

General Purpose Amplifier and MMIC Biasing

INTRODUCTION

Freescale Semiconductor's GaAs MMICs and General Purpose Amplifier (GPA) devices are all designed to operate from a single positive voltage supply. The GPAs have output powers ranging from 15 to 33 dBm. They are currently designed with five different circuit techniques:

- Darlington Pair
- Darlington Pair with Active Bias
- Discrete with Diode Active Bias
- Discrete with integrated current mirror
- Field Effect Transistor (FET) operating at self bias

and use three different device technologies:

- Indium Gallium Phosphide Heterostructure Bipolar Transistors (InGaP HBT)
- GaAs Heterostructure Field Effect Transistor (HFET)
- GaAs Enhancement Mode Pseudomorphic High Electron Mobility Transistors (E-pHEMT)

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 primary circuit methods. The low power GPAs (P1dB from 15 to 25 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.

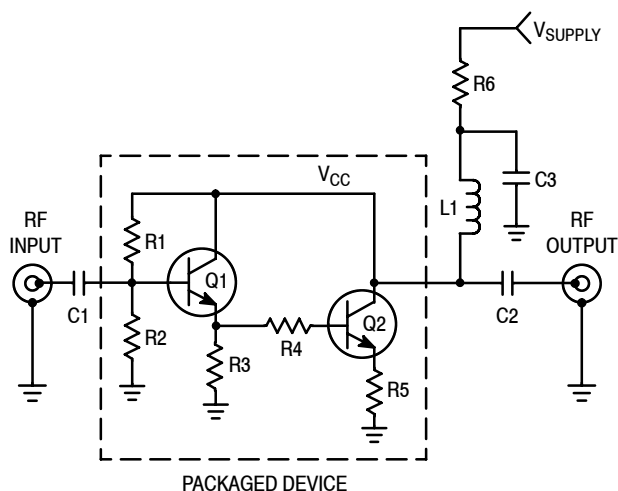


Figure 1. Darlington Pair InGaP HBT Bias Scheme

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). 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.

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 (Fig. 2).

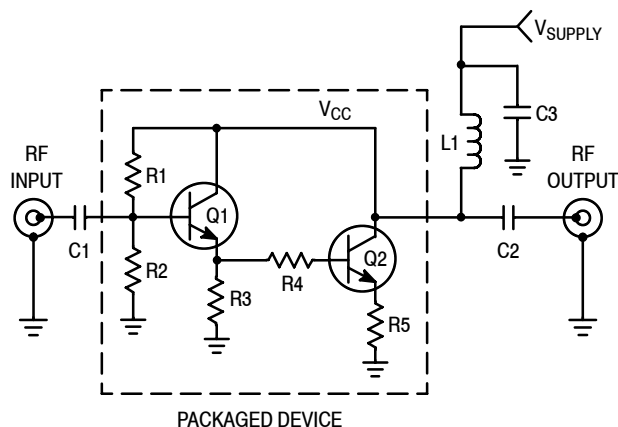


Figure 2. Improved Darlington Pair InGaP HBT Bias Scheme without External Bias Resistor

Freescale has continued to improve bias and performance stability over temperature as well as reducing sensitivity to supply voltage variations by introducing Darlington Pair devices with an integrated active bias (Fig. 3).

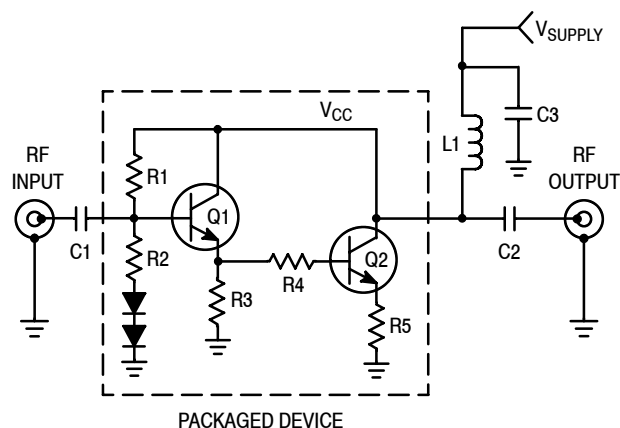


Figure 3. Active Bias Darlington Pair InGaP HBT and E-pHEMT Bias Scheme

The second circuit method is used on the intermediate power amplifiers (P1dB ranging from 21 to 33 dBm). These are designed with a MMIC that contains a discrete device, Q1, with an integrated active bias. This approach is used for devices based on E-pHEMT technology as well.

This active bias approach means that the bias current has minimal shift with normal supply voltage deviations over the specified operating temperature range.

One design approach that utilizes this method is the discrete MMIC with diode bias (Fig. 4).

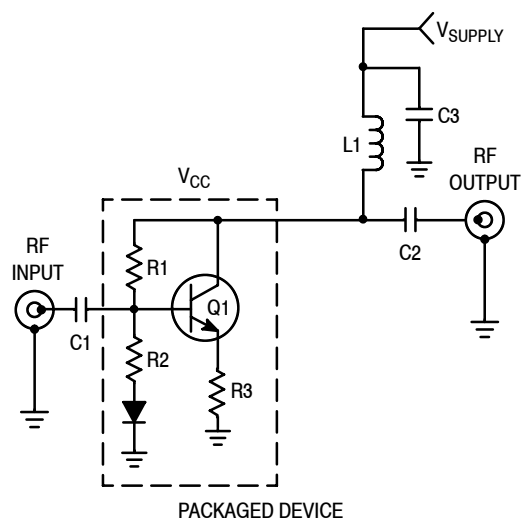


Figure 4. Discrete Device with Active Bias

The second design approach that uses this method is the MMIC with a discrete RF device and current mirror (Fig. 5).

