AMPS Power Amplifier (PA) Provides 50% PAE

The MAX2251 low-voltage linear power amplifier (PA) was designed for TDMA/AMPS dual-band systems. The device is offered in a 2.06mm x 2.06mm chip-scale package making it ideal for portable devices where PCB space is at a premium. When optimized for and operated in an AMPS mode system, a near 50% PAE across the band is possible as demonstrated in this document.

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General

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Objective

Optimize the standard MAX2251 Evaluation kit for AMPS only operation at 50% power added efficiency across the cellular band (824MHz to 849MHz).

Procedure

Figure 1 illustrates the basic setup used for all testing performed. A standard evaluation kit was obtained and measured for initial AMPS performance. The results of the initial "out of the box" measurement are shown in Table 1.

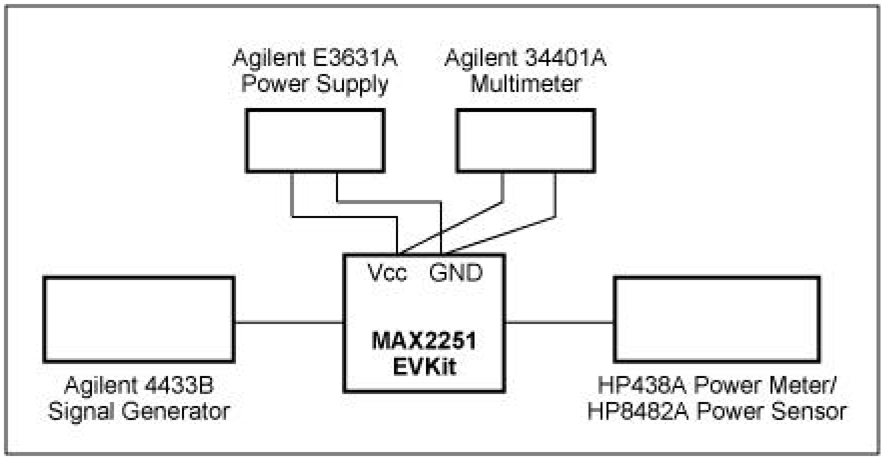


Figure 1.

Table 1. "Out of the Box"

Parameter	Measured Value	Units
Fin	836	MHz
Pout	30	dBm
Pin	2.36	dBm
Gp	27.64	dB
Icc	791	mA
Vcc	3.3	Vdc
PAE	38.2	%

The MAX2251 evaluation kit is built and tested for optimal operation in both AMPS and TDMA modes. The linearity requirements for TDMA are such that the PA's internal stages must operate non-saturated. This is not the case for AMPS, and in order to realize optimum efficiency in an AMPS only system, the circuit may be re-tuned. To that end, the first adjustment was made to the output matching network. On the EVKit this consists of nothing more than a pull-up inductor, PCB micro-strip, and a shunt capacitor. The shunt cap's position can be varied along the micro-strip to adjust the match, and the position is referenced by tick-marks on the PCB's silkscreen. The data in Table 1 was with the shunt cap. (C12) positioned at tick mark #1 (closest to the IC).

After measuring the standard EVKit, the output match was adjusted by placing C12 at increasing distances from the IC, and it was found that the optimum location was at approximately tick mark #3.5. It was further determined through experimentation that the value of C12 should be reduced to 9.1pF from the design value of 10pF. This produced reasonable efficiency at mid-band (approximately 48%).

After optimizing the output match, the inter-stage match was focused on. Like the output stage, the inter-stage match on the EVKit is accomplished with a slide-able shunt capacitor (C5). Experimentation proved the best position to be approximately 0.100" away from the IC (unlike the output, there are no tick-marks on the interstage strip-line). This adjustment provided a slight increase in mid-band.

The third approach taken in re-tuning the MAX2251 was to determine the optimum bias current for each of the two stages. The device employs an on-chip bandgap reference allowing for independent external bias control of each stage. This can be accomplished through the use of an external resistor for each stage (R3, and R4), or by summing a current into the stages' respective bias port. In order to determine the ideal combination of bias currents, the arrangement shown in Figure 2 was employed (note that the setup in Figure 1 was still in place only with these additions).

