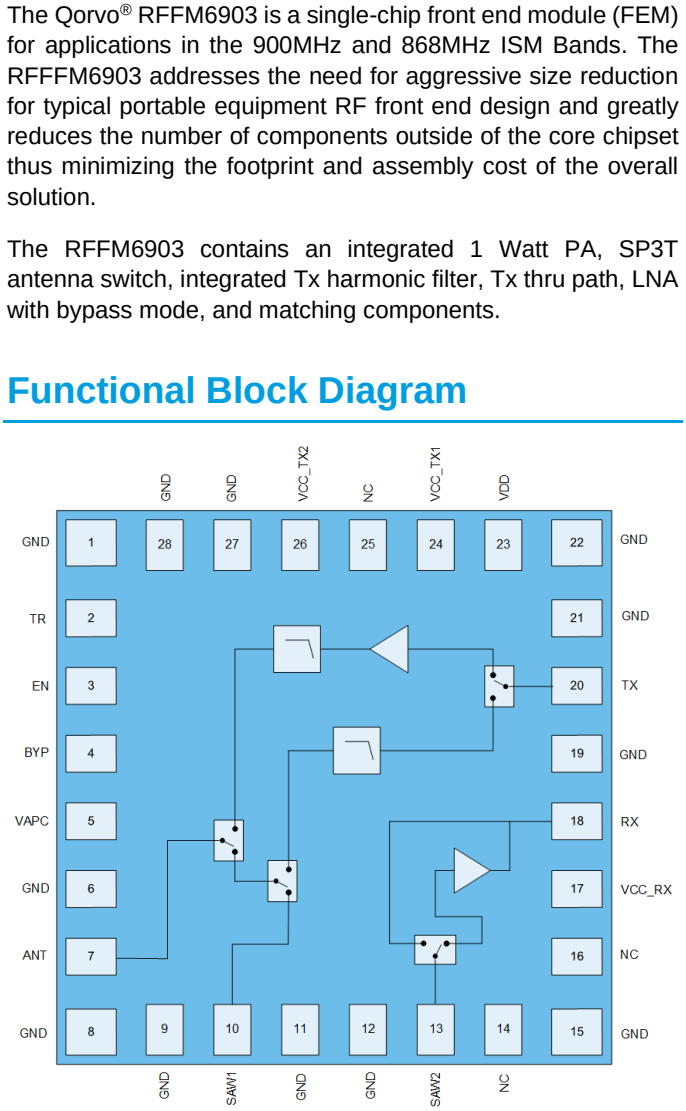
# RFFM6903

## ISM Front End Module

## Product Overview

The Qorvo® RFFM6903 is a single-chip front end module (FEM) for applications in the 900MHz and 868MHz ISM Bands. The RFFFM6903 addresses the need for aggressive size reduction for typical portable equipment RF front end design and greatly reduces the number of components outside of the core chipset thus minimizing the footprint and assembly cost of the overall solution.

The RFFM6903 contains an integrated 1 Watt PA, SP3T antenna switch, integrated Tx harmonic filter, Tx thru path, LNA with bypass mode, and matching components.




*Top View*




*28 Pad 6x6 mm Laminate Package*

## Functional Block Diagram

## Key Features

- 890-960 MHz
- Integrated 50Ω Input/Output Match
- Tx Output Power: 30dBm
- Separate TX/RX 50Ω transceiver interface
- Integrated PA, filtering LNA with Bypass Mode
- Transmit Thru path

## Applications

- Wireless Automatic Metering
- Portable Battery Powered Equipment
- Smart Energy

## Ordering Information

| Part Number | Description |
|---|---|
| RFFM6903SB | Sample bag with 5 pieces |
| RFFM6903SQ | Sample bag with 25 pieces |
| RFFM6903SR | 7” reel with 100 pieces |
| RFFM6903TR13 | 13” reel with 2,500 pieces |
| RFFM6903PCK-410 | Evaluation board w/ 5 pc bag |

## Absolute Maximum Ratings

| Parameter | Conditions | Rating |
|---|---|---|
| Voltage | | +5.25 V |
| Control Voltage | | VDD – 0.2 $V_{DC}$ |
| Storage Temperature | | -40 to 150 °C |
| RF Input Power at TX | Transmit Mode | +15 dBm |
| RF Input Power at TX | Transmit Bypass Mode | +20 dBm |
| RF Input Power at ANT | | +33 dBm |
| RF Input Power at SAW2 | | +5 dBm |
| T/R Port Load VSWR | Transmit Mode | 10:1 |

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.

## Recommended Operating Conditions

| Parameter | Min. | Typ. | Max. | Units |
|---|---|---|---|---|
| Operating Frequency | 890 | 925 | 960 | MHz |
| RF Port Impedance | | 50 | | Ω |
| Device Voltage (VCC_TX1 & VCC_TX2, VDD) | +2.5 | +3.6 | +4.2 | V |
| Device Voltage (VCC_RX) | +2.5 | +3.3 | +4.2 | V |
| TX Output Power Control Voltage (VAPC) | 0 | +2.25 | +2.5 | V |
| $T_{OPERATING}$* | -40 | | +85 | °C |

Electrical specifications are measured at specified test conditions. Specifications are not guaranteed over all recommended operating conditions. . * $T_{OPERATING}$ is temperature at package ground.

