May 01, 2002

APPLICATION NOTE 1006

Optimized GSM Matching for the MAX2653 Dual LNA

A discussion of how nonlinearity in GSM/DCS/PCS LNAs cause degradation in receiver blocking performance. An optimal matching circuit for the MAX2653 GSM/DCS/PCS LNA is provided, along with bench blocking measurements. At 1850MHz, G=17.7dB and NF=2.1dB in the presence of a -26dBm +24MHz in-band blocker.

The MAX2653 silicon germanium (SiGe) low noise amplifier (LNA) is a high performance amplifier designed for DCS1800 and PCS1900 mobile handset applications. This device provides low noise figure, high gain, and high input 3rd order intercept point performance in meeting DCS and PCS handset system requirements.

One very important aspect which RF circuit and system designers are most concerned with, is meeting the DCS/PCS in-band and out-of-band blocking requirements. Perhaps one of the most difficult blocking performance standards in DCS radios is the 3MHz blocker which is at ±3MHz away from the wanted receive carrier. This signal is specified at -26dBm at the antenna input. With the input switch and top filter loss taken into account, this interfering blocker could be as high as -29dBm at the LNA input.

It has been reported that receiver desensitization can be caused by amplifier's nonlinearity[1]. Two mechanisms contribute to a noise rise phenomenon. The first mechanism is the gain compression caused by third-order nonlinearity, while the second is the second-order non-linearity in the amplifier circuit. In the latter case, low-frequency noise sources in the circuit are mixed or upconverted with the blocker, thus introducing undesired excess noise in the wanted receive signal frequency. Depending on the low-frequency noise bandwidth, this upconverted noise desensitization could reduce the overall carrier-to-noise ratio (CNR) enough to fail -99dBm sensitivity requirement in the presence of both in-band and out-of-band blockers.

The MAX2653 LNA is designed to ensure that the blocking system requirements in GSM standards will be met with sufficient margin. Test setup for DCS band noise spectrum measurement in presence of an in-band blocker is shown in Figure 1. The MAX2653 applications circuit is shown in Figure 2.

