

# Ultra-Linear, Low Noise, Broadband pHEMT Amplifiers: Redefining Broadband Gain Block Capability

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Broadband gain blocks have historically been the workhorse building blocks of receive and transmit lineups, operating anywhere from a few MHz to several GHz. These devices are characterized by internal 50 Ohm matching, which results in input and output return losses better than -10 dB over the full operating frequency range. In the distant past, these devices were fabricated in silicon, bipolar junction transistor (BJT) technology, which then gave way to aluminum gallium arsenide (AlGaAs) hetero-junction bipolar transistor (HBT) devices which achieved higher levels of gain and linearity than their older, silicon predecessors. More recently, silicon germanium (SiGe) and indium gallium phosphide (InGaP) HBT devices have come on the scene

with SiGe based devices displaying high gain and very low noise figure (NF) and moderate linearity. To date, the highest performing gain blocks were implemented using InGaP HBT. This process yielded industry standard devices with good linearity, gain and moderate NF along with consistent performance over temperature.

Older gain block architectures used a simple biasing circuit consisting of an external resistor in series with the supply rail. This resistor provided feedback which worked to stabilize the device quiescent current over process and temperature variations, doing so at the expense of efficiency. The advent of integrated active bias represented a significant performance improvement for these devices. Operating from a typical supply of 5.0 volts,

these active bias devices yield stable current, good RF performance and improved efficiency since there is no wasted power over an external series resistor.

Today, broadband gain block devices implemented in state-of-the-art pseudomorphic high electron mobility transistors (pHEMT) are delivering outstanding gain and linearity along with NF values that are much lower than their InGaP HBT predecessors. That said, good broadband linearity for all these devices has typically meant output 1 dB compression point (OP1dB) values around +20 dBm and output third-order intercept (OIP3) values in the range of +35 to +40 dBm. A new and growing family of high power, low noise devices from Guerrilla RF is breaking through these barriers to deliver broadband

devices with significantly higher OP1dB and OIP3 with NF values less than 1.0 dB.

Guerrilla RF's Power LNA™ device family currently consists of high power, low noise devices that, with simple matching, can be tuned to cover 100 MHz up to 5.0 GHz with fractional bandwidths greater than 60 percent. Here we define fractional bandwidth as the useable bandwidth of the device divided by the center frequency of that bandwidth. Note the broadband matching performance of the GRF5040 evaluation board from 1600 to 3000 MHz shown in Figure 1.

### Linearity

Figures 2 and 3 show the broadband OP1dB and OIP3 responses of the GRF5040 evaluation board using this same tune.

