Application Note

Biasing Information for the AG Series Gain Blocks

WJ Communications (WJ) has recently released a family consisting of 22 models of basic amplifier gain blocks – the AG Series products. The AG Series family is built upon indium gallium phosphide heterostructure bipolar transistors (InGaP HBTs) in a Darlington Pair configuration (Figure 1). The AG Series offers RF designers a broadband gain block function in various industry-standard surface mount packages: SOT-363, SOT-86, and SOT-89. The wide bandwidth and various gain / OIP3 / P1dB levels the AG Series models offer an array of choices to RF designers. The devices' 50 Ω input and output impedances ensure that no matching networks are needed. For proper operation the devices only require an input and output blocking capacitor, an RF choke (inductor), a bypass capacitor, and a dropping resistor. The proper dropping resistance values required for normal operation are discussed in detail herein.

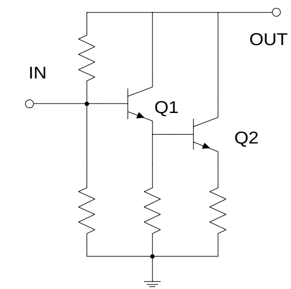

Figure 1. AG Series Schematic Diagram

As shown in Figure 1, the internal circuit configuration for the gain blocks is a Darlington Pair embedded in a resistive network. Each MMIC's internal resistor values determines the gain level, and each MMIC's individual transistor sizing determines the linearity and compression point performance. In contrast to WJ's well known voltage-controlled GaAs MESFET devices, the HBT's discussed herein are current-controlled. Therefore, for optimal operation with a stable operating point it is recommended that the devices be operated with a constant-current, DC source. If HBT devices are connected directly to a constant-voltage DC source, the current will vary widely with small changes in supply voltage, temperature, and device-to-device variation. This configuration is not recommended as variations in current from the optimal operating current can degrade OIP3 and P1dB performance. Operating the device with less current than recommended will also degrade the OIP3 and P1dB performance. Furthermore, operating the device with more current than recommended may heat up the junction temperature past the recommended value and prematurely reduce the otherwise long MTTF of the device.

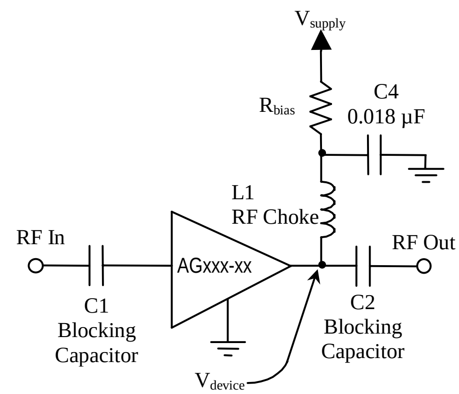

Figure 2. Application Circuit

Practical applications typically use a series resistor between the device and the voltage source to approximate a constant-current source. The value for the resistor can be calculated with the knowledge of the supply voltage used and device information given on each model's datasheet—the recommended operating current and device voltage.

$$R_{bias} = (V_{supply} - V_{device}) / I_{device}$$

The series resistor configuration also prevents potential current runaway as the device heats up. HBT's typically draw more current as the intrinsic device heats up. Any current increase caused by increased temperature will be stabilized by using the appropriate dropping resistor. The device "wants" to draw more current as temperature rises, and the increased current will cause a larger voltage drop across the resistor. This in turn will supply the device with a lower available device voltage. The lower device voltage causes the device to draw less current. This type of feedback stabilizes the current sourced by the supply. In general, a higher voltage supply (and thus using a larger dropping resistance value) creates more stabilization of the current draw over temperature.

The below table lists the 11 basic AG amplifiers and various supply voltages to aid in proper resistor selection. The "-86, -63, and –89 nomenclatures" are omitted from the table for clarity since operating conditions apply to each particular model (i.e. AG201, AG202 etc.) regardless of the package type. The resistor tolerance should be 1% as variation in impedance directly correlates to the variation of current that the device will draw. As stated above, any variance in the optimal operating current can affect the device's RF performance. When choosing the proper resistance value, particular care should be taken to choose the size of the resistor for the appropriate power rating. For example, 0603 size resistors have a power rating of $^{1}/_{16}$ Watts. The power dissipated by the resistor should generally be derated to half the value of the power rating of the resistor. The power passing through the resistor can be calculated by:

$$\text{Power dissipated by resistor} = (\text{Operating current})^2 * \text{Resistor value}$$

Table of Recommended Resistor Values for AG Series Gain Blocks

	AG201	AG202	AG203	AG302	AG303	AG402	AG403	AG503	AG602	AG603	AG604
Device Voltage (V)	4.1	4.14	4.14	4.22	4.21	4.8	4.8	4.95	5.1	5.1	5.1
Device Current (mA)	20	20	20	35	35	60	60	45	75	75	75
Supply Voltage (V)											
5	45	43	43	22.3	22.6						
6	95	93	93	50.9	51.1	20	20	23.3	12	12	12
7	145	143	143	79.4	79.7	36.7	36.7	45.6	25.3	25.3	25.3
8	195	193	193	108	108	53.3	53.3	67.8	38.7	38.7	38.7
9	245	243	243	137	137	70	70	90.0	52	52	52
10	295	293	293	165	165	86.7	86.7	112	65.3	65.3	65.3
12	395	393	393	222	223	120	120	157	92	92	92
24	995	993	993	565	565	320	320	423	252	252	252