DATA SHEET

SE2433T: 2.4 GHz Power Amplifier

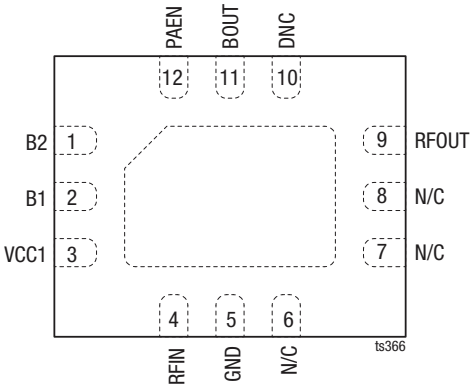
Applications

- ISM band applications
- Smart meters
- In-home appliances
- Smart thermostats
- Remote controls

Features

- Suitable for Zigbee®, Bluetooth® Low Energy, and Bluetooth 1.0
- High output power at +24 dBm
- Integrated interstage matching
- Integrated 50 Ω input matching
- Fast switch ON/OFF time <1 µs
- 2.0 V to 3.6 V supply operation
- Standby current <1 µA
- QFN package (12-pin, 2.5 x 2 x 0.55 mm, (MSL1, 260 °C per JEDEC J-STD-020)

Skyworks Green™ products are compliant with all applicable legislation and are halogen-free. For additional information, refer to *Skyworks Definition of Green™*, document number SQ04–0074.



N/C pins can be connected to ground, but the DNC pin should be left floating

Figure 2. SE2433T Pinout (Top View)

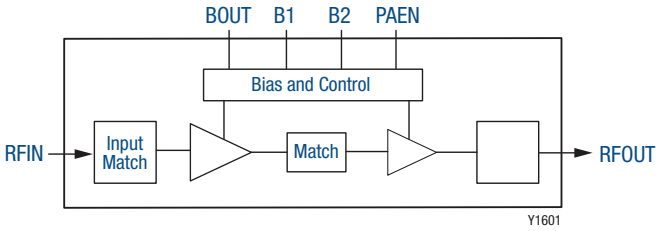


Figure 1. SE2433T Block Diagram

Description

The SE2433T is a high-performance power amplifier, suitable for Zigbee, Bluetooth Low Energy, and Bluetooth 1.0 applications.

The SE2433T is designed for ease of use and maximum flexibility, with an integrated input match and a digital enable control for Complementary Metal Oxide Semiconductor (CMOS) compatible device on/off control.

A functional block diagram of the SE2433T is provided in Figure 1. Figure 2 shows the pinout for the SE2433T. Table 1 lists the pin assignments and signal descriptions.

Table 1. SE2433T Signal Descriptions (Note 1)

Pin	Name	Description	Pin	Name	Description
1	B2	Connect through bias resistor to Pin 11, second stage bias.	7	N/C	Not connected.
2	B1	Connect through bias resistor to Pin 11, first stage bias.	8	N/C	Not connected.
3	VCC1	Power supply. Connect to positive supply.	9	RFOUT	RF output port.
4	RFIN	Input port, Connect to 50 Ω single-ended RF source, DC short to GND.	10	DNC	Do not connect.
5	GND	Ground. Connect to PCB ground.	11	BOUT	Bias supply, Connect to through bias resistors to pins 1 and 2.
6	N/C	Not connected.	12	PAEN	PA enable, Connect to GPIO signal to control power-up status (see Table 7) .
			Paddle	GND	Exposed die paddle; electrical and thermal ground; Connect to PCB ground.

Note 1: The N/C pins can be connected to ground, but the DNC pin should be left floating.

Electrical and Mechanical Specifications

Table 2 provides the absolute maximum ratings, and Table 3 shows the recommended operating conditions. Electrical characteristics are shown in Tables 4 and 5.

Logic characteristics and logic controls are provided in Tables 6 and 7, respectively.

Typical performance characteristics are shown in Figures 3 through 14.

Table 2. SE2433T Absolute Maximum Ratings (Note 1)

Parameter	Symbol	Minimum	Maximum	Units
Supply voltage	V_{CC}	–0.3	3.6	V
Control pin voltages		–0.3	3.6	V
Operating temperature	T_{OP}	–0.3	85	°C
Storage temperature	T_{STG}	–40	125	°C
TX input power	P_{IN_MAX}	–40	+6	dBm
Electrostatic discharge:	ESD			
Human Body Model (HBM), Class 1B			500	V

Note 1: Exposure to maximum rating conditions for extended periods may reduce device reliability. There is no damage to device with only one parameter set at the limit and all other parameters set at or below their nominal value. Exceeding any of the limits listed here may result in permanent damage to the device.

***CAUTION**: Although this device is designed to be as robust as possible, electrostatic discharge (ESD) can damage this device. This device must be protected at all times from ESD. Static charges may easily produce potentials of several kilovolts on the human body or equipment, which can discharge without detection. Industry-standard ESD precautions should be used at all times.*

Table 3. SE2433T Recommended Operating Conditions

Parameter	Symbol	Minimum	Typical	Maximum	Units
Ambient temperature	T_A	–40	+25	+85	°C
Supply voltage on VCC	V_{CC}	2.0	3.0	3.6	V

Table 4. SE2433T Electrical Specifications: DC Electrical Characteristics (VCC = 3.0 V, TA = +25 °C, as Measured on the Evaluation Board [De-Embedded to Device], All Unused Ports Terminated at 50 Ω, Unless Otherwise Noted)

