

### UltraCMOS® RF Digital Attenuator 2-bit, 18 dB, 35–6000 MHz

#### Product Description

The PE43205 is a 50Ω, HaRP™ technology-enhanced fast switching 2-bit RF Digital Step Attenuator (DSA) designed for use in 3G/4G wireless infrastructure and other high performance RF applications.

This DSA is a pin-compatible upgraded version of the PE43204 with a wider frequency and power supply range, and extended operating temperature range.

Covering an 18 dB attenuation range in 6 dB and 12 dB steps, it maintains high RF performance and low power consumption from 35 MHz through 6 GHz. PE43205 is offered in a 12-lead 3x3 mm QFN package. In addition, no external blocking capacitors are required if 0 VDC is present on the RF ports.

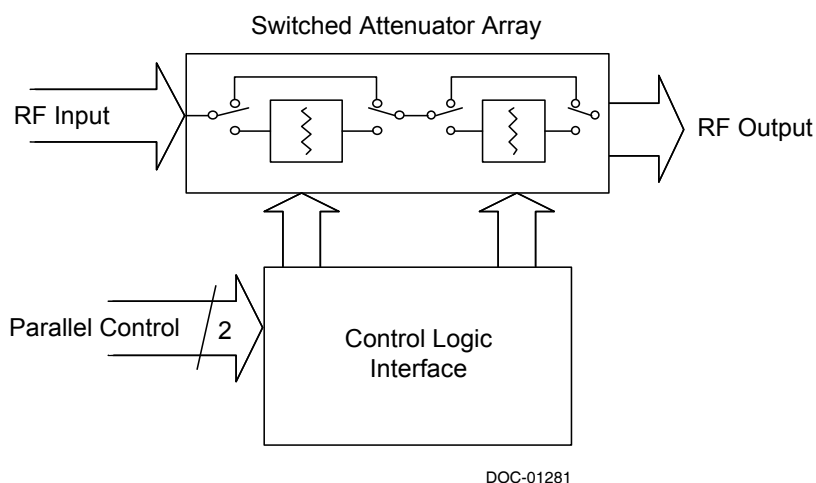
The PE43205 is manufactured on pSemi's UltraCMOS® process, a patented variation of silicon-on-insulator (SOI) technology on a sapphire substrate.

pSemi's HaRP™ technology enhancements deliver high linearity and excellent harmonics performance. It is an innovative feature of the UltraCMOS process, offering the performance of GaAs with the economy and integration of conventional CMOS.

#### Features

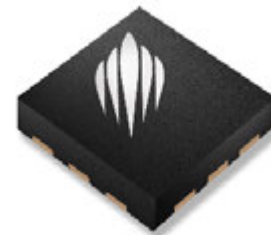
- Attenuation: 6 dB / 12 dB steps to 18 dB
- Fast switching time of 29 ns
- Low attenuation error
  - 0.10 dB @ 2 GHz
  - 0.15 dB @ 3 GHz
- High linearity
  - +61 dBm IIP3 @ 1950 MHz
- Wide supply range of 2.3V to 5.5V
- 1.8V control logic compatible
- 105°C operating temperature
- ESD performance
  - 2 kV HBM on all pins
  - 100V MM on all pins
  - 1 kV CDM on all pins
- Parallel control

