**DATA SHEET**
# SE2528L: 2.4 GHz Power Amplifier with Power Detector

## Applications

- DSSS 2.4 GHz WLAN (IEEE802.11b)
- OFDM 2.4 GHz WLAN (IEEE802.11g)
- Access Points, PCMCIA, PC cards

## Features

- Single 3.3 V Supply Operation
  - 21 dBm, EVM = 3 %, 802.11g, OFDM 54 Mbps
  - 24 dBm, ACPR < -32 dBc, 802.11b
- Dual Supply Operation
  - 23 dBm, EVM = 3 %, 802.11g, OFDM 54 Mbps
  - 25 dBm, ACPR < -32 dBc, 802.11b
- 33 dB Gain
- Pin for pin compatible to the SE2525L
- Selectable Power Detector Slope for use with multiple chipsets (Negative and Positive)
- Integrated power amplifier enable pin ($V_{EN}$)
- Lead Free package, 16 pin 4 mm x 4 mm x 0.9 mm QFN, MSL 1

## Ordering Information

| Part Number | Package | Remark |
|---|---|---|
| SE2528L | 16 Pin QFN | Samples |
| SE2528L-R | 16 Pin QFN | Tape and Reel |
| SE2528L-EK1 | Evaluation Kit | Standard |

## Functional Block Diagram

## Product Description

The SE2528L is a 2.4 GHz power amplifier designed for use in the 2.4 GHz ISM band for wireless LAN applications. The device incorporates two selectable power detectors for closed loop monitoring of the output power.

The SE2528L is form, fit and function identical to Skyworks' SE2525L. The SE2528L design can be placed on SE2525L designs to provide higher output power with only a few component changes.

The SE2528L also offers a high power mode by operating at 5 V. This provides an extra 2 dB of improved EVM performance.

The SE2528L includes a digital enable control for device on/off control.

The device is pin for pin compatible to Skyworks' SE2525L, allowing both devices to share the same application board with only a few component changes required. This provides users with both a high and low power solution without changing the layout.

The SE2528L temperature compensated power detector has two selectable power detectors slopes, positive and negative. This allows easy use with multiple chipsets. The detector is also highly immune to mismatch at its output with less than 1.5 dB of variation with a 2:1 mismatch.

