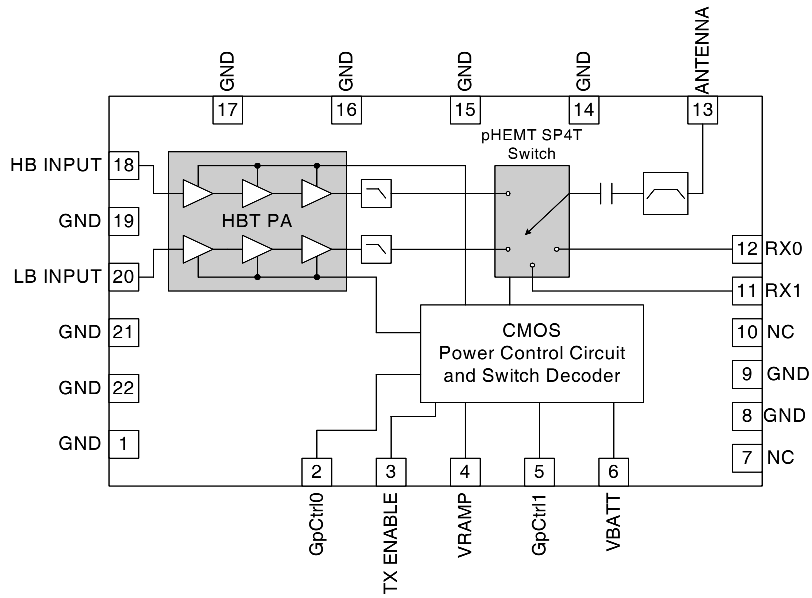
RF4180

DUAL-BAND GSM900/DCS1800 TRANSMIT MODULE

RoHS Compliant and Pb-Free Product
Package Style: Module 6mmx8mm



Functional Block Diagram

Features

- Enhanced Performance Transmit Module
- Small Form Factor 6mmx8mmx1.2mm
- No External Routing
- High Efficiency @ rated P_{OUT} V_{BATT}=3.5V GSM900 43% DCS1800 35%
- Low RX Insertion Loss
- Symmetrical RX Ports
- 0dBm to 6dBm Drive Level, >50dB of Dynamic Range
- Excellent ESD Protection at Antenna Port: 8kV
- Integrated Power Flattening Circuit

Applications

- 3V Dual-Band GSM/GPRS Handsets
- GSM900/DCS1800 Products
- GPRS Class 12 Compatible
- Portable Battery-Powered Equipment

Product Description

The RF4180 is a dual band (GSM900/DCS1800) transmit module with two symmetrical receive ports and GSM/GPRS Class 12 compliant. This transmit module builds upon RFMD's leading power amplifier with PowerStar® integrated power control technology, pHEMT switch technology and integrated transmit filtering for best-in-class harmonics. This results in high performance, a reduced solution size, and the ease of implementation simplifies transmitter design. The device is designed for use as the final portion of the transmit in GSM900/DCS1800 and eliminates the need for PA to antenna switch module matching. The device provides 50Ω matched input and output ports with no matching required.

The RF4180 features RFMD's latest integrated power flattening circuit, which significantly reduces current and power variation into load mismatch. The RF4180 also integrates an ESD filter to provide excellent ESD protection at the antenna port. The RF4180 is designed to provide high efficiency at rated P_{OUT}.

RF4180	Dual-Band GSM900/DCS1800 Transmit Module
RF4180SB	Transmit Module 5-Piece Sample Pack
RF4180PCBA-41X	Fully Assembled Evaluation Board

Optimum Technology Matching® Applied

☑ GaAs HBT	☐ SiGe BiCMOS	☑ GaAs pHEMT	☐ GaN HEMT
☐ GaAs MESFET	☐ Si BiCMOS	☑ Si CMOS	☐ RF MEMS
☐ InGaP HBT	☐ SiGe HBT	☐ Si BJT	

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Absolute Maximum Ratings

Parameter	Rating	Unit
Supply Voltage	-0.3 to +6.0	V
Power Control Voltage (V_{RAMP})	-0.3 to +1.8	V
Input RF Power	+10	dBm
Max Duty Cycle	50	%
Output Load VSWR	20:1	
Operating Temperature	-30 to +85	°C
Storage Temperature	-55 to +150	°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).

Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
Recommended Operating Conditions					
Overall Power Control V_{RAMP}					
Power Control “ON”			1.8	V	Max. P_{OUT}
Power Control “OFF”		0.25		V	Min. P_{OUT}
V_{RAMP} Input Capacitance		15	20	pF	DC to 2MHz
V_{RAMP} Input Current			10	µA	$V_{RAMP}=V_{RAMP\ MAX}$
Turn On/Off Time			2	us	V_{RAMP}=0V to $V_{RAMP\ MAX}$
Power Control Range		50		dB	V_{RAMP}=0V to $V_{RAMP\ MAX}$
Overall Power Supply					
Power Supply Voltage	3.0	3.5	4.8	V	Nominal Operating Limits
Power Supply Current		1	20	µA	P_{IN}<-30dBm, TX Enable=Low, V_{RAMP}=0V, Temp=-20°C to +85°C, V_{BATT}=4.8V
Overall Control Signals					
GpCtrl0, GpCtrl1 “Low”	0	0	0.5	V	
GpCtrl0, GpCtrl1 “High”	1.25	2.0	3.0	V	
GpCtrl0, GpCtrl1 “High Current”		1	2	uA	
TX Enable “Low”	0	0	0.5	V	
TX Enable “High”	1.25	2.0	3.0	V	
TX Enable “High Current”		1	2	uA	

Module Control and Antenna Switch Logic

TX ENABLE	GpCtrl1	GpCtrl0	TX Module Mode
0	0	0	Low Power Mode (Stand-by)
0	1	0	RX 0
0	1	1	RX 1
1	1	0	TX High Power Mode LB (GSM900)
1	1	1	TX High Power Mode HB (DCS1800)

