

## DATA SHEET

# RFX2401C: 2.4 GHz Zigbee® / ISM Front-End Module

## Applications

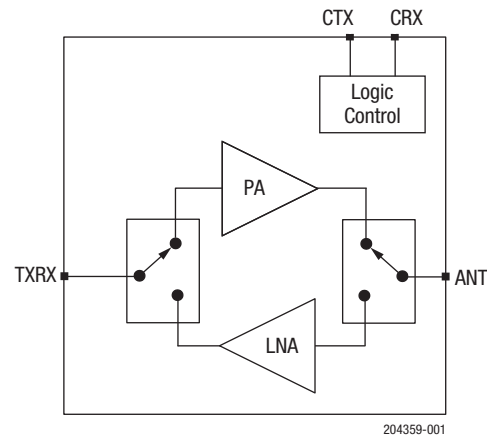
- Zigbee extended range devices
- Zigbee smart power
- Wireless sound and audio systems
- Home and industrial automation
- Wireless sensor networks
- Custom 2.4 GHz radio systems

## Features

- 2.4 GHz Zigbee high-power single-chip, single-die RF front-end IC
- Single-ended 50  $\Omega$  input and output ports
- Integrated PA with up to +22 dBm output power
- Integrated LNA with 2.5 dB noise figure
- Transmit/receive switch circuitry
- High transmit signal linearity meeting standards for OQPSK modulation
- Low voltage (1.2 V) CMOS control logic
- ESD protection circuitry on all ports
- DC decoupled RF ports
- Full on-chip matching and decoupling circuitry
- Market proven CMOS technology
- Small QFN, 16-pin (3 x 3 x 0.55 mm) package with exposed ground pad (MSL1, 260 °C per JEDEC J-STD-020)



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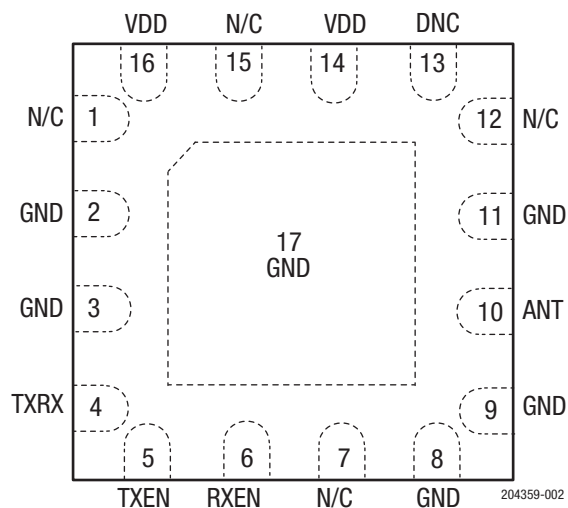
**Figure 1. RFX2401C Block Diagram**

## Description

The RFX2401C is a fully integrated front-end module that incorporates all the RF functionality needed for IEEE 802.15.4 / Zigbee, wireless sensor network, and any other wireless systems in the 2.4 GHz ISM band. The RFX2401C architecture integrates the PA, LNA, transmit and receive switching circuitry, and the associated matching network, all in a single package.

Typical high-power applications include home and industrial automation, smart power, and RF4CE among others. Combining superior performance, high sensitivity and efficiency, low noise, small form factor, and low cost, the RFX2401C is the perfect solution for applications requiring extended range and bandwidth. RFX2401C has simple and low-voltage CMOS control logic, and a wide operating supply voltage range.

The device is provided in a compact, 16-pin 3 x 3 mm Quad Flat No-Lead (QFN) package. A functional block diagram is shown in Figure 1. The pin configuration and package are shown in Figure 2. Signal pin assignments and functional pin descriptions are provided in Table 1.



