SE2435L: 860 to 930 MHz High-Power RF Front-End Module

Applications

- Smart meters
- In-home appliances
- Smart thermostats

Features

- Integrated PA with 30 dBm output power
- Integrated LNA with programmable bypass
- Integrated antenna switching with transmit/receive diversity function
- Low FEM noise figure of 2 dB, typical
- Single-ended 50 Ω transmit/receive RF interface
- Fast turn-on/turn-off time: < 1 µsec
- Supply voltage: 2.0 to 4.8 V
- Sleep mode current: < 1 µA
- QFN (24-pin, 4 x 4 x 0.9 mm) NiPdAu plated package (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.
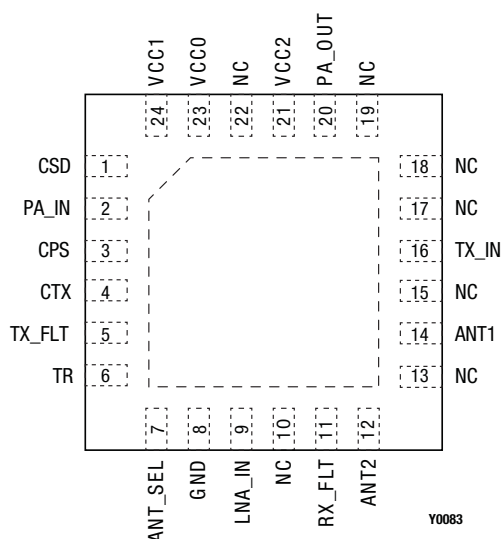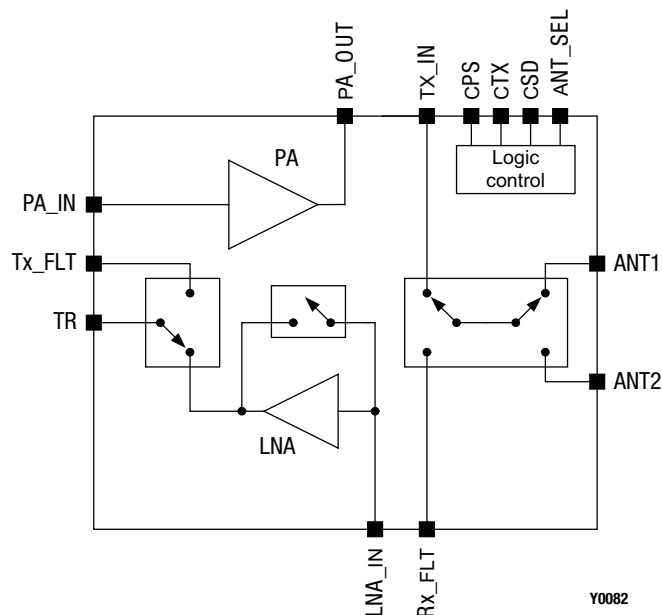

Figure 1. SE2435L Block Diagram

Description

The SE2435L is a high performance, highly integrated RF Front End Module designed for high-power Industrial, Scientific, Medical (ISM) band applications operating in the 860 to 930 MHz frequency range.

The SE2435L is designed for ease of use and maximum flexibility with fully matched 50 Ω input and output, and digital controls compatible with 1.6 to 3.6 V CMOS levels.

The RF blocks operate over a wide supply voltage range from 2.0 to 4.8 V allowing the SE2435L to be used in battery powered applications over a wide spectrum of the battery discharge curve.

The SE2435L is packaged in a 24-pin, 4 x 4 mm Quad Flat No-Lead (QFN) package.

A functional block diagram of the SE2435L is provided in Figure 1. Figure 2 shows the pinout for the SE2435L. Table 1 lists the pin assignments. Table 2 provides the absolute maximum ratings, and Table 3 shows the recommended operating conditions.

