# RFDA0047

## DIGITAL CONTROLLED VARIABLE GAIN AMPLIFIER 400MHZ TO 2700MHZ

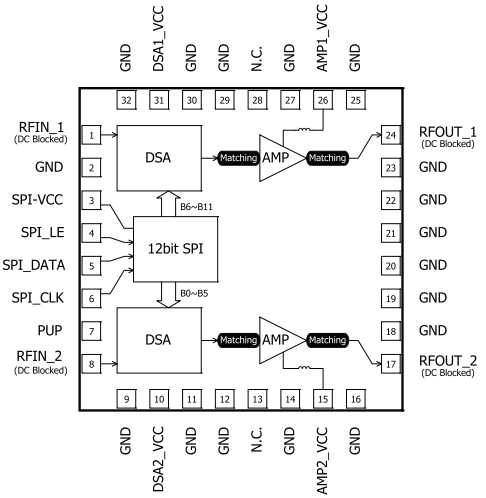
Package: MCM 32-Pin, 7.0mm x 7.0mm

## Features

- Dual Channel VGA
- Frequency Range 400MHz to 2700MHz
- Full Internal Matching and No External Bias Inductors
- Two 6-Bit Digital Step Attenuators
- 12-Bit SPI Serial Control Programming
- High Channel Isolation = 50dBc
- Max Gain = 13dB at 900MHz
- Gain Control Range = 31.5dB (0.5dB Step Size)
- High OIP3/P1dB = +39/19dBm at 900MHz
- Single + 5V Supply
- Small 32-Pin, 7.0mm x 7.0mm, MCM
- Power-up Programming

## Applications

- Cellular, 3G Infrastructure
- WiBro, WiMAX, LTE
- Microwave Radio
- High Linearity Power Control




Functional Block Diagram

## Product Description

RFMD's RFDA0047 is a dual channel digital controlled variable gain amplifier featuring high linearity over the entire gain control range with noise figure less than 6.5dB in its maximum gain state. The gains of two 6-bit digital step attenuators are programmed with a serial mode control interface (SPI). The RFDA0047 is packaged in a small 7.0mm x 7.0mm leadless laminate MCM, which contains plated through thermal vias for ultra-low thermal resistance. This module is easy to use with no external matching components required.

### Ordering Information

| | |
|---|---|
| RFDA0047TR13 | 13" Reel with 2500 pieces |
| RFDA0047TR7 | 7" Reel with 750 pieces |
| RFDA0047SR | 7" Reel with 100 pieces |
| RFDA0047SQ | Sample Bag with 25 pieces |
| RFDA0047PCK-410 | 400MHz to 2700MHz PCBA with 5-piece sample 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 | ☐ SOI |

RF MICRO DEVICES®, RFMD®, Optimum Technology Matching®, Enabling Wireless Connectivity™, PowerStar®, POLARIS™ TOTAL RADIO™ and UltimateBlue™ are trademarks of RFMD, LLC. BLUETOOTH is a trademark owned by Bluetooth SIG, Inc., U.S.A. and licensed for use by RFMD. All other trade names, trademarks and registered trademarks are the property of their respective owners. ©2012, RF Micro Devices, Inc.



7628 Thorndike Road, Greensboro, NC 27409-9421 · For sales or technical support, contact RFMD at **(+1) 336-678-5570** or **customerservice@rfmd.com**.

## Absolute Maximum Ratings

| Parameter | Rating | Unit |
|---|---|---|
| Supply Voltage | +5.5 | $V_{DC}$ |
| DS Supply Current | 205 | mA |
| Power Dissipation | 1100 | mW |
| Maximum Input RF Power | 24 | dBm |
| Operating Temperature ($T_{CASE}$) | -40 to +85 | °C |
| Storage Temperature | -40 to +150 | °C |
| Junction Temperature | 165 | °C |
| ESD Rating (HBM) | 1000 (Class 1C) | V |
| Moisture Sensitivity Level | MSL 3 | |

MTTF = 1.0E6 hours at 165°C junction temperature

**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 EU Directive 2011/65/EU (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.

RFMD Green: RoHS compliant per EU Directive 2011/65/EU, halogen free per IEC 61249-2-21, < 1000 ppm each of antimony trioxide in polymeric materials and red phosphorus as a flame retardant, and <2% antimony in solder.

