INCREASE DESIGN FLEXIBILITY USING HBT AMPLIFIERS WITH CURRENT CONTROL

Introduction

In applications where the designer must control power level, several traditional circuits such as AGC amplifiers, voltage variable attenuators or digital attenuators are commonly used. In transmit applications where active power control is needed or in half duplex systems that require transmitter shut down during the receive cycle, a driver amplifier or power amplifier with power down capability is desired.

When a power-down amplifier is implemented into the system design, the important characteristics of the amplifier include switching speed, quiescent current and a simple control interface. Also, in order to minimize burst noise generation, the shape of the amplitude modulated RF pulse may become important. The method of power control implemented in the amplifier design will affect the amplifiers ability to satisfy these requirements.

Table 1 lists Hittite Microwave Corporation's family of HBT driver and power amplifiers with an integrated power-down control. These amplifiers feature not only fast switching, power-down capability and low quiescent current, but also the ability to adjust the output power continuously over a wide range. The ability to adjust output power continuously means the designer can adjust the DC current consumption of the amplifier to a level just sufficient to meet the system electrical requirements without unnecessarily wasting DC power and consequently increasing power dissipation.

Part Number	Frequency Range (GHz)	P1dB (dBm)	Vcc (Volts)	Vpd (Volts)
HMC415LP3	4.4 - 6.0	+23	3	0 - 3
HMC414MS8G	2.2 - 2.8	+27	5	0 - 3.6
HMC413QS16G	1.7 - 2.3	+27	5	0 - 3.6
HMC408LP3	5.1 - 5.9	+30	5	0 - 5
HMC407MS8G	5.0 - 7.0	+25	5	0 - 5
HMC406MS8G	5.0 - 6.0	+26	5	0 - 5
HMC327MS8G	3.0 - 4.0	+27	5	0 - 5
HMC326MS8G	3.0 - 4.5	+23.5	5	0 - 5

Table 1 - HBT Amplifier Family with Power-Down Control

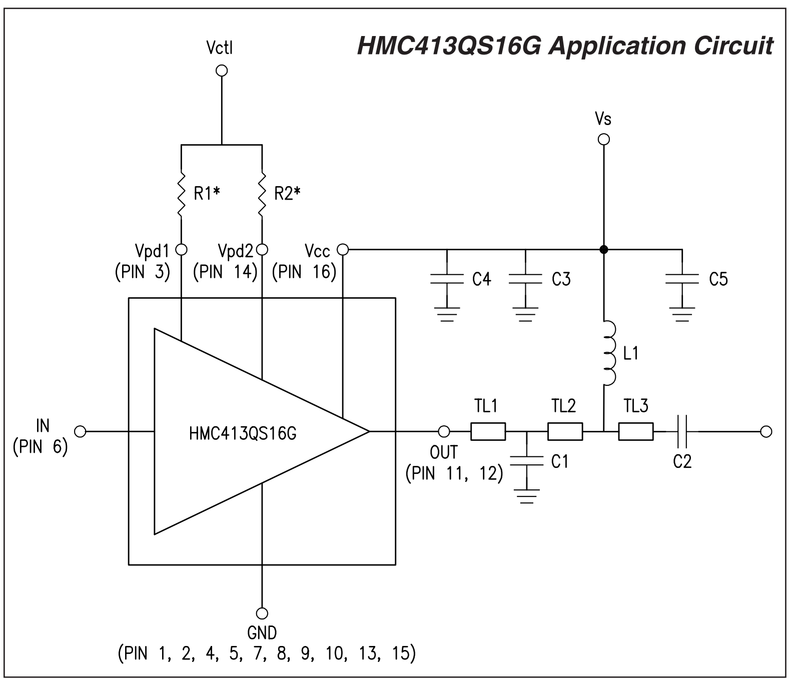

Figure 1 - Amplifier Application Circuit

Typical Application Circuit

A typical application circuit for use at Cellular frequencies utilizing the HMC413QS16G HBT amplifier is shown in Figure 1. In the figure, the three-stage amplifier is biased with a fixed 5-volt supply (Vs) and a control voltage (Vctl) that is set between 0 and 3.6 volts to control the output power. Setting Vctl to 0 volts shuts down the amplifier circuit resulting in a quiescent current of approximately 2 micro amps. Adjusting Vctl to 3.6 volts results in full power and a steady state current of approximately 220 mA. The remaining external circuitry is standard biasing and matching.

