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RF7170D

DUAL-BAND EGSM900/DCS1800 TRANSMIT MODULE

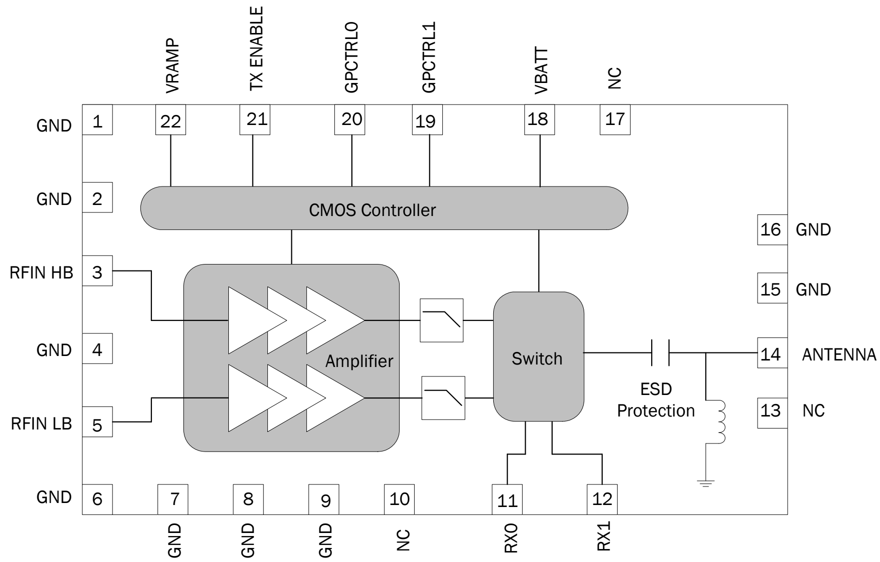
Package Style: Module, 6.63mm x 5.24mm x 1.0mm

Features

- 8kV Robust ESD Protection at Antenna Port
- Enhanced Performance Transmit Module
- No External Routing
- High Efficiency at Rated P_{OUT} V_{BATT}=3.5V GSM900=41% DCS1800=37%
- Low RX Insertion Loss
- Symmetrical RX Ports
- 0dBm to 6dBm Drive Level, >50dB of Dynamic Range
- Integrated Power-Flattening Circuit for Lower Power Variation under Mismatch Conditions
- V_{BATT} Tracking Circuit for Improved Switching Spectrum Performance under Low V_{BATT} Conditions

Applications

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



Functional Block Diagram

Product Description

The RF7170D is a dual-band (EGSM900/DCS1800) GSM/GPRS Class-12-compliant transmit module with two symmetrical receive ports. 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 harmonic performance. The results are high performance, reduced solution size, and ease of implementation. The device is designed for use as the final portion of the transmitter section in an EGSM900/DCS1800 handset and eliminates the need for a PA-to-antenna switch module matching network. The device provides 50Ω matched input and output ports requiring no external matching components.

The RF7170D features RFMD's latest integrated power-flattening circuit, which significantly reduces current and power variation into load mismatch. Additionally, a V_{BATT} tracking feature is incorporated to maintain switching performance as supply voltage decreases. The RF7170D also integrates an ESD filter to provide excellent ESD protection at the antenna port. The RF7170D is designed to provide maximum efficiency at rated P_{OUT}.

Ordering Information

RF7170D	Dual-Band EGSM900/DCS1800 Transmit Module
RF7170DSB	Transmit Module 5-Piece Sample Pack
RF7170DPCBA-41X	Fully Assembled Evaluation Board

Optimum Technology Matching® Applied

☑ GaAs HBT	☐ SiGe BiCMOS	☑ GaAs pHEMT	☐ GaN HEMT
☐ GaAs MESFET	☐ Si BiCMOS	☑ Si CMOS	☐ BiFET HBT
☐ InGaP HBT	☐ SiGe HBT	☐ Si BJT	☐ LDMOS

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 Case Temperature	-20 to +85	°C
Storage Temperature	-55 to +150	°C

Caution! ESD sensitive device.

Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
ESD					
ESD Antenna Port			8	kV	IEC 61000-4-2
ESD All Ports			1000	V	HBM, JES022-A114
			1000	V	CDM, JEDEC JESD22-C101
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 200kHz
V_{RAMP} Input Current			10	μA	$V_{RAMP}=V_{RAMP\ MAX}$
Power Control Range		50		dB	V_{RAMP}=0.25V to $V_{RAMP,\ MAX}$
Power Supply Range	3.0	3.5	4.8	V	Operating Limits
Power Supply Current		40	80	μA	P_{IN}<-30dBm, TX Enable=Low, V_{RAMP}=0.25V, Temp=-20°C to +85°C, V_{BATT}=4.8V
GpCtrl0/1 “Low”	0	0	0.5	V	
GpCtrl0/1 “High”	1.25	2.0	V_{BATT}	V	
GpCtrl0/1 “High Current”		1	2	μA	
TX Enable “Low”	0	0	0.5	V	
TX Enable “High”	1.25	2.0	V_{BATT}	V	
TX Enable “High Current”		1	2	μA	
RF Port Input and Output Impedance		50		Ω	

TX Enable	GpCtrl1	GpCtrl0	TX Module Mode
0	0	0	Low Power Mode (Standby)
0	1	0	RX0 RX Mode
0	1	1	RX1 RX Mode
1	1	0	EGSM900 TX Mode
1	1	1	DCS1800 TX Mode

Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
EGSM900 Mode					Nominal Conditions unless otherwise stated. V_{BATT}=3.5V, P_{IN}=3dBm, Temp=+25°C, TX Enable=High, V_{RAMP}=1.8V, TX Mode: GpCtrl1=High, GpCtrl0=Low, Duty Cycle=25%, Pulse Width=1154µs
Operating Frequency Range	880		915	MHz	
Input Power	0	3	6	dBm	Full P_{OUT} guaranteed at minimum drive level.
Input VSWR		1.7:1	2.5:1		Over P_{OUT} range (5dBm to 33dBm)
Maximum Output Power	33	34.1		dBm	Nominal Conditions
	31	34.0		dBm	V_{BATT}=3.1V to 4.8V, P_{IN}=0dBm to 6dBm, Temp=-20°C to +85°C, Duty Cycle=50%, Pulse Width=2308ms, $V_{RAMP}\leq$1.8V
Minimum Power Into 3:1 VSWR	30.0	31.4		dBm	The measured delivered output power to the load with the mismatch loss already taken into account with 1dB variation margin.
Efficiency	36	41		%	Set V_{RAMP}=$V_{RAMP\ RATED}$ for P_{OUT}=33dBm
2nd Harmonic		-40	-33	dBm	V_{RAMP}=$V_{RAMP\ RATED}$ for P_{OUT}=33dBm
3rd Harmonic		-40	-33	dBm	V_{RAMP}=$V_{RAMP\ RATED}$ for P_{OUT}=33dBm
All Other Harmonics up to 12.75GHz			-33	dBm	V_{RAMP}=$V_{RAMP\ RATED}$ for P_{OUT}=33dBm
Non-Harmonic Spurious up to 12.75GHz			-36	dBm	V_{RAMP}=$V_{RAMP\ RATED}$ for P_{OUT}=33dBm, also over all power levels (5dBm to 33dBm)
Forward Isolation 1		-61	-41	dBm	TX Enable=Low, P_{IN}=6dBm, V_{RAMP}=0.25V
Forward Isolation 2		-28	-15	dBm	TX Enable=High, P_{IN}=6dBm, V_{RAMP}=0.25V
Output Noise Power					
925MHz to 935MHz		-86	-77	dBm	V_{RAMP}=$V_{RAMP\ RATED}$ for P_{OUT}=33dBm, RBW=100kHz
935MHz to 960MHz		-87	-83	dBm	
1805MHz to 1880MHz		-117.5	-87	dBm	
Output Load VSWR Stability (Spurious Emissions)			-36	dBm	VSWR=12:1; all phase angles. (Set V_{RAMP}=$V_{RAMP\ RATED}$ for $P_{OUT}\leq$33dBm into 50Ω load; load switched to VSWR=12:1)
Output Load VSWR Ruggedness	No damage or permanent degradation to device.				VSWR=20:1; all phase angles. (Set V_{RAMP}=$V_{RAMP\ RATED}$ for $P_{OUT}\leq$33dBm into 50Ω load; load switched to VSWR=20:1)

Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
DCS1800 Mode					Nominal Conditions unless otherwise stated. V_{BATT}=3.5V, P_{IN}=3dBm, Temp=+25°C, TX Enable=High, V_{RAMP}=1.8V, TX Mode: GpCtrl1=High, GpCtrl0=High, Duty Cycle=25%, Pulse Width=1154µs
Operating Frequency Range	1710		1785	MHz	
Input Power	0	3	6	dBm	Full P_{OUT} guaranteed at minimum drive level.
Input VSWR		1.5:1	2.5:1		Over P_{OUT} range (0dBm to 30dBm)
Maximum Output Power	30	31.5		dBm	Nominal Conditions
	28	31.5		dBm	V_{BATT}=3.1V to 4.8V, P_{IN}=0dBm to 6dBm, Temp=-20°C to +85°C, Duty Cycle=50%, Pulse Width=2308ms, $V_{RAMP} \leq$ 1.8V
Minimum Power Into 3:1 VSWR	27	28.5		dBm	The measured delivered output power to the load with the mismatch loss already taken into account with 1dB variation margin.
Efficiency	32	37		%	Set V_{RAMP}=$V_{RAMP\ RATED}$ for P_{OUT}=30dBm
2nd Harmonic		-40	-33	dBm	V_{RAMP}=$V_{RAMP\ RATED}$ for P_{OUT}=30dBm
3rd Harmonic		-40	-33	dBm	V_{RAMP}=$V_{RAMP\ RATED}$ for P_{OUT}=30dBm
4th Harmonic		-36	-30	dBm	V_{RAMP}=$V_{RAMP\ RATED}$ for P_{OUT}=30dBm
All Other Harmonics up to 12.75GHz			-33	dBm	V_{RAMP}=$V_{RAMP\ RATED}$ for P_{OUT}=30dBm
Non-Harmonic Spurious up to 12.75GHz			-36	dBm	V_{RAMP}=$V_{RAMP\ RATED}$ for P_{OUT}=30dBm, also over all power levels (0dBm to 30dBm)
Forward Isolation 1		-64	-53	dBm	TX Enable=Low, P_{IN}=6dBm, V_{RAMP}=0.25V
Forward Isolation 2		-28	-15	dBm	TX Enable=High, P_{IN}=6dBm, V_{RAMP}=0.25V
Output Noise Power					
925MHz to 935MHz		-101	-77	dBm	V_{RAMP}=$V_{RAMP\ RATED}$ for P_{OUT}=30dBm, RBW=100kHz
935MHz to 960MHz		-100	-83	dBm	
1805MHz to 1880MHz		-94	-79	dBm	
Output Load VSWR Stability (Spurious Emissions)			-36	dBm	VSWR=12:1; all phase angles. (Set V_{RAMP}=$V_{RAMP\ RATED}$ for $P_{OUT} \leq$30dBm into 50Ω load; load switched to VSWR=12:1)
Output Load VSWR Ruggedness	No damage or permanent degradation to device.				VSWR=20:1; all phase angles. (Set V_{RAMP}=$V_{RAMP\ RATED}$ for $P_{OUT} \leq$30dBm into 50Ω load; load switched to VSWR=20:1)

