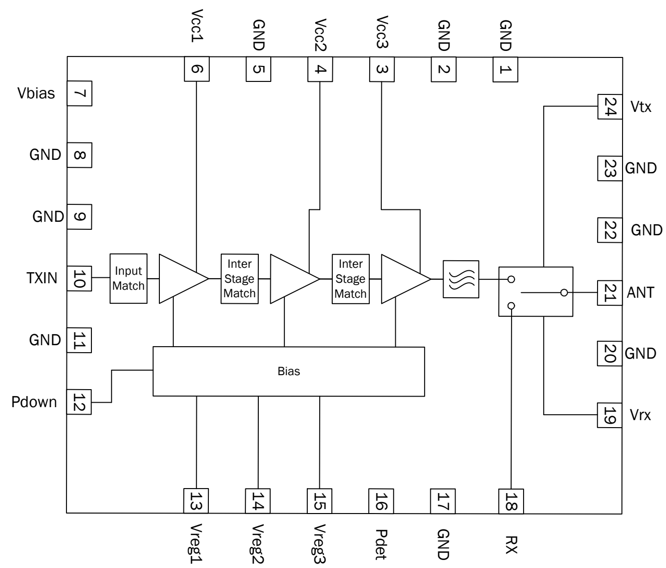
RFFM7600

5.0V, 2.5GHz TO 2.7GHz HIGH POWER FRONT END MODULE

Package: 6mm x 6mm Laminate



Functional Block Diagram

Features

- 34dB Typical Gain Across Frequency Band
- P_{OUT} = 27dBm <2.5% EVM WiMAX
- 2.5GHz to 2.7GHz Frequency Range
- P_{OUT} = 24dBm, -48dBc ACPR LTE DL
- Integrated 3-stage PA, filtering and T/R switch.
- Integrated Power Detector and High Impedance Control Pin

Applications

- WiMAX Applications
- LTE TDD Application
- Customer Premises Equipment (CPE)
- Data Cards and Terminals
- Spread-Spectrum and MMDS Systems

Product Description

The RFFM7600 is a Front End Module, designed for the WiMAX 2.5GHz to 2.7GHz market with LTE bands between 2.5GHz to 2.7GHz. It consists of a Power Amplifier with Tx harmonic filtering and T/R switching. RFFM7600 is provided in a 6mm x 6mm laminate package, incorporating SMD's for filtering and matching.

Ordering Information

RFFM7600PCK-410	RFFM7600 Eval board with 5-piece bag
RFFM7600SB	5-Piece bag
RFFM7600SR	100-Piece Reel
RFFM7600TR7	2500-Piece reel
RFFM7600SQ	25-Piece bag

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	

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Absolute Maximum Ratings

Parameter	Rating	Unit
Supply Voltage (RF Applied)	-0.5 to +5.25	V
Supply Voltage (No RF Applied)	-0.5 to +6.0	V
DC Supply Current	1000	mA
A Input RF Power	+10*	dBm
Operating Ambient Temperature	-30 to +85	°C
Storage Temperature	-40 to +150	°C
Moisture Sensitivity	MSL3	

*Maximum Input Power with a 50Ω load.

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.

RFMD Green: RoHS compliant per EU Directive 2002/95/EC, halogen free per IEC 61249-2-21, < 1000ppm each of antimony trioxide in polymeric materials and red phosphorus as a flame retardant, and <2% antimony in solder.

Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
Typical Conditions					T = 25°C, V_{CC} = 5V, V_{REG} = 2.85V, P_{DOWN} = 2.85V;
Frequency	2570		2620	MHz	LTE Band 38 Compliance: LTE Downlink; using a 20MHz, LTE DL ETM1.1 waveform, unless otherwise noted.
Output Power	24	24.5		dBm	
ACP (adjacent Channel)		-48	-45	dBc	At rated P_{OUT}
EVM			3	%	
Operating Current		700		mA	At P_{OUT} = 24dBm
Quiescent Current		575		mA	
Frequency	2500		2700	MHz	LTE Band 41 Compliance: LTE Downlink; using a 20MHz, LTE DL ETM1.1 waveform, unless otherwise noted.
Output Power	23	24		dBm	
ACP (adjacent Channel)		-48	-41	dBc	At rated P_{OUT}
EVM			3	%	
Operating Current		700		mA	At P_{OUT} = 24dBm
Quiescent Current		575		mA	
TX Other					Compliance: LTE Downlink; using a 20MHz, LTE DL ETM1.1 waveform, unless otherwise noted.
2nd Harmonic		-45	-38	dBm/MHz	At rated P_{OUT}
3rd Harmonic		-50		dBm/MHz	
Frequency	2500		2700	MHz	Compliance: IEEE802.16e, using a 10MHz, IEEE802.6e waveform, unless otherwise noted.
802.16e Output Power		27		dBm	25°C 10MHz 802.16e mask
EVM		2.5	3	%	
Gain	32	34		dB	
Gain Variation	-2		2	dB	
Gain in Low Gain/Power Mode		15		dB	V_{REG2} = 0V
Operating Current		825		mA	
Quiescent Current		575		mA	
2nd Harmonic		-43		dBm/MHz	Over all conditions
3rd Harmonic		-50		dBm/MHz	