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Vpd Input Characteristics

Vpd1 and Vpd2 are analog input control pins that control the device current and subsequently the RF performance of the amplifier. The I-V characteristic of these pins is shown in Figure 2. For input voltages less than approximately 1.2 volts, there is less than 2 micro amps of DC current consumption. Above this base-emitter junction voltage, the input assumes a linear resistor characteristic up to the maximum specified Vpd input voltage of 3.6 volts. At maximum Vpd1 the driving circuit must be able to source approximately 7.5 mA of current.

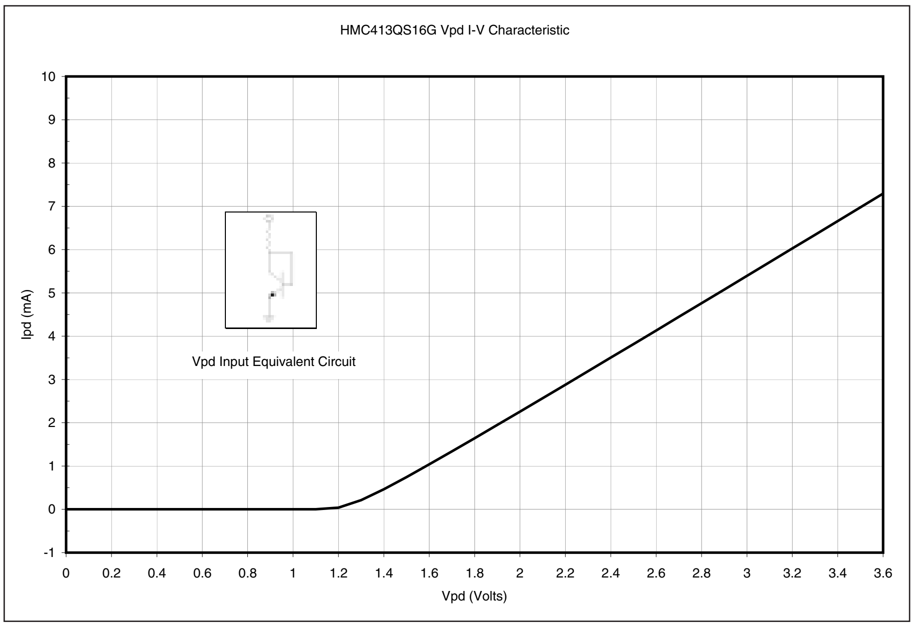

Figure 2 - I-V Characteristics of the Vpd Input

Switching Speed Performance

The switching speed characteristic of a typical HBT amplifier is shown in Figure 3 (for Ton) and Figure 4 (for Toff). In both cases the definition of switching speed is the elapsed time between the 50% level of the control input and the 90% (for Ton) level of the RF envelope or 10% (for Toff) level of the RF envelope. In the example shown, Ton is approximately 40 nSec while Toff is approximately 20 nSec.