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Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
RX Section					Nominal Conditions unless otherwise stated. V_{BATT}=3.5V, P_{IN}=-10dBm, Temp=+25°C, TX Enable=Low, V_{RAMP}=0.2V RX0 Mode: GpCtrl1=High, GpCtrl0=Low, RX1 Mode: GpCtrl1=High, GpCtrl0=High, EGSM900 RX=925MHz to 960MHz, DCS1800 RX=1805MHz to 1880MHz
Insertion Loss EGSM900 ANT-RX0/RX1		1.0	1.3	dB	RX Freq=EGSM900 RX. See Note 1.
In-Band Ripple EGSM900 ANT-RX0/RX1		0.05	0.2	dB	RX Freq=EGSM900 RX
Input VSWR EGSM900 ANT-RX0/RX1		1.3:1	1.5:1		RX Freq=EGSM900 RX
Insertion Loss DCS1800 ANT-RX0/RX1		1.3	1.6	dB	RX Freq=DCS1800RX. See Note 1.
In-Band Ripple DCS1800 ANT-RX0/RX1		0.1	0.2	dB	RX Freq=DCS1800 RX
Input VSWR DCS1800 ANT-RX0/RX1		1.5:1	1.8:1		RX Freq=DCS1800 RX
TX Section					
Switch Leakage P_{OUT} at RX Port EGSM900 ANT-RX0/RX1		-18	-10	dBm	EGSM900 TX mode: Freq=880MHz to 915MHz, GpCtrl1=High, GpCtrl0=Low, V_{RAMP}=$V_{RAMP\ RATED}$ for P_{OUT}=33dBm at antenna port. See Note 2.
Switch Leakage P_{OUT} at RX Port DCS1800 ANT-RX0/RX1		-15	-10	dBm	DCS1800 TX mode: Freq=1710MHz to 1785MHz, GpCtrl1=High, GpCtrl0=High, V_{RAMP}=$V_{RAMP\ RATED}$ for P_{OUT}=30dBm at antenna port. See Note 2.

Note 1: The insertion loss values listed take board resistive losses into account.

Note 2: Isolation specifications are set to ensure at least the following isolation at rated power. Calculation example using typical values:
Switch Leakage=P_{OUT} at Antenna - P_{OUT} at RX Port. LB switch leakage=33-(-18)=51dB, HB switch leakage=30-(-15)=45dB.

Pin	Function	Description
1	GND	Ground.
2	GND	Ground.
3	RF IN HB	RF input to the DCS1800 band.
4	GND	Ground.
5	RF IN LB	RF input to the EGSM900 bands.
6	GND	Ground.
7	GND	Ground.
8	GND	Ground.
9	GND	Ground.
10	NC	No connect.
11	RX0	RX0 of antenna switch. This port is interchangeable with RX1.
12	RX1	RX1 of antenna switch. This port is interchangeable with RX0.
13	NC	No connect.
14	ANTENNA	Antenna port. This is a 50Ω output.
15	GND	Ground.
16	GND	Ground.
17	NC	No connect.
18	VBATT	Power supply for the module. This should be connected to the battery terminal using as wide a trace as possible.
19	GPCTRL1	Control pin that together with GpCtrl0 selects the band of operation.
20	GPCTRL0	Control pin that together with GpCtrl1 selects the band of operation.
21	TX ENABLE	This signal enables the PA module for operation with a logic high. The switch is put in TX mode determined by GpCtrl0 and GpCtrl1.
22	VRAMP	V_{RAMP} ramping signal from DAC. A simple RC filter is integrated into the RF7170D module. V_{RAMP} may or may not require additional filtering depending on the baseband selected.
23	GND	Ground.

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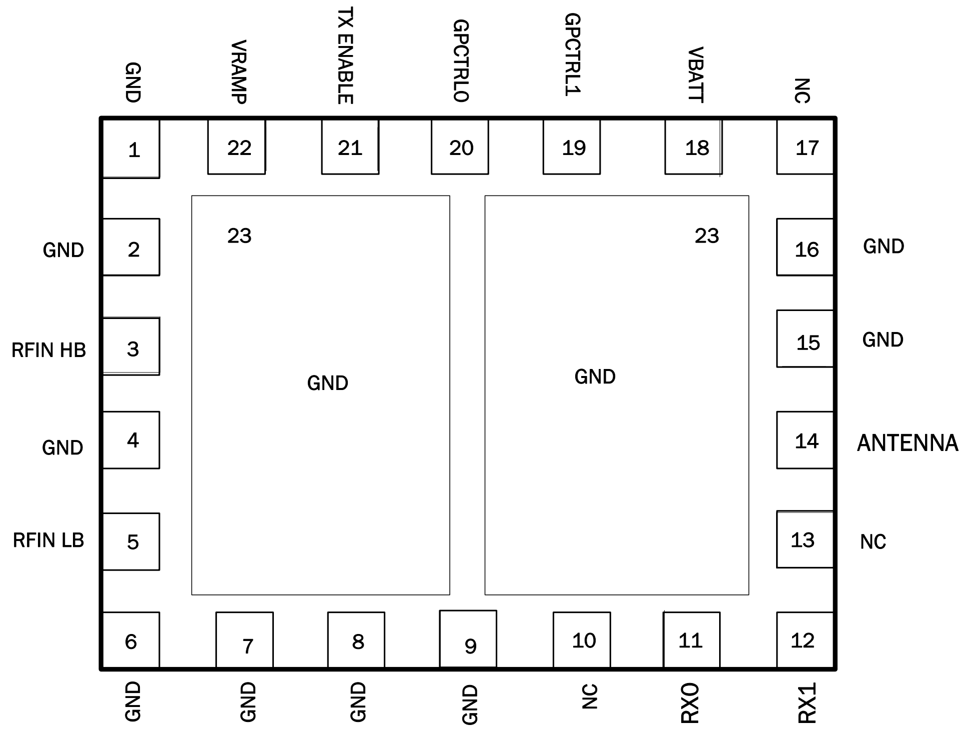
Pin Out