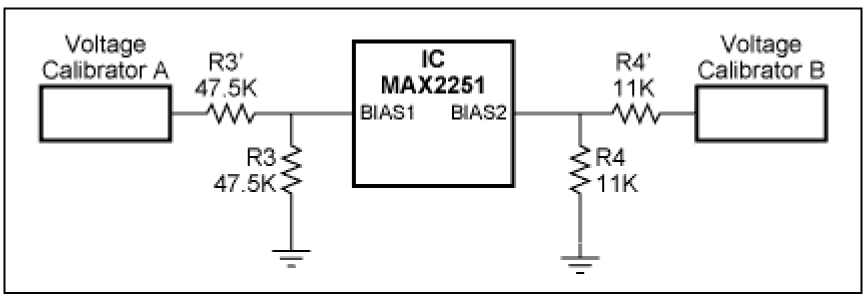


Figure 2.

With the above configuration, each stage's bias current could be adjusted and the effects seen in real time. Once the best performance setting was found, the voltage on each calibrator was noted. Calibrator A was set to deliver 1.9Vdc, and calibrator B was set at 1.69Vdc. Measuring the true bandgap voltage at Bias1 and Bias 2 allowed for rough calculation of the current flowing into each port:

$V_A = 1.9Vdc$
$V_{bias1} = 1.266Vdc$
$R3' = 47.5k\Omega$
$R3 = 47.5k\Omega$

The current through R3' was calculated:

$I_{R3'} = (V_A - V_{bias1}) / R3' = (1.9Vdc - 1.266Vdc) / 47.5k\Omega$
$I_{R3'} = 13.347uA$

And the current through R3 was calculated:

$I_{R3} = V_{bias1} / R3 = 1.266Vdc / 47.5k\Omega$
$I_{R3} = 26.936uA$

Then the actual current into Bias1 was found:

$I_{bias1} = I_{R3} - I_{R3'} = 26.936uA - 13.347uA$
$I_{bias1} = 13.589uA$

Finally a new resistor value was chosen for R3:

$R3_{new} = V_{bias1} / I_{bias1} = 1.266Vdc / 13.589uA$
$R3_{new} = 95.3k\Omega$

A 95.3kΩ resistor was then substituted for the R3 (the closest value on-hand), and R3' was removed.

This process was repeated for R4 and R4':

$V_B = 1.69Vdc$
$V_{bias2} = 1.148Vdc$
$R4' = 11k\Omega$
$R4 = 11k\Omega$

The current through R4' was calculated:

$I_{R4'} = (V_B - V_{bias2}) / R4' = (1.69Vdc - 1.148Vdc) / 11k\Omega$
$I_{R4'} = 49.273uA$

And the current through R4 was calculated:

$I_{R4} = V_{bias2} / R4 = 1.148Vdc / 11k\Omega$
$I_{R4} = 104.364uA$

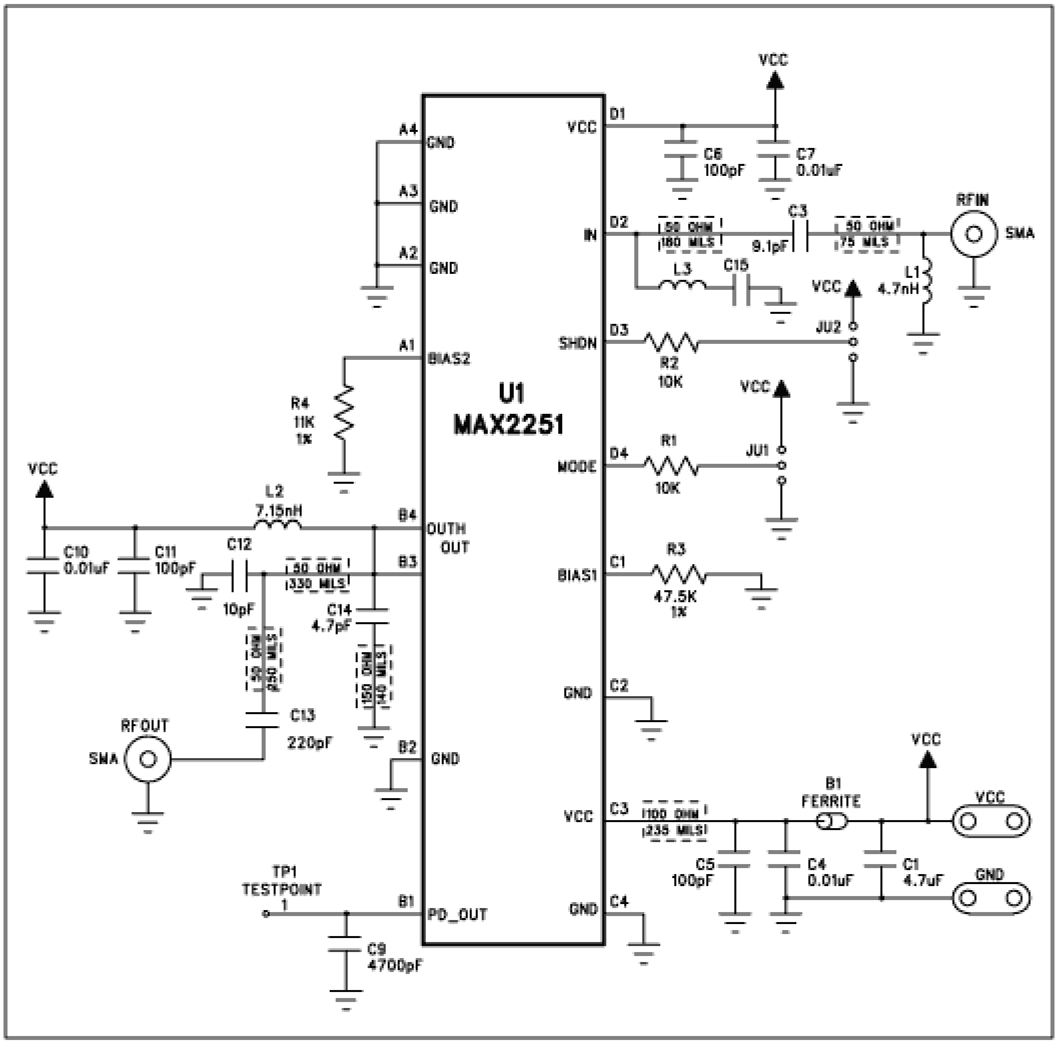
Then the actual current into Bias2 was found:

$I_{bias2} = I_{R4} - I_{R4'} = 104.364uA - 49.273uA$
$I_{bias2} = 55.091uA$

Finally a new resistor value was chosen for R4:

$R4_{new} = V_{bias2} / I_{bias2} = 1.148Vdc / 55.091uA$
$R4_{new} = 20.838k\Omega$

A 20kΩ and 800Ω resistor were used in series to replace R4, and R4' was removed.



Results

The final result after adjusting the output match, the inter-stage match, and the first and second stage bias resistors can be seen in Table 2.

Table 2. Final Result

Parameter	Measured Value			Units
Fin	824	836	849	MHz
Pout	30	30	30	dBm
Pin	3.22	4.0	5.38	dBm
Gp	26.78	26	24.62	dB
Icc	620	609	604	mA
Vcc	3.3	3.3	3.3	Vdc
PAE	48.7	49.6	50	%

As shown, the MAX2251 can be utilized in an AMPS environment with some very minor circuit design adjustments. With just the right amount of attention, it becomes a viable solution that saves PCB space, battery life, development time, and ultimately product cost.

MORE INFORMATION

MAX2251: QuickView -- Full (PDF) Data Sheet (208k) -- Free Sample