**Figure 1. Functional Diagram**



**Figure 2. Package Type**

12-lead 3x3 mm QFN



**Table 1. Electrical Specifications @ +25°C, V<sub>DD</sub> = 2.3V to 5.5V**

| Parameter                       | Condition                       | Min   | Typ  | Max  | Unit |
|---------------------------------|---------------------------------|-------|------|------|------|
| Frequency range                 |                                 | 35    |      | 6000 | MHz  |
| Attenuation range               | 6 dB and 12 dB steps            |       | 0–18 |      | dB   |
| Insertion loss                  | 35 MHz–2 GHz                    |       | 0.50 | 0.60 | dB   |
|                                 | 2–3 GHz                         |       | 0.60 | 0.70 | dB   |
|                                 | 3–4 GHz                         |       | 0.70 | 0.80 | dB   |
|                                 | 4–5 GHz                         |       | 0.85 | 1.10 | dB   |
|                                 | 5–6 GHz                         |       | 1.05 | 1.30 | dB   |
| Attenuation error               | 0 dB–18 dB attenuation settings |       |      |      |      |
|                                 | 35 MHz–2 GHz                    | –0.45 | 0.10 | 0.40 | dB   |
|                                 | >2–3 GHz                        | –0.45 | 0.15 | 0.50 | dB   |
|                                 | >3–4 GHz                        | –0.15 | 0.45 | 1.05 | dB   |
|                                 | >4–5 GHz                        | –0.15 | 0.55 | 1.25 | dB   |
| >5–6 GHz                        | –0.30                           | 0.75  | 1.55 | dB   |      |
| Return loss                     | 35 MHz–2 GHz                    |       | 17   |      | dB   |
|                                 | 2–3 GHz                         |       | 14   |      | dB   |
|                                 | 3–4 GHz                         |       | 11   |      | dB   |
|                                 | 4–5 GHz                         |       | 10   |      | dB   |
|                                 | 5–6 GHz                         |       | 9    |      | dB   |
| Relative phase                  | All states                      |       |      |      |      |
|                                 | 35 MHz–2 GHz                    |       | 9    |      | deg  |
|                                 | 2–3 GHz                         |       | 12   |      | deg  |
|                                 | 3–4 GHz                         |       | 17   |      | deg  |
|                                 | 4–5 GHz                         |       | 22   |      | deg  |
| 5–6 GHz                         |                                 | 24    |      | deg  |      |
| Input 0.1dB compression point * | 200 MHz–6 GHz                   |       | 30   |      | dBm  |
| IIP3                            | 1950 MHz                        |       | 61   |      | dBm  |
| Switching time                  | 50% DC CTRL to 90% or 10% RF    |       | 29   |      | ns   |

Note: \* Input 0.1 dB compression point is a linearity figure of merit. Refer to *Table 3* for operating RF input power (50Ω).

**Table 1A. Electrical Specifications @ +105°C, V<sub>DD</sub> = 2.3V to 5.5V**

| Parameter                       | Condition                       | Min   | Typ   | Max  | Unit |
|---------------------------------|---------------------------------|-------|-------|------|------|
| Frequency range                 |                                 | 35    |       | 6000 | MHz  |
| Attenuation range               | 6 dB and 12 dB steps            |       | 0–18  |      | dB   |
| Insertion loss                  | 35 MHz–2 GHz                    |       | 0.60  | 0.70 | dB   |
|                                 | 2–3 GHz                         |       | 0.65  | 0.80 | dB   |
|                                 | 3–4 GHz                         |       | 0.80  | 0.90 | dB   |
|                                 | 4–5 GHz                         |       | 0.95  | 1.20 | dB   |
|                                 | 5–6 GHz                         |       | 1.15  | 1.45 | dB   |
| Attenuation error               | 0 dB–18 dB attenuation settings |       |       |      |      |
|                                 | 35 MHz–2 GHz                    | –0.35 | –0.03 | 0.25 | dB   |
|                                 | >2–3 GHz                        | –0.45 | –0.10 | 0.30 | dB   |
|                                 | >3–4 GHz                        | –0.45 | –0.15 | 0.65 | dB   |
|                                 | >4–5 GHz                        | –0.35 | 0.25  | 0.85 | dB   |
| >5–6 GHz                        | –0.45                           | 0.40  | 1.15  | dB   |      |
| Return loss                     | 35 MHz–2 GHz                    |       | 18    |      | dB   |
|                                 | 2–3 GHz                         |       | 15    |      | dB   |
|                                 | 3–4 GHz                         |       | 11    |      | dB   |
|                                 | 4–5 GHz                         |       | 10    |      | dB   |
|                                 | 5–6 GHz                         |       | 9.5   |      | dB   |
| Relative phase                  | All states                      |       |       |      |      |
|                                 | 35 MHz–2 GHz                    |       | 9     |      | deg  |
|                                 | 2–3 GHz                         |       | 13    |      | deg  |
|                                 | 3–4 GHz                         |       | 17    |      | deg  |
|                                 | 4–5 GHz                         |       | 23    |      | deg  |
| 5–6 GHz                         |                                 | 25    |       | deg  |      |
| Input 0.1dB compression point * | 200 MHz–6 GHz                   |       | 30    |      | dBm  |
| IIP3                            | 1950 MHz                        |       | 63    |      | dBm  |
| Switching time                  | 50% DC CTRL to 90% or 10% RF    |       | 31    |      | ns   |

Note: \* Input 0.1 dB compression point is a linearity figure of merit. Refer to *Table 3* for operating RF input power (50Ω).

