

Package Style: QFN, 12-pin, 2.5 mm x 2.5 mm

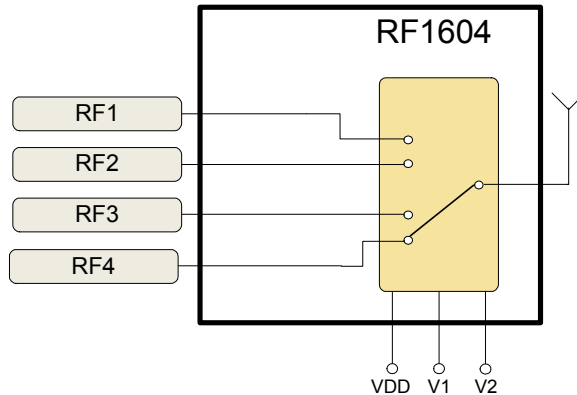


### Features

- 2 kV HBM ESD Protection on All Ports
- Low Frequency to >2.7 GHz Operation
- Low Insertion Loss: 0.4 dB at 1 GHz
- Very High Isolation: 40 dB at 1 GHz
- Compatible With Low Voltage Logic ( $V_{HIGH} Min = 1.3V$ )
- High Linearity:  $IIP2 > 120 dBm$
- No External DC Blocking Capacitors Required on RF Paths Unless DC is applied Externally

### Applications

- Multi-Mode GSM/EDGE/WCDMA, and LTE Applications
- GSM/GPRS/EDGE Switch Applications
- Cellular Infrastructure Applications
- Receive Diversity Switching
- General Purpose Switching Applications



Functional Block Diagram

### Product Description

The RF1604 is a single-pole four-throw (SP4T) switch designed for general purpose switching applications which require very low insertion loss and high power handling capability with minimal DC power consumption. The excellent linearity performance achieved by the RF1604 make it ideal for use in multimode GSM/EDGE/WCDMA, LTE, and cellular infrastructure applications. The RF1604 offers very high isolation between the RF ports, providing greater RF separation between the transmit and receive paths, which is critical in full-duplex systems. Additionally, RF1604 includes integrated decoding logic, allowing just two control lines needed for switch control. The RF1604 is packaged in a very compact 2.5 mm x 2.5 mm, 12-pin, leadless QFN package.

### Ordering Information

RF1604	Broadband High Power SP4T Switch
RF1604PCBA-410	Fully Assembled Evaluation Board

### Optimum Technology Matching® Applied

- |                                      |                                      |   |                                   |
|--------------------------------------|--------------------------------------|---|-----------------------------------|
| <input type="checkbox"/> GaAs HBT    | <input type="checkbox"/> SiGe BiCMOS | <input type="checkbox"/> GaAs pHEMT         | <input type="checkbox"/> GaN HEMT |
| <input type="checkbox"/> GaAs MESFET | <input type="checkbox"/> Si BiCMOS   | <input checked="" type="checkbox"/> Si CMOS | <input type="checkbox"/> RF MEMS  |
| <input type="checkbox"/> InGaP HBT   | <input type="checkbox"/> SiGe HBT    | <input type="checkbox"/> Si BJT             | <input type="checkbox"/> LDMOS    |

## Absolute Maximum Ratings

Parameter	Rating	Unit
V <sub>DD</sub>	3.0	V
Maximum Power Handling (6 to 1 VSWR over Temperature)	+36	dBm
Operating Temperature	-30 to +85	°C
Storage Temperature	-35 to +100	°C



**Caution!** ESD sensitive device.

Exceeding any one or a combination of the Absolute Maximum Rating conditions may cause permanent damage to the device. Extended application of Absolute Maximum Rating conditions to the device may reduce device reliability. Specified typical performance or functional operation of the device under Absolute Maximum Rating conditions is not implied.

RoHS status based on EUDirective2002/95/EC (at time of this document revision).

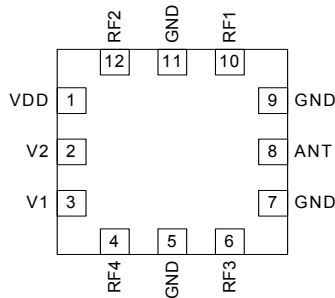
The information in this publication is believed to be accurate and reliable. However, no responsibility is assumed by RF Micro Devices, Inc. ("RFMD") for its use, nor for any infringement of patents, or other rights of third parties, resulting from its use. No license is granted by implication or otherwise under any patent or patent rights of RFMD. RFMD reserves the right to change component circuitry, recommended application circuitry and specifications at any time without prior notice.

Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
<b>Electrical Characteristics</b>					Active Mode: V <sub>HIGH</sub> ≥ 1.8V, V <sub>LOW</sub> ≤ 0.3V; Temp = 25 °C; V <sub>DD</sub> = 2.5V P <sub>IN</sub> = 35 dBm @ 0.9GHz or 33dBm @ 1.98GHz; All RF ports terminated to Z <sub>0</sub> = 50Ω.
<b>Insertion Loss</b>					
RF1, RF2, RF3, RF4-ANT		0.40	0.50	dB	0.5GHz to 1GHz
		0.45	0.55	dB	1.0GHz to 2.0GHz
		0.45	0.55	dB	2.0GHz to 2.5GHz
		0.7	0.85	dB	2.5GHz to 3.5GHz
<b>Isolation</b>					
RF1, RF2, RF3, RF4-ANT	36	40		dB	0.5GHz to 1.0GHz
	31	35		dB	1.0GHz to 2.0GHz
	30	33		dB	2.0GHz to 2.5GHz
	23	28		dB	2.5GHz to 3.5GHz
<b>RF Port Return Loss</b>					
RF1, RF2, RF3, RF4-ANT	23	30		dB	0.5GHz to 3.5GHz, All RF ports in Insertion Loss state.
<b>900MHz Harmonics</b>					
Second Harmonic (2f <sub>0</sub> )		-85	-75	dBc	P <sub>IN</sub> = 35dBm
Third Harmonic (3f <sub>0</sub> )		-90	-75	dBc	
<b>1980MHz Harmonics</b>					
Second Harmonic (2f <sub>0</sub> )		-85	-75	dBc	P <sub>IN</sub> = 33dBm
Third Harmonic (3f <sub>0</sub> )		-90	-75	dBc	
<b>IIP2</b>					
RF1, RF2, RF3, RF4-ANT Cell	115	120		dBm	Tone 1: 836.5MHz at 26dBm, Tone 2: 1718MHz at -20dBm, Receive Freq: 881.5MHz
RF1, RF2, RF3, RF4-ANT AWS	115	120		dBm	Tone 1: 1732.5MHz at 26dBm, Tone 2: 3865MHz at -20dBm, Receive Freq: 2132.5MHz
RF1, RF2, RF3, RF4-ANT PCS	115	120		dBm	Tone 1: 1880MHz at 26dBm, Tone 2: 3840MHz at -20dBm, Receive Freq: 1960MHz

Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
<b>IIP3</b>					
RF1, RF2, RF3, RF4-ANT Cell	68	73		dBm	Tone 1: 836.5MHz at 26dBm, Tone 2: 791.5MHz at -20dBm, Receive Freq: 881.5MHz
RF1, RF2, RF3, RF4-ANT IMT	68	73		dBm	Tone 1: 1950MHz at 26dBm, Tone 2: 1760MHz at -20dBm, Receive Freq: 2140MHz
<b>Triple Beat Ratio (TBR)</b>					
TBR BC0 (GSM800)	85	99		dBc	VSWR=2:1; Temp=-20°C, 25°C, +85°C
TBR BC1 (PCS)	85	99		dBc	VSWR=2:1; Temp=-20°C, 25°C, +85°C
TBR BC4	85	99		dBc	VSWR=2:1; Temp=-20°C, 25°C, +85°C
TBR BC5 (GSM400)	85	99		dBc	VSWR=2:1; Temp=-20°C, 25°C, +85°C
TBR BC14 (PCS)	85	99		dBc	VSWR=2:1; Temp=-20°C, 25°C, +85°C
TBR BC15 (AWS)	85	99		dBc	VSWR=2:1; Temp=-20°C, 25°C, +85°C
<b>Max Operating Power</b>					
			35	dBm	VSWR=6:1, Temp= -30° to +85°C
<b>Switching Time</b>					
Switching Speed ON		2	5	μs	50% control to 90% RF
Switching Speed OFF		2	5	μs	50% control to 10% RF
Start-Up Time			10	μs	Maximum set up time for the switch to reach fully compliant operation
<b>Supply and Control Signal Characteristics</b>					
Switched Supply Voltage ( $V_{DD}$ )					
$V_{HIGH}$	2.2	2.5	2.7	V	
$V_{LOW}$		0	0.3	V	
Switched Supply Current ( $V_{DD}$ )					
$I_{HIGH}$		50	100	μA	$P_{IN} = 35\text{ dBm}$
$I_{LOW}$		0		mA	
Control Voltage ( $V1, V2$ )					
$V_{HIGH}$	1.3	1.8	2.6	V	
$V_{LOW}$	0	0	0.3	V	
Control Current ( $V1, V2$ )					
$I_{HIGH}$		1.0	5.0	μA	
$I_{LOW}$		0.5	1.0	μA	