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Theory of Operation

Product Description

The RF7170D is a dual-band, transmit module (TxM) with fully-integrated power control functionality, harmonic filtering, band selectivity, and TX/RX switching. The TxM is self-contained, having 50Ω I/O terminals and two symmetrical RX ports, allowing 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 of continuous control range and 70dB of total dynamic range, using a DAC-compatible, analog voltage input. The TX Enable features provides for PA activation (TX mode) or RX mode/standby. Internal switching provides a low-loss, low-distortion path from the antenna port to the TX path (or RX port), while maintaining proper isolation. Integrated filtering provides ETSI-compliant harmonic suppression at the antenna port even under high mismatch conditions, which is important as modern antennas often present a load that significantly deviates from nominal impedance.

Overview

The RF7170D simplifies the phone design by eliminating the need for the complicated control loop, harmonic filters, and TX/RX switch along with their associated matching components. The power control loop can be driven directly from the DAC output in the baseband circuit. The module has two RX ports for EGSM900 and DCS1800 bands of operation. The two RX ports are symmetrical; they can be used either as EGSM900 or DCS1800 bands of operation. To control the mode of operation, there are three logic control signals: TX Enable, GpCtrl0, and GpCtrl1. RF7170D offers high efficiency at the rated P_{OUT} as backed-off efficiency is improved in this TxM.

Power Ramping and Timing

The RF7170D 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 RF7170D. 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 RF7170D requires at least 2μs 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 TXEN is high, the V_{RAMP} signal is held at a constant 0.25V, and 2μs 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.

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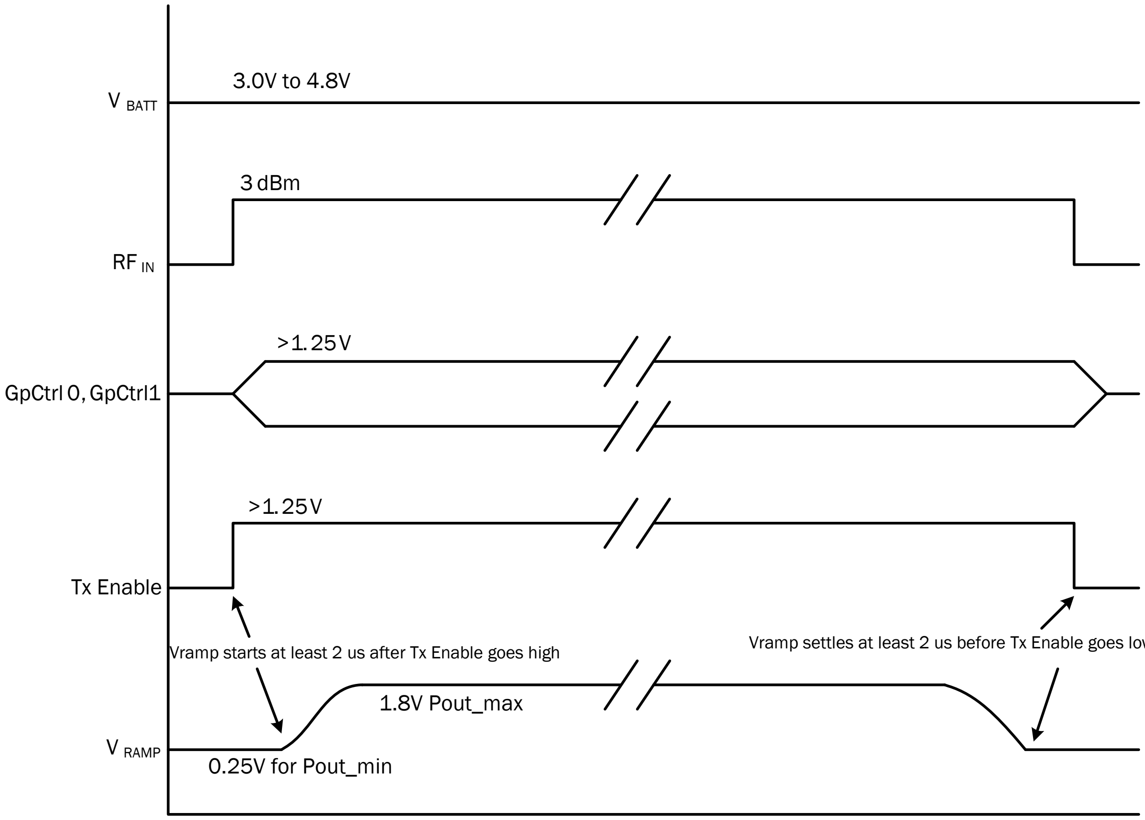
Power On Sequence



1. Apply VBATT
2. Apply GpCtrl0, GpCtrl1, RFIN and TX Enable
3. Apply VRAMP at least 2 μs after TX Enable
4. The Power Down Sequence is in opposite order of the Power On Sequence.