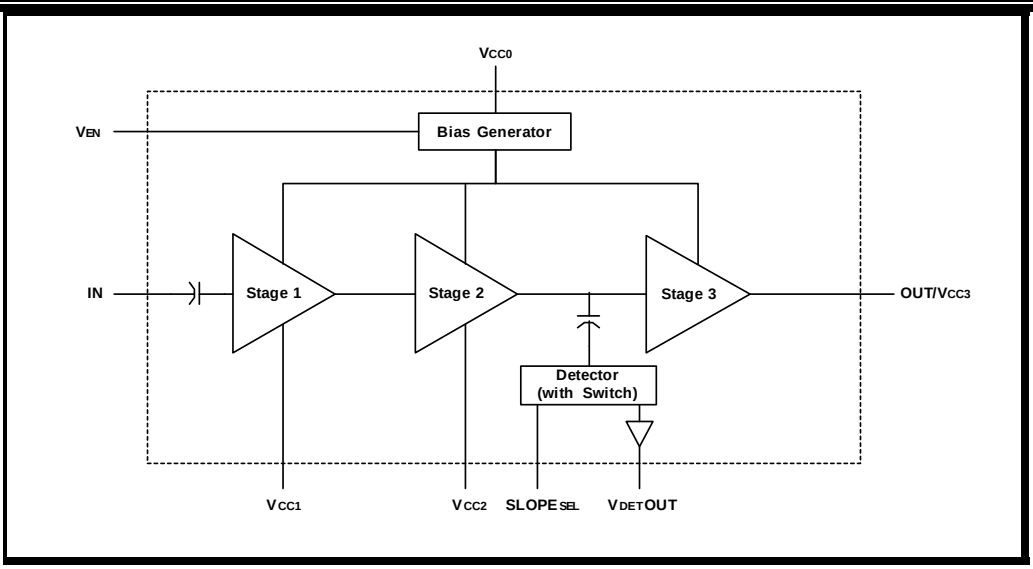



**Figure 1: Functional Block Diagram**

## Pin Out Diagram

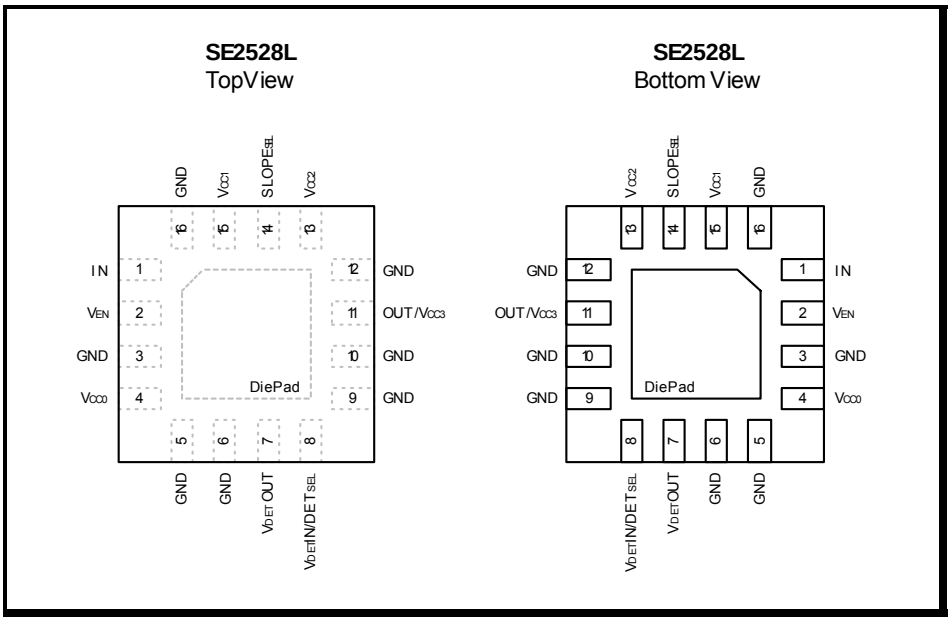



**Figure 2: SE2528L Pin-Out Diagram**

## Pin Out Description

| Pin No. | Name | Description |
|---|---|---|
| 1 | IN | Power amplifier RF input |
| 2 | VEN | Digital pin used to power up and power down the IC |

| | | |
|---|---|---|
| 3 | GND | Ground |
| 4 | $V_{CC0}$ | Bias/control circuit supply voltage |
| 5 | GND | Ground |
| 6 | GND | Ground |
| 7 | $V_{DET}$ OUT | Analog power detector output |
| 8 | $V_{DET}$ IN/$DET_{SEL}$ | Power Detector Input (Not used, must be grounded) |
| 9 -10 | GND | Ground |
| 11 | OUT/ $V_{CC3}$ | Power Amplifier RF output and Stage 3 collector supply voltage |
| 12 | GND | Ground |
| 13 | $V_{CC2}$ | Stage 2 collector supply |
| 14 | $SLOPE_{SEL}$ | Slope Select (N/C = Positive, GND = Negative) |
| 15 | $V_{CC1}$ | Stage 1 collector supply |
| 16 | GND | Ground |
| Die Pad | GND | Exposed die pad; electrical and thermal ground |

## Absolute Maximum Ratings

These are stress ratings only. Exposure to stresses beyond these maximum ratings for a long period of time 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 on pins $V_{CC0}$, $V_{CC1}$, and $V_{CC2}$ | -0.3 | 4 | V |
| $V_{CC3}$ | Supply Voltage on pins $V_{CC3}$ (Note: SE2528L application circuit must be followed for operation above 3.6 V) | -0.3 | 5.5 | V |
| $V_{EN}$ | Power Amplifier Enable | -0.3 | $V_{CC0}$ + 0.3 | V |
| IN | RF Input Power | - | 2 | dBm |
| $T_{STG}$ | Storage Temperature Range | -40 | 150 | °C |
| $T_j$ | Maximum Junction Temperature | - | 150 | °C |
| $ESD_{HBM}$ | JEDEC JESD22-A114 | - | 100 | V |

## Recommended Operating Conditions

| Symbol | Parameter | Min. | Max. | Unit |
|---|---|---|---|---|
| $V_{CC}$ | Supply Voltage on pins $V_{CC0}$, $V_{CC1}$, $V_{CC2}$ | 2.9 | 3.6 | V |

| Symbol | Parameter | Min. | Max. | Unit |
|---|---|---|---|---|
| $V_{CC3}$ | Supply Voltage on pins $V_{CC3}$ (Note: SE2528L application circuit must be followed for operation above 3.6 V) | 2.9 | 5.5 | V |
| $T_A$ | Ambient Temperature | -40 | 85 | °C |

## DC Electrical Characteristics

Conditions: $V_{CC}$ = $V_{CC3}$ = $V_{EN}$ = 3.3 V, $T_A$ = 25 °C, as measured on Skyworks Solutions' SE2528L-EV1 evaluation board, unless otherwise noted.