**Figure 2. RFX2401C Pinout  
(Top View)**

**Table 1. RFX2401C Signal Descriptions**

| Pin | Name | Description                                           | Pin | Name | Description                                          |
|-----|------|-------------------------------------------------------|-----|------|------------------------------------------------------|
| 1   | N/C  | Not connected internally                              | 9   | GND  | Ground                                               |
| 2   | GND  | Ground                                                | 10  | ANT  | Connect to 50 $\Omega$ antenna (DC shorted to GND)   |
| 3   | GND  | Ground                                                | 11  | GND  | Ground                                               |
| 4   | TXRX | RF signal to/from the transceiver (DC shorted to GND) | 12  | N/C  | Not connected internally                             |
| 5   | TXEN | CMOS input to control TX enable                       | 13  | DNC  | Do not connect                                       |
| 6   | RXEN | CMOS input to control RX enable                       | 14  | VDD  | Alternate supply pin, internally connected to pin 16 |
| 7   | N/C  | Not connected internally                              | 15  | N/C  | Not connected internally                             |
| 8   | GND  | Ground                                                | 16  | VDD  | Voltage supply connection                            |

## Electrical and Mechanical Specifications

The absolute maximum ratings of the RFX2401C are provided in Table 2. The recommended operating conditions are specified in Table 3.

The electrical specifications are provided in Tables 4 and 5. The state of the RFX2401C is determined by the logic provided in Table 6.

**Table 2. RFX2401C Absolute Maximum Ratings<sup>1</sup>**

| Parameter                                          | Conditions                     | Minimum | Maximum | Units   |
|----------------------------------------------------|--------------------------------|---------|---------|---------|
| DC VDD voltage supply                              |                                | 0       | 4.0     | V       |
| DC control pin voltage                             | Through 1 k $\Omega$ resistor  | 0       | 3.6     | V       |
| DC VDD current consumption                         | Through VDD pins when TX is ON |         | 350     | mA      |
| DC control pin current consumption                 |                                |         | 1       | $\mu$ A |
| TX RF input power                                  | All operating modes            |         | +5      | dBm     |
| ANT RF input power                                 | When RX is "ON"                |         | +5      | dBm     |
| Junction temperature                               |                                |         | 150     | °C      |
| Storage ambient temperature                        | No RF and DC voltages applied  | -50     | +150    | °C      |
| Electrostatic discharge:<br>Human Body Model (HBM) |                                |         | 3250    | 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. All maximum RF input power ratings assume 50  $\Omega$  terminal impedance.

**ESD HANDLING:** 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 when handling or transporting. Static charges may easily produce potentials of several kilovolts on the human body or equipment, which can discharge without detection. Industry-standard ESD handling precautions should be used at all times.

**Table 3. RFX2401C Recommended Operating Conditions<sup>1</sup>**

| Parameter                     | Conditions                    | Min | Typ | Max  | Units |
|-------------------------------|-------------------------------|-----|-----|------|-------|
| DC VDD voltage supply         | All VDD pins                  | 2.0 | 3.3 | 3.6  | V     |
| Control voltage HIGH          | Through 1 k $\Omega$ resistor | 1.2 |     | VDD  | V     |
| Control voltage LOW           |                               | 0   |     | 0.3  | V     |
| Operating ambient temperature | Note 2                        | -40 |     | +125 | °C    |
| $\theta_{ja}$                 |                               |     | 35  |      | °C/W  |

<sup>1</sup> During production test, devices will be tested at 5 V.

<sup>2</sup> For operation above +85 °C, use the  $\theta_{ja}$  as guidance for system design to assure the junction temperature will not exceed the maximum of +150 °C.

**Table 4. RFX2401C Electrical Specifications<sup>1</sup> (V<sub>DD</sub> = 3.3 V, All Unused Ports Terminated with 50  $\Omega$ , T<sub>A</sub> = 25 °C, Unless Otherwise Noted)**