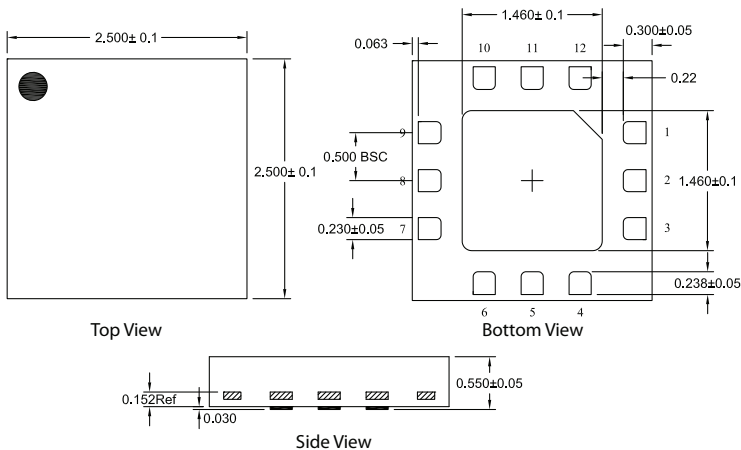
Pin	Function	Description
1	VDD	Supply. The voltage at this node will be switched and it is important that the switch is operating within the specified start up time. This signal might be used as a mode control.
2	V2	Control signal 2.
3	V1	Control signal 1.
4	RF4	RF output 4.
5	GND	Ground.
6	RF3	RF output 3.
7	GND	Ground.
8	ANT	RF input (connected to antenna).
9	GND	Ground.
10	RF1	RF output 1.
11	GND	Ground.
12	RF2	RF output 2.
Pkg Base	GND	Ground.

### Pin Out



Top View

### Package Drawing



## General Information

### Truth Table for Switch States

State	V1	V2	RF Path
1	V <sub>LOW</sub>	V <sub>LOW</sub>	ANT-RF1
2	V <sub>LOW</sub>	V <sub>HIGH</sub>	ANT-RF2
3	V <sub>HIGH</sub>	V <sub>LOW</sub>	ANT-RF3
4	V <sub>HIGH</sub>	V <sub>HIGH</sub>	ANT-RF4

### Control Logic

The switch is operable in four states (see Truth Table). When V<sub>DD</sub> is high, the switch is active. The start-up time is defined as the delay time that control signal(s) cross 0.8V threshold until KF output level is 90% of final RF voltage peak.

### Power Sequence

ON Sequence: First turn ON V<sub>DD</sub>, then apply control signals.

OFF Sequence: First turn OFF the control signals, then turn OFF V<sub>DD</sub>.

### Note:

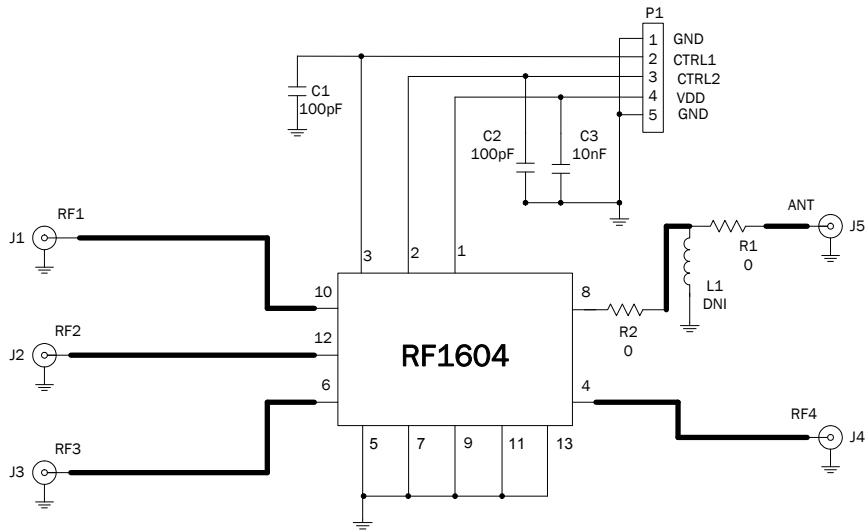
Not following the power ON/OFF sequence could cause damage to the switch and may affect the long-term reliability of the device.