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Parameter				Unit	Condition
Tx General Spec					Compliance: IEEE802.16e, using a 10MHz, IEEE802.6e waveform, unless otherwise noted.
Gain	32	34		dB	At P_{OUT} = 24dBm
Gain Variation	-2		2	dB	
Input Return Loss	10	15		dB	In specified frequency band
V_{REG}	2.8	2.85	2.9	V	
I_{REG}		8	10	mA	
Power Detect Range	0.2		2.1	V	P_{OUT} range of 0dBm to 30dBm
P_{DOWN} Current		11		mA	V_{CC} = 5V, V_{REG} =2.85V, P_{DOWN} = 0V
Leakage Current		0.2	0.5	mA	V_{CC} = 5V, V_{REG}= 0V, P_{DOWN} = 0V
Turn-on Time		0.4	1	µs	Output stable to within 90% of final gain
Stability	-25		30	dBm	No spurs above -47dBm into 4:1 VSWR
No Damage into Output VSWR			10:1		50Ω load at nominal pin
Max Pin (Ruggedness - 50Ω)			10	dBm	No damage
RX Spec					Compliance: IEEE802.16e, using a 10MHz, IEEE802.6e waveform, unless otherwise noted.
Rx Insersion Loss		0.7	1	dB	
RX to ANT isolation - in Tx mode		26		dB	
RX to TX isolation - in Tx mode		25		dB	
Control					Compliance: IEEE802.16e, using a 10MHz, IEEE802.6e waveform, unless otherwise noted.
Voltage Logic High	2.8	3.1	3.4	V	
Voltage Logic Low	0		0.3	V	
Control Current - Logic High		5	10	µA	
Control Current - Logic Low		0.1	1	µA	
T/R switching time			0.5	µs	
Other					Compliance: IEEE802.16e, using a 10MHz, IEEE802.6e waveform, unless otherwise noted.
Thermal Resistance Rth_j		14		°C/W	
ESD					
Human Body Model	500			V	EIA/JESD22-114A RF Pin to Ground
	500			V	EIA/JESD22-114A DC Pin to Ground
Charge Device Model	1000			V	JESD22-C101C all pins to Ground

RFFM7600 Truth Table

Status	PDOWN	VTX	VRX
TX Mode	1	1	0
RX Mode	0	0	1

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Pin Names and Descriptions

Pin	Name	Description
1	GND	Ground connection
2	GND	Ground connection
3	VCC3	This pin is connected internally to the collector of the 3rd stage RF device. To achieve specified performance, the layout of these pins should match the Recommended Land Pattern.
4	VCC2	This pin is connected internally to the collector of the 2nd stage RF device. To achieve specified performance, the layout of these pins should match the Recommended Land Pattern.
5	GND	Ground connection
6	VCC1	This pin is connected internally to the collector of the 1st stage RF device. To achieve specified performance, the layout of these pins should match the Recommended Land Pattern.
7	VBIAS	Supply voltage for the bias reference and control circuits.
8	GND	Ground connection
9	GND	Ground connection
10	TXIN	RF input is internally matched to 50Ω and DC blocked.
11	GND	Ground connection
12	PDOWN	Power down pin. Apply <0.6V_{DC} to power down the three power amplifier stages. Apply 1.75V_{DC} to 5.0V_{DC} to power up. If function is not desired, Pin may be connected to V_{REG}.
13	VREG1	First stage bias voltage. This Pin requires regulated supply for best performance.
14	VREG2	Second stage bias voltage. This Pin requires regulated supply for best performance.
15	VREG3	Third stage bias voltage. This Pin requires regulated supply for best performance.
16	PDET	Power detector provides an output voltage proportional to the RF output power level.
17	GND	Ground connection
18	RX	RF Output is internally matched to 50Ω and DC blocked.
19	VRX	Switch control for RX mode
20	GND	Ground connection
21	ANT	RF Output is internally matched to 50Ω and DC blocked.
22	GND	Ground connection
23	GND	Ground connection
24	VTX	Switch control for TX mode
PkG Base	GND	Ground connection

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Theory of Operation and Applications

The RFFM7600 is a single-chip integrated front end module (FEM) for high performance LTE DL and WiMAX applications in the 2.5GHz to 2.7GHz ISM band. The FEM greatly reduces the number of external components minimizing footprint and assembly cost of the overall LTE TDD and 802.16e solution. The RFFM7600 has an integrated linear power amplifier, a power detector, and Tx filtering and a switch, which is capable of switching between Rx and Tx operations. The device is manufactured using InGaP HBT and pHEMT processes on a 6mm x 6mm x 0.95mm laminate package. The module meets or exceeds the RF front end needs of the LTE DL and WiMAX RF systems. As the RFFM7600 is fully RF matched to 50Ω internally and requires minimal external components, it is very easy to implement on to PCB designs. To reduce the design and optimization process on the customer application, the evaluation board layout should be copied as close as possible, in particular the ground and via configurations. Gerber files of RFMD PCBA designs can be provided upon request. The supply voltage lines should present an RF short to the FEM by using bypass capacitors on the VCC traces. To simplify bias conditions, the RFFM7600 requires a single positive supply voltage (VCC), a positive current control bias (VREG) supply or high impedance enable, and a positive supply for switch control. The built-in power detector of the RFFM7600 can be used as power monitor in the system. All inputs and outputs are internally matched to 50Ω.