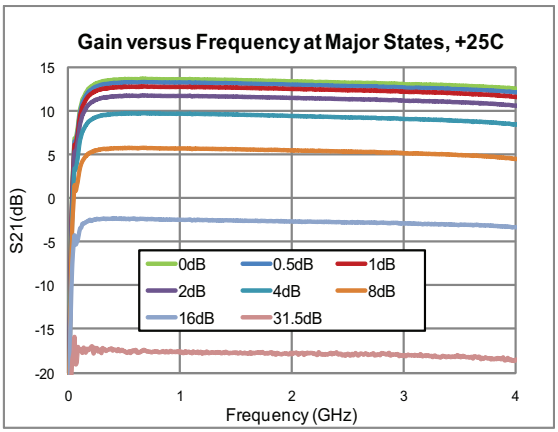
| Parameter | Specification | | | Unit | Condition |
|---|---|---|---|---|---|
| | Min. | Typ. | Max. | | |
| **Overall** | | | | | Temp=25°C, $V_{CC}$ = $V_{DD}$ = 5V, standard application circuit |
| Frequency | 400 | | 2700 | MHz | |
| Max Gain | | 13 | | dB | Attenuation = 0dB |
| Gain Control Range | | 31.5 | | dB | |
| Step Accuracy | +/- (0.15+5% attenuation setting) | | | dB | Major state error up to 2700MHz |
| P1dB | | 19 | | dBm | Attenuation = 0dB at 900MHz |
| Output IP3 | | 39 | | dBm | $P_{OUT}$ =0dBm/tone, 1MHz spacing at 900MHz |
| Control Interface | | 12 | | bit | SPI interface |
| Settling Time | | 250 | | ns | tON, tOFF (10%/90% RF) |
| Noise Figure | | 7 | | dB | Attenuation = 0dB |
| Channel-to-Channel Isolation | | 50 | | dB | Input at RFIN1 (or RFIN2), the isolation between two outputs |
| Impedance | | 50 | | Ω | |
| Input Return Loss | | -18 | | dB | 900MHz |
| Output Return Loss | | -18 | | dB | 900MHz |
| Total Supply Voltage | 4.75 | 5.0 | 5.25 | V | |
| Supply Current | | 170 | | mA | From $V_{CC}$_SPI, $V_{CC}$_AMP1 and $V_{CC}$_AMP2 |
| Thermal Resistance | | 40 | | °C/W | Junction to backside of device |

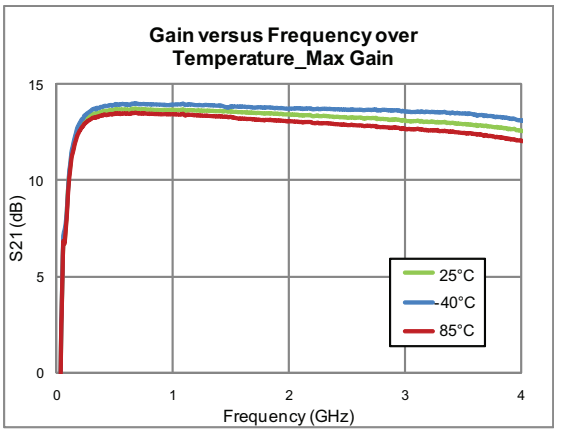
| Parameter | Unit | 680MHz | 900MHz | 1700MHz | 2300MHz | 2550MHz | 2700MHz |
|---|---|---|---|---|---|---|---|
| Max Small Signal Gain | dB | 13.5 | 13.5 | 13.3 | 13 | 13 | 13 |
| Output P1dB | dBm | 19 | 19 | 19 | 18 | 18 | 17.5 |
| Output IP3* | dBm | 40 | 39.5 | 35 | 32.5 | 31.5 | 31 |
| Noise Figure | dB | 6.5 | 6.5 | 7 | 7.5 | 7.5 | 7.5 |