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Total supply current	$I_{CC-Tx20}$ $I_{CC-Tx17}$ $I_{CC-Tx10}$	P_{OUT} = +20 dBm P_{OUT} = +18 dBm P_{OUT} = +12 dBm		100 80 50		mA mA mA
Quiescent current	I_{CQ}	No RF		25		mA
OFF supply current	I_{CC_OFF}	PAEN = 0 V, No RF			1	µA

Table 5. SE2433T Electrical Specifications: AC Electrical Characteristics (VCC = 3.0 V, PAEN = 3.0 V, TA = 25 °C, as Measured on the Evaluation Board [De-Embedded to Device], All Unused Ports Terminated with 50 Ω, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Frequency	f		2400		2483	MHz
Output power (Notes 1 and 5)	P_{OUT}	V_{CC} = 3.6 V, P_{IN} = +5.5 dBm V_{CC} = 3.3 V, P_{IN} = +5.5 dBm V_{CC} = 3.0 V, P_{IN} = +2 dBm V_{CC} = 2.7 V, P_{IN} = 0 dBm V_{CC} = 2.0 V, P_{IN} = 0 dBm V_{CC} = 3.0 V, P_{IN} = –11 dBm		+24.5 +23.0 +20.0 +19.0 +17.0 +10		dBm dBm dBm dBm dBm dBm
Small signal gain high-power mode	S21	2400 to 2483 MHz	19.5	22	24	dB
Small signal gain variation (Note 1)	ΔS21	Gain variation across channels, 2400 to 2483 MHz			1	dB_{P-P}
Harmonics (Notes 1, 2, and 6)	HD2, HD3	P_{OUT} = +20 dBm			–42	dBm/MHz
Turn-on time (Note 3)	t_R				800	ns
Turn-off time (Note 4)	t_F				800	ns
Stability	STAB	CW, P_{IN} = 0 dBm, 0.1 GHz to 20 GHz, load VSWR = 6:1	All non-harmonically related outputs less than –42 dBm/MHz			
Ruggedness	RU	CW, P_{IN} = +6 dBm, load VSWR = 10:1	No permanent damage			

Note 1: 2400 to 2483 MHz.

Note 2: IEEE 802.15.4 source.

Note 3: From 50% of PAEN edge to 90% of final RF output power.

Note 4: From 50% of PAEN edge to 10% of final RF output power.

Note 5: OEVM = 1% max.

Note 6: Using recommended output matching network.

Table 6. SE2433T Logic Characteristics
(V_{CC} = 3.0 V, T_A = +25 °C, as Measured on the Evaluation Board [De-Embedded to Device], All Unused Ports Terminated with 50 Ω, Unless Otherwise Noted)

Parameter	Symbol	Min	Typ	Max	Unit
Logic input high	V_{IH}	1.6		3.6	V
Logic input low	V_{IL}	0		0.3	V
Logic input high	I_{IH}			1	µA
Logic input low	I_{IL}			1	µA

Table 7. SE2433T Logic Controls
(V_{CC} = 3.0 V, T_A = +25 °C)

Mode	Mode Description	PAEN
0	PA disabled	0
1	PA enabled	1

Note 1: Logic '0' level compliant to V_{IL} as specified in Table 6.

Note 2: Logic '1' level compliant to V_{IH} as specified in Table 6.

Typical Performance Characteristics

(VCC = VDD = 3 V, TA = +25 °C, f = 2.44 GHz, ZigBee Signal with Symbol Rate = 1 Msps, Unless Otherwise Noted)

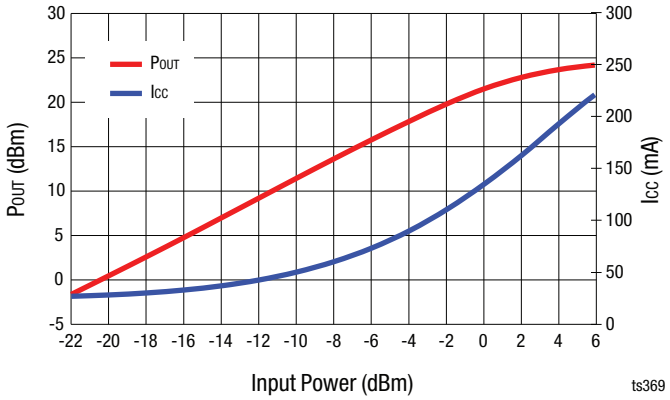


Figure 3. POUT and ICC vs PIN, CW

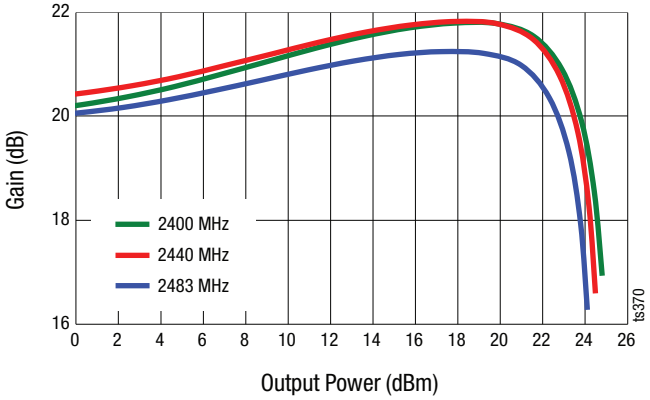


Figure 4. Gain vs POUT, CW

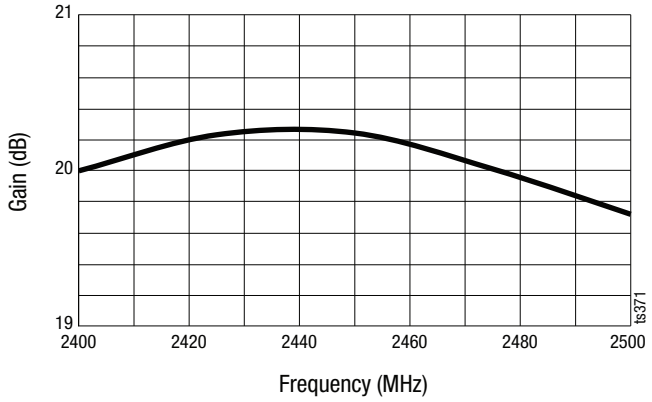


Figure 5. Small Signal Gain vs Frequency, CW

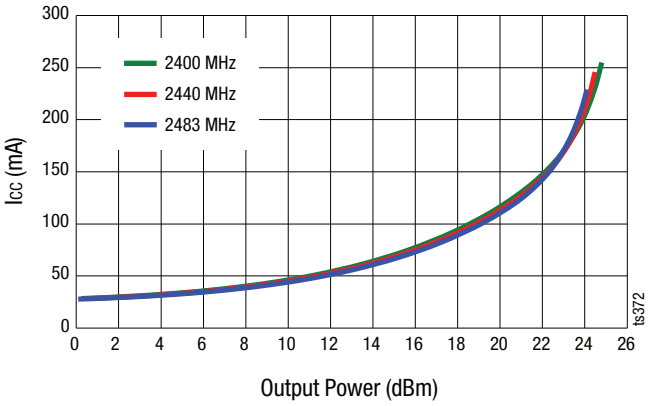


Figure 6. ICC vs POUT, CW

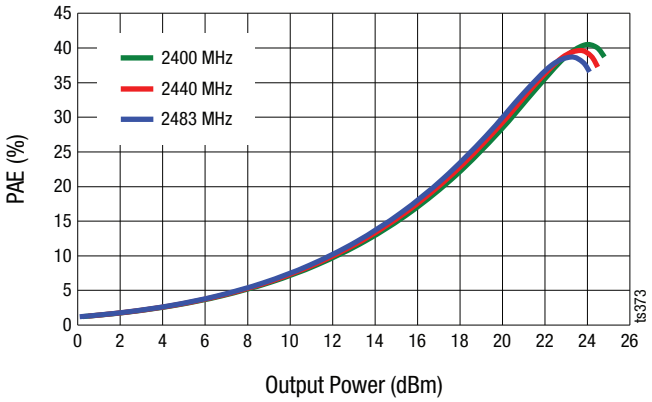


Figure 7. PAE vs POUT, CW

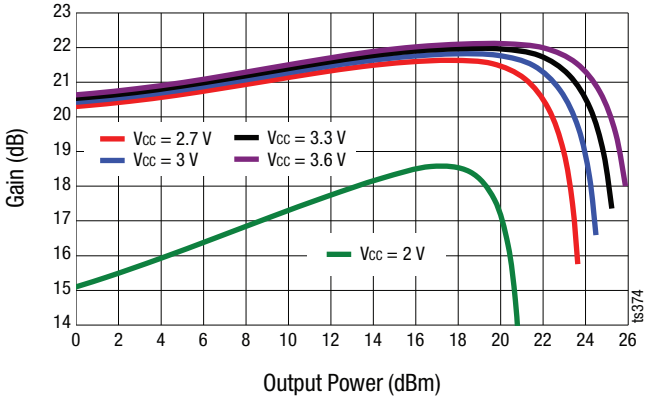


Figure 8. Gain vs POUT and VCC, CW

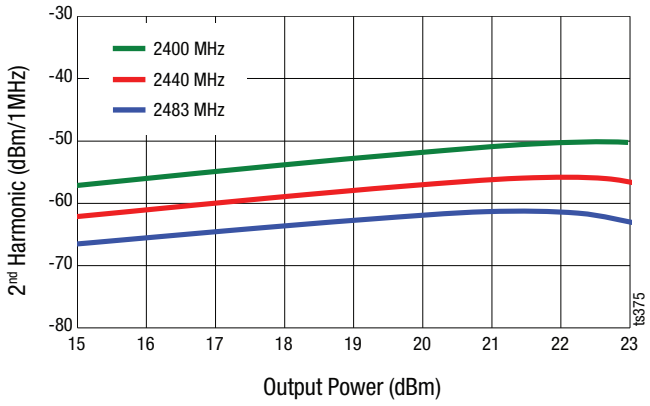


Figure 9. 2nd Harmonic vs POUT, Zigbee

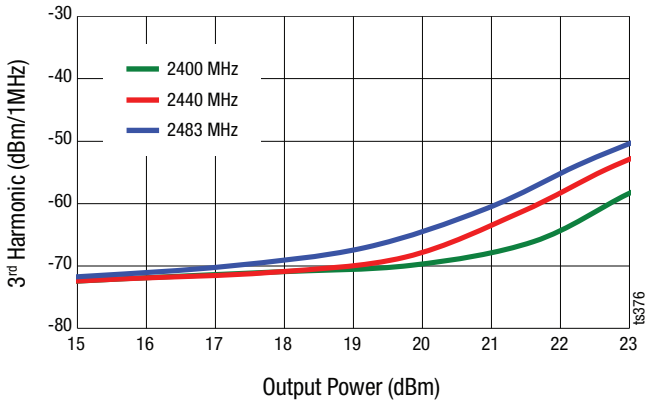


Figure 10. 3rd Harmonic vs POUT, Zigbee

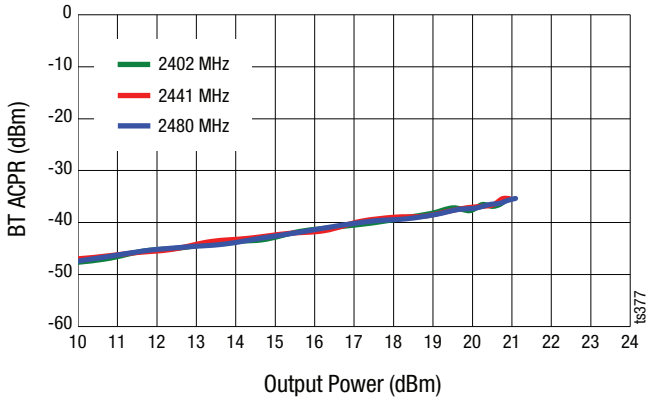


Figure 11. BT ACPR CH–2 vs POUT, BT-BDR-DH1

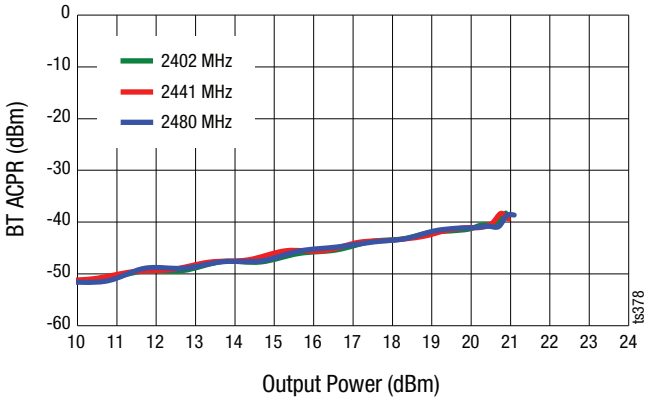


Figure 12. BT ACPR CH–3 vs POUT, BT-BDR-DH1

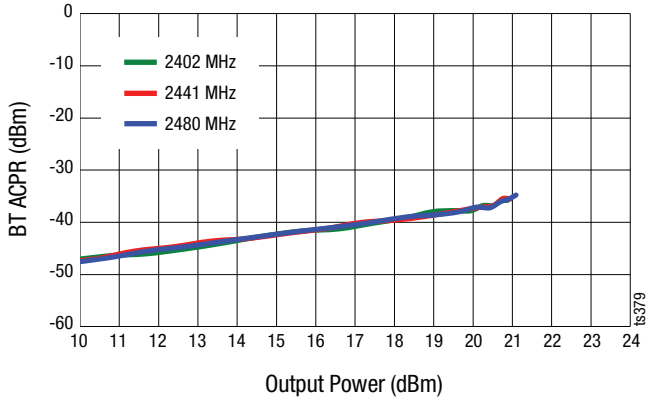


Figure 13. BT ACPR CH+2 vs POUT, BT-BDR-DH1

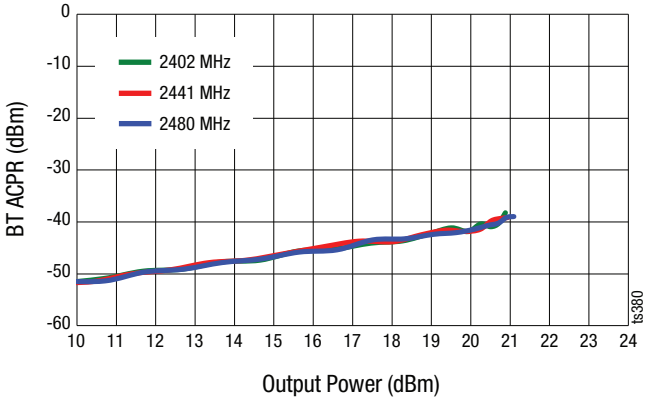


Figure 14. BT ACPR CH+3 vs POUT, BT-BDR-DH1

Evaluation Board Description

The SE2433T Evaluation Board is used to test the performance of the SE2433T FEM. The Evaluation Board schematic diagram is shown in Figure 15. A reference design schematic is shown in Figure 16. A photograph of the Evaluation Board is shown in Figure 17. Component values for the SE2433T Evaluation Board are listed in the Bill of Materials (BOM) in Table 8.

Circuit Design Considerations

The following design considerations are general in nature and must be followed regardless of final use or configuration:

- Paths to ground should be made as short as possible.
- The ground pad of the SE2433T has special electrical and thermal grounding requirements. This pad is the main thermal conduit for heat dissipation. Since the circuit board acts as the heat sink, it must shunt as much heat as possible from the device.

  Therefore, design the connection to the ground pad to dissipate the maximum wattage produced by the circuit board. Multiple vias to the grounding layer are required.

NOTE: *A poor connection between the ground pad and ground increases junction temperature (T_J), which reduces the life of the device.*

Evaluation Board Setup Procedure

1. Connect (J1 and J2) to 50 Ω instruments. Terminate all unused ports (if applicable) with 50 Ω.
2. Connect the supply ground to Pin 7.
3. Connect 3.0 V to Pins 1, 3, and 6 of J3.
4. Apply an RF signal to connector J1 (RF_IN) to monitor the 2.4 GHz amplifier performance. Monitor the output power on connector J2 (RF_OUT).

CAUTION: *Care should be taken not to overdrive the amplifier by applying too much RF on the input. A suitable starting input power for the device is –20 dBm.*

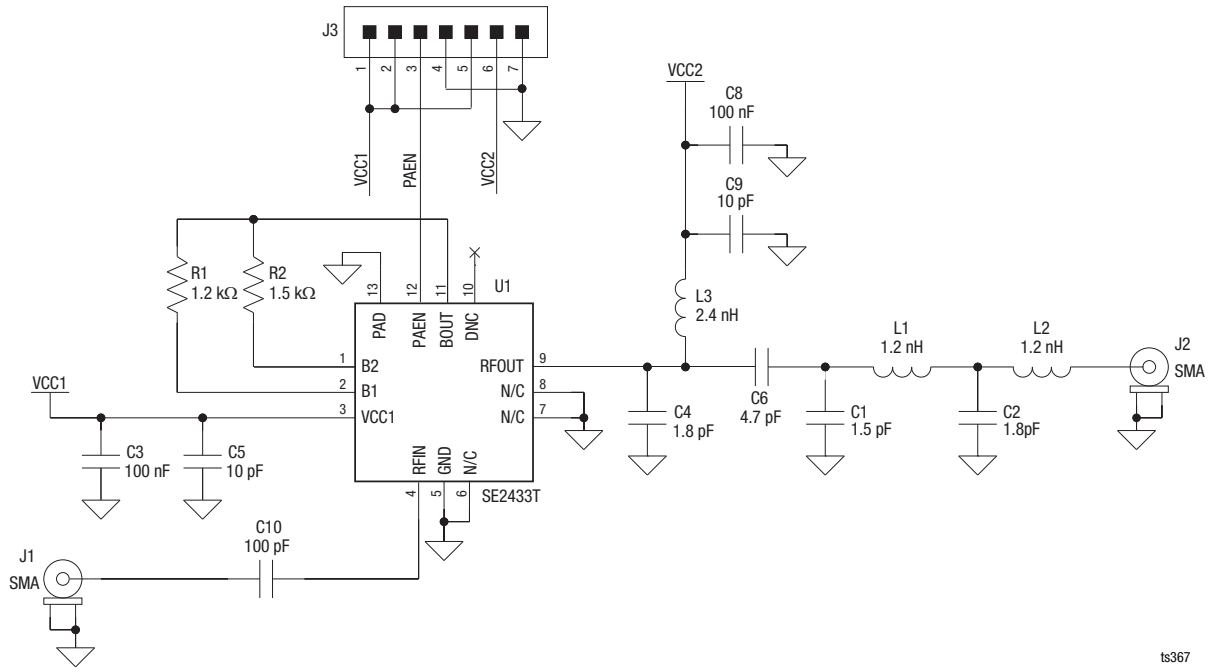


Figure 15. SE2433T Evaluation Board Schematic

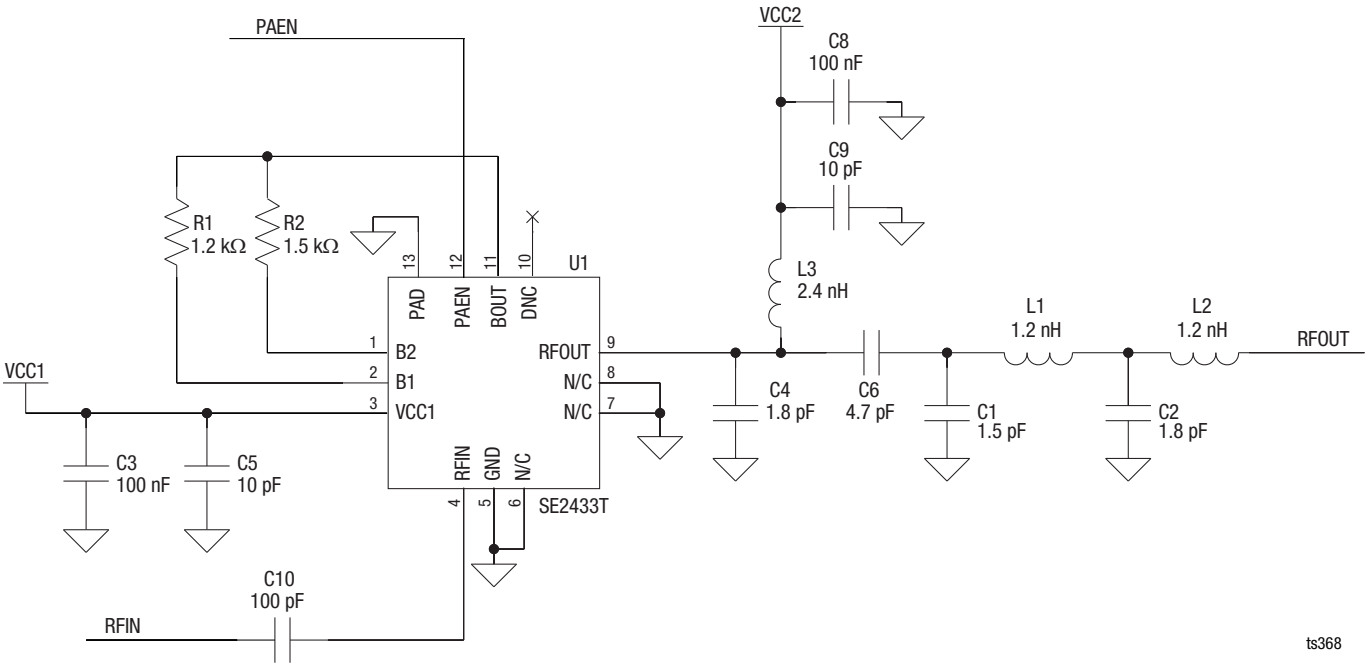


Figure 16. SE2433T Reference Design Schematic

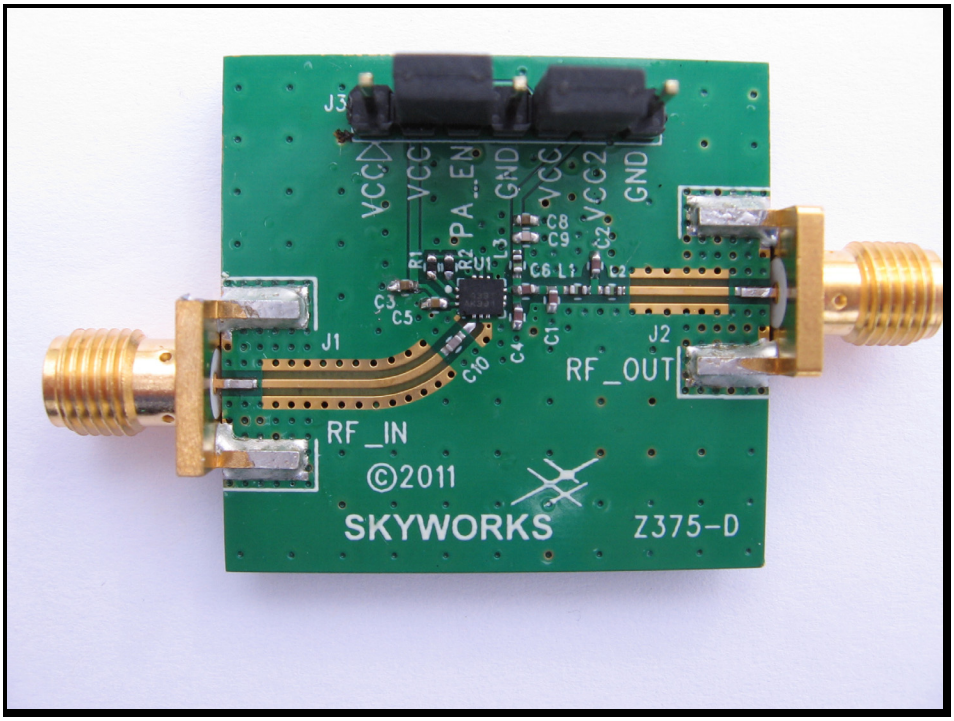


Figure 17. SE2433T Evaluation Board

Table 8. SE2433T Evaluation Board Bill of Materials

Component	Value	Manufacturer	Mfr Part Number	Package	Description
C1	1.5 pF	Murata	GRM1555C1H1R5CZ01	0402	Multilayer ceramic
C2, C8	100 nF	Murata	GRM1555R71C104KA88D	0402	Multilayer ceramic
C4, C2	1.8 pF	Murata	GRM1555C1H1R8CZ01	0402	Multilayer ceramic
C5, C9	10 pF	Murata	GRM1555C1H100JZ01	0402	Multilayer ceramic
C6	4.7 pF	Murata	GRM1555C1H4R7CZ01	0402	Multilayer ceramic
C10	100 pF	Murata	GRM1555C1H101JZ01	0402	Multilayer ceramic
J1, J2	SMA	Johnson Components	142-0701-851	End launch	SMA end launch straight jack receptacle – tab contact
J3	7X1	Samtec	TSW-107-07-G-S	100 mil	
L1, L2	1.2 nH	Murata	LQG15HN1N2S02D	0402	High-frequency multilayer
L3	2.4 nH	Murata	LQG15HN2N4S02D	0402	High-frequency multilayer
R1	1.2 kΩ	Panasonic	ERJ2GEJ122	0402	Thick film chip resistor
R2	1.5 kΩ	Panasonic	ERJ2GEJ152	0402	Thick film chip resistor
U1	SE2433T	Skyworks	SE2433T	QFN 2X2.5–12	802.15.4 PA

Package Dimensions

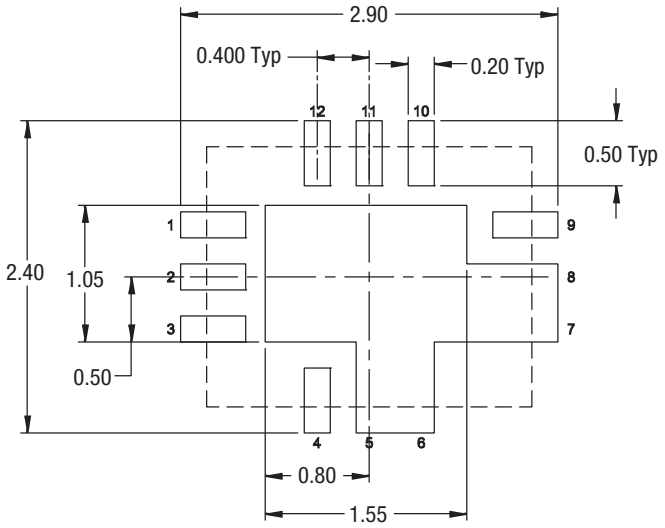
The recommended land and solder patterns for the SE2433T are provided in Figure 18. Typical part markings are shown in Figure 19. Package dimensions for the are shown in Figure 20, and tape and reel dimensions are provided in Figure 21.

Package and Handling Information

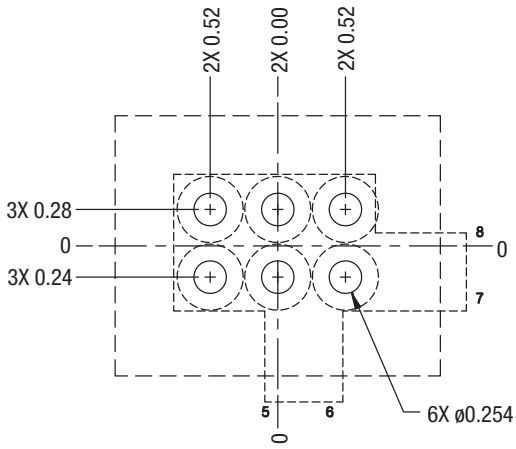
Instructions on the shipping container label regarding exposure to moisture after the container seal is broken must be followed. Otherwise, problems related to moisture absorption may occur when the part is subjected to high temperature during solder assembly.

The SE2433T is rated to Moisture Sensitivity Level 1 (MSL1) at 260 °C. It can be used for lead or lead-free soldering. For additional information, refer to the Skyworks Application Note, *Solder Reflow Information*, document number 200164.

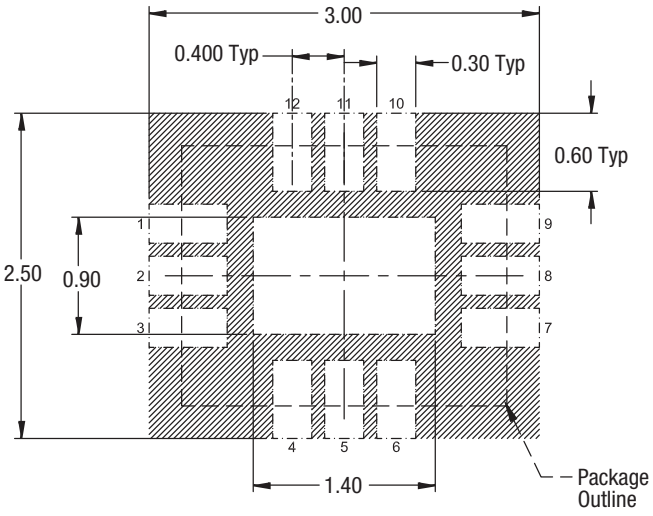
Care must be taken when attaching this product, whether it is done manually or in a production solder reflow environment. Production quantities of this product are shipped in a standard tape and reel format.



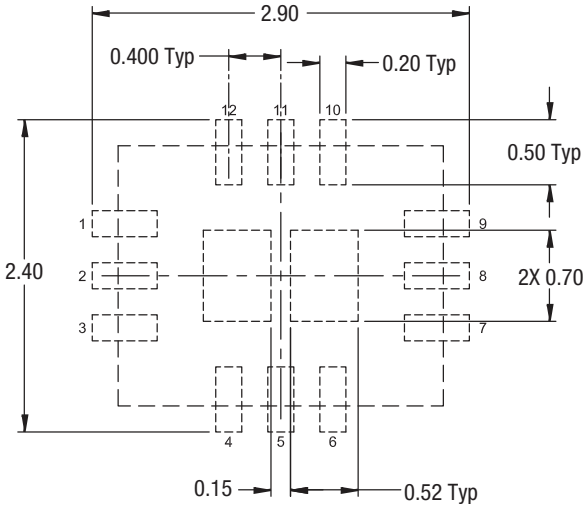
Board Metal



Via Pattern
(Note 4)



Solder Mask Pattern
(Note 6)



Stencil Pattern
(Note 5)

58% Solder Coverage
on Center Pad

Notes:

1. All dimensions are in millimeters.
2. Dimensions and tolerances per ASME 14.5M–1994.
3. Unless specified, dimensions are symmetrical about center lines.
4. Via hole recommendations:
0.025 mm Cu via wall plating (minimum), via holes to be filled with conductive paste and plated over.
5. Stencil recommendations:
0.10 mm stencil thickness, laser cut apertures, trapezoidal walls and rounded corners offer better paste release.
6. Solder mask recommendations:
Contact board fabricator for recommended solder mask offset and tolerance.

Y2440

Figure 18. SE2433T Recommended Land and Solder Patterns (Top View)

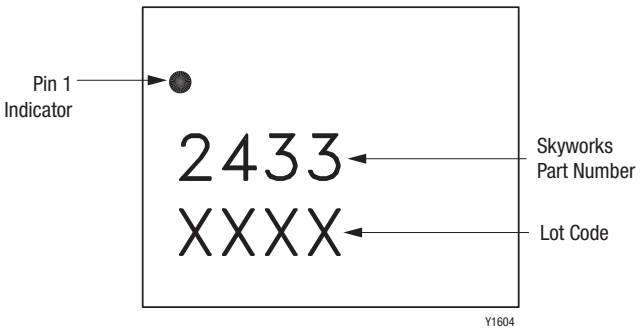
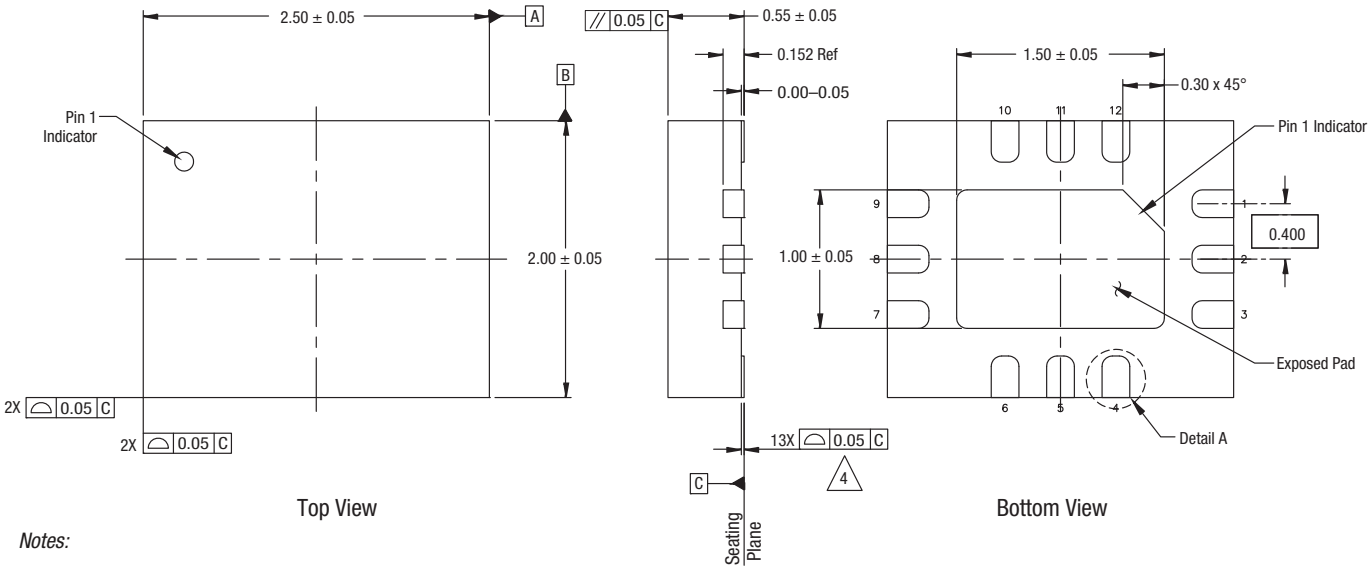


Figure 19. Typical Part Markings (Top View)



Notes:

1. *All measurements are in millimeters.*
2. *Dimensions and tolerances according to ASME Y14.5M-2009.*
3. *Unless otherwise specified, the following values apply:*

Decimal Tolerance:	*Angular Tolerance:*
X.X (1 place) ± 0.1 mm	*±1/2°*
X.XX (2 places) ± 0.05 mm	
X.XXX (3 places) ± 0.025 mm	

4. *Coplanarity applies to the terminals as well as all other bottom surface metallization.*
5. *Dimension applies to metallized terminal. If terminal tip has a radius, dimension should not be measured in that radius area.*
6. *Unless specified, dimensions are symmetrical about center lines.*

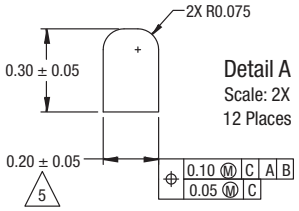
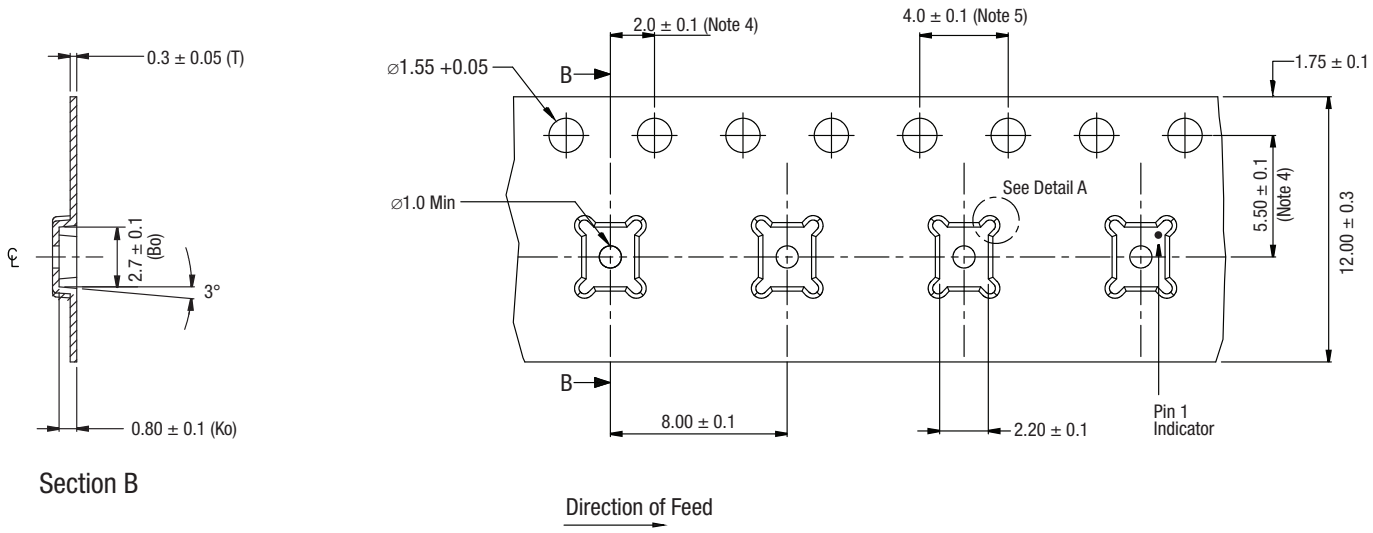


Figure 20. SE2433T Package Dimensions



Notes:

1. *Carrier tape must meet all requirements of Skyworks GP01-D233 procurement spec for tape and reel shipping.*
2. *Carrier tape: black conductive polystyrene.*
3. *Cover tape: transparent conductive material.*
4. *Measured from center line of sprocket hole to center line of pocket.*
5. *Ten-sprocket hole pitch cumulative tolerance: ±0.20 mm.*
6. *All measurements are in millimeters.*

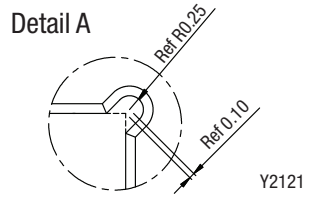


Figure 21. SE2433T Tape and Reel Dimensions

Ordering Information

Model Name	Manufacturing Part Number	Evaluation Board Part Number
SE2433T: 2.4 GHz Power Amplifier	SE2433T-R	SE2433T-EK1

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