BFIDGING THE RF GAP

### 2.4GHZ TRANSMIT / RECEIVE ZIGBEE RFEIC WITH DIVERSITY SWITCH

## Description

The RFX2411 is a fully integrated, single-chip, single-die RFeIC (RF Front-end Integrated Circuit) which incorporates all the RF functionality needed for wireless ZigBee / smart energy applications. The RFX2411 architecture integrates the PA, LNA, Transmit and Receive switching circuitry, the associated matching network, a harmonic filter and a diversity switch all in a CMOS single-chip device. It also includes a bypass mode to provide maximal level of flexibility for system implementations.

This RFeIC is designed for use in 2.4 GHz ISM band and supports the 802.15.4 and ZigBee standard. 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, RFX2411 is the perfect solution for applications requiring extended range and bandwidth. RFX2411 has simple and low-voltage CMOS control logic, and requires minimal external components for system implementation. The PA power detect circuit is also integrated.

## Features

- 2.4GHz ZigBee High Power Single-Chip, SingleDie RF Front-End IC
- Antenna Diversity Switch
- 2.4GHz Transmit High Power Amplifier with LowPass Harmonic Filter
- Low Noise Amplifier
- Transmit/Receive Switch Circuitry
- High Transmit Signal Linearity Meeting Standards for OQPSK Modulation
- Integrated Power Detector for Transmit Power Monitor and Control
- Low Voltage (1.2V) CMOS Control Logic
- ESD Protection Circuitry on All Ports
- DC Decoupled RF Ports
- Internal RF Decoupling on All VDD Bias Pins
- Low Noise Figure for the Receive Channel

Very Low DC Power Consumption

- Full On-chip Matching and Decoupling Circuitry
- Minimal External Components Required
- 50-Ohm Input / Output Matching
- Market Proven CMOS Technology
- $3 \times 3 \times 0.55 \mathrm{~mm}$ Small Outline QFN-20 Package with Exposed Ground Pad


## Applications

- ZigBee Extended Range Devices
- ZigBee Smart Power
- RF4CE Remote Control
- Home and Industrial Automation
- Custom 2.4GHz Radio Systems
- Mobile and Battery ZigBee Systems

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PIN ASSIGNMENTS:

| Pin Number Name |  |  |
| :---: | :---: | :--- |
| $1,11,13,19,21$ | GND | Ground - Must be connected to Ground in the Application Circuit |
| 2,4 | NC | No Internal Connection |
| 5 | TXRX | RF signal to/from the Transceiver: DC shorted to GND |
| 6 | TXEN | CMOS Input to Control TX Enable |
| 7 | RXEN | CMOS Input to Control RX Enable |
| 8 | PDET | Analog Voltage Proportional to the PA Power Output |
| 9 | MODE | CMOS Input to control mode of operation |
| 10 | SWant | CMOS Input to select antenna for diversity |
| 12 | ANTB | RF Signal from the PA or RF Signal Applied to the LNA; DC Shorted to GND |
| 14 | ANTA | RF Signal from the PA or RF Signal Applied to the LNA; DC Shorted to GND |
| 15 | IND | Inductor to GND |
| $3,16,17$ | DNC | Reserved - Do Not Connect in the Application Circuit |
| 18 | VDD1 | Voltage Supply Connection |
| 20 | VDD2 | Voltage Supply Connection |

PIN-OUT DIAGRAM:


TXEN RXEN PDET MODE SWANT

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## ABSOLUTE MAXIMUM RATINGS:

| Parameters | Mnits | Max | Conditions |  |
| :--- | :---: | :---: | :---: | :---: |
| DC VDD Voltage Supply | V | 0 | 4.0 | All VDD Pins |
| DC Control Pin Voltage | V | 0 | 3.6 | Through 1Kohm resistor |
| DC VDD Current Consumption | mA |  | 350 | Through VDD Pins when TX is "ON" |
| TX RF Input Power | dBm |  | +5 |  |
| ANT RF RX Input Power | dBm |  | +5 |  |
| Junction Temperature | ${ }^{\circ} \mathrm{C}$ |  | +150 | No RF and DC Voltages Applied <br> Appropriate care required according to <br> JEDEC Standards |
| Storage Ambient Temperature | ${ }^{\circ} \mathrm{C}$ | -50 | +150 |  |
| ESD Voltage (HBM) | V | $>1000$ |  | Human Body Model |

Note: Sustained operation at or above the Absolute Maximum Ratings for any one or combinations of the above parameters may result in permanent damage to the device and is not recommended.