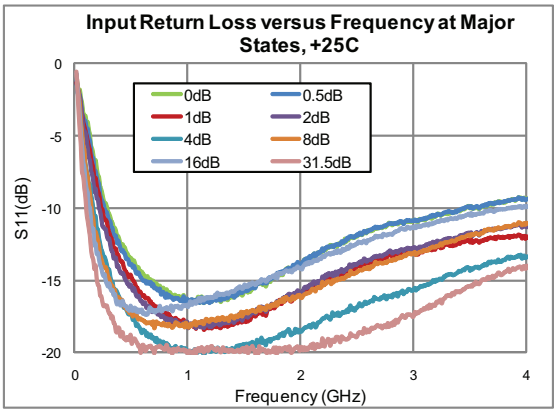
* Note: OIP3 is tested at $P_{OUT}$ = 0dBm/Tone and 1MHz spacing

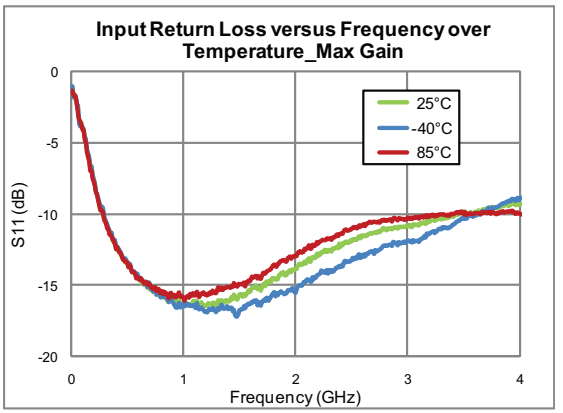

7628 Thorndike Road, Greensboro, NC 27409-9421 · For sales or technical support, contact RFMD at **(+1) 336-678-5570** or **customerservice@rfmd.com**.

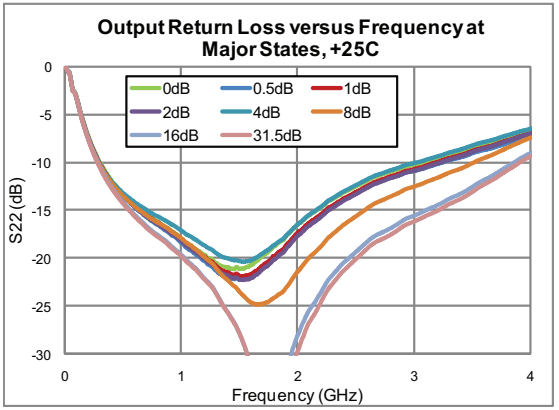
## Typical Broadband Performance $V_{CC}$ = 5.0V, $I_{CC}$ = 170mA