Figure 2. SE2435L Pinout – 24-Pin QFN (Top View)

Table 1. SE2435L Signal Descriptions

Pin #	Name	Description	Pin #	Name	Description
1	CSD	Shutdown control input	14	ANT1	Antenna port 1
2	PA_IN	PA input (from Tx filter)	15	NC	Not connected internally to the device
3	CPS	Rx path select control input	16	TX_IN	Tx signal to antennas (from OMN)
4	CTX	Transmit enable control input	17	NC	Not connected internally to the device
5	TX_FLT	Transmit signal (to Tx filter)	18	NC	Not connected internally to the device
6	TR	Bi-directional RF signal to/from transceiver	19	DNC	Do not connect
7	ANT_SEL	Antenna select control input	20	PA_OUT	PA output (to OMN)
8	GND	Ground	21	VCC2	Positive power supply
9	LNA_IN	LNA input (from Rx filter)	22	NC	Not connected internally to the device
10	NC	Not connected internally to the device	23	VCC0	Positive power supply
11	RX_FLT	Rx signal from antennas (to Rx filter)	24	VCC1	Positive power supply
12	ANT2	Antenna port 2	Paddle	GND	Exposed die paddle; electrical and thermal ground. Connect to PCB ground
13	NC	Not connected internally to the device			

Table 2. SE2435L Absolute Maximum Ratings

Parameter	Symbol	Minimum	Maximum	Units
Supply voltage (no RF)	V_{CC}	−0.3	5.5	V
Operating temperature	T_A	−40	85	°C
Storage temperature	T_{STG}	−40	125	°C
Tx input power at TR port	$P_{IN\_TX\_MAX}$		+10	dBm
Rx input power at ANT1 or ANT2 ports	$P_{IN\_RX\_MAX}$		+10	dBm
Electrostatic Discharge: Human Body Model (HBM), Class 1C	ESD		1000	V

Notes: 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. SE2435L Recommended Operating Conditions

Parameter	Symbol	Minimum	Typical	Maximum	Units
Supply voltage on VCC	V_{CC}	2.0	4.0	4.8	V
Ambient temperature	T_A	−40	+25	+85	°C

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Electrical and Mechanical Specifications

Electrical specifications are provided in Tables 4 through 8.
Typical performance characteristics are illustrated in Figures 3
through 21.

Table 4. SE2435L DC Electrical Specifications: (Note 1)
(VCC = 4.0 V, TA = +25 °C, as Measured on the SE2435L-EK1 Evaluation Board [De-Embedded to Device], Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Total supply current, transmit mode	ICC_TX30	CPS = CSD = CTX = high: POUT = +30 dBm		550		mA
	ICC_TX27	POUT = +27 dBm		380		mA
	ICC_TX24	POUT = +24 dBm		275		mA
Total supply current, receive mode	ICC_RX	CPS = CSD = high, CTX = 0 V		6		mA
Total supply current, receive bypass mode	ICC_RXB	CSD = high, CPS = CTX = 0 V			280	μA
Quiescent current	ICQ_TX	No RF, CPS = CSD = CTX = high		50		mA
Sleep supply current	ICC_OFF	No RF, CSD = CTX = CPS = 0 V		0.05	1.00	μA

Note 1: Performance is guaranteed only under the conditions listed in this Table.

Table 5. SE2435L Electrical Specifications: Control Logic Characteristics (Note 1)
(TA = +25 °C, as Measured on the SE2435L-EK1 Evaluation Board [De-Embedded to Device], Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Control voltage: High	VIH		1.6		Vcc (Note 2)	V
Low	VIL		0		0.3	V
Input current: High	IIH				1	μA
Low	IIL				1	μA

Note 1: Performance is guaranteed only under the conditions listed in this Table.

Note 2: For Pin 7, ANT_SEL, the maximum is 3.6 V.

Table 6. SE2435L Electrical Specifications: Mode Control Logic (TA = +25)

Mode	CPS	CSD	CTX	ANT_SEL
Sleep (all off)	0	0	0	X
Receive bypass	0	1	0	X
Receive LNA mode	1	1	0	X
Transmit	X	1	1	X
ANT1 port enabled	X	X	X	0
ANT2 port enabled	X	X	X	1

Note 1: "1" = 1.6 to Vcc, "0" = 0 to 0.3 V, "X" = don't care..