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Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
GSM900 Band					Nominal test conditions unless otherwise stated. All unused ports are terminated. V_{BATT}=3.5V, P_{IN}=3dBm, Temp=+25°C, TX Enable=High, V_{RAMP}=V_{RAMP_RP}, TX Mode: GpCtrl1=High, GpCtrl0=Low, Duty Cycle=25%, Pulse Width=1154µs
Operating Frequency Range	880		915	MHz	
Input Power	0	3	6	dBm	
Input VSWR			3:1		Over P_{OUT} range (5dBm to 33dBm)
Maximum Output Power	33	33.6		dBm	Full P_{OUT} guaranteed at minimum drive level. Duty Cycle=25%, Pulse Width=1154µs, V_{RAMP}≤1.8V
	32.5			dBm	Duty Cycle=50%, Pulse Width=2308µs, V_{RAMP}≤1.8V
	31			dBm	V_{BATT}=3.0V to 4.8V, P_{IN}=0dBm to 6dBm, Temp=-20°C to +85°C, Duty Cycle=50%, Pulse Width=2308µs, V_{RAMP}≤1.8V
Power Added Efficiency (PAE)	38	43		%	Set V_{RAMP}=V_{RAMP_RP} for P_{OUT}=33dBm
Harmonics up to 12.75GHz			-33	dBm	V_{RAMP}=V_{RAMP_RP} for P_{OUT}=33dBm, also over all power levels (5dBm to 33dBm)
Non-Harmonic Spurious up to 12.75GHz			-36	dBm	V_{RAMP}=V_{RAMP_RP} for P_{OUT}=33dBm, also over all power levels (5dBm to 33dBm)
Forward Isolation 1		-56	-41	dBm	TX Enable=Low, P_{IN}=6dBm, V_{RAMP}=0.25V
Forward Isolation 2		-25	-17	dBm	TX Enable=High, P_{IN}=6dBm, V_{RAMP}=0.25V
Output Noise Power					
925MHz to 935MHz		-80	-74	dBm	V_{RAMP}=V_{RAMP_RP} for P_{OUT}=33dBm, RBW=100kHz
935MHz to 960MHz		-85	-83	dBm	
Output Load VSWR Stability (Spurious Emissions)			-36	dBm	VSWR=12:1; all phase angles (Set V_{RAMP}=V_{RAMP_RP} for P_{OUT}≤33dBm into 50Ω load; load switched to VSWR=12:1), V_{BATT}=3.0V to 4.8V, P_{IN}=0dBm to 6dBm, Temp=-10°C to +85°C
Output Load VSWR Ruggedness	No damage or permanent degradation to device				VSWR=20:1; all phase angles (Set V_{RAMP}=V_{RAMP_RP} for P_{OUT}=33dBm into 50Ω load; load switched to VSWR=20:1), V_{BATT}=3.0V to 4.8V, P_{IN}=0dBm to 6dBm, Temp=-30°C to +85°C
Input and Output Impedance		50		Ω	

Note: V_{RAMP_RP}=V_{RAMP} set for 33dBm at nominal conditions.

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Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
DCS1800 Band					Nominal test conditions unless otherwise stated. All unused ports are terminated. V_{BATT}=3.5V, P_{IN}=3dBm, Temp=+25°C, TX Enable=High, V_{RAMP}=V_{RAMP_RP}, TX Mode: GpCtrl1=High, GpCtrl0=High, Duty Cycle=25%, Pulse Width=1154µs
Operating Frequency Range	1710		1785	MHz	
Input Power	0	3	6	dBm	
Input VSWR			2.5:1		Over P_{OUT} range (0dBm to 30dBm)
Maximum Output Power	30.0	31.5		dBm	Full P_{OUT} guaranteed at minimum drive level. Duty Cycle=25%, Pulse Width=1154µs, V_{RAMP}≤1.8V
	29.5			dBm	Duty Cycle=50%, Pulse Width=2308µs, V_{RAMP}≤1.8V
	28			dBm	V_{BATT}=3.0V to 4.8V, P_{IN}=0dBm to 6dBm, Temp=-20°C to +85°C, Duty Cycle=50%, Pulse Width=2308µs, V_{RAMP}≤1.8V
Power Added Efficiency (PAE)	30	35		%	Set V_{RAMP}=V_{RAMP_RP} for P_{OUT}=30dBm
Harmonics up to 12.75GHz			-33	dBm	V_{RAMP}=V_{RAMP_RP} for P_{OUT}=30dBm, also over all power levels (0dBm to 30dBm)
Non-Harmonic Spurious up to 12.75GHz			-36	dBm	V_{RAMP}=V_{RAMP_RP} for P_{OUT}=30dBm, also over all power levels (0dBm to 30dBm)
Forward Isolation 1		-60	-53	dBm	TX Enable=Low, P_{IN}=6dBm, V_{RAMP}=0.25V
Forward Isolation 2		-18	-10	dBm	TX Enable=High, P_{IN}=6dBm, V_{RAMP}=0.25V
Output Noise Power					
1805MHz to 1880MHz		-87	-79	dBm	V_{RAMP}=V_{RAMP_RP} for P_{OUT}=30dBm, RBW=100kHz
Output Load VSWR Stability (Spurious Emissions)			-36	dBm	VSWR=12:1; all phase angles (Set V_{RAMP}=V_{RAMP_RP} for P_{OUT}≤30dBm into 50Ω load; load switched to VSWR=12:1), V_{BATT}=3.0V to 4.8V, P_{IN}=0dBm to 6dBm, Temp=-10°C to +85°C
Output Load VSWR Ruggedness	No damage or permanent degradation to device				VSWR=20:1; all phase angles (Set V_{RAMP}=V_{RAMP_RP} for P_{OUT}=30dBm into 50Ω load; load switched to VSWR=20:1), V_{BATT}=3.0V to 4.8V, P_{IN}=0dBm to 6dBm, Temp=-30°C to +85°C
Input and Output Impedance		50		Ω	

Note: V_{RAMP_RP}=V_{RAMP} set for 30dBm at nominal conditions.

