Cascaded ABA Series for High Gain and High Isolation Amplifiers up to 2400 MHz

Application Note 5227

Introduction

This application note describes a two-stage cascaded amplifier using Avago Technologies' Broadband Amplifier (ABA) silicon RF ICs. Avago Technologies offers two series of ABA devices; the ABA-3 series that operate from a 3 V supply and ABA-5 series that operate from a 5 V supply. High gain (>40 dB) and good noise figure (<4 dB) can be achieved using this cascaded configuration, making it suitable for IF amplifiers in DBS applications. In addition, the high reverse isolation (>55 dB) and flat output power at the saturation region offer advantages for this cascaded amplifier when used as LO buffers.

Circuit Design

The amplifier is designed to operate from a supply voltage of 5 V for ABA-5 series and 3 V for ABA-3 series as shown in the schematic diagram in Figure 1. The power supply voltage is applied at pin 4 (Vcc pin) and pin 6 (RF output pin) of each of the ICs.

RF chokes are required at pin 6 on both ICs to provide low resistance at DC and a high impedance at the operating frequency (RF), and these RF chokes are terminated with bypass capacitors. Blocking capacitors are used on the input and output of the ICs. Based on the internal circuit design of the ABA series, the gain can be extended down to DC, but the limit would be defined by the values of the blocking capacitors and choke.

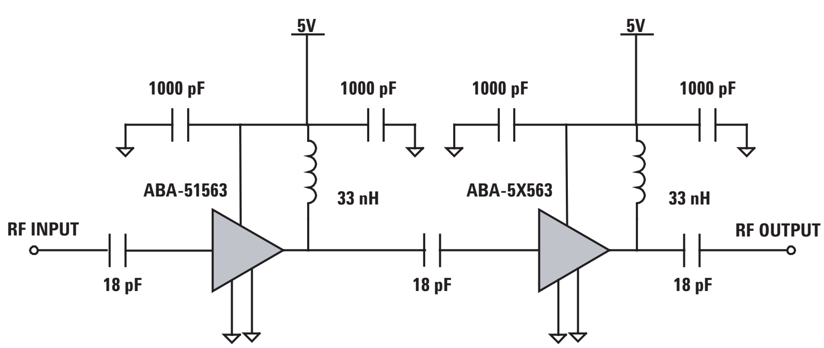

Figure 1. Schematic of cascaded ABA series

Test board

The ABA series is designed for nominal 50 Ω input and output impedance. The board used to test the cascade configuration was designed to exhibit 50 Ω characteristic impedance using FR4 with a thickness of 32 mils. The board can be ordered from our website: http://www.avagotech.com/ The typical LNB of a DBS system has an IF port with a nominal 75 Ω output (to be compatible with other set-top down converter and satellite TV equipment), and the board could be redesigned for this impedance using micro-strip matching. This board only demonstrates the performance in a 50 Ω environment.

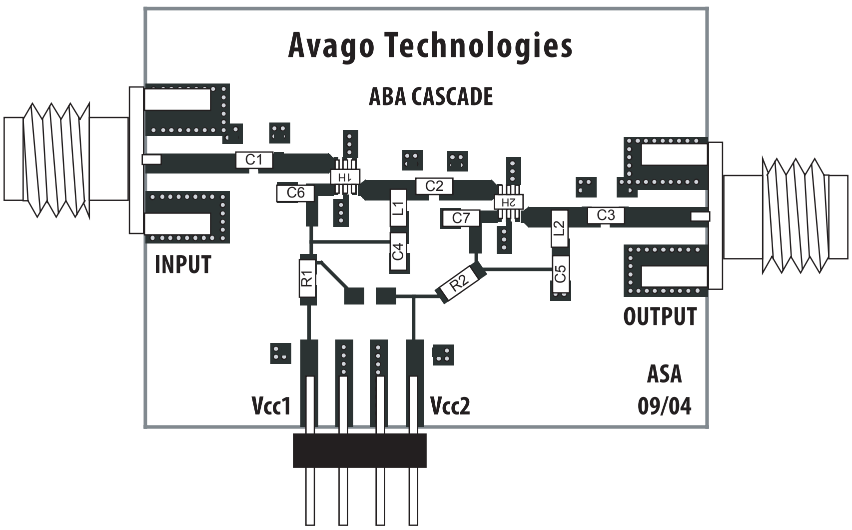

Figure 2. Populated board of cascaded ABA series

Table 1. List of components for the populated board

Frequency	Designation	Value	Part number
800 MHz to 2.4 GHz	C1, C2, C3	18 pF	Garret 0603CG180J9B20
	C4, C5, C6, C7	1000 pF	Murata GRM40X7R102K50
	L1, L2	33 nH	Coilcraft 1008CS-330XMBC
	R1, R2	0 Ω	