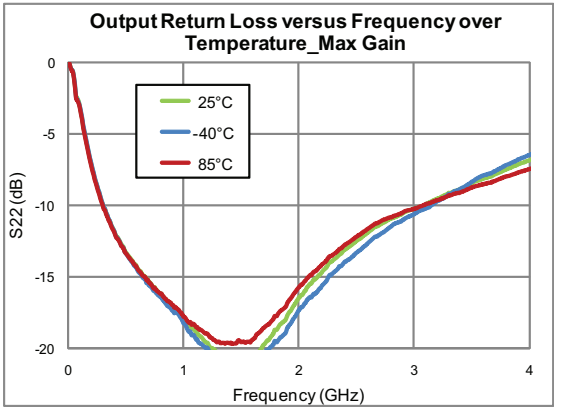


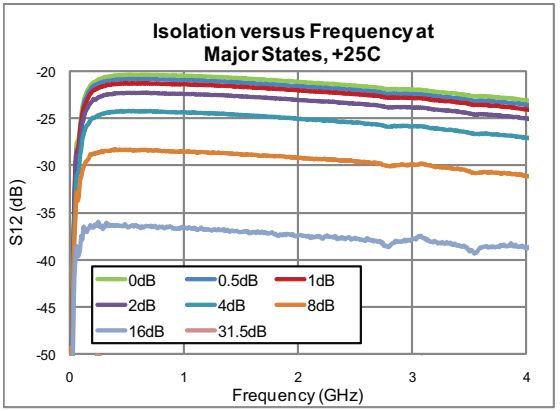



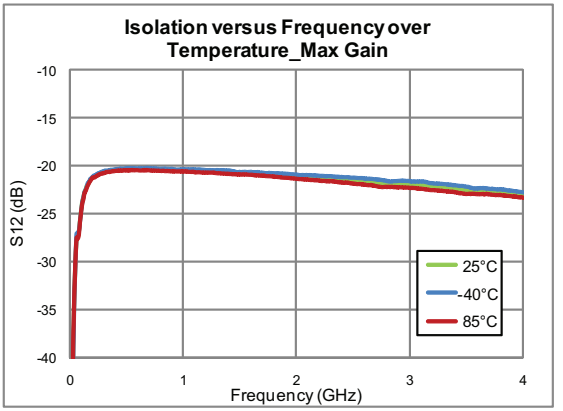



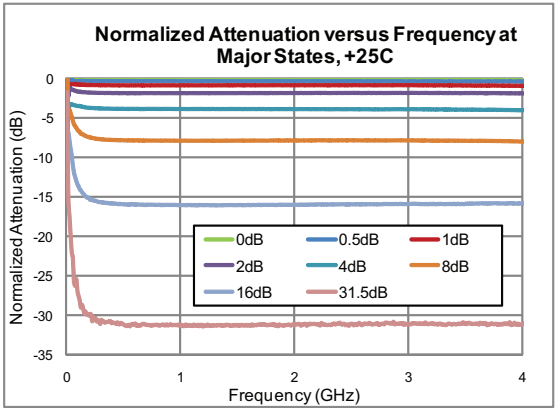


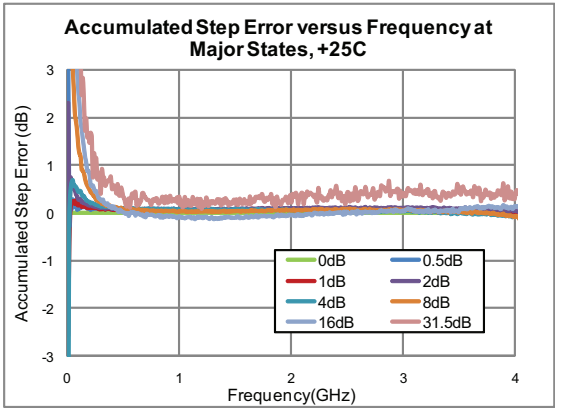
7628 Thorndike Road, Greensboro, NC 27409-9421 · For sales or technical support, contact RFMD at (+1) 336-678-5570 or customerservice@rfmd.com.

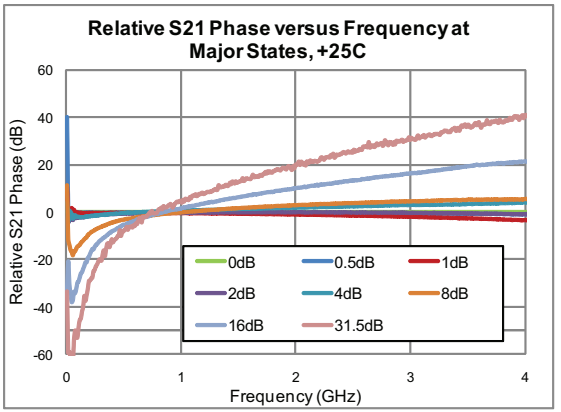
## Typical Broadband Performance $V_{CC}$ = 5.0V, $I_{CC}$ = 170mA



