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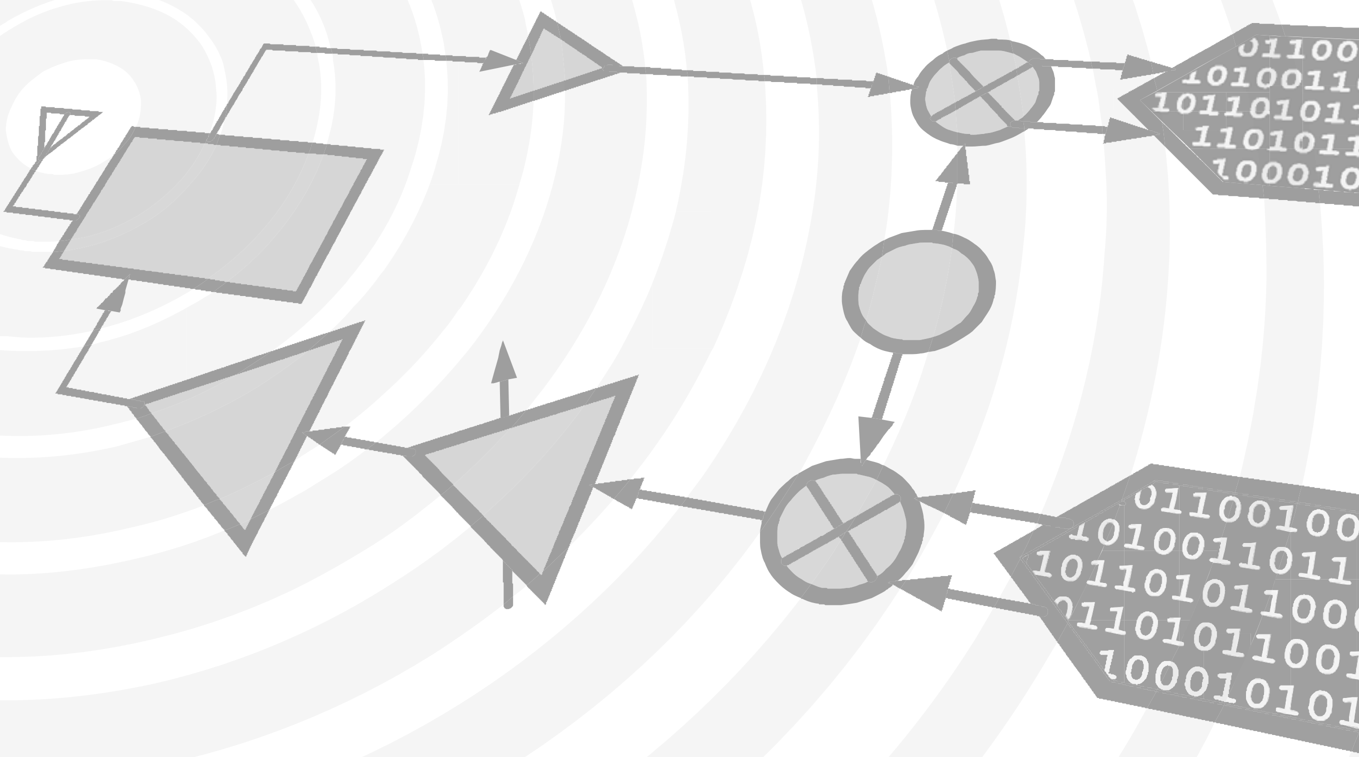

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Introduction

Hittite Microwave has designed various amplifiers that require the user to bias the amplifier manually. These amplifiers fall into three categories: standard, cascode, and Hetrojunction Bipolar Transistor (HBT) amplifiers. A standard amplifier will require two supplies, one positive power supply for the drain and one negative supply for the gate. Some amplifiers will have multiple stages, so each stage will need to be biased separately. HBT amplifiers are self biased amplifiers that have a control voltage. Hittite Microwave also has incorporated amplifiers into other products lines including, mixers, frequency multipliers, and multi-chip modules which sometimes require the same biasing technique.

A cascode distributed amplifier will require three supplies: one positive power supply for the drain, one negative supply for the first gate, and a positive supply for the second gate. Cascode amplifiers are used in wideband amplifier applications that also need good reverse isolation and higher input and output impedances. This application note will help the user understand the bias sequence to prevent damage to the device.

