

General Purpose Amplifier Biasing

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INTRODUCTION

Freescale Semiconductor's General Purpose Amplifier (GPA) devices are all designed to operate from a single positive voltage supply. The GPAs have output powers ranging from 12 to 34 dBm. They are currently designed with three different circuit techniques:

- Darlington Pair
- Discrete with integrated current mirror
- Field Effect Transistor (FET) operating at zero gate voltage drain leakage current (I_{DSS})

and use two different device technologies:

- Indium Gallium Phosphide Heterostructure Bipolar Transistors (InGaP HBT)
- GaAs Heterostructure Field Effect Transistor (HFET)

The required biasing methods for the different circuit schemes are described in this application note.

GPA CIRCUIT DESIGN METHODS

Freescale's InGaP HBTs are designed using one of two different circuit methods. The low power GPAs (P1dB from 12 to 24 dBm) are designed using a Darlington Pair (Fig. 1). The Darlington Pair is biased when voltage is applied to the collector of discrete devices Q1 and Q2. Resistor R1 is used for negative feedback of the amplifier but is also part of the voltage divider with R2 to establish the base bias on Q1.

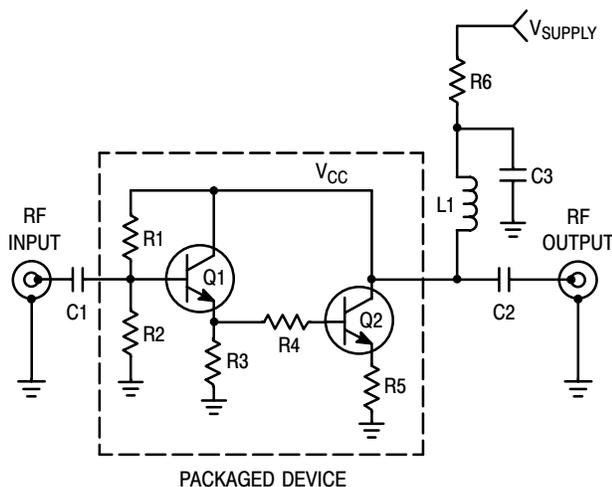


Figure 1. Darlington Pair InGaP HBT Bias Scheme

HBT devices are current-driven; therefore, Freescale recommends that designers use a constant current source to minimize the impact of shifts in supply voltage and shifts in the temperature of the operating environment. Deviations from the optimal current can impact both power and linearity performance. A series resistor between the voltage supply and collectors of the Darlington is the easiest way to emulate a constant current source (R6 in Fig. 1). This is necessary for the MMG3001NT1, MMG3002NT1 and MMG3003NT1 devices.

Because the RF output of the Darlington Pair is also used for the DC bias, an RF choke is required (L1) to connect the voltage supply to the output. RF coupling capacitors may also be required on the RF input and RF output because the input and output of the devices are DC coupled.

Since the release of these first three devices, Freescale has developed a method to eliminate the need for an external resistor and to enable the devices to operate directly from a positive 5 Volt supply. This approach has exceptional current stability over temperature and has a pending patent. All Darlington HBT products with the exception of the MMG3001NT1, MMG3002NT1 and MMG3003NT1 use this approach (Fig. 2).

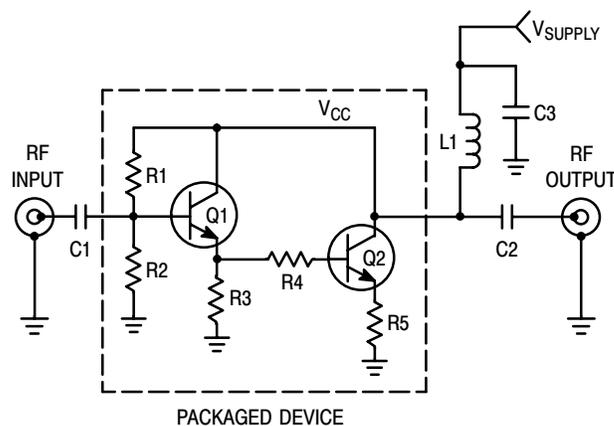


Figure 2. Improved Darlington Pair InGaP HBT Bias Scheme

The second circuit method is used on the intermediate power amplifiers (P1dB ranging from 27 to 34 dBm). These are designed with a MMIC that contains a discrete device, Q1, with an integrated current mirror to drive the base (Fig. 3).