## Electrical Specifications

| Parameter | Conditions | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|
| **TRANSMIT (TX-ANT) MODE** | **Unless otherwise noted: VCC_TX1 = 3.6V, VCC_TX2 = 3.6V, VDD = 3.6V, VCC_RX = 0.0V, VAPC = 2.25V, EN = 1.8V, TR = 1.8V, BYP = 0.2V, T=+25ºC** | | | | |
| Output Power | $V_{CC}$Tx1, $V_{CC}$Tx2 = 3.6V, $P_{IN}$ = +10dBm | 30 | 30.5 | | dBm |
| | $V_{CC}$Tx1, $V_{CC}$Tx2 = 2.7V, $P_{IN}$ = +10dBm | 28 | | | dBm |
| Gain | $V_{CC}$Tx1, $V_{CC}$Tx2 = 3.6V, $P_{IN}$ = +10dBm | 20 | | | dB |
| | $V_{CC}$Tx1, $V_{CC}$Tx2 = 2.7V, $P_{IN}$ = +10dBm | 18 | | | dB |
| TX Port Return Loss | | 12.5 | | | dB |
| ANT Port Return Loss | | 7 | | | dB |
| Quiescent Current | $I_{CC}$_TX1/2; $I_{CC}$ TX1 + $I_{CC}$ TX2, RF = Off | | 100 | 180 | mA |
| | $I_{DD}$ | | 7 | | mA |
| | $I_{CC}$_RX | | 11.5 | | µA |
| Operating Current | $P_{OUT}$ = 30.5dBm, ICC TX1 + ICC TX2 | | 840 | 960 | mA |
| $I_{DD}$ | $P_{OUT}$ = 30.5dBm | | 12 | 18 | mA |
| ANT-SAW1 Isolation | | 44 | | | dB |

| Parameter | Conditions | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|
| 2nd Harmonics | $P_{OUT}$ = 30.5dBm | | | -60 | dBc |
| 3rd Harmonics | $P_{OUT}$ = 30.5dBm | | | -60 | dBc |
| **TRANSMIT BYPASS (TX-ANT) MODE** | **Unless otherwise noted VCCTx1 = 3.6V, VCCTx2 = 3.6V, VDD = 3.6V, VCCRx = 0.0V, VAPC = 0.0V, EN = 1.8V, TR = 1.8V, BYP = 1.8V, T=+25ºC** | | | | |
| Insertion Loss | $P_{IN}$ = +5dBm | | 2 | 2.7 | dB |
| TX Port Return Loss | | 18 | | | dB |
| ANT Port Return Loss | | 13.5 | | | dB |
| Input P1dB | | 27 | 28 | | dBm |
| Input IP3 | | | 41 | | dBm |
| ANT-SAW1 Isolation | | 24 | | | dB |
| 2nd Harmonic Attenuation | $P_{IN}$ = +12dBm, Second Harmonic Insertion Loss | | | -46 | dBc |
| 3rd to 10th Harmonic Attenuation | $P_{IN}$ = +12dBm, Third - Tenth Harmonic Insertion Loss | | | -47 | dBc |
| **RECEIVE (SAW2-RX) LNA ON MODE** | **Unless otherwise noted: VCCTx1 = 3.3V, VCCTx2 = 3.3V, VDD = 3.3V, VCCRx = 3.3V, VAPC = 0.0V, EN = 1.8V, TR = 0.2V, BYP = 0.2V, T=+25ºC** | | | | |
| Gain | | 13.5 | 15.5 | 16 | dB |
| ANT-SAW1 Insertion Loss | | | 0.5 | | dB |
| Noise Figure | | | 2.1 | | dB |
| SAW2 Port Return Loss | | 18 | | | dB |
| RX Port Return Loss | | 10 | | | dB |
| ANT Port Return Loss | | 9 | 10 | | dB |
| SAW1 Port Return Loss | | 9 | 10 | | dB |
| Input $P_{1dB}$ | | | -2.5 | | dBm |
| Input IP3 | | +1.4 | +3 | | dBm |
| $I_{DD}$ | | | 150 | | µA |
| Rx Operating Current | | 4 | 5 | 6 | mA |
| **RECEIVE (SAW2-RX) BYPASS MODE** | **Unless otherwise noted: VCCTx1 = 3.3V, VCCTx2 = 3.3V, VDD = 3.3V, VCCRx = 3.3V, VAPC = 0.0V, EN = 1.8V, TR = 0.2V, BYP = 1.8V, T=+25ºC** | | | | |
| Bypass Loss | | 1.6 | 2.2 | 2.4 | dB |
| ANT-SAW1 Insertion Loss | | | 0.5 | | dB |
| SAW2 Port Return Loss | | 11 | | | dB |
| RX Port Return Loss | | 14 | | | dB |
| ANT Port Return Loss | | 9 | 10 | | dB |
| SAW1 Port Return Loss | | 9 | 10 | | dB |
| Input $P_{1dB}$ | | | +17.5 | | dBm |
| Input IP3 | | | +42 | | dBm |
| Current | $I_{CC}$_TX1/2 | | 90 | | µA |
| | $I_{DD}$ | | 100 | | µA |
| | $I_{CC}$_RX | | 50 | | nA |
| **GENERAL SPECIFICATIONS** | **Unless otherwise noted: VCC_TX1 = 3.6V, VCC_TX2 = 3.6V, VDD = 3.6V, VCC_RX = 3.6V, VAPC = 0.0V, EN = Low, TR = X, BYP = X, PA = OFF, LNA = OFF, T=+25ºC** | | | | |
| Leakage Current | VDD | | 0.05 | 1.0 | µA |
| | VCC_TX1, VCC_TX2 | | 0.05 | 1.0 | µA |
| | VCC_RX | | 0.05 | 1.0 | µA |

