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DATA SHEET
SE2594L: Dual-Band 802.11a/b/g/n Wireless LAN Front-End
Preliminary Information

Applications

- IEEE802.11b DSSS WLAN
- IEEE802.11g OFDM WLAN
- IEEE802.11a OFDM WLAN
- IEEE802.11n WLAN
- Access Points, PCMCIA, PC cards

Features

- All RF ports matched to 50 Ω
- Integrated 2.4 GHz PA, 5 GHz PA, TX Filter, T/R switches and diplexers
- Integrated Power Detector for each TX Chain
- 21 dBm O/P Power, 802.11b, 11 Mbps, ACPR = 35 dBc
- 18 dBm @ 3.0 % EVM, 802.11g, 54 Mbits
- 16.5 dBm @ 3.0 % EVM, 802.11a, 54 Mbits
- Single supply voltage: 3.3 V \pm 10 %
- Lead free, Halogen free, RoHS compliant, MSL 3
- 5mm x 5mm x 0.9mm, QFN Package

Ordering Information

| Part No. | Package | Remark |
|-------------|------------|----------------|
| SE2594L | 32 pin QFN | Samples |
| SE2594L-R | 32 pin QFN | Tape and Reel |
| SE2594L-EK1 | N/A | Evaluation kit |

Product Description

The SE2594L is a complete 802.11a/b/g/n WLAN RF front-end module providing all the functionality of the power amplifiers, filtering, power detector, T/R switch, diplexers and associated matching. The SE2594L provides a complete 2.4 GHz and 5 GHz WLAN RF solution from the output of the transceiver to the antenna in an ultra compact form factor.

Designed for ease of use, all RF ports are matched to 50 Ω to simplify PCB layout and the interface to the transceiver RFIC. The SE2594L also includes a transmitter power detector for each band and transmit chain with 20 dB of dynamic range for each transmit chain. Each transmit chain has a separate digital enable control for transmitter power ramp on/off control. The power ramp rise/fall time is less than 0.7 μ sec.

The device also provides a notch filter from 3.260-3.267 GHz and 3.28-3.89 GHz prior to the input of each 2.4 GHz and 5 GHz power amplifiers, respectively.

The SE2594L packaged in 5mm x 5mm x 0.9mm, Halogen free, Lead free, ROHS compliant, MSL 3 QFN package.