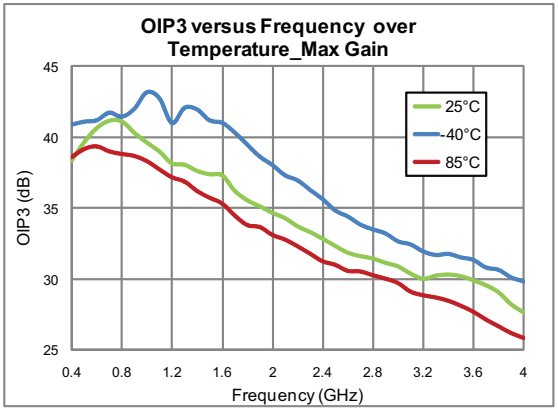



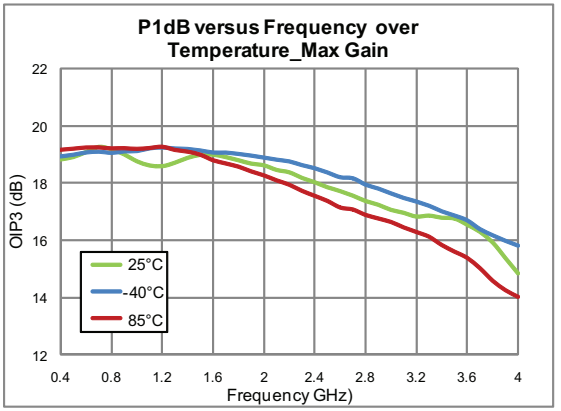



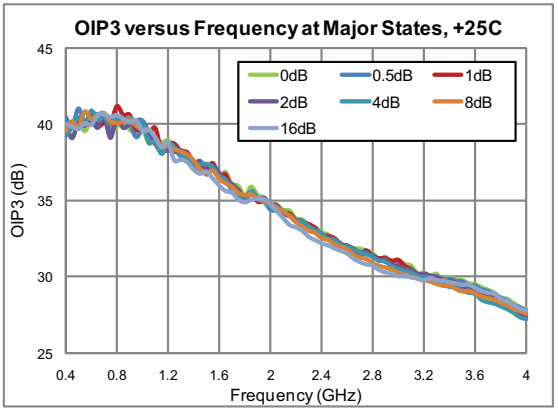


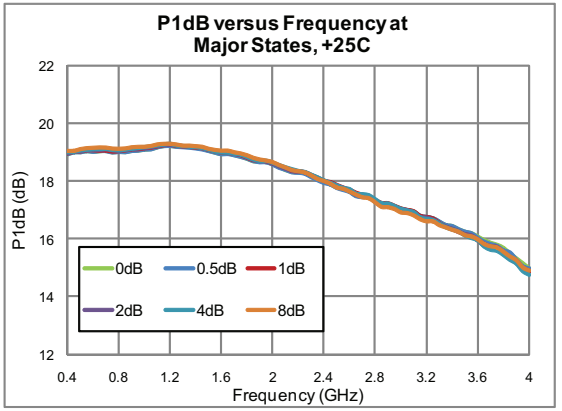
7628 Thorndike Road, Greensboro, NC 27409-9421 · For sales or technical support, contact RFMD at (+1) 336-678-5570 or customerservice@rfmd.com.

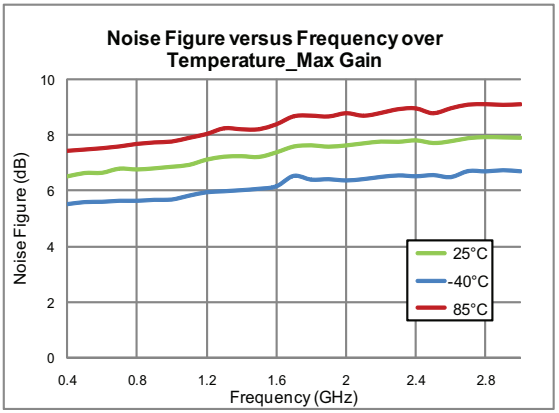
## Typical Broadband Performance $V_{CC}$ = 5.0V, $I_{CC}$ = 170mA

