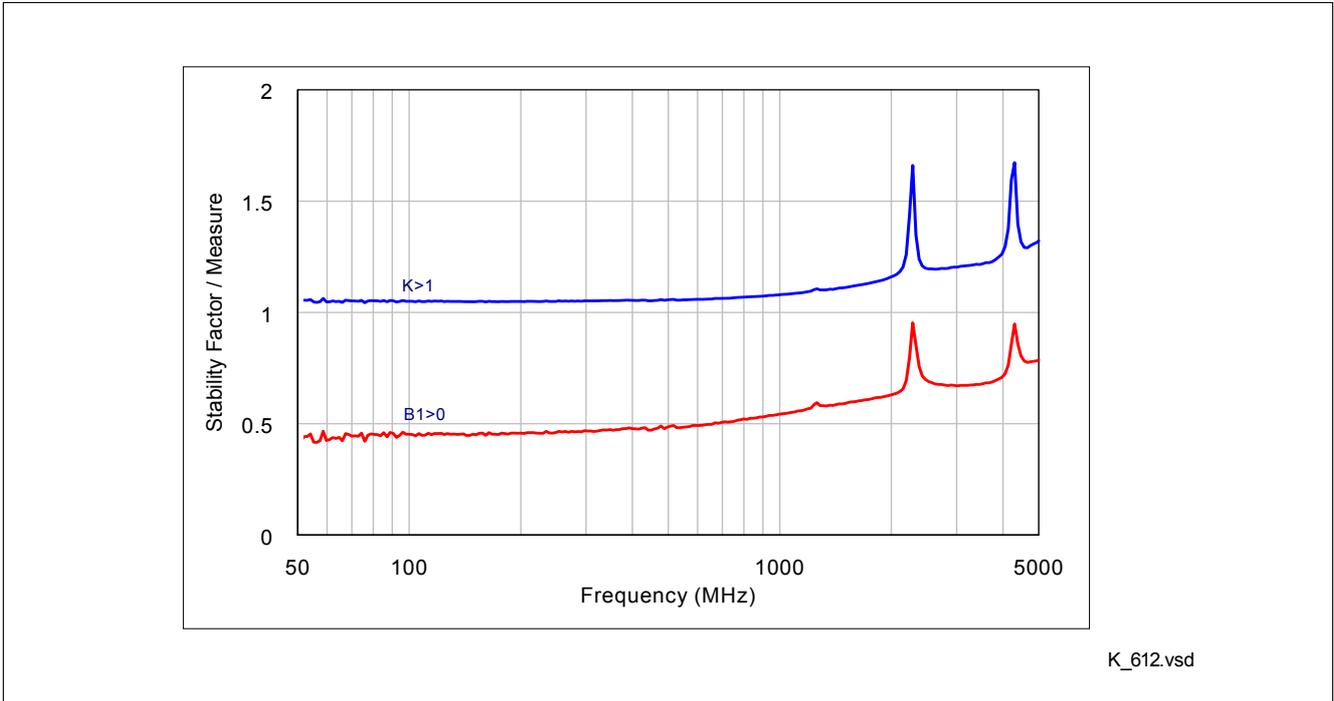**Figure 6   Gain vs. Frequency**
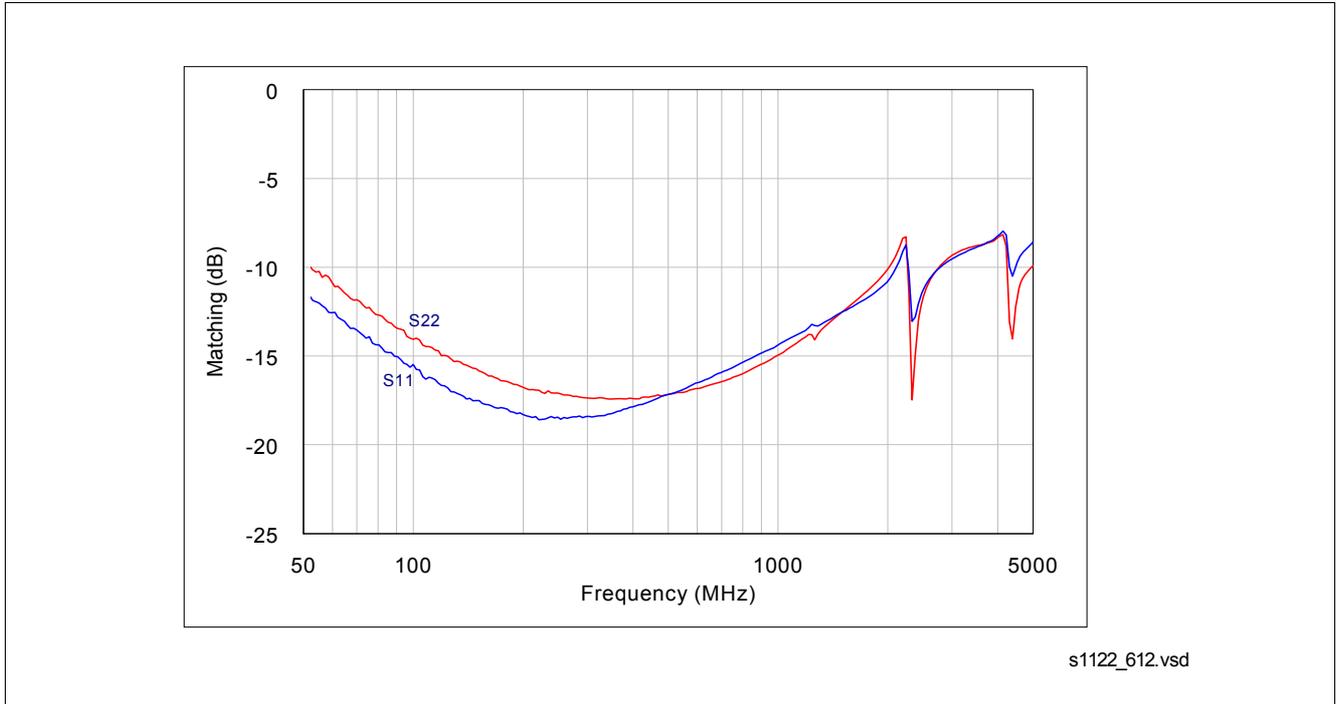
Figure 7   Input Return Loss and Output Return Loss vs. Frequency