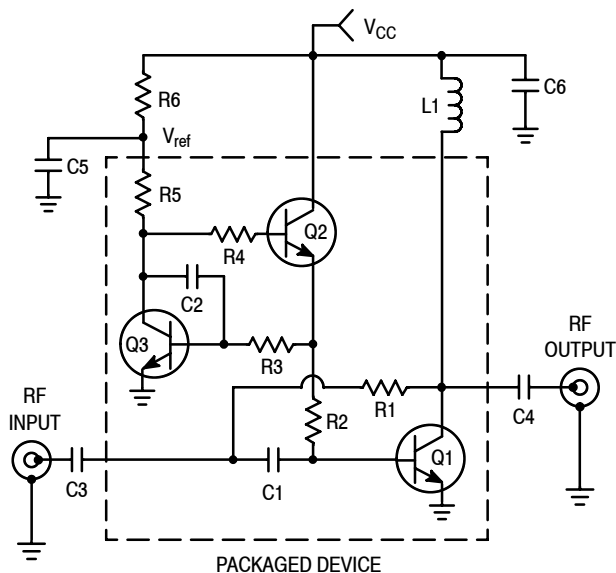


Figure 5. Intermediate Power Discrete with Integrated Current Mirror InGaP HBT Bias Scheme

R6 in Fig. 5 is an external dropping resistor that is required to establish the reference voltage on the current mirror that drives the bias of Q1.

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. 5) are also required.

The third circuit approach in GPAs is used for the HFET devices. The 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. 5). 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 0 Volts on the gate when 5 Volts are applied to the drain. R3 is used to provide negative feedback and to reduce V_{GS} to reduce the quiescent current via self bias. L1 is again required as an RF choke as well as the RF coupling capacitors, C2 and C3.

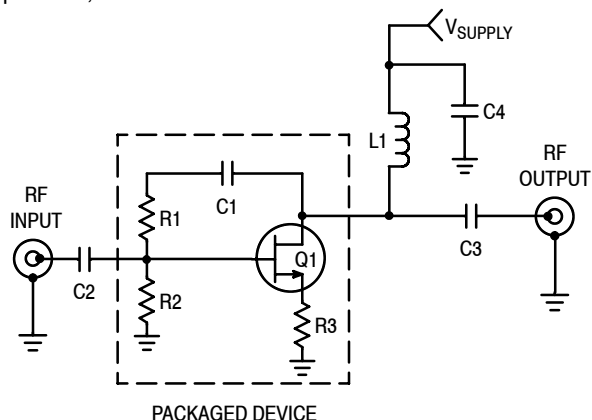


Figure 6. HFET Bias Scheme

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.

REVISION HISTORY

The following table summarizes revisions to this document.

Revision	Date	Description
1	Sept. 2007	<ul style="list-style-type: none"> • Added connection nodes to V_{CC} and Q1 collector, Fig. 3, Intermediate Power InGaP HBT Bias Scheme, p. 2 • Added Revision History, p. 3
2	July 2008	<ul style="list-style-type: none"> • Application note updated to reflect changes in device portfolio and addition of technology.
3	Mar. 2011	<ul style="list-style-type: none"> • Application note updated to reflect changes in device portfolio and E-pHEMT technology references.

How to Reach Us:

Home Page:

www.freescale.com

Web Support:

<http://www.freescale.com/support>

USA/Europe or Locations Not Listed:

Freescale Semiconductor, Inc.
Technical Information Center, EL516
2100 East Elliot Road
Tempe, Arizona 85284
1-800-521-6274 or +1-480-768-2130
www.freescale.com/support

Europe, Middle East, and Africa:

Freescale Halbleiter Deutschland GmbH
Technical Information Center
Schatzbogen 7
81829 Muenchen, Germany
+44 1296 380 456 (English)
+46 8 52200080 (English)
+49 89 92103 559 (German)
+33 1 69 35 48 48 (French)
www.freescale.com/support

Japan:

Freescale Semiconductor Japan Ltd.
Headquarters
ARCO Tower 15F
1-8-1, Shimo-Meguro, Meguro-ku,
Tokyo 153-0064
Japan
0120 191014 or +81 3 5437 9125
support.japan@freescale.com

Asia/Pacific:

Freescale Semiconductor China Ltd.
Exchange Building 23F
No. 118 Jianguo Road
Chaoyang District
Beijing 100022
China
+86 10 5879 8000
support.asia@freescale.com

For Literature Requests Only:

Freescale Semiconductor Literature Distribution Center
1-800-441-2447 or +1-303-675-2140
Fax: +1-303-675-2150
LDCForFreescaleSemiconductor@hibbertgroup.com

Information in this document is provided solely to enable system and software implementers to use Freescale Semiconductor products. There are no express or implied copyright licenses granted hereunder to design or fabricate any integrated circuits or integrated circuits based on the information in this document.

Freescale Semiconductor reserves the right to make changes without further notice to any products herein. Freescale Semiconductor makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does Freescale Semiconductor assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation consequential or incidental damages. "Typical" parameters that may be provided in Freescale Semiconductor data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals", must be validated for each customer application by customer's technical experts. Freescale Semiconductor does not convey any license under its patent rights nor the rights of others. Freescale Semiconductor products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the Freescale Semiconductor product could create a situation where personal injury or death may occur. Should Buyer purchase or use Freescale Semiconductor products for any such unintended or unauthorized application, Buyer shall indemnify and hold Freescale Semiconductor and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that Freescale Semiconductor was negligent regarding the design or manufacture of the part.

Freescale™ and the Freescale logo are trademarks of Freescale Semiconductor, Inc. All other product or service names are the property of their respective owners.

© Freescale Semiconductor, Inc. 2005, 2007-2008, 2011. All rights reserved.