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $I_{CC-802.11b}$ | Supply Current (Sum of $V_{CC0}$, $V_{CC1}$, $V_{CC2}$, $V_{CC3}$) | $P_{OUT}$ = 24 dBm, 11 Mbps CCK signal, BT = 0.45, $V_{CC}$ = $V_{CC3}$ = 3.3 V | - | 300 | - | mA |
| | | $P_{OUT}$ = 25 dBm, 11 Mbps CCK signal, BT = 0.45, $V_{CC}$ = 3.3 V, $V_{CC3}$ = 5.0 V | - | 375 | 475 | mA |
| $I_{CC-802.11g}$ | Supply Current (Sum of $V_{CC0}$, $V_{CC1}$, $V_{CC2}$, $V_{CC3}$) | $P_{OUT}$ = 21 dBm, 54 Mbps OFDM signal, 64 QAM, $V_{CC}$ = $V_{CC3}$ = 3.3 V | - | 230 | - | mA |
| | | $P_{OUT}$ = 23 dBm, 54 Mbps OFDM signal, 64 QAM, $V_{CC}$ = 3.3 V, $V_{CC3}$ = 5.0 V | - | 290 | 340 | mA |
| $I_{OFF}$ | Supply Current | $V_{EN}$ = 0 V, No RF | - | 3 | 10 | µA |
| $V_{ENH}$ | Logic High Voltage | - | 1.3 | - | $V_{CC}$ | V |
| $V_{ENL}$ | Logic Low Voltage | - | 0 | - | 0.5 | V |

## AC Electrical Characteristics

### *802.11b/g AC Electrical Characteristics (3.3 V)*

Conditions: $V_{CC}$ = $V_{CC3}$ = $V_{EN}$ = 3.3 V, f = 2.45 GHz, $T_A$ = 25 °C, as measured on Skyworks Solutions' SE2528L-EV1 evaluation board, unless otherwise noted

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $f_{L-U}$ | Frequency Range | - | 2400 | - | 2500 | MHz |
| $P_{1dB}$ | Output 1dB compression point | No modulation | 25 | 26.5 | - | dBm |
| $S_{21}$ | Small Signal Gain | $P_{IN}$ = -25 dBm | 30 | 33 | 36 | dB |
| $\Delta S_{21}$ | Gain Variation over band | $P_{IN}$ = -25 dBm, $f_{IN}$= 2400 to 2500 MHz | - | 1 | - | dB |
| ACPR | Adjacent Channel Power Ratio<br>±11 MHz offsets from carrier<br>±22 MHz offsets from carrier | $P_{OUT}$ = 24 dBm, 11 Mbps CCK signal, BT = 0.45 | <br>-<br>- | <br>-37<br>-60 | <br>-30<br>-50 | dBc |
| 2f | Harmonic | $P_{OUT}$ = 24 dBm, CW | - | -40 | - | dBm/MHz |
| 3f | | | - | -40 | - | dBm/MHz |
| EVM | Error Vector Magnitude | $P_{OUT}$ = 21 dBm, 54 | - | 3.0 | - | % |

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| | | Mbps OFDM signal, 64 QAM | | | | |
| $t_r$, $t_f$ | Rise and Fall Time | - | - | 0.5 | - | µSec |
| STAB | Stability | $P_{IN}$ ≤ 2 dBm, $P_{OUT}$ = 24 dBm, 54 Mbps OFDM signal, 64 QAM VSWR = 6:1 All Phases | All non-harmonically related outputs less than -50 dBc/100 kHz | | | |
| VSWR | Tolerance to output load mismatching | $P_{IN}$ ≤ 2 dBm, $P_{OUT}$ = 24 dBm, 54 Mbps OFDM signal, 64 QAM VSWR = 10:1 All Phases | No damage | | | |

### *802.11b/g AC Electrical Characteristics (5 V)*

Conditions: $V_{CC}$ = $V_{EN}$ = 3.3 V, $V_{CC3}$ = 5 V, f = 2.45 GHz, $T_A$ = 25 °C, as measured on Skyworks Solutions' SE2528L-EV1 evaluation board, unless otherwise noted.

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $f_{L-U}$ | Frequency Range | - | 2400 | - | 2500 | MHz |
| $P_{1dB}$ | Output 1dB compression point | No modulation | 27 | 28.5 | - | dBm |
| $S_{21}$ | Small Signal Gain | $P_{IN}$ = -25 dBm | 30 | 34 | 36.5 | dB |
| $\Delta S_{21}$ | Gain Variation over band | $P_{IN}$ = -25 dBm, $f_{IN}$= 2400 to 2500 MHz | - | 1 | - | dB |
| ACPR | Adjacent Channel Power Ratio<br>±11 MHz offsets from carrier<br>±22 MHz offsets from carrier | $P_{OUT}$ = 25 dBm, 11 Mbps CCK signal, BT = 0.45 | <br>-<br>- | <br>-37<br>-60 | <br>-30<br>-50 | dBc |
| 2f | Harmonic | $P_{OUT}$ = 25 dBm, CW | - | -45 | - | dBm/MHz |
| 3f | | | - | -35 | - | dBm/MHz |
| EVM | Error Vector Magnitude | $P_{OUT}$ = 23 dBm, 54 Mbps OFDM signal, 64 QAM | - | 3.0 | - | % |
| $t_r$, $t_f$ | Rise and Fall Time | - | - | 0.5 | - | µSec |
| STAB | Stability | $P_{IN}$ ≤ 2 dBm, $P_{OUT}$ = 25 dBm, 54 Mbps OFDM signal, 64 QAM VSWR = 6:1 All Phases | All non-harmonically related outputs less than -50 dBc/100 kHz | | | |
| VSWR | Tolerance to output load mismatching | $P_{IN}$ ≤ 2 dBm, $P_{OUT}$ = 25 dBm, 54 Mbps OFDM signal, 64 QAM VSWR = 10:1 All | No damage | | | |