Figure 8   Reverse Isolation vs. Frequency

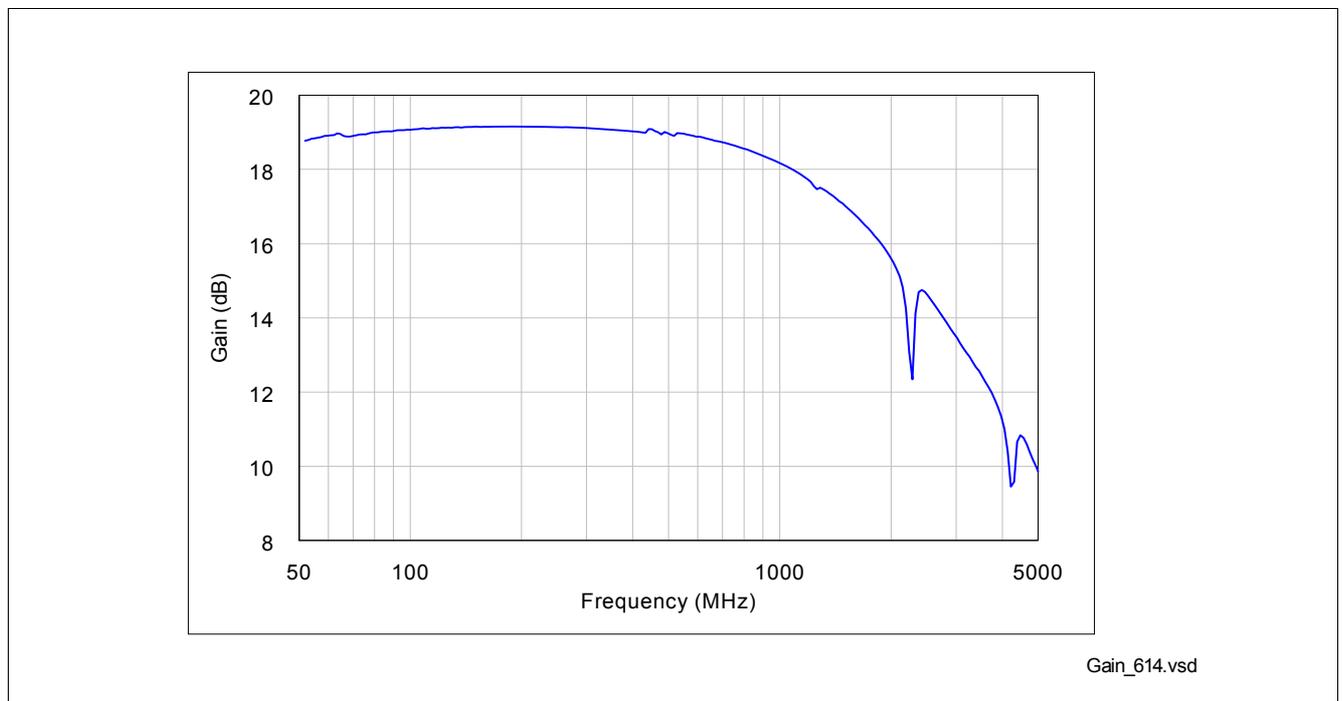**Figure 9** **Stability Factor K and Stability Measure B1 vs. Frequency**