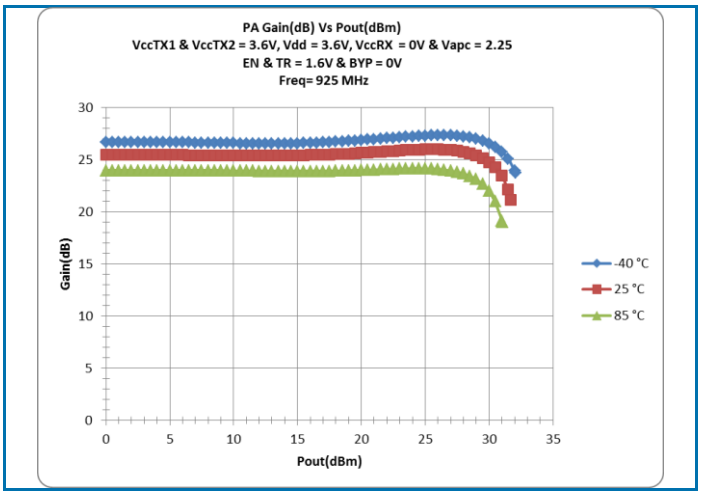
| Parameter | Conditions | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|
| Control Voltage - High | | 1.6 | | 4 | V |
| Control Current - High | | | 0.1 | | µA |
| Control Voltage - Low | | | 0.2 | 0.3 | V |
| Control Current - Low | | | 0.1 | | µA |
| VAPC High Current | Across all rated voltages at rated power | | 50 | | µA |
| Thermal Resistance, $\theta_{jc}$ | 3.6V $V_{CC}$, 100% Duty, 30.2 dBm $P_{OUT}$, $T_{REF}$ = 85° C | | 24.73 | | °C/W |

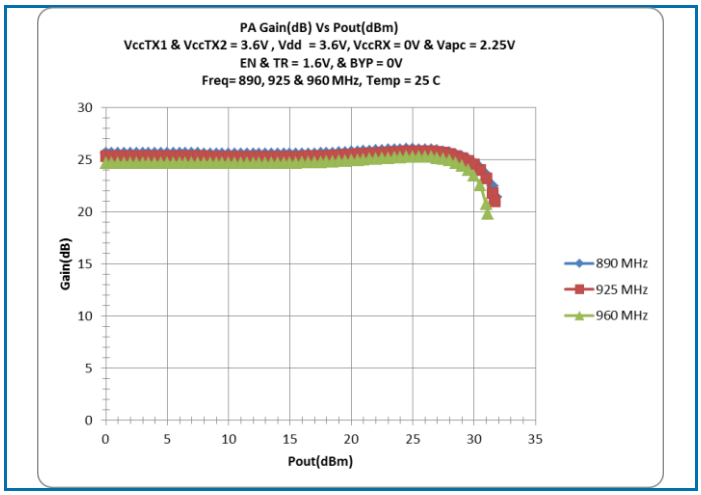
Notes:
1. 868MHz data available upon request.

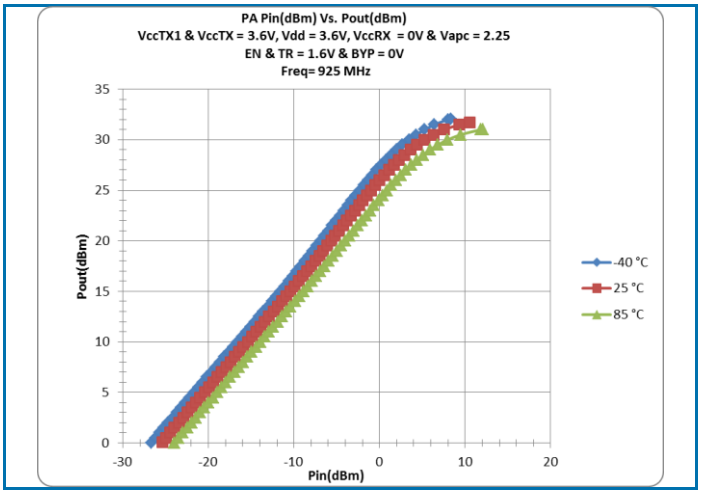
## Logic Truth Table

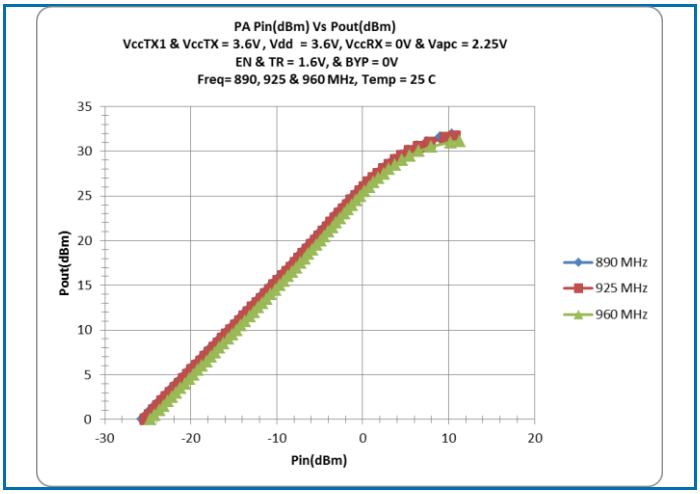
| Mode | TR | EN | BYP | PA | LNA |
|---|---|---|---|---|---|
| Transmit | High | High | Low | On | Off |
| Transmit Bypass | High | High | High | Off | Off |
| Receive | Low | High | Low | Off | On |
| Receive Bypass | Low | High | High | Off | Off |
| Shutdown | X | Low | X | Off | Off |

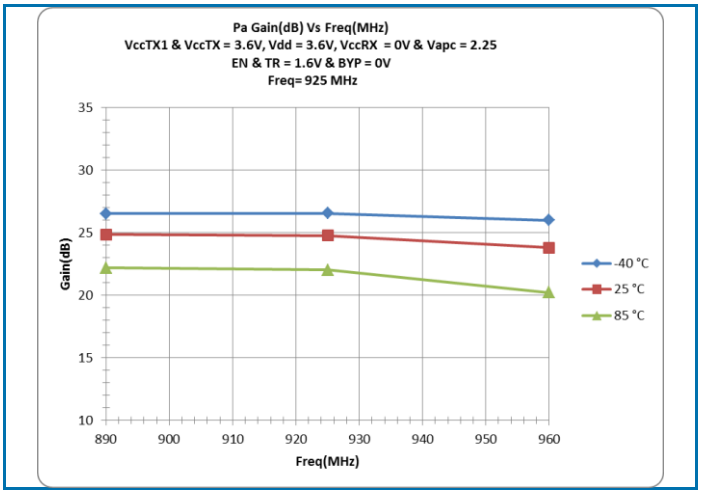
## Typical Performance

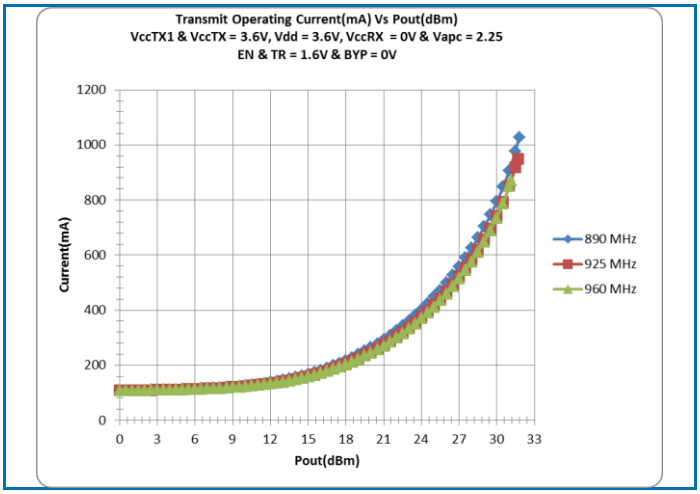


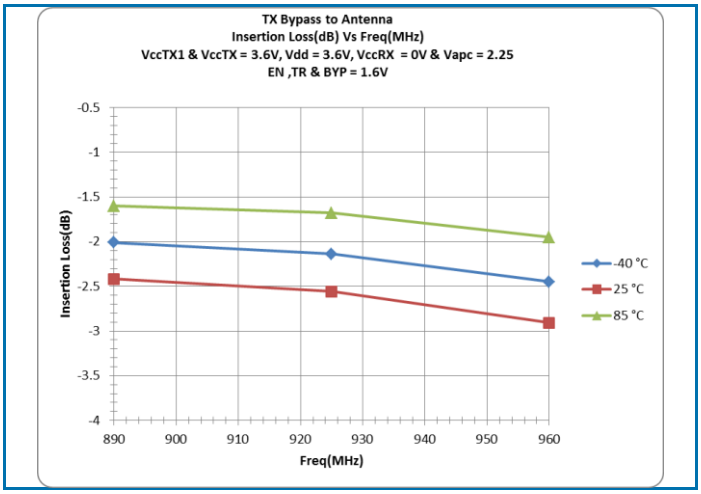



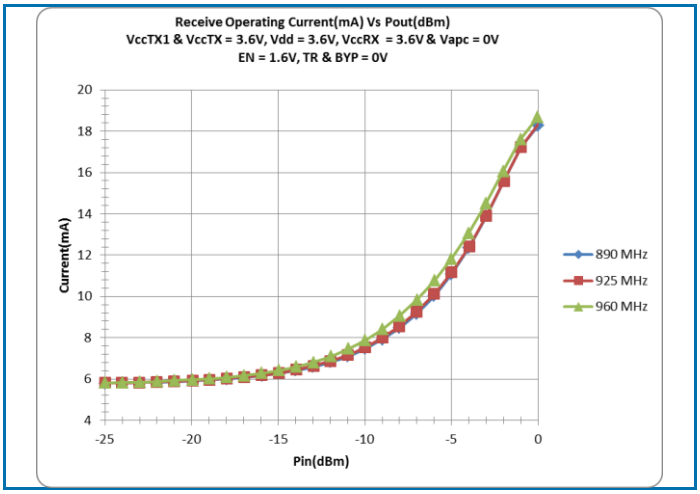

PA Pin(dBm) Vs. Pout(dBm)
VccTX1 & VccTX = 3.6V, Vdd = 3.6V, VccRX = 0V & Vapc = 2.25
EN & TR = 1.6V & BYP = 0V
Freq= 925 MHz
Pout(dBm)
Pin(dBm)
-40 °C
25 °C
85 °C

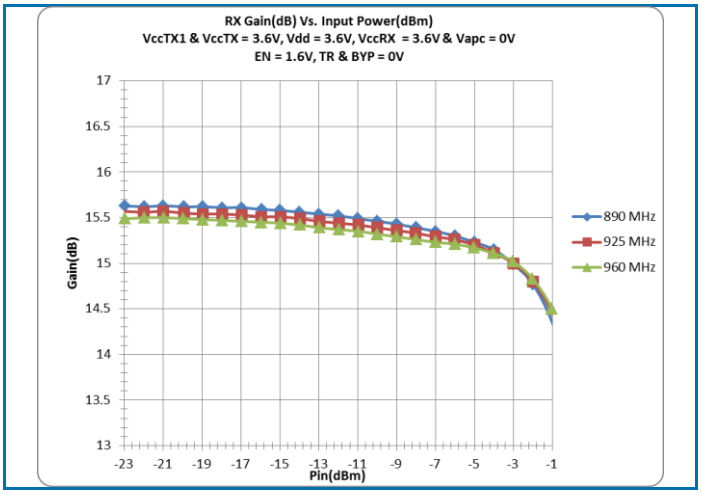

PA Pin(dBm) Vs Pout(dBm)
VccTX1 & VccTX = 3.6V, Vdd = 3.6V, VccRX = 0V & Vapc = 2.25V
EN & TR = 1.6V, & BYP = 0V
Freq= 890, 925 & 960 MHz, Temp = 25 C
Pout(dBm)
Pin(dBm)
890 MHz
925 MHz
960 MHz

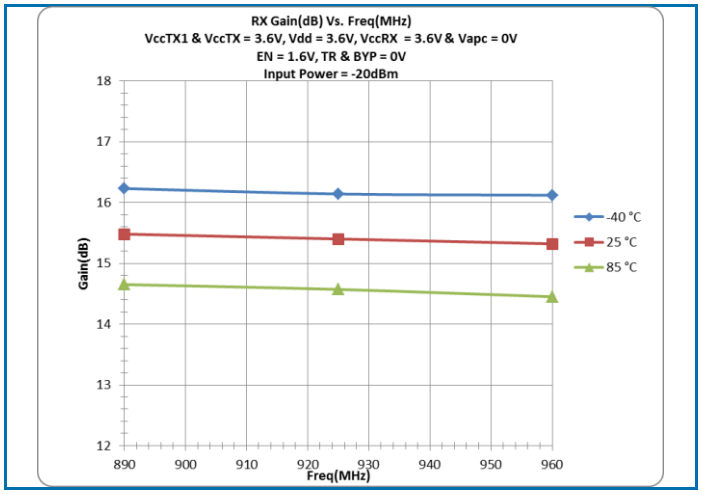

Pa Gain(dB) Vs Freq(MHz)
VccTX1 & VccTX = 3.6V, Vdd = 3.6V, VccRX = 0V & Vapc = 2.25
EN & TR = 1.6V & BYP = 0V
Freq= 925 MHz
Gain(dB)
Freq(MHz)
-40 °C
25 °C
85 °C

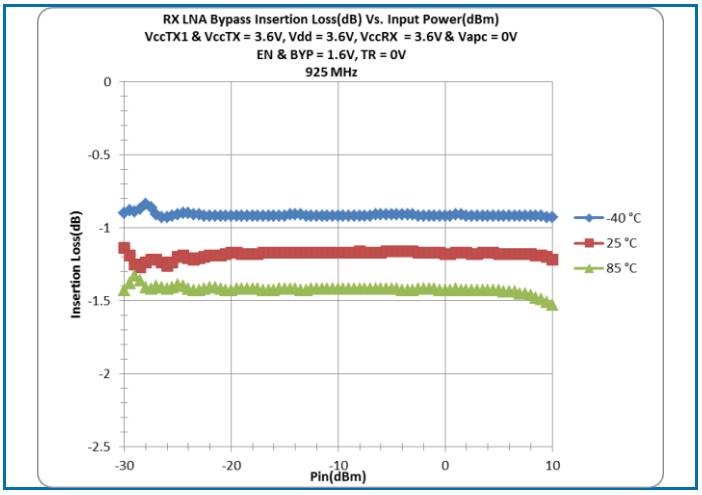

Transmit Operating Current(mA) Vs Pout(dBm)
VccTX1 & VccTX = 3.6V, Vdd = 3.6V, VccRX = 0V & Vapc = 2.25
EN & TR = 1.6V & BYP = 0V
Current(mA)
Pout(dBm)
890 MHz
925 MHz
960 MHz

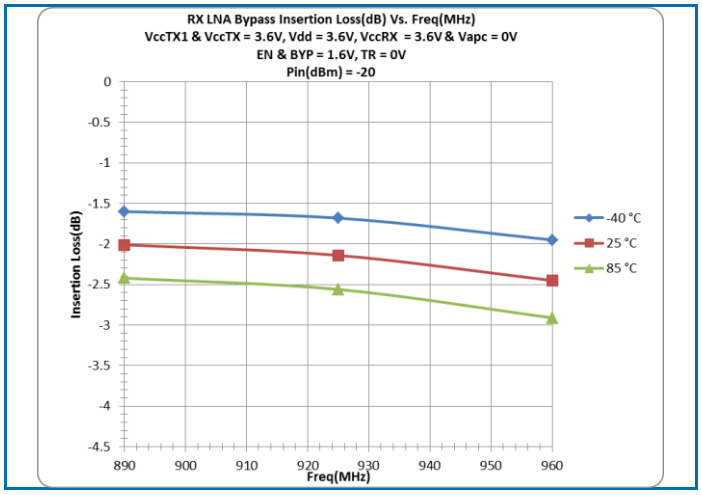

TX Bypass to Antenna
Insertion Loss(dB) Vs Freq(MHz)
VccTX1 & VccTX = 3.6V, Vdd = 3.6V, VccRX = 0V & Vapc = 2.25
EN ,TR & BYP = 1.6V
Insertion Loss(dB)
Freq(MHz)
-40 °C
25 °C
85 °C

