RFMD

DESIGN APPLICATION NOTE --- AN010

SGA-2486 Gain Flatness Compensation Circuit

Abstract

New SiGe amplifier gain blocks exhibit a combination of wide bandwidth, high gain and IP3 with a low noise figure. This application note describes circuits that have been developed to improve gain flatness over a wide frequency range.

Introduction

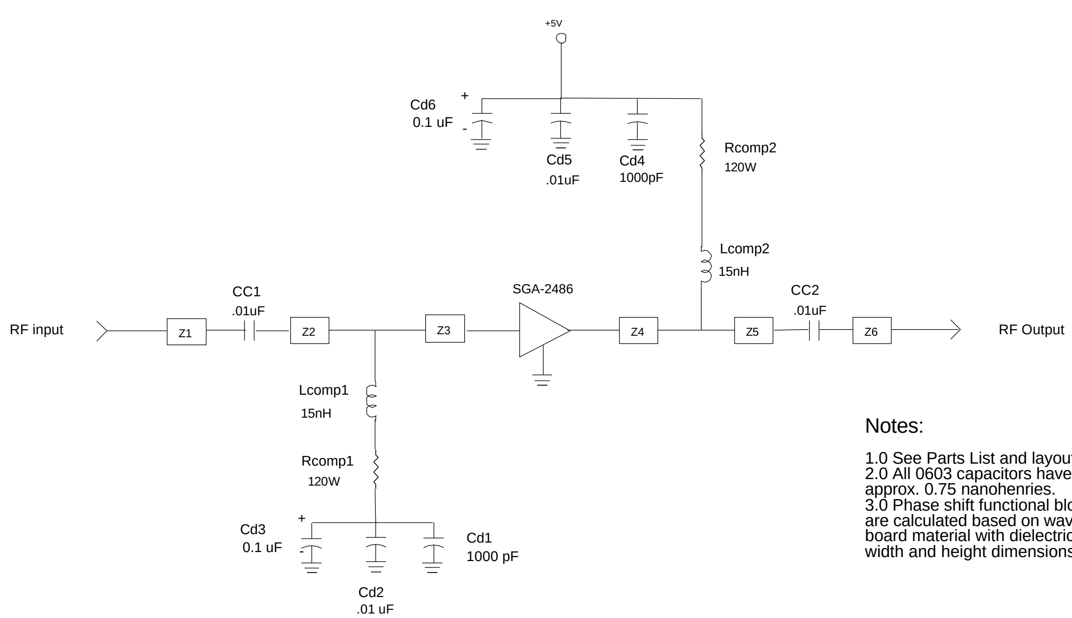
The SGA-2486 (datasheet # EDS-100629) is a high gain, wideband cascadable SiGe gain block. It exhibits a combination of low power, high IP3 and low noise figure. It does however show an expected gain roll-off versus frequency characteristic of about 3 dB between 50 and 2150 MHz. This is easily corrected using the application circuit topology shown in Figure 1 below. Circuit components Lcomp1, Rcomp1, Lcomp2, Rcomp2 determine gain flatness and must also be selected to preserve input/output return loss. The value of Rcomp2 is further constrained by biasing requirements. The circuit below operates with a 5 volt supply and draws 20 mA. It is characterized for the 50 - 2150 MHz frequency range.

Design / Performance Summary

The circuit layout and performance data are shown on pages 2 and 3. The circuit was constructed on our standard 86 package evaluation board according to the schematic shown in Figure 1. The performance highlights to be noted are :

- 16 dB of gain and 1 dB total gain variation over the 50-2150 MHz frequency range.
- Greater than 17dB input / 20 dB output return loss over the 50-2150 MHz frequency range.
- Flat Group Delay characteristic-only about 150 picoseconds added group delay over the 50-2150 MHz frequency range.
- Unconditionally stable over operating range.
- Pages 3 & 4 show how to use the circuit below with an output RC network to achieve less than 0.1 dB flatness from 20-1000 MHz or 0.3 dB flatness from 20-2150 MHz.

