GUERRILLA RF

Application Note

Leveraging Differences in Packaging to Customize Amplifier Performance

AN004

The GRF4004 is a high-linearity driver with low noise. It is fabricated in a 250 nm E-mode pHEMT process and packaged in GRF's standard 1.5 mm DFN-6. For applications above 1500 MHz which require high input-referenced linearity and very low noise, it is ideal. However, for sub-1 GHz applications, its high gain degrades the input-referenced P1dB and IP3.

So, if we want to quickly modify the GRF4004, how could we do that? Is there an easy way to change the device packaging so that we can create a GRF4004 derivative product optimized for a different frequency band?

Here is the challenge: *Improve the input linearity of the device while allowing only minimal impact to the NF*.

Adding resistive loss to the input would certainly improve the input linearity, but with an unacceptable impact to NF. Similarly, allowing S(1,1) to degrade via reactive mismatch on the input will improve the input linearity, but most applications require a minimum input return loss of 10 dB or more for a specific application frequency.

A third option is available which allows for the input linearity to be increased, while the input return loss and NF are minimally impacted. This method involves increasing the inductance to ground on the source node of the amplifier.

Within a packaged device, the FET source node is connected to the package die flag (ground) via a thin, inductive bond wire. During the creation of the GRF4004, this bond wire length (inductance) was optimized to achieve the best tradeoff of RF performance over a wide range of frequencies.

To achieve our goal of decreasing the low-frequency gain, and thus optimizing input linearity, it was necessary to increase the length of the source bond wire to ground. There was only so much physical space to accomplish this in the 1.5 mm package, so we decided to place the die into our larger 2x2 mm DFN-8 package. In this environment, the bond wire length was then optimized to achieve the desired gain, NF, return losses and input linearity in the 700-960 MHz band. This derivative product is called the GRF2114.

If you look at the tables below, you may notice that the GRF2114 IIP3 was improved most of all. It is not unusual for this increased source inductance to result in both improved OIP3 and reduced gain. The combination of these two results here accounted for a large increase in input-referenced IP3. As usual, there is a tradeoff with this source inductance technique: the use of increased source inductance results in gain roll-off at the high end of the band. This is why the gain flatness over 700-960 MHz is slightly worse for GRF2114 than it is for GRF4004.

Descriptor	Freq (MHz)	Gain (dB)	IIP3 (dBm)	OIP3 (dBm)	IP1dB (dBm)	OP1dB (dBm)	EVB NF (dB)
GRF4004_5V/135mA	700	22.0	15.8	37.8	4.1	25.0	0.92
GRF4004_5V/135mA	830	21.3	15.7	37.0	5.0	25.1	0.84

GRF4004_5V/135mA	960	20.3	16.0	36.2	6.0	25.2	0.84

Descriptor	Freq (MHz)	Gain (dB)	IIP3 (dBm)	OIP3 (dBm)	IP1dB (dBm)	OP1dB (dBm)	EVB NF (dB)
GRF2114_5V/135mA	700	19.1	20.9	40.0	7.3	25.4	1.00
GRF2114_5V/135mA	830	18.0	22.6	40.6	8.7	25.7	0.93
GRF2114_5V/135mA	960	16.7	24.2	40.9	10.2	25.9	0.96

In the above example, the improvement in input-referenced linearity of GRF2114 compared to its parent device is significant, thus highlighting one of the primary methods we use to optimize for one particular frequency range over another. For a given MMIC die, the device packaging and internal bond wire configuration make significant contributions to the performance of the device.

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Revision History

Revision	Date | Reason for Revision
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