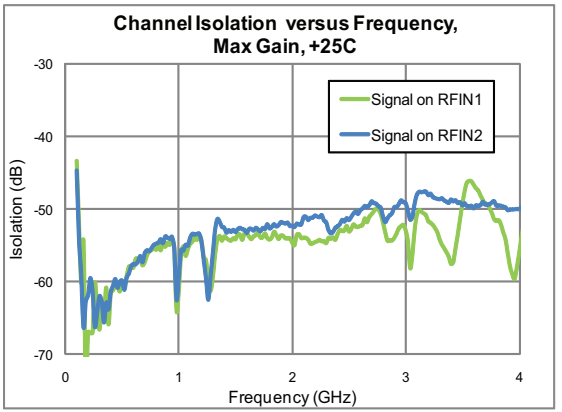


## Truth Table

| Channel 1 Control Bit | | | | | | Gain Relative to Maximum Gain |
|---|---|---|---|---|---|---|
| D11 | D10 | D9 | D8 | D7 | D6 | |
| 1 | 1 | 1 | 1 | 1 | 1 | 0dB |
| 1 | 1 | 1 | 1 | 1 | 0 | -0.5dB |
| 1 | 1 | 1 | 1 | 0 | 1 | -1dB |
| 1 | 1 | 1 | 0 | 1 | 1 | -2dB |
| 1 | 1 | 0 | 1 | 1 | 1 | -4dB |
| 1 | 0 | 1 | 1 | 1 | 1 | -8dB |
| 0 | 1 | 1 | 1 | 1 | 1 | -16dB |
| 0 | 0 | 0 | 0 | 0 | 0 | -31.5dB |

| Channel 2 Control Bit | | | | | | Gain Relative to Maximum Gain |
|---|---|---|---|---|---|---|
| D5 | D4 | D3 | D2 | D1 | D0 | |
| 1 | 1 | 1 | 1 | 1 | 1 | 0dB |
| 1 | 1 | 1 | 1 | 1 | 0 | -0.5dB |
| 1 | 1 | 1 | 1 | 0 | 1 | -1dB |
| 1 | 1 | 1 | 0 | 1 | 1 | -2dB |
| 1 | 1 | 0 | 1 | 1 | 1 | -4dB |
| 1 | 0 | 1 | 1 | 1 | 1 | -8dB |
| 0 | 1 | 1 | 1 | 1 | 1 | -16dB |
| 0 | 0 | 0 | 0 | 0 | 0 | -31.5dB |

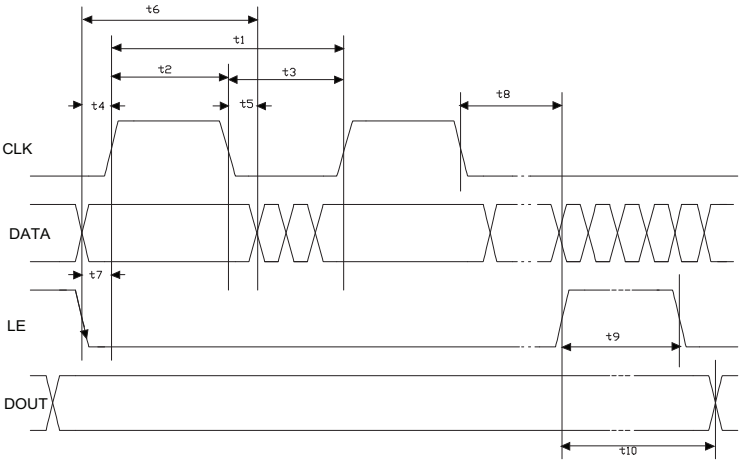
| Power-up Programming Truth Table | |
|---|---|
| **PUP** | **Attenuator Setting** |
| High | Attenuation at min, 0dB |
| Low | Attenuation at max, 31.5dB |

| Logic Voltage Levels | |
|---|---|
| **State** | **Logic** |
| Low | 0V to 0.8V |
| High | 2.0V to 5.0V |

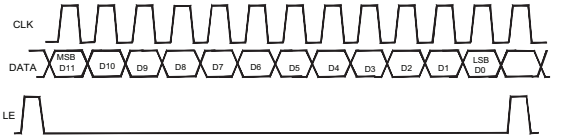

7628 Thorndike Road, Greensboro, NC 27409-9421 · For sales or technical support, contact RFMD at (+1) 336-678-5570 or customerservice@rfmd.com.

## Serial Port Interface

SPI Timing Diagram




Programming Example - 12 bit




### SPI Timing Diagram Specifications

| Parameter | Limit | Unit | Comment |
|---|---|---|---|
| t1 | 25 | MHz max | CLK Frequency |
| t2 | 20 | ns min | CLK High |
| t3 | 20 | ns min | CLK Low |
| t4 | 5 | ns min | DATA to CLK Setup Time |
| t5 | 5 | ns min | DATA to CLK Hold Time |
| t6 | 30 | ns min | DATA Valid |
| t7 | 5 | ns min | LE to CLK Setup Time |
| t8 | 5 | ns min | CLK to LE Setup Time |
| t9 | 10 | ns min | LE Pulse Width |
| t10 | 20 | ns max | Output Set |


7628 Thorndike Road, Greensboro, NC 27409-9421 · For sales or technical support, contact RFMD at (+1) 336-678-5570 or customerservice@rfmd.com.