Transmit Path

The RFFM7600 has a typical gain of 34dB from 2.5GHz to 2.7GHz, and delivers >27dBm typical output power in WiMAX and >24dBm typical in LTE DL with ACP <-45dBc The RFFM7600 requires a single positive of 5.0V to operate at full specifications. The VREG pin requires a regulated supply at 2.85V to maintain nominal bias current.

Out of Band Rejection

The RFFM7600 contains a low pass filtering (LPF) to attenuate the 2nd Harmonics to -38dBm/MHz (typical). Depending upon the end-user's application, additional filters may be needed to meet the out of band rejection requirements of the system.

Receive Path

The Rx path has a 50Ω single-ended port. The Receive port return loss is 9.6dB minimum. In this mode, the FEM has an insertion loss of 0.8dB and 30dB (typical) isolation to Tx port.

RFFM7600 Biasing Instructions to the Eval board:

- WiMAX or LTE DL Transmit:
- Connect the FEM to a signal generator at the input and a spectrum analyzer at the output. Set the pin at signal generator is at -20dBm.
- Bias V_{CC} to 5.0V first with V_{REG} = 0.0V. If available, enable the current limiting function of the power supply to 1100mA.
- Refer to switch operational truth table to set the control lines at the proper levels for Tx. It is recommended to maintain at least 2.85V on VTX during Tx mode. A lower VTX voltage will enable the switch in Tx mode, but 2.85V is needed to ensure that the switch stays in Tx mode during high power peaks. Using a VTX voltage less than 2.85V in Tx mode could result in abnormal operation or device damage.
- Turn on V_{REG} to 2.85V (typ.). On VREG (of Eval board), regulated supply is recommended. Be extremely careful not to exceed 3.0V on the VREG pin or the part may exceed device current limits.
- Turn on P_{DOWN} to 2.85V (typ.). PDOWN Pin can be tied to VREG supply.

  NOTE: It is important to adjust the V_{CC} voltage source so that +5V is measured at the board; and the +2.85V of V_{REG} is measured at the board. The high collector currents will drop the collector voltage significantly if long leads are used. Adjust the bias voltage to compensate.
- Turn on RF of signal generator and gradually increase power level to the rated power.

  CAUTION: If the input signal exceeds the maximum rated power, the RFFM7600 evaluation board can be permanently damaged.
- To turn off FEM, turn off RF power of signal generator; then P_{DOWN}, V_{REG} and V_{CC}.

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- Receive
- To receive WiMAX or LTE set the switch control lines per the truth table.

General Layout Guidelines and Considerations:
For best performance the following layout guidelines and considerations must be followed regardless of final use or configuration:

1. The ground pad of the RFFM7600 has special electrical and thermal grounding requirements. This pad is the main RF ground and main thermal conduit path for heat dissipation. The GND pad and vias pattern and size used on the RFMD evaluation board should be replicated. The RFMD layout files in Gerber format can be provided upon request. Ground paths (under device) should be made as short as possible.
2. The RF lines should be well separated with solid ground in between the traces to eliminate any possible RF leakages or cross-talking.
3. Bypass capacitors should be used on the DC supply lines. The VCC lines may be connected after the RF bypass and decoupling capacitors to provide better isolation between each VCC line.

RFFM7600 Tx Production and System Calibration Recommendation:
It is highly recommended to follow the DC biasing step and RF power settings in the production calibration or test.

1. Connect the RF cables of input and output then connect to the proper equipment.
2. Apply V_{CC}, then V_{REG} as per the data sheet recommendations.
3. Set FEM in Tx mode by the truth table.
4. Apply P_{DOWN} = high.
5. Set RF input to the desired frequency and initial RF input power at -20dBm. This will insure the power amplifier is in a linear state and not over driven.
6. Sweep RF from low to high output power and take measurements at the rated output power.
7. Ensure that the output power at turn on does not saturate the power amplifier. The recommended output power should be about 10dB to 20dB below the nominal input power. Start calibrating from low to high power in reasonable steps until the rated power is reached then take the measurements.

   CAUTION: If the input signal exceeds the maximum rated input power specifications, the RFFM7600 could be permanently damaged.