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Functional Block Diagram

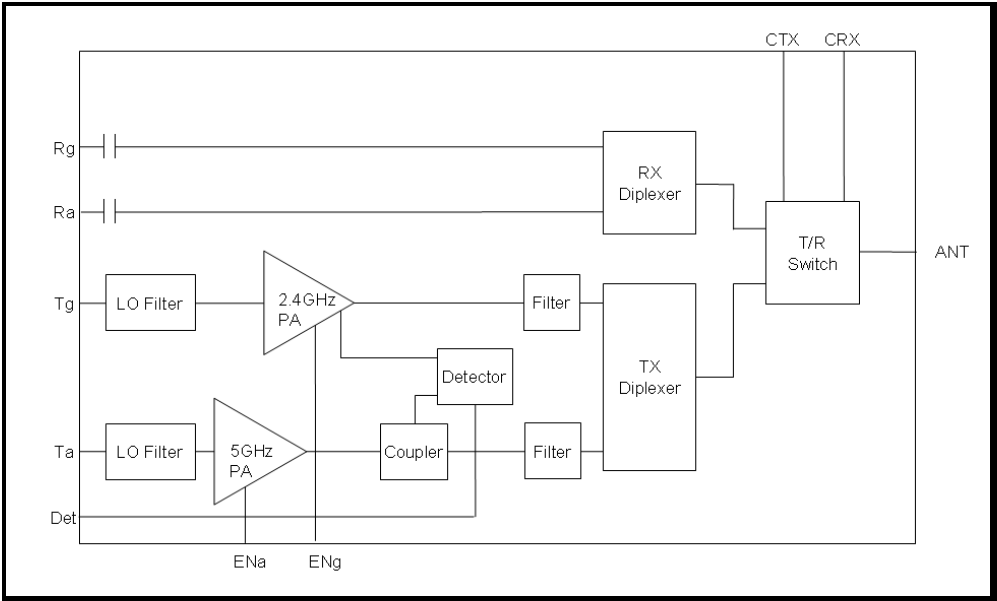


Figure 1: SE2594L Functional Block Diagram

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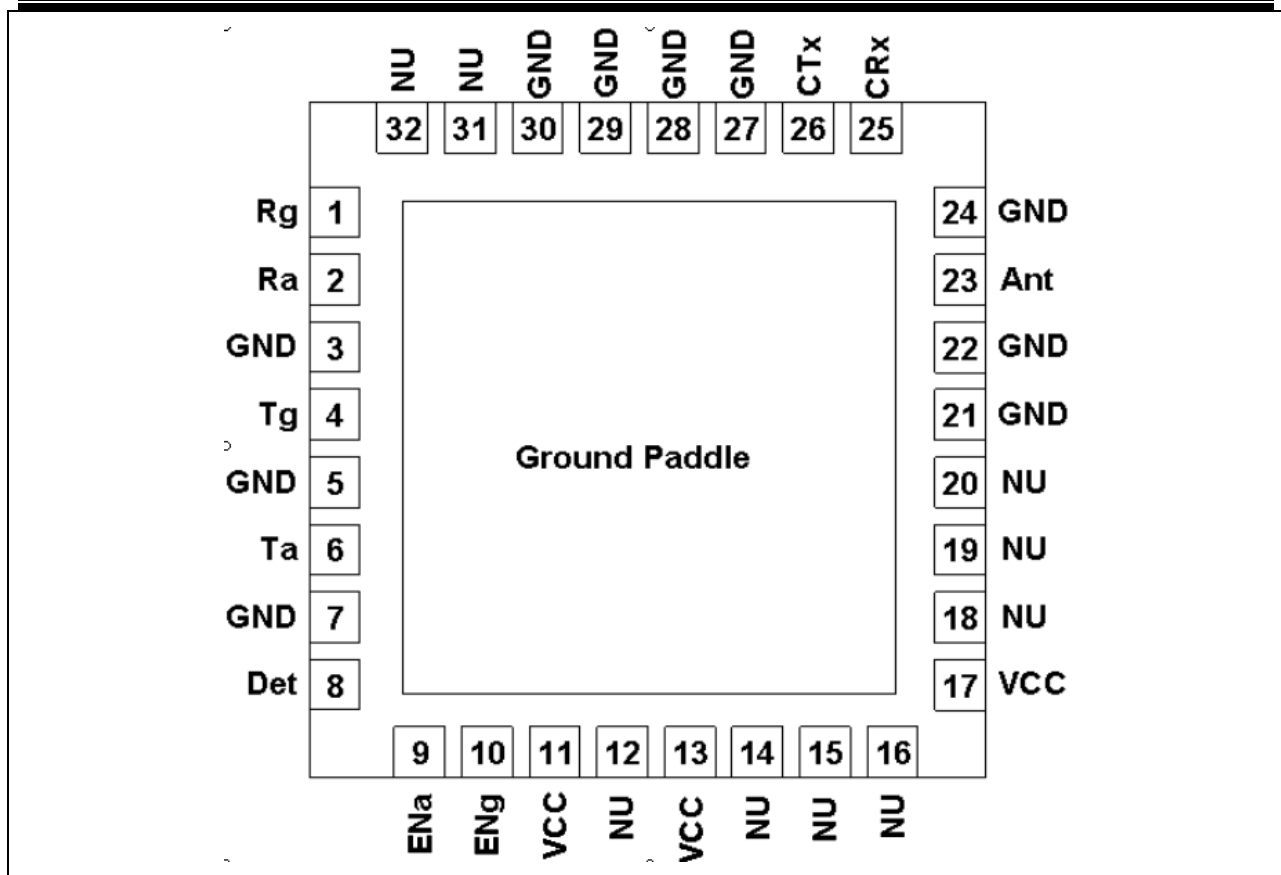


Figure 2: SE2594L Pin Out (Top View Through Package)

Pin Out Description

| Pin No. | Name | Description |
|---------|------|--|
| 1 | Rg | 2.4 GHz RF Receive Output, DC blocked |
| 2 | Ra | 5 GHz RF Receive Output, DC blocked |
| 3 | GND | Ground |
| 4 | Tg | 2.4 GHz RF Transmit Input, DC short to GND |
| 5 | GND | Ground |
| 6 | Ta | 5 GHz RF Transmit Input, DC short to GND |
| 7 | GND | Ground |
| 8 | Det | 2.4/5 GHz Power Detector Output |
| 9 | ENa | 5 GHz Power Amplifier Enable |
| 10 | ENg | 2.4 GHz Power Amplifier Enable |
| 11 | VCC | Supply Voltage |
| 12 | NU | No Used |
| 13 | VCC | Supply Voltage |
| 14 | NU | Not Used |

| Pin No. | Name | Description |
|---------|------|-------------------------|
| 17 | VCC | Supply Voltage |
| 18 | NU | Not Used |
| 19 | NU | Not Used |
| 20 | NU | Not Used |
| 21 | GND | Ground |
| 22 | GND | Ground |
| 23 | Ant | Antenna |
| 24 | GND | Ground |
| 25 | CRx | Receive Switch Control |
| 26 | CTx | Transmit Switch Control |
| 27 | GND | Ground |
| 28 | GND | Ground |
| 29 | GND | Ground |
| 30 | GND | Ground |

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| | | | | | |
|----|----|----------|----|----|----------|
| 15 | NU | Not Used | 31 | NU | Not Used |
| 16 | NU | Not Used | 32 | NU | Not Used |

Absolute Maximum Ratings

These are stress ratings only. Exposure to stresses beyond these maximum ratings may cause permanent damage to, or affect the reliability of the device. Avoid operating the device outside the recommended operating conditions defined below. This device is ESD sensitive. Handling and assembly of this device should be at ESD protected workstations.

| Symbol | Definition | Min. | Max. | Unit |
|------------------|--|------|------|------|
| V _{CC} | Supply Voltage | -0.3 | 4.0 | V |
| PU | ENa, ENg | -0.3 | 4.0 | V |
| TX _{RF} | Ta, Tg, ANT terminated in 6:1 load or better | - | 12.0 | dBm |
| T _A | Operating Temperature Range | -40 | 85 | °C |
| T _{STG} | Storage Temperature Range | -40 | 150 | °C |