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| | | Phases | | | | |

### *Detector Selection Logic*

Conditions: $V_{CC}$ = $V_{EN}$ = 3.3 V, $V_{CC3}$ = 3.3 V OR 5 V, $T_A$ = 25 °C, as measured on Skyworks Solutions' SE2528L-EV1 evaluation board, unless otherwise noted

| SLOPE$_{SEL}$ | Detector Slope | Detector Signal Source |
|---|---|---|
| Open Circuit | Positive | Internal |
| Ground | Negative | Internal |

## Power Detector

### *Positive Slope*

Conditions: "$V_{CC}$ = $V_{CC3}$ = $V_{EN}$ = 3.3 V" OR "$V_{CC}$ = $V_{EN}$ = 3.3 V, $V_{CC3}$ = 5 V", f = 2.45 GHz, SLOPE$_{SEL}$ = Open Circuit, $V_{DET}$ IN/DET$_{SEL}$ = GND, $T_A$ = 25 °C, as measured on Skyworks Solutions' SE2528L-EV1 evaluation board, unless otherwise noted

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| PDR | $P_{OUT}$ detect range | - | 0 | - | $P_{1dB}$ | dBm |
| VDET | Detector voltage | $P_{OUT}$ = 23 dBm | 0.92 | 1.04 | 1.16 | V |
| VDET | Detector voltage | $P_{OUT}$ = 21 dBm | 0.75 | 0.88 | 0.99 | V |
| VDET | Detector voltage | $P_{OUT}$ = NO RF | 0.26 | 0.32 | 0.36 | V |
| PDZ$_{OUT}$ | Output Impedance | - | 250 | - | 700 | Ω |
| PDZ$_{LOAD}$ | DC load impedance | - | 10 | - | - | kΩ |

### *Negative Slope*

Conditions: "$V_{CC}$ = $V_{CC3}$ = $V_{EN}$ = 3.3 V" OR "$V_{CC}$ = $V_{EN}$ = 3.3 V, $V_{CC3}$ = 5 V", f = 2.45 GHz, $V_{DET}$OUT load = 2.4 kohm, SLOPE$_{SEL}$ = $V_{DET}$ IN/DET$_{SEL}$ = GND, $T_A$ = 25 °C, as measured on Skyworks Solutions' SE2528L-EV1 evaluation board, unless otherwise noted

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| PDR | $P_{OUT}$ detect range | - | 0 | - | $P_{1dB}$ | dBm |
| VDET | Detector voltage | $P_{OUT}$ = 23 dBm | 0.19 | 0.30 | 0.45 | V |
| VDET | Detector voltage | $P_{OUT}$ = 21 dBm | 0.31 | 0.42 | 0.54 | V |
| VDET | Detector voltage | $P_{OUT}$ = NO RF | 0.9 | 0.95 | 1.02 | V |
| PDZ$_{OUT}$ | Output Impedance | - | 2.2 | 2.4 | 3.0 | kΩ |

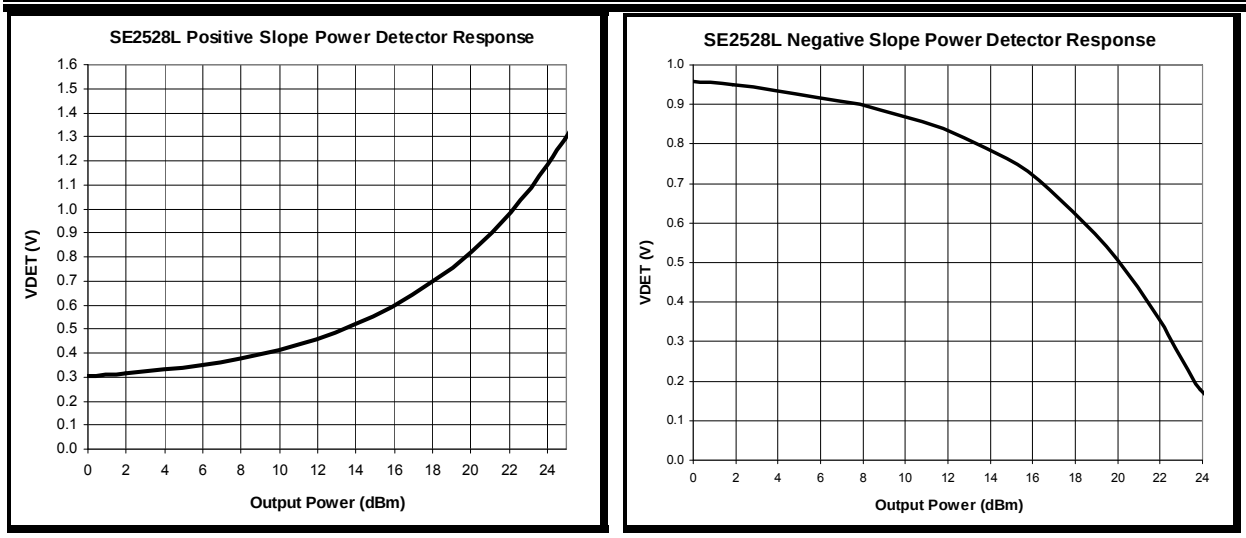



**Figure 3: SE2528L Power Detector Characteristic**

## Typical 3.3V Performance Characteristics

Conditions: $V_{CC}$ = $V_{CC3}$ = $V_{EN}$ = 3.3 V, f = 2.45 GHz, $T_A$ = 25 °C, as measured on Skyworks Solutions' SE2528L-EV1 evaluation board, unless otherwise noted

### *802.11g Performance*

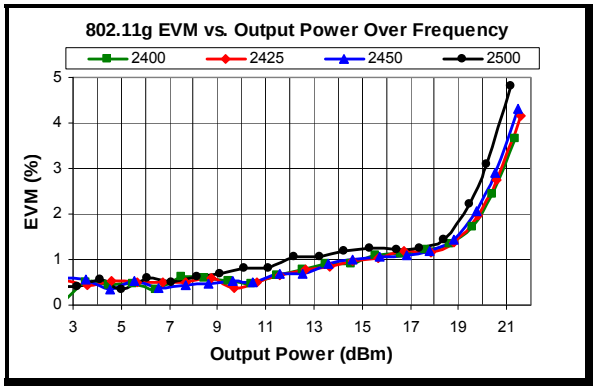
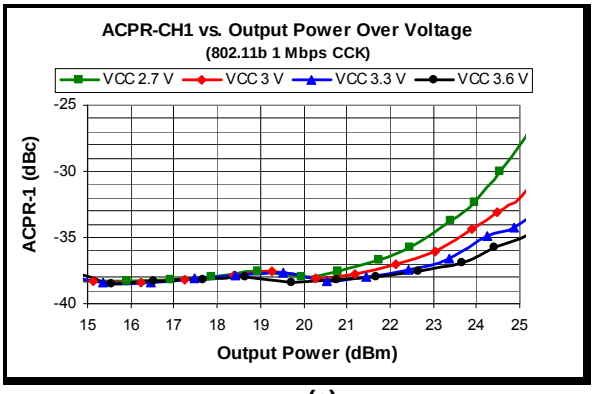
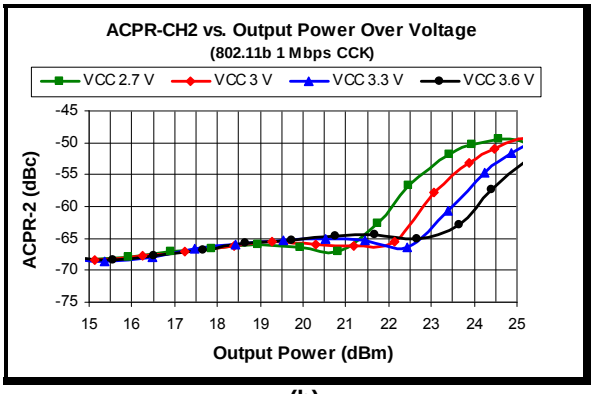



**Figure 4: SE2528L 802.11g 54 Mbps EVM (Over Frequency)**

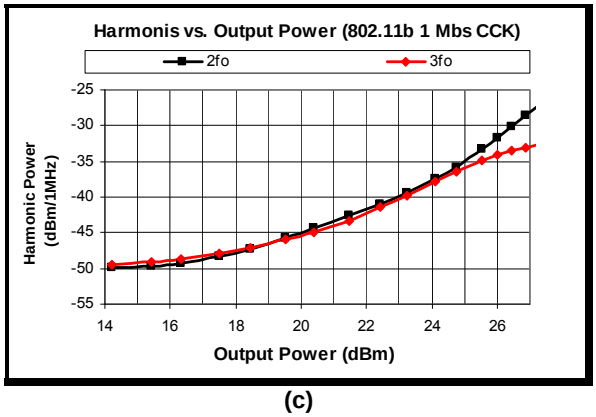
### *802.11b Performance*




**(a)**




**(b)**

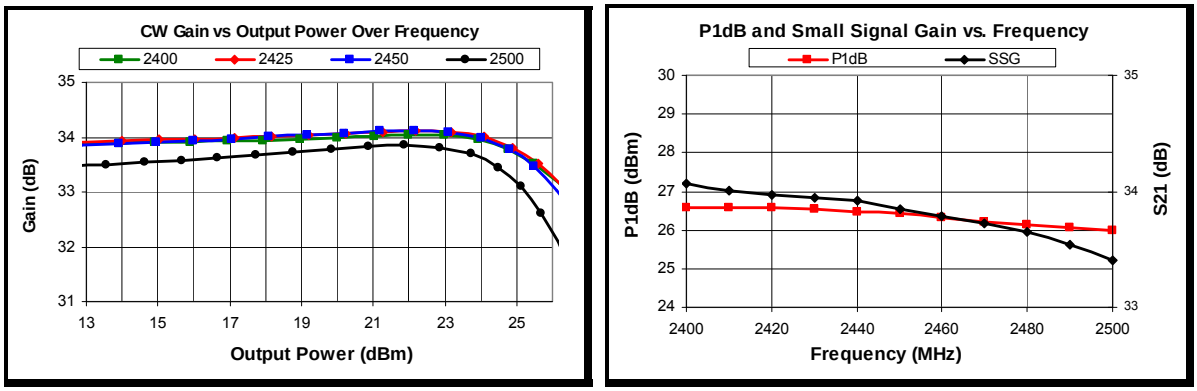



**(c)**

**Figure 5: Typical 802.11b Performance (a) ACPR-CH1 vs. Output Power Over Voltage, (b) ACPR-2 vs. Output Power Over Voltage and (c) 2nd and 3rd Harmonics vs. Output Power**

## Typical 3.3V Performance Characteristics (Continued)

### *General (CW)*




(a) (b)

**Figure 6: Typical CW Performance (a) Gain vs. Output Power over Frequency and (b) P1db and Small Signal Gain vs. Frequency**

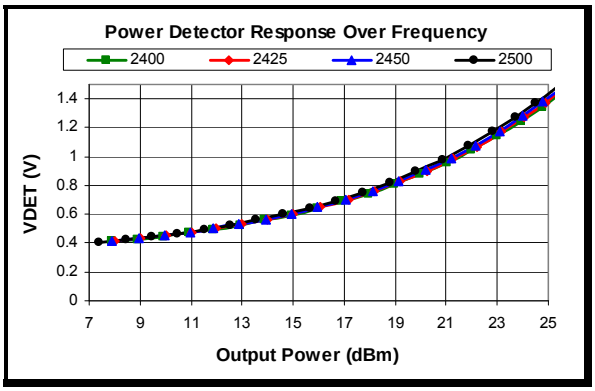



**Figure 7: Power Detector Response Over Frequency**

## Typical 5 V Performance Characteristics

Conditions: $V_{CC}$ = $V_{EN}$ = 3.3 V, $V_{CC3}$ = 5 V, f = 2.45 GHz, $T_A$ = 25 °C, as measured on Skyworks Solutions' SE2528L-EV1 evaluation board, unless otherwise noted

### *802.11g Performance*

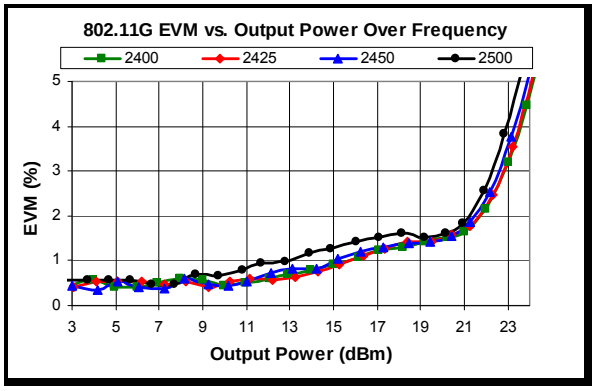
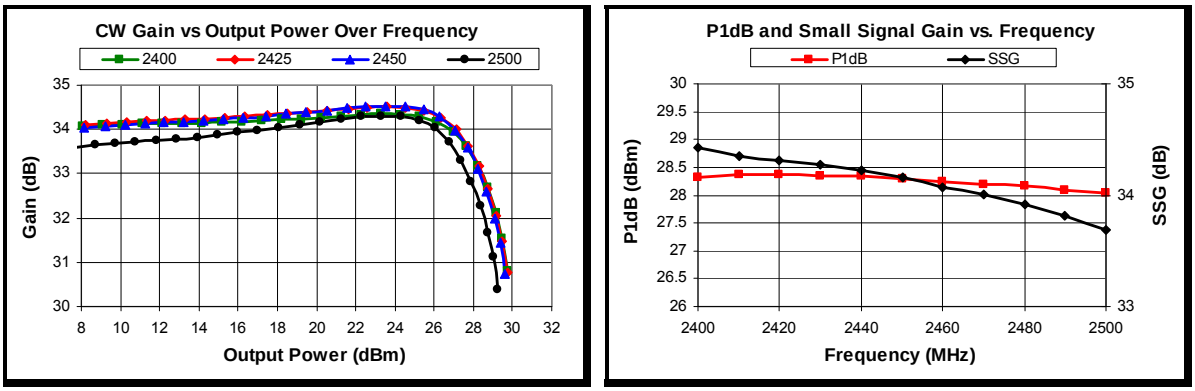



**Figure 8: SE2528L 802.11g 54 Mbps EVM**

### General (CW)




**(a)** **(b)**

**Figure 9: CW Typical Performance (a) Gain vs. Output Power over Frequency and (b) P1db and Small Signal Gain vs. Frequency**

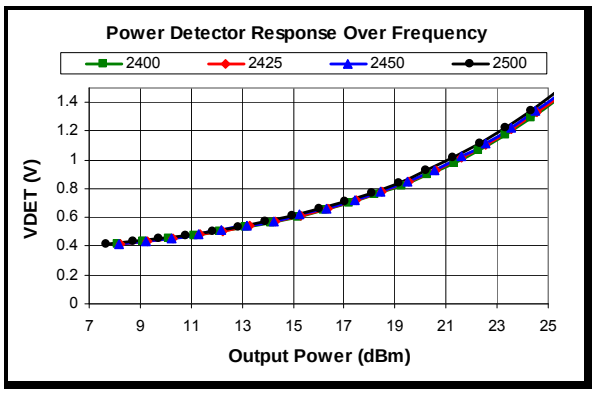



**Figure 10: Power Detector Response (Over Frequency)**

## Application Circuit

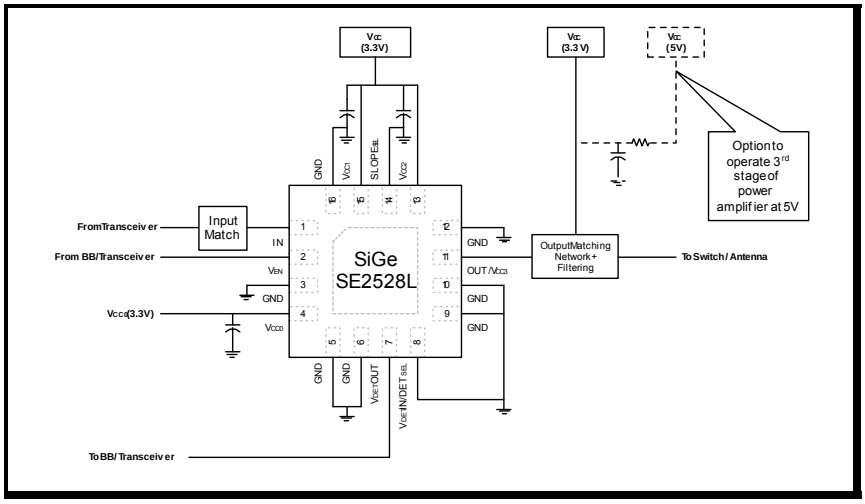



**Figure 11: SE2528L Application Circuit**

## 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 SE2528L 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*
- "ESD Control Policy", *Document Number SQ03-0062*

Caution! Class 0 ESD sensitive device

## Branding Information

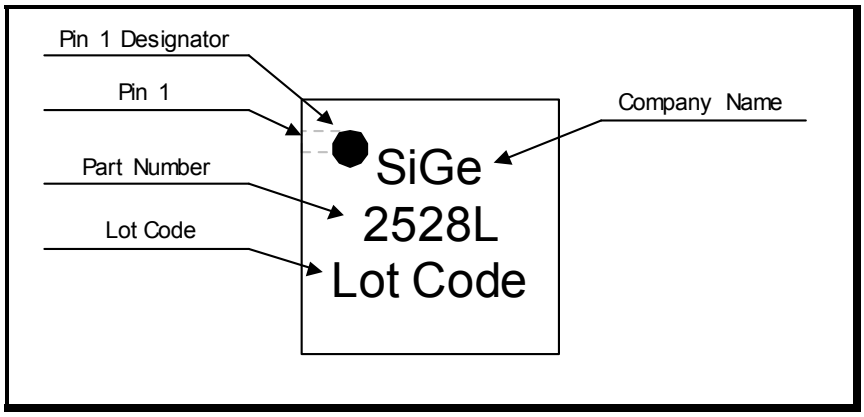



**Figure 12: SE2528L Branding Information**

## Tape and Reel Information

| Parameter | Value |
|---|---|
| Devices Per Reel | 3000 |
| Reel Diameter | 13 inches |
| Tape Width | 12 millimeters |

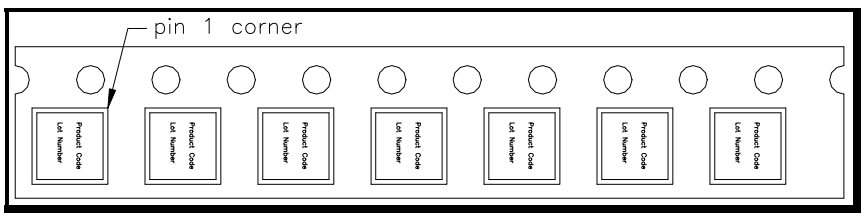



**Figure 13: SE2528L-R Tape and Reel Information**

## Package Information

This package is lead free.