Table 7. SE2435L Electrical Specifications: AC Transmit Mode
(Vcc = 4 V, TA = +25 °C, as Measured on the SE2435L-EK1 Evaluation Board [De-Embedded to Device], All Unused Ports Terminated at 50 Ω, Unless Otherwise Noted. Input Port TR, Output Ports ANT1 and ANT2. Lumped Elements Filter Connected between the Tx_FLT and PA_IN Pins)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Frequency range	f		860	-	930	MHz
Output power at ANT1 or ANT2 ports in the 900 to 930 MHz frequency range (Notes 1 and 5)	P_{OUT_900}	Vcc = 4.8 V Vcc = 4.0 V Vcc = 3.6 V Vcc = 3.0 V		31.5 30.5 29.5 28.0		dBm
Output power at ANT1 or ANT2 ports in the 860 to 870 MHz frequency range (Notes 2 and 5)	P_{OUT_860}	Vcc = 4.0 V Vcc = 3.6 V Vcc = 3.0 V Vcc = 2.0 V		27 24 21 18		dBm
PA power added efficiency	PAE_{PA}	Pout = 28 dBm at PA_OUT port, 915 MHz		64		%
Small signal gain (Note 1)	S_{21_900}	900 to 930 MHz	26			dB
Small signal gain (Note 2)	S_{21_860}	860 to 870 MHz	26			dB
Small signal gain variation (Notes 1 and 2)	ΔS_{21}	Gain variation across frequency range			2	dBp-p
Output return loss (Notes 1 and 2)	$S22_{ANT1,2}$	Into 50 Ω, ANT1 and ANT2 ports		−10	−6	dB
2nd harmonic (Notes 1 and 3)	2fo	P_{OUT} = 30 dBm			−22	dBc
3rd to 10th harmonic (Notes 1 and 3)	3fo to 10fo	P_{OUT} = 30 dBm			−72	dBc
Turn on time (Note 4)	T_{ON}				1	µs
Turn off time (Note 5)	T_{OFF}				1	µs
Stability	STAB	CW, P_{IN} = 0 dBm 0.1 GHz to 20 GHz load VSWR = 6:1	All non-harmonically related outputs less than −43 dBm			
Ruggedness	RU	CW, P_{OUT} = 30 dBm into 50 Ω, load VSWR = 10:1	No permanent damage			

Note 1: 900 to 930 MHz with specified matching network on the SE2435L-EK1 evaluation board.

Note 2: 860 to 870 MHz with specified matching network on the SE2435L-EK1 evaluation board.

Note 3: Measured with continuous wave signal.

Note 4: From 50% of CTX edge to 90% of final RF output power.

Note 5: From 50% of CTX edge to 10% of final RF output power.

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Table 8. SE2435L Electrical Specifications: AC Receive Mode
(V$_{CC}$ = 4 V, T$_A$ = +25 °C, f = 900 to 930 MHz and 860 to 870 MHz, as Measured on the SE2435L-EK1 Evaluation Board [De-Embedded to Device], All Unused Ports Terminated at 50 Ω, Unless Otherwise Noted. Input Port ANT1 or ANT2, Output Port TR. 0 Ω Connected between the Rx_FLT and LNA_IN Pins in lieu of External Filters)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Frequency range	F$_{IN}$		860	-	930	MHz
Receive gain	Rx_gain		14	16	18	dB
Receive noise figure	NF			2	2.5	dB
Input 3rd order intercept	IIP3		−5	−2	-	dBm
Input 1-dB compression point	IP1dB		−15	−12		dBm
Antenna port return loss	S11$_{ANT1,2}$	Into 50 Ω, ANT1 and ANT2 ports		−12	−8	dB
Turn on time (Note 1)	T$_{ON}$				1	us
Turn off time (Note 2)	T$_{OFF}$		-		1	us
Gain in bypass mode	G_bp		−3	−2	-	dB
Input 1-dB compression point in bypass mode	IP1dB		+10			dBm

Note 1: From 50% of CTX edge to 90% of final RF output power.

