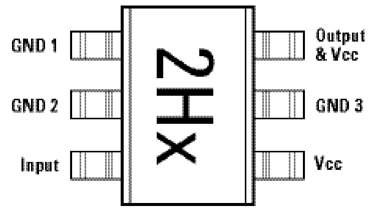
# ABA-52563
## 3.5 GHz Broadband Silicon RFIC Amplifier

# Application Note 1349




**Introduction**

Avago Technologies' ABA-52563 is a low current silicon gain block RFIC amplifier housed in a 6-lead SC-70 (SOT-363) surface mount plastic package. Providing a nominal gain of 21.5 dB and P1dB of 9.7 dBm at 2 GHz, this device is ideal for small signal gain stage or IF amplification.

Distinguished features of the ABA-52563 are high gain, good input and output VSWR, and broad bandwidth making this device useful in various applications including Cellular, Cordless, Special Mobile Radio, PCS, ISM, Wireless LAN, DBS, TVRO, and TV Tuner applications.

In addition to the ABA-52563, Avago Technologies also offers a series of ABA devices with a range of P1dB. The table below is a quick reference on the performance of the series measured at 2 GHz on the board.

| Symbol | Unit | ABA-51563 | ABA-52563 | ABA-53563 |
|---|---|---|---|---|
| P1dB | dBm | 1.8 | 9.7 | 12.5 |
| OIP3 | dBm | 11.4 | 20.1 | 22.6 |
| Icc | mA | 18 | 35 | 46 |
| Gp | dB | 21.5 | 21.5 | 21.5 |
| NF | dB | 3.7 | 3.2 | 3.5 |
| VSWR in | | 1.3 | 1.2 | 1.2 |
| VSWR out | | 1.3 | 1.4 | 1.3 |

**Note:**
Demoboard performance comparison at 2 GHz using the circuit and components described in the section *2 GHz Narrowband Example*.

### Application Guidelines

The ABA-52563 is designed with a two-stage cascade consisting in general of a single input transistor driving a Darlington connected output pair. Resistive feedback is used to set the RF performance. The collector of the first stage directly drives the base of the output stage without any interstage blocking capacitor that would limit the low frequency response. The second stage, fed back using both series and shunt resistors, sets the match, gain and flatness of the RFIC. The Avago Technologies' HP25 silicon bipolar process with a cut off frequency, $f_T$, of 25 GHz results in a device with low current draw and useful operation up to 3.5 GHz. The ABA-52563 is very easy to use. For most applications, all that is required to operate the device is to apply a voltage to Pin 4 (Vcc) and Pin 6 (Output and Vcc). All bias regulation circuitry is integrated into the RFIC.

### RF Input and Output

The RF Input and Output ports of the ABA-52563 are closely matched to 50Ω.

### DC Bias

The ABA-52563 is a voltage-biased device that operates at 5V with a nominal current of 35 mA. Figure 1 shows a typical implementation of the ABA-52563.

The supply voltage for the ABA-52563 must be applied to two terminals, the Vcc and the RF Output pins. The Vcc connection to the amplifier is RF bypassed by placing a capacitor to ground near the Vcc pin of the amplifier package. The power supply connection to the RF Output pin is achieved by means of an RF choke (inductor). The reactance of the RF choke must be relatively higher than 50Ω in order to prevent loading of the RF Output. Blocking capacitors are normally placed in series with the RF Input and RF Output to isolate the DC voltages on these pins from the circuit adjacent to the amplifier. The values of the blocking capacitors are selected to provide a reactance at the lowest frequency of operation that is relatively smaller than 50Ω.

### PCB Layout

The ABA-52563 is packaged in the miniature SOT-363 (SC-70) surface mount package. A PCB pad layout for the SOT-363 package is shown in Figure 2. This layout provides ample allowance for package placement by automated assembly equipment without adding pad parasitic that could impair the high frequency performance of the ABA-52563. The layout is shown with a nominal SOT-363 package footprint superimposed on the PCB pads for reference.

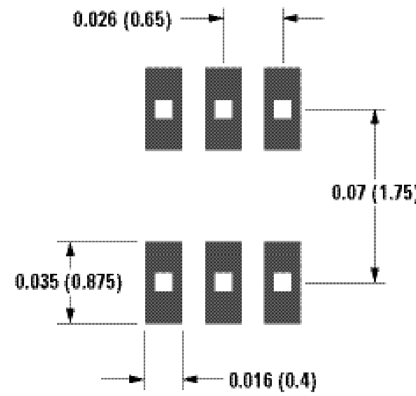



Figure 2. PCB Pad Layout. Dimensions are in inches (millimeters).