Recommended Operating Conditions

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|-----------------|---------------------|------|------|------|------|
| V _{CC} | Supply Voltage | 3.0 | 3.3 | 3.6 | V |
| T _A | Ambient Temperature | -40 | 25 | 85 | °C |

DC Electrical Characteristics

Conditions: V_{CC} = 3.3 V, T_A = 25 °C, as measured on Skyworks Solutions' SE2594L-EV1 evaluation board (de-embedded to device), all unused ports terminated with 50 ohms, unless otherwise noted

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|---------------------|---------------------------------------|---|------|------|------|------|
| I _{CC-G} | Total 802.11g Transmit Supply Current | P _{OUT} = 18 dBm, 54 Mbps OFDM signal, 64 QAM ENg = 3.3 V, ENa = 0 V | - | 150 | - | mA |
| I _{CC-B} | Total 802.11b Transmit Supply Current | P _{OUT} = 21 dBm, 11 Mbps CCK signal, BT = 0.45, ENg = 3.3 V, ENa = 0 V | - | 180 | - | mA |
| I _{CC-A} | Total 802.11a Transmit Supply Current | P _{OUT} = 16 dBm, 54 Mbps OFDM signal, 64 QAM, ENa = 3.3 V, ENg = 0 V | - | 220 | 250 | mA |
| I _{CC_OFF} | Total Supply Current | No RF, ENg = ENa = 0 V | - | 2 | 100 | µA |

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Logic Characteristics

Conditions: $V_{CC} = 3.3\text{ V}$, $T_A = 25\text{ }^\circ\text{C}$, as measured on Skyworks Solutions' SE2594L-EV1 evaluation board (de-embedded to device), all unused ports terminated with 50 ohms, unless otherwise noted.

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|-----------|---|------------|------|------|----------|---------------|
| V_{ENH} | Logic High Voltage for ENG, ENa (Module On) | - | 1.8 | - | V_{CC} | V |
| V_{ENL} | Logic Low Voltage ENG, ENa (Module Off) | - | 0 | - | 0.5 | V |
| I_{ENH} | Input Current Logic High Voltage (ENG, ENa) | - | - | 350 | 400 | μA |
| I_{ENL} | Input Current Logic Low Voltage (ENG, ENa) | - | - | 0.2 | - | μA |

Switch Characteristics

Conditions: $V_{CC} = 3.3\text{ V}$, $T_A = 25\text{ }^\circ\text{C}$, as measured on Skyworks Solutions' SE2594L-EV1 evaluation board (de-embedded to device), all unused ports terminated with 50 ohms, unless otherwise noted.

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|----------------|--|---|------|------|----------|---------------|
| V_{CTL_ON} | Control Voltage (On State) | - | 3.0 | - | 3.6 | V |
| V_{CTL_OFF} | Control Voltage (OFF State) | - | 0.0 | - | 0.2 | V |
| SW_{ON} | Low Loss Switch Control Voltage | High State = $V_{CTL_ON} - V_{CTL_OFF}$ | 2.8 | - | V_{CC} | V |
| SW_{OFF} | High Loss Switch Control Voltage | Low State = $V_{CTL_OFF} - V_{CTL_OFF}$ | 0 | - | 0.3 | V |
| I_{CTL_ON} | Switch Control Bias Current (RF Applied) | On pin (CTx, CRx) being driven high. RF Applied | - | - | 100 | μA |
| I_{CTL_ON} | Switch Control Bias Current (No RF) | On pin (CTx, CRx) being driven high. No RF | - | - | 30 | μA |
| C_{CTL} | Control Input Capacitance | - | - | - | 100 | pF |

Switch Control Logic Table

| CTx | CRx | Tg, Ta – ANT | Rg, Ra – ANT |
|-------------------------|------------|---------------------------------|--------------|
| SW_{ON} | SW_{OFF} | ON | OFF |
| SW_{OFF} | SW_{ON} | OFF | ON |
| SW_{OFF} | SW_{OFF} | OFF | OFF |
| All Other States | | Unsupported Switch State | |

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2.4 GHz AC Electrical Characteristics

2.4 GHz Transmit Characteristics

Conditions: $V_{CC} = 3.3\text{ V}$, $ENg = CTx = 3.3\text{ V}$, $ENa = CRx = 0\text{ V}$, $T_A = 25\text{ }^\circ\text{C}$, as measured on Skyworks Solutions' SE2594L-EV1 evaluation board, all unused ports terminated with 50 ohms, unless otherwise noted.