All Maximum RF Input Power Ratings assume 50-Ohm terminal impedance.

## RECOMENDED OPERATING CONDITIONS:

| Parameters |  | Units | Min | Typ | Max |
| :--- | :---: | :---: | :---: | :---: | :---: |
| DC VDD Voltage Supply (Note 1) | V | 2.0 | 3.3 | 3.6 | All VDD Pins |
| Control Voltage "High" | V | 1.2 |  | VDD | Through 1Kohm resistor |
| Control Voltage "Low" | V | 0 |  | 0.3 |  |
| DC Control Pin Current Consumption | $\mu \mathrm{A}$ |  | 1 |  | Mode, SWant, TXEN, RXEN |
| DC Shutdown Current | $\mu \mathrm{A}$ |  | 1 |  | Mode, SWant, TXEN, RXEN = <br> Low |
| PA Turn On/Off Time | $\mu \mathrm{sec}$ |  |  | 1 |  |
| LNA Turn On/Off Time | $\mu \mathrm{sec}$ |  |  | 1 |  |
| Antenna Switch Time | $\mu \mathrm{sec}$ |  |  | 1 |  |
| Operating Ambient Temperature | ${ }^{\circ} \mathrm{C}$ | -40 |  | +125 | See Note 2 |
| Oja | ${ }^{\circ} \mathrm{C} / \mathrm{W}$ |  | 35 |  |  |

Note 1: For normal operation of the RFX2411, VDD must be continuously applied to all VDD supply pins.

Note2: For operation above $+85^{\circ} \mathrm{C}$, use the $\theta j a$ as guidance for system design to assure the junction temperature will not exceed the maximum of $+150^{\circ} \mathrm{C}$.

TRANSMIT TECHNICAL PARAMETERS (VDD=3.3V; T=+25 ${ }^{\circ} \mathrm{C}$ )

| Parameters | Units | Min | Typ | Max | Conditions |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Operating Frequency Band | GHz | 2.4 |  | 2.5 | All RF Pins Terminated by 50 Ohm |
| Saturated Output Power | dBm |  | +21 |  |  |
| Output P1dB | dBm |  | +19 |  | CW Input |
| Small-Signal Gain | dB |  | 26 |  | High Idq TX Mode |
|  | dB |  | 24 |  | Low Idq TX Mode |
| Second Harmonic | dBc |  | -35 |  | Pout $<=+20 \mathrm{dBm}$, CW at ANT Pin |
| Third Harmonic | dBc |  | -35 |  | Pout $<=+20 \mathrm{dBm}$, CW at ANT Pin |
| Total Supply Current | mA |  | 95 |  | Pout $=+20 \mathrm{dBm}$, High Idq TX Mode |
|  | mA |  | 95 |  | Pout $=+20 \mathrm{dBm}$, Low Idq TX Mode |
| TX Quiescent Current | mA |  | 18 |  | High Idq TX Mode |
|  | mA |  | 15 |  | Low Idq TX Mode |
| Input Return Loss | dB |  | -15 |  |  |
| Output Return Loss | dB |  | -7 |  |  |
| Power Detector Voltage | V |  | 0.14 |  | Pout $=+5 \mathrm{dBm}, 10 \mathrm{k} \Omega$ load |
|  | V |  | 0.9 |  | Pout $=+20 \mathrm{dBm}, 10 \mathrm{k} \Omega$ load |
| Input / Output Impedance Single-Ended | Ohm |  | 50 |  |  |
| RF Leakage Active Antenna to non-Active Antenna | dB |  | -18 |  | Antenna A/B leaking into Antenna B/A |
| Load VSWR for Stability (Set Pout=20dBm at 50 ohm) | N/A |  | 6:1 |  | All Non-Harmonically Related Spurs Less than $-60 \mathrm{dBm} / \mathrm{MHz}$ (CW) |
| Load VSWR for Ruggedness (Set Pout=20dBm at 50 ohm) | N/A |  | 10:1 |  | No Damage |