3.2 BGA614

Table 4   Measured Electrical Performance on Evaluation Board[1]

Parameter	50 MHz	500 MHz	1000 MHz	Unit
Supply Voltage		5		V
Biasing Resistor		68		Ω
DC current		39.2		mA
Gain	18.7	19.0	18.1	dB
Noise Figure	2.15	2.35	2.2	dB
Input 1dB Compression Point	-6.5	-5.5	-5	dBm
Input 3rd Order Intercept Point[2]	---[3]	4.5	4.5	dBm
Input Return Loss	11.6	17.5	14.3	dB
Output Return Loss	9.8	17.6	15.3	dB
Reverse Isolation	22.4	21.7	21.6	dB

1) Including all PCB losses

2) Input power -20 dBm / tone; ∆f = 1 MHz

3) No power combiner for this frequency available in lab

Gain_614.vsd

Figure 10   Gain vs. Frequency
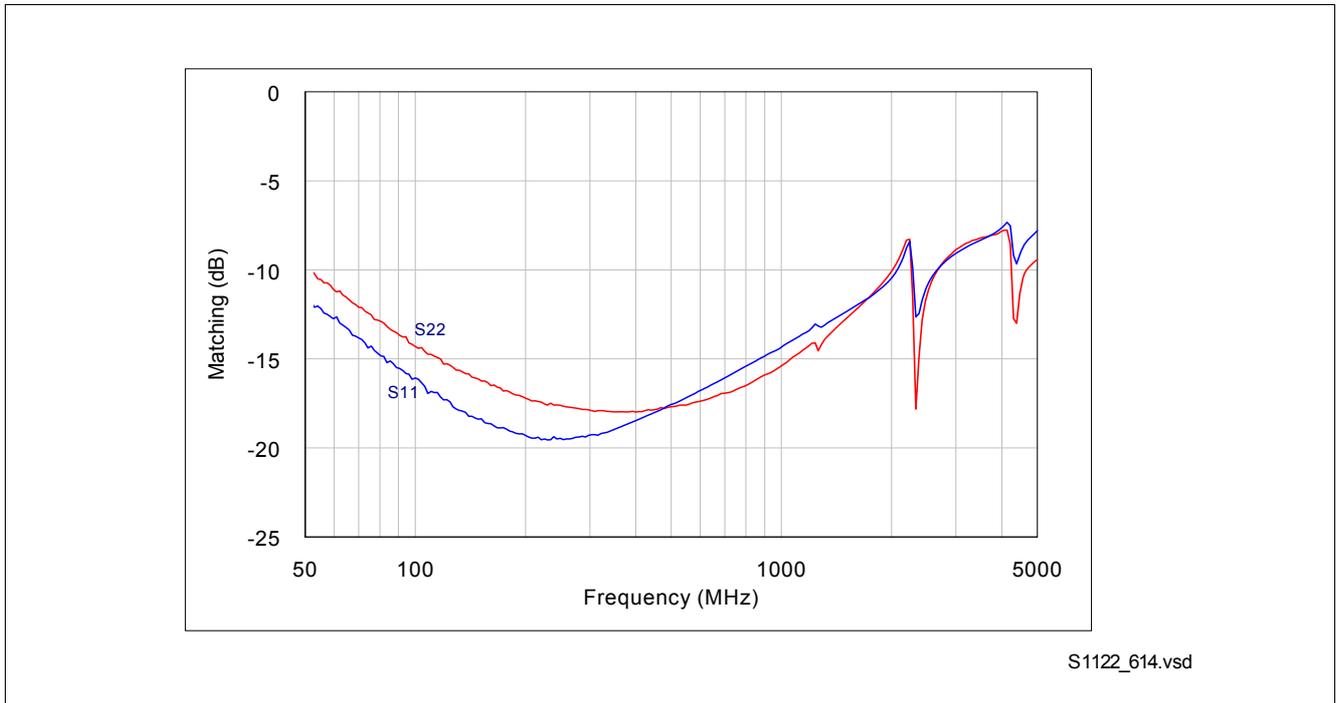
Figure 11   Input Return Loss and Output Return Loss vs. Frequency
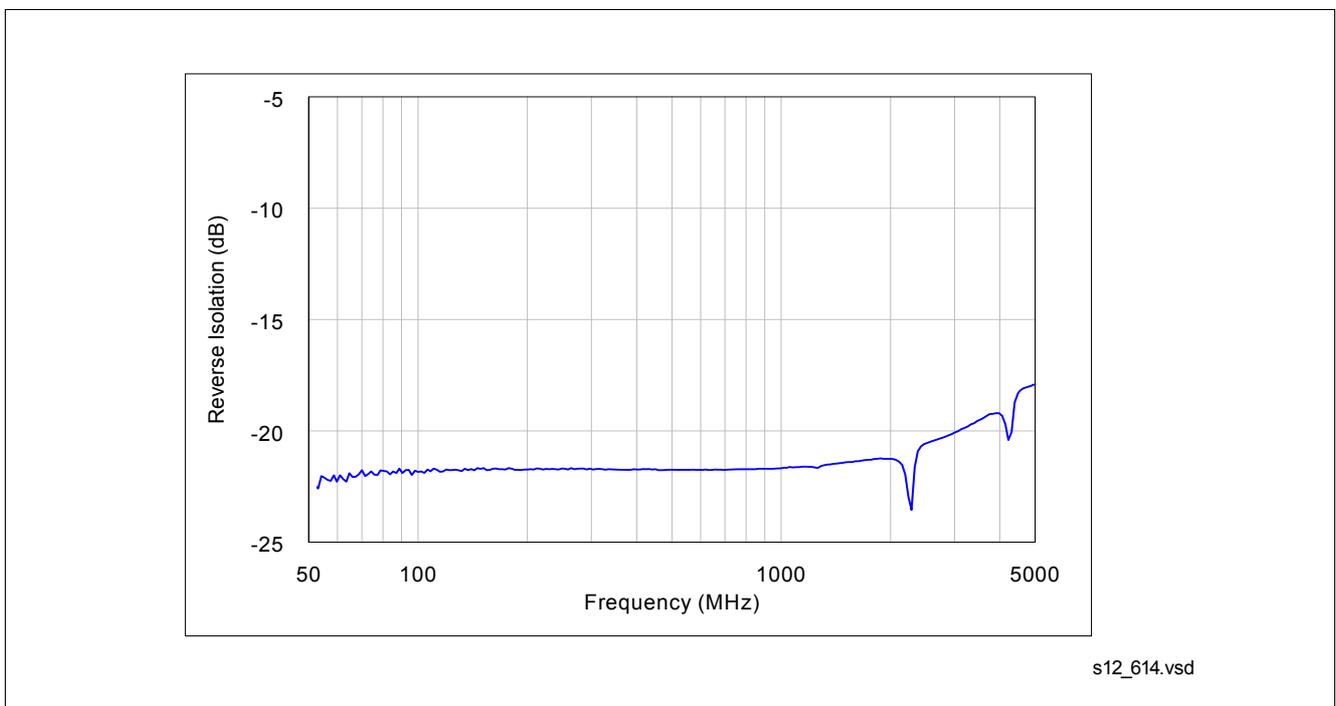