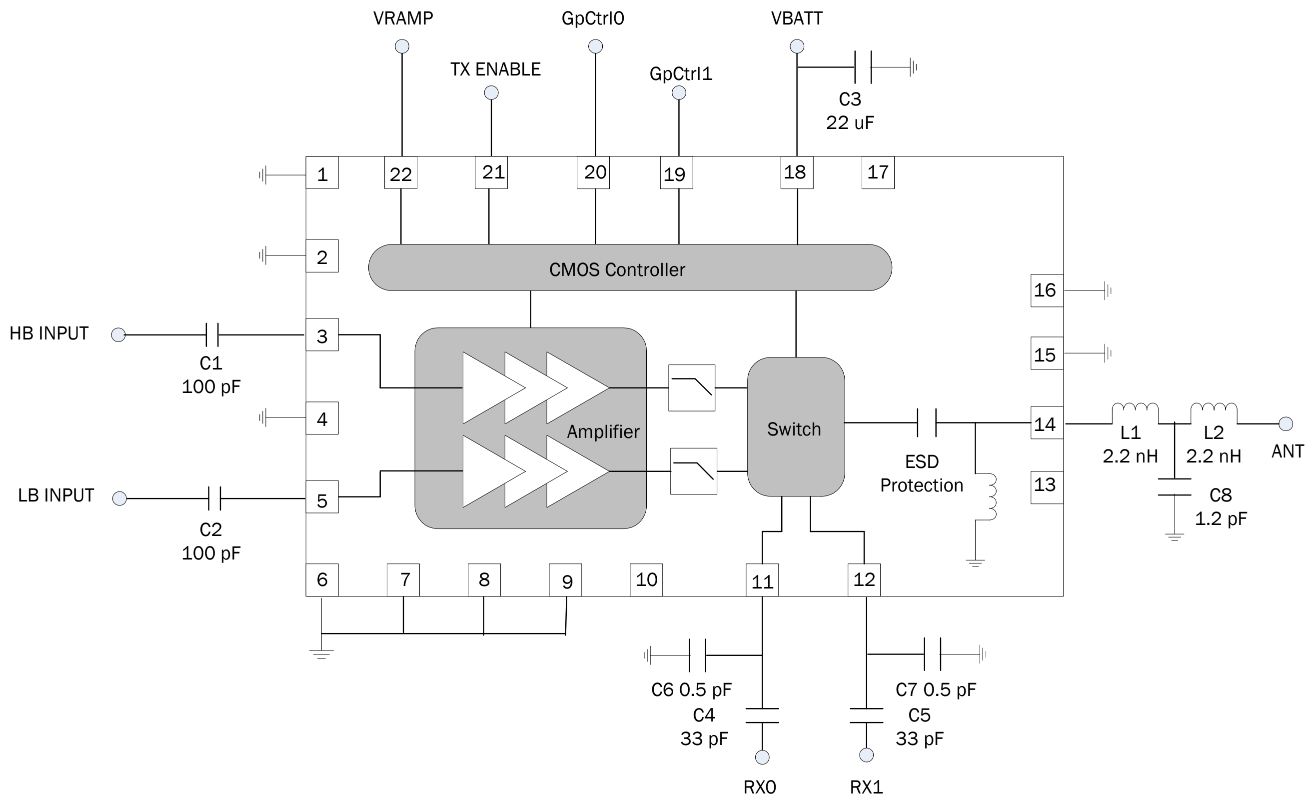
Power Flattening and V_{BATT} Tracking

The RF7170D has an integrated power flattening circuit that reduces the amount of current variation when a mismatch is presented to the output of the PA. 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, the current varies as the phase. The power flattening circuit monitors current through an internal sense resistor. As the current changes, the loop is adjusted in order to maintain current. The result is flatter power and reduced current into mismatch.