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RECEIVE TECHNICAL PARAMETERS (VDD=3.3V; T=+25 $\left.{ }^{\circ} \mathrm{C}\right)$

| Parameters | Units | Min | Typ | Max | Conditions |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Operating Frequency Band | GHz | 2.4 |  | 2.5 | All RF Pins Terminated by 50 Ohm |
| Gain | dB |  | 14 |  | Low Noise Figure Mode |
|  |  |  | 10 |  | Low Current Mode |
| Noise Figure | dB |  | 2.5 |  | Low Noise Figure Mode |
|  |  |  | 3.5 |  | Low Current Mode |
| Input $P_{1 d B}$ | dBm |  | -8 |  | Low Noise Figure Mode |
|  |  |  | -3 |  | Low Current Mode |
| RX Quiescent Current | mA |  | 9 |  | Low Noise Figure Mode |
|  |  |  | 4 |  | Low Current Mode |
| RF Port Impedance | Ohm |  | 50 |  | At TXRX and ANT Pins |
| Input Return Loss | dB |  | -8 |  | At ANT Pin, Low NF Mode |
| Output Return Loss | dB |  | -12 |  | At TXRX Pin, Low NF Mode |

BYPASS MODE TECHNICAL PARAMETERS (VDD=3.3V; T=+25 $\left.{ }^{\circ} \mathrm{C}\right)$ :

| Parameters |  | Units | Min | Typ | Max |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Conditions |  |  |  |  |  |
| Operating Frequency | GHz | 2.4 |  | 2.5 |  |
| Insertion Loss | dB |  | 5 |  |  |
| Input P1dB | dBm |  | 10 |  | At ANTA or ANTB |
| Current Consumption | uA |  | 1 |  | Through VDD Supply Pins |

CONTROL LOGIC TRUTH TABLE

| TXEN | RXEN |  | MODE |
| :---: | :---: | :---: | :---: | Mode of Operation


| SWant | Mode of Operation |
| :---: | :---: |
| 1 | ANTA port enabled |
| 0 | ANTB port enabled |

Note: "1" denotes high voltage state (> 1.2 V )
" 0 " denotes low voltage stage ( $<0.3 \mathrm{~V}$ ) at Control Pins
" $X$ " denotes do not care: either " 1 " or " " " can be applied

## PCB LAND PATTERN



PACKAGE MARKING:


## PACKAGE DIMENSIONS:



| Dimensions(mm) |  |  |  |
| :---: | :---: | :---: | :---: |
|  | Min | Nom | Max |
| $\mathbf{A}$ | 0.5 | 0.55 | 0.6 |
| $\mathbf{A}_{1}$ | 0.00 |  | 0.05 |
| $\mathbf{b}$ | 0.15 | 0.2 | 0.25 |
| $\mathbf{D}$ | 2.95 | 3.00 | 3.05 |
| $\mathbf{D}_{2}$ | 1.65 | 1.70 | 1.75 |
| E | 2.95 | 3.00 | 3.05 |
| $\mathbf{E}_{2}$ | 1.65 | 1.70 | 1.75 |
| e | 0.35 | 0.4 | 0.45 |
| $\mathbf{L}$ | 0.35 | 0.40 | 0.45 |

Preliminary Data Sheet

## TAPE AND REEL INFORMATION:





| Size | 12 mm |
| :---: | :---: |
| A | $330_{-2.0}^{* 0.2}$ |
| B | 1.5 min |
| C | $13.0_{-0.2}^{* 0.9}$ |
| D | 20.2 min |
| N | $100_{-0.0}^{* 2.0}$ |
| W1 | $12.4_{-3.0}^{* 3.0}$ |
| W2 | $12.4-3.0$ |
| W3 | $16.4-2.0$ |
| PART\# | SRL-12134H |