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Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
RX Section					Nominal test conditions unless otherwise stated. V_{BATT}=3.5V, P_{IN}=3dBm, Temp=+25°C, TX Enable=Low, V_{RAMP}=1.8V, RX0 mode: GpCtrl1=High, GpCtrl0=Low, RX1 mode: GpCtrl1=High, GpCtrl0=High, RX0 Freq=925MHz to 960MHz, RX1 Freq=1805MHz to 1880MHz
Insertion Loss GSM900 ANT-RX0/ RX1		1.0	1.2	dB	Freq=925MHz to 960MHz
In-Band Ripple GSM900 ANT-RX0/RX1			0.2	dB	Freq=925MHz to 960MHz
Input VSWR GSM900 ANT, RX0/RX1			2:1		Freq=925MHz to 960MHz
Insertion Loss DCS1800 ANT-RX0/RX1		1.1	1.3	dB	Freq=1805MHz to 1880MHz
In-Band Ripple DCS1800 ANT-RX0/RX1			0.2	dB	Freq=1805MHz to 1880MHz
Input VSWR DCS1800 ANT, RX0/RX1			2:1		Freq=1805MHz to 1880MHz
TX Section					
Switch Leakage P_{OUT} at RX Port GSM900 ANT-RX0/RX1			13	dBm	GSM900 TX mode: Freq=880MHz to 915MHz, GpCtrl1=High, GpCtrl0=Low, V_{RAMP}=V_{RAMP_RP} for P_{OUT}=33dBm at antenna port
Switch Leakage P_{OUT} at RX Port DCS1800 ANT-RX0/RX1			11	dBm	DCS1800 TX mode: Freq=1710MHz to 1785MHz, GpCtrl1=High, GpCtrl0=High, V_{RAMP}=V_{RAMP_RP} for P_{OUT}=30dBm at antenna port

Note: Isolation specification set to ensure at least 20dB of isolation.
Calculation Example: Isolation=P_{OUT} @ Antenna-P_{OUT} @ RX Port. Isolation HB=30-10=20dB. Isolation LB=33-10=23dB.

Pin	Function	Description
1	GND	
2	GPCTRL0	Control pin that together with GpCtrl1 controls the T/R switch and the CMOS controller provides the logic decoding.
3	TX ENABLE	This signal enables the PA module biases for operation with a logic high. The switch is put in TX mode determined by GpCtrl0 and GpCtrl1.
4	VRAMP	Analog signal used to control the output power. This signal also ramps the output power up and down.
5	GPCTRL1	Control pin that together with GpCtrl0 controls the T/R switch and the CMOS controller provides the logic decoding.
6	VBATT	Power supply for the module. This should be connected to the battery terminal using as wide a trace as possible.
7	NC	
8	GND	
9	GND	
10	NC	
11	RX1	RX1 port of antenna switch. This is a 50Ω output. Interchangeable between the low and high frequency bands (GSM900 and GSM1800).
12	RX0	RX0 port of antenna switch. This is a 50Ω output. Interchangeable between the low and high frequency bands (GSM900 and GSM1800).
13	ANT	Antenna port of the switch. This is a 50Ω output. Provides DC blocking as well as ESD protection.
14	GND	
15	GND	
16	GND	
17	GND	
18	HB RF IN	RF input to the DCS1800 band PA. This is a 50Ω input.
19	GND	
20	LB RF IN	RF input to the GSM900 band PA. This is a 50Ω input.
21	GND	
22	GND	
23	GND	

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Theory of Operation

The RF4180 is a dual-band (GSM900/DCS1800) transmit module (TXM) with fully integrated power control functionality, harmonic filtering, band selectivity, and TX/RX switching. The TXM is self-contained, with 50Ω I/O terminals with two symmetrical RX ports allowing the dual-band operation. The power control function eliminates all power control circuitry, including directional couplers, diode detectors, and power control ASICs, etc. The power control capability provides 50dB continuous control range, and 70dB total control range, using a DAC-compatible, analog voltage input. The TX Enable feature provides for PA activation (TX mode) or RX mode. Internal switching provides a low-loss, low-distortion path from the antenna port to the TX path (or RX port) while maintaining proper isolation.

The RF4180 dual-band TXM with integrated CMOS power control and switch decoder circuit which comes in a compact 6mmx8mmx1.2mm solution size simplifies the phone design by eliminating the need for the complicated control loop design, harmonic filters, TX/RX switch and possible matching components between the antenna and the power amplifier. The power control loop can be driven directly from the DAC output of the transceiver. The module has 2 RX ports for GSM900 and DCS1800 bands of operation. The two RX ports are symmetrical. They can be used for either GSM900 or DCS1800, easing any layout issues. The RF4180 module also integrates an ESD filter to provide excellent ESD protection of ±8kV at the antenna port. The three logic signals are used to control the mode of operation: TX Enable, GpCtrl0, and GpCtrl1.

The RF4180 uses RFMD's enhanced PowerStar® architecture power control technique with combo-bias control to achieve maximum efficiency at rated P_{OUT} (reduced power level). This architecture optimizes PAE at rated P_{OUT} with full supply voltage on collectors of PA and achieves max P_{OUT} by increasing base bias voltage which is a function of V_{RAMP}. With this combo-bias control, V_{CC} voltage is linear and reaches maximum value at $V_{RAMP}=V_{RAMP\_RATED}$, (where $P_{OUT}=33$dbm in LB and $P_{OUT}=30$dbm in HB) and stays at maximum value until $V_{RAMP}=V_{RAMP\_PEAK}$. The incorporated control loop regulates the collector voltage of the amplifiers while the stages are held at a constant bias until $V_{RAMP}<V_{RAMP\_RATED}$. At $V_{RAMP}>V_{RAMP\_RATED}$, the PA utilizes base-biasing for power margin enhancement to achieve peak output power.