This active bias approach means that the bias current has minimal shift with normal supply voltage deviations over the specified operating temperature range. R6 in Fig. 3 is an external dropping resistor that is required to establish the reference voltage on the current mirror that drives the bias of Q1.

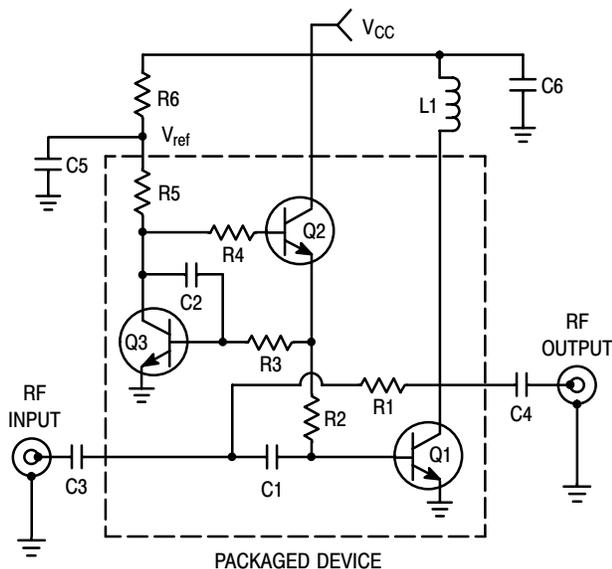


Figure 3. Intermediate Power InGaP HBT Bias Scheme

The reference voltage (V_{ref}) is different for each device based on its size. The data sheets for each device list the specific reference voltage required for optimal bias current. L1 is required to prevent the DC supply line from improperly loading the RF output. RF coupling capacitors (C3 and C4 in Fig. 3) are also required.

The third circuit approach in GPAs is used for the HFET devices. Bias of this type of device is very similar to the Darlington circuit technology.

The HFETs are discrete devices that operate directly from a 5 Volt supply voltage (Fig. 4). The DC blocking capacitor that is integrated in the feedback loop prevents the gate voltage from being established with R1 and R2; therefore, the HFET devices operate at I_{DSS} when 5 Volts are applied to the drain. L1 is again required as an RF choke as well as the RF coupling capacitors, C2 and C3.

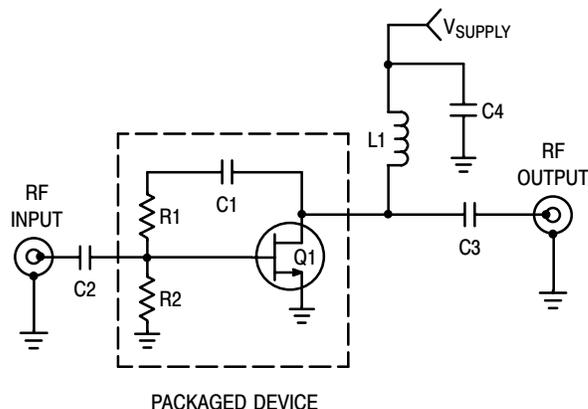


Figure 4. HFET Bias Scheme

SUMMARY

The GPA lineup from Freescale is designed to operate from a single positive voltage supply, which makes them easy to use. Designers using these devices should be careful to bias the devices correctly using the appropriate method for the type of device used. If the current is set too low, linearity and power will degrade. If the current is set too high, there is some risk of compromising reliability.

The techniques outlined here are a guide to the bias approaches for the different technologies and products available from Freescale. The data sheets for each device should be followed to achieve optimal performance from all GPAs.

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