## Recommended Solder Reflow Profile



| Profile Feature | Sa-Pb Eutectic Assembly | Pb-Free Assembly |
| :---: | :---: | :---: |
| Preheat/Soak Temperature Min $\left(T_{\text {swin }}\right)$ Temperature $M$ Max $\left(T_{\text {mina }}\right)$ Time ( $\mathrm{t}_{5}$ ) from $\left(\mathrm{T}_{\text {sman }}\right.$ to $\left.\mathrm{T}_{\text {smax }}\right)$ | $\begin{gathered} 100^{\circ} \mathrm{C} \\ 150^{\circ} \mathrm{C} \\ 60-120 \text { seconds } \end{gathered}$ | $\begin{gathered} 150^{\circ} \mathrm{C} \\ 200^{\circ} \mathrm{C} \\ 60-120^{\text {seconds }} \end{gathered}$ |
| Ramp-up rate ( $T_{L}$ to $T_{p}$ ) | $3^{\circ} \mathrm{C} / \mathrm{second}$ max. | $3^{\text {2 }}$ C/second max. |
| Liquidous temperature ( $T_{L}$ ) Time (L) maintained above $T_{L}$ | $\begin{gathered} 183^{\circ} \mathrm{C} \\ 60-150 \text { seconds } \end{gathered}$ | $\begin{gathered} 217^{\circ} \mathrm{C} \\ 60-150 \text { seconds } \end{gathered}$ |
| Peak package body temperature ( $T_{p}$ ) | For users $T_{p}$ must not exceed the Classification temp in Table 4-1. <br> For suppliers $T_{p}$ must equal or exceed the Classification temp in Table 4-1. | For users $T_{p}$ must not exceed the Classification temp in Table 4-2. <br> For suppliers $T_{p}$ must equal or exceed the Classification temp in Table 4-2. |
| Time $\left(4_{0}\right)^{*}$ within $5^{\circ} \mathrm{C}$ of the specified classification temperature ( $\mathrm{T}_{\mathrm{c}}$ ), see Figure 5-1. | 20* seconds | $30^{*}$ seconds |
| Ramp-down rate ( $T_{0}$ to $T_{L}$ ) | $6^{\circ} \mathrm{C} / \mathrm{second}$ max. | 6 *Clsecond max. |
| Time $25{ }^{*} \mathrm{C}$ to peak temperature | 6 minutes max. | 8 minutes max. |

SnPb Eutectic Process - Classification Temperatures ( $\mathrm{T}_{\mathrm{e}}$ )

| Package Thickness | Volume $\mathrm{mm}^{*}$ <br> $<350$ | Volume $\mathrm{mm}^{2}$ <br> 2350 |
| :---: | :---: | :---: |
| $<2.5 \mathrm{~mm}$ | $235^{\circ} \mathrm{C}$ | $220^{*} \mathrm{C}$ |
| $\geq 2.5 \mathrm{~mm}$ | $220{ }^{\circ} \mathrm{C}$ | $220^{\circ} \mathrm{C}$ |

Pb-Free Process - Classification Temperatures ( $\mathrm{T}_{\mathrm{o}}$ )

| Package <br> Thickness | Volume $\mathrm{mm}^{2}$ <br> $\langle 350$ | Volume $\mathrm{mm}^{2}$ <br> $350-2000$ | Volume $\mathrm{mm}^{2}$ <br> $>2000$ |
| :---: | :---: | :---: | :---: |
| $\alpha .6 \mathrm{~mm}$ | $260^{\circ} \mathrm{C}$ | $260^{\circ} \mathrm{C}$ | $260^{\circ} \mathrm{C}$ |
| $1.6 \mathrm{~mm}-2.5 \mathrm{~mm}$ | $260^{\circ} \mathrm{C}$ | $250^{\circ} \mathrm{C}$ | $245^{\circ} \mathrm{C}$ |
| $>2.5 \mathrm{~mm}$ | $250^{\circ} \mathrm{C}$ | $245^{\circ} \mathrm{C}$ | $245^{\circ} \mathrm{C}$ |