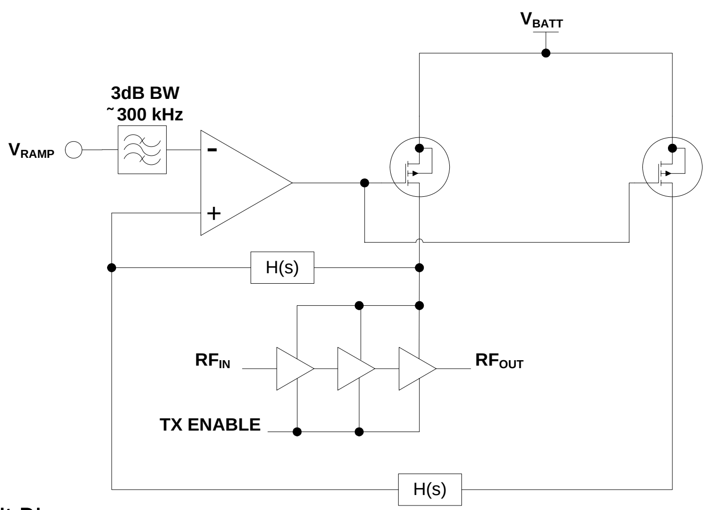

Figure 1. RF4180 Basic Circuit Diagram

By regulating collector voltage (V_{CC}), stages are held in saturation across all power levels. As V_{CC} decreases, output power decreases as described in the equation below:

$$Pout_{dBm} = 10\log\frac{(2\cdot Vcc - Vsat)^2}{8\cdot Rl\cdot 10^{-3}}$$

RF4180 power is ramped up and down through the V_{RAMP} control voltage which then controls the collector voltage of the amplifier stages. The RF signal applied at the RFIN pin must be a constant amplitude signal and should be high enough to saturate the amplifier. The input power (P_{IN}) range is indicated in the specifications. Power levels below this range will result in reduced maximum output power.

Power and Current Into Mismatch

Transmitters are often designed to operate only under perfect 50Ω loads. In the real application when a PA is subjected to mismatch conditions, performance degrades most likely in a reduction of output power, increased harmonic levels, increased transient spectrum, and catastrophic failures.

RF4180 has an integrated power flattening circuit that reduces the amount of current variation under load mismatch. When a mismatch is presented to the output of the PA, its output impedance is varied and could present a load that will increase output power. As the output power increases, so does current consumption. The current consumption can become very high if not monitored and limited. The power-flattening circuit is integrated onto the CMOS controller and requires no input from the user.

Into a mismatch, current varies as phase changes. The power-flattening circuit monitors current through an internal sense resistor. As current changes, the loop is adjusted in order to maintain current. Under nominal conditions, this loop is not activated and is seemingly transparent. The result is flatter power and reduced current into mismatch as shown in the following figures.