Figure 12   Reverse Isolation vs. Frequency
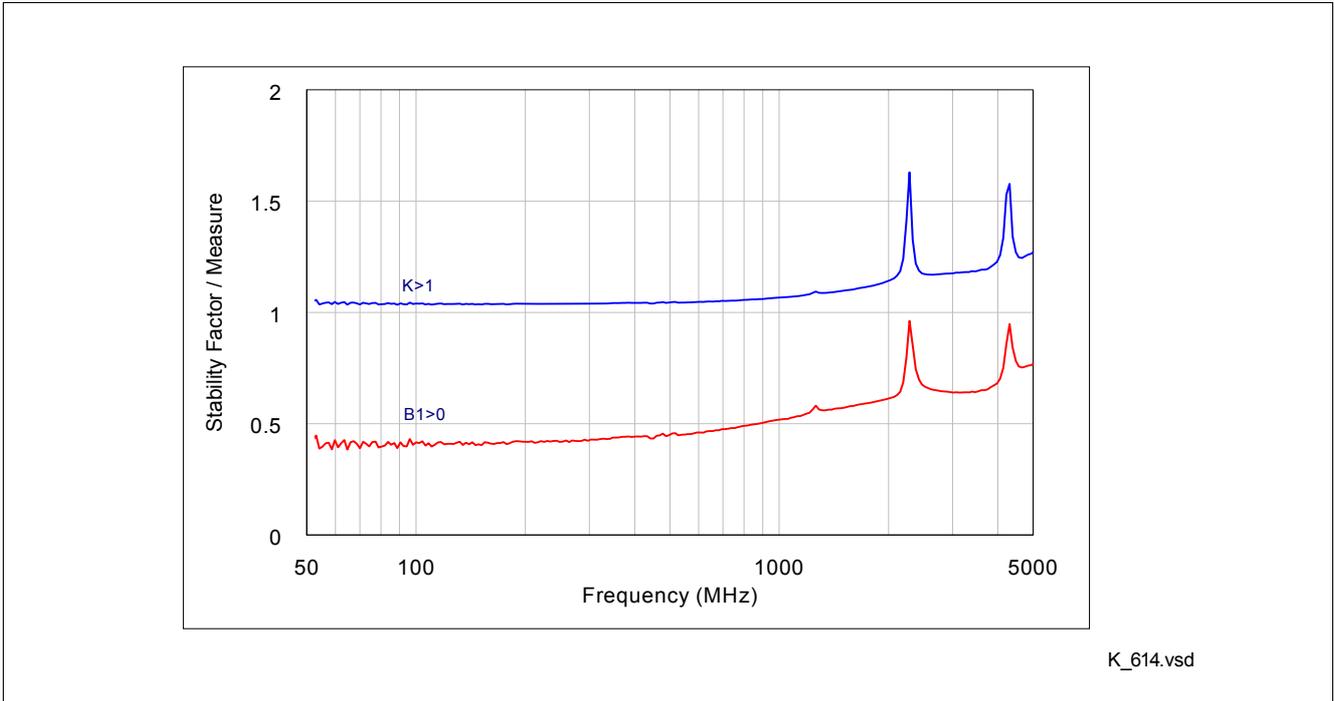
Figure 13   Stability Factor K and Stability Measure B1 vs. Frequency

3.3   BGA616

Table 5   Measured Electrical Performance on Evaluation Board[1]

Parameter	50 MHz	500 MHz	1000 MHz	Unit
Supply Voltage	5			V
Biasing Resistor	15			Ω
DC current	59.6			mA
Gain	18.5	19.0	18.1	dB
Noise Figure	2.8	2.9	2.8	dB
Input 1dB Compression Point	-1	0	1	dBm
Input 3rd Order Intercept Point[2]	---[3]	9		dBm
Input Return Loss	11.6	17.5	14.3	dB
Output Return Loss	9.8	17.6	15.3	dB
Reverse Isolation	22.4	21.7	21.6	dB

