

## PRELIMINARY DATA SHEET

# SE2605L: High Power (+26 dBm) 802.11n WLAN Power Amplifier with Integrated Power Detector

## Applications

- IEEE 802.11n WLAN enabled:
  - Access points
  - Media gateways
  - Set top boxes
  - LCD TVs
- Other broadband triple-play multimedia applications

## Features

Linear output power for IEEE 802.11n, 64-QAM,  
 $EVM \leq 3\% = +26 \text{ dBm} @ 5.0 \text{ V}$

- High gain: 32 dB
- Power shutdown mode
- Superior gain flatness
- Fully matched at RF input/output ports
- Load insensitive power detector
- Small footprint QFN (16-pin, 3 x 3 mm) SMT package (MSL3, 260 °C per JEDEC J-STD-020)

## Description

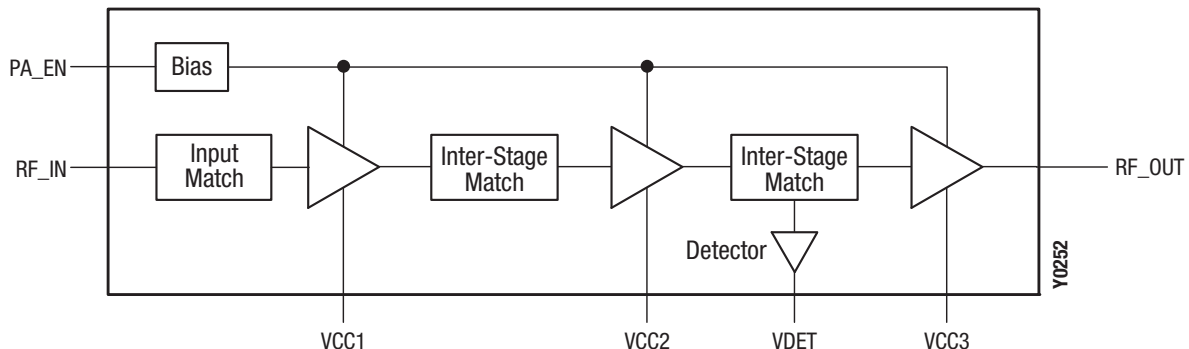
The SE2605L is a 2 GHz Microwave Monolithic Integrated Circuit (MMIC) Power Amplifier (PA) with superior output power, linearity, and efficiency. These features make the SE2605L ideal for Wireless Local Area Network (WLAN IEEE 802.11n) applications.

The device is fabricated using SiGe BiCMOS technology. The device is internally matched and mounted in a 20-pin, 4 x 4 mm Quad Flat No-Lead (QFN) Surface-Mounted Technology (SMT) package, which allows for a highly manufacturable low cost solution.

A block diagram of the SE2605L is shown in Figure 1. The device package and pinout for the 16-pin QFN are shown in Figure 2. Signal pin assignments and functional pin descriptions are described in Table 1.



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**Figure 1. SE2605L Block Diagram**

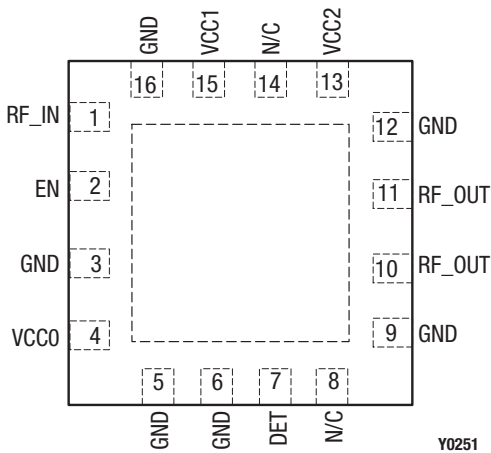


Figure 2. SE2605L Pinout (Top View)

