



GRF400X Series Amplifiers

Exceptional broadband RF performance and internal matching combine with flexible biasing to enable both high levels of component reuse and tomorrow's low voltage radio architectures.

Free of the constraints associated with highly integrated radios, discrete RF designs offer optimized levels of performance and design flexibility at each stage in a transmit or receive lineup. System level requirements determine the optimal radio architecture and drive the RF specifications for each radio stage. Given noise figure (NF), gain, linearity, voltage supply rail and power consumption targets, the designer can choose the optimal device for the requirement at hand.

In the past, discrete amplifier designs were achieved using simple packaged bi-polar and field effect transistor (FET) devices which required all impedance matching, ESD protection, feedback/stabilization and bias circuitry to be implemented externally resulting in a high part count along with a relatively large application footprint. Thankfully, today's designers have access to a wide variety of monolithic microwave integrated circuit (MMIC) devices which typically integrate some or all of the RF matching, the bias circuitry and ESD protection on a single die.

High performance amplifier applications are widespread but generally include the following:

Low Noise Amplifier (LNA): The LNA serves to minimize the cascaded noise figure (NF) of the entire receiver to best preserve the signal to noise ratio (SNR) at the receiver input. The cascaded receiver NF consists of the LNA NF plus the NF contribution of the rest of the receiver which, in turn, is minimized by the LNA gain. First or single-stage LNAs place an emphasis on NF and gain since linearity requirements are typically moderate. For this type of LNA, today's pseudo-morphic high electron mobility (pHEMT) MMICs offer the best performance. Second stage LNAs typically require manageable NF in the 1 - 3 dB range but place a much higher emphasis on input referenced linearity. Here again, pHEMT MMIC devices such as the **GRF400X** family offer outstanding solutions. The following are a few specific recommendations:

Single or First-Stage LNAs: **GRF4002** and **GRF4003** offer outstanding NF along with adjustable current and voltage flexibility from 1.8 to 5.0 volts making these devices ideal for this application. Their outstanding linearity allows them to meet or exceed linearity requirements while achieving the highest possible efficiency.



Second Stage LNAs: GRF4002, GRF4003 and GRF4004, with bias currents and supply voltages optimized for linearity, are excellent candidates for this application. Their high third order intercept points (IP3) and 1 dB compression points (P1dB) combined with broadband NF values in the 0.7 to 1.1 dB range enable both outstanding cascaded NF and input referenced linearity for the LNA chain.

Linear Driver Amplifier: Typically found in the later part of a cascade of discrete amplifiers, these devices provide required gain and a low distortion signal to the following higher power amplifiers. The required linearity varies widely depending on the amplifiers place in a particular lineup; historically, these applications have been typically addressed by hetero-junction bi-polar transistor (HBT) MMIC devices. With the advent of our new GRF4002, GRF4003 and GRF4004, designers have powerful new pHEMT based solutions offering outstanding broadband linearity over frequency and supply voltage thus enabling the highest level of component reuse within a particular design as well as across differing platforms.

