Keywords: rf, rfic, gps if filter, simulated, butterworth, response, GPS, cascaded gain, noise figure, rf ics, radio frequency, rfics

APPLICATION NOTE 2242

MAX2538 Uses GPS IF LC filter Optimized for 183.6MHz IF

Sep 26, 2003

Abstract: This application note presents the design of a GPS IF filter at 183.6MHz for use with the MAX2538. Simulated and measured response and performance data are provided. The filter is Butterworth response, second order, with capacitor coupling. Insertion loss is 3.2dB. The GPS cascaded gain is 28.9dB, and the noise figure is 1.8dB.

General Description of MAX2538

The MAX2538 LNAs (low noise amplifiers) and mixers are optimized for CDMA (code division multiple access) applications in the cellular and PCS bands. The MAX2538 addresses triple-band, quad-mode applications by providing switched signal paths for AMPS, digital cellular, and digital PCS. The mixers provide switched IF ports that can be used interchangeably with either mixer input port. In addition, all versions in the family provide an LNA/Mixer/LO (local oscillator) path for GPS (global positioning system) down conversion.

Click here for an overview of the wireless components used in a typical radio transceiver.

Objective

Design a second-order, 1kΩ, capacitor-coupled, Butterworth LC filter for a GPS IF at 183.6MHz to eliminate the use of an IF SAW filter. This solution saves cost and printed circuit board (PCB) area.

Step 1:

For simplicity and design speed, filter design software is used. In this example, Filter Solutions 8.1* was used.

The Filter design parameters are:

2^{nd} order Bandpass Butterworth, capacitor-coupled filter
F_C = 183.6MHz
BW = 15MHz
Z_{IN} = Z_{OUT} = 1kΩ
Inductor Q = 35–50
Capacitor Q = 350–500

Figure 1.

The circuit below (**Figure 2**) and the frequency response (**Figure 3**) are the results obtained with Filter Solutions software. The light-blue, upper traces shown in Figure 3 are for a filter with lossless components. The red trace depicts the expected performance with lossy components.

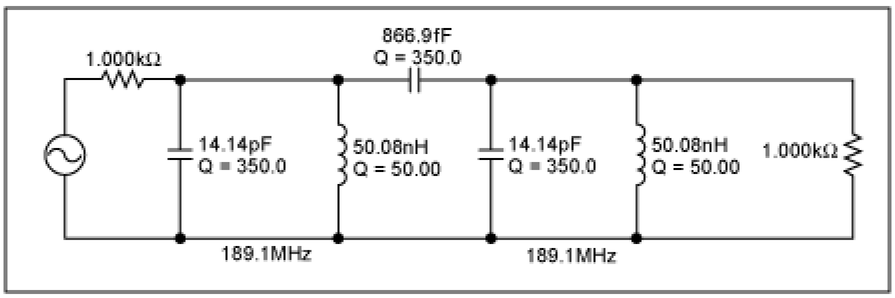

Figure 2.

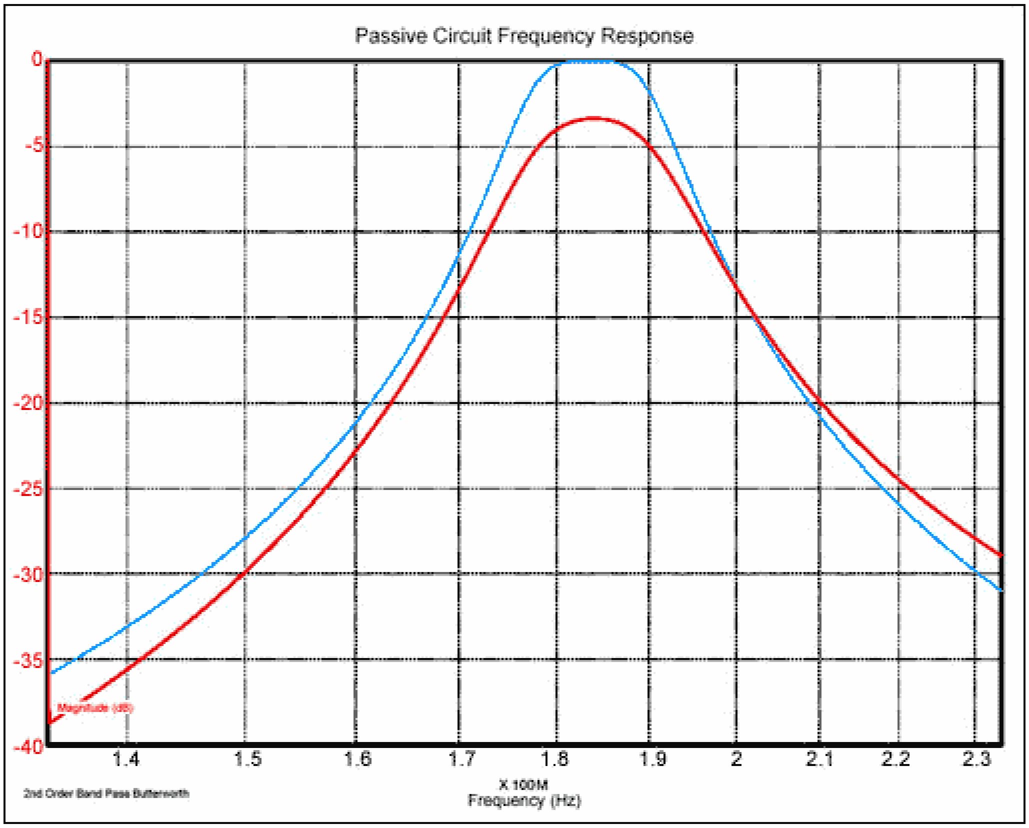

Figure 3.