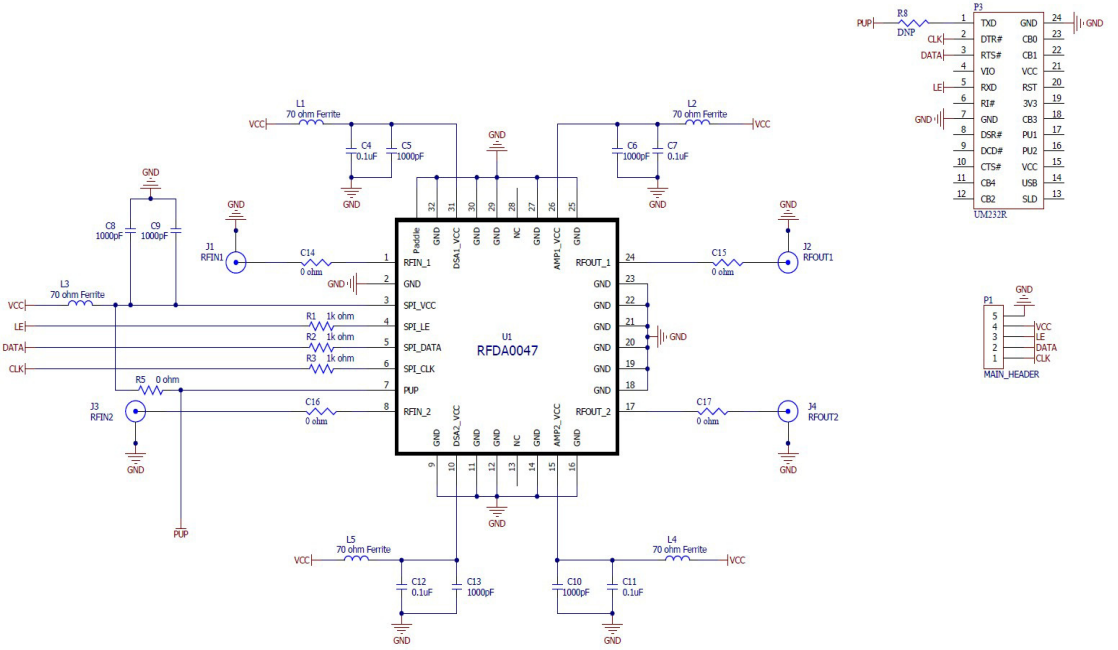
## Pin Names and Descriptions

| Pin | Name | Description |
|---|---|---|
| 1 | RFIN_1 | AMP 1 RF Input |
| 2 | GND | RF/DC Ground Connection |
| 3 | SPI_VCC | Supply Voltage for SPI Chip |
| 4 | SPI_LE | Serial Latch Enable Input |
| 5 | SPI_DATA | Serial Data Input |
| 6 | SPI_CLK | Serial Clock Input |
| 7 | PUP | Power-up Programming Pin |
| 8 | RFIN_2 | AMP 2 RF Input |
| 9 | GND | RF/DC Ground Connection |
| 10 | DSA2_VCC | Supply Voltage for DSA2 Chip |
| 11 | GND | RF/DC Ground Connection |
| 12 | GND | RF/DC Ground Connection |
| 13 | NC | No Connection |
| 14 | GND | RF/DC Ground Connection |
| 15 | AMP2_VCC | Supply Voltage for Amplifier 2 |
| 16 | GND | RF/DC Ground Connection |
| 17 | RFOUT_2 | AMP 2 RF Output |
| 18 | GND | RF/DC Ground Connection |
| 19 | GND | RF/DC Ground Connection |
| 20 | GND | RF/DC Ground Connection |
| 21 | GND | RF/DC Ground Connection |
| 22 | GND | RF/DC Ground Connection |
| 23 | GND | RF/DC Ground Connection |
| 24 | RFOUT_1 | AMP 1 RF Output |
| 25 | GND | RF/DC Ground Connection |
| 26 | AMP1_VCC | Supply Voltage for Amplifier 1 |
| 27 | GND | RF/DC Ground Connection |
| 28 | NC | No Connection |
| 29 | GND | RF/DC Ground Connection |
| 30 | GND | RF/DC Ground Connection |
| 31 | DSA1_VCC | Supply Voltage for DSA1 Chip |
| 32 | GND | RF/DC Ground Connection |