1) Including all PCB losses

2) Input power -20 dBm / tone; ∆f = 1 MHz

3) No power combiner for this frequency available in lab

Gain_616.vsd
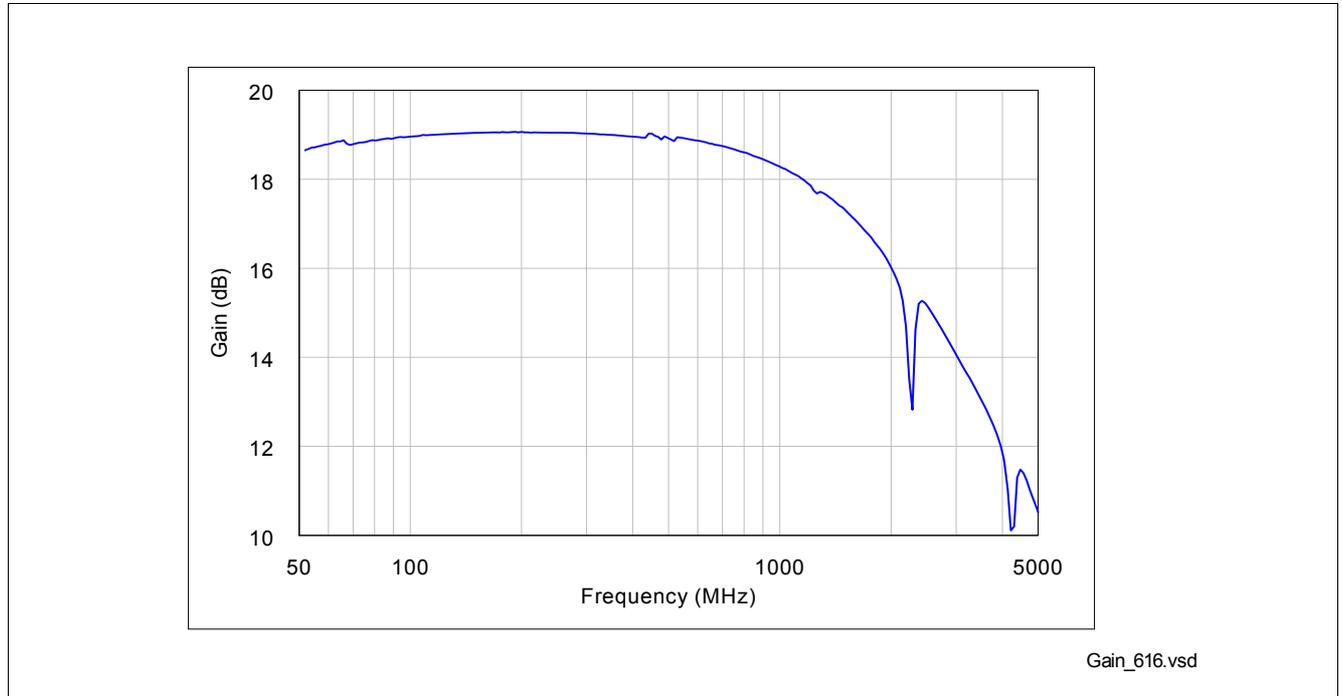