SGA-2486 @ 50-2150 MHz Application Circuit



Ref. Des.	Zc	Length (Degrees @ 1000 MHz)
Z1	50	12.3
Z2	50	3.3
Z3	50	12.9
Z4	50	13.5
Z5	50	3.3
Z6	50	12.0

Notes:

1.0 See Parts List and layout on page 2.
2.0 All 0603 capacitors have an implied series inductance of approx. 0.75 nanohenries.
3.0 Phase shift functional block elements between components are calculated based on wavelength of 1000 MHz signal on FR4 board material with dielectric constant of 4.1 and microstrip width and height dimensions of W=.061 inch and h=.030 inch.

Figure 1

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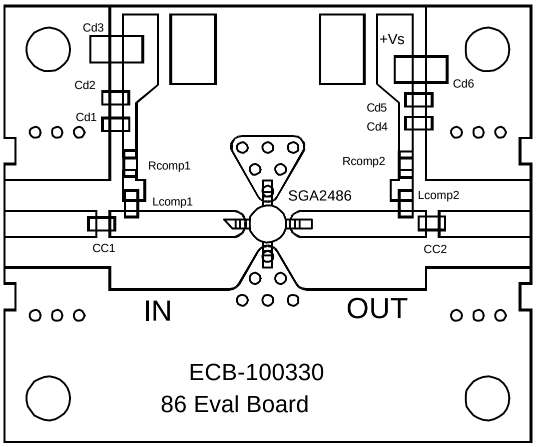
Application Circuit Board Layout, for 50-2150 Mhz (Reference Figure 1 Schematic.)

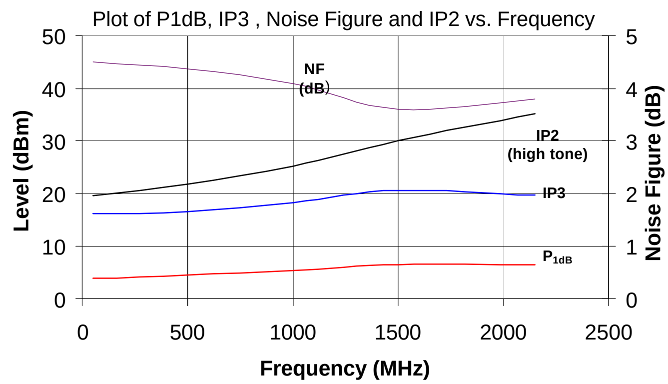


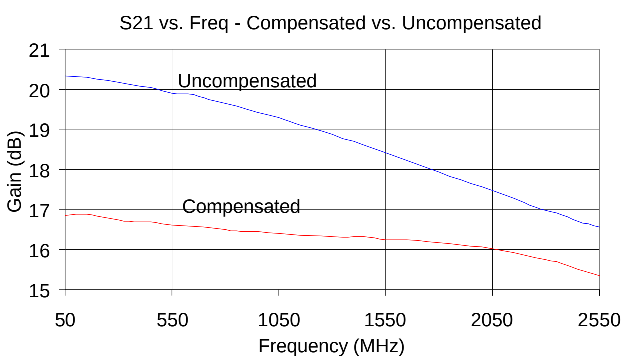
Notes:
Board Material: FR4, **e=4.1**
Dielectric Thickness = 30 mils
Metal Thickness: 1Oz. (1.4 mil)
Backside fully plated