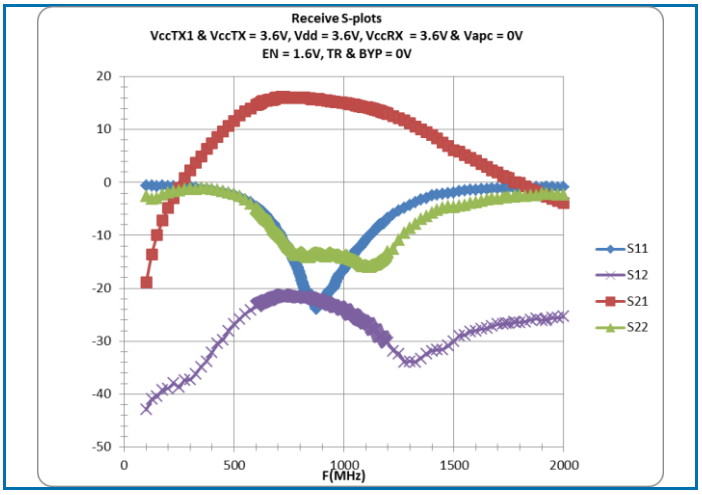

Receive Operating Current(mA) Vs Pout(dBm)
VccTX1 & VccTX = 3.6V, Vdd = 3.6V, VccRX = 3.6V & Vapc = 0V
EN = 1.6V, TR & BYP = 0V
Current(mA)
Pin(dBm)
890 MHz
925 MHz
960 MHz

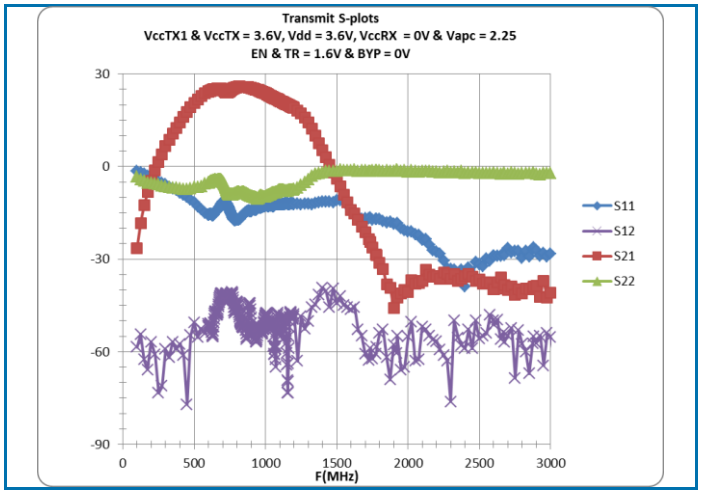

RX Gain(dB) Vs. Input Power(dBm)
VccTX1 & VccTX = 3.6V, Vdd = 3.6V, VccRX = 3.6V & Vapc = 0V
EN = 1.6V, TR & BYP = 0V
Gain(dB)
Pin(dBm)
890 MHz
925 MHz
960 MHz


RX Gain(dB) Vs. Freq(MHz)
VccTX1 & VccTX = 3.6V, Vdd = 3.6V, VccRX = 3.6V & Vapc = 0V
EN = 1.6V, TR & BYP = 0V
Input Power = -20dBm
Gain(dB)
Freq(MHz)
-40 °C
25 °C
85 °C

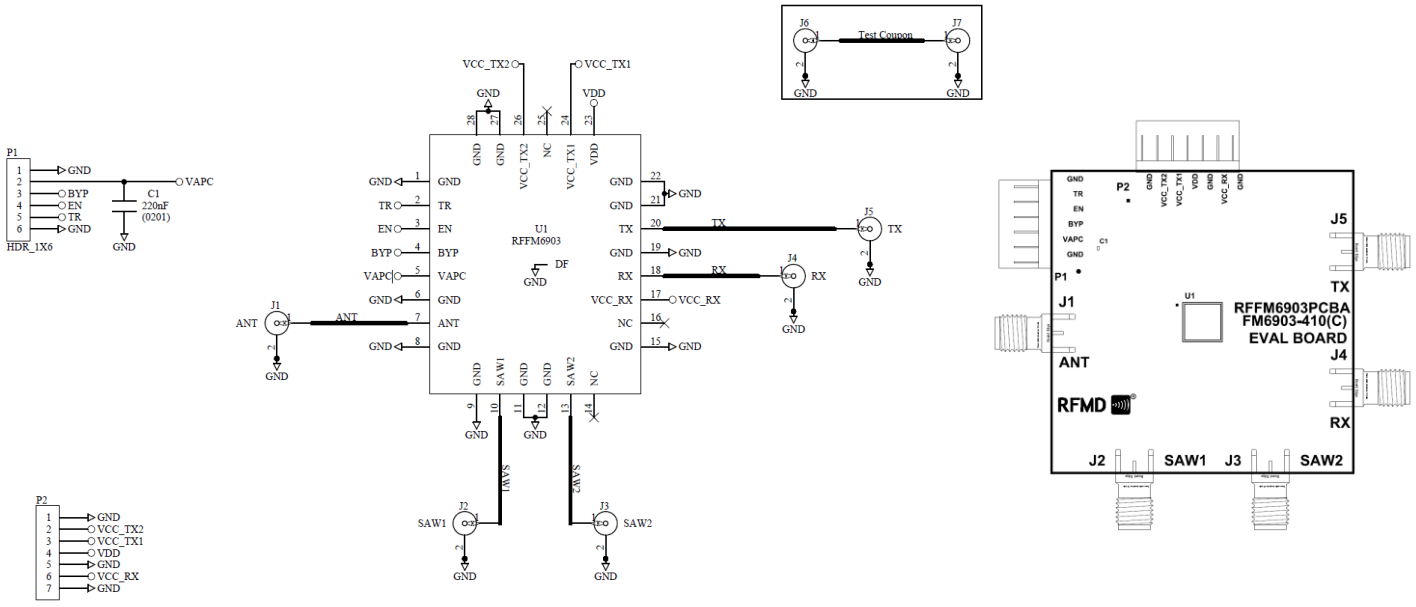

RX LNA Bypass Insertion Loss(dB) Vs. Input Power(dBm)
VccTX1 & VccTX = 3.6V, Vdd = 3.6V, VccRX = 3.6V & Vapc = 0V
EN & BYP = 1.6V, TR = 0V
925 MHz
Insertion Loss(dB)
Pin(dBm)
-40 °C
25 °C
85 °C