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Unit |
|------------------|---------------------------------------|---|--|------|-------------------|---------------|
| F_{IN} | Frequency Range | - | 2400 | - | 2500 | MHz |
| $P_{802.11g}$ | Output power | 54 Mbps OFDM signal, 64QAM, EVM = 3.0 % | - | 18 | - | dBm |
| $P_{802.11b}$ | Output power | 11 Mbps CCK signal, BT = 0.45 ACPR($\pm 11\text{MHz offset}$) < -35 ACPR($\pm 22\text{MHz offset}$) < -55 | - | 21 | - | dBm |
| P_{1dB} | P1dB | - | 23 | 24 | - | dBm |
| S_{21} | Small Signal Gain | - | 25 | - | 30 | dB |
| ΔS_{21} | Small Signal Gain Variation Over Band | - | - | 1.0 | 2.0 | dB |
| $S_{21}1.6$ | Gain at Ref-VCO $\div 2$ | 1600 MHz | - | - | 21 | dB |
| $S_{21}3.2$ | Gain at Ref-VCO | 3216.00 to 3256.00 MHz 3262.00 to 3263.21 MHz 3269.33 to 3276.00 MHz 3282.67 to 3312.00 MHz | - | - | 9 4 9 17 | dB |
| 2f,3f | Harmonics | $P_{out} \leq 21\text{ dBm}$, 1Mbps, CCK | - | - | -45.2 | dBm/MHz |
| t_{dr}, t_{df} | Delay and rise/fall Time | 50 % of V_{EN} edge and 90/10 % of final output power level | - | - | 0.4 | μs |
| S_{11} | Input Return Loss | - | 10 | 15 | - | dB |
| STAB | Stability | CW, $P_{OUT} = 21\text{ dBm}$ 0.1 GHz – 21 GHz Load VSWR = 6:1 | All non-harmonically related outputs less than -42 dBm/MHz | | | |
| R_u | Ruggedness | $T_g = 12\text{dBm}$, ANT load varies over 10:1 VSWR, $ENg = 0$ or 3.3 V | No Irreversible damage | | | |

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2.4 GHz Receive Characteristics

Conditions: $V_{CC} = 3.3\text{ V}$, $CR_x = 3.3\text{ V}$, $EN_g = EN_a = CT_x = 0\text{ V}$, $T_A = 25\text{ }^\circ\text{C}$, as measured on Skyworks Solutions' SE2594L-EV1 evaluation board (de-embedded to device), all unused ports terminated with 50 ohms, unless otherwise noted.

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Unit |
|----------------------|-------------------------|---|------|------|------|------|
| F _{OUT} | Frequency Range | - | 2400 | - | 2500 | MHz |
| RX _{IL} | Insertion Loss | - | - | 1.5 | 1.9 | dB |
| RX _{RL} | Return Loss | - | 10 | 15 | - | dB |
| TR _{ISOL-2} | Rx Leakage | CT _x = SWON, CR _x = SWOFF, Device transmitting (EN _g = 3.3 V) 18.0 dBm @ ANT, Power measured @ RX_OUT | - | - | 0 | dBm |
| ANTR _{ISOL} | Antenna to Rx isolation | Small signal input into ANT, Device not transmitting, Power measured @ R _g , CT _x (Ant to Rx Iso) = SWON, CR _x = SWOFF | 18 | - | 28 | dB |

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5 GHz AC Electrical Characteristics

5 GHz Transmit Characteristics

Conditions: $V_{CC} = 3.3\text{ V}$, E_{Na} and $CTx = 3.3\text{ V}$, $E_{Ng} = CRx = 0\text{ V}$, $T_A = 25\text{ °C}$, as measured on Skyworks Solutions' SE2594L-EV1 evaluation board, all unused ports terminated with 50 ohms, unless otherwise noted.

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Unit |
|------------------|---|---|--|------|-------|---------------|
| F_{IN} | Frequency Range | - | 4900 | - | 5875 | MHz |
| $P_{802.11a}$ | Nominal Output Power | 54 Mbps OFDM signal, 64 QAM, EVM = 3.0 % | - | 16.5 | - | dBm |
| P_{1dB} | P1dB | - | 21 | 22.5 | - | dBm |
| S_{21} | Small Signal Gain | - | 23 | - | 30 | dB |
| ΔS_{21} | Small Signal Gain Variation Over 40 MHz Channel | | - | - | 0.5 | dB |
| | Small Signal Gain Variation Over sub-bands | 4.9 – 5.1 GHz 5.15 – 5.7 GHz 5.7 – 5.85 GHz | - | 1 | 3 | dB |
| $S_{21\ 1.9}$ | Gain at Ref-VCO $\div 2$ | 1942 MHz | - | - | 14 | dB |
| $S_{21\ 3.2}$ | Gain at Ref-VCO | 3200 to 3900 MHz | - | - | 5.5 | dB |
| 2f,3f | Harmonics @16dBm, 54Mbps, 802.11a | 4900 – 5850 MHz | - | - | -48.2 | dBm/MHz |
| t_{dr}, t_{df} | Delay and rise/fall Time | 50 % of V_{EN} edge and 90/10 % of final output power level | - | - | 0.4 | μs |
| S_{11} | Input Return Loss | - | - | 6 | - | dB |
| STAB | Stability | 64 QAM, $P_{OUT} = 16\text{ dBm}$ 0.1 GHz – 21 GHz Load VSWR = 6:1 | All non-harmonically related outputs less than -42 dBm/MHz | | | |
| R_u | Ruggedness | $TXa = 12\text{ dBm}$, ANT load varies over 10:1 VSWR, $E_{Na} = 0$ or 3.3 V | No Irreversible damage | | | |

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5 GHz Receive Characteristics

Conditions: $V_{CC} = 3.3\text{ V}$, $CR_X = 3.3\text{ V}$, $ENg = ENa = CTx = 0\text{ V}$, $T_A = 25\text{ }^\circ\text{C}$, as measured on Skyworks Solutions' SE2594L-EV1 evaluation board (de-embedded to device), all unused ports terminated with 50 ohms, unless otherwise noted.