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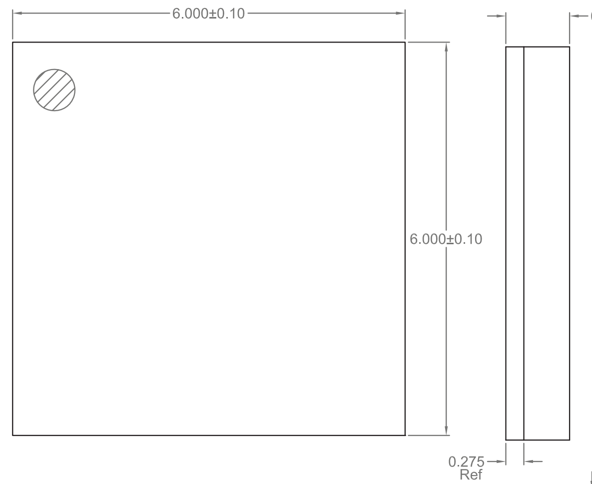
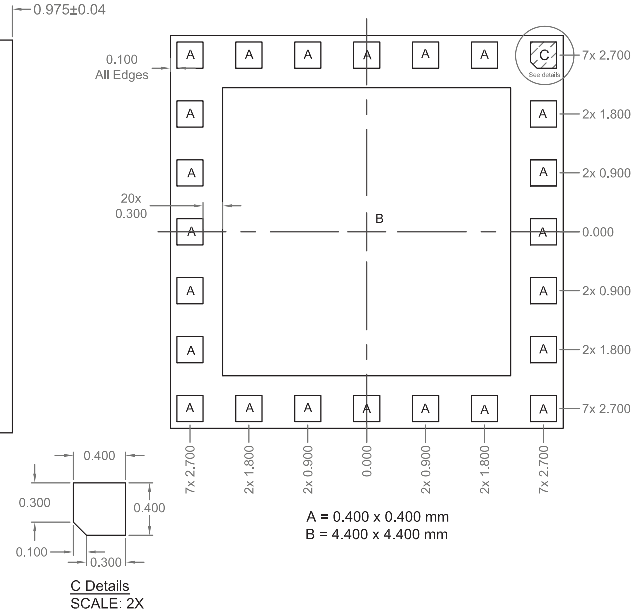
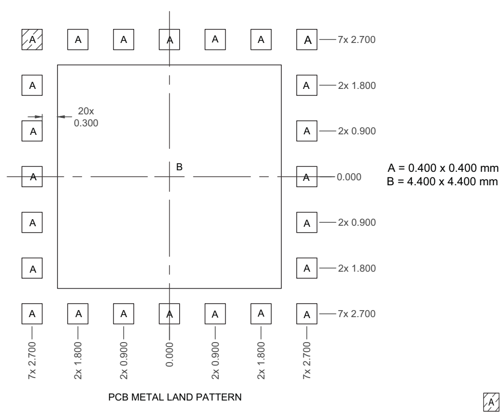
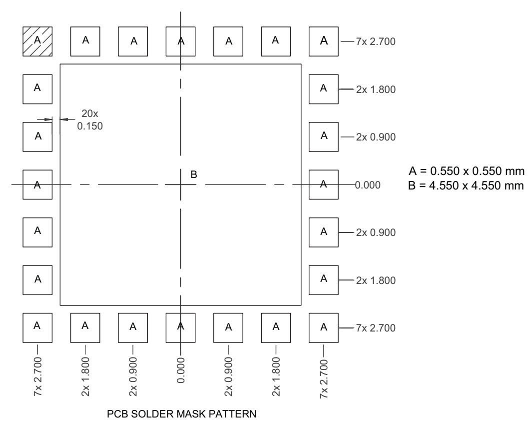
Package Drawing

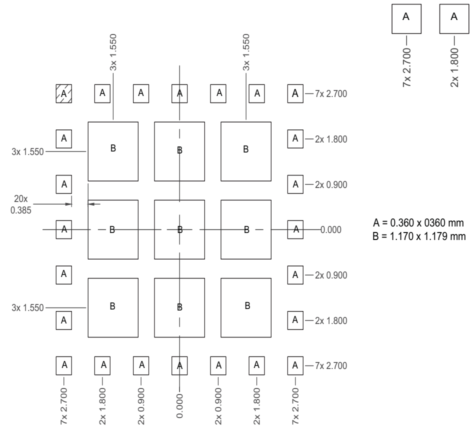




Notes:
1. Shaded area represents Pin 1 location
2. Defining I/O Pad Center:
   To define center of the I/O pad opening, draw a right triangle in one corner of the I/O pad
   Then take the center of the hypotenuse to determine center of I/O pad







Notes:
1. Shaded area represents Pin 1 location

Note: Thermal vias for center slug "B" should be incorporated into the PCB design. The number and size of thermal vias will depend on the application. Example of the number and size of vias can be found on the RFMD evaluation board layout.