Cascaded System

In this application note, two ABA devices were cascaded to yield high gain and high isolation. The calculation of the cascaded gain and isolation is relatively straightforward. The total performance equals the summation of each amplifier's gain or isolation in decibels. Nevertheless, for the cascaded NF, P1dB and OIP3, the following equations will be used.

$$N_{sys} = F_1 + \frac{F_2 - 1}{G_1} \quad (1)$$

$$\frac{1}{P1dB_{sys}} = \frac{1}{P1dB_1 G_2} + \frac{1}{P1dB_2} \quad (2)$$

$$\frac{1}{OIP3_{sys}} = \frac{1}{OIP3_1 G_2} + \frac{1}{OIP3_2} \quad (3)$$

Table 2 below summarizes the individual performance of the ABA series at 2 GHz. Using the values in this table and above equations, the performance of a two-stage cascaded ABA series device can be calculated. AppCad, a free downloadable software from Avago Technologie (http://www.avagotech.com/) can also be used to calculate system performance.

Table 2. Typical performance of ABA series at 2 GHz

Symbol	Unit	ABA 31563	ABA 32563	ABA 51563	ABA 52563	ABA 53563	ABA 54563
Vc	V	3	3	5	5	5	5
Icc	mA	14	38	18	35	46	80
P1dB	dBm	2	7.8	1.8	9.7	12.5	15.8
OIP3	dBm	12.9	18.8	11.4	20.1	22.6	28.8
Gp	dB	21.9	18.9	21.5	21.5	21.5	22.5
NF	dB	3.9	3.5	3.7	3.2	3.5	4.3
VSWR in	–	1.29	1.12	1.3	1.2	1.2	1.2
VSWR out	–	1.42	1.49	1.3	1.4	1.3	1.4

Example of calculation

The first stage amplifier is an ABA-51563 and the second stage is an ABA-54563.

Cascaded Gain = 44 dB

Cascaded NF = 3.72 dB

Cascaded P1dB = 15.23 dBm

Cascaded OIP3 = 27.63 dBm

Test and results

Using the test board in Figure 2, the measured result of the cascaded ABAs can be summarized in Table 3. The measured P1dB and OIP3 are quite close to the calculated values.

Using the list of components in Table 1, the gain and isolation curves over frequency are plotted in Figure 3 and 4 respectively.

Table 3. Summary of cascaded measurement at 2 GHz

Test parameter	Unit	ABA-51 and ABA-52	ABA-51 and ABA-53	ABA-51 and ABA-54	ABA-31 and ABA-32
Current	mA	53	64	98	52
Gain	dB	40.5	42.5	43.5	37.5
NF	dB	4	4	4	3.6
P1dB	dBm	9.04	12.61	15.48	8.0
OIP3	dBm	20.25	23.20	26.20	19.73