RX LNA Bypass Insertion Loss(dB) Vs. Freq(MHz)
VccTX1 & VccTX = 3.6V, Vdd = 3.6V, VccRX = 3.6V & Vapc = 0V
EN & BYP = 1.6V, TR = 0V
Pin(dBm) = -20
Insertion Loss(dB)
Freq(MHz)
-40 °C
25 °C
85 °C


Receive S-plots
VccTX1 & VccTX = 3.6V, Vdd = 3.6V, VccRX = 3.6V & Vapc = 0V
EN = 1.6V, TR & BYP = 0V
F(MHz)
S11
S12
S21
S22


Transmit S-plots
VccTX1 & VccTX = 3.6V, Vdd = 3.6V, VccRX = 0V & Vapc = 2.25
EN & TR = 1.6V & BYP = 0V
F(MHz)
S11
S12
S21
S22

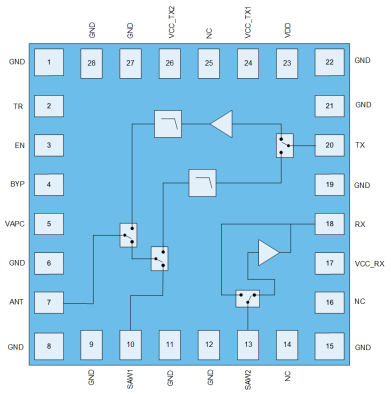
## Evaluation Board Schematic and Layout




## Bill of Material

| Ref. Des. | Value | Description | Manuf. | Part number |
|---|---|---|---|---|
| - | - | Printed Circuit Board | | |
| U1 | - | 900MHz ISM Front End Module | Qorvo | RFFM6903 |
| C1 | 0.22 µF | Capacitor, Chip, 20%, 6.3V, X5R, 0201 | Murata | GRM033R60J224ME15D |
| C2, C3, C4 | - | Do Not Install | | |