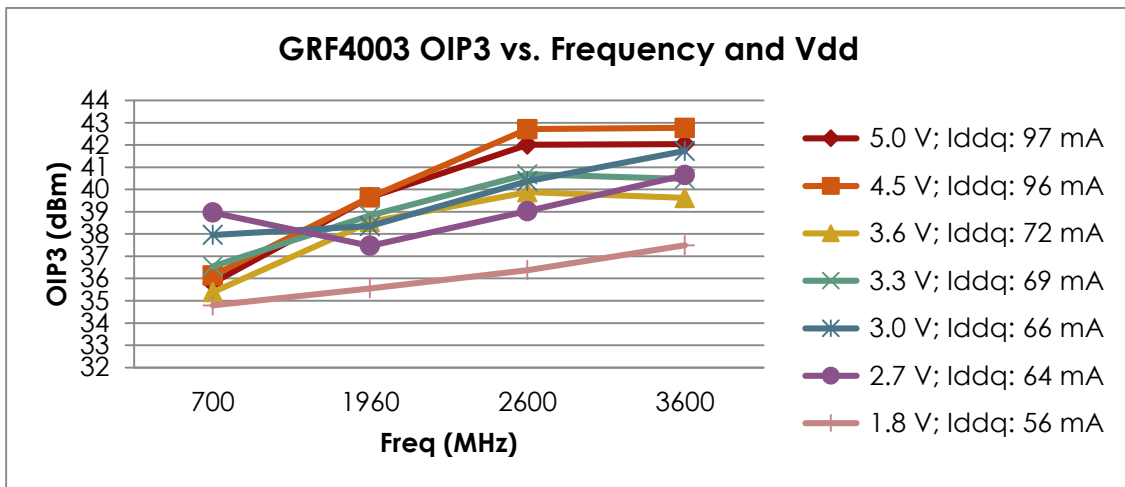
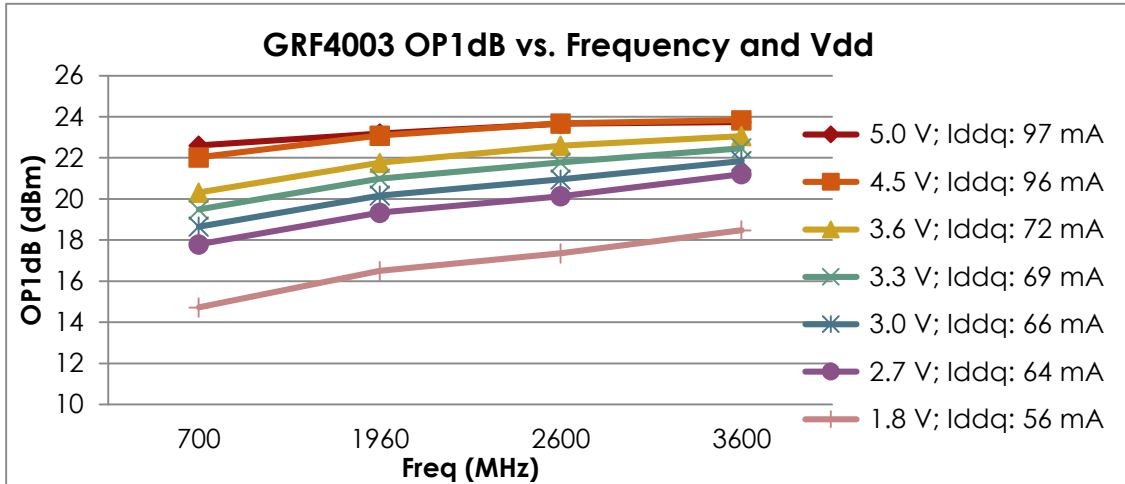
Intermediate Frequency (IF) Amplifier: This application typically requires a combination of high gain, high linearity and low NF in order to minimize the cascaded NF of an IF based radio architecture while introducing minimal distortion to the amplified signal. A common example here would be a low noise, high linearity amplifier immediately preceding a high insertion loss IF surface acoustic wave (SAW) filter. Their broadband linearity, NF and internal matching make the GRF4002 and GRF4003 devices ideal for such applications.

General Purpose Amplifier: Often the amplifiers within a cascaded chain need only provide gain with minimal NF and linearity requirements. This is typically the domain of low cost Darlington gain blocks which operate at a fixed bias current with a rigid supply voltage of 5.0 volts. Superior candidates for this type of application would be the GRF4001, GRF4002 and GRF4003 devices which provide high gain and outstanding linearity over a range of V_{dd} from 1.8 to 5.0 volts and with I_{ddq} levels in the 20 to 100 mA range. This biasing flexibility allows the device efficiency to be optimized for a given linearity requirement and results in a superior low cost solution for general purpose amplification. In short, this family of devices represent a vast improvement over today's commonly used high-end Darlington gain blocks in terms of performance, design flexibility, reuse and cost.

Local Oscillator (LO) Buffer Amplifier: High performance mixer LO drive level requirements can reach +20 dBm or more. With output P1dB levels up to +25 dBm (GRF4004), the GRF400X family of devices qualify as excellent LO buffer design solutions.

Measured evaluation board linearity data plots for the GRF4003 is shown on the following page. Note the exceptional device linearity over a range of V_{dd} values from 5.0 volts down to 1.8 volts. Although not shown, gain and NF performance is very flat over V_{dd} and I_{ddq} variation. This low voltage capability is common to all the GRF400X devices. Please refer to the GRF400x data sheets for more detailed characterization data including performance over temperature.

Measured Linearity Data; GRF4003 Evaluation Board:



Conclusion: Not limited by difficult external matching, dependence on a fixed supply rail or quiescent current and with broadband frequency capability to 3800 MHz, these devices offer unmatched levels of reuse. Used as an LNA, driver amplifier, general purpose gain block, IF amplifier or LO buffer, their low voltage capability provides high performance support for applications using supply rails down to an incredibly low 1.8 volts. Their outstanding low voltage IP3, P1dB, NF and gain will enable the ultra-high efficiency radio architectures of tomorrow.

Internal matching results in a minimal number of external components and all three devices utilize a common 1.5 x 1.5 mm DFN package and evaluation board. The Guerrilla RF applications engineering team is always available to provide device recommendations, tuned evaluation boards, measured device data and design assistance as needed.