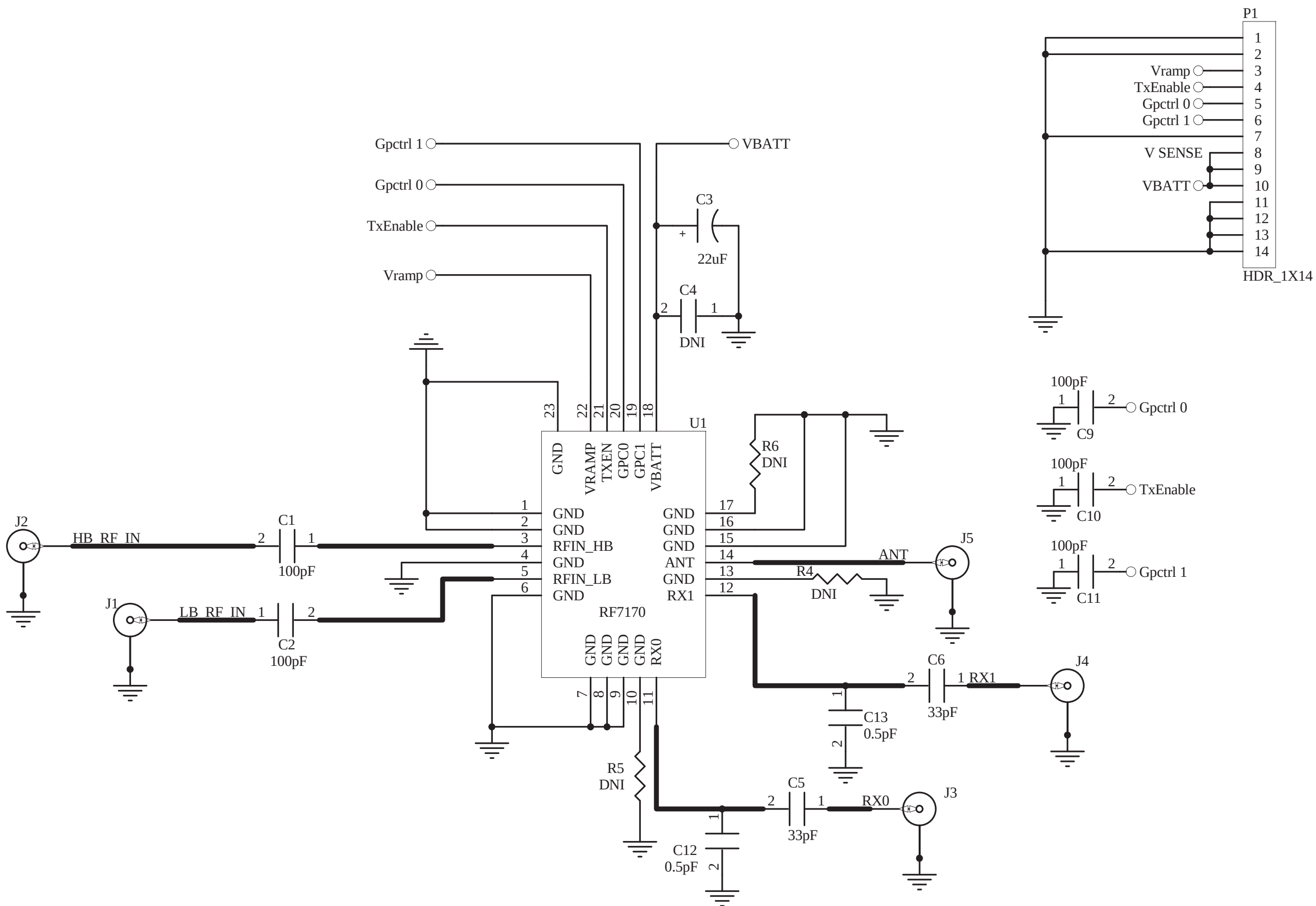
The RF7170D also incorporates a V_{BATT} tracking feature that eliminates the need for the transceiver/baseband to regulate the ramping signal as the supply voltage decreases. The internal circuit monitors the supply voltage and adjusts the ramping signal such that the switching spectrum is minimally impacted.

Application Schematic



*All inputs, outputs, and antenna traces are 50 Ω micro strip.
**VBATT capacitor value may change depending on application.
***RX0 and RX1 usually connect to SAW filters; C4 and C5 are used to block dc voltage present on the RX ports. C6 and C7 are used to match the RX ports to a 50 Ω filter.
****If placing an attenuation network on the input to the power amplifier, ensure that it is positioned on the transceiver side of capacitor C1 (or C2) to prevent adversely affecting the base biasing of the power amplifier.
*****L1, L2, and C8 is a suggested external LPF to suppress higher order harmonics. Actual component values will depend on the application.

Evaluation Board Schematic



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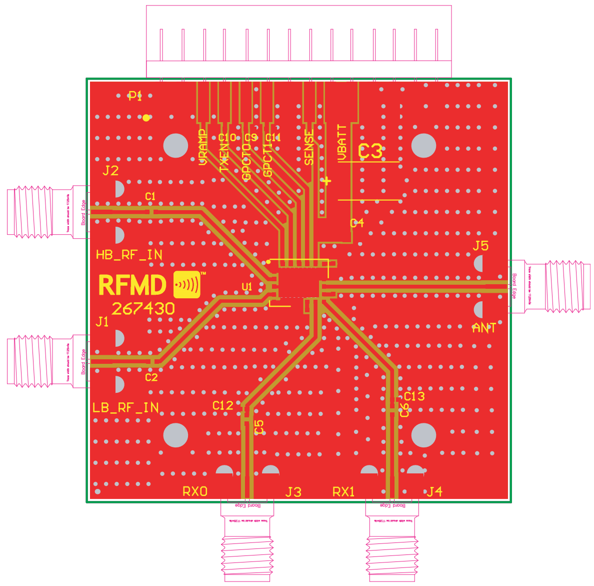
Evaluation Board Layout