### PCB Materials

Typical choices for PCB material for low cost wireless applications are FR-4 or G-10 with a thickness of 0.025 or 0.032 inches. A thickness of 0.062 inches is the maximum that is recommended for use with this particular device. The use of a thicker board material increases the inductance of the plated through vias used for RF grounding and may deteriorate circuit performance. Adequate grounding is needed not only to obtain maximum amplifier performance, but also to reduce any possibility of instability.

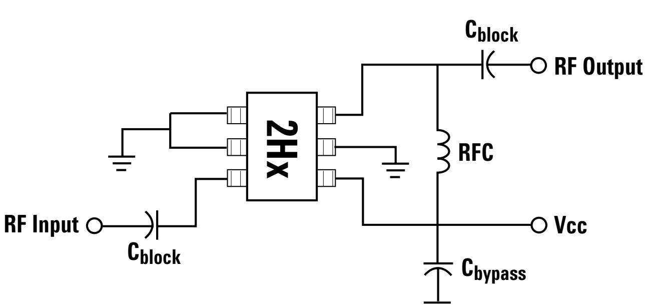



Figure 1. Typical Application Circuit.

## Examples Using the Demoboard

### Demoboard Description

An example layout for an amplifier using the ABA-52563 is shown in Figure 3. This example uses a microstripline design (solid ground plane on the backside of the circuit board). The circuit board material is 0.032-inch thick FR-4. Plated through-holes (vias) are used to bring the ground to the topside of the circuit where needed. Multiple vias are used to reduce the inductance of the path to ground.

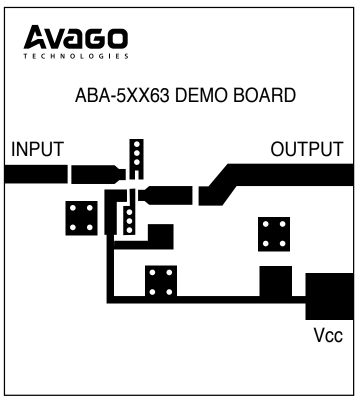



Figure 3. RF Layout.

Figure 4 shows an assembled amplifier. The +5 volt supply is fed directly into the Vcc pin of the ABA-52563 and into the RF Output pin through the RF choke (RFC).

DC blocking capacitors are required at the input and output of the IC. The values of blocking capacitors are determined by the lowest frequency of operation for a particular application.

### Passive Component Values

The capacitor's reactance is chosen to be 10% or less of the amplifier's input or output impedance at the lowest operating frequency. For example, an amplifier to be used in an application covering the 2 GHz band would require an input blocking capacitor of at least 16 pF, which is 5Ω of reactance at 2 GHz.

The Vcc connection to the amplifier must be RF bypassed by placing a capacitor to ground at the bias pad of the board. Like the DC blocking capacitors, the value of the Vcc bypass capacitor is determined by the lower operating frequency for the amplifier. The reactance of the RF choke should be large compared to 50Ω. A typical value for 2 GHz amplifier would be 22 nH which is about 266Ω.

For this demonstration board, capacitor C3 provides RF bypassing for both the Vcc pin and the power supply end of the RFC. Capacitor C4 is optional and may be used to add additional bypassing for the Vcc line.

A well bypassed Vcc line is especially necessary in cascades of amplifier stages to prevent oscillation that may occur as a result of RF feedback through the power supply lines. Since the gain of the ABA-52563 extends down to DC, the frequency response of the amplifier is limited only by the values of the capacitors and choke.

### 2 GHz Narrowband Example

Based on the calculation in the previous section on 2 GHz applications, the value chosen for the RF choke was 22 nH. All of the blocking and bypass capacitors are 18 pF. These values provide excellent amplifier performance at 2 GHz as depicted in the comparison table on the first page.

### 50 MHz to 2 GHz Wideband Example

Larger values for the choke and capacitors can be used to extend the lower end of the bandwidth. For wideband applications from 50 MHz to 2 GHz, 620 nH was chosen for the RF choke and 1000 pF for the blocking and bypass capacitors.