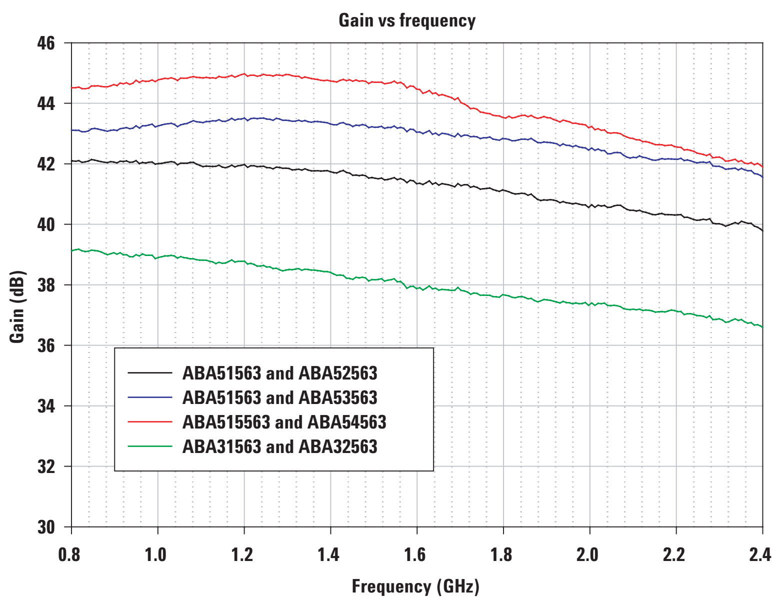

Figure 3. Gain versus frequency

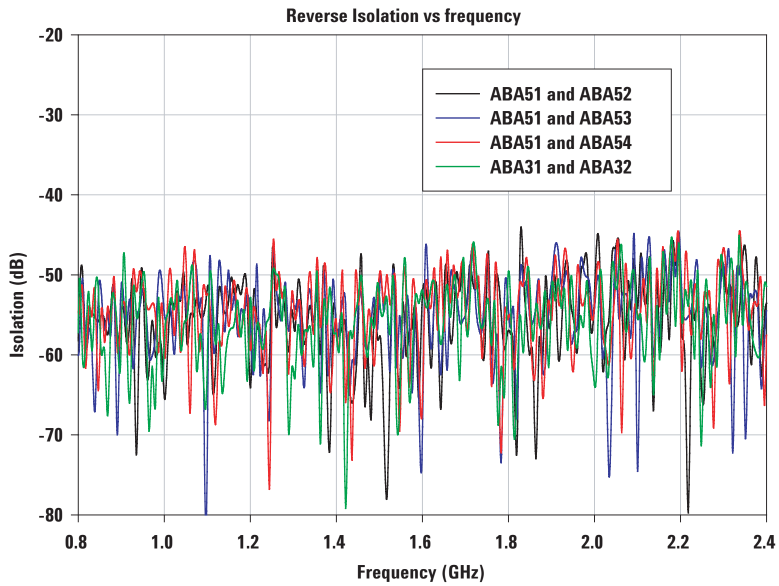

Figure 4. Reverse isolation loss versus frequency

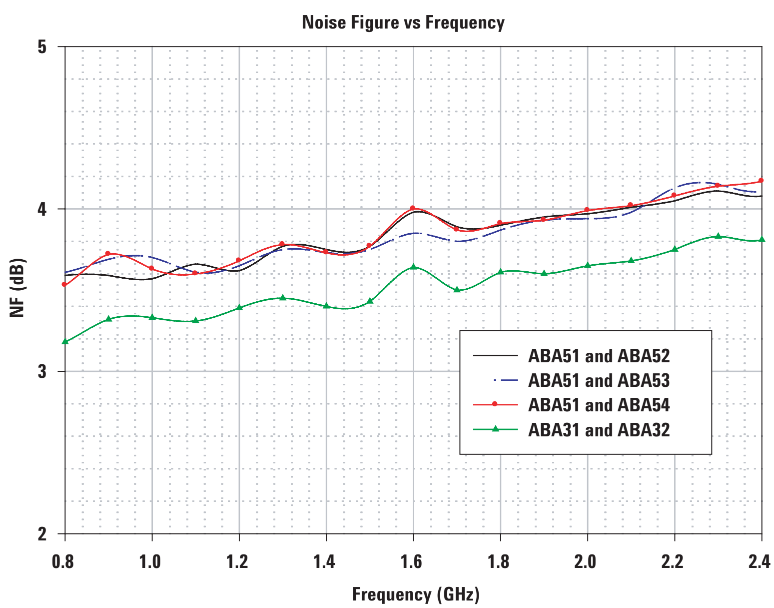

Figure 5. Noise figure versus frequency

The cascaded ABAs, as shown in Figure 3, offer very high gain (40 dB) over a wide range frequency (800 MHz to 2400 MHz). The input power used in this measurement was -30 dBm. The overall noise figure was around 3.5 dB to 4.4 dB for the ABA-5 series and around 3.4 dB to 4.6 dB for the ABA-3 series across 800 MHz to 2400 MHz. Another parameter that improves significantly through cascading is the reverse isolation. The reverse isolation was measured to be better than 50 dB across the frequency. This characteristic made this configuration suitable for a buffer application.

A careful selection of passive components will contribute to the over frequency performance of the cascaded amplifier. An illustration of a poor selection of capacitance and inductance values that resulted in undesirable results is shown in Figure 6. The blocking and bypass capacitors were chosen to be 1000 pF while the choke inductor was chosen to be 620 nH. These component values gave good performance at lower frequency, however there are disturbances on the gain curve at 1.4 GHz to 1.5 GHz. Comparing this plot to the s-parameter data available in the datasheet, this graph does not represent the actual performance of the ABA series over a wide frequency of operation, but it includes the resonant frequency of the RF choke and blocking capacitors used to build this board. The curve can be simulated in ADS using the s2p files from the component supplier's to investigate the response.