To start, be sure to have the equipment you intend to use to bias the amplifier and that the amplifier is already in a fixture suitable for connection of DC voltages and RF, microwave, or millimeterwave cable connectors. Nothing should be connected yet. Be sure to use ESD procedures at all times as the devices are ESD sensitive. See the Hittite ESD Application Note HANDLING GUIDELINES FOR ESD PROTECTION OF GaAs MMICs. For the device you intend to test you should have a complete current copy of the Hittite data sheet and be familiar with it. The current version of the datasheet can be found at our website.

HBT Self-Biased Amplifier Bias Sequence

1. There are two types of HBT amplifiers, self biased, and self biased with current control. Figure 1 shows the HBT self biased amplifier which is the simplest to bias. These amplifiers only require that the collector voltage be turned on. There is a bias resistor which sets the current. The amplifier has a current mirror which controls the base voltage.
2. The resistor value can be calculated by the equation:

$$R_C = \frac{V_C - V_{CC}}{I_{CC}}$$

3. Turn on the power supply and set for zero (0) volts – be sure to verify this by using a digital multi-meter. Measure the voltage between the plus and minus terminals of the power supplies since they are floating.
4. Connect the amplifier RF ports to the microwave test equipment. In some cases DC blocks or DC Bias tees may be required for the RF ports. Check the data sheet to determine whether they are required.
5. Connect the minus terminal of the collector power supply to the amplifier ground and the positive terminal of the power supply to the amplifier collector terminal (Vc).

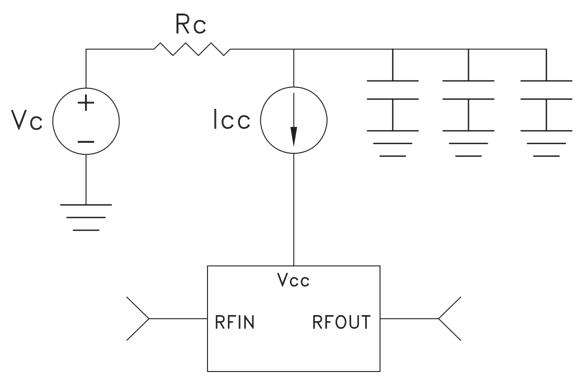

Figure 1 - HBT Self Biased Amplifier

6. Monitor the collector current. Increase the collector power supply to the desired collector operation voltage shown on the data sheet. When the power supply voltage is reached, Vc, the correct collector current should be seen, Icc.
7. A part that is damaged may have some of the following symptoms; high drain current that can't be changed by adjusting the supply voltage, no drain current, low or no gain. If damage is suspected; review the data sheet, review the procedure to bias the amplifier, and review your assembly instructions versus the assembly.

HBT Self-Biased Amplifier with Control Bias Sequence

1. The second HBT amplifier has current control. This is similar to the self biased HBT amplifier but now the current mirror has a control voltage. This is referred to as the power down (PD) control voltage which sets the current. Figure 2 shows a typical block schematic.

HBT Self-Biased Amplifier with Control Bias Sequence (Continued)

2. Turn on the power supplies and set for zero (0) volts – be sure to verify this by using a digital multi-meter. Measure the voltage between the plus and minus terminals of the power supplies since they are floating.
3. Connect the amplifier RF ports to the microwave test equipment. In some cases DC blocks or DC Bias tees may be required for the RF ports. Check the data sheet to determine whether they are required.
4. Connect the minus terminal of the collector power supply to the amplifier ground and the positive terminal of the power supply to the amplifier collector terminal (Vc).
5. Connect the minus terminal of the collector power supply to the amplifier ground and the positive terminal of the power supply to the amplifier power down control terminal (Vpd).
6. Monitor the collector current. Increase the collector power supply voltage to the voltage from the datasheet. There should be no collector current, Icc.
7. Monitor the collector current. Increase the power down control power supply voltage to the voltage required. When the supply reaches the data sheet values, the correct collector current, Icc, should be seen.
8. A part that is damaged may have some of the following symptoms; high drain current that can't be changed by adjusting the gate voltage, no drain current, low or no gain. If damage is suspected; review the data sheet, review the procedure to bias the amplifier, and review your assembly instructions versus the assembly.