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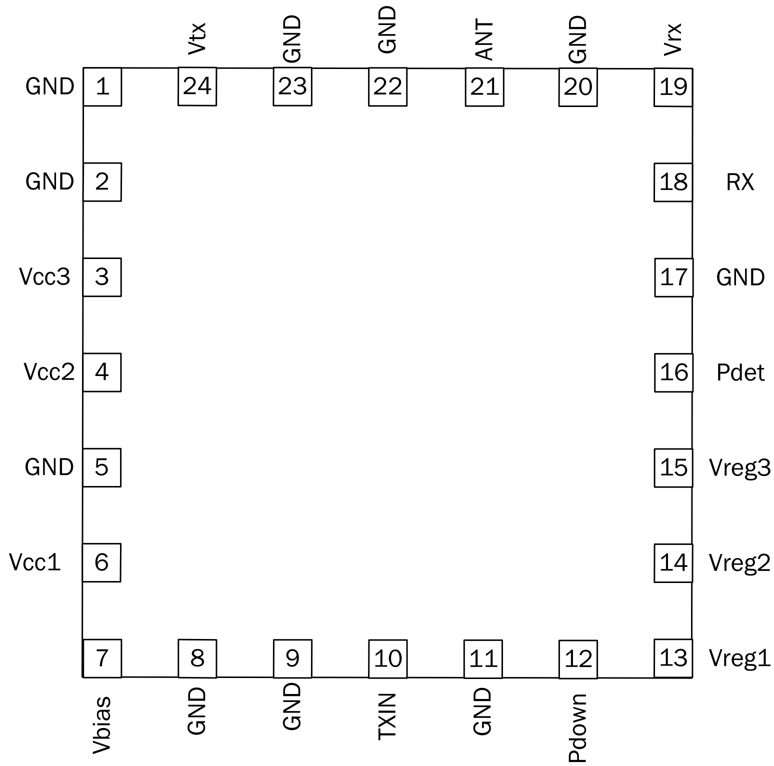
Pin Out



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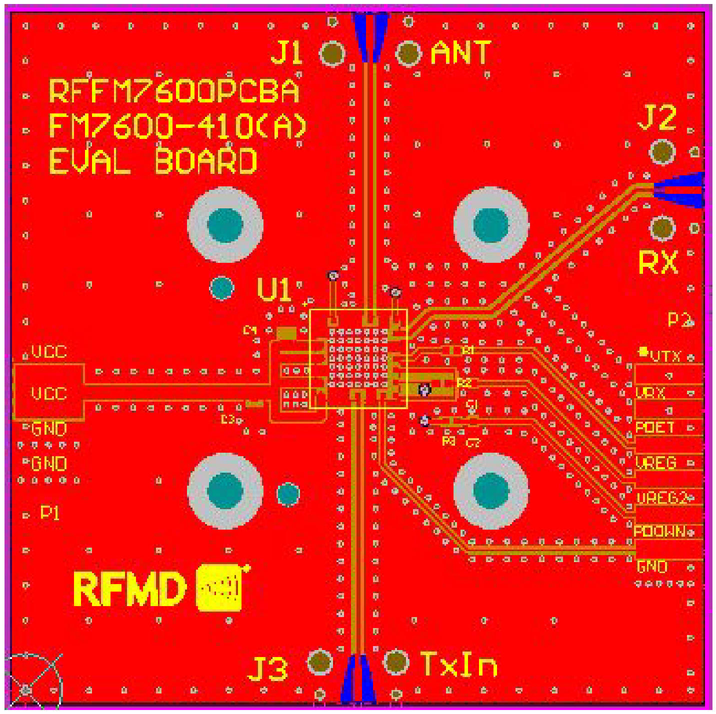
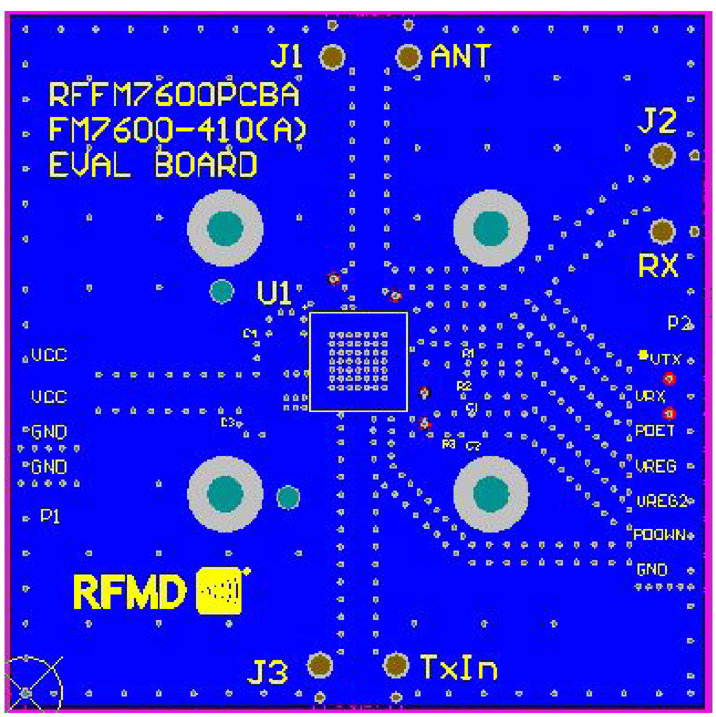
RFFM7600 Evaluation Board