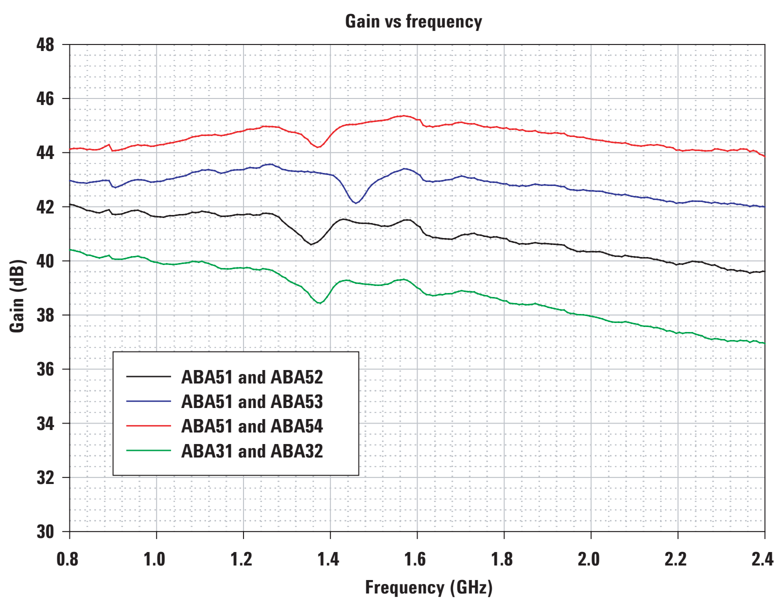

Figure 6. Gain curve over frequency with poor selection of passive components

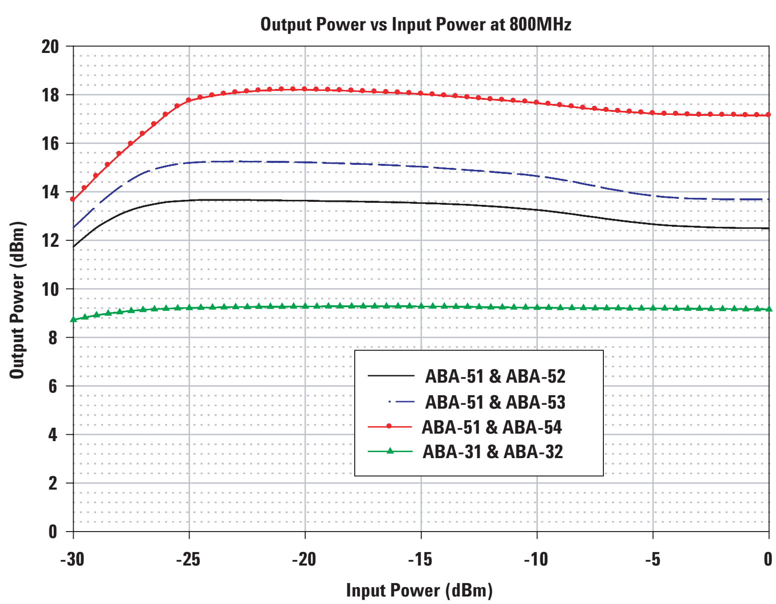

Figure 7. Output versus input power at 800 MHz

LO buffer application with high isolation

The performance of this configuration as a buffer amplifier will be discussed here. Following are the output versus input power curves at 800 MHz, 1.6 GHz, 2 GHz and 2.4 GHz. As can be seen in the plots, the output power experienced small variation over a wide range of input power.

By operating the cascaded amplifiers at this input range and having a very good isolation (>50 dB), this cascaded configuration can be used as a LO buffer to a mixer or modulator. It is known that operating an amplifier at the saturation region will help suppress the AM noise.