Step 2:

Use the MAX2538 GPS Mixer model to design the matching network between the MAX2538 GPS differential mixer outputs (pin 20 and 21) and the 1kΩ IF filter.

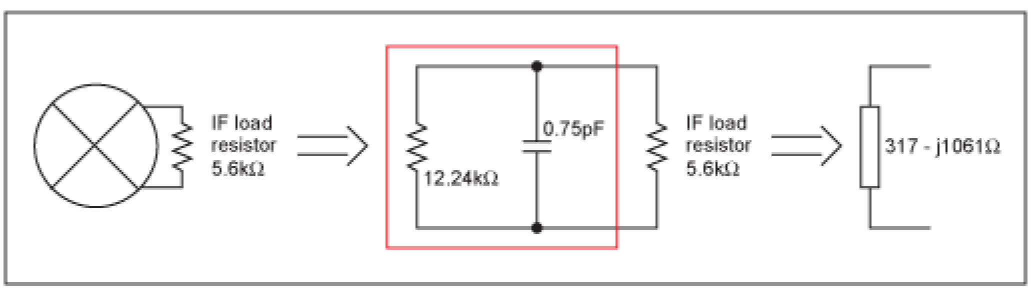

Figure 4.

Step 3:

Use a High Frequency Circuit Simulator to simulate the frequency response of the GPS IF filter matched to the GPS IF filter. Agilent ADS 2002 was used for this example. To reduce the number of passive components and reduce the insertion loss, integrate one resonant tank (the resonator on the input side) with the matching network required to match the mixer's output impedance to the 1kΩ filter.

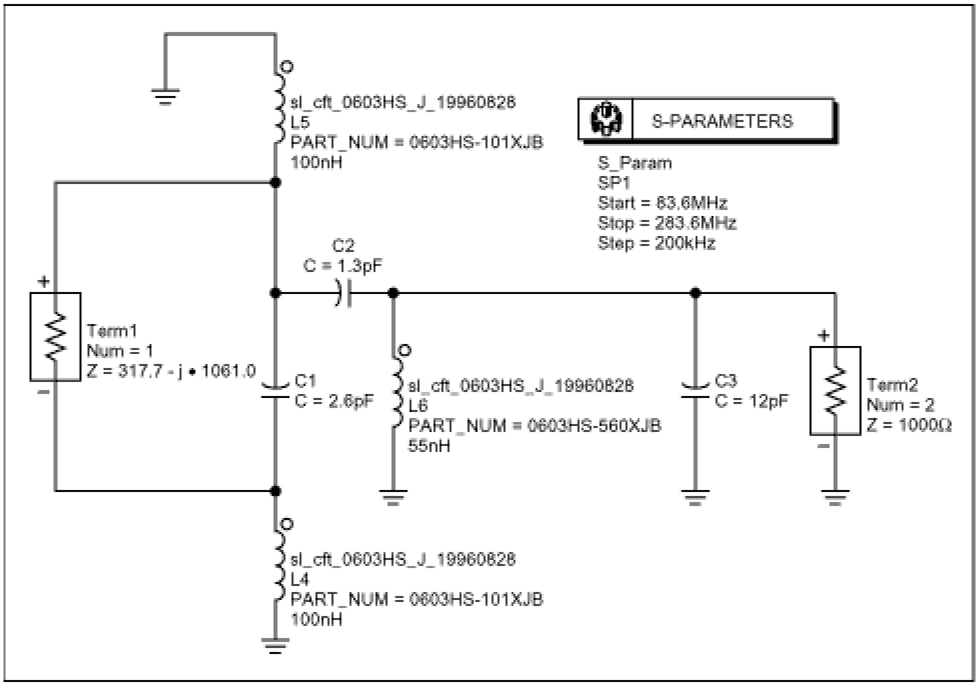

Figure 5.

Figure 6 is the frequency response of the GPS IF Filter matched to the MAX2538 GPS Mixer.

