Application Note

Using the AG40x-xx with a +5 V supply

The Communications Edge ™

Product Information

Because of the small resistance value required to drop the voltage from a +5 V supply to the nominal device voltage for the WJ AG40x-xx gain blocks, it the passive biasing configuration shown in the datasheet is not recommended. An active-bias current mirror would be more suitable for operating the AG40x-xx device if only a +5 supply is available. The active-biased circuit maintains a constant current into the collector (output) of the HBT amplifier by continually adjusting the base voltage (input). This configuration allows the user not to use a dropping resistor for the application of the device. HBT devices also generally source varying collector currents over temperature; the constant-current active-bias circuit limits this current variation and allows for temperature compensation due to the varying effects of the V_{be} junction in the biasing transistors.

The active-bias circuit, shown in Figure 1, uses dual PNP transistors to provide a constant current into gain block. The gain block should be connected with the biasing circuit without the use of the dropping resistor. This recommended active-bias constant-current circuit adds 7 components to the parts count for implementation, but should cost only an extra USD$0.123 to realize ($0.10 for U1, $0.0029 for R1, R2, R3, R4, R5, and $0.0085 for C1).

Temperature compensation is achieved by tracking the voltage variation with the temperature of the emitter-to-base junction of the two PNP transistors. As a 1st order approximation, this is achieved by using matched transistors with approximately the same Ibe current. Thus the transistor emitter voltage adjusts the amplifier base voltage so that the device draws a constant current, regardless of the temperature. A Rohm dual transistor - UMT1N - is recommended for cost, minimal board space requirements, and to minimize the variation between the two transistors. Minimizing the variability between the base-to-emitter junctions allow more accuracy in setting the current draw.

The value for the resistor components can be determined with KVL circuit theory. R3 is can be determined by:

$$V_3 = R3 * I_1 \quad (1)$$

$$V_{device} = V_{be2} + V_3 = V_{be2} + R3 * I_1 \quad (2)$$

$$R3 = \frac{(V_{device} - V_{be2})}{I_1} \quad (3)$$

Using another equation derived from KVL (equation 4) allows for the derivation of R1 using (3):

$$I_1 = \frac{V_{cc} - V_{be1}}{R1 + R3} \quad (4)$$

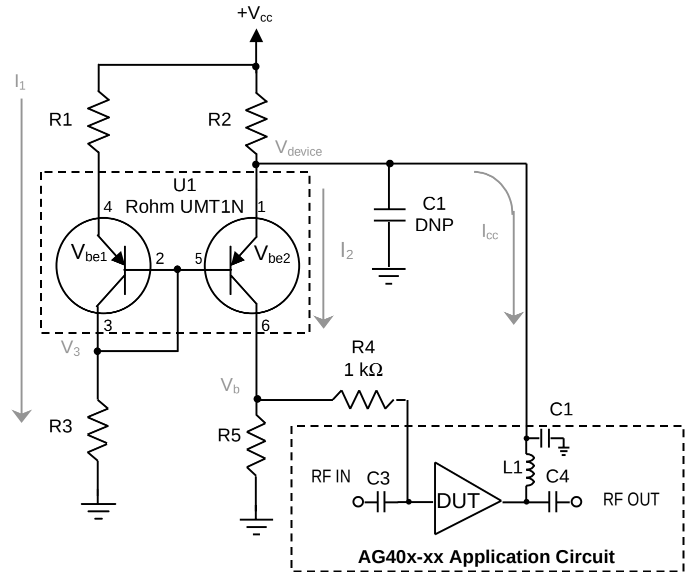
$$R1 = \frac{(V_{cc} - V_{device} + V_{be2} - V_{be1})}{I_1} \quad (5)$$

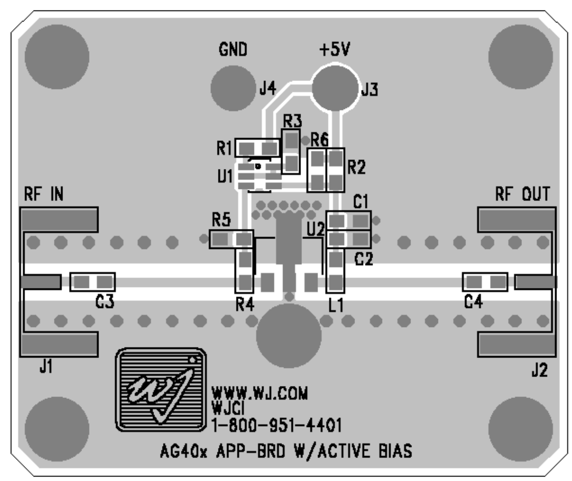
R2 and R5 can be determined with KVL theory. It is assumed that the no gate current passes through the DUT in forming (7). R4 is used as a high impedance choke to minimize any RF energy entering the biasing circuit from the amplifier input. The value for R4 can be arbitrarily set to be 1 kΩ.

$$R2 = \frac{V_{cc} - V_{device}}{I_{cc} + I_2} \quad (6)$$

$$R5 = \frac{V_b}{I_2} \quad (7)$$

To provide the minimal amount of current variation over temperature, the emitter-to-base junctions of the two transistors should be as closely matched to each other as possible. This can be accomplished by setting the current passing through them I1 and I2 to be equal. Thus, Vbe1 and Vbe2 are assumed to be equal. Equations (3), (5), (6), and (7) can be simplified with these assumptions and also setting I1 and I2 to be 4 mA. In addition, Icc is assumed to be much larger than I2 to further simplify the equations.





$$R1 = 250 * (V_{cc} - V_{device}) \quad (8)$$

$$R2 = (V_{cc} - V_{device}) / I_{cc} \quad (9)$$

$$R3 = 250 * V_{device} - V_{be}) \quad (10)$$

$$R5 = 250 * V_b \quad (11)$$

Using these equations and assuming the Vbe to be 0.7 V, the following values are recommended for the WJ AG40x-xx devices. The actual calculated values were rounded to realizable standard sizes. A base voltage V_b of +2 V is assumed to set the collector current for device.

Parameter	AG40x-xx
Supply Voltage: Vcc	+5 V
Vdevice	+4.90 V
Ids	60 mA
R1	22.1 Ω
R2	1.7 Ω
R3	1 kΩ
R4	1 kΩ
R5	500 Ω

The accuracy of Icc is determined directly by the precision of the R2 value. Therefore, a high precision R2 component is recommended. All other resistors can be chosen to be a standard 0603 package size for standard 5% precision tolerance.