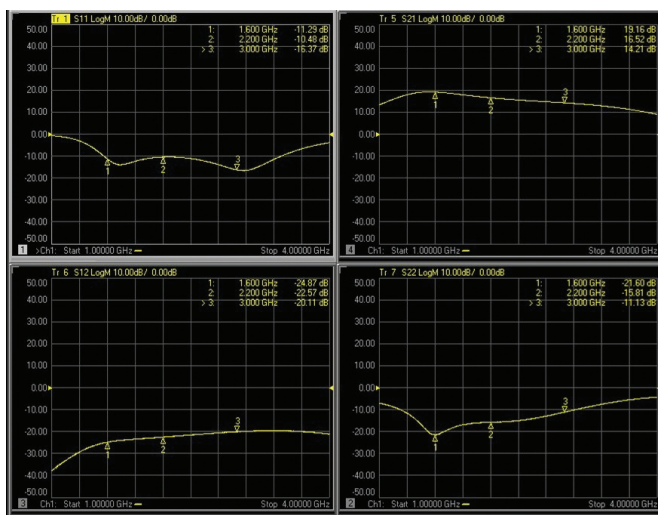


Figure 1: GRF5040 Power LNA evaluation board S-Parameters

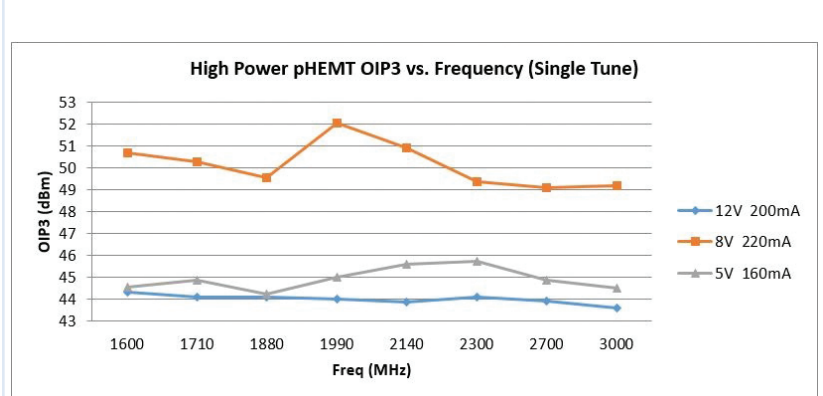


Figure 3: GRF5040 Broadband OIP3 response

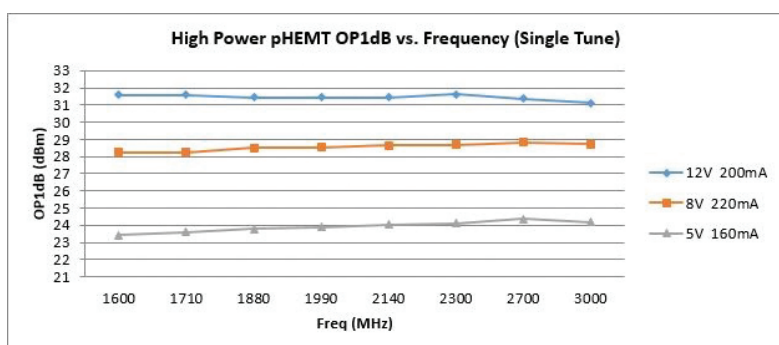


Figure 2: GRF5040 broadband OP1dB response

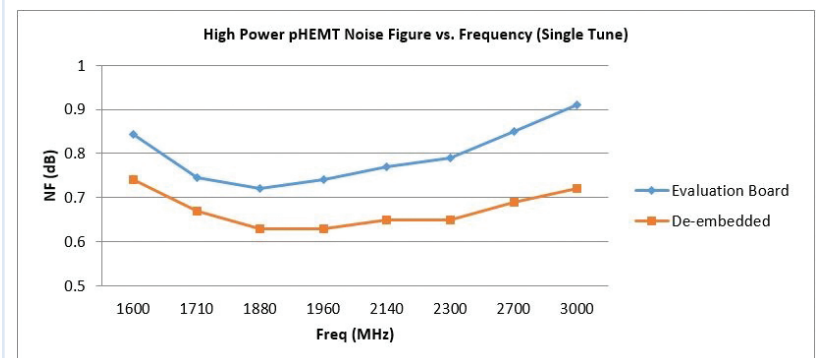


Figure 4: GRF5040 broadband NF performance

Figure 2 highlights the extraordinary OP1dB response of the GRF5040 device and the flatness of that response over this 1600 to 3000 MHz bandwidth. All the members of the Power LNA family can operate from a wide range of supply Vdd from 5.0 to as high as 12.0 volts with OP1dB rising with higher Vdd and exceeding +31 dBm at 12 volts.

Most devices in the Guerrilla RF portfolio include a Venable input, which allows the device Iddq to be set independently from the device Vdd. This feature is included in the Power LNA family and it allows the device efficiency to be optimized in accordance with the linearity requirements of a particular application.

OIP3 performance of the GRF5040 is also outstanding over the full bandwidth of this tune. Note that, unlike with OP1dB, the optimal OIP3 Vdd level is around 8 volts.

The extremely flexible biasing capability of these devices thus allows the optimal configuration for either IP3, P1dB or some optimal combination of those two parameters. Figure 3 shows the broadband OIP3 capability of the device using this 1600-3000 MHz tune.

Again, notice the flat OIP3 linearity response over frequency and the capability of achieving an OIP3 in the +50 dBm range over the full bandwidth of the tune.

#### Noise Figure

We have now seen the outstanding broadband matching and linearity performance of this GRF5040 Power LN device. For a device that can serve as either a linear driver amplifier or a final PA, depending on the application, the NF performance is outstanding at less than 1.0 dB across the band.

Figure 4 shows the broadband NF performance for both the

de-embedded device and for the entire evaluation board from SMA connector to SMA connector. This data was taken at 5.0 volts Vdd with Iddq set to 160 mA, but the NF changes little with higher Vdd and higher levels of Iddq.

#### Summary

Guerrilla RF's new family of Power LNA devices with internal active bias, exemplified by the GRF5040, offer a new level of broadband gain block performance. Simple matching yields broadband tunes with fractional bandwidths as high as 60 percent, along with ultra-high linearity performance that is flat across the band. Combining this linearity performance with NF values well below 1.0 dB results in devices which can be used as final power amplifiers, linear or saturated drivers or as rugged first, second or third stage LNAs.

With these devices, broadband matching, ultra-high linearity and sub 1.0 dB NF all come together to deliver unheard-of gain block capability well suited to cellular infrastructure, military communications and other high performance broad market applications.

The Guerrilla RF Applications team of industry veterans is committed to providing detailed custom engineering support through all stages of your product design process from initial prototyping through mass production. For more information, please visit [www.guerrilla-rf.com](http://www.guerrilla-rf.com).

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