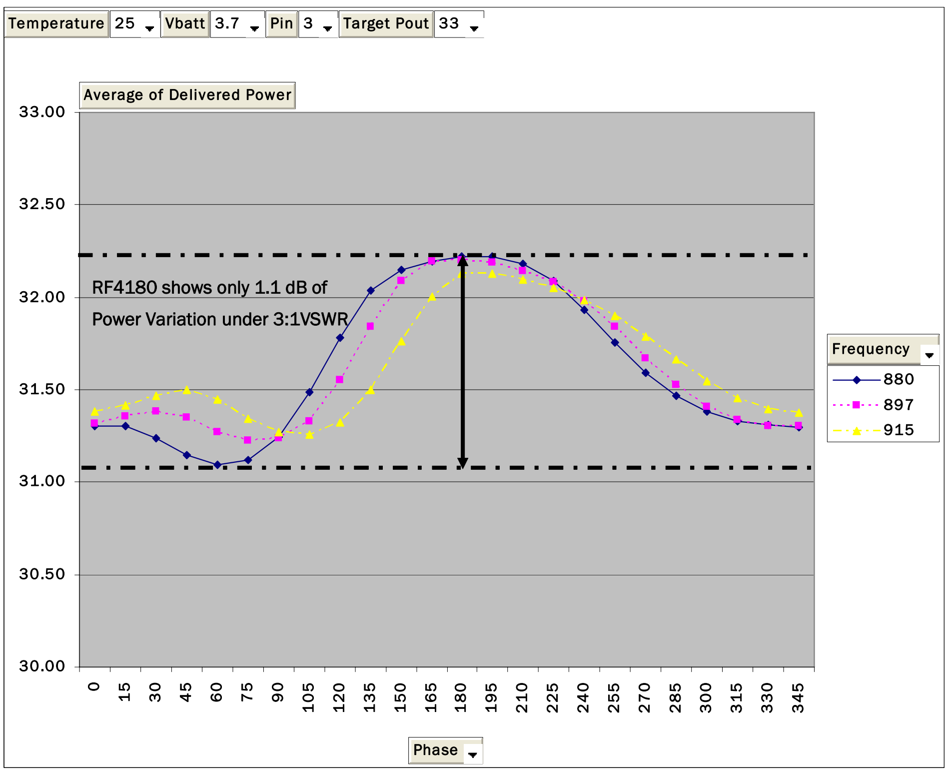

Figure 2. RF4180 Power Variation Under Mismatch VSWR 3:1

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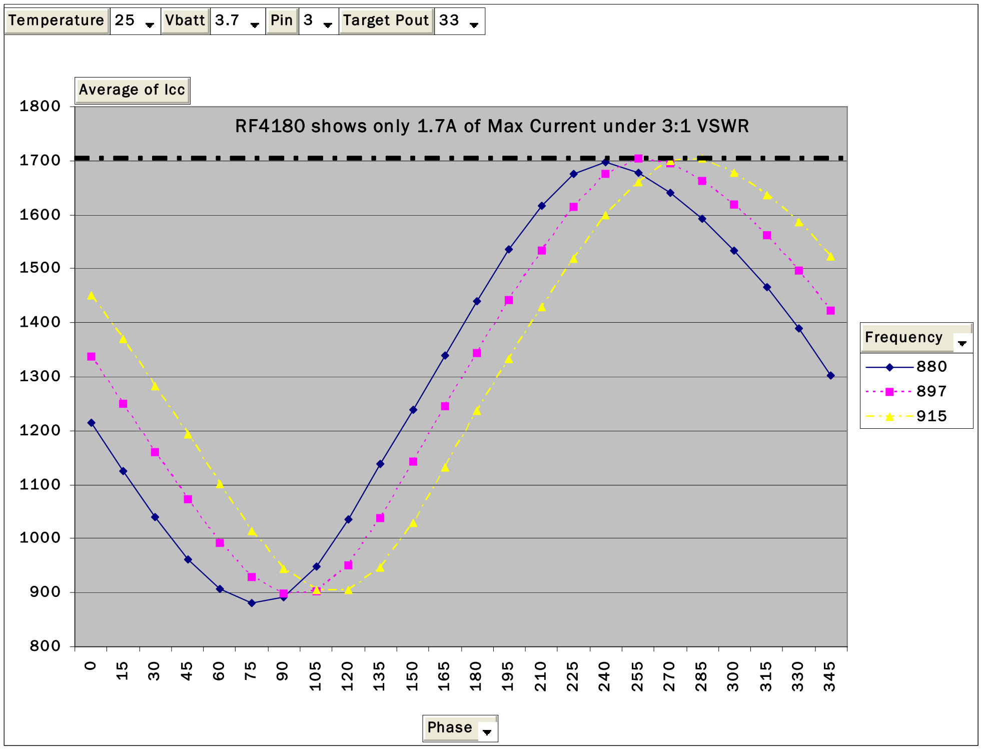

Figure 3. RF4180 Current Variation Under Mismatch VSWR 3:1

Electrostatic Discharge Sensitivity

The RF4180 TXM offers excellent ESD protection, 8kV at the antenna port. The contact discharge testing was performed in compliance with IEC 61000-4-2 requirements. The human body model testing and charged device model testing were performed in compliance with JESD22-A114 and JESD22-C101C.

Power Ramping and Timing

The RF4180 should be powered on according to the power-on sequence below. It is designed to prevent operation of the amplifier under conditions that could cause damage to the device or erratic operation.

There are some setup times associated with the control signals of the RF4180. The most important of these is the settling time between TXEN going high and when V_{RAMP} can begin to increase. This time is often referred to as the "pedestal" and is required so that the internal power control loop and bias circuitry can settle after being turned on. The RF4180 requires at least 2 μs or two quarter-bit times for proper settling of the power control loop.

The power-down sequence is in opposite order of the power-on sequence. As described in the figure below, V_{BATT} is applied first to provide bias to the silicon control chip. Then the RF drive is applied. Finally, when TX_ENABLE is high, the V_{RAMP} signal is held at constant 0.25 V, and 2 μs later, V_{RAMP} begins to ramp up. The shape of V_{RAMP} is important for maintaining the switching transients. The basic shape of the ramping function should be raised cosine to achieve best transient performance.

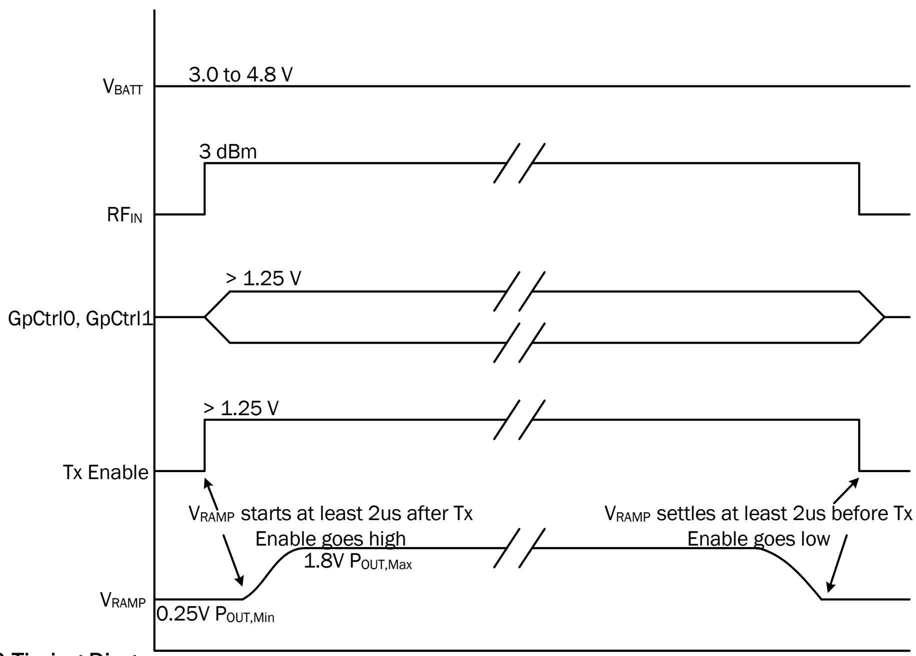

Figure 4. RF4180 Timing Diagram

Power-On Sequence:

1. Apply V_{BATT}.
2. Apply GpCtrl0, GpCtrl1, RFIN, and TX Enable.
3. Apply V_{RAMP} at least 2 μs after TX Enable.

Summary

RF4180 is an enhanced performance transmit module which assures minimal external component count and compact module area. The integrated power flattening circuit in RF4180 significantly reduces current and power variation into load mismatch.