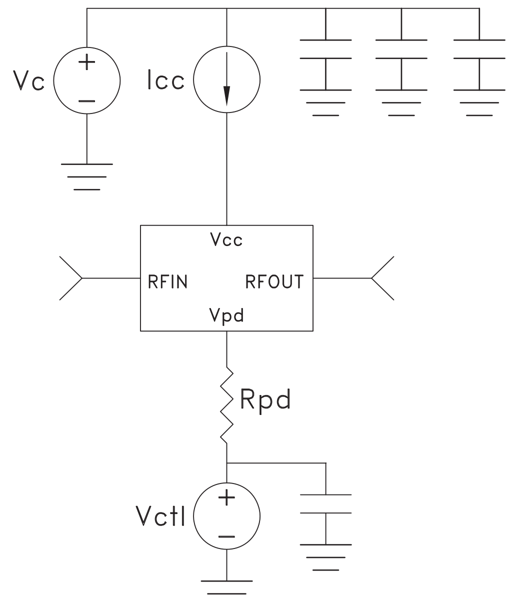

Figure 2 - HBT Self bias Amplifier with Control

Standard Amplifier Bias Sequence

1. The standard amplifier has a drain voltage and a gate voltage. The gate voltage is used to adjust the drain current for proper operation of the amplifier. Figure 3 shows a typical block schematic.
2. This procedure assumes the amplifier under test is a part that requires a dual supply; a positive supply for the drain-source and a negative supply for the gate-source. If there are multiple gate controls it is assumed for this procedure that they are connected together. Use knob style voltage power supplies – not key pad entry types. The supplies should be used in a floating manner with no connection to the supply ground terminal.
3. Turn on power supplies and set both to zero (0) volts – be sure to verify this by using a digital multi-meter. Measure the voltage between the plus and minus terminals of the power supplies since they are floating.
4. Connect the amplifier RF ports to the microwave test equipment. In some cases DC blocks or DC Bias tees may be required for the RF ports. Check the data sheet to determine whether they are required.
5. Connect the minus terminal of the drain power supply to the amplifier ground and the positive terminal of the gate power supply to the amplifier ground.

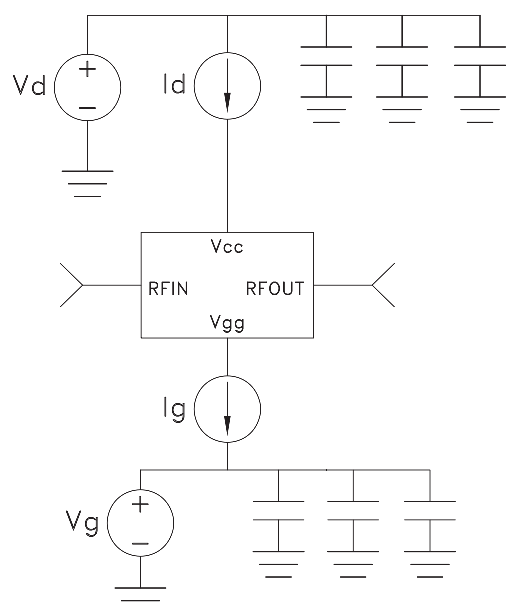

Figure 3 - Standard Amplifier

Standard Amplifier Bias Sequence *(Continued)*

6. Now connect the negative terminal of the gate power supply to the amplifier gate terminal. Connect the positive terminal of the drain power supply to the amplifier drain terminal. Note: at this point no current should be flowing since the voltage supplies are set to zero (0) volts.
7. Increase the gate power supply voltage to a voltage sufficient to pinch off drain current. For a pHEMT this would typically be between -2 and -1 Volts. Note that “increasing the gate voltage” in this case causes a more negative voltage on the gate of the amplifier due to the way the gate power supply is connected to the amplifier. There is no “drain current” since the drain power supply is currently set to zero volts. A small amount of gate current could be measured at this point due to gate leakage. If there is gate leakage the current should be on the order of micro-amperes.
8. Increase the drain power supply voltage to the desired drain operating voltage (per data sheet; typically +3V to +7V for pHEMT). If the gate has not been pinched off enough there may be some drain current. This current should not be more than several millamperes.
9. Finally, monitor the drain current while reducing the gate power supply voltage. Drain current will start to flow. Adjust the current to the level recommended on the data sheet.
10. If any oscillations are observed modify the test board to include 200 Ohm resistors in series with the gate line (or lines). These resistors should be placed as close as possible to the gate terminals of the amplifier.
11. A part that is damaged may have some of the following symptoms; high drain current that can’t be changed by adjusting the gate voltage, no drain current, low or no gain, a voltage on either of the RF ports on a part that is DC blocked on the MMIC. If damage is suspected; review the data sheet, review the procedure to bias the amplifier, and review your assembly instructions versus the assembly.

Cascode Distributed Amplifier Bias Sequence

1. The cascode distributed amplifier uses a fundamental cell of two FET’s in series, source to drain. This fundamental cell is then duplicated a number of times. The major benefit is an increase in the operation bandwidth. Figure 4 shows a typical block schematic
2. This procedure assumes the cascode distributed amplifier under test is a part that requires three power supplies. The first is a positive power supply for the drain-source (Vdd), the second is negative supply for the gate-source (Vgg1), and a third is a positive supply for a second gate (Vgg2). Use knob style voltage power supplies - not key pad entry types. The supplies should be used in a floating manner with no connection to the supply ground terminal.
3. Turn on all the power supplies and set for zero (0) volts – be sure to verify this by using a digital multi-meter. Measure the voltage between the plus and minus terminals of the power supplies since they are floating.
4. Connect the amplifier RF ports to the microwave test equipment. In some cases DC blocks or DC Bias tees may be required for the RF ports. Check the data sheet to determine whether they are required.
5. Connect the minus terminal of the drain power supply to the amplifier ground, the positive terminal of the first gate power supply, and leave the second gate power supply to open circuitry.
6. Now connect the negative terminal of the first gate power supply to the amplifier gate terminal (Vgg1). Connect the positive terminal of the drain power supply to the amplifier drain termi-

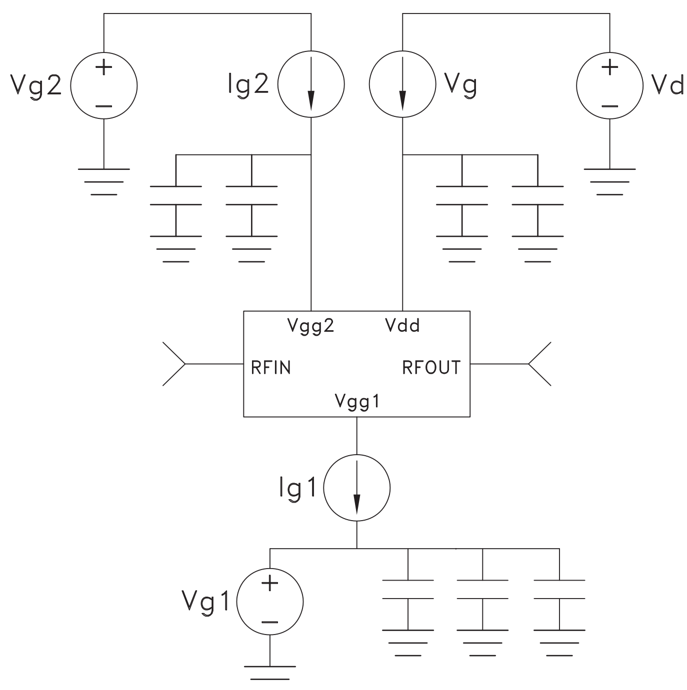

Figure 4 - Cascode Distributed Amplifier

Cascode Distributed Amplifier Bias Sequence *(Continued)*

nal (Vdd). Note: at this point no current should be flowing since all the voltage supplies are set to zero (0) volts.

7. Increase the first gate power supply voltage to a voltage sufficient to pinch off drain current. For a pHEMT this would typically be between -2 and 1 Volts. Note that "increasing the gate voltage" in this case causes a more negative voltage on the gate of the amplifier due to the way the gate power supply is connected to the amplifier. There is no "drain current" since the drain power supply is currently set to zero volts. A small amount of gate current could be measured at this point due to gate leakage and this could be in the milli-ampere region.
8. Increase the drain power supply voltage to the desired drain operating voltage (per data sheet; typically +5 to +12 Volts for pHEMT). The drain current should still be in the micro-ampere range but could be in the milli-ampere since the gate power supply may not be completely turning off the amplifier.
9. make the connection from the second gate power supply to the second gate (Vgg2). Increase the second gate power supply voltage to bias the upper stage. For a pHEMT this would typically be between +0 to +5 Volts. The gate current for both the first gate and second gate should be in the micro-ampere region. There still should be very little drain current.
10. Finally, monitor the drain current while reducing the first gate power supply voltage. Drain current will start to flow. Adjust the current to the level recommended on the data sheet.
11. If any oscillations are observed modify the test board to include 200 Ohm resistors in series with the gate line (or lines). These resistors should be placed as close as possible to the gate terminals of the amplifier. You may also need to add larger bypass capacitors on the gate lines since cascaded distributed amplifier are susceptible to low frequency oscillations.
12. A part that is damaged may have some of the following symptoms; high drain current that can't be changed by adjusting the gate voltage, no drain current, low or no gain, a voltage on either of the RF ports on a part that is DC blocked on the MMIC. If damage is suspected; review the data sheet, review the procedure to bias the amplifier, and review your assembly instructions versus the assembly.