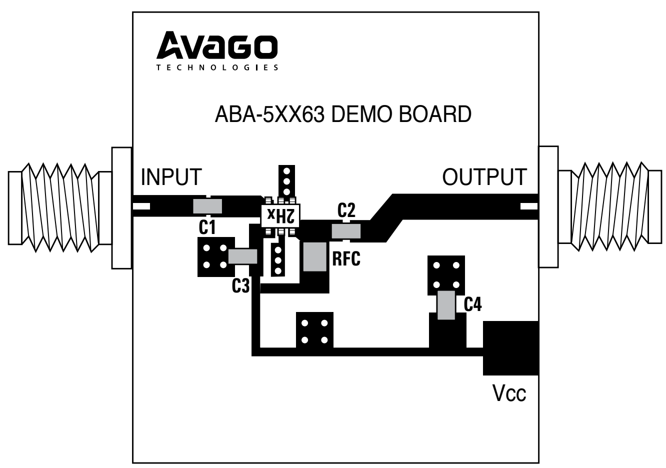



Figure 4. Assembled Amplifier.

Table 1 consists of the components used to assemble both boards. The measurements of the wideband application can be seen in Figures 5, 6, and 7.

A convenient method for making RF connection to the demonstration board is to use a PCB mounting type of SMA connector (Johnson 142-0701-881 or equivalent). These connectors can be slipped over the edge of the PCB and the center conductors soldered to the input and output lines. The ground pins of the connectors are soldered to the ground plane on the backside of the board. The extra ground pins for the top of the board are not needed and can be clipped off.

### Design for Other Frequencies

RF design software such as Avago Technologies' AppCad is very handy to determine the values of the blocking capacitors and RF choke for any operating frequency. This software is available at http://www.Avagotech.com/view/AppCad

**Table 1. List of Components.**

| | Component | Value | Part number |
|---|---|---|---|
| 2 GHz | C1, C2, C3 | 18 pF | Garret 0603CG180J9B20 |
| | RFC | 22 nH | Coilcraft 1008CS-220XMBC |
| | C4 (optional) | 390 pF | |
| 50 MHz to 2 GHz | C1, C2, C3 | 1000 pF | Murata GRM40X7R102K50 |
| | RFC | 620 nH | Coilcraft 1008CS-621XXKBC1 |
| | C4 (optional) | 1 µF | |
| | SMA Connectors | | Johnson 142-0701-881 |