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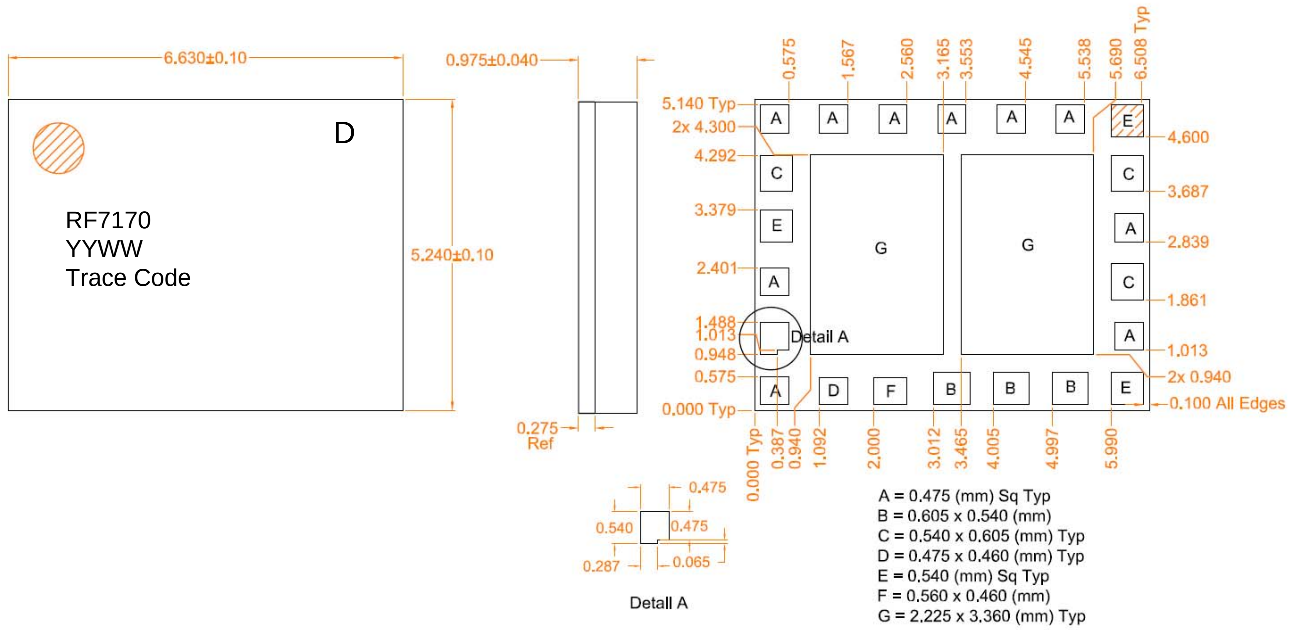
Package Drawing



Notes:

YY indicates year, WW indicates work week, and Trace Code is a sequential number assigned at device assembly.

Shaded areas represent Pin 1 location.

PCB Design Requirements

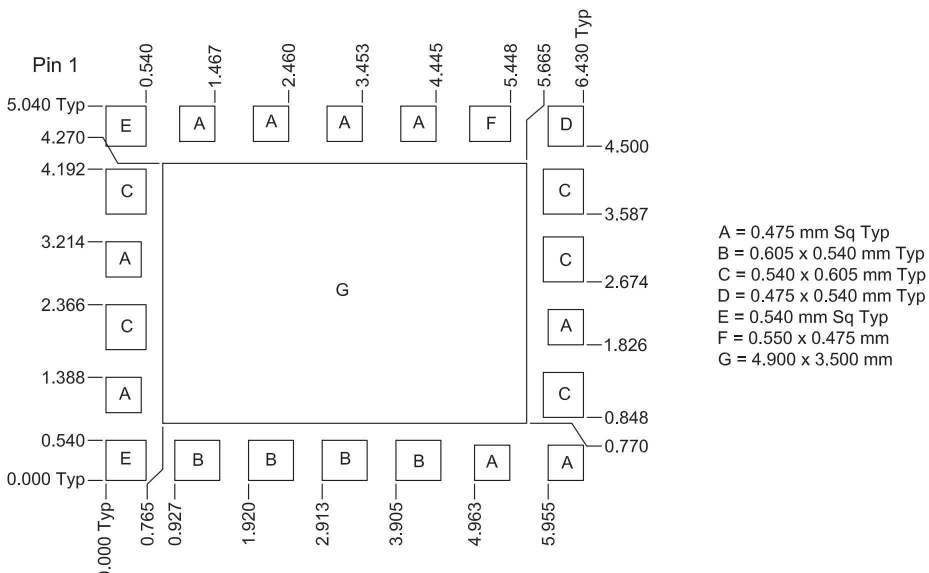
PCB Surface Finish

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



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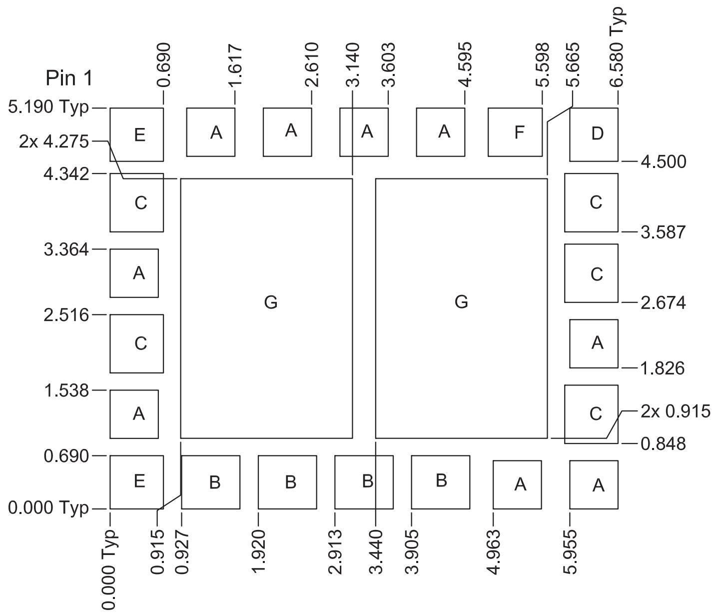
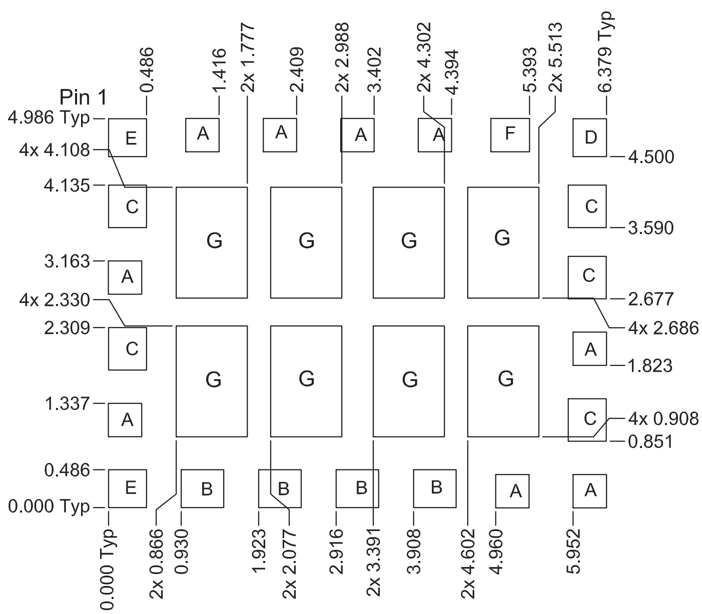
PCB Solder Mask Pattern