## Pin Configuration and Description

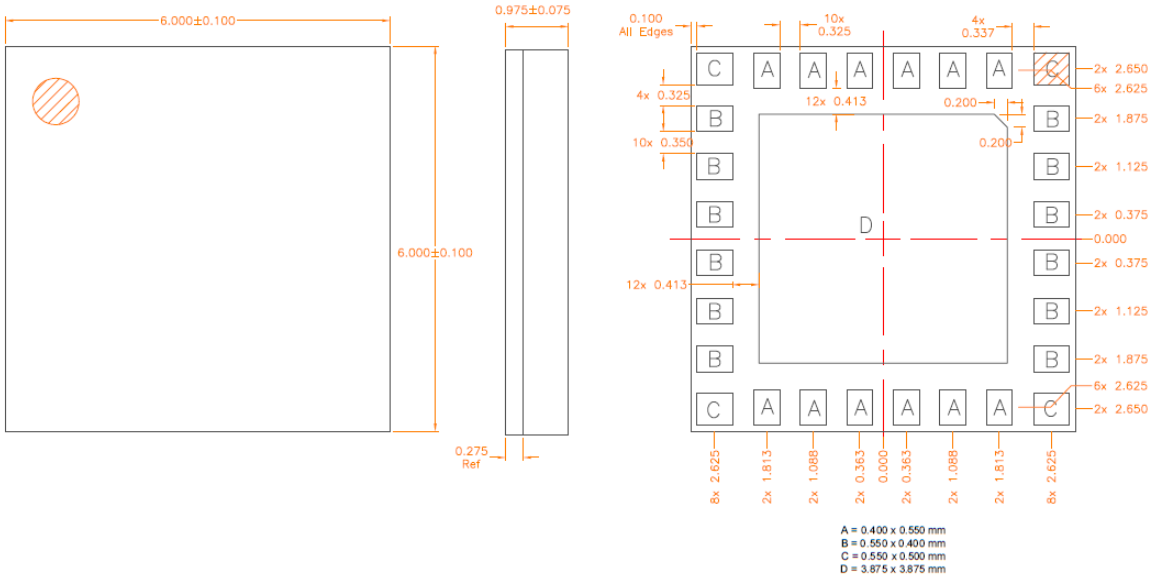



*Top View*

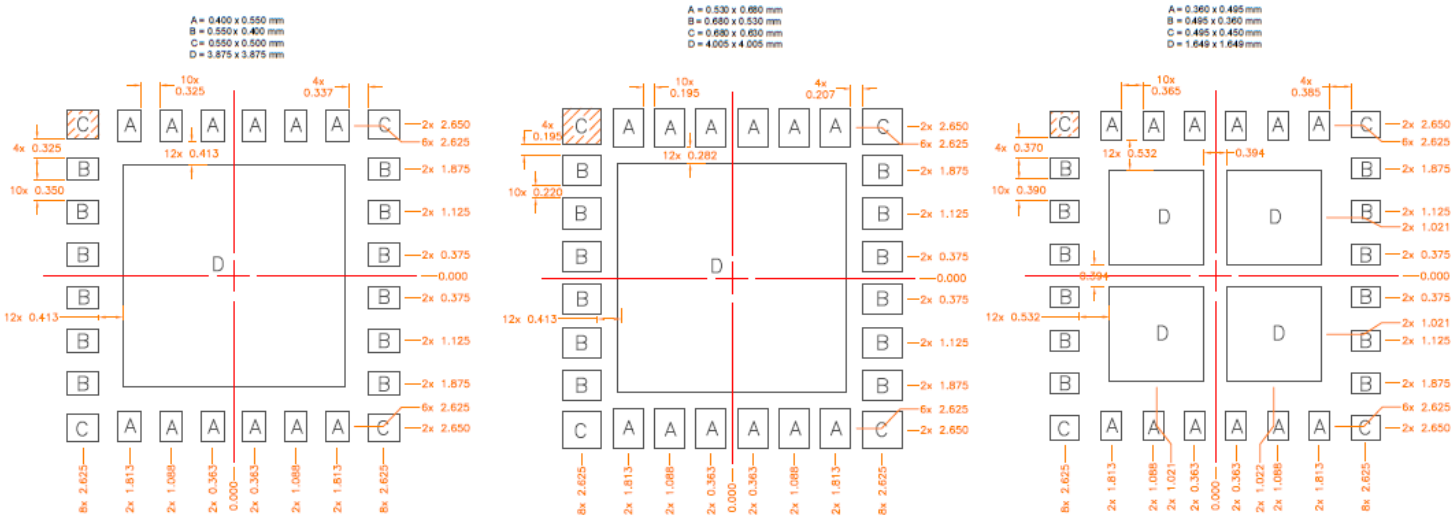
| Pin Number | Label | Description |
|---|---|---|
| 1 | GND | Ground connection. |
| 2 | TR | Control pin. |
| 3 | EN | Control pin. |
| 4 | BYP | Control pin. |
| 5 | VAPC | Control pin. |
| 6 | GND | Ground connection. |
| 7 | ANT | RF bi-directional antenna port. Internally matched to 50 Ω and DC blocked. |
| 8 | GND | Ground connection. |
| 9 | GND | Ground connection. |
| 10 | SAW1 | Receive side of antenna switch. Internally matched to 50 Ω and DC blocked. |
| 11 | GND | Ground connection. |
| 12 | GND | Ground connection. |
| 13 | SAW2 | RX and RX bypass input port. Internally matched to 50 Ω and DC blocked. |
| 14 | NC | No connection |
| 15 | GND | Ground connection. |
| 16 | NC | No connection |
| 17 | VCC_RX | Supply voltage |
| 18 | RX | RF output. Internally matched to 50 Ω and DC shorted. (1) |
| 19 | GND | Ground connection. |
| 20 | TX | RF input. Internally matched to 50 Ω and DC shorted. (1) |
| 21 | GND | Ground connection. |
| 22 | GND | Ground connection. |
| 23 | VDD | Supply voltage |
| 24 | VCC_TX1 | Supply voltage |
| 25 | NC | No connection |
| 26 | VCC_TX2 | Supply voltage |
| 27 | GND | Ground connection. |
| 28 | GND | Ground connection. |
| Backside Paddle | - | RF/DC ground. Use recommended via pattern to minimize inductance and thermal resistance. See PCB Mounting Pattern for suggested footprint. |

## Mechanical Information

**Dimensions and PCB Mounting Pattern**




Notes:
1. Shaded area represents Pin 1 location.




Notes:
2. All dimensions are in millimeters. Angles are in degrees.
3. Dimension and tolerance formats conform to ASME Y14.4M-1994.
4. The terminal #1 identifier and terminal numbering conform to JESD 95-1SPP-012

## Handling Precautions

| Parameter | Rating | Standard |
|---|---|---|
| ESD – Human Body Model (HBM) | Class 1A (350V) | JESD22-A114 |
| ESD – Charged Device Model (CDM) | Class II (300 V) | JESD-22A101 |
| MSL – Moisture Sensitivity Level | Level 3 | IPC/JEDEC J-STD-020 |



Caution!

ESD sensitive device

## Solderability

Compatible with both lead-free (260 °C max. reflow temperature) and tin/lead (245 °C max. reflow temperature) soldering processes.

Package lead plating: Electroless Ni/Electroless Pd/Immersion Au (ENEPIG)

## RoHS Compliance

This part is compliant with the 2011/65/EU RoHS directive (Restrictions on the Use of Certain Hazardous Substances in Electrical and Electronic Equipment), as amended by Directive 2015/863/EU.

This product also has the following attributes:

- Lead free
- Halogen Free (Chlorine, Bromine)
- Antimony Free
- TBBP-A ($C_{15}H_{12}Br_4O_2$) Free
- SVHC Free

## Contact Information

For the latest specifications, additional product information, worldwide sales and distribution locations:

**Web:** www.qorvo.com

**Tel:** 1-844-890-8163

**Email:** customer.support@qorvo.com

## Important Notice

The information contained herein is believed to be reliable; however, Qorvo makes no warranties regarding the information contained herein and assumes no responsibility or liability whatsoever for the use of the information contained herein. All information contained herein is subject to change without notice. Customers should obtain and verify the latest relevant information before placing orders for Qorvo products. The information contained herein or any use of such information does not grant, explicitly or implicitly, to any party any patent rights, licenses, or any other intellectual property rights, whether with regard to such information itself or anything described by such information. **THIS INFORMATION DOES NOT CONSTITUTE A WARRANTY WITH RESPECT TO THE PRODUCTS DESCRIBED HEREIN, AND QORVO HEREBY DISCLAIMS ANY AND ALL WARRANTIES WITH RESPECT TO SUCH PRODUCTS WHETHER EXPRESS OR IMPLIED BY LAW, COURSE OF DEALING, COURSE OF PERFORMANCE, USAGE OF TRADE OR OTHERWISE, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.**
Without limiting the generality of the foregoing, Qorvo products are not warranted or authorized for use as critical components in medical, life-saving, or life-sustaining applications, or other applications where a failure would reasonably be expected to cause severe personal injury or death.

Copyright 2020 © Qorvo, Inc. | Qorvo is a registered trademark of Qorvo, Inc.