Top Layer



Bottom Layer



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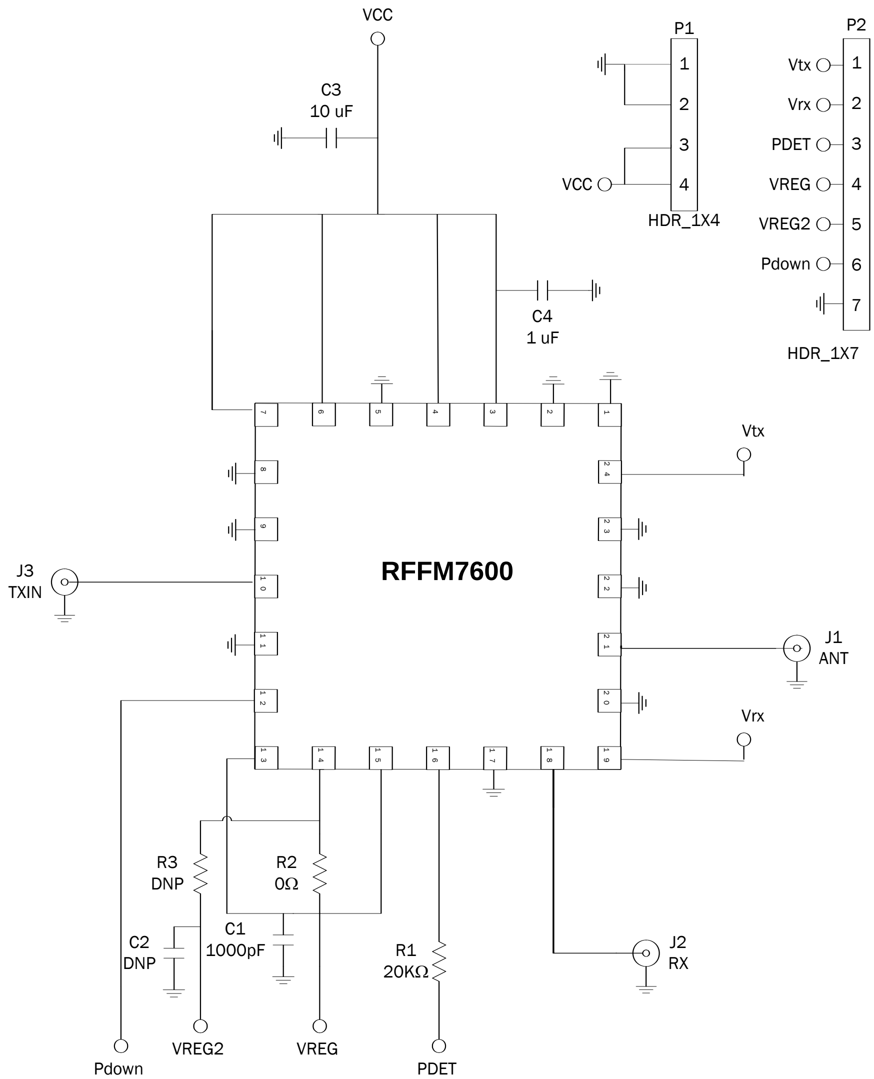
Evaluation Board Schematic



Bill of Materials (BOM)

Description	Qty	Reference Designator	Manufacturer	Manufacturer's P/N
CAP, 1000pF, 10%, 50V, X7R, 0402	1	C1	Murata Electronics	GRM155R71H102KA01D
CAP, 1uF, 10%, 10V, X5R, 0603	1	C4	Murata Electronics	GRM188R61A105KA61D
CAP, 10uF, 10%, 10V, X5R, 0805	1	C3	Murata Electronics	RM21BR61A106KE19L
CONN, SMA, END LNCH, UNIV, HYB MNT, FLT	3	J1, J2, J3	MOLEX	SD-73251-4000
RES, 20K, 5%, 1/16W, 0402	1	R1	PANASONIC INDUSTRIAL CO	ERJ-2GEJ203
RES, 0 OHM, 0402	3	R2	Kamaya, Inc	RMC1/16SJPTH
DNI	2	R3, C2		
RFFM7600	1	U1	RFMD	RFFM7600

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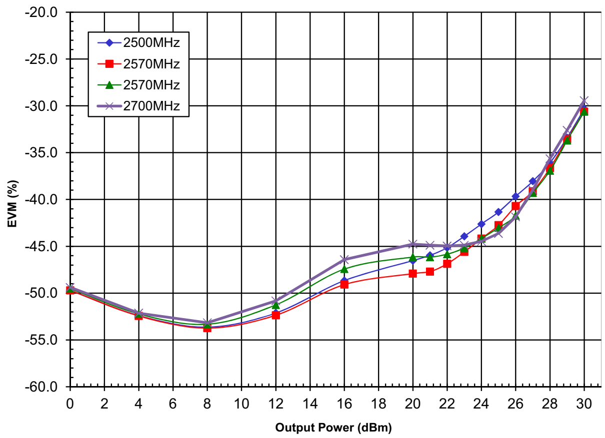
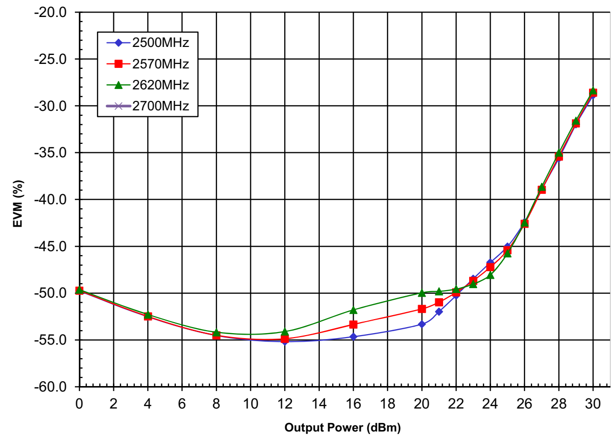
Performance Plots