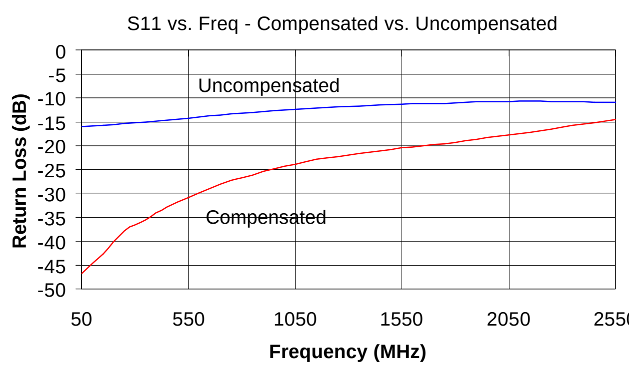
Figure 2

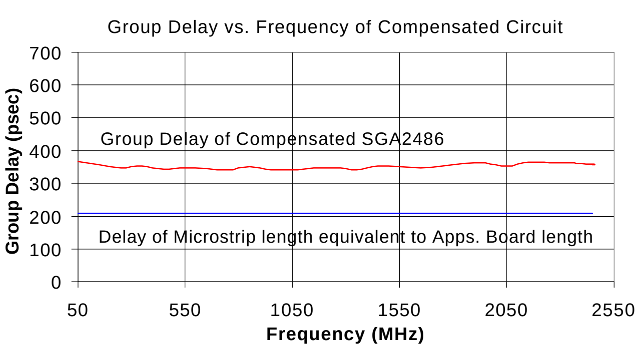
Parts List

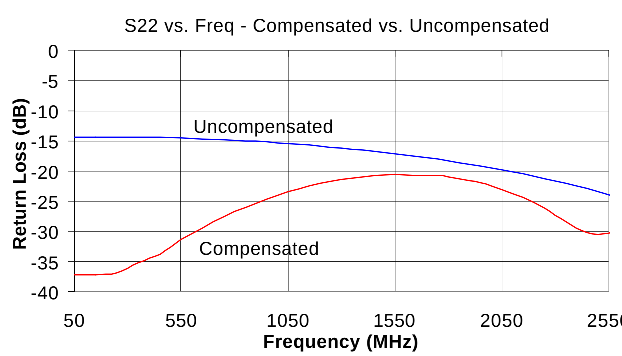
REF. DESIG.	DESCRIPTION	VALUE	PART NUMBER / STYLE
CC1,2	CAP.	.01 uF	0603 package (ROHM MCH 18)
CD1,4	CAP.	1000 pF	0603 package (ROHM MCH 18)
CD2,5	CAP.	.01 uF	0603 package (ROHM MCH 18)
CD3,6	CAP. (POLAR)	0.1 uF	"A" size package, 35V Tantulum
RCOMP1,2	RES.	120 Ohms	0603 package
LCOMP1,2	IND.	15 nH	TOKO LL1608-FH15NJ (0603)









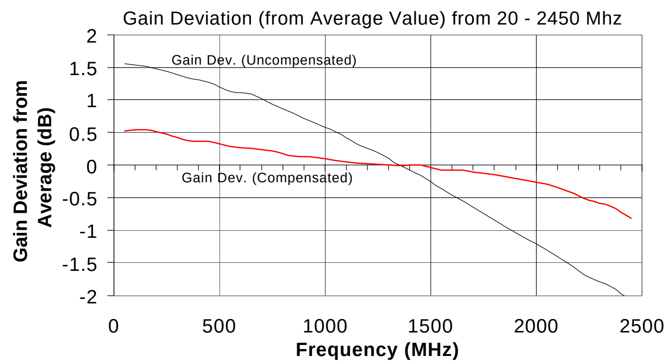


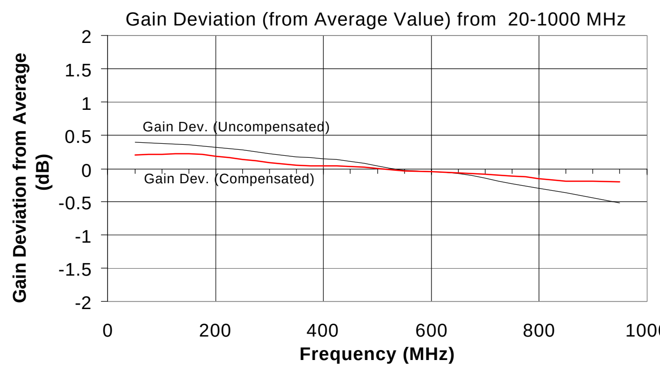
Gain Flatness Performance (Circuit in Figure 1.)

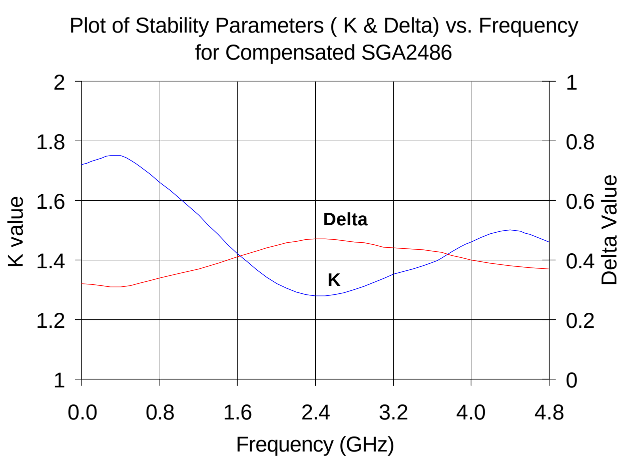
The three graphs in the right hand column show gain deviation with frequency derived by taking the difference between the gain at a particular frequency and the average gain calculated over the indicated frequency ranges.