A = 0.625 mm Sq Typ
B = 0.755 x 0.690 mm Typ
C = 0.690 x 0.755 mm Typ
D = 0.625 x 0.690 mm Typ
E = 0.690 mm Sq Typ
F = 0.700 x 0.625 mm
G = 2.225 x 3.360 mm Typ

PCB Stencil Pattern



A = 0.428 mm Sq Typ
B = 0.544 x 0.486 mm Typ
C = 0.486 x 0.544 mm Typ
D = 0.428 x 0.486 mm Typ
E = 0.486 mm Sq Typ
F = 0.495 x 0.428 mm
G = 0.911 x 1.422 mm Typ

Tape and Reel Information

Carrier tape basic dimensions are based on EIA481. The pocket is designed to hold the part for shipping and loading onto SMT manufacturing equipment, while protecting the body and the solder terminals from damaging stresses. The individual pocket design can vary from vendor to vendor, but width and pitch will be consistent.

Carrier tape is wound or placed onto a shipping reel either 330 mm (13 inches) in diameter or 178 mm (7 inches) in diameter. The center hub design is large enough to ensure the radius formed by the carrier tape around it does not put unnecessary stress on the parts.

Prior to shipping, moisture sensitive parts (MSL level 2a-5a) are baked and placed into the pockets of the carrier tape. A cover tape is sealed over the top of the entire length of the carrier tape. The reel is sealed in a moisture barrier ESD bag which is placed in a cardboard shipping box. It is important to note that unused moisture sensitive parts need to be resealed in the moisture barrier bag. If the reels exceed the exposure limit and need to be rebaked, most carrier tape and shipping reels are not rated as bakeable at 125°C. If baking is required, devices may be baked according to section 4, table 4-1, column 8 of Joint Industry Standard IPC/JEDEC J-STD-033A.

The following table provides useful information for carrier tape and reels used for shipping the devices described in this document.

RFMD Part Number	Reel Diameter Inch (mm)	Hub Diameter Inch (mm)	Width (mm)	Pocket Pitch (mm)	Feed	Units per Reel
RF7170DTR13	13 (330)	4 (102)	12	8	Single	2500
RF7170DTR7	7 (178)	2.4 (61)	12	8	Single	750

QFN (Carrier Tape Drawing with Part Orientation)

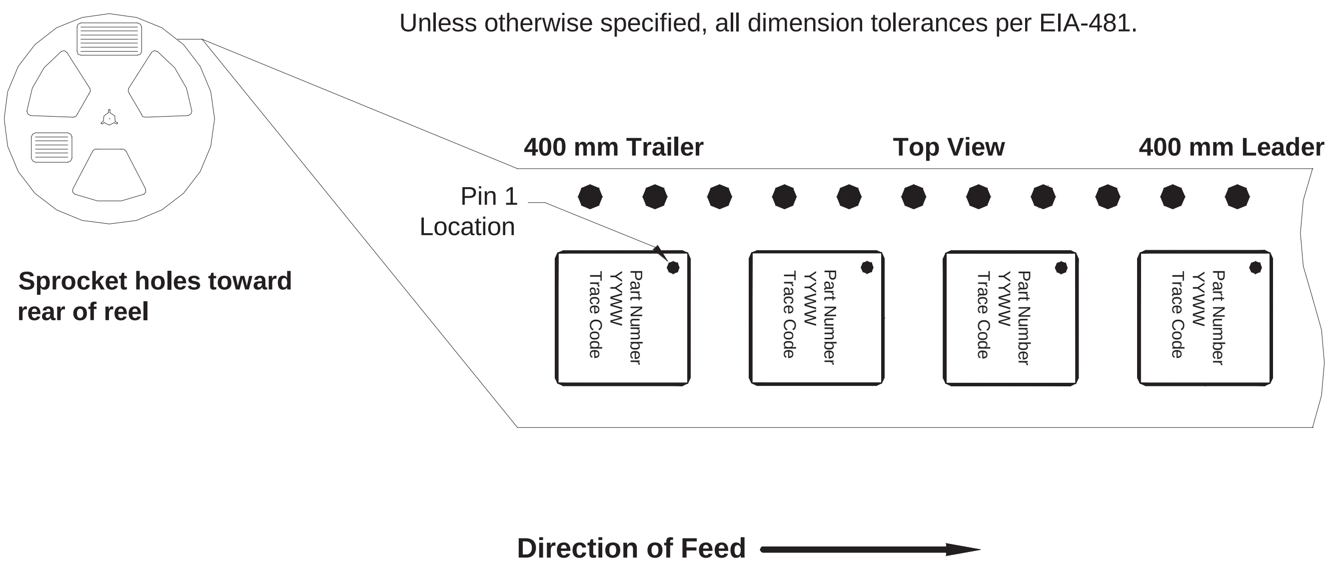


Figure 1. 5.24mmx6.63mm (Carrier Tape Drawing with Part Orientation)

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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

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