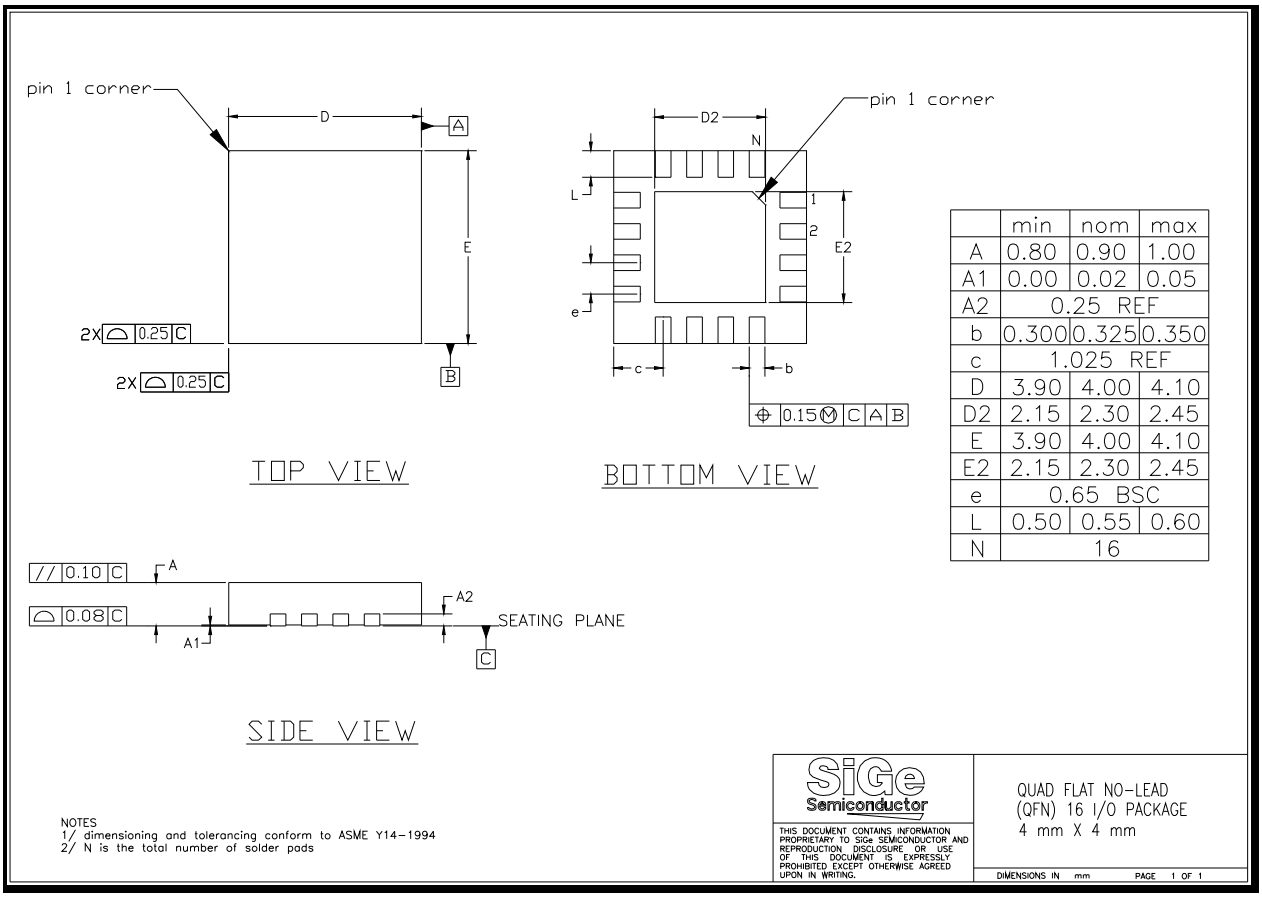



**Figure 14: SE2528L Package Drawing**

## Document Change History

| Revision | Date | Notes |
|---|---|---|
| 1.1 | Apr 13, 2006 | Created |
| 1.2 | Sep 10, 2008 | Updated to remove blocking capacitor requirement on RF Input pin |
| 1.3 | May 26, 2009 | Amended back page |
| 1.4 | Feb 9, 2011 | Extended operating temperature to Industrial grade. |
| 1.5 | Mar 28, 2012 | Updated with Skyworks logo and disclaimer statement |