### Electrical Test Methods

The electrical parameters for the switch were measured on RFMD evaluation board. The test PWB includes means for decoupling RF signals from control signal port (shunt capacitor at control signal ports).

All measurements are done with calibration plane at switch pins. The effect of test board losses and phase delay has been removed from the results.

## Evaluation Board Schematic



**Denotes 50 ohm transmission line**

## PCB Design Requirements

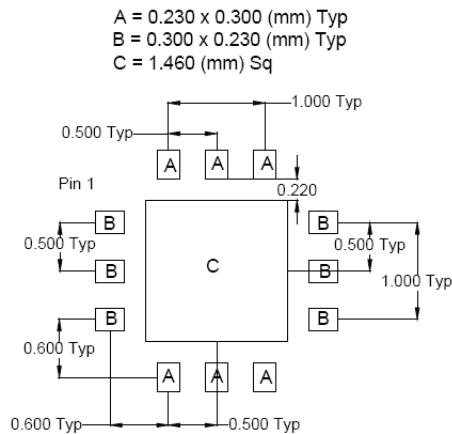
### PCB Surface Finish

The PCB surface finish used for RFMD's qualification process is electroless nickel, immersion gold. Typical thickness is 3 μinch to 8 μinch gold over 180 μinch nickel.

### PCB Land Pattern Recommendation

PCB land patterns for RFMD components are based on IPC-7351 standards and RFMD empirical data. The pad pattern shown has been developed and tested for optimized assembly at RFMD. The PCB land pattern has been developed to accommodate lead and package tolerances. Since surface mount processes vary from company to company, careful process development is recommended.

### PCB Metal Land Pattern

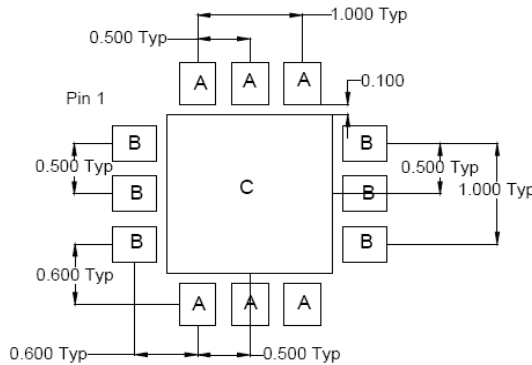


PCB METAL LAND PATTERN

## PCB Solder Mask Pattern

Liquid Photo-Imageable (LPI) solder mask is recommended. The solder mask footprint will match what is shown for the PCB metal land pattern with a 2 mil to 3 mil expansion to accommodate solder mask registration clearance around all pads. The center-grounding pad shall also have a solder mask clearance. Expansion of the pads to create solder mask clearance can be provided in the master data or requested from the PCB fabrication supplier.

A = 0.350 x 0.420 (mm) Typ  
 B = 0.420 x 0.350 (mm) Typ  
 C = 1.580 (mm) Sq



PCB SOLDER MASK LAND PATTERN

## Thermal Pad and Via Design

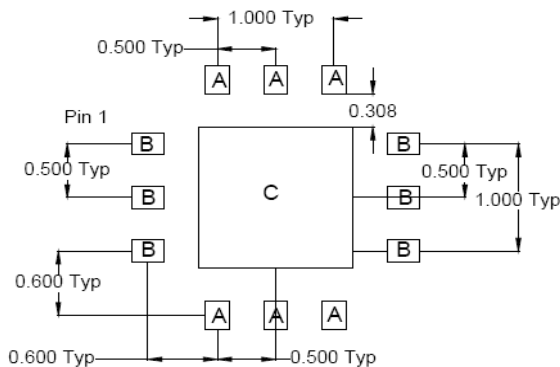
The PCB land pattern has been designed with a thermal pad that matches the die paddle size on the bottom of the device.

Thermal vias are required in the PCB layout to effectively conduct heat away from the package. The via pattern has been designed to address thermal, power dissipation and electrical requirements of the device as well as accommodating routing strategies.

The via pattern used for the RFMD qualification is based on thru-hole vias with 0.203mm to 0.330mm finished hole size on a 0.5mm to 1.2mm grid pattern with 0.025mm plating on via walls. If micro vias are used in a design, it is suggested that the quantity of vias be increased by a 4:1 ratio to achieve similar results.



A = 0.207 x 0.270 (mm) Typ  
 B = 0.270 x 0.207 (mm) Typ  
 C = 1.314 (mm) Sq



PCB STENCIL PATTERN