Note 2: From 50% of CTX edge to 10% of final RF output power.

Table 9. SE2435L DC Electrical Specifications: Diversity Antenna Function
(V$_{CC}$ = 4 V, T$_A$ = +25 °C, f = 900 to 930 MHz and 860 to 870 MHz, as Measured on the SE2435L-EK1 Evaluation Board [De-Embedded to Device], All Unused Ports Terminated at 50 Ω, Unless Otherwise Noted)

Parameter	Symbol	Min	Typical	Max	Units
Isolation between ANT1 and ANT2 ports	ISOL$_{ANTSW}$		−20	-	dB
Insertion loss from TX_IN to ANT1	Tx_ANT1		0.8	-	dB
Insertion loss from TX_IN to ANT2	Tx_ANT2		0.8	-	dB
Insertion loss from ANT1 to RX_FLT	Rx_ANT1		0.6	-	dB
Insertion loss from ANT2 to RX_FLT	Rx_ANT2		0.6	-	dB
Insertion loss from TR to TX_FLT	TxRx_Tx		0.5	-	dB
ANT1 to ANT2 switching time transmit mode	T$_{ANT1-ANT2\_Tx}$		800	-	ns
ANT1 to ANT2 switching time receive mode	T$_{ANT1-ANT2\_Rx}$		400	-	ns

Package Dimensions

The layout footprint for the SE2435L is provided in Figure 3. Typical case markings are shown in Figure 4. Package dimensions for the are shown in Figure 5, and tape and reel dimensions are provided in Figure 6.

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 SE2435L 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.

Notes:

1. *All dimensions are in millimeters.*
2. *Interpret dimensions and tolerances per ASME Y14.5M-1994.*
3. *Unless specified, dimensions are symmetrical about center lines.*
4. *Via hole recommendations:*
   0.025 mm Cu via wall plating (minimum),
   solder mask on the far side should tent or plug via holes.
5. *Stencil recommendations: 0.125 mm stencil thickness, laser cut apertures, trapedodial walls and rounded corners offer the best paste release.*
6. *Solder mask recommendations: Contact board fabricator for recommended solder mask offset and tolerance.*

Figure 3. SE2435L Recommended Footprint (Top View)

Pin 1 Designator

e4

SiGe
2435L
XXXX

Part Number

Lot Code
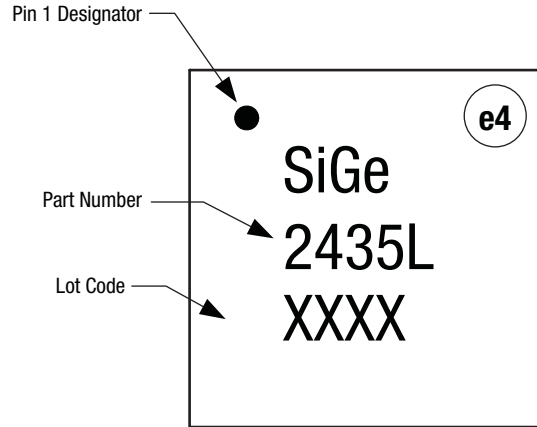
Figure 4. Typical Case Markings
(Top View)