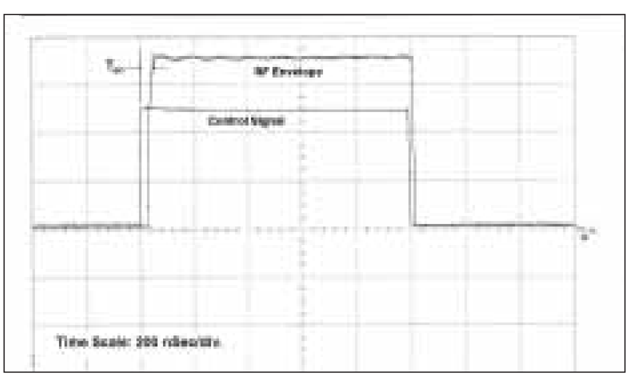

Figure 3 - T_{on} Switching Speed

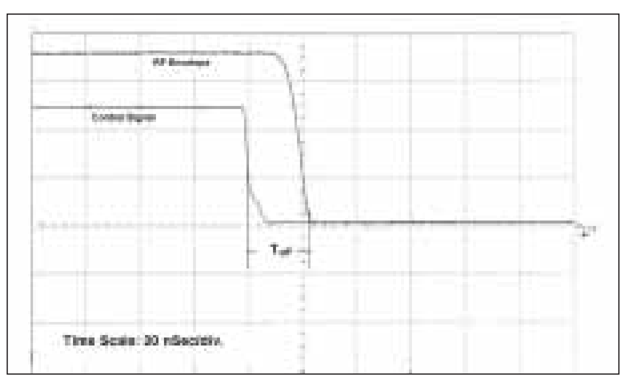

Figure 4 - T_{off} Switching Speed

RF Performance With Varying Vpd

In Figure 5, the device current (Icc), P1dB and output IP3 is plotted as a function of control input voltage Vpd. By studying this chart it is straightforward to pick an appropriate operating condition to satisfy any application requirement. The device current is very linear over the useful control range from 1.6 to 3.6 volts. Furthermore, this current varies only 10% over the operating temperature range from –40C to +85C as shown in Figure 6. At 1.6 volts, the amplifier is only consuming 1/5th of the DC current. At the same time, the P1dB performance of the amplifier is varied over more than a 12-dB range. Figure 7 shows the output 1-dB compression point of the amplifier as a function of the control input voltage. Over the temperature range from –40C to +85C the output P1dB varies less than ± 1 dB. In applications where an amplifier is used in more than one location, the ability to efficiently adjust the output P1dB and current consumption is highly desirable.