| Parameter                                             | Symbol | Test Condition                                                    | Min  | Typ  | Max   | Units    |
|-------------------------------------------------------|--------|-------------------------------------------------------------------|------|------|-------|----------|
| Frequency range                                       | f      |                                                                   | 2.4  |      | 2.525 | GHz      |
| <b>Transmit Mode</b>                                  |        |                                                                   |      |      |       |          |
| Saturated output power                                |        |                                                                   |      | +22  |       | dBm      |
| Small-signal gain                                     |        |                                                                   | 21.5 | 25   | 26.5  | dB       |
| Second harmonic                                       |        | P <sub>OUT</sub> = +20 dBm, IEEE 802.15.4 OQPSK modulation signal |      | -10  |       | dBm/MHz  |
| Third harmonic                                        |        | P <sub>OUT</sub> = +20 dBm, IEEE 802.15.4 OQPSK modulation signal |      | -20  |       | dBm/MHz  |
| Input return loss                                     |        |                                                                   |      | -10  |       | dB       |
| Output return loss                                    |        |                                                                   |      | -6   |       | dB       |
| Input / output impedance single-ended                 |        |                                                                   |      | 50   |       | $\Omega$ |
| TX quiescent current                                  |        | No RF applied                                                     |      | 17   |       | mA       |
| TX high-power current                                 |        | P <sub>OUT</sub> = +20 dBm                                        |      | 90   |       | mA       |
| Load VSWR for stability (P <sub>OUT</sub> = +20 dBm)  |        | All non-harmonically related spurs less than -43 dBm/MHz          |      | 6:1  |       | N/A      |
| Load VSWR for ruggedness (P <sub>OUT</sub> = +20 dBm) |        | No damage                                                         |      | 10:1 |       | N/A      |
| <b>Receive Mode</b>                                   |        |                                                                   |      |      |       |          |
| Gain                                                  |        |                                                                   |      | 12   |       | dB       |
| Noise figure                                          |        |                                                                   |      | 2.5  |       | dB       |
| Input return loss                                     |        |                                                                   |      | -10  |       | dB       |
| Output return loss                                    |        |                                                                   |      | -12  |       | dB       |
| Rf port impedance                                     |        |                                                                   |      | 50   |       | $\Omega$ |
| Rx quiescent current                                  |        | No RF applied                                                     |      | 8    |       | mA       |
| Input P1dB                                            |        | At ANT pin                                                        |      | -8   |       | dBm      |

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

**Table 5. RFX2401C Standby Mode Technical Parameters**

| Parameter                            | Symbol | Test Condition | Min | Typ  | Max | Units   |
|--------------------------------------|--------|----------------|-----|------|-----|---------|
| DC shutdown current                  |        |                |     |      | 1   | $\mu$ A |
| TXRX-ANT insertion loss (S21)        |        | Pin < -20 dBm  |     | -50  |     | dB      |
| ANT-TXRX insertion loss (S21)        |        |                |     | -50  |     | dB      |
| Return loss (S11)                    |        | From TXRX port |     | -1.5 |     | dB      |
| Transmit-receive switching time      |        |                |     | 800  |     | nsec    |
| Shutdown and ON state switching time |        |                |     | 800  |     | nsec    |

**Table 6. RFX2401C Control Logic<sup>1</sup>**

| Mode      | TXEN | RXEN |
|-----------|------|------|
| TX active | 1    | x    |
| RX active | 0    | 1    |
| Shutdown  | 0    | 0    |

<sup>1</sup> "1" denotes high voltage state (> 1.2 V)

"0" denotes low voltage stage (< 0.3 V) at control pins

"X" denotes do not care: either "1" or "0" can be applied

## Application Schematic Board Description

A suggested RFX2401C FEM application schematic diagram is shown in Figure 3. A schematic of the Evaluation Board is shown in Figure 4.

## 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.
- If the transceiver TXRX port has DC present, use a capacitor to block this voltage from reaching the RFX2401C.
- The ground pad of the RFX2401C has special electrical and thermal grounding requirements. This pad is the main thermal conduit for heat dissipation. Because the circuit board acts as the heat sink, it must shunt as much heat as possible from the device.

Multiple vias to the grounding layer are required. Use thermal vias to assure efficient heat dissipation.

- Locate the bypass capacitors as close as possible to the ground pad. Use two ground vias.
- The VDD (pin 14) is an optional VDD pin, internally connected to pin 16.
- The N/C pins 1, 7, 12, and 15 may be left open or connected to GND.
- If the antenna circuits have DC present, use a capacitor to block this voltage from reaching the RFX2401C.