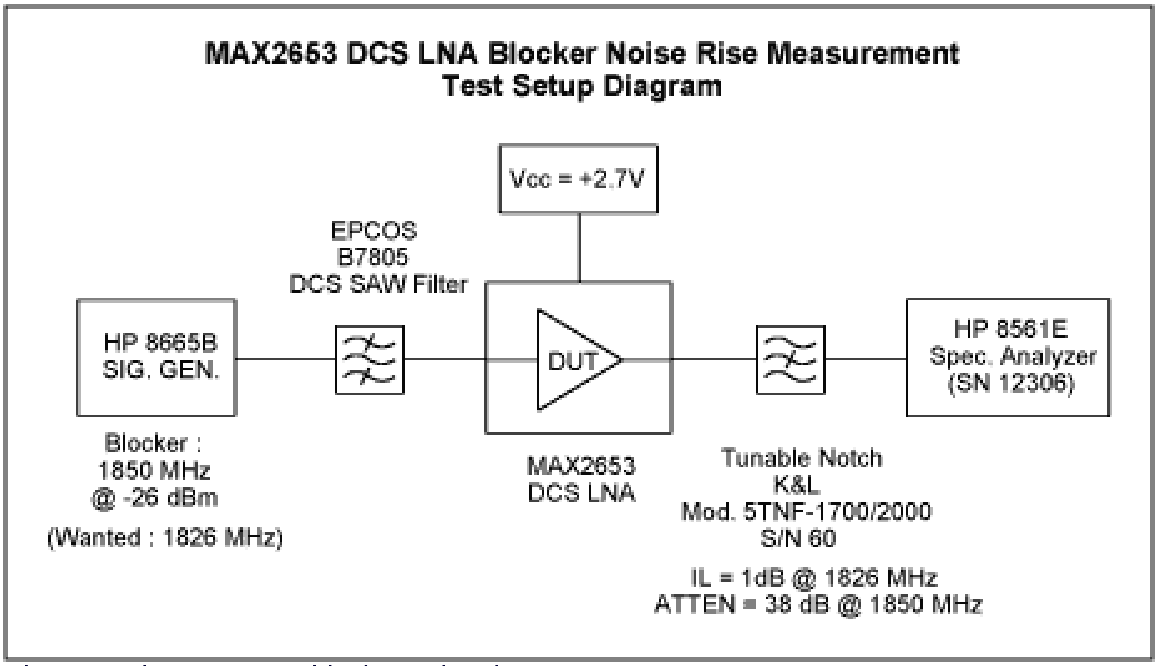

Figure 1. The MAX2653 blocker noise rise measurement setup

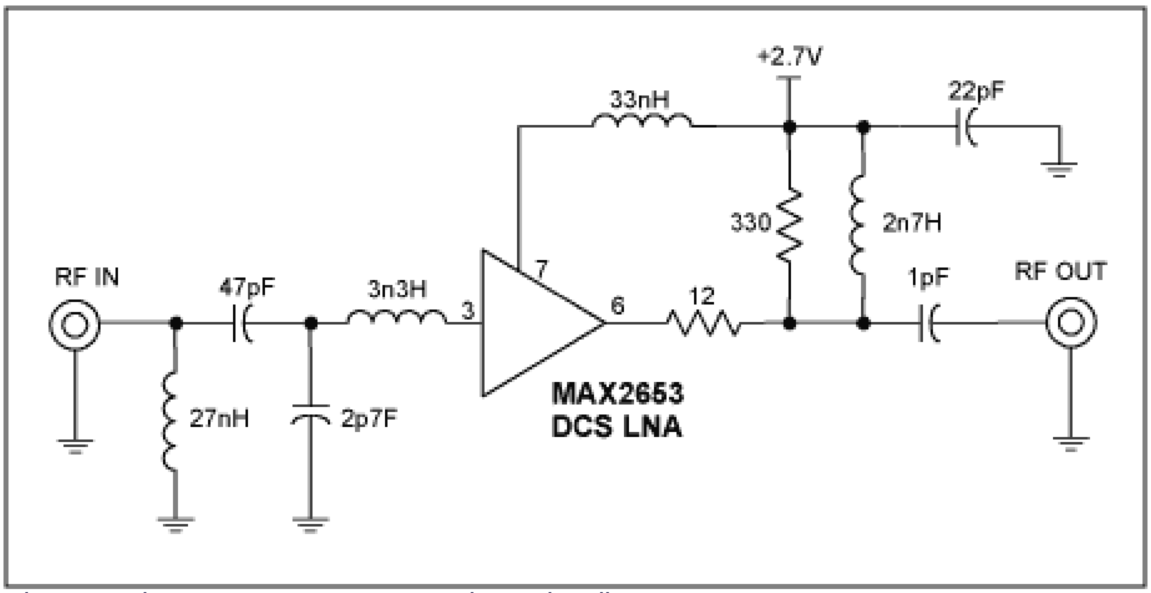

Figure 2. The MAX2653 DCS LNA schematics diagram

Two input matching circuit topologies shown in Figure 2 and 4 provide an optimum low-frequency termination match and minimum noise figure at the LNA input. Spectral plots of noise rise due to in-band blocker are shown in Figure 3 and 5 respectively.

The output matching circuit consists of a 12Ω resistor in series with the collector output of the LNA (Pin 6) to enhance the overall stability of S11 and S22. The 33nH inductor in series with the Vcc bias (Pin 7) and the DC power supply serves as a RF choke, providing additional RF isolation between the Vcc bias pin and the output matching network. These two elements ensure that the LNA is unconditionally stable over out-of-band frequencies. S-parameter measurement was conducted on a modified MAX2653 Evaluation Kit using Agilent 8753E network analyzer. K stability factor is calculated to be greater than 1.0 from 300MHz to 5GHz. Refer to Figure 6 to 9 for frequency response summary.

Similar topologies can be applied to E-GSM and PCS1900 bands for other MAX265x devices.