Figure 14   Gain vs. Frequency
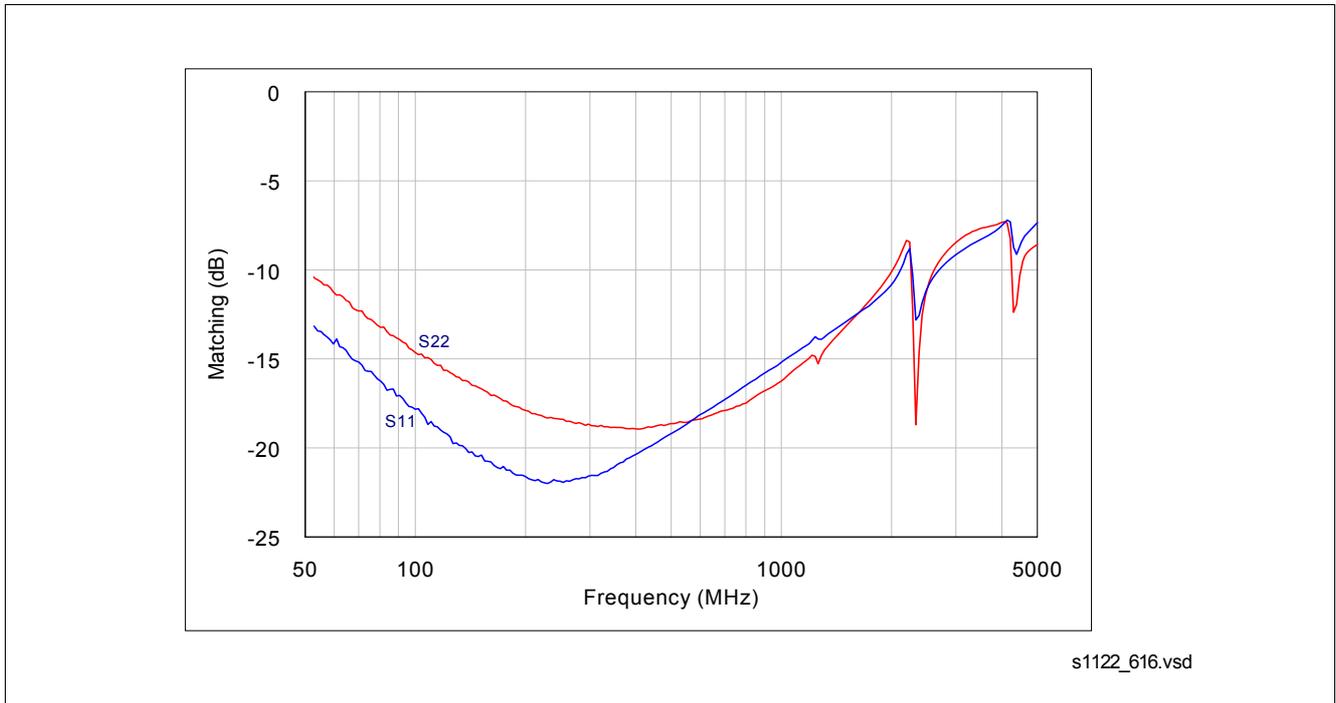
Figure 15   Input Return Loss and Output Return Loss vs. Frequency
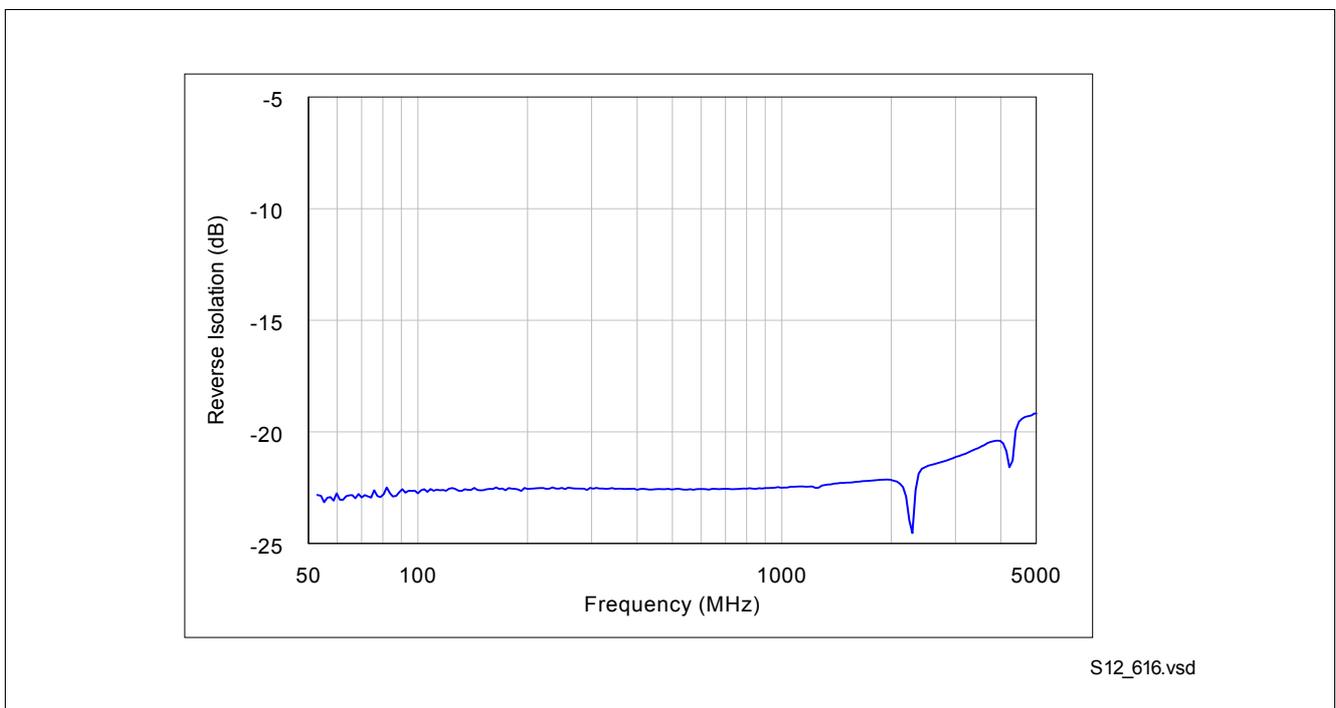