Figure 3. Pin Configuration (Top View)

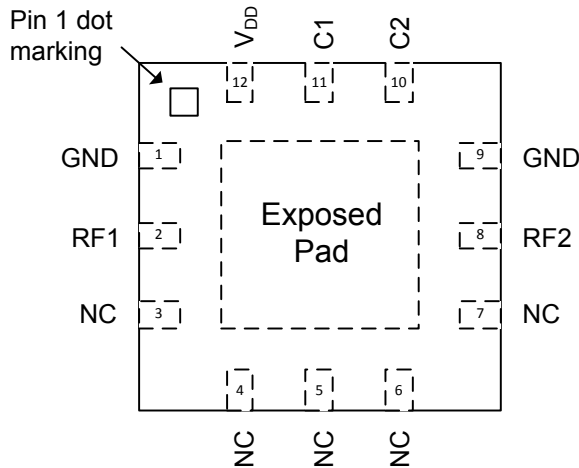


Table 2. Pin Descriptions

| Pin # | Pin Name         | Description                    |
|-------|------------------|--------------------------------|
| 1     | GND              | Ground                         |
| 2     | RF1 <sup>2</sup> | RF1 port                       |
| 3     | NC <sup>1</sup>  | No connect                     |
| 4     | NC <sup>1</sup>  | No connect                     |
| 5     | NC <sup>1</sup>  | No connect                     |
| 6     | NC <sup>1</sup>  | No connect                     |
| 7     | NC <sup>1</sup>  | No connect                     |
| 8     | RF2 <sup>2</sup> | RF2 port                       |
| 9     | GND              | Ground                         |
| 10    | C2               | Attenuation control bit, 12 dB |
| 11    | C1               | Attenuation control bit, 6 dB  |
| 12    | V <sub>DD</sub>  | Supply voltage (nominal 3.3V)  |

Notes: 1. Pins 3 through 7 may be tied to ground if desired, but they are not connected to ground internal to the package.  
2. RF pins 2 and 8 must be at 0 VDC. The RF pins do not require DC blocking capacitors for proper operation if the 0 VDC requirement is met.

Table 3. Operating Ranges

| Parameter  | Symbol                  | Min  | Typ | Max            | Unit |
|--|-------------------------|------|-----|----------------|------|
| Supply voltage   | V <sub>DD</sub>         | 2.3  |     | 5.5            | V    |
| Supply current   | I <sub>DD</sub>         |      | 130 | 200            | μA   |
| Digital input high                                       | V <sub>IH</sub>         | 1.17 |     | 3.6            | V    |
| Digital Input Low  | V <sub>IL</sub>         | -0.3 |     | 0.6            | V    |
| Digital input leakage                                    |                         |      |     | 10             | μA   |
| RF input power, CW<br>35 MHz–4 GHz<br>>4 GHz–6 GHz       | P <sub>MAX,CW</sub>     |      |     | See Fig. 4 +24 | dBm  |
| RF input power, pulsed *<br>35 MHz–4 GHz<br>>4 GHz–6 GHz | P <sub>MAX,PULSED</sub> |      |     | See Fig. 4 +27 | dBm  |
| Operating temperature range                              | T <sub>OP</sub>         | -40  | +25 | +105           | °C   |

Note: \* Pulsed, 5% duty cycle of 4620 μs period, 50Ω

Table 4. Absolute Maximum Ratings

| Parameter/Condition                        | Symbol               | Min  | Max   | Unit |
|--|----------------------|------|-------|------|
| Supply voltage                             | V <sub>DD</sub>      | -0.3 | 5.5   | V    |
| Voltage on any digital input               | V <sub>I</sub>       | -0.3 | 3.6   | V    |
| Storage temperature range                  | T <sub>ST</sub>      | -65  | +150  | °C   |
| Maximum input power                        | P <sub>MAX,ABS</sub> |      | +27.5 | dBm  |
| ESD voltage HBM <sup>1</sup> , on all pins | V <sub>ESD,HBM</sub> |      | 2000  | V    |
| ESD voltage MM <sup>2</sup> , on all pins  | V <sub>ESD,MM</sub>  |      | 100   | V    |
| ESD voltage CDM <sup>3</sup> , on all pins | V <sub>ESD,CDM</sub> |      | 1000  | V    |

Notes: 1. Human Body Model (MIL-STD 883 Method 3015.7)  
2. Machine Model (JEDEC JESD22-A115)  
3. Charged Device Model (JEDEC JESD22-C101)

Exceeding absolute maximum ratings may cause permanent damage. Operation should be restricted to the limits in the Operating Ranges table. Operation between operating range maximum and absolute maximum for extended periods may reduce reliability.