In-Band Blocker Noise Rise Test Result

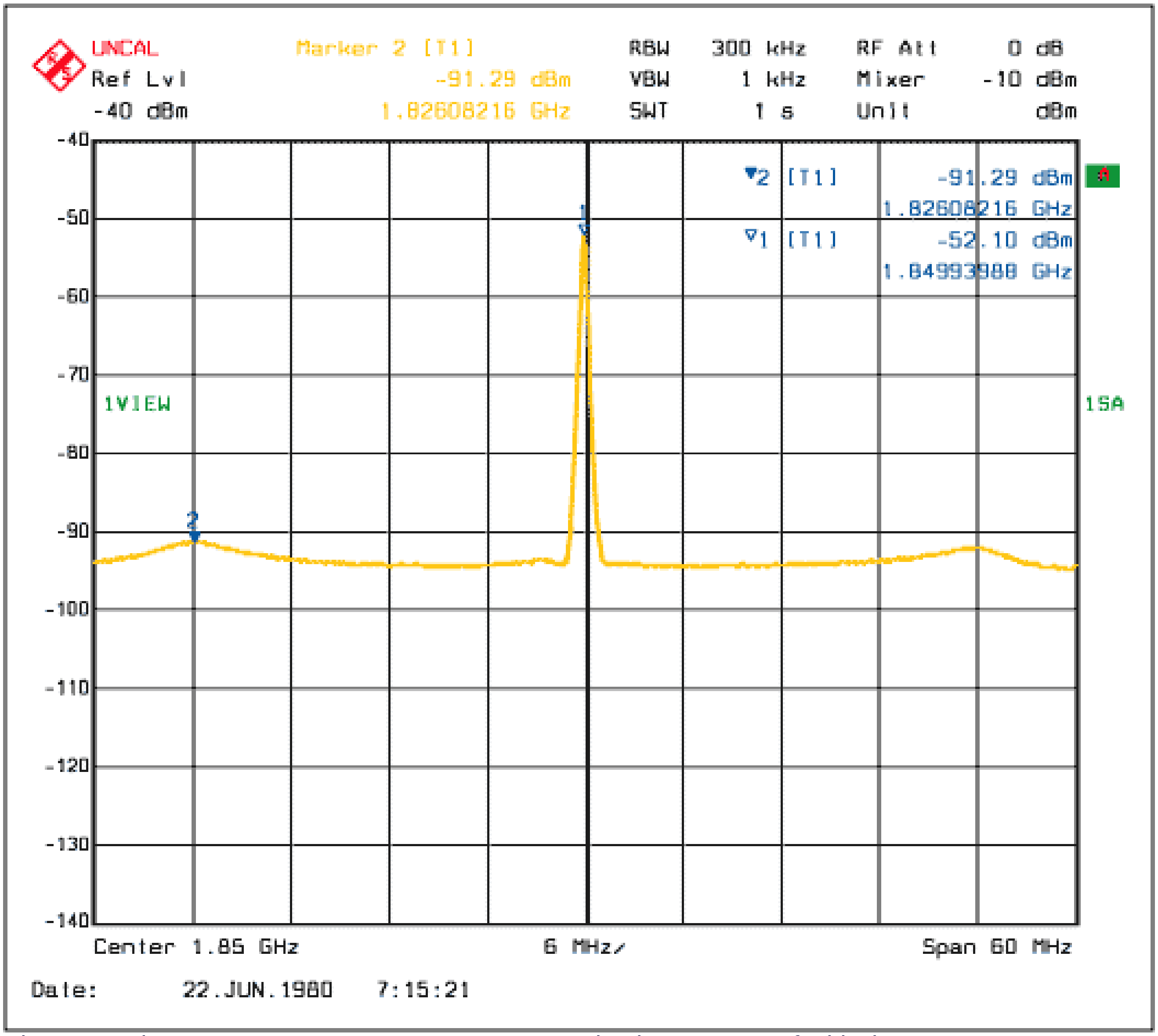

Figure 3. Noise spectrum at MAX2653 LNA output under the presence of a blocker

Test conditions: In-band blocker level applied to input top filter is -26dBm at 1850 MHz (~24MHz offset above wanted signal at 1826MHz)

Parameter	Description	
Noise Power at 1826 MHz @ 200kHz BW		-93.5 dBm
Wanted Signal at 1826 MHz	-99 dBm - (I.L of switch and top filter) + LNA Gain	-99 - 3 + 17.7 = -84.3 dBm
Carrier-to-Noise Ratio (CNR)	Signal - Noise	9.2 dB

Frequency	Gain	Noise Figure (dB)
1820	17.70	1.97
1850	17.68	2.05
1880	17.70	2.13

In-Band Blocker Noise Rise Test Result (Alternative Input Match Topology)