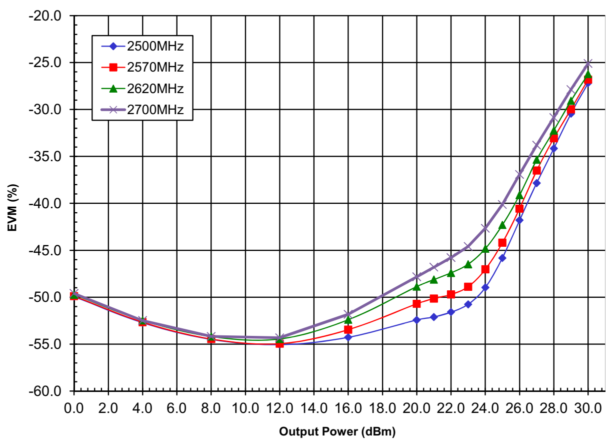
APLR (dB) versus P_{OUT} (dBm)
- 40°C
V_{CC} = 5V_{DC} V_{REG} = 2.85V_{DC}
E-TM1.1 with LTE DL 20MHz



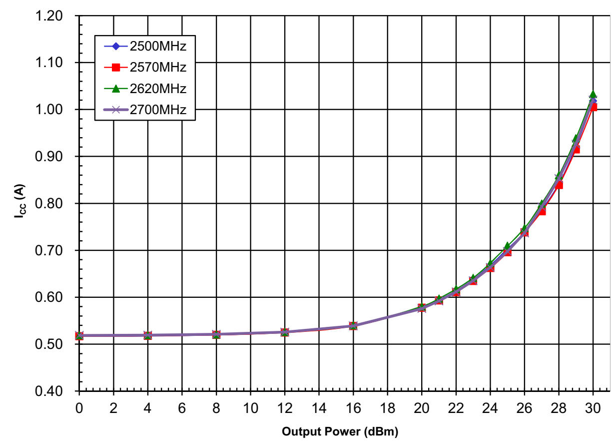
ACLR (dB) versus P_{OUT} (dBm)
25° C
V_{CC} = 5V_{DC} V_{REG} = 2.85V_{DC}
E-TM1.1 with LTE DL 20MHz



ACLR (dB) versus P_{OUT} (dBm)
85° C
V_{CC} = 5V_{DC} V_{REG} = 2.85V_{DC}
E-TM1.1 with LTE DL 20MHz



I_{CC} (A) versus P_{OUT} (dBm)
- 40° C
V_{CC} = 5V_{DC} V_{REG} = 2.85V_{DC}



I_{CC} (A) versus P_{OUT} (dBm)
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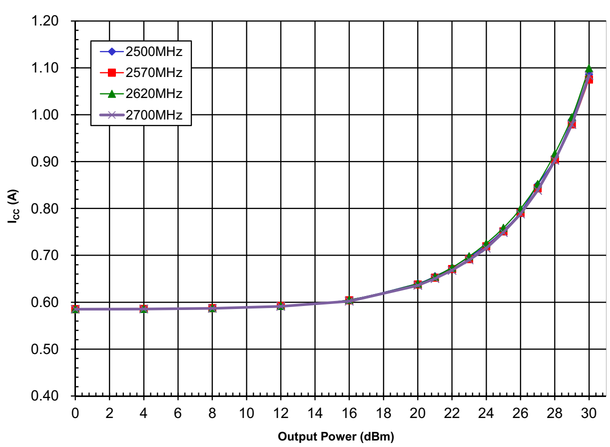

I_{CC} (A) versus P_{OUT} (dBm)
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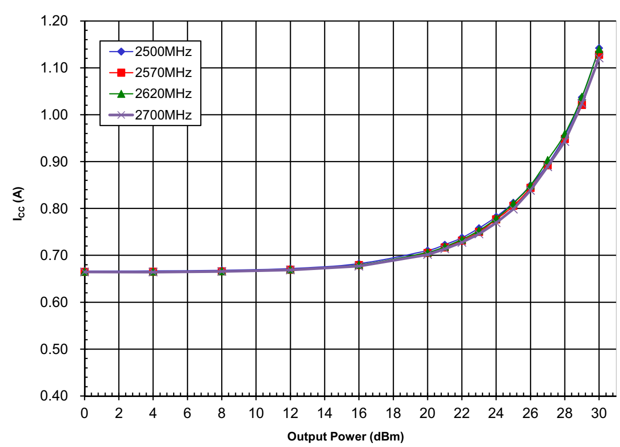

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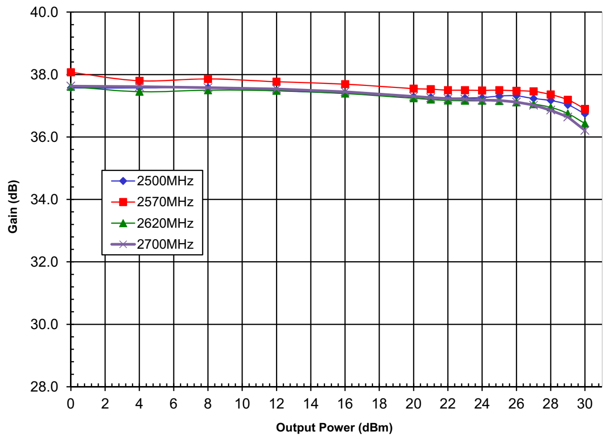
Performance Plots

Gain (dB) versus P_{OUT} (dBm)
- 40° C
V_{CC} = 5V_{DC} V_{REG} = 2.85V_{DC}



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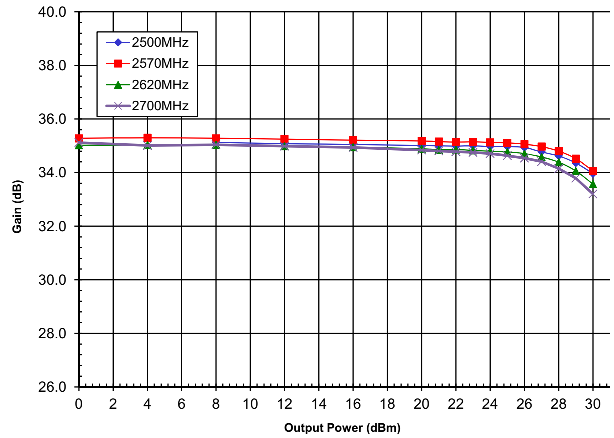

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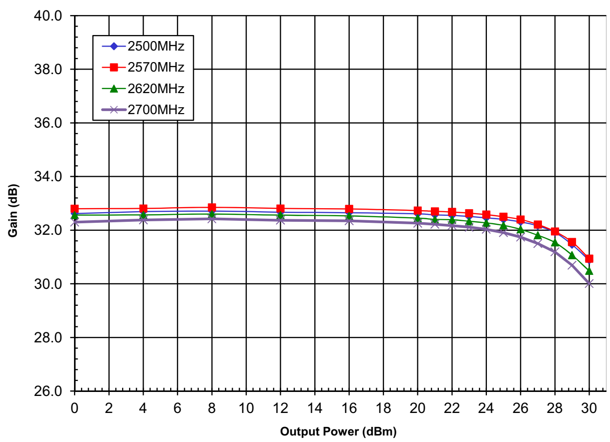
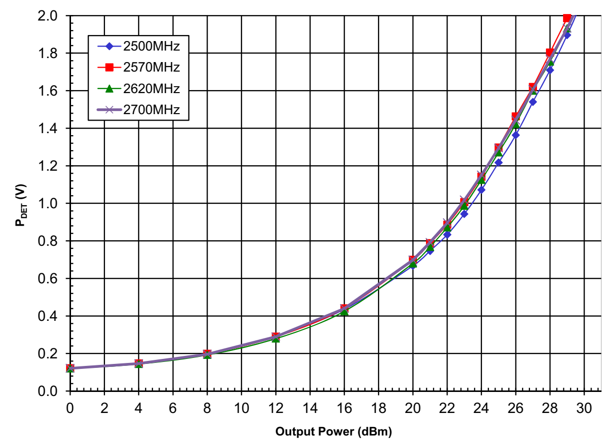


Power Detect (V) versus P_{OUT} (dBm)
- 40° C
V_{CC} = 5V_{DC} V_{REG} = 2.85V_{DC}



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25° C
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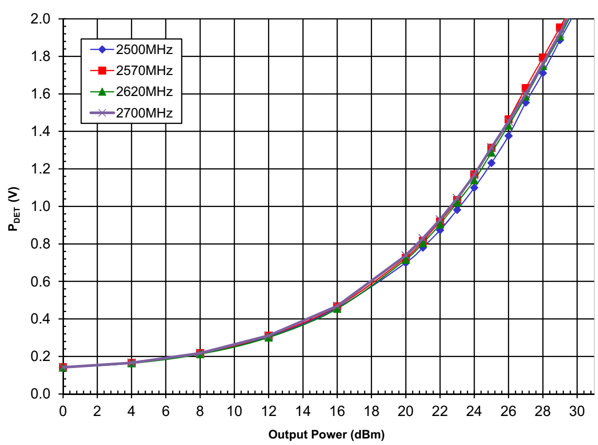

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