**Electrostatic Discharge (ESD) Precautions**

When handling this UltraCMOS device, observe the same precautions that you would use with other ESD-sensitive devices. Although this device contains circuitry to protect it from damage due to ESD, precautions should be taken to avoid exceeding the specified rating.

**Latch-Up Avoidance**

Unlike conventional CMOS devices, UltraCMOS devices are immune to latch-up.

**Switching Frequency**

The PE43205 has a maximum 25 kHz switching rate. Switching rate is defined to be the speed at which the DSA can be toggled across attenuation states. Switching time is the time duration between the point the control signal reaches 50% of the final value and the point the output signal reaches within 10% or 90% of its target value.

**Spurious Performance**

The typical low-frequency spurious performance of the PE43205 is -135 dBm.

**Table 5. Attenuation Word Truth Table**

| C1 | C2 | Attenuation Setting RF1–RF2 |
|----|----|-----------------------------|
| L  | L  | Reference I.L.              |
| H  | L  | 6 dB                        |
| L  | H  | 12 dB                       |
| H  | H  | 18 dB                       |

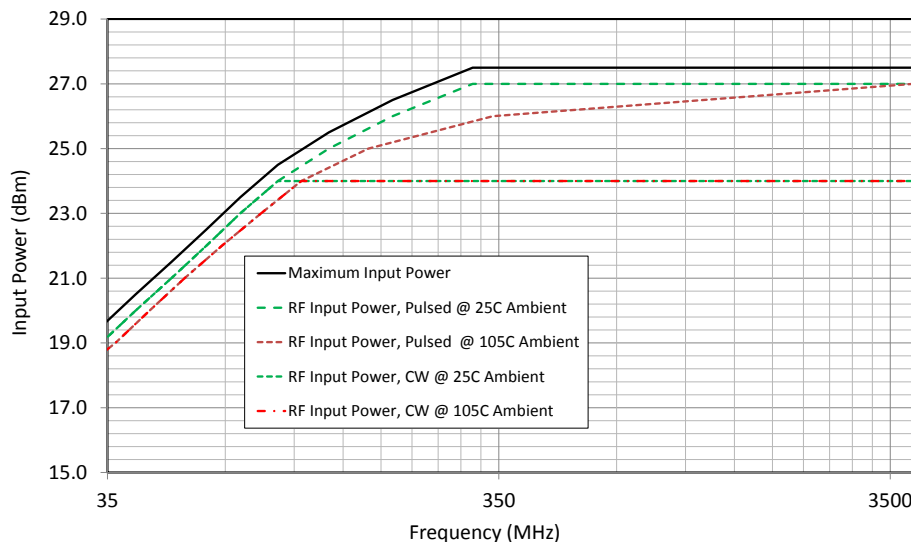
**Moisture Sensitivity Level**

The Moisture Sensitivity Level rating for the PE43205 in the 12-lead 3x3 mm QFN package is MSL1.

**Exposed Solder Pad Connection**

The exposed solder pad on the bottom of the package must be grounded for proper device operation.

**Figure 4. Power De-Rating Curve for 35 MHz–4 GHz**



Typical Performance Data @ +25°C and  $V_{DD} = 3.3V$ , unless otherwise specified

Figure 5. Attenuation vs. Attenuation Setting

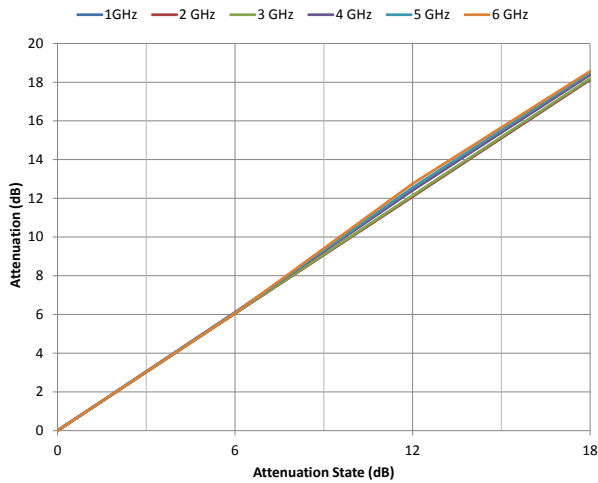


Figure 6. Attenuation Error vs. Frequency

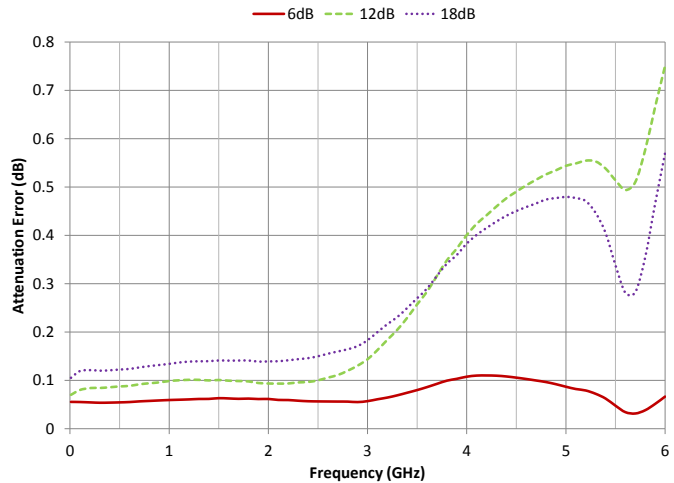


Figure 7. Insertion Loss vs. Temperature

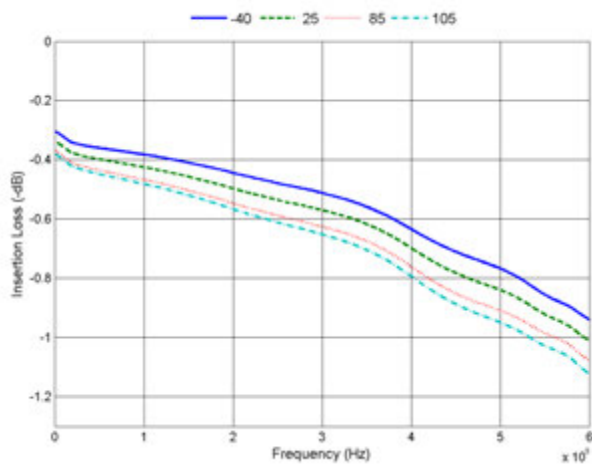


Figure 8. Input Return Loss vs. Attenuation State

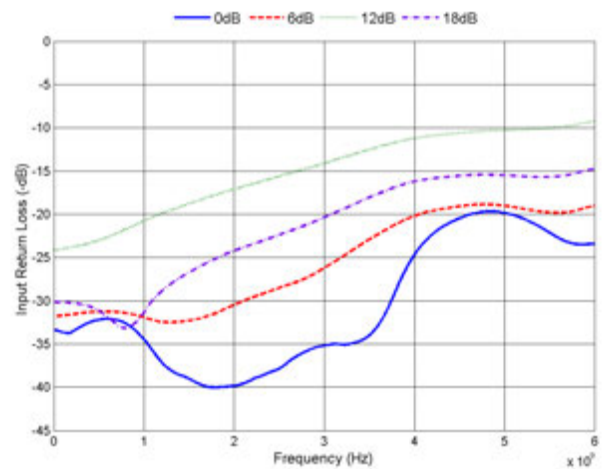


Figure 9. Output Return Loss vs. Attenuation State

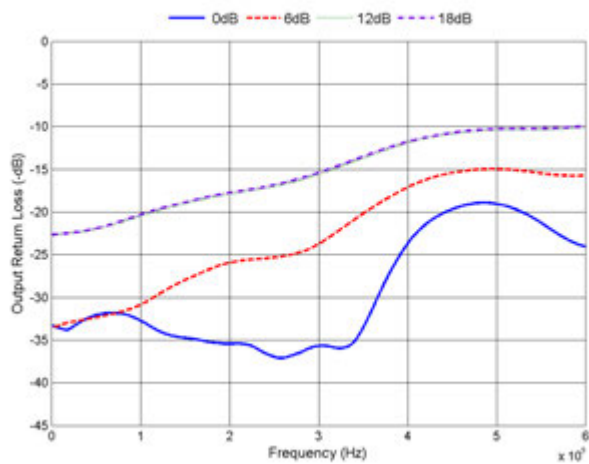
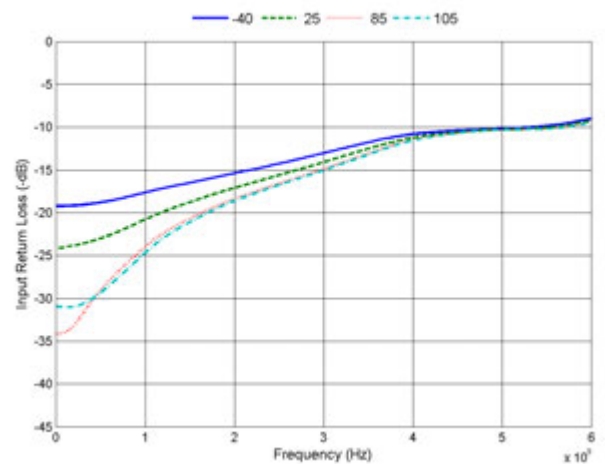


Figure 10. Input Return Loss vs. Temperature @ 12 dB State



Typical Performance Data @ 25°C and  $V_{DD} = 3.3V$ , unless otherwise specified

Figure 11. Output Return Loss vs. Temperature  
@ 12 dB State

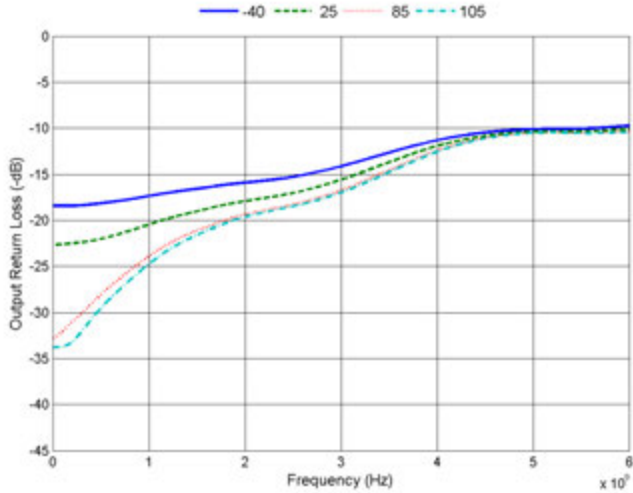
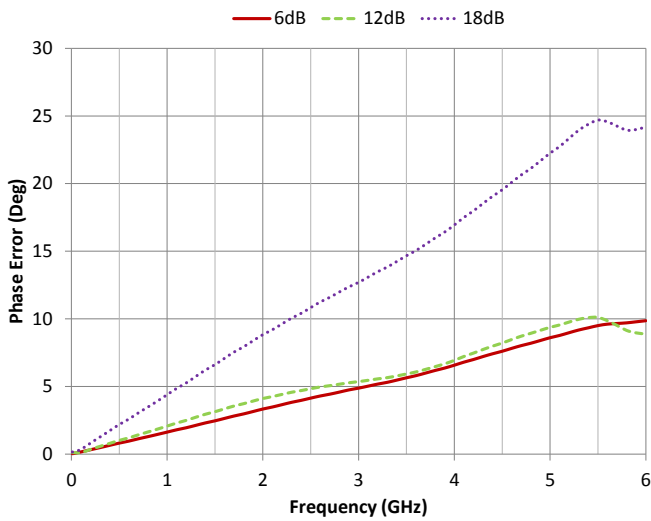


Figure 12. Relative Phase vs. Frequency



## Evaluation Kit

The 2-bit DSA evaluation kit board was designed to ease customer evaluation of pSemi's PE43205.

To evaluate the PE43205, apply 3.3V to the  $V_{DD}$  header pin and Ground to the GND header pin. The DUT can be controlled two ways:

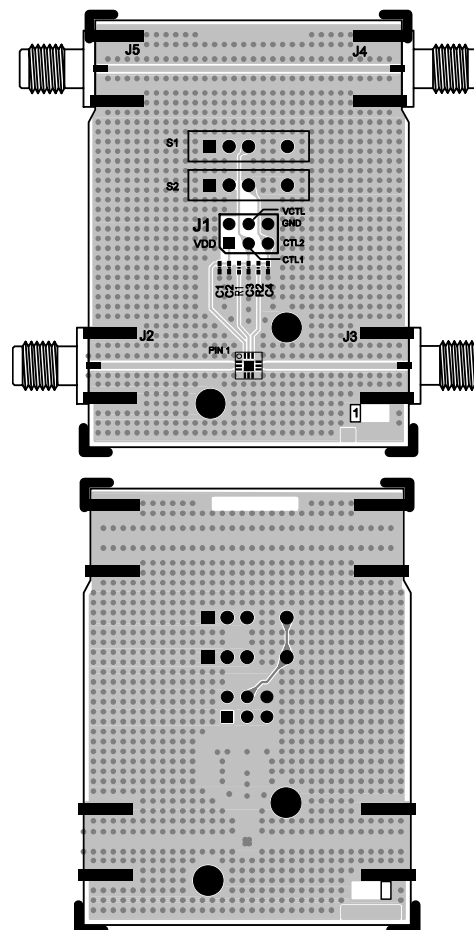
1. *The mechanical switches in conjunction with the VCTL pin can be used.* Apply desired control voltage to VCTL header pin. The top mechanical switch controls the 6 dB stage, the bottom mechanical switch controls the 12 dB stage. For each switch, the left position is the 0V condition, while the right position is the  $V_{CTRL}$  condition. The middle position leaves the control pin floating.
2. *The CTL1 and CTL2 pins on the header can be used.* Each pin directly controls the 6 dB and 12 dB stage respectively. The VCTL pin on the header is left open. The mechanical switches may be left uninstalled or must be kept in the middle position.

Note: To accurately measure the fast switching performance of the PE43205, C3 and C4 should be removed.

## Power-up Control Settings

The PE43205 will always power up into the state determined by the voltages on the two control pins. The DSA can be preset to any state within the 18 dB range by pre-setting the parallel control pins prior to power-up. There is a 10  $\mu$ s delay between the time the DSA is powered-up to the time the desired state is set. If the control pins are left floating during power-up, the device will default to the minimum attenuation setting (insertion loss state).

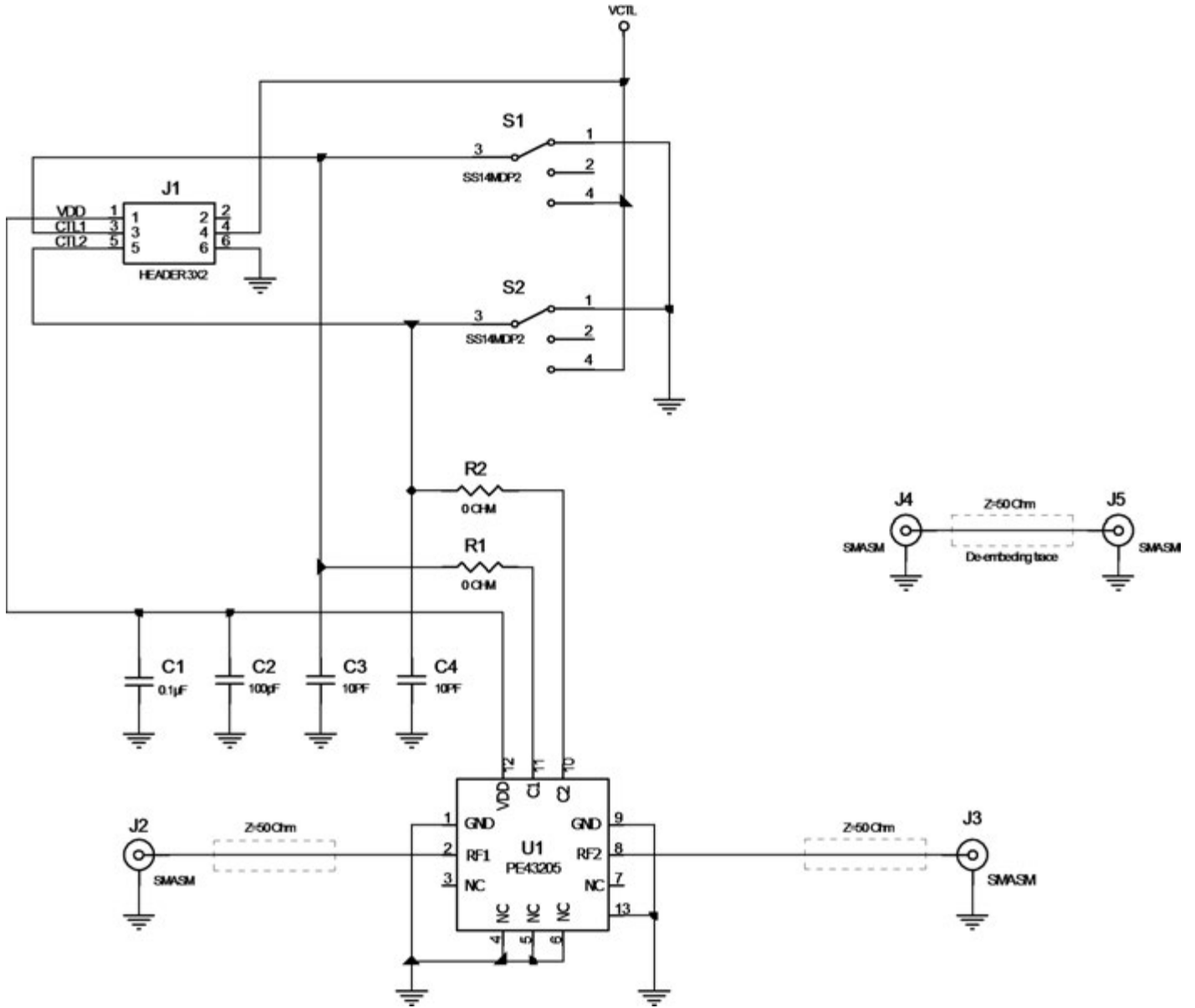
**Figure 13. Evaluation Board Layout**



PRT-53374



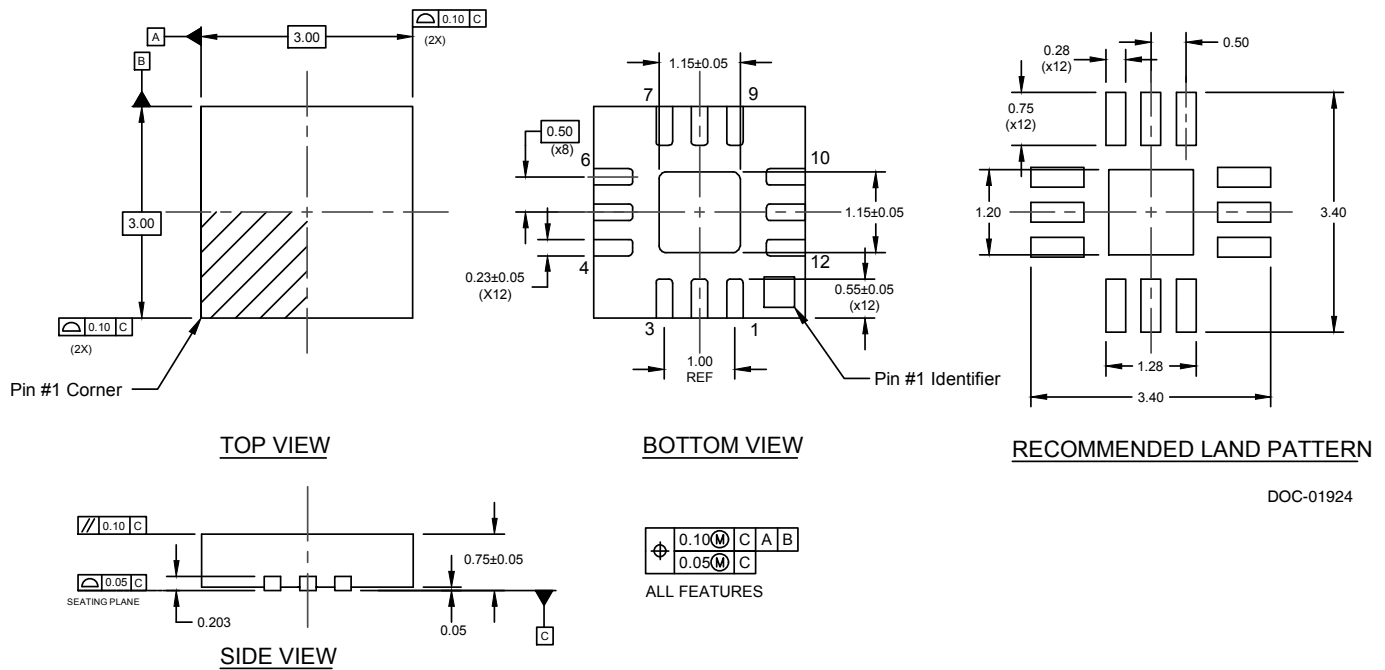
Figure 14. Evaluation Board Schematic



- Notes: 1. Use PCB part number PRT-53374.  
2. CAUTION: Contains parts and assemblies susceptible to damage by electrostatic discharge (ESD).

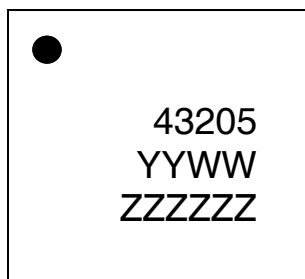
DOC-30927

**Figure 15. Package Drawing**  
12-lead 3x3 mm QFN



Note: Pin 1 identification tab is electrically connected to the exposed ground paddle.

**Figure 16. Top Marking Specifications**



- = Pin 1 designator
- 43205 = Five digit part number
- YYWW = Date Code, last two digits of the year and work week
- ZZZZZZ = Maximum six characters of the assembly lot code

DOC-51207