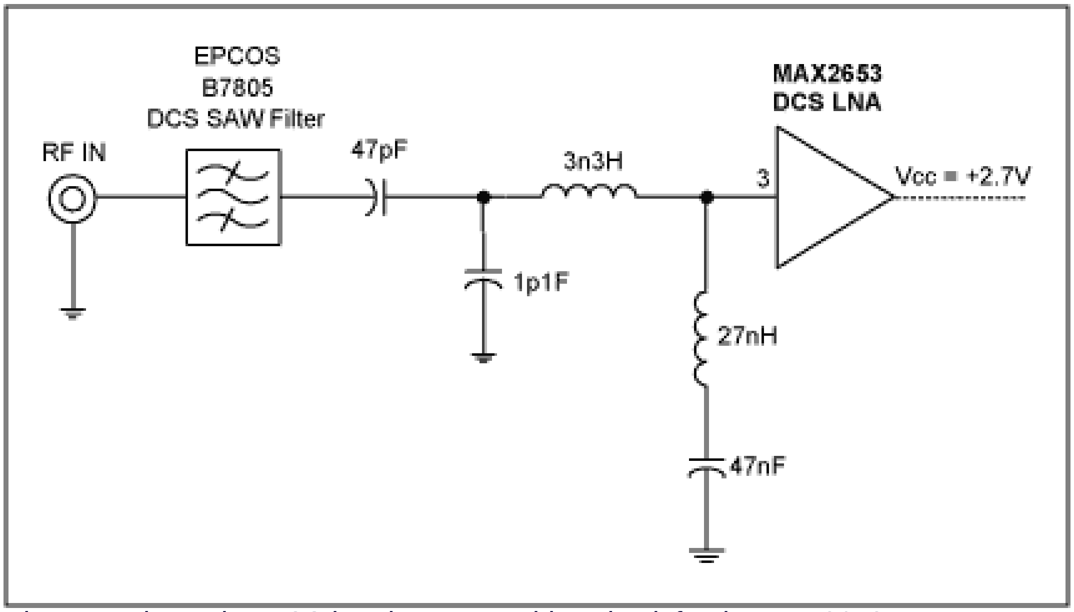

Figure 4. Alternative DCS band Input matching circuit for the MAX2653

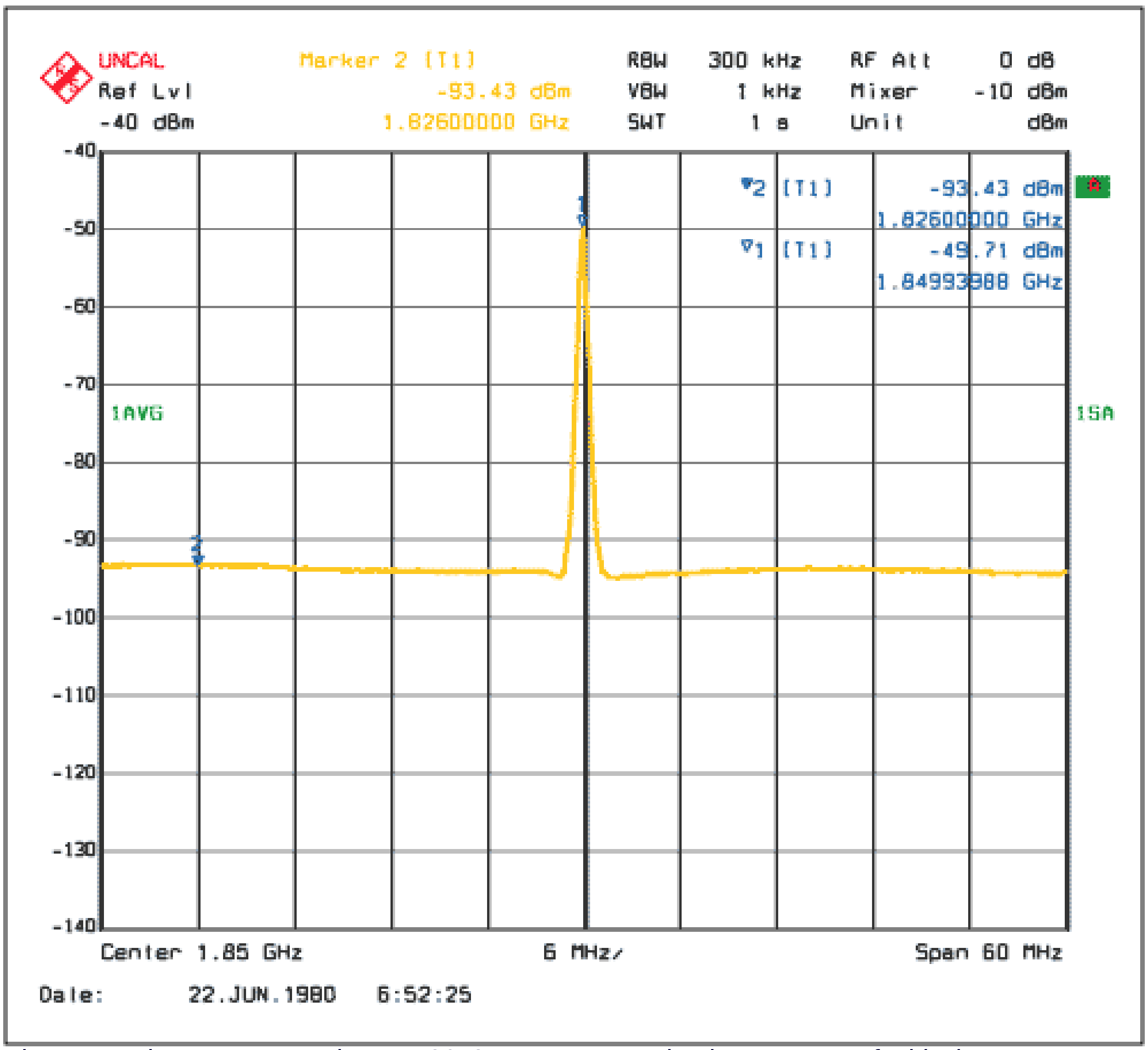

Figure 5. Noise spectrum at the MAX2653 LNA output under the presence of a blocker

Test conditions: In-band blocker level applied to input top filter is ?26dBm at 1850 MHz (~24MHz offset above wanted signal at 1826MHz)

Parameter	Description	
