High Power RF LDMOS Transistors Target WCDMA, IMT2000/UMTS Applications at 2100 MHz

This month's cover features new devices for 2-1/2G and 3G wireless systems

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Motorola has developed new 220 watt (P_{3dB}) push-pull and 155 watt (P_{3dB}) single-ended transistors for base station power amplifiers.. The devices are internally matched, common-source, N-channel, enhancement-mode, laterally diffused metal-oxide semiconductor (LDMOS) FETs, designed for IMT2000/UMTS single or multicarrier applications covering the 2110-2170 MHz band and incorporating WCDMA digital modulation.

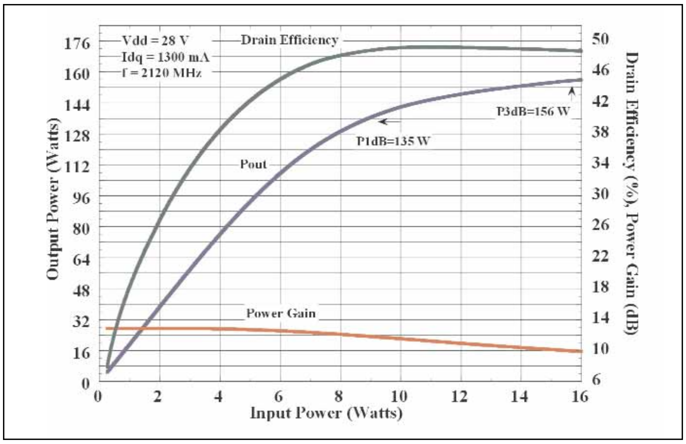
The two new devices, MRF21180 (push-pull) and MRF21125 (single-ended), feature exceptional P_{1dB} and P_{3dB} output power capabilities, which are essential for high peak to average ratio digital modulation signals such as WCDMA. Figures 1 and 2 show the MRF21180 and MRF21125 typical output power, efficiency, and gain vs. input power at 2120 MHz with V_{dd} (drain operating voltage) at 28 volts. At the respective P_{1dB} points of 170 watts and 135 watts, drain efficiencies of 42 and 49 percent are achieved. The respective P_{3dB} points are 220 watts and 155 watts.

Both parts are internally matched at the input and output for simplified matching over the 2110-2170 MHz band. The performance over this band is illustrated in Figures 3 and 4. The rule of thumb of –30 dBc IM_3 (third order intermodulation distortion) for 2-tones with 10 MHz spacing at the respective PEP (peak envelope power) ratings was used to show the broadband linearity of the two devices. A compromise among gain, efficiency, and IMD was made to achieve the best overall broadband performance. The resulting load and source impedances to achieve this best overall broadband performance is shown in Table 1 for both devices. For the MRF21180 at a PEP of 170 watts, an IM_3 of better than –30 dBc is maintained across the band with an input return loss of better than –12 dB and drain efficiency and power gain in excess of 33 percent and 11.5 dB respectively.

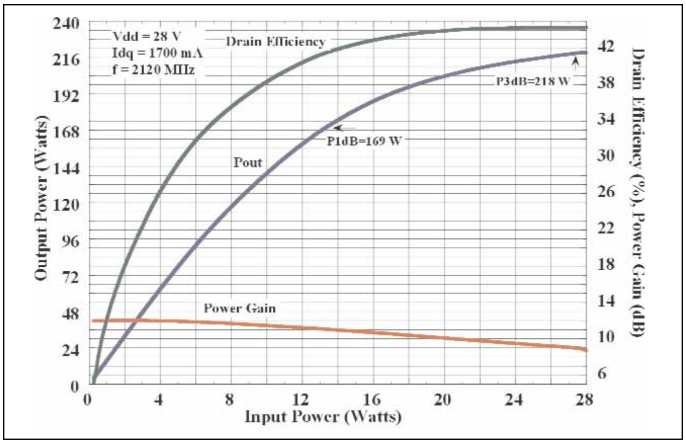
Similarly, for the MRF21125, at a PEP of 125 watts, an IM_3 of better than –30 dBc is maintained across the band with input return loss of better than –12dB, drain efficiency greater than 34 percent, and a minimum gain of 12 dB.

While Figures 1 through 4 show high saturation power capability and very good linearity at rated PEP levels, Figures 5 and 6 show the IM_3 performance vs. output power, which is better than –45 dBc at 10 dB back-off power.

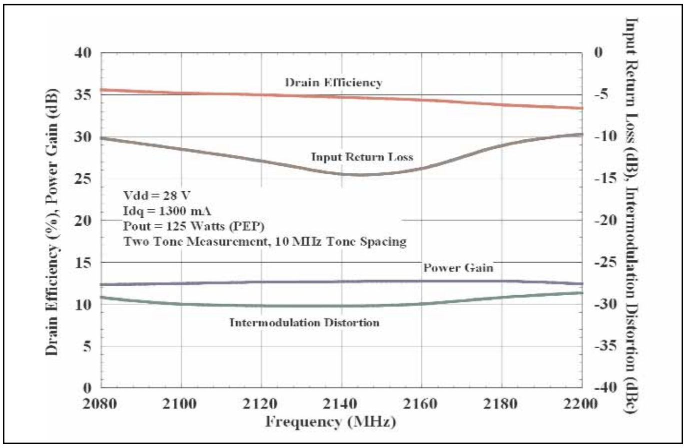
All three of these characteristics are essential for multicarrier power amplifiers used for WCDMA base stations.



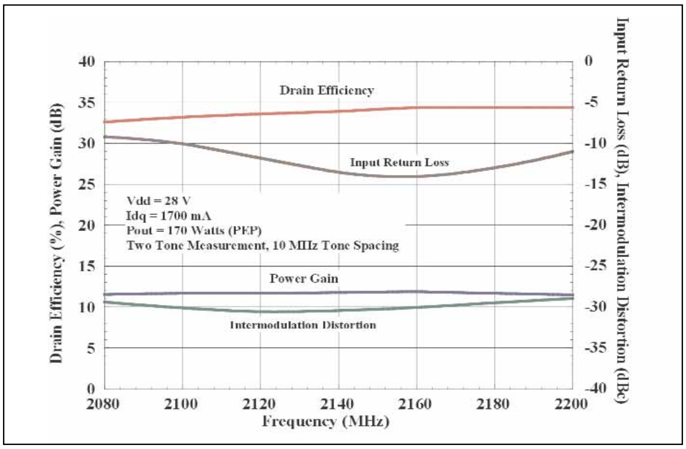
▲ **Figure 1. MRF21125 two-tone performance vs. frequency.**



▲ **Figure 2. MRF21125 output power vs. input power.**



▲ **Figure 3. MRF21180 output power vs. input power.**



▲ **Figure 4. MRF21180 two-tone performance vs. frequency.**

For a 2-carrier WCDMA application a base-station manufacturer requires a 20 to 25 watt power level at the antenna port, as well as adjacent channel power (ACP) and IM_3 that is –55 dB relative to the carrier channel power. Figure 7 shows a snapshot of a 2-carrier WCDMA spectrum 10 MHz apart. The bandwidth of a single channel is 3.84 MHz (chip rate of the digital signal) with the WCDMA signal at a peak-to-average ratio of 8.5 dB at .01 percent probability on the CCDF plot (complementary cumulative distribution function). The adjacent channels will be ±5 MHz away from each carrier center frequency and the ±ACP relative to each carrier's integrated power level is measured in a 3.84 MHz integration bandwidth. Likewise, the IM_3 products ($\pm IM_3$) will be ±10 MHz away and are also measured in a 3.84 MHz integrated bandwidth.

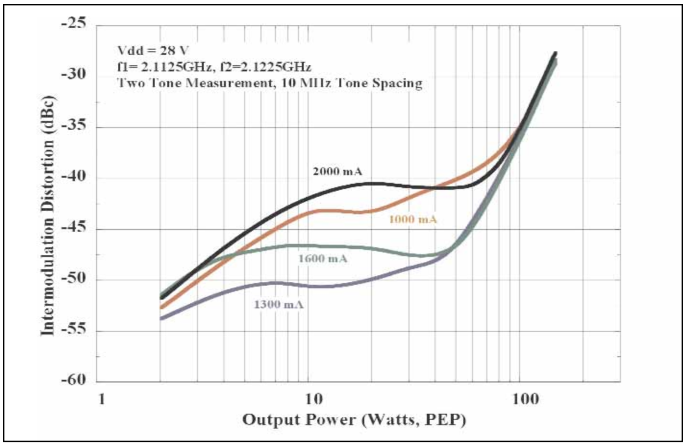
The most popular linearization technique used by manufacturers for WCDMA application is the feedforward correction loop. This technique achieves around 15 to 20 dB minimum adjacent channel and IM_3 rejection. Delay and coupling losses require about 2.5 to 3 dB higher power at the amplifier output than at the antenna port. Examples of output device configurations for a WCDMA base station PA incorporating the feedforward technique are discussed below.

Figures 8 and 9 show the gain, efficiency, $\pm IM_3$ and ±ACP vs. 2-carrier WCDMA power for each device. Most notably, the IM_3 is the determining factor in the rejection that is needed to achieve the –55 dBc level.

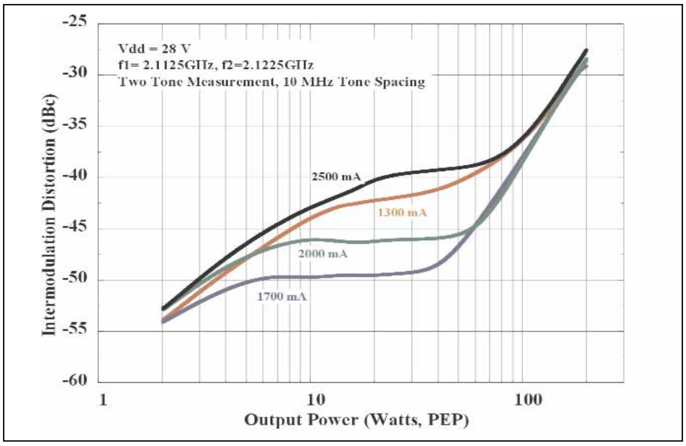
One MRF21180 device, running at 44 watts and –35 dBc IM_3, is sufficient to meet the 20 to 25 watt output power level at the antenna port, with overall system ACP and IM_3 55 dB below the carrier when combined with a linearization correction of better than 20 dB. The

	Freq.	Zin (Ω)	Zout (Ω)
MRF21125	2.11GHz	3.81 + j6.86	1.56 – j1.58
	2.14GHz	4.33 + j7.90	1.53 – j1.90
	2.17GHz	4.84 + j8.46	1.48 – j2.26
MRF21180	2.11GHz	4.03 – j3.71	3.79 – j4.04
	2.14GHz	3.57 – j4.11	3.52 – j4.33
	2.17GHz	3.20 – j4.57	3.30 – j4.77

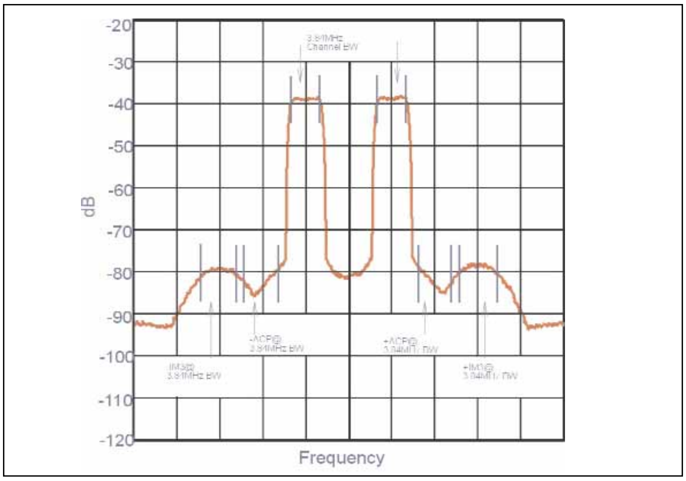
▲ **Table 1. Device impedances across the WCDMA band.**