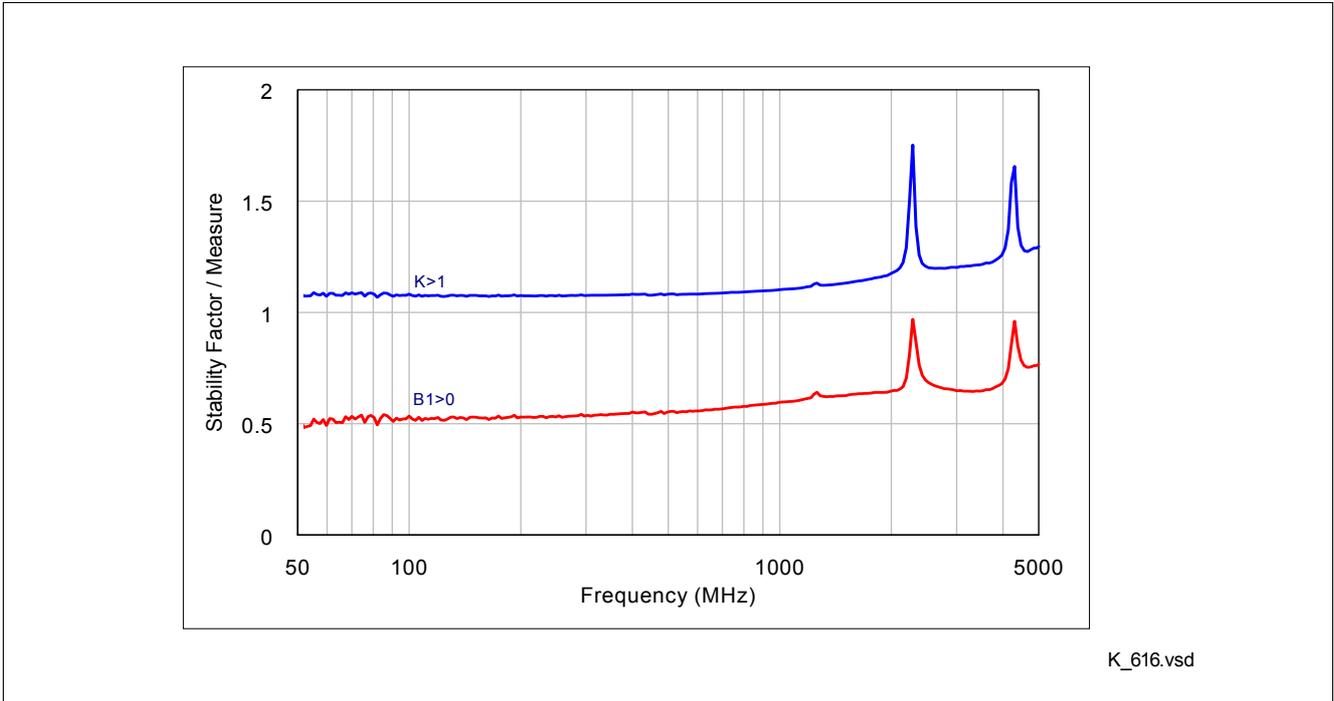**Figure 16   Reverse Isolation vs. Frequency**

K_616.vsd

Figure 17   Stability Factor K and Stability Measure B1 vs. Frequency