Noise Power at 1826 MHz @ 200kHz BW		-95.1 dBm
Wanted Signal at 1826 MHz	-99 dBm - (I.L of switch and top filter) + LNA Gain	-99 - 3 + 17.7 = -84.3 dBm
Carrier-to-Noise Ratio (CNR)	Signal - Noise	10.8 dB

Frequency	Gain	Noise Figure (dB)
1820	17.70	2.07
1850	17.70	2.17
1880	17.69	2.15

The MAX2653 Frequency Response

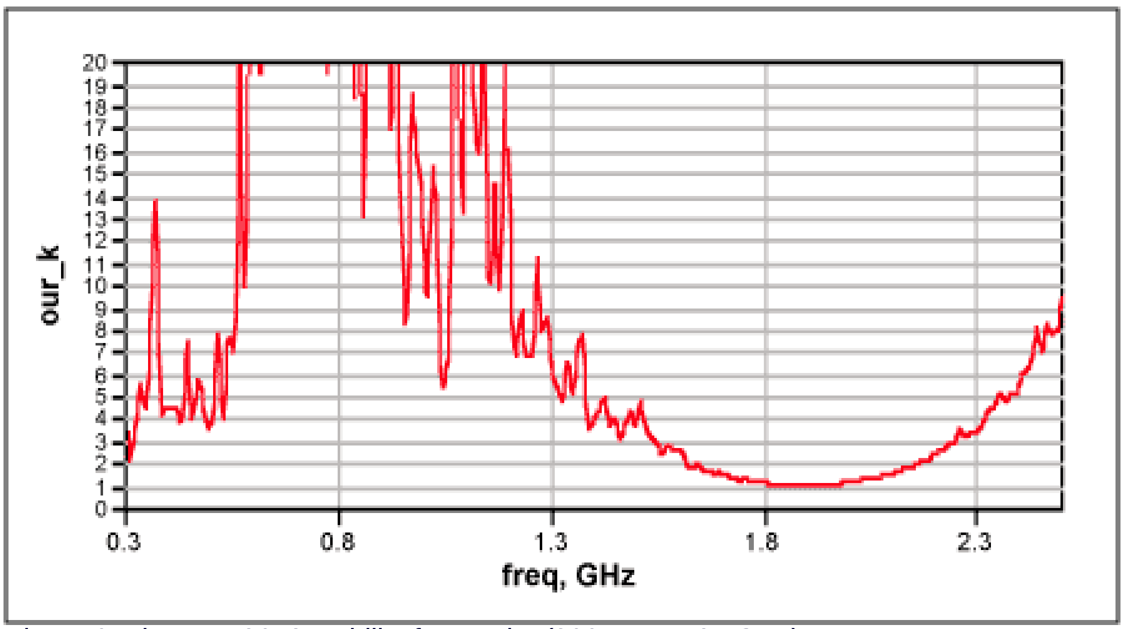

Figure 6. The MAX2653 stability factor plot (300MHz to 2.5GHz)