Fine Tuning of Gain Flatness

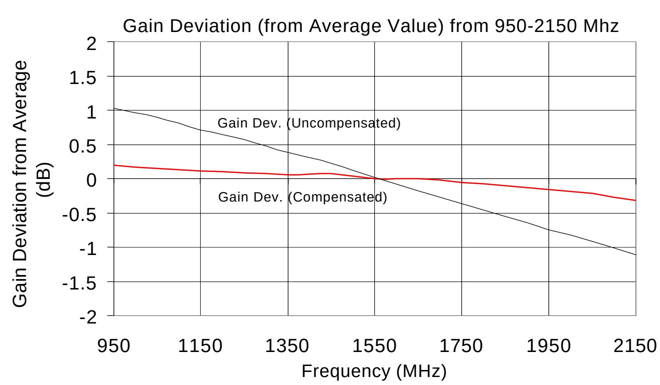
Figure 3 shows how to add a pi-pad to the output of the previously shown SGA2486 application circuit to obtain finer gain flatness. The resistor values of the pad are selected for a 50 Ohm match in either direction with a shunt capacitor across the bridging resistor. The d.c. attenuation value should be initially selected to be slightly larger than the gain difference between the frequency range endpoints. It is then iterated as necessary. The value of the shunt capacitor is then adjusted in a simulator to obtain maximum flatness over the frequency range. In the case of the 20-1000 MHz frequency range, a flatness of less than 0.1 dB was obtained. Over the 20-2150 MHz band, the flatness was reduced only to slightly less than 0.3 dB, mainly because the slope of the gain/ frequency response lessened between about 1000 and 1700 MHz, causing a response peak.







(Note: For unconditional stability K>1, Delta<1)



Schematic Diagram of SGA2486 Applications Circuit from Figure 1 combined with pi-pad R/C network at output.Tables of component values for pi-pad at two frequency ranges are included below, along with expected performance data for each configuration.

Ref. Des.	Zc	Length (Degrees @ 1000 MHz)
Z1	50	12.3
Z2	50	3.3
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Z5	50	3.3
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Output pi-pad network enlarged for clarity. See corresponding tables of component values below.