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Unit |
|--------------------|-------------------------|---|------|------|------|------|
| F _{OUT} | Frequency Range | - | 4900 | - | 5875 | MHz |
| RX _{IL} | Insertion Loss | - | - | 2 | 2.5 | dB |
| RX _{RL} | Return Loss | - | 10 | 15 | - | dB |
| T _{ALEAK} | Tx Power Leakage | Pout = 16 dBm, ENa = 3.3 V, CTx = 3.3 V, CRx = 0 V | - | - | 0 | dBm |
| ATT _a | Antenna to Rx isolation | Small signal input into ANT, Device not transmitting, Power measured @ RX _{RF} , CTx (Ant to Rx Iso) = SWON, CRx = SWOFF | 16 | - | 27 | dB |

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2.4 GHz Power Detector Characteristic

Conditions: $V_{CC} = ENg = CTx = 3.3\text{ V}$, $CRx = 0\text{ V}$, $T_A = 25\text{ }^\circ\text{C}$, as measured on Skyworks Solutions' SE2594L-EV1 evaluation board (de-embedded to device), all unused ports terminated with $50\ \Omega$, unless otherwise noted.

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Unit |
|----------------------|--|--|------|------|------|----------|
| F _{OUT} | Frequency Range | - | 2400 | - | 2500 | MHz |
| PDR | Power detect range, peak power | Measured at ANT | 0 | - | 22 | dBm |
| PDZ _{OUT} | DC Output impedance | - | - | 2400 | - | Ω |
| PDV _{P21} | Output Voltage, P _{OUT} = 21dBm | - | - | 0.85 | - | V |
| PDV _{P18} | Output Voltage, P _{OUT} = 18dBm | - | - | 0.68 | - | V |
| PDV _{pnoRF} | Output Voltage, P _{OUT} = No RF | - | - | 0.30 | - | V |
| LPF _{-3dB} | Power detect low pass filter -3dB corner frequency | Load = high impedance Typ: $1\text{ M}\Omega$ | - | 1500 | - | KHz |

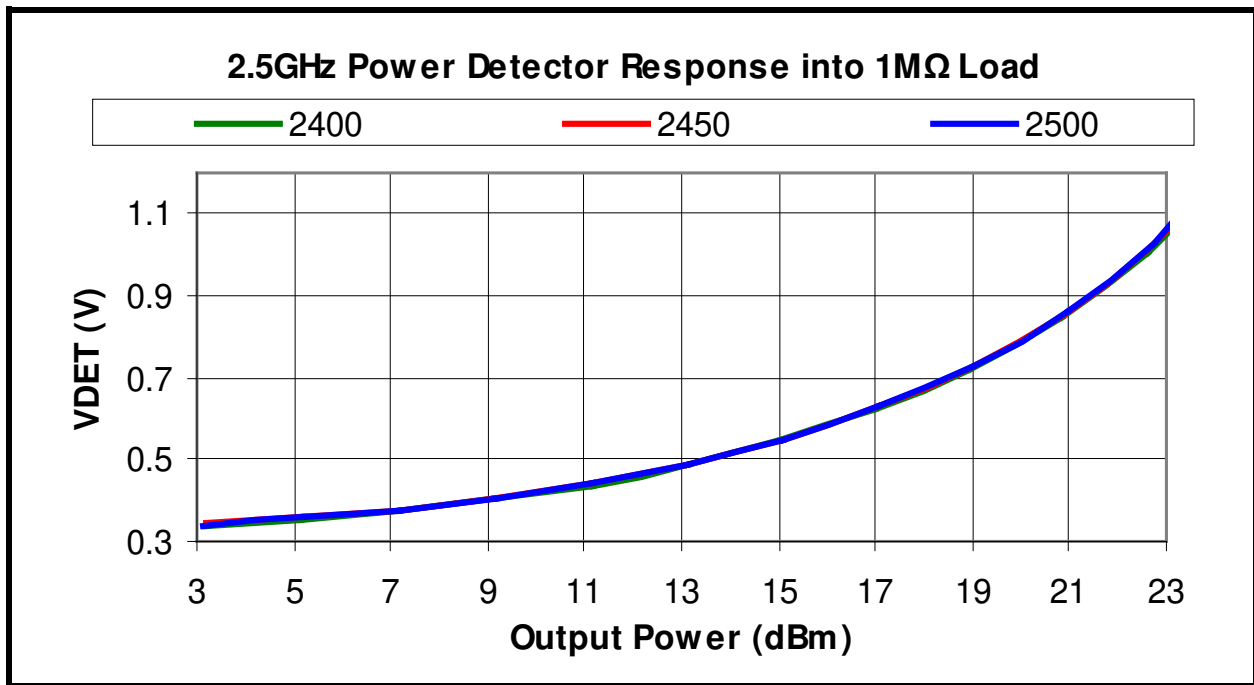


Figure 3: SE2594L Power Detector vs. Output Power over Frequency (CW Signal)

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5 GHz Power Detector Characteristic

Conditions: $V_{CC} = E_{NA} = C_{TX} = 3.3\text{ V}$, $C_{RX} = 0\text{ V}$, $T_A = 25\text{ }^\circ\text{C}$, as measured on Skyworks Solutions' SE2594L-EV1 evaluation board (de-embedded to device), all unused ports terminated with $50\ \Omega$, unless otherwise noted.