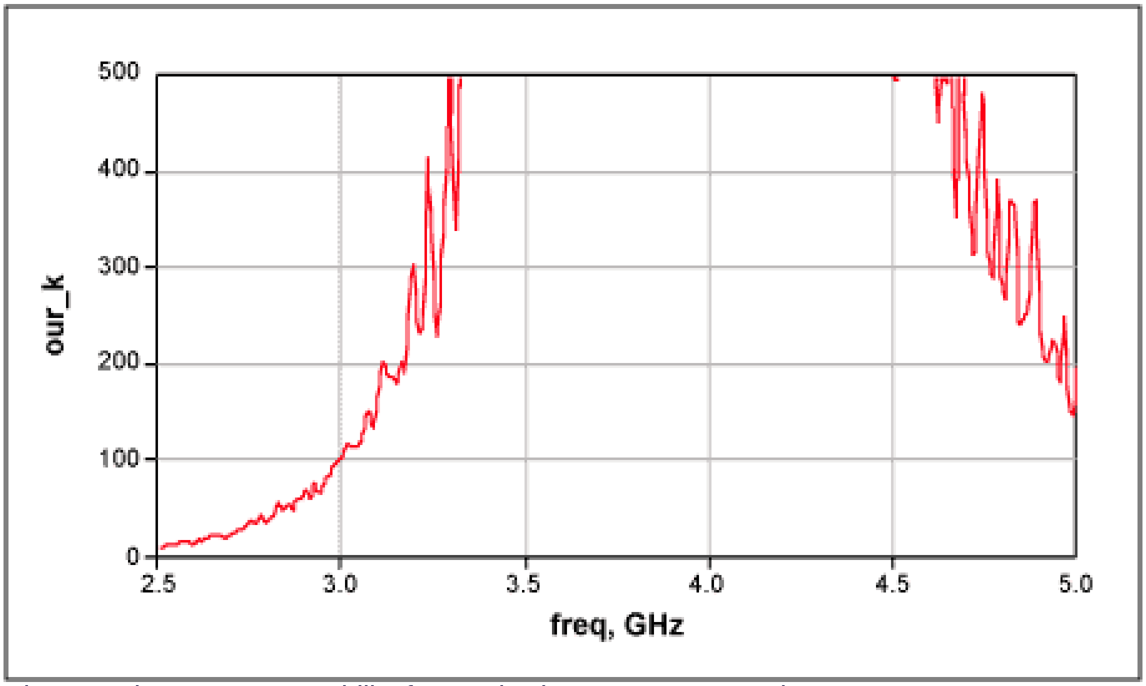

Figure 7.The MAX2653 stability factor plot (2.5GHz to 5.0 GHz)