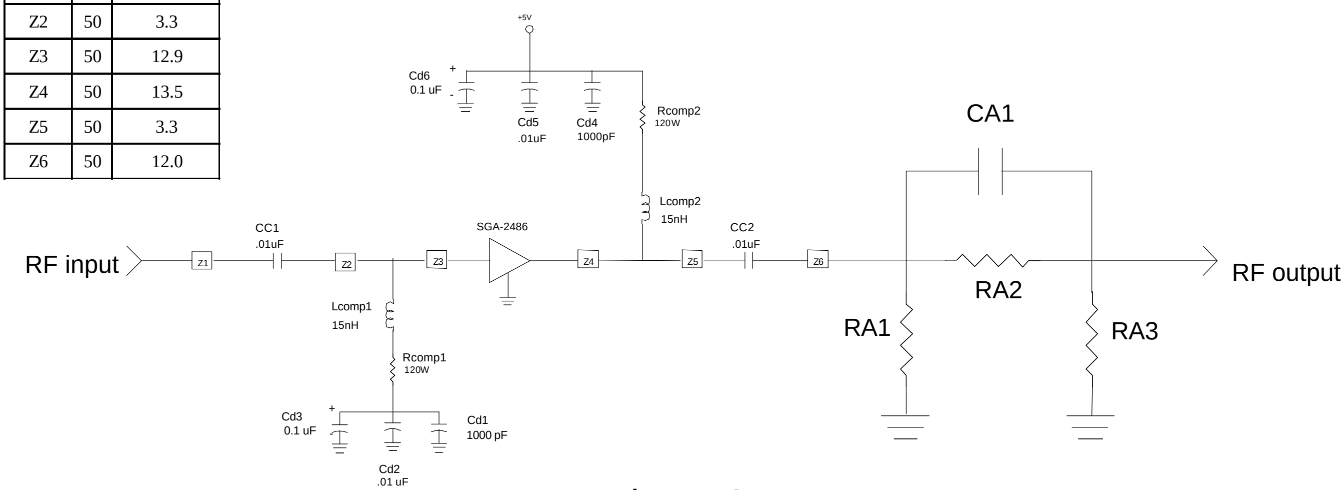


Figure 3

Table of Component Values for f =20-1000 MHz. (Use 0603 style resistors and capacitors)

RA1 (Ohms)	RA2 (Ohms)	RA3 (Ohms)	CA1 (pF)	Low Freq. Attenuation (dB)	Freq Range (MHz)	Gain (dB)
750	6.8	750	39	-1.2	20-1000	15.7

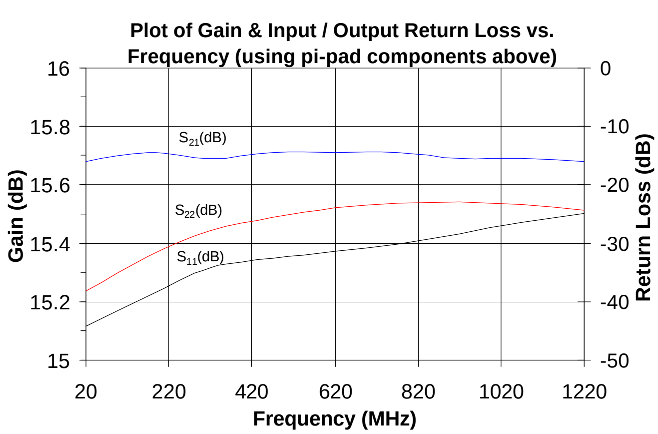
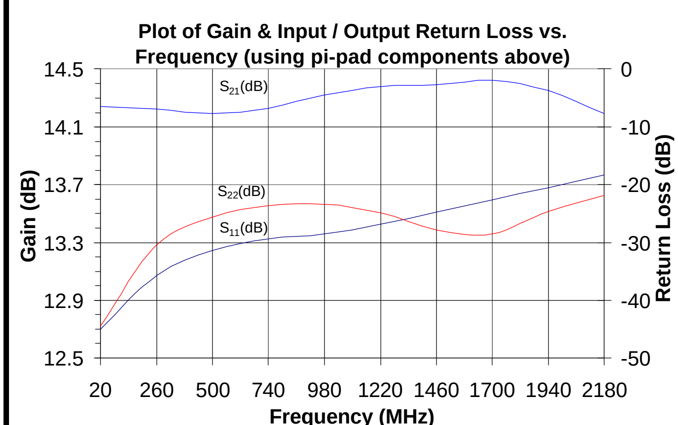


Table of Component Values for f = 20-2150 MHz (Use 0603 style resistors and capacitors)

RA1 (Ohms)	RA2 (Ohms)	RA3 (Ohms)	CA1 (pF)	Low Freq. Attenuation (dB)	Freq Range (MHz)	Gain (dB)
330	15	330	8.2	-2.6	20-2150	14.2



Conclusion

This application note has shown a simple solution using passive components to improve the gain flatness of the SGA-2486 SiGe cascadable gain block. This device, with low cost, wideband performance, low power dissipation and high gain is an excellent choice for use in many applications.

For applications requiring flat gain over a specified frequency range the circuit shown in Figure 1 improves gain flatness significantly. The addition of the simple inductor/resistor matching networks to the normal device biasing topolology allows the gain flatness to be held to 1dB over a broad frequency range (20 MHz to 2150 MHz). Adding an optional pi-pad to the output (shown in Figure 3) improves gain flatness to +/- 0.2 dB. Systems that require very flat gain from DC to 1000 MHz (such as CATV), can achieve +/- 0.1 dB gain flatness using this circuit.

We hope that this application note and the products offered by RFMD will assist you in achieving your design goals.