RF Power Reference Design
LTE 750 MHz Power Amplifier Lineup
InGaP HBT Driving GaAs pHfEMT

Amplifier Lineup Characteristics

This reference design provides a high-gain amplifier solution, specifically tuned for LTE and W-CDMA base station applications occupying the 725 to 760 MHz frequency band.

- Typical Single-Carrier LTE Performance
- GPA: $V_{CC} = 5$ Vdc, $I_{CC} = 132$ mA
- Power GaAs FET: $V_{DD} = 12$ Vdc, $I_{DQ} = 180$ mA, $V_{GS} = -0.82$ Vdc
- Output Power: 1.0 Watts Avg.
- 10 MHz Channel Bandwidth @ 10 MHz Offset
- Input Signal $\text{PAR} = 10.5$ dB @ 0.01% Probability on CCDF, IQ Magnitude Clipping

<table>
<thead>
<tr>
<th>Frequency</th>
<th>$G_{ps}$ (dB)</th>
<th>$\eta$ (%)</th>
<th>Output PAR (dB)</th>
<th>ACPR (dBc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>740 MHz</td>
<td>36.5</td>
<td>23.4</td>
<td>9.0</td>
<td>-40.3</td>
</tr>
<tr>
<td>750 MHz</td>
<td>36.4</td>
<td>24.1</td>
<td>9.0</td>
<td>-40.4</td>
</tr>
<tr>
<td>760 MHz</td>
<td>36.4</td>
<td>24.8</td>
<td>8.9</td>
<td>-40.4</td>
</tr>
</tbody>
</table>

- Output Capable of Handling 3:1 VSWR, @ 12 Vdc, 750 MHz, 10 Watts CW Output Power
- Designed for Digital Predistortion Error Correction Systems

MMG3014N/MRFG35010AN REFERENCE DESIGN

The amplifier lineup consists of a GaAs HBT pre-driver and GaAs pHfEMT driver amplifier, tuned for optimal gain, efficiency, linearity and dynamic range performance at 1.0 Watts average output power. Performance characteristics of the reference design are provided in this document. Contact your local Freescale sales office or authorized Freescale distributor for additional information on reference design board availability for hands-on assessment and customization.
AMPLIFIER LINEUP TEST CONDITIONS

- GPA: \( V_{CC} = 5 \text{ Vdc}, \ I_{CC} = 132 \text{ mA} \)
- Power GaAs FET: \( V_{DD} = 12 \text{ Vdc}, \ I_{DQ} = 180 \text{ mA}, \ V_{GS} = -0.82 \text{ Vdc} \)
- Output Power: 1.0 Watts Avg.
- IQ Magnitude Clipping

Note: Refer to Appendix A for Power-up Sequence

AMPLIFIER LINEUP — ALTERNATE CHARACTERISTICS

- Typical Single-Carrier W-CDMA Performance
- Measured in 3.84 MHz Channel Bandwidth @ 5 MHz Offset
- Input Signal PAR = 8.5 dB @ 0.01% Probability on CCDF

<table>
<thead>
<tr>
<th>Frequency</th>
<th>( G_{ps} ) (dB)</th>
<th>( \eta_D ) (%)</th>
<th>Output PAR (dB)</th>
<th>ACPR (dBc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>740 MHz</td>
<td>36.4</td>
<td>23.8</td>
<td>8.3</td>
<td>-40.9</td>
</tr>
<tr>
<td>750 MHz</td>
<td>36.3</td>
<td>24.5</td>
<td>8.2</td>
<td>-41.0</td>
</tr>
<tr>
<td>760 MHz</td>
<td>36.3</td>
<td>25.2</td>
<td>8.1</td>
<td>-41.0</td>
</tr>
</tbody>
</table>

REFERENCE DESIGN HARDWARE

Figure 2. Performance Optimized Hardware

HEATSINKING

When operating this fixture it is important that adequate heatsinking is provided for the device. Excessive heating of the device may degrade the values of the included measurements and continued operation at excessive temperatures may destroy the device.
Table 1. MMG3014N Driving MRFG35010AN Test Circuit Component Designations and Values

<table>
<thead>
<tr>
<th>Part</th>
<th>Description</th>
<th>Part Number</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1, C18</td>
<td>100 pF Chip Capacitors</td>
<td>ATC600F101JT250XT</td>
<td>ATC</td>
</tr>
<tr>
<td>C2</td>
<td>22 pF Chip Capacitor</td>
<td>ATC600F220JT250XT</td>
<td>ATC</td>
</tr>
<tr>
<td>C3, C16</td>
<td>10 pF Chip Capacitors</td>
<td>ATC100A100JP150XT</td>
<td>ATC</td>
</tr>
<tr>
<td>C4, C15</td>
<td>100 pF Chip Capacitors</td>
<td>ATC100A101JP150XT</td>
<td>ATC</td>
</tr>
<tr>
<td>C5, C14</td>
<td>100 pF Chip Capacitors</td>
<td>ATC100B101JP500XT</td>
<td>ATC</td>
</tr>
<tr>
<td>C6, C13</td>
<td>1000 pF Chip Capacitors</td>
<td>ATC100B102JP500XT</td>
<td>ATC</td>
</tr>
<tr>
<td>C7, C12</td>
<td>0.1 μF Chip Capacitors</td>
<td>CDR33BX104AKYS</td>
<td>Kemet</td>
</tr>
<tr>
<td>C8, C11</td>
<td>39K pF Chip Capacitor</td>
<td>ATC200B393KP50XT</td>
<td>ATC</td>
</tr>
<tr>
<td>C9, C10</td>
<td>22 μF, 35 V Tantalum Capacitors</td>
<td>T491X226K035AT</td>
<td>Kemet</td>
</tr>
<tr>
<td>C17</td>
<td>12 pF Chip Capacitor</td>
<td>ATC600F120JT250XT</td>
<td>ATC</td>
</tr>
<tr>
<td>C19</td>
<td>1.8 pF Chip Capacitor</td>
<td>ATC600F1R8BT250XT</td>
<td>ATC</td>
</tr>
<tr>
<td>C20</td>
<td>8.2 pF Chip Capacitor</td>
<td>ATC600F8R2BT250XT</td>
<td>ATC</td>
</tr>
<tr>
<td>C21, C23</td>
<td>220 pF Chip Capacitors</td>
<td>C0805C221J5GAC</td>
<td>Kemet</td>
</tr>
<tr>
<td>C22</td>
<td>5.6 pF Chip Capacitor</td>
<td>06035J5R6BBS</td>
<td>AVX</td>
</tr>
<tr>
<td>C24</td>
<td>2.2 μF, 16 V Tantalum Capacitor</td>
<td>T491A225K016AS</td>
<td>Kemet</td>
</tr>
<tr>
<td>C25</td>
<td>0.1 μF Chip Capacitor</td>
<td>C0603C104J5RAC</td>
<td>Kemet</td>
</tr>
<tr>
<td>L1</td>
<td>4.7 nH Chip Inductor</td>
<td>LL1608-FH4N7S</td>
<td>TOKO</td>
</tr>
<tr>
<td>L2</td>
<td>10 nH Chip Inductor</td>
<td>LL1608-FH10NJ</td>
<td>TOKO</td>
</tr>
<tr>
<td>Q1</td>
<td>Power FET GaAs Transistor</td>
<td>MRFG35010ANT1</td>
<td>Freescale</td>
</tr>
<tr>
<td>Q2</td>
<td>InGaP HBT GPA</td>
<td>MMG3014NT1</td>
<td>Freescale</td>
</tr>
<tr>
<td>R1</td>
<td>51 Ω, 1/8 W Chip Resistor</td>
<td>RM73BJT510J</td>
<td>KOA Speer</td>
</tr>
<tr>
<td>R2</td>
<td>5.1 Ω, 1/4 W Chip Resistor</td>
<td>CRCW08055R10JNEA</td>
<td>Newark</td>
</tr>
<tr>
<td>PCB</td>
<td>0.020&quot;, εr = 3.5</td>
<td>RO4350B</td>
<td>Rogers</td>
</tr>
</tbody>
</table>

Figure 3. MMG3014N Driving MRFG35010AN Board Layout
TYPICAL CHARACTERISTICS — 10 MHz LTE Test Signal

(Single-Carrier LTE, Test Model 1.1, 10 MHz, PAR = 10.5 dB @ 0.01% Probability on CCDF)

**Figure 4. Power Gain versus Output Power**

**Figure 5. Drain Efficiency versus Output Power**

**Figure 6. Adjacent Channel Power versus Output Power**

**Figure 7. Peak-to-Average Ratio versus Output Power**

**10 MHz LTE TEST SIGNAL**

**Figure 8. CCDF LTE IQ Magnitude Clipping, Single-Carrier Test Signal**

**Figure 9. Single-Carrier LTE Spectrum**

MMG3014N Driving MRFG35010AN LTE Reference Design
TYPICAL CHARACTERISTICS — 8.5 dB Input PAR W-CDMA Test Signal
(Single-Carrier W-CDMA, 3GPP Test Model 1, 64 DPCH, PAR = 8.5 dB @ 0.01% Probability on CCDF)

Figure 10. Power Gain versus Output Power

Figure 11. Drain Efficiency versus Output Power

Figure 12. Adjacent Channel Power versus Output Power

Figure 13. Peak-to-Average Ratio versus Output Power

8.5 dB W-CDMA TEST SIGNAL

Figure 14. CCDF W-CDMA IQ Magnitude Clipping, Single-Carrier Test Signal

Figure 15. Single-Carrier W-CDMA Spectrum
Figure 16. Small-Signal Gain, Input and Output Return Loss versus Frequency

Figure 17. Power Gain and Drain Efficiency versus Output Power
APPENDIX A

Power-Up Sequence

The MMG3014N and MRFG35010AN devices are biased separately. Apply bias as follows:

1. Terminate the RF input and output with 50 Ω impedances: no RF signal applied.
2. Apply -1.5 Vdc supply across the -VGS (negative gate voltage) and GND terminals of MRFG35010AN.
3. Apply +12 Vdc supply across the +VDS (positive drain voltage) and GND terminals of MRFG35010AN.
4. Increase the -VGS value to set the IDQ (drain quiescent current) to 180 mA. -VGS should be approximately -0.82 Vdc.
5. Apply +5 V supply to VCC terminal of MMG3014N.
6. ICC should be around 132 mA.
7. Apply RF signal to input terminal and set signal level to -20 dBm.

Power-Down Sequence

1. Remove RF signal from input terminal.
2. Remove VCC from MMG3014N.
3. Adjust MRFG35010AN's -VGS to -1.5 Vdc.
4. IDQ should be near zero.
5. Remove +VDS from MRFG35010AN.
6. Remove -VGS from MRFG35010AN.
APPENDIX B

Tuning Tips

- Adjusting the value or location of C19 and C20 will have significant effect on ACPR, output return loss and efficiency.
- Adjusting the values or locations of C17 on MRFG35010AN input will have significant impact on gain and input return loss.
APPENDIX C

Simulation Models

Download simulation models of MMG3014N and MRFG35010AN from:

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