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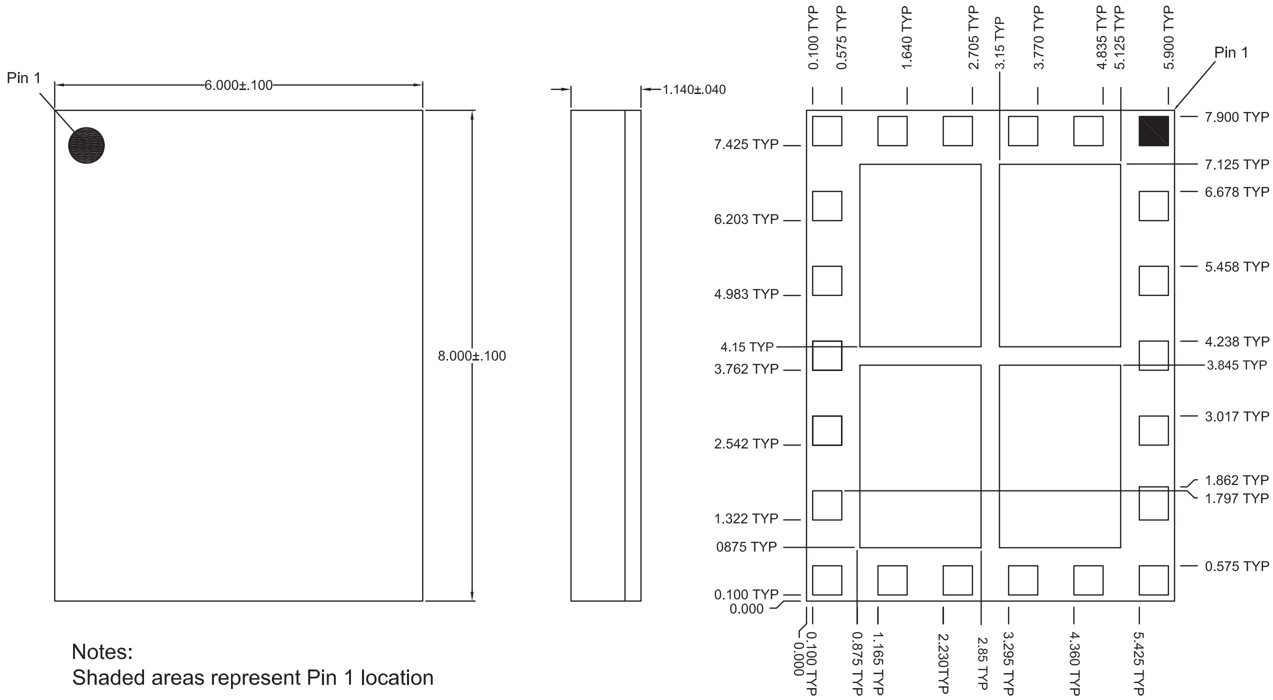
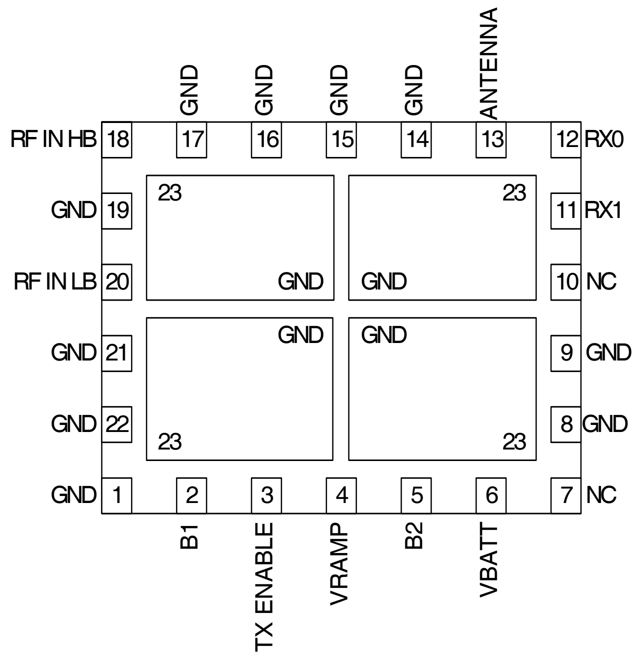
Package Drawing



Notes:
Shaded areas represent Pin 1 location

Pin Out

(Top View)



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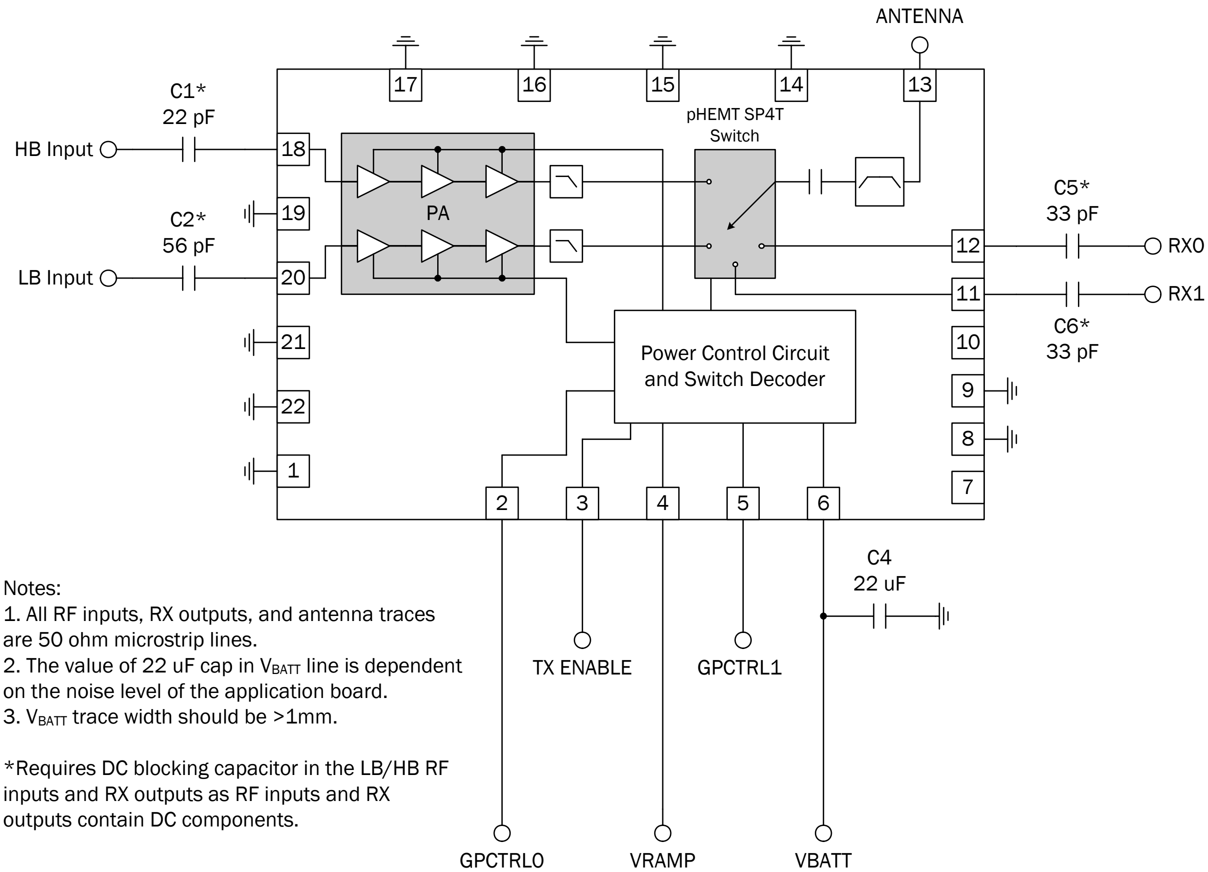
Application Schematic