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Unit |
|---------------------|--|--|------|------|------|----------|
| F _{OUT} | Frequency Range | - | 4900 | - | 5850 | MHz |
| PDR | Power detect range, peak power | Measured at ANT | 0 | - | 21 | dBm |
| PDZ _{OUT} | DC Output impedance | - | - | 2400 | - | Ω |
| PDV _{p18} | Output Voltage, P _{OUT} = 18dBm | - | - | 0.80 | - | V |
| PDV _{p16} | Output Voltage, P _{OUT} = 16dBm | - | - | 0.70 | - | V |
| PDV _{NoRF} | Output Voltage, P _{OUT} = No RF | - | - | 0.30 | - | V |
| LPF _{-3dB} | Power detect low pass filter -3dB corner frequency | Load = high impedance Typ: 1 M Ω | - | 1500 | - | KHz |

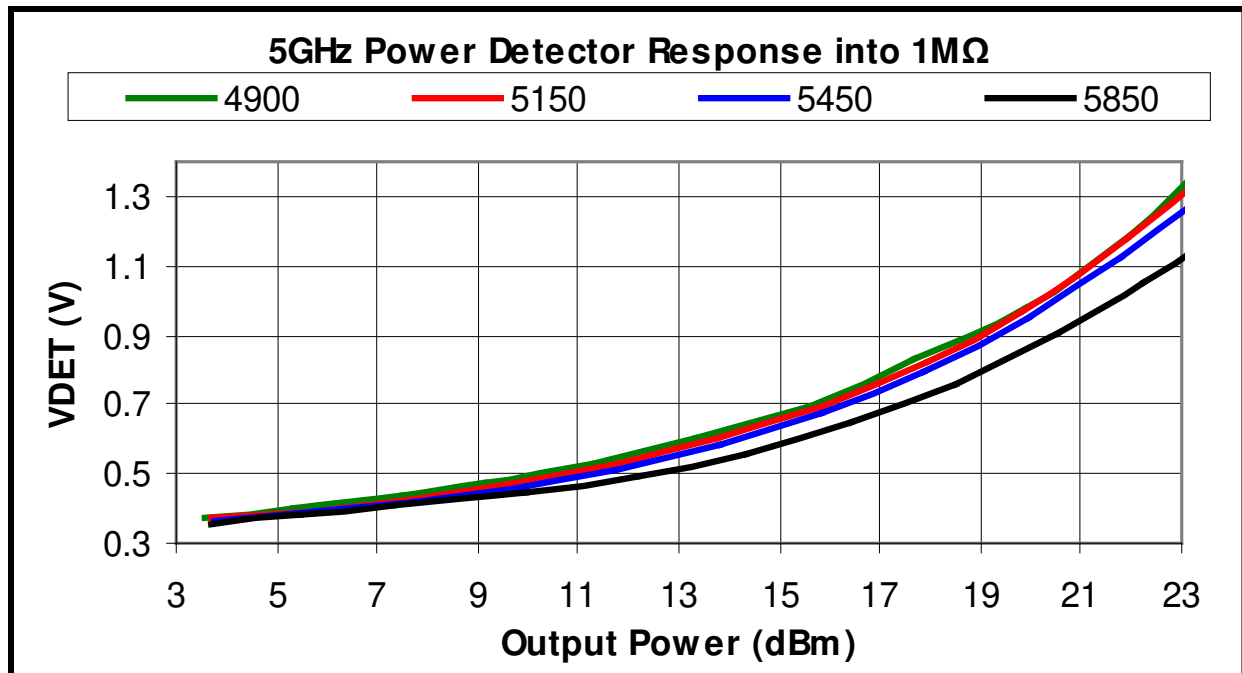


Figure 4: Preliminary SE2594L Power Detector vs. Output Power over Frequency (CW Signal)