Table 1. SE2605L Signal Descriptions

| Pin | Name  | Description                                      | Pin | Name   | Description                                      |
|-----|-------|--------------------------------------------------|-----|--------|--------------------------------------------------|
| 1   | RF_IN | RF Input                                         | 9   | GND    | Ground                                           |
| 2   | EN    | Power amplifier enable                           | 10  | RF_OUT | RF output                                        |
| 3   | GND   | Ground                                           | 11  | RF_OUT | RF output                                        |
| 4   | VCC0  | Power supply for bias circuit                    | 12  | GND    | Ground                                           |
| 5   | GND   | Ground                                           | 13  | VCC2   | Power supply for second stage                    |
| 6   | GND   | Ground                                           | 14  | N/C    | Not connected. Can be left floating or grounded. |
| 7   | DET   | Power detector output                            | 15  | VCC1   | Power Supply driver stages                       |
| 8   | N/C   | Not connected. Can be left floating or grounded. | 16  | GND    | Ground                                           |

Technical Description

The SE2605L PA contains all of the needed RF matching and DC biasing circuits. The device also provides an output power detector voltage.

The SE2605L is a three-stage, SiGe BiCMOS device optimized for high linearity and power efficiency. These features make the device suitable for wideband digital applications, where PA linearity and power consumption are of critical importance (e.g., WiFi systems or WLANs).

The device has been characterized with the highest specified data rates for IEEE 802.11n (64 QAM). Under these stringent test conditions, the device exhibits excellent spectral purity and power efficiency.

Electrical and Mechanical Specifications

The absolute maximum ratings of the SE2605L are provided in Table 2. Recommended operating conditions are specified in Table 3. Electrical specifications are provided in Tables 4, 5, and 6.

**Table 2. SE2605L Absolute Maximum Ratings<sup>1</sup>**

| Parameter                                                    | Symbol           | Minimum | Maximum | Units |
|--------------------------------------------------------------|------------------|---------|---------|-------|
| Supply voltage                                               | VCC1, VCC2, VCC3 | -0.3    | +5.5    | V     |
| Enable voltage                                               | PA_EN            | -0.3    | +3.6    | V     |
| RF input power                                               | P <sub>IN</sub>  |         | +12     | dBm   |
| Operating temperature                                        | T <sub>OP</sub>  | -40     | +85     | °C    |
| Storage temperature                                          | T <sub>ST</sub>  | -40     | +150    | °C    |
| Junction temperature                                         | T <sub>J</sub>   |         | +160    | °C    |
| Thermal resistance                                           | Θ <sub>JC</sub>  |         | 13      | °C/W  |
| Electrostatic discharge:<br>Human Body Model (HBM), Class 1C | ESD              |         | 1000    | V     |

<sup>1</sup> 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. SE2605L Recommended Operating Conditions**

| Parameter                  | Symbol           | Minimum | Typical | Maximum | Units |
|----------------------------|------------------|---------|---------|---------|-------|
| Supply voltage             | VCC1, VCC2, VCC3 | 3.0     | 5.00    | 5.25    | V     |
| Enable voltage             | PA_EN            | 1.8     |         | 3.6     | V     |
| Case operating temperature | T <sub>OP</sub>  | -40     | +25     | +85     | °C    |

**Table 4. SE2605L Electrical Specifications: DC Characteristics<sup>1</sup>**

(VCC1 = VCC2 = VCC3 = 5.0 V, PA\_EN = 3.3 V, T<sub>OP</sub> = +25 °C as Measured on the Evaluation Board, Unless Otherwise Noted)