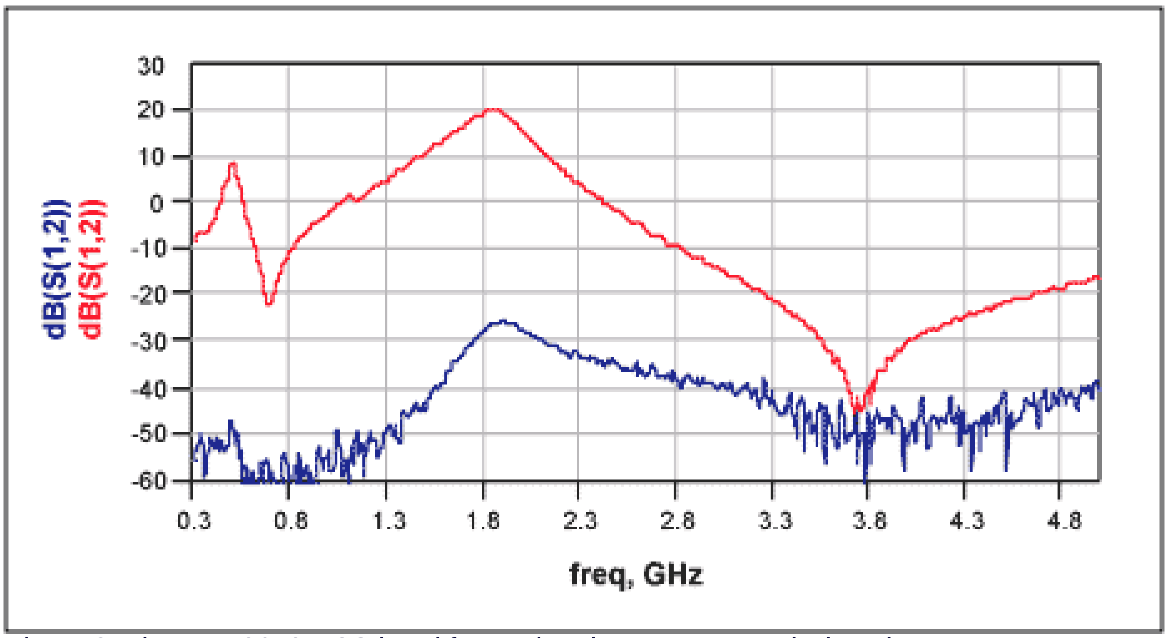

Figure 8. The MAX2653 DCS band forward and reverse transmission plot

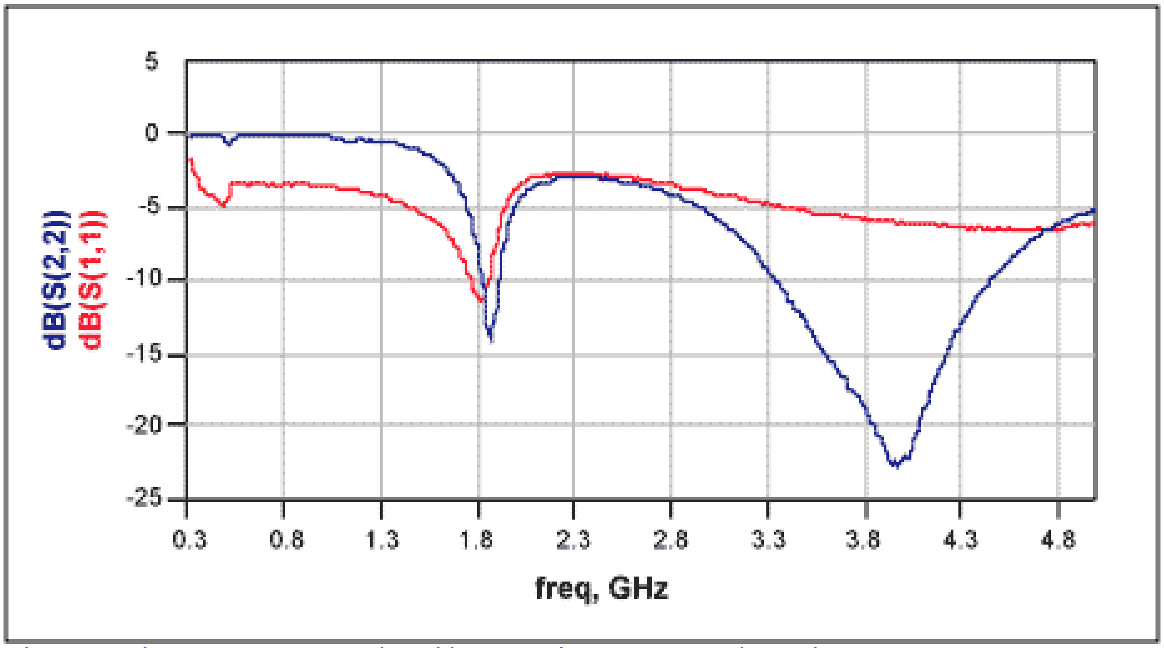

Figure 9. The MAX2653 DCS band input and output return loss plot

References

1. R. G. Meyer and A. K. Wong, *Blocking and Desensitization in RF Amplifiers*, IEEE J. Solid-State Circuits, vol. 30, pp. 944-946, Aug. 1995.

More Information

MAX2653: QuickView -- Full (PDF) Data Sheet -- Free Samples