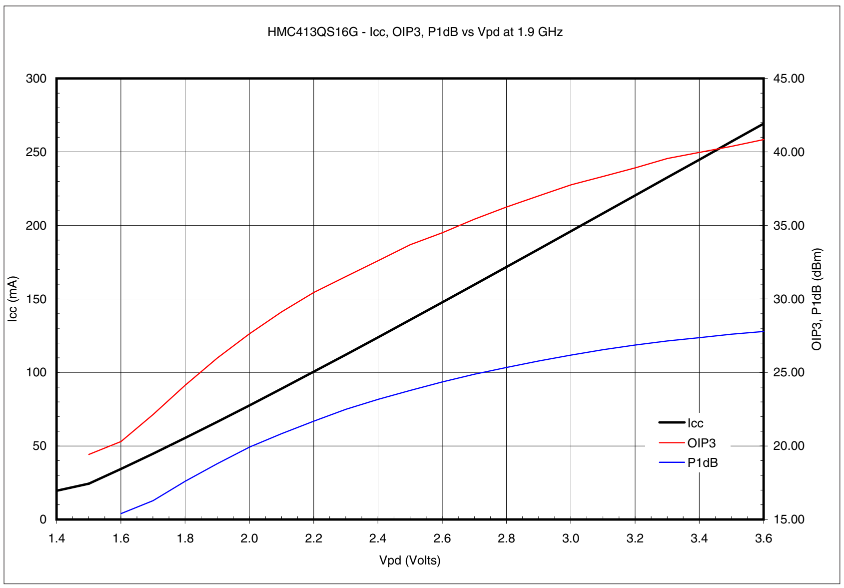

Figure 5 - Icc, P1dB & OIP3 vs. Vpd

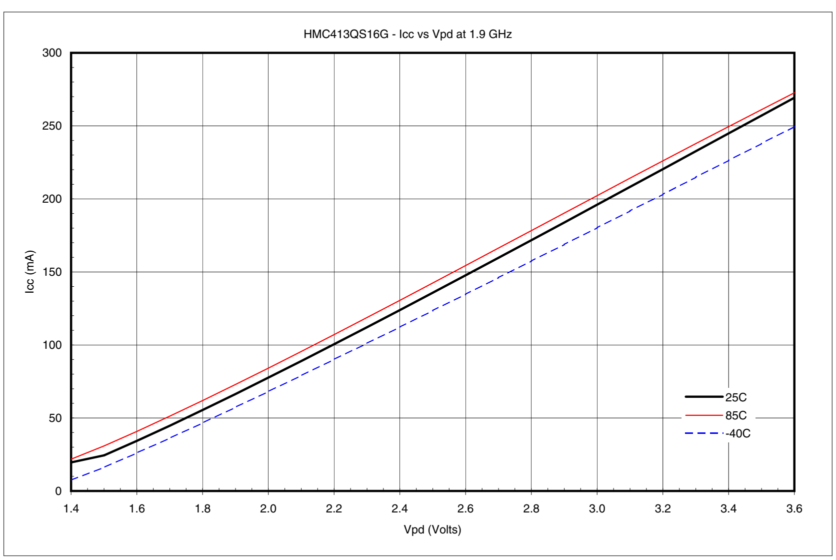

Figure 6 - Amplifier Current vs. Vpd

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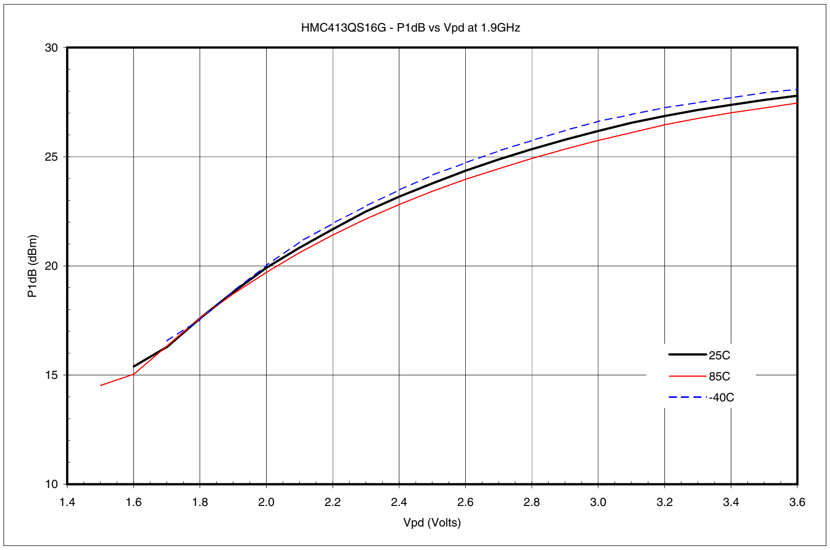

Figure 7 - P1dB vs. Vpd

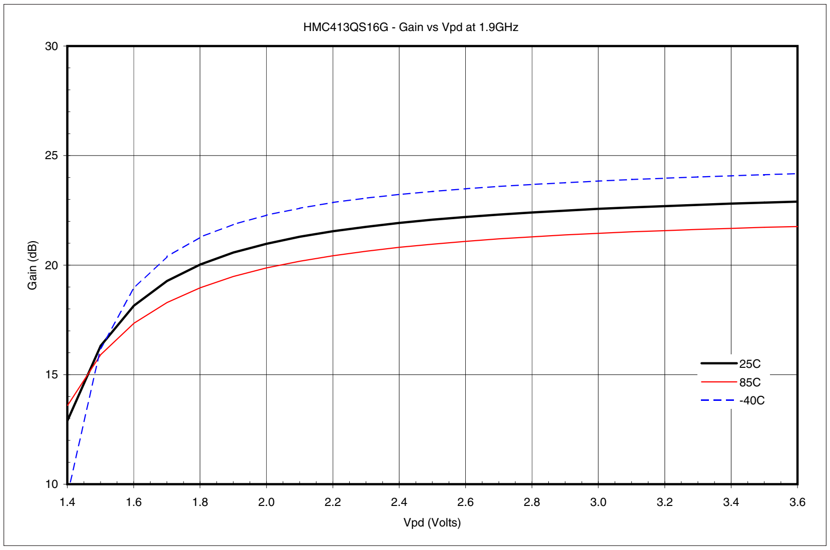

Figure 8 - Gain vs. Vpd

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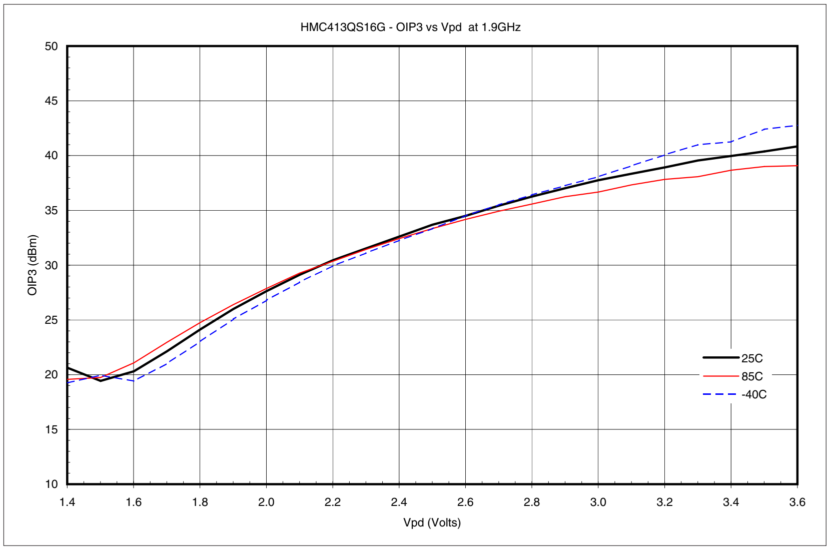