Notes:
1. All RF inputs, RX outputs, and antenna traces are 50 ohm microstrip lines.
2. The value of 22 uF cap in V_{BATT} line is dependent on the noise level of the application board.
3. V_{BATT} trace width should be >1mm.

*Requires DC blocking capacitor in the LB/HB RF inputs and RX outputs as RF inputs and RX outputs contain DC components.

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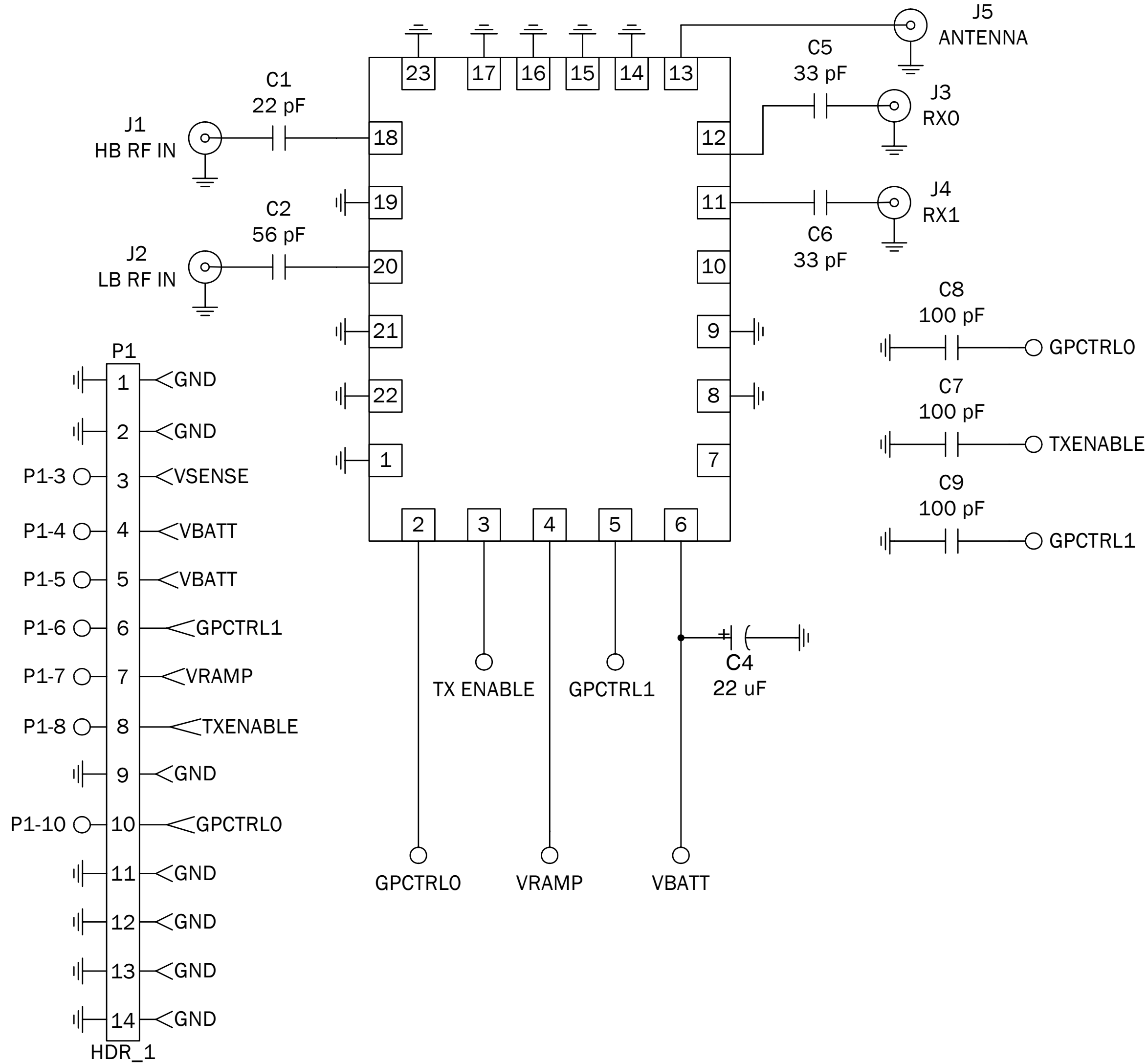
Evaluation Board Schematic