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

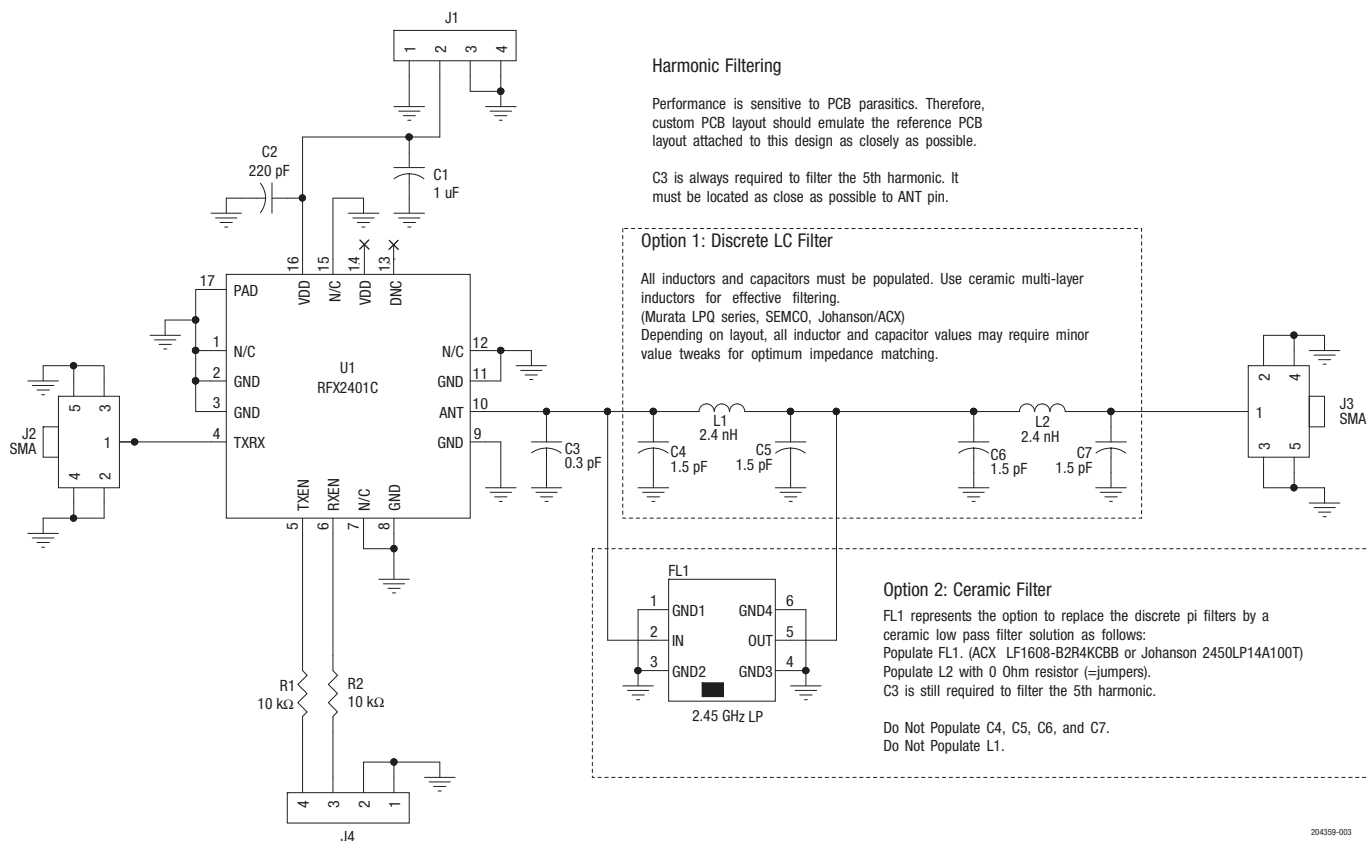


Figure 3. RFX2401C Application Schematic

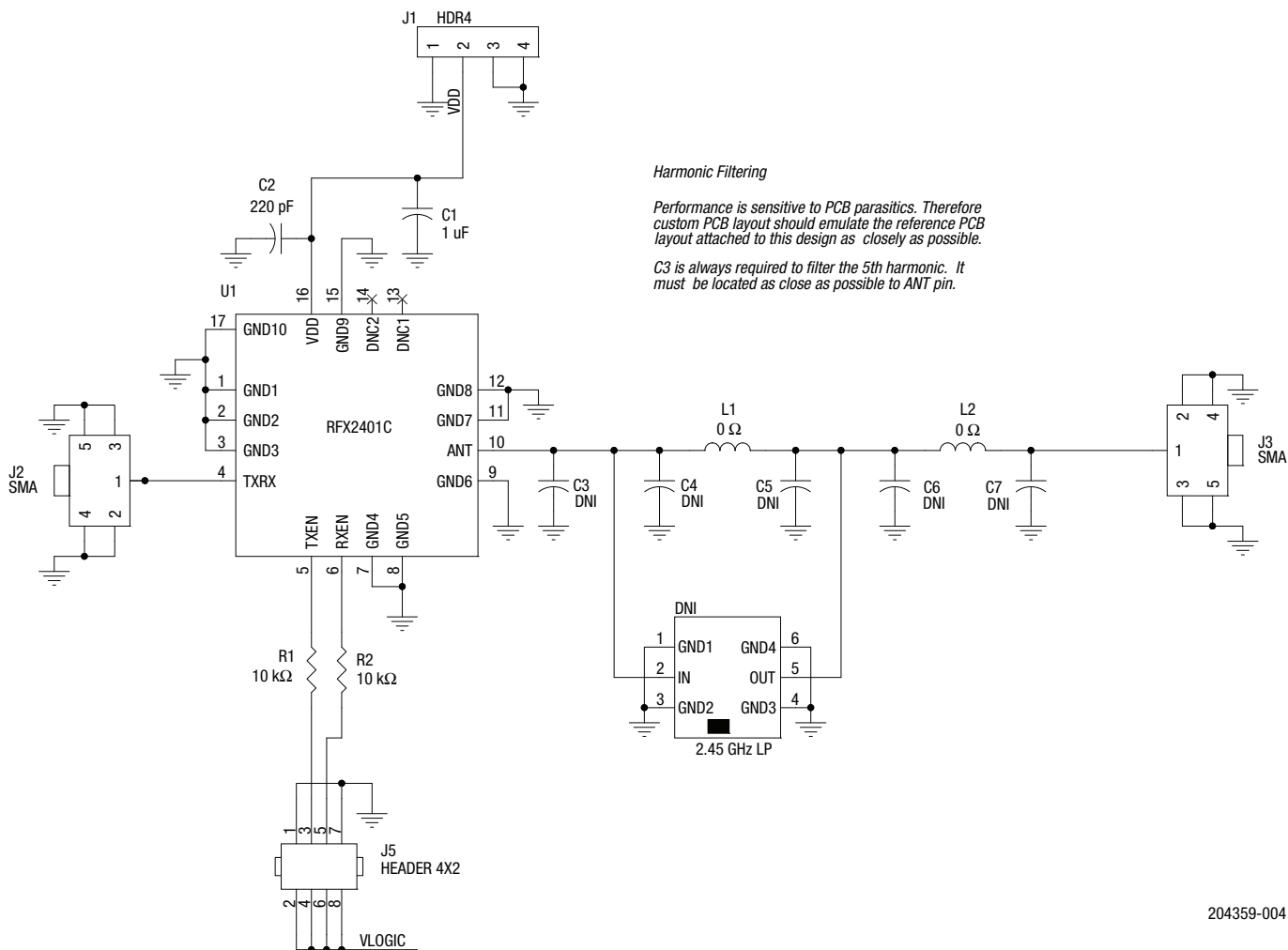


Figure 4. RFX2401C Evaluation Board Schematic

## Package Dimensions

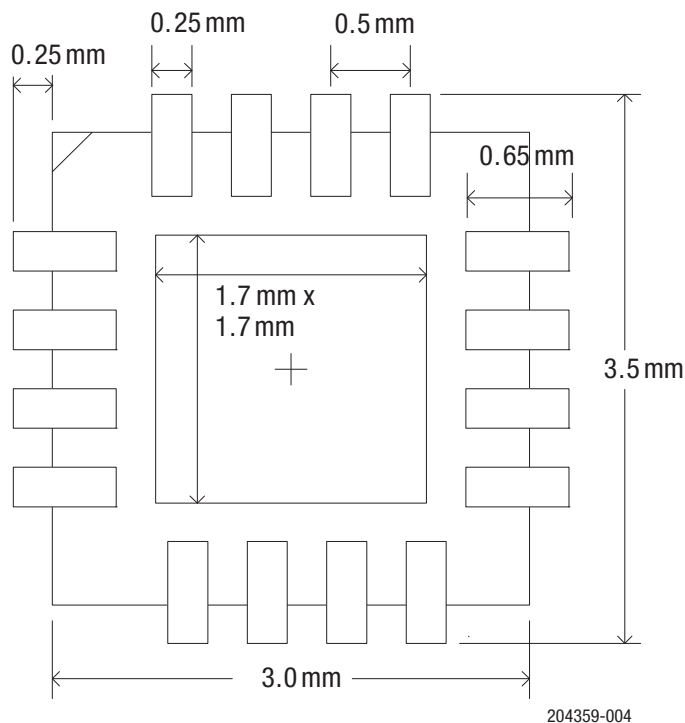
The PCB layout footprint for the RFX2401C is shown in Figure 5. Typical part markings are shown in Figure 6. Package dimensions are shown in Figure 7, and tape and reel dimensions are provided in Figure 8.