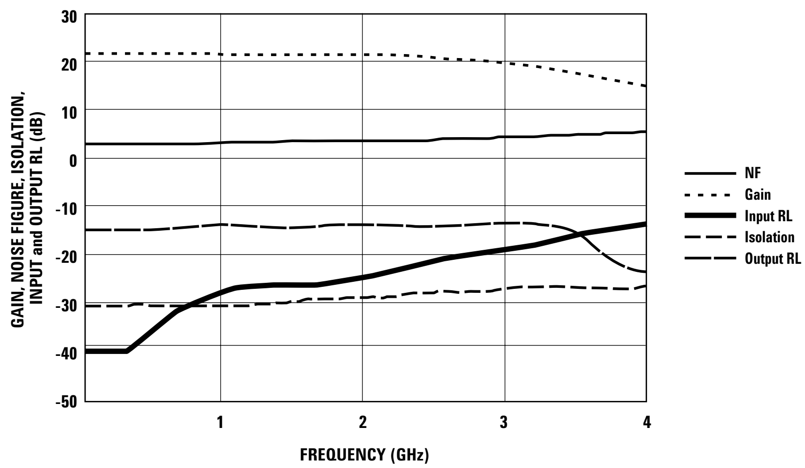



**Figure 5. Gain, Noise Figure, Isolation, Input and Output Return Loss Results as measured on the wideband board.**

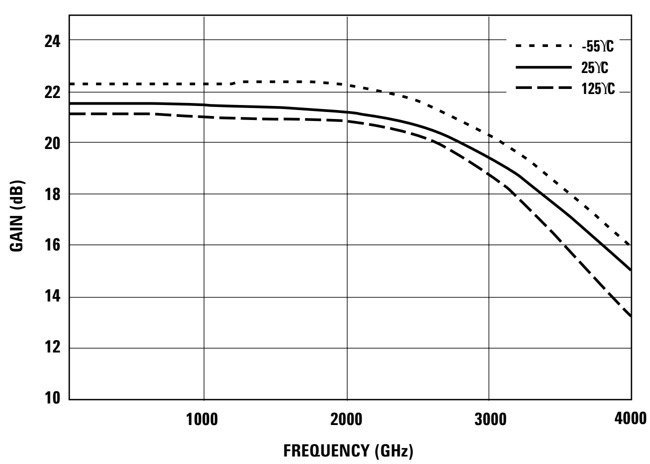



**Figure 6. Gain vs. Frequency and Temperature as measured on the wideband board.**

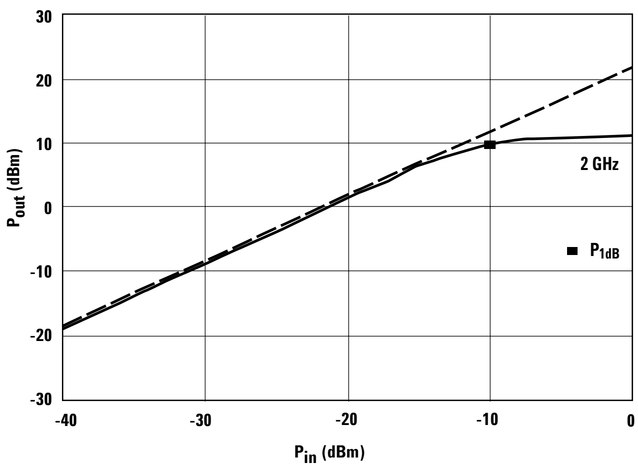



**Figure 7. P1dB as measured on the wideband board.**

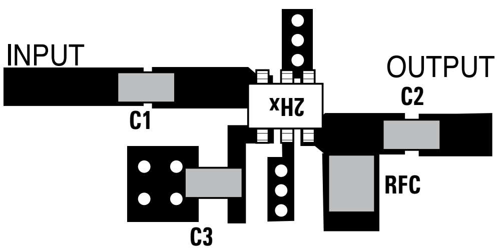



**Figure 8. Magnified Assembled Board.**

#### Notes on RF Grounding

As a direct result of the circuit topology discussed in the earlier paragraph, the performance of ABA-52563 is extremely sensitive to ground path ("emitter") inductance. The two-stage design potentially creates a feedback loop being formed through the ground returns of the stages. If the path to ground provided by the external circuit is "long" (high in impedance) compared to the path back through the ground return of the other stage, instability can occur. This feedback loop formed through the ground returns is illustrated in Figure 9.

This phenomenon can show up as a "peaking" in the gain versus frequency response (perhaps creating a negative gain slope amplifier), an increase in input VSWR, or even as return gain (a reflection coefficient greater than unit) at the input of the RFIC.

Evidently, an excellent grounding is critical when using the ABA-52563. The use of plated through-holes or equivalent minimal path ground returns right at the device is essential. The designs should be done on the thinnest substrate that is practical. The parasitic inductance of a pair of vias passing through 0.032-inch thick PC board is approximately 0.1 nH, while that of a pair via holes passing through 0.062 inches is closer to 0.5 nH. It is recommended that the PCB trace for the ground pins NOT be connected together underneath the body of the package. PCB pads hidden under the package cannot be adequately inspected for SMT solder quality.

These stability effects are entirely predictable. A circuit simulation using the datasheet S-parameters and including a description of the ground path (via model or equivalent "emitter" inductance) will give an accurate picture of the performance that can be expected. Device characterizations are made with the ground leads of the ABA-52563 directly contacting a solid copper block (system ground) at a distance of 2 to 4 mils from the body of the package. Thus, the information in the datasheet is a true description of the performance capability of the RFIC and contains minimal contributions from the test fixture.

#### Phase Reference Planes

The positions of the reference planes used to measure S-parameters for this device are shown in Figure 10. As seen in the illustration, the reference planes are located at the point where the package leads contact the test circuit.

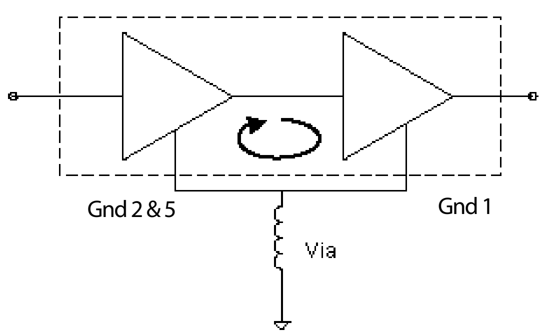



Figure 9. ABA Potential Ground Loop.

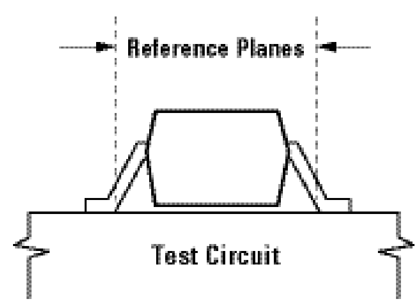



Figure 10. Phase Reference Plane.



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