▲ **Figure 5. MRF21125 IMD vs. power and I_{dq}.**



▲ **Figure 6. MRF21180 IMD vs. power and I_{dq}.**



▲ **Figure 7. Carrier WCDMA spectrum.**

gain and efficiency at this level are 12.0 dB and 23.5 percent. However, should a manufacturer require some margin in rejection of IM_3, two MRF21125 devices running around 23 watts and –41 dBc IM_3 can be used at an expense of overall efficiency. The efficiency of the MRF21125 at the 23 watt level is typically 20.0 percent and the gain is 13 dB.

In conclusion, the MRF21180 and MRF21125 are very attractive for single or multicarrier WCDMA or other base station applications in the 2110 to 2170 MHz band which require high saturation power levels and low distortion requirements at peak and operating output power levels. Also, their ruggedness, consistency, ease of use, cost, and 100 percent production testing under WCDMA conditions make the MRF21180 and MRF21125 attractive for the WCDMA market. ■

References

1. B. Davidson, C. Dragon, E. Krvavac, W. Burger, D. Joersz, N. Dixit, “High Power RF-LDMOS Transistors for Wireless Communication Base Station Applications,” Microwave Workshops and Exhibition (Japan), 1999.

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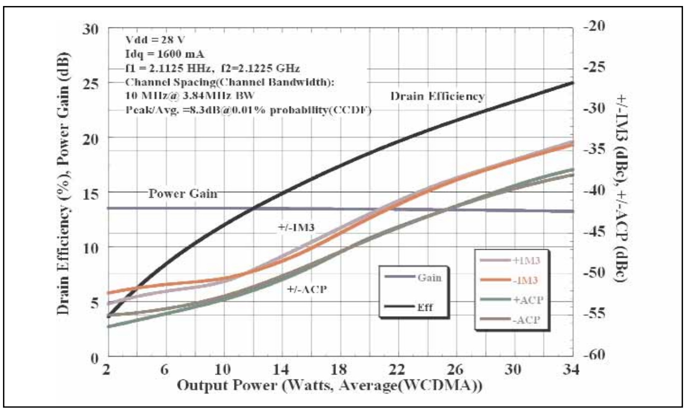
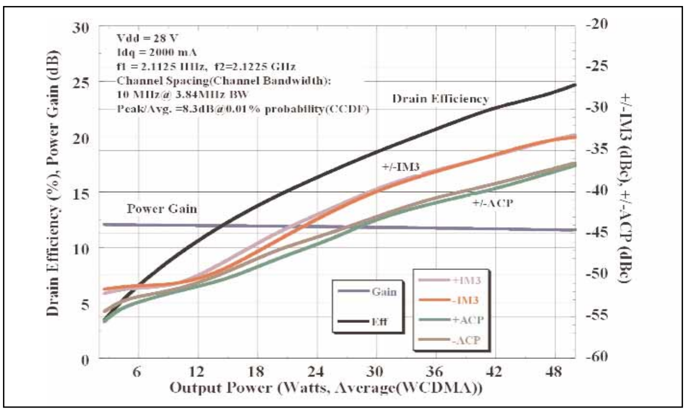


▲ **Figure 8. MRF21125 ACP and IM_3 performance vs. output power.**



▲ **Figure 8. MRF21180 ACP and IM_3 performance vs. output power.**