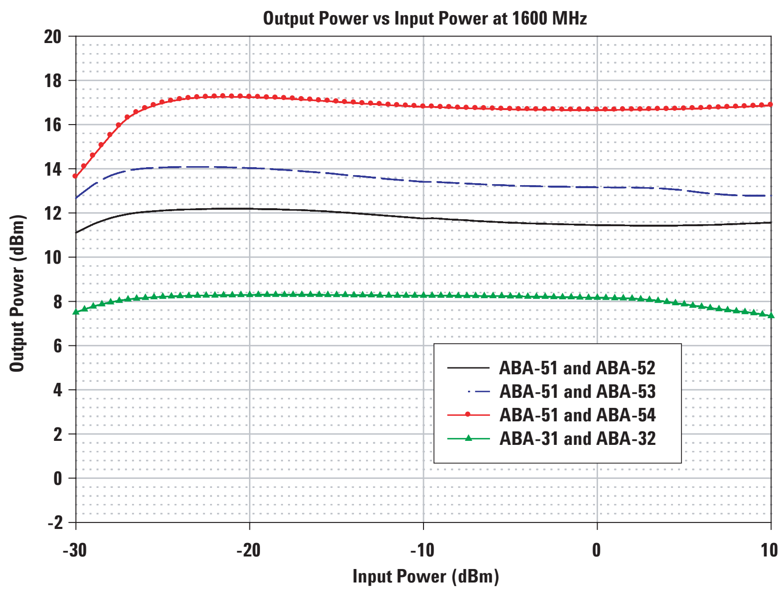

Figure 8. Output versus input power at 1600 MHz

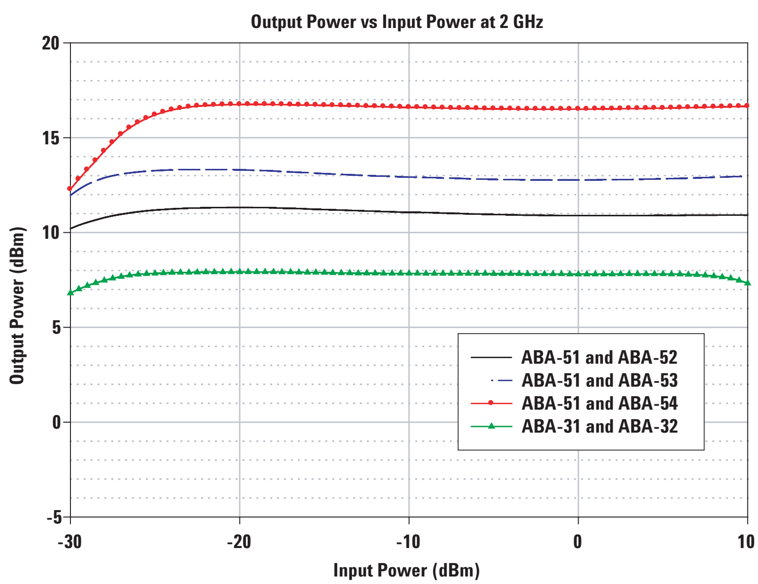

Figure 9. Output versus input power at 2 GHz

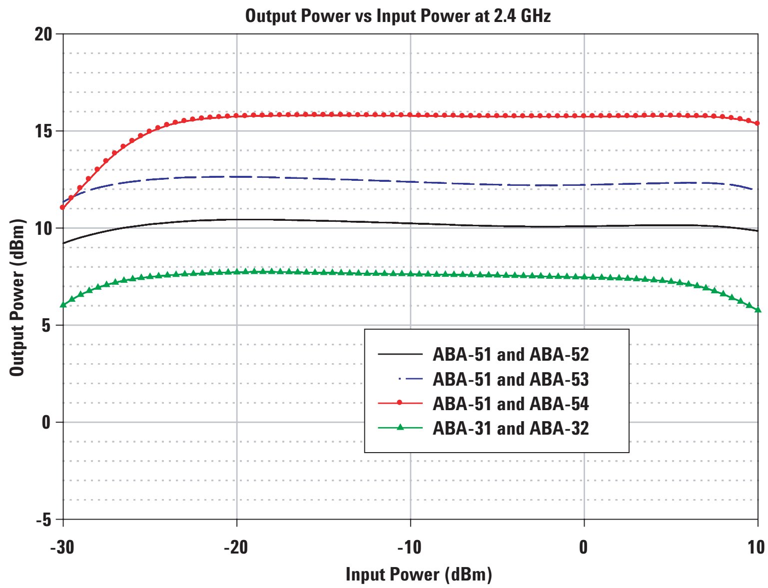

Figure 10. Output versus input power at 2.4 GHz

Conclusions

The applications for cascaded ABA series amplifiers as high gain amplifiers and high isolation buffer amplifiers have been presented in this note. The internal matching of the ABA series is close to 50 Ω, making them easy to be implemented by using a minimal number of RF chokes, blocking and bypass capacitors. In addition, the internal feedback in the device also offers good performance over a wide frequency range and temperature variation.

References

[1] Avago Technologies Application Note 5052: "ABA-54563 High P1dB Broadband Silicon Amplifier".

[2] R.W. Rhea "Oscillator design and computer simulation", 2nd ed., Noble Publishing Corporation, Georgia, 1995, pp. 121- 123.

[3] Information on ABA-5X563 devices can be found at http://www.avagotech.com/

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