## Package and Handling Information

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.

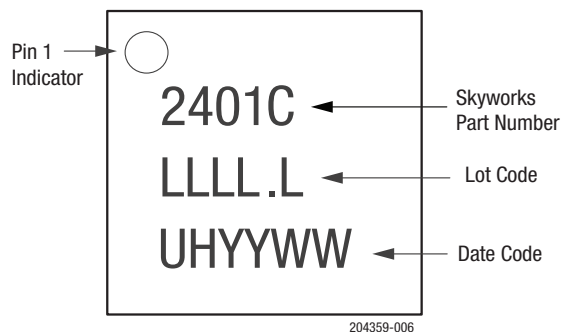
The RFX2401C is rated to Moisture Sensitivity Level 1 (MSL1) at 260 °C. It can be used for lead or lead-free soldering. For additional information, refer to the Skyworks Application Note, *Solder Reflow Information*, document number 200164.

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.

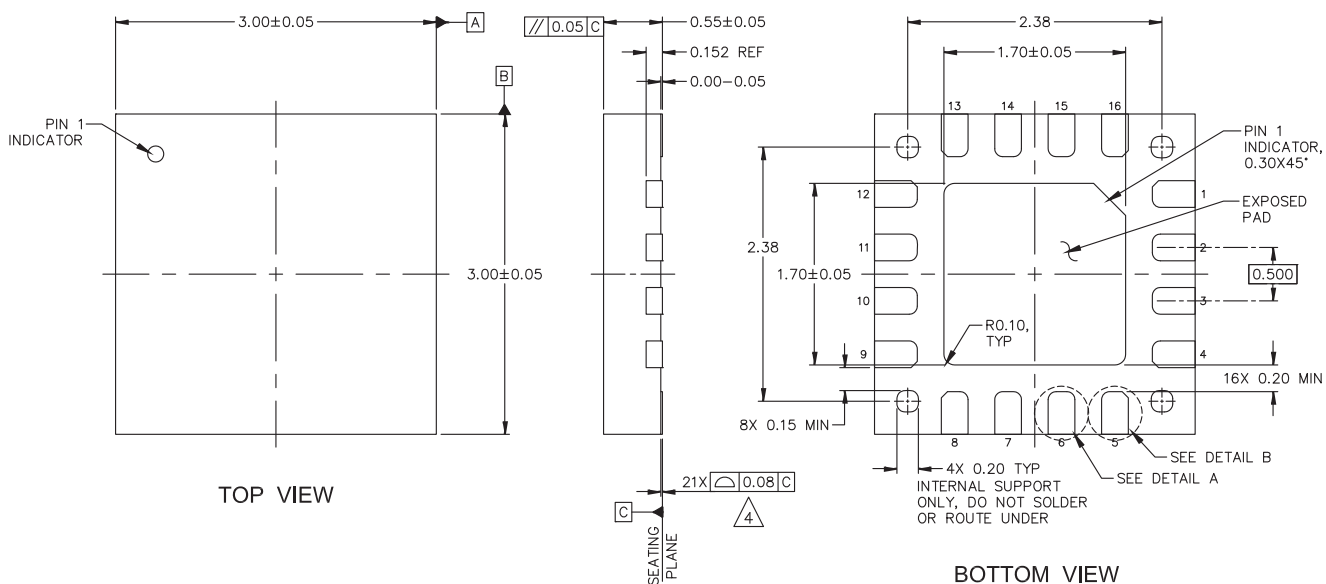


**Figure 5. RFX2401C PCB Layout Footprint  
(Top View)**





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

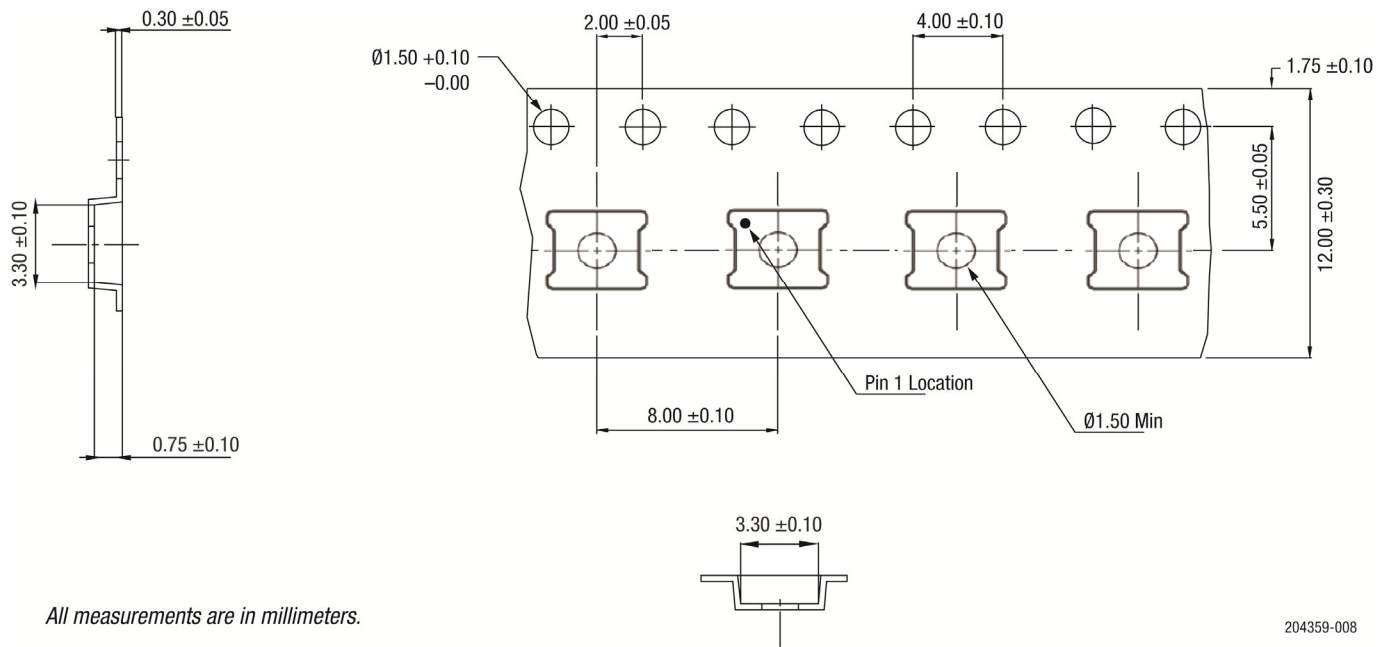


**NOTES:**

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.
2. DIMENSIONS ARE IN MILLIMETERS.
3. TOLERANCING (UNLESS OTHERWISE SPECIFIED).  

|                           |                           |
|---------------------------|---------------------------|
| <u>DECIMAL TOLERANCE:</u> | <u>ANGULAR TOLERANCE:</u> |
| X.X (1 PLC) ± 0.1mm       | ± 1/2°                    |
| X.XX (2 PLC) ± 0.05mm     |                           |
| X.XXX (3 PLC) ± 0.025mm   |                           |
4. COPLANARITY APPLIES TO THE TERMINALS AS WELL AS ALL OTHER BOTTOM SURFACE METALLIZATION.
5. DIMENSION APPLIES TO METALIZED TERMINAL. IF TERMINAL TIP HAS A RADIUS, DIMENSION SHOULD NOT BE MEASURED IN THAT RADIUS AREA.
6. PLATING REQUIREMENTS PER SOURCE CONTROL DRAWING (SCD) 2504.
7. UNLESS SPECIFIED DIMENSIONS ARE SYMMETRICAL ABOUT CENTER LINES.

**Figure 7. RFX2401C Package Dimensions**



**Figure 8. RFX2401C Tape and Reel Dimensions**

## Ordering Information

| Part Number | Product Description                   | Evaluation Board Part Number |
|-------------|---------------------------------------|------------------------------|
| RFX2401C    | 2.4 GHz Zigbee / ISM Front-End Module | RFX2401C-EK1                 |

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