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Package Drawing

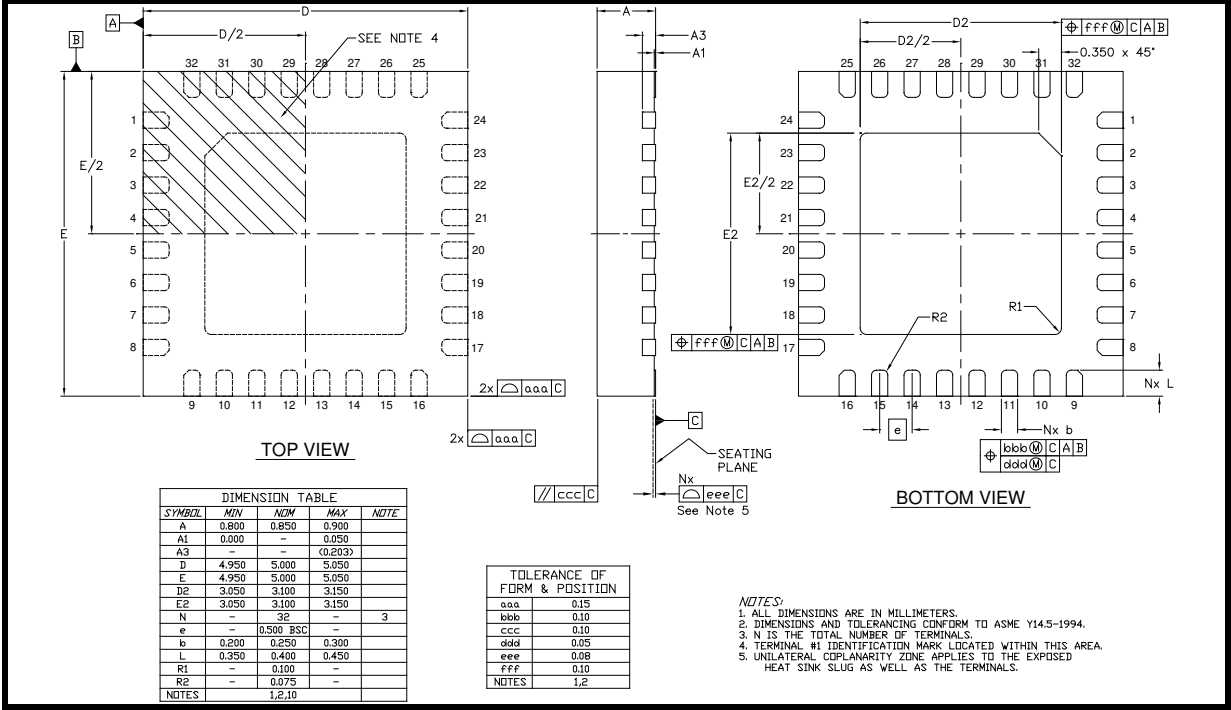


Figure 5: Package Drawing: Topside

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Recommended Land and Solder Patterns

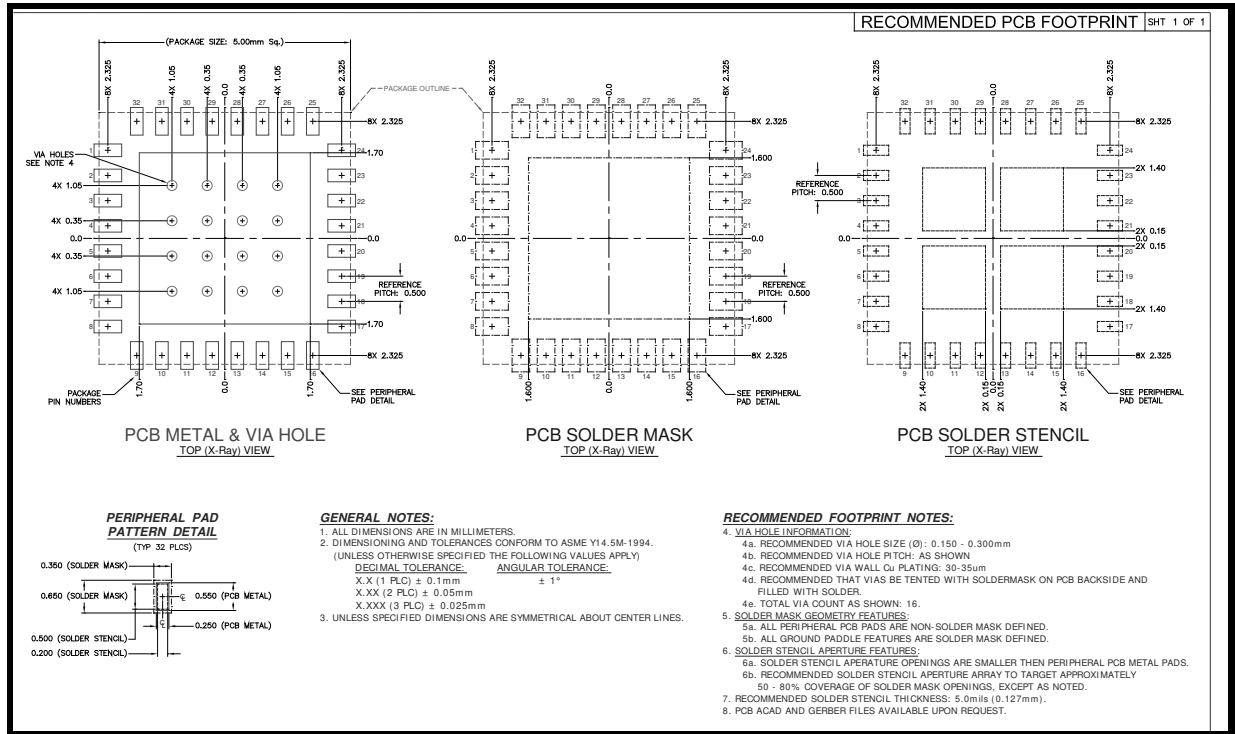


Figure 6: Recommended Land and Solder Patterns

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Package Handling Information

Because of its sensitivity to moisture absorption, instructions on the shipping container label must be followed regarding exposure to moisture after the container seal is broken, otherwise, problems related to moisture absorption may occur when the part is subjected to high temperature during solder assembly. The SE2594L is capable of withstanding a Pb free solder reflow. Care must be taken when attaching this product, whether it is done manually or in a production solder reflow environment. If the part is manually attached, precaution should be taken to insure that the device is not subjected to temperatures above its rated peak temperature for an extended period of time. For details on both attachment techniques, precautions, and handling procedures recommended, please refer to:

- “Quad Flat No-Lead Module Solder Reflow & Rework Information”, *Document Number QAD-00045*
- “Handling, Packing, Shipping and Use of Moisture Sensitive QFN”, *Document Number QAD-00044*



Caution! Class 0 ESD sensitive device

Product Branding

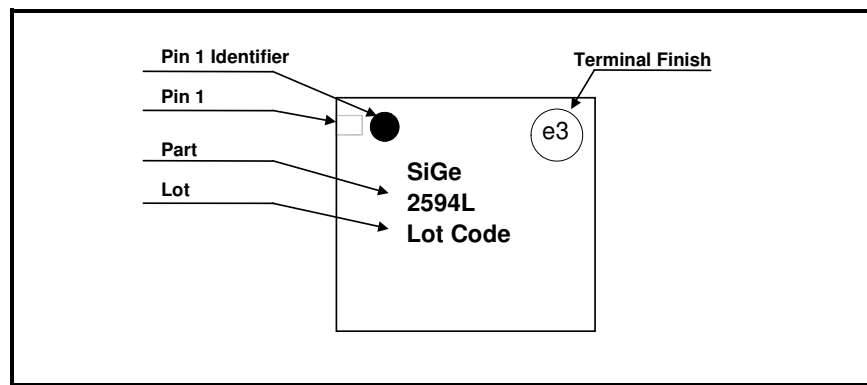


Figure 7: SE2594L Branding Information

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Tape and Reel Information

Production quantities of this product are shipped in a standard tape-and-reel format. Specific tape and reel dimensions and sizing is shown in Table 1 and Figure .

| Parameter | Value |
|------------------|-----------|
| Devices Per Reel | 3000 |
| Reel Diameter | 13 inches |

Table 1: Tape and Reel Dimensions

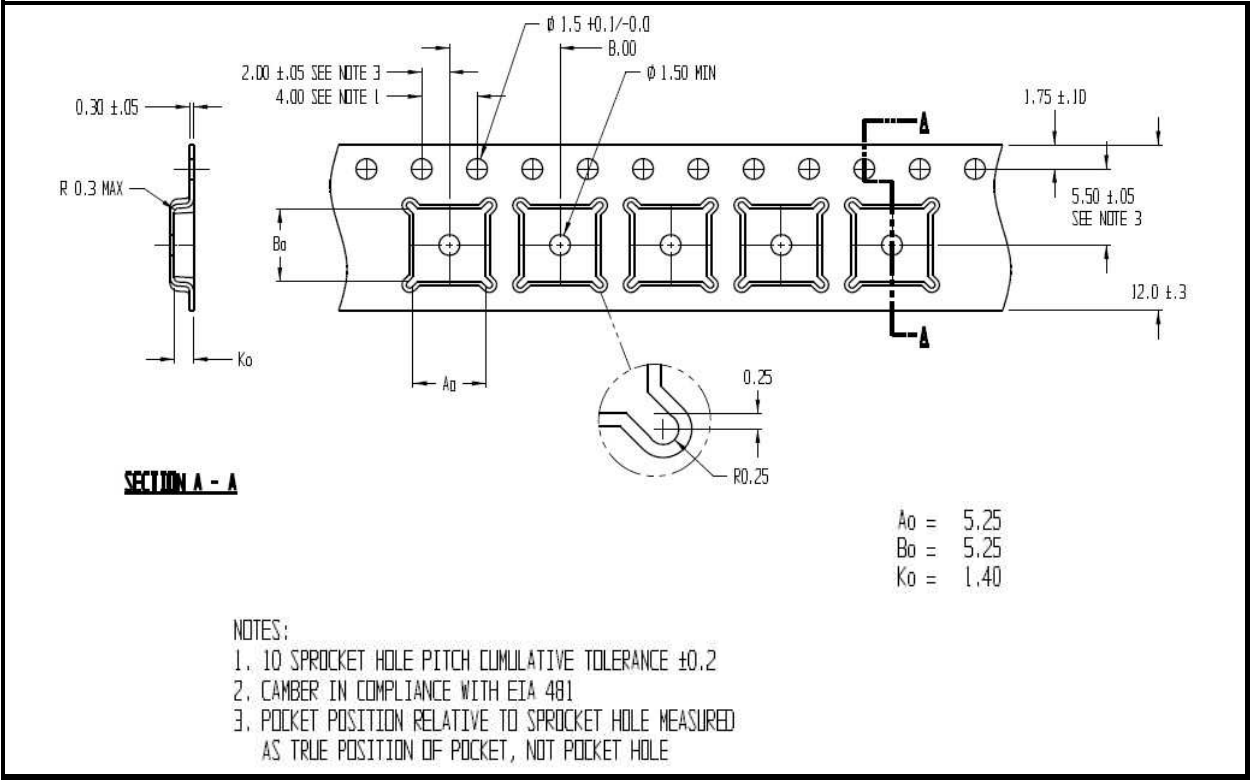


Figure 8: Detailed Tape and Reel Information (All dimensions in Millimeters)



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Document Change History

| Revision | Date | Notes |
|----------|-------------|--|
| 1.0 | Aug-20-2008 | Created |
| 1.1 | Apr-9-2009 | Added VCC to Pin 13 Corrected terminal finish indicator in Branding Information |
| 1.2 | Dec-8-2009 | Updated per Design Validation Test. |
| 1.3 | Jan-11-2010 | Updated ICC_OFF specification |
| 1.4 | Feb-11-2011 | Updated for Industrial temperature range |
| 1.5 | Jun-30-2011 | Corrected Recommended Operating Condition to Industrial Temperature Range |
| 1.6 | Mar-20-2012 | Corrected top marking terminal finish |
| 1.7 | Mar-28-2012 | Updated with Skyworks logo and disclaimer statement |

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