Figure 9 - Output IP3 vs. Vpd

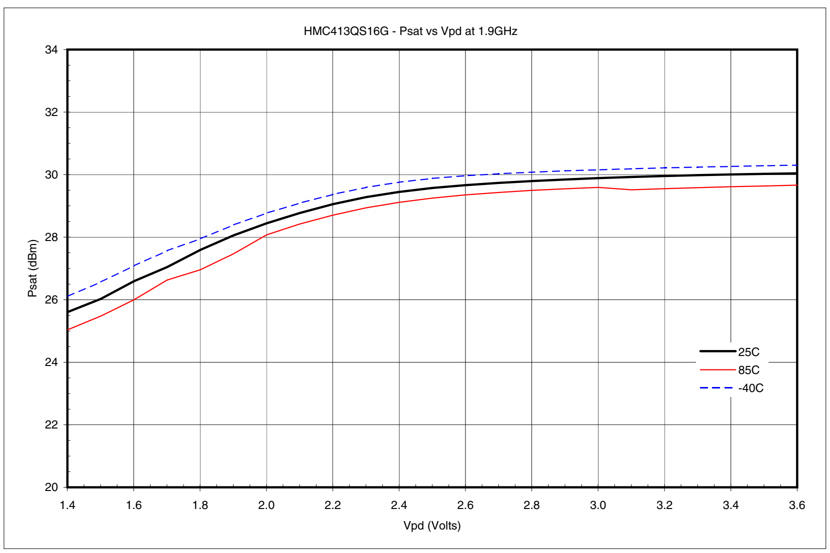

Figure 10 - Saturated Power vs. Vpd

Figure 8, 9 and 10 show the gain, output IP3 and saturated power (Psat) of the amplifier as a function of control input voltage Vpd over the full operating temperature range for –40C to +85C. Unlike the DC current consumption and P1dB, the gain varies by only 5-dB over the range of Vpd input voltages from 1.6 to 3.6 volts.

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System Applications

As the PA or driver stage in a transceiver, amplifiers with power control are commonly used in radio architectures for several different reasons:

- Diversity control

  In this application, the PA and/or driver stages are shut down during the receive cycle to minimize power consumption and interference in the receiver.

- VSWR monitor

  In order to protect the output amplifier stage from very poor VSWR mismatches that occur when the antenna is damaged or disconnected, a sensing circuit is commonly introduced at the output of the power amplifier and its' output is fed back to a fast controller which can then control the power amplifier.

- Transmit level detection

  Monitoring the RF input level to the PA and driver amplifier can optimize the system efficiency by reducing the output power and device current. While the amplifier gain, OIP3 and power will be reduced, at lower input levels this tradeoff can be made without compromising system performance.

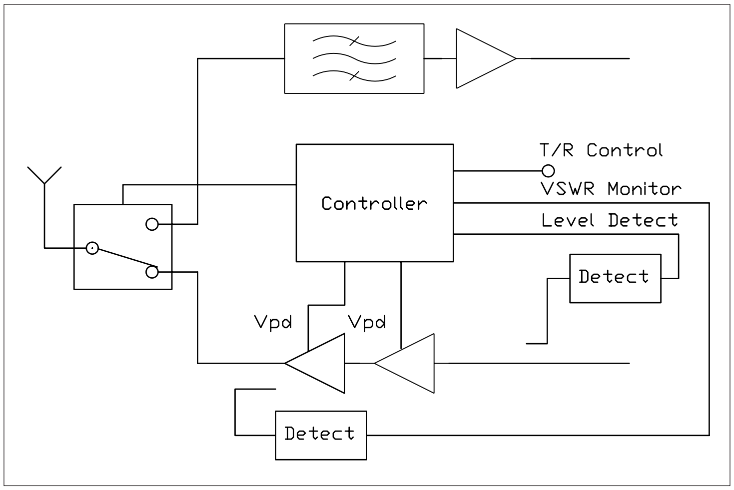

Figure 11 - System Architecture Using Power Control

All of the above functions can be accomplished simultaneously with a single control line to the amplifier by setting the appropriate Vpd control voltage. In Figure 11, that voltage is shown being determined by a system controller that takes all of the above factors into account.

Conclusion

The method of power control implemented in an amplifier's design affects the amplifier's ability to satisfy modern system requirements. By using current control that varies linearly over a wide range of input control voltage, the amplifiers key performance parameters can be reliably controlled and continuously varied.

For further information regarding Hittite Microwave Corporation's amplifiers with power control, please contact Hittite directly at (978) 250-3343 or visit our website at www.hittite.com.

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