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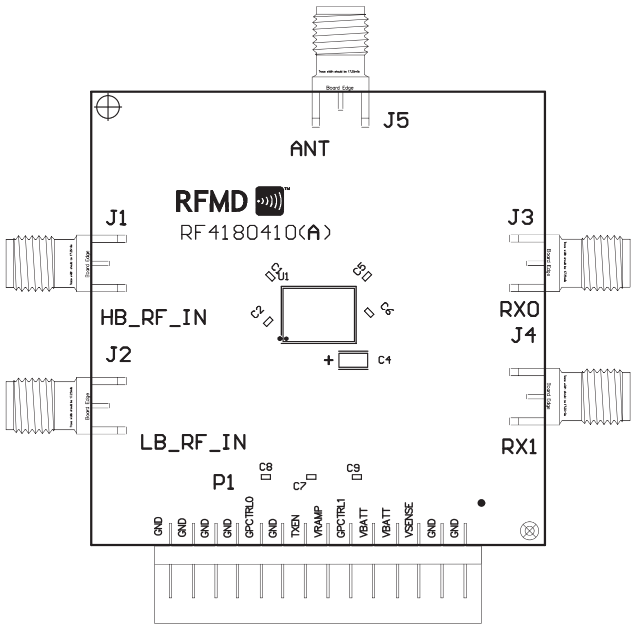
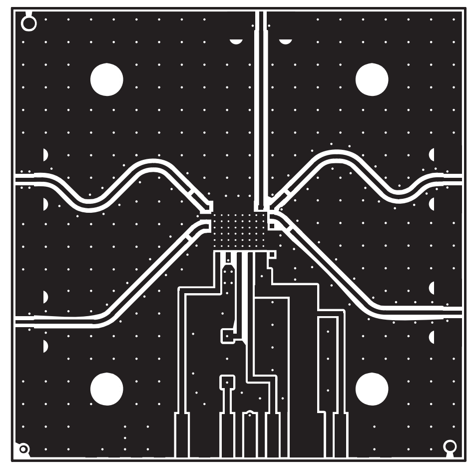
Evaluation Board Layout
Board Size 2.0” x 2.0”
Board Thickness 0.032”, Board Material FR-4, Multi-layer

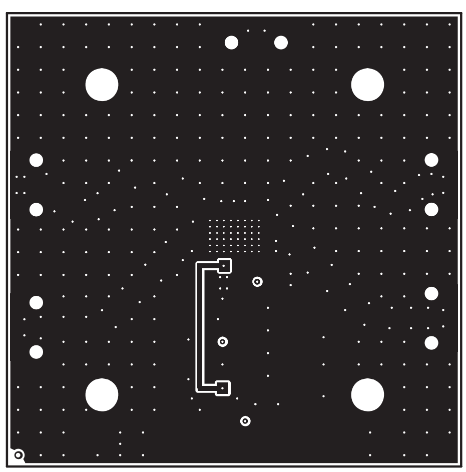
Assembly



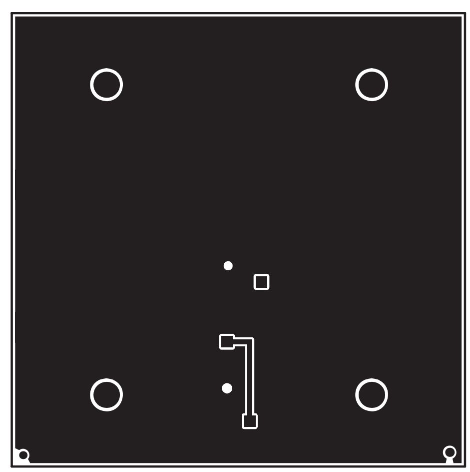
Top



Inner 1



Back



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PCB Design Requirements

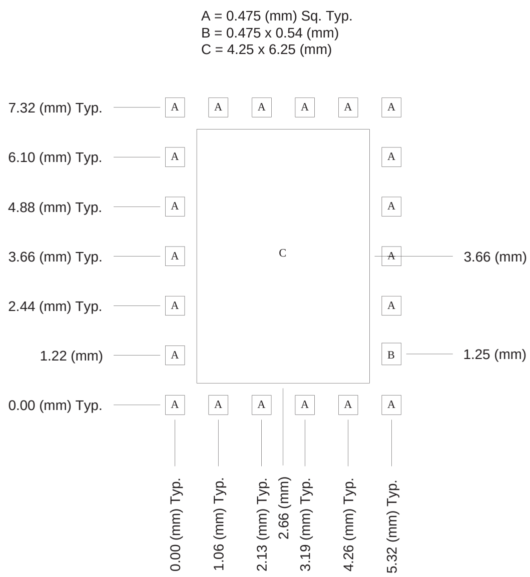
PCB Surface Finish

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.

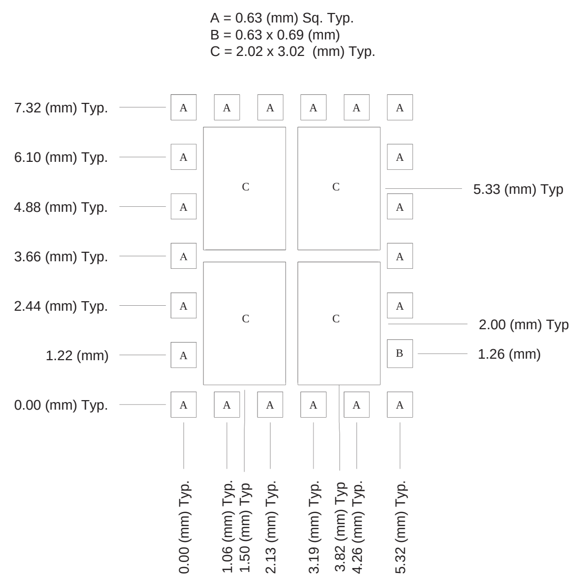
PCB Land Pattern Recommendation

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 and Solder Mask Pattern



RF4180 Metal Land Pattern



RF4180 Solder Mask Pattern

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RoHS* Banned Material Content

RoHS Compliant:	Yes
Package total weight in grams (g):	0.121
Compliance Date Code:	-
Bill of Materials Revision:	-
Pb Free Category:	e4

Bill of Materials	Parts Per Million (PPM)					
	Pb	Cd	Hg	Cr VI	PBB	PBDE
Die	0	0	0	0	0	0
Molding Compound	0	0	0	0	0	0
Lead Frame	0	0	0	0	0	0
Die Attach Epoxy	0	0	0	0	0	0
Wire	0	0	0	0	0	0
Solder Plating	0	0	0	0	0	0

This RoHS banned material content declaration was prepared solely on information, including analytical data, provided to RFMD by its suppliers, and applies to the Bill of Materials (BOM) revision noted above.

* DIRECTIVE 2002/95/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment