Keywords: DECT, power amplifier, PA,2.4GHz, 2400MHz, 2500MHz, DECT 1.9GHz

APPLICATION NOTE 6443

TUNING THE MAX2248 FOR 2.4GHZ APPLICATIONS

Abstract: The MAX2248 is a single-supply, low-voltage power amplifier (PA) that is specifically designed for applications in the 1.9GHz RF band. However, the MAX2248 can be tuned to 2.4GHz applications. This application note describes what changes are required to tune the MAX2248 evaluation kit to provide optimal gain and harmonic distortion in the 2.4GHz frequency band.

Introduction

The MAX2248 is a single-supply, low-voltage power amplifier (PA) IC with integrated digital power-control circuitry and logic-level shutdown. It is designed specifically for applications in the 1880MHz to 1930MHz frequency band. The PA provides a nominal +20dBm output power in the highest power mode.

With some modification of the input and output matching networks, the MAX2248 can be optimized for applications in the 2.4GHz to 2.5GHz frequency band. With the proper matching network, the PA can deliver +19dBm output power from a 3.2V supply, at the highest gain setting.

See **Table 1** for the performance of the PA over supply voltage and frequency variations. See **Table 2** for the performance of PA including output power, current consumption, and second-order harmonic distortion at different gain settings.

Tuning Methodology

The MAX2248 is a high-frequency power amplifier that requires a relatively small number of external components for matching. The components installed on the evaluation kit (EV kit) are guaranteed to give optimal performance over the 1.9GHz band, but these components can be tuned to get optimal performance over the 2.4GHz band. This section details how the tuning for 2.4GHz can be done on the MAX2248 EV kit (MAX2248EVKIT#).

Input Match

For the input side, a two-element LC match optimizes the input return loss for 2.4GHz. Remove the existing L and C on the EV kit and short the transmission line. Using a calibrated network analyzer, measure the input return loss (s11) over the 2.4GHz band and do port extension up to the pins of the IC. Doing so provides the de-embedded s-parameters, which can be imported into any tuning software to find the optimum L and C network values that minimize s11. In the software model, make sure to account for the transmission line segment from the pin of the IC to the inductor. The optimal L and C values obtained through simulation can be further fine-tuned experimentally to find the best values that give lowest input return loss.

See **Figure 1** for exact values of L2 and C100 that make up the input match for 2.4GHz band.

Output Match

The primary power-matching structure at the output is a lowpass network formed by the series transmission line section and the open-stub transmission line section. This transmission line network acts like a series inductance and shunt capacitance.

To minimize the second-order harmonic distortion, the length of the open-ended transmission line needs to be adjusted. Start by reducing the length of this open-ended transmission line until the desired harmonic distortion is achieved. There is a trade-off between getting better harmonic performance versus higher output power that needs to be determined. On the EV kit the optimum value of harmonic distortion and output power is achieved with the length of open stub (TL2) being 46 degrees at 2.4GHz.

To achieve better gain at 2.4GHz, the length of series transmission line can be reduced. On the EV kit this is achieved by cutting the longer transmission line and connecting to the shortest path (TL1) that is 46 degrees at 2.4GHz. The capacitor C14 is also removed from the output.

See **Figure 1** to see how the output match is achieved for 2.4GHz band on the MAX2248 EV kit.

2.4GHz Tuning Solution

The MAX2248 EV kit was tuned to operate optimally at 2.4GHz band. At the input matching network, L2 was changed to 5.1nH, C13 was removed, and a shunt cap C100 of 0.7pF was added after the inductor. The output stage match was achieved by using the shortest available series transmission line (TL1), which is 46 degrees at 2.4GHz and cutting the open-ended stub (TL2) so that its length is 46 degrees at 2.4GHz, as shown in the layout in **Figure 2**. **Figure 3** shows the EV kit tuned for 2.4GHz.

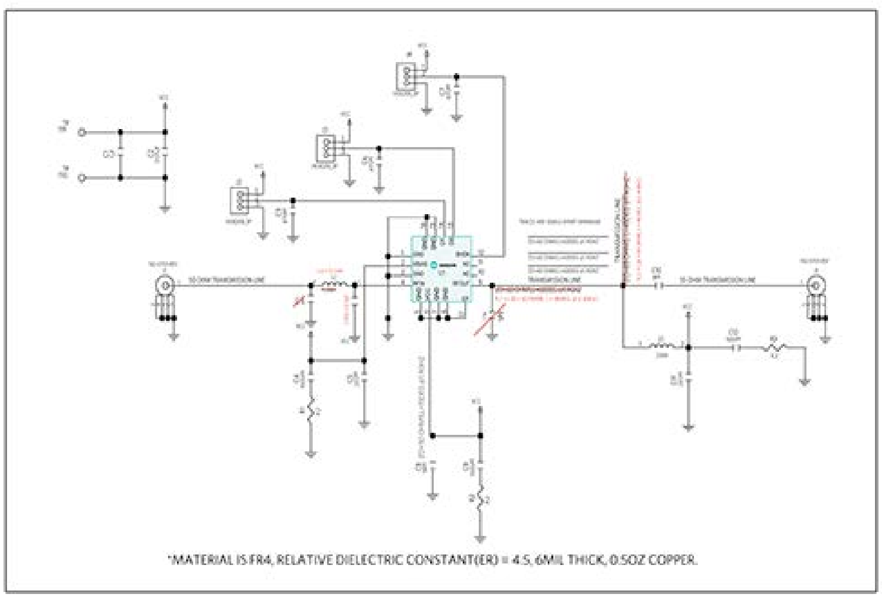

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Figure 1. MAX2248 EV kit schematic changes for 2.4GHz tuning.

PCB Layout Change

PCB Layout Change

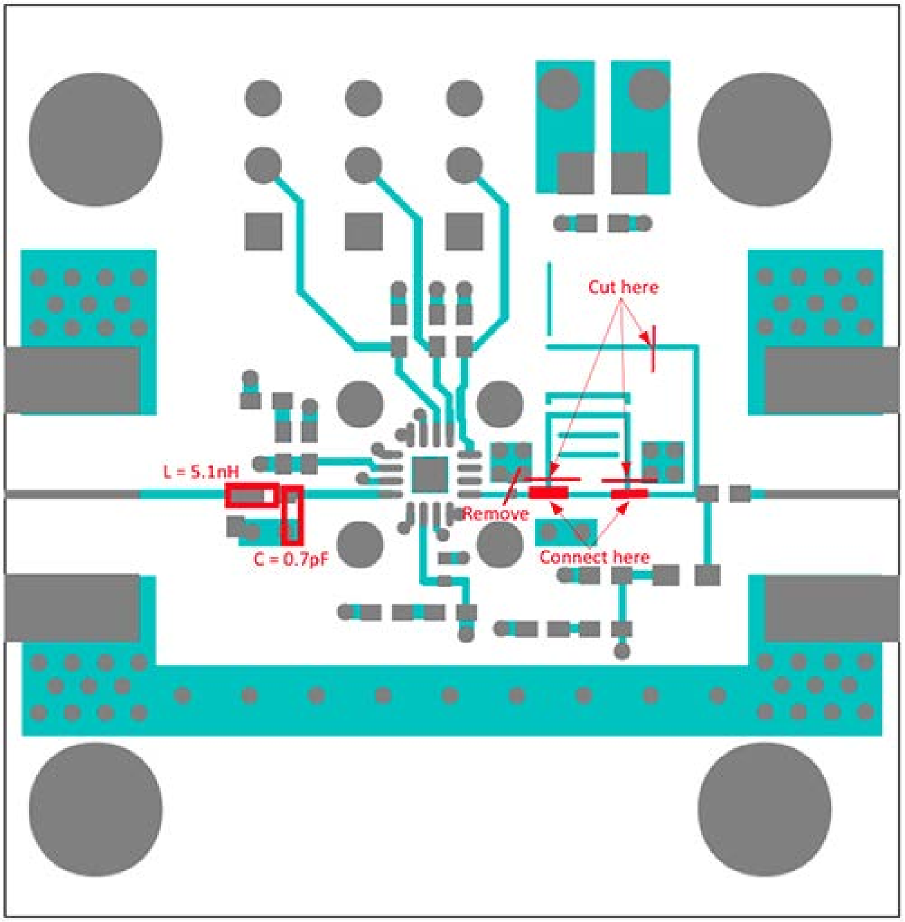

Figure 2. MAX2248 EV kit PCB changes for 2.4GHz tuning.

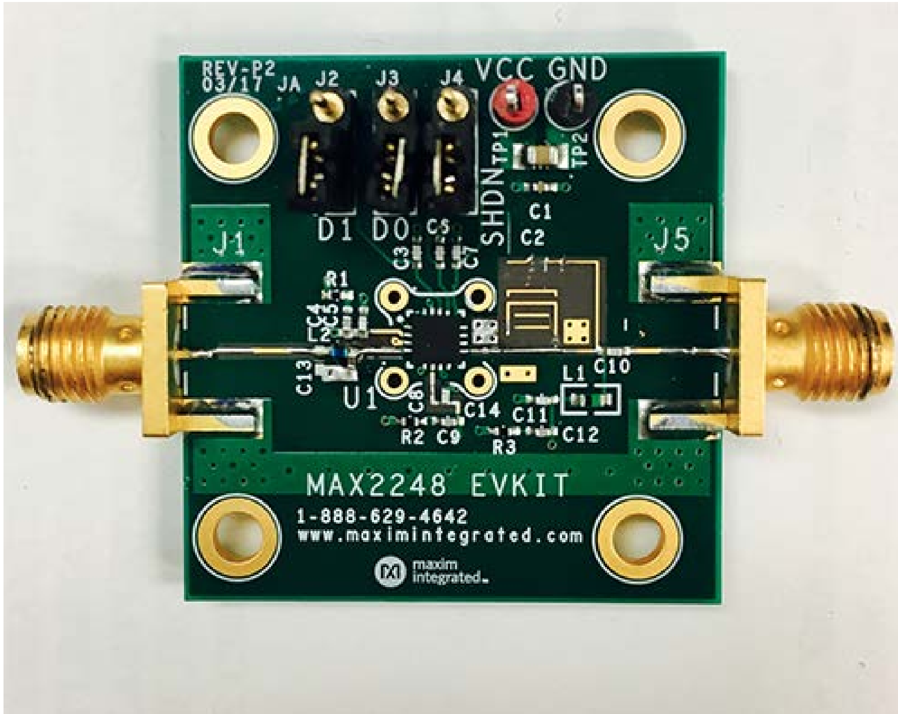

Figure 3. MAX2248 EV kit tuned for 2.4GHz.

2.4GHz Tuned EV Kit BOM (changes to the BOM are highlighted in red)

Reference	Qty	Value	Tolerance	Description	Part Number	Manufacturer
C1	1	1µF	±10%	0805 ceramic capacitor, SMT	GRM21BR71C105KA01	Murata
C2	1	0.01µF	±10%	0402 ceramic capacitor, SMT	C0402C103K3RAC; GRM155R71E103KA01D; C1005X7R1E103K	KEMET; Murata; TDK
C3, C6, C7	3	470pF	±5%	0402 ceramic capacitors, SMT	GCM1555C1H471JA16; GRM1555C1H471JA01	Murata
C4, C9, C12	3	1000pF	±5%	0402 ceramic capacitors, SMT	GRM1555C1H102JA01; C1005C0G1H102J050	Murata; TDK
C5, C11	2	220pF	±5%	0402 ceramic capacitors, SMT	GRM1555C1H221JA01	Murata
C8	1	18pF	±5%	0402 ceramic capacitors, SMT	C0402C180J5GAC; GRM1555C1H180JA01J; C1005C0G1H180J050	KEMET/Murata/TDK

C10	1	8pF	±0.25pF	0402 ceramic capacitor, SMT	GRM1555C1H8R0CZ01D	Murata
C13	DNI	1pF	±0.05pF	0402 ceramic capacitor, SMT	GJM1555C1H1R0WB01	Murata
C14	DNI	1pF	±0.05pF	0201 ceramic capacitor, SMT	GRM0334C1H1R0WA01	Murata
C1000	1	0.7pF	±0.1pF	0402 ceramic capacitor, SMT, 50V	GRM1555C1HR70BA01D	Murata
L1	1	22nH	±10%	0603 ceramic inductor, SMT	LQG18HN22NJ00	Murata
L2	1	5.1nH	±0.2nH	0402 Wirewound inductor, SMT	LQW15AN5N1C00	Murata
R1, R2, R3	3	8.2W	±5%	0402 thick film resistors	RMC1/16S-8R2J	Kamaya
J1, J5	2	142-0701-851		2-pin connector, end launch jack receptacle	142-0701-851	Johnson Components
J2, J3, J4	3	HEADER_3P		3-pin connector, male, through hole	800-10-003-10-001000	Mill-Max
SU2, SU3, SU4	3	STC02SYAN		2 (1 x 2) position shunt connector black	STC02SYAN	Sullins Connector Solutions
TP1	1	N/A		Test point, red	5000	Keystone
TP2	1	N/A		Test point, black	5001	Keystone
U1	1	MAX2248		MAX2248, 16 TQFN-EP; PACKAGE CODE T1633+5	MAX2248	Maxim
TL1	1	Zo = 60½, 46 degrees at		Series transmission		

		2.4GHz	line segment
TL2	1	Zo = 65½, 46 degrees at 2.4GHz	Open transmission line segment

Performance of Tuned MAX2248 at 2.4GHz

This section shows the performance achieved on a tuned MAX2248 EV kit in the 2400MHz to 2500MHz RF band. An output power of +19dBm can be achieved at the highest gain setting, with the typical 3.2V supply while consuming only 88mA of current. The harmonic distortion is also a decent -10.6dBm. The output power can be further increased to +22dBm with a 4.5V supply voltage.

Table 1. Output Power and Supply Current Over Different V_{CC} and Frequencies
(Conditions: Input Power = +3dBm, D0 = 1, D1 = 1, TA = +25°C.)

	f = 2400MHz		f = 2450MHz		f = 2500MHz	
V_{CC} (V)	P_{OUT} (dBm)	I_{CC} (mA)	P_{OUT} (dBm)	I_{CC} (mA)	P_{OUT} (dBm)	I_{CC} (mA)
3.2	19.0	88	18.6	86	18.2	84
3.6	20.2	96	19.8	93	19.3	90
4.5	22.2	110	21.4	103	20.5	90

Table 2. Supply Current, Output Power and Harmonic Distortion at Different Gain Settings
(Conditions: Input Power = +3dBm, Freq = 2.4GHz, V_{CC} = 3.2V, T_A = +25°C.)

Digital Control Inputs		Supply Current, Output Power and 2nd Harmonic Distortion		
D1	D0	I_{CC} (mA)	P_{OUT} at 2.4GHz (dBm)	2nd Harmonic Distortion at 4.8GHz (dBm)
0	0	69	-0.9	-29.5
0	1	71	7.5	-21.5
1	0	76	13.9	-17.5
1	1	88	19.0	-10.6

Conclusion

With some modifications to the input and output match networks, the MAX2248 EV kit can be tuned to give optimal performance in the 2.4GHz to 2.5GHz frequency band. It can deliver up to +19dBm of output power at the maximum gain setting while consuming only 88mA of supply current.

The MAX2248 EV kit (MAX2248EVKIT#) can be tuned following the guidelines provided in this application note. The de-embedded s11 s-parameter file for MAX2248 can also be downloaded from the MAX2248 QuickView webpage under Design Resources.

Related Parts		
MAX2248	1.9GHz Power Amplifier	Free Samples
MAX2248EVKIT	Evaluation Kit for the MAX2248	

More Information
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