Top View

Side View

Bottom View
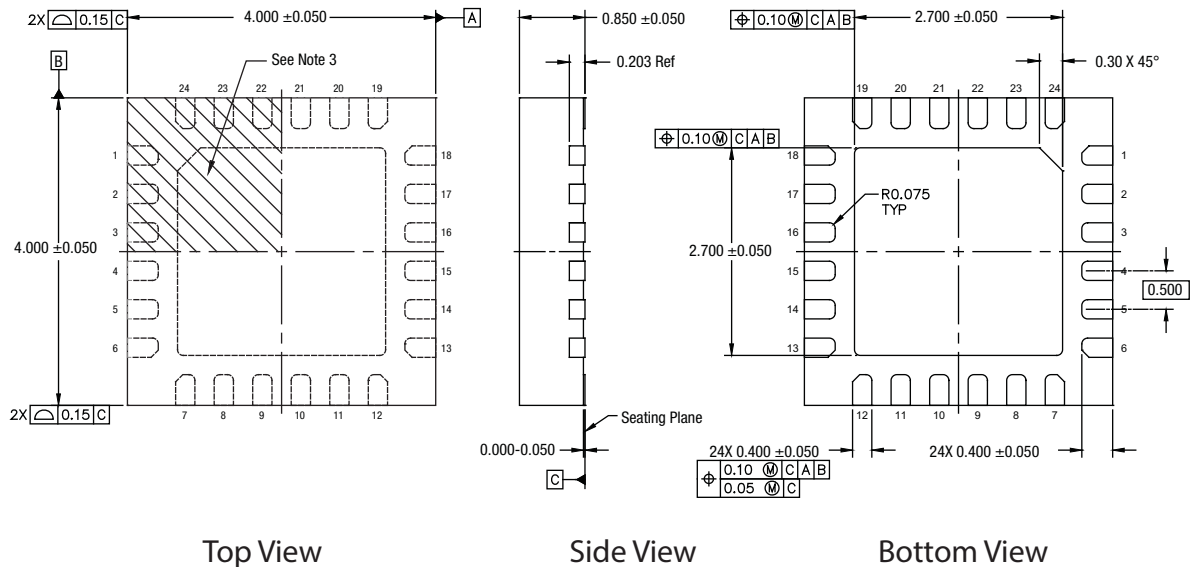
Notes:

1. *Dimensions are in millimeters.*
2. *Interpret dimensions and tolerances per ASME Y14.5M-1994.*
   Unless otherwise specified, the following values apply:
   Decimal tolerance: *Angular tolerance:*
   X.X (1 place) ± 0.1 mm   *± 1°*
   X.XX (2 places) ± 0.05 mm
   X.XXX (3 places) ± 0.025 mm
3. *Terminal #1 identification mark located within marked area.*
4. *Unless specified, dimensions are symmetrical about center lines.*

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Figure 5. SE2435L Package Dimensions
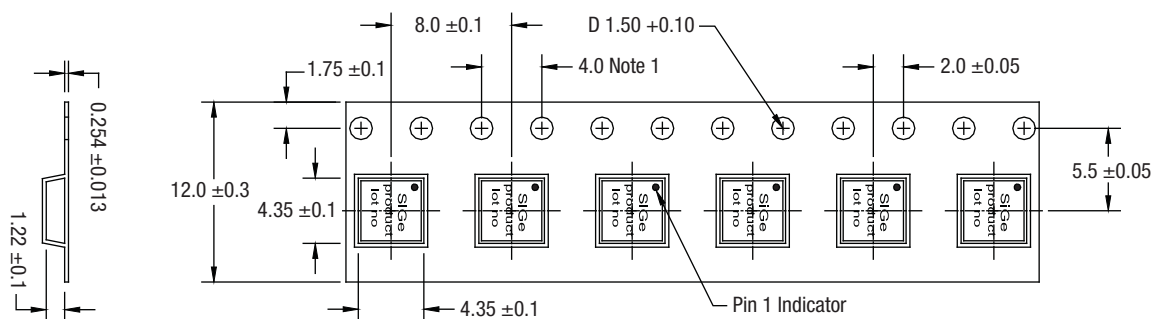
Notes:

1. 10-Sprocket hole pitch cumulative tolerance ±0.2.
2. Camber in compliance with EIA-481.

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Figure 6. SE2435L Tape and Reel Dimensions

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Ordering Information

Model Name	Manufacturing Part Number	Evaluation Board Part Number
SE2435L -S SE2435L -R SE2435L -EK1		