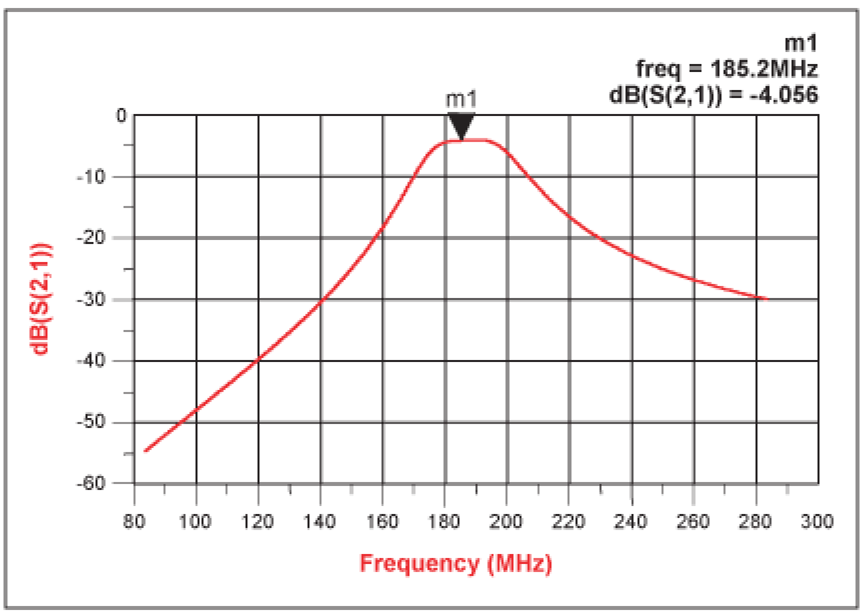

Figure 6.

Step 4:

After implementing the circuit obtained in Agilent ADS, the cascaded measurement of the MAX2538 from the GPS LNA input to the GPS IF filter output was performed.

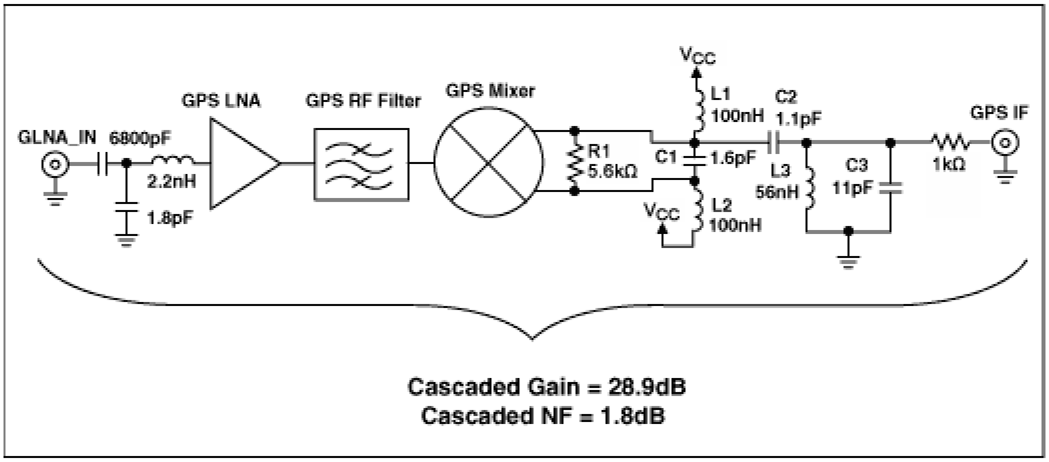

Figure 7.

Test Conditions

V_{CC} = 2.85V

F_{RF} = 1575.42MHz, PIN_{RF} = -40dBm
IF= 183.6MHz
F_{LO} = 2087.73MHz, PIN_{LO}= -7dBm
GPS LNA gain = 17.5dB
GPS mixer gain = 10dB
GPS RF SAW filter loss = -1.8dB

The 1kΩ resistor at the output is used for measurement purposes only, since the output of the filter is 1kΩs. To calculate cascaded gain, add the measured gain to the attenuation introduced by the mismatch between 50Ωs and 1050Ωs.

Attenuation = 0.5 × |20log(50 / 1050)| = 13.22dB

Cascaded gain = measured gain + 0.5 × |20log(50 / 1050)| from LNA input to 1kΩ output (GPS IF output).

Cascaded gain = 15.7dB + 13.22dB = 28.9dB

Cascaded gain = LNA gain + RF filter loss + mixer gain + IF filter loss = 28.9dB

Discrete GPS IF filter loss = +28.9dB - 17.5dB + 1.8dB - 10.0dB = 3.2dB

Cascaded NF is measured from LNA input to 1kΩ output (GPS IF output).

Cascaded NF = 1.8dB

Component values used in the IF section:

C1 = 1.6pF ±0.1pF	GRM36COG1R6B050 Murata (0402)
C2 = 1.1pF ±0.1pF	GRM36COG1R1B050 Murata (0402)
C3 = 11pF ±0.1pF	GJ61555C1H110JB01B Murata (0402)
L1, L2 = 100nH	0603CS-R10XJB CoilCraft (0603)

L3 = 56nH ±5%	0603CS-56NXJB CoilCraft (0603)
R1 = 5.6kΩ ±1%	

*Filter Solutions by Nuhertz Technologies, L.L.C., http://www.filter-solutions.com

Related Parts	
MAX2538	Quadruple-Mode PCS/Cellular/GPS LNA/Mixers

More Information
For Technical Support: http://www.maximintegrated.com/support
For Samples: http://www.maximintegrated.com/samples
Other Questions and Comments: http://www.maximintegrated.com/contact

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