| Parameter                      | Symbol          | Test Condition                                                   | Min | Typical | Max | Units |
|--------------------------------|-----------------|------------------------------------------------------------------|-----|---------|-----|-------|
| Supply current                 | I <sub>CC</sub> | 802.11n:<br>P <sub>OUT</sub> = +26 dBm,<br>MCS7, 54 Mbps, 64 QAM | 400 | 500     | 560 | mA    |
|                                |                 | P <sub>OUT</sub> = +29 dBm, 11Mbps,<br>CCK signal, BT = 0.45     | 600 | 650     | 690 | μA    |
|                                |                 | PA_EN = 0 V, No RF                                               |     | 10      | 100 |       |
| Quiescent Current              | I <sub>CQ</sub> | No RF                                                            |     | 220     |     | mA    |
| Enable voltage:<br>High<br>Low | PAEN_H          |                                                                  | 1.8 |         | 3.6 | V     |
|                                | PAEN_L          |                                                                  | 0   |         | 0.5 | V     |
| Enable current                 | I <sub>EN</sub> |                                                                  |     | 300     |     | μA    |
| Enable pin input impedance     | Z <sub>EN</sub> | Passive pull down                                                |     | 10      |     | kΩ    |

<sup>1</sup> Performance is guaranteed only under the conditions listed in this table.

**Table 5. SE2605L Electrical Specifications: General<sup>1</sup>**  
**(VCC1 = VCC2 = VCC3 = 5.0 V, PA\_EN = 3.3 V, T<sub>OP</sub> = +25 °C, Unless Otherwise Noted)**

| Parameter                                     | Symbol                          | Test Condition                                                   | Min                                                | Typical | Max | Units   |
|-----------------------------------------------|---------------------------------|------------------------------------------------------------------|----------------------------------------------------|---------|-----|---------|
| Frequency range                               | f                               |                                                                  | 2.4                                                |         | 2.5 | GHz     |
| Output power                                  | P <sub>OUT</sub>                | 54 Mbps OFDM signal, 64 QAM, 3% EVM                              | +24                                                | +26     |     | dBm     |
|                                               |                                 | 11 Mbps CCK signal, BT = 0.045, mask                             | +27                                                | +29     |     | dBm     |
| 1 dB output compression point                 | OP1dB                           | P <sub>IN</sub> = CW                                             | +29                                                | +32     |     | dBm     |
| Small signal gain                             | IS21I                           |                                                                  | 30                                                 | 33      | 36  | dB      |
| Input return loss                             | IS11I                           |                                                                  | 10                                                 | 15      |     | dB      |
| Gain variation                                | Δ S21                           | Over 40 MHz channel                                              |                                                    | 0.5     |     | dB      |
|                                               |                                 | Over entire band                                                 |                                                    | 1.0     |     | dB      |
| 2 <sup>nd</sup> and 3 <sup>rd</sup> harmonics | 2fo, 3fo                        | P <sub>OUT</sub> = +29 dBm                                       |                                                    | -50     | -45 | dBm/MHz |
| Rise and fall time                            | t <sub>R</sub> , t <sub>F</sub> | 50% of V <sub>EN</sub> edge to 10%/90% of final power level      |                                                    | 0.5     |     | μs      |
| Stability                                     |                                 | P <sub>OUT</sub> = +29 dBm, VSWR = 4:1, all phases               | All non-harmonically related outputs < -42 dBm/MHz |         |     |         |
| Ruggedness                                    | Ru                              | P <sub>IN</sub> = +12dBm, 50% duty cycle, VSWR = 6:1, all phases | No damage                                          |         |     |         |

<sup>1</sup> Performance is guaranteed only under the conditions listed in this table.

**Table 6. SE2605L Electrical Specifications: Power Detector Characteristics<sup>1</sup>**  
**(VCC = 5.0 V, PA\_EN = 3.3 V, T<sub>OP</sub> = +25 °C, f = 2.45 GHz, Unless Otherwise Noted)**

| Parameter                   | Symbol  | Test Condition                | Min  | Typical | Max   | Units |
|-----------------------------|---------|-------------------------------|------|---------|-------|-------|
| Output power detector range | PDR     |                               | 0    |         | OP1dB | dBm   |
| Detector voltage            | VDET    | P <sub>OUT</sub> = +30 dBm    | 0.90 | 1.00    | 1.15  | V     |
|                             |         | P <sub>OUT</sub> = +26 dBm    | 0.65 | 0.73    | 0.82  | V     |
|                             |         | P <sub>OUT</sub> = 5 dB       | 0.30 | 0.33    | 0.36  | V     |
| Detector accuracy           | ERRDET  | VSWR = 3:1<br>-1.5 to +1.5 dB | -1.5 |         | +1.5  | dB    |
| Output impedance            | PDZOUT  |                               |      | 2.3     |       | kΩ    |
| DC load impedance           | PDZLOAD |                               |      | 26.5    |       | kΩ    |

<sup>1</sup> Performance is guaranteed only under the conditions listed in this table.

## Evaluation Board Description

The SE2605L Evaluation Board is used to test the performance of the SE2605L WLAN PA. A schematic diagram of the SE2605L Evaluation Board is shown in Figure 3. A photograph of the Evaluation Board is shown in Figure 4. Component values for the SE2605L Evaluation Board are listed in Table 7.

## 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 SE2605L 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. For further information, refer to the Skyworks Application Note *PCB Design Guidelines for High Power Dissipation Packages*, document number 201211.
- Bypass capacitors should be used on the DC supply lines. Refer to the schematic drawing in Figure 3 for further details.

- The RF lines should be well separated from each other with solid ground in between traces to maximize input-to-output isolation.

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

## Evaluation Board Setup Procedure

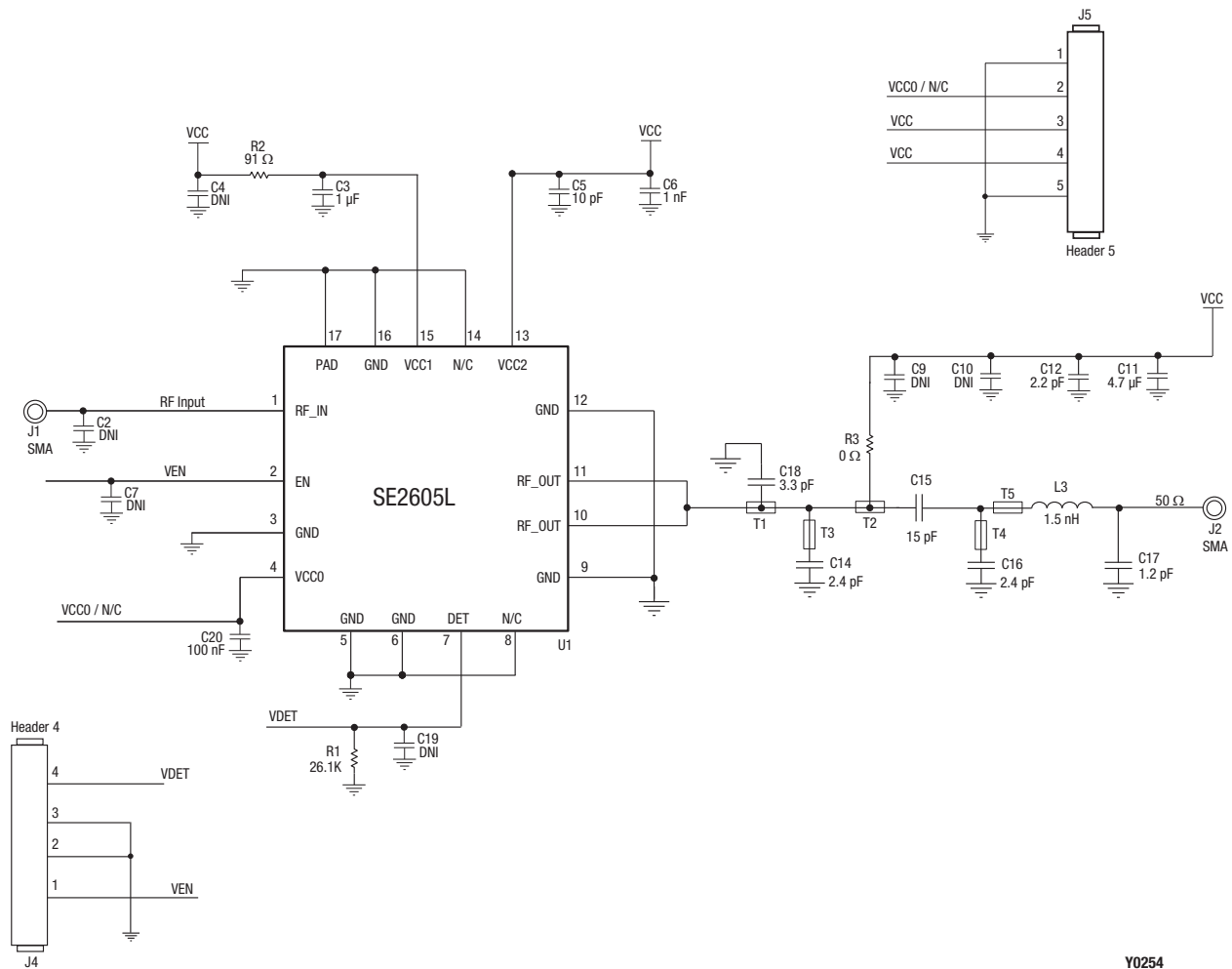
1. Connect system ground to pin 1 of connector J5.
2. Apply 5.0 V to pins 3 and 4 of connector J5.
3. By applying 3.3 V on PA\_EN (pin 1 of the J4 header), the PA is enabled. By placing a ground on PA\_EN, the PA is disabled and placed in a shutdown state, drawing minimal current.
4. The 2 GHz amplifier performance can be monitored by applying an RF signal to connector J1 (RF\_IN). Monitor the output power on the RF\_OUT port connector, J1.

Detector performance can be monitored on pin 4 of connector J4.

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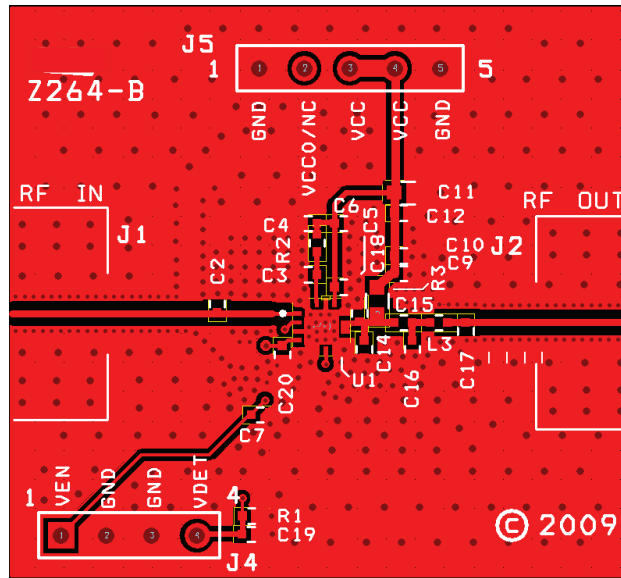
**CAUTION:** Do not overdrive the amplifier by applying too much RF on the device input. A suitable starting input power setting is  $-20$  dBm.

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Figure 3. SE2605L Evaluation Board Schematic



Y0262

Figure 4. SE2605L Evaluation Board

Table 7. SE2605L Evaluation Board Bill of Materials

| Component           | Quantity | Value       | Vendor    | Part Number       |
|---------------------|----------|-------------|-----------|-------------------|
| C2,C4,C7,C9,C10,C19 | 6        | DNI         |           |                   |
| C3                  | 1        | 1 $\mu$ F   | Murata    | GRM155R60J105KE19 |
| C5                  | 1        | 10 Pf       | Murata    | GRM1555C1H100JZ01 |
| C6                  | 1        | 1 nF        | Murata    | GRM155R71H102KA01 |
| C11                 | 1        | 4.7 $\mu$ F | Murata    | GRM188R60J475KE19 |
| C12                 | 1        | 2.2 pF      | Murata    | GRM1555C1H2R2CZ01 |
| C14 and C16         | 2        | 2.4 pF      | Murata    | GRM1555C1H2R4CZ01 |
| C15                 | 1        | 1.2 pF      | Murata    | GRM1555C1H150JZ01 |
| C17                 | 1        | 3.3 pF      | Murata    | GRM1555C1H1R2CZ01 |
| C18                 | 1        | 27 $\Omega$ | Murata    | GRM1555C1H3R3CZ01 |
| C20                 | 1        | 100 nF      | Murata    | GRM155R61A104KA01 |
| J1 and J2           | 2        | SMA         | Johnson   | 142-0701-851      |
| J4                  | 1        | Header 4    | Samtec    | TSW-104-07-G-S    |
| J5                  | 1        | Header 5    | Samtec    | TSW-105-07-G-S    |
| L3                  | 1        | 1.5 nH      | Murata    | LQG15HN1N5S02D    |
| PCB1                | 1        | Z264-B      | Skyworks  | Z264-B            |
| R1                  | 1        | 26.7 K      | Panasonic | ERJ2RKF2672       |
| R2                  | 1        | 91 $\Omega$ | Panasonic | ERJ2GEJ910        |
| R3                  | 1        | 0 $\Omega$  | Panasonic | ERJ3GEJ0R0        |
| U1                  |          | SE2605L     | Skyworks  | SE2605L           |

## Package Dimensions

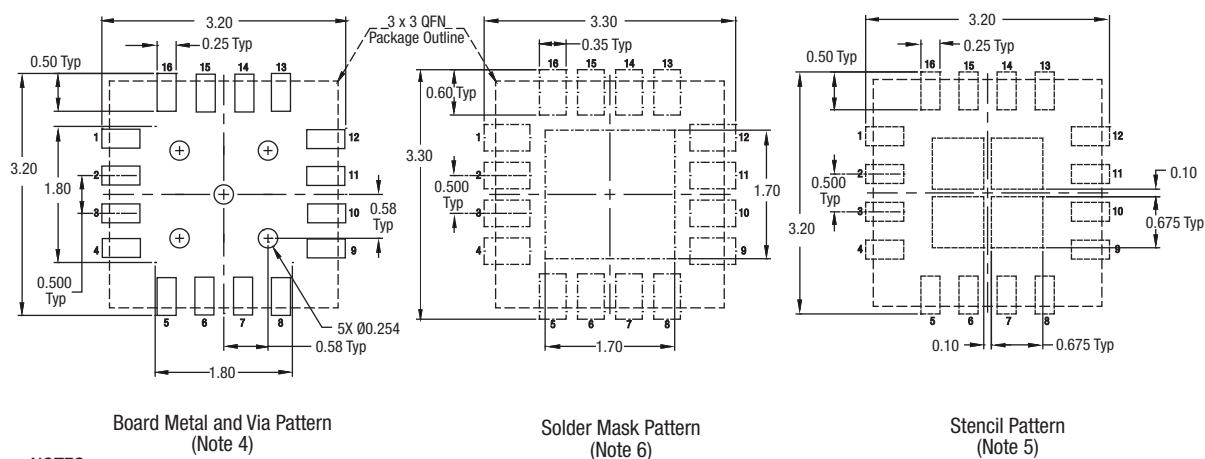
The PCB layout footprint for the SE2605L is provided in Figure 5. Typical part markings are shown in Figure 6. Package dimensions are shown in Figure 7, and tape and reel dimensions are provided in Figure 8.

## Package and Handling Information

Since the device package is sensitive to moisture absorption, it is baked and vacuum packed before shipping. 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 SE2605L is rated to Moisture Sensitivity Level 3 (MSL3) 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.

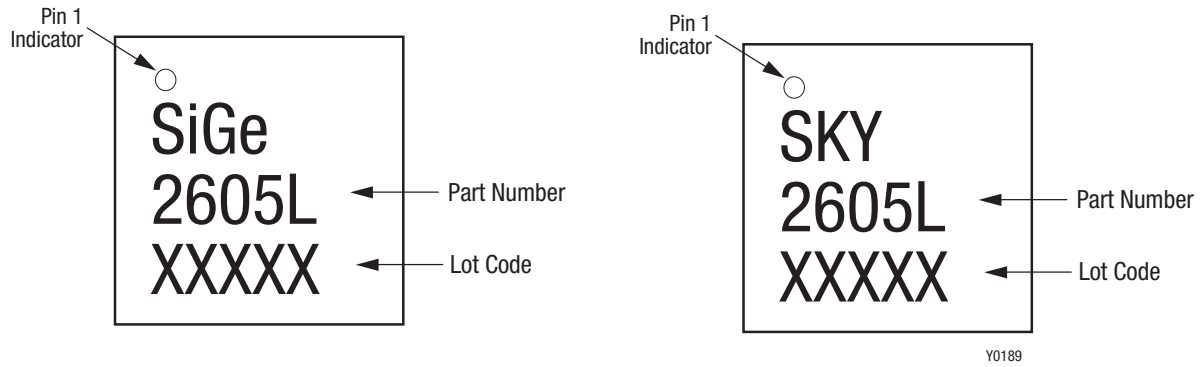


### NOTES:

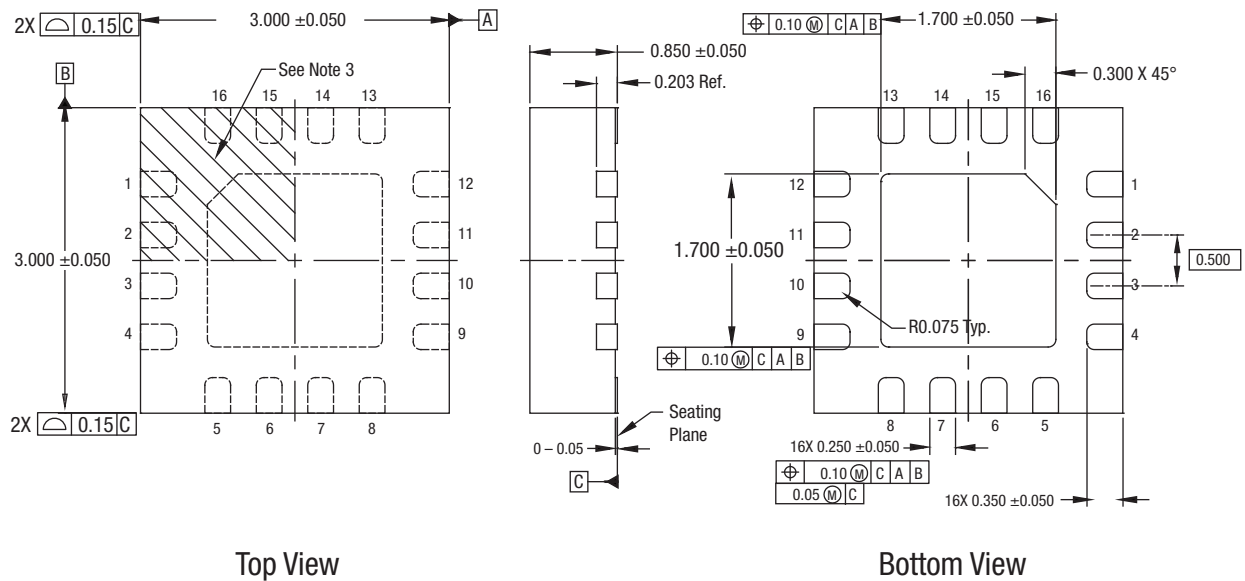
1. All dimensions are in millimeters.
2. Dimensions and tolerances per ASME Y14.5M-1994.
3. Unless specified, dimensions are symmetrical about center lines.
4. Via hole recommendations:  
Size (Ø): 0.150 to 0.300 mm  
Pitch: 0.500  
Cu via wall plating: 30-35 µm  
Should be tented with solder mask on PCB backside and filled with solder.
5. Stencil recommendations: 0.127 mm stencil thickness.
6. Solder mask recommendations: Aperture array to target approximately 50 to 80% coverage of solder mask openings, except as noted.

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**Figure 5. PCB Layout Footprint for the SE2605L**



**Figure 6. Typical Part Markings (Top View)**

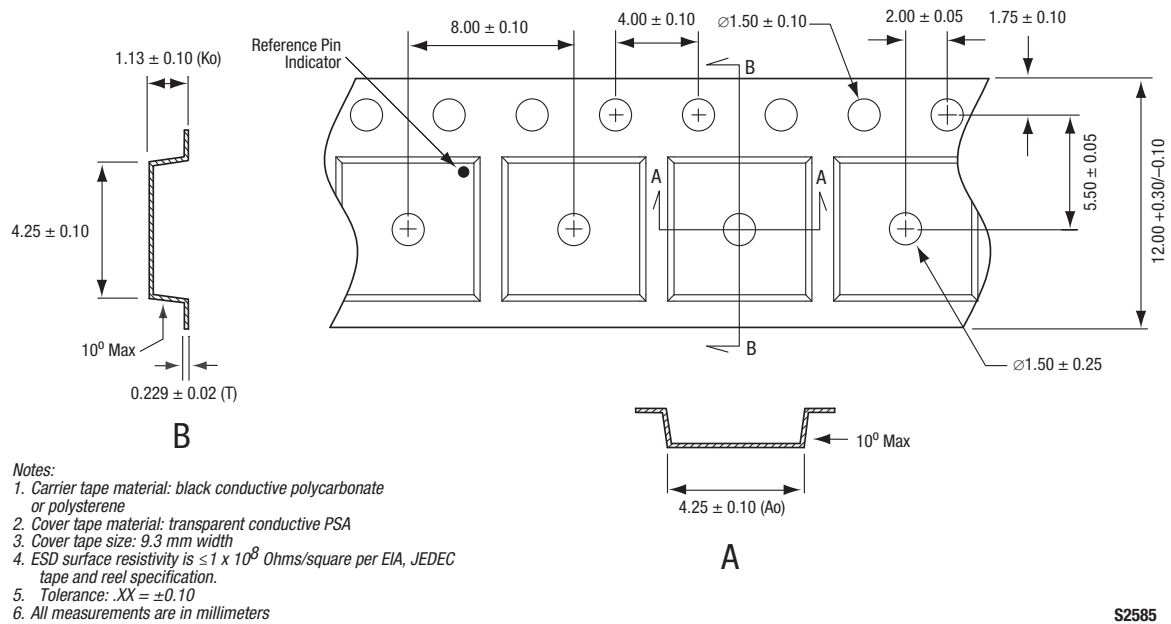


**NOTES:**

1. All measurements are in millimeters.
2. Dimensioning and tolerancing according to ASME Y14.5M-1994.  
Unless otherwise specified the following values apply:  
Decimal Tolerance: Angular Tolerance:  
X.X (1 place)  $\pm 0.1$  mm  $\pm 1^\circ$   
X.XX (2 places)  $\pm 0.05$  mm  
X.XXX (3 places)  $\pm 0.025$  mm
3. Terminal #1 identification mark located within marked area.
4. Coplanarity applies to the exposed heat sink ground pad as well as the terminals.
5. Unless specified, dimensions are symmetrical about center lines.

Y0265

**Figure 7. SE2605L Package Dimensions**



**Figure 8. SE2605L Tape and Reel Dimensions**

## Ordering Information

| Model Name                              | Manufacturing Part Number | Evaluation Board Part Number |
|-----------------------------------------|---------------------------|------------------------------|
| SE2605L High Power WLAN Power Amplifier | SE2605L                   | SE2605L-EK1                  |

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