7628 Thorndike Road, Greensboro, NC 27409-9421 · For sales or technical support, contact RFMD at (+1) 336-678-5570 or customerservice@rfmd.com.

## Evaluation Board Schematic

400MHz to 2700MHz Application Circuit




## Evaluation Board Build of Materials (BOM)

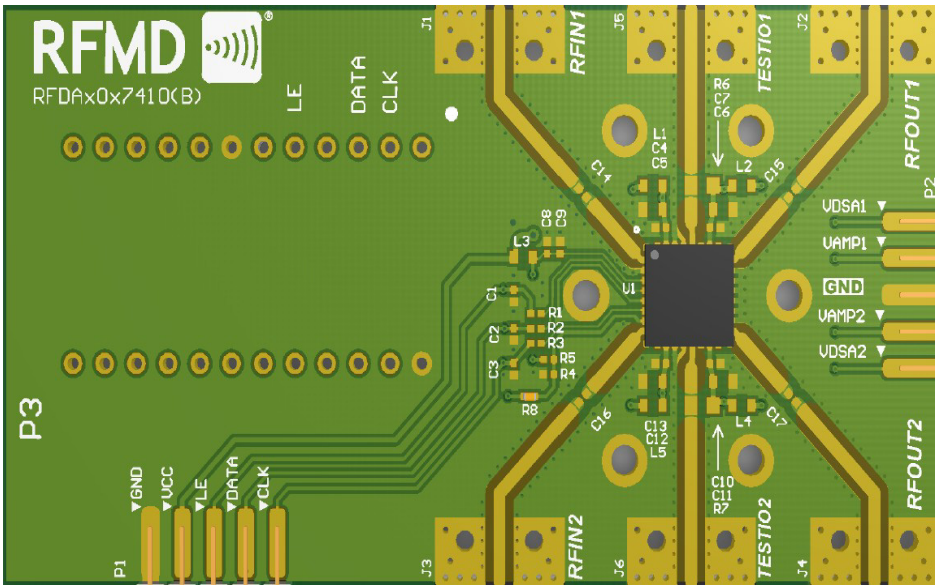
400MHz to 2700MHz Application Circuit

| Description | Reference Designator | Manufacturer | Manufacturer's P/N |
|---|---|---|---|
| RFDAx0x7, PCB | | DDI | RFDAx0x7410 |
| RFDA0047SB | U1 | RFMD | RFDA0047 |
| RES, 0Ω, 0402 | C14-C17, R5 | Kamaya, Inc | RMC1/16SJPTH |
| CAP, 1000pF, 10%, 50V, X7R, 0402 | C1-C3, C5-C6, C8-C10, C13 | Murata Electronics | GRM155R71H102KA01E |
| CAP, 0.1µF, 10%, 16V, X7R, 0603 | C4, C7, C11-C12 | Murata Electronics | GRM188R71C104KA01D |
| FER, BEAD, 70Ω, 4A, 0603 | L1-L5 | Murata Electronics | BLM18SG700TN1D |
| RES, 1K, 5%, 1/16W, 0402 | R1-R3 | KOA Speer | RK73B1ETTP102J |
| CONN, SMA, END LNCH, RND PIN, 0.059" | J1-J4 | Gigalane | PSF-S01-006 |
| CONN, HDR, ST, PLRZD, 5-PIN, 0.100" | P1 | ITW Pancon | MPSS100-5-C |
| DNP | R4, R6-R7, J5-J6, P2 | N/A | N/A |


7628 Thorndike Road, Greensboro, NC 27409-9421 · For sales or technical support, contact RFMD at **(+1) 336-678-5570** or **customerservice@rfmd.com**.

## Evaluation Board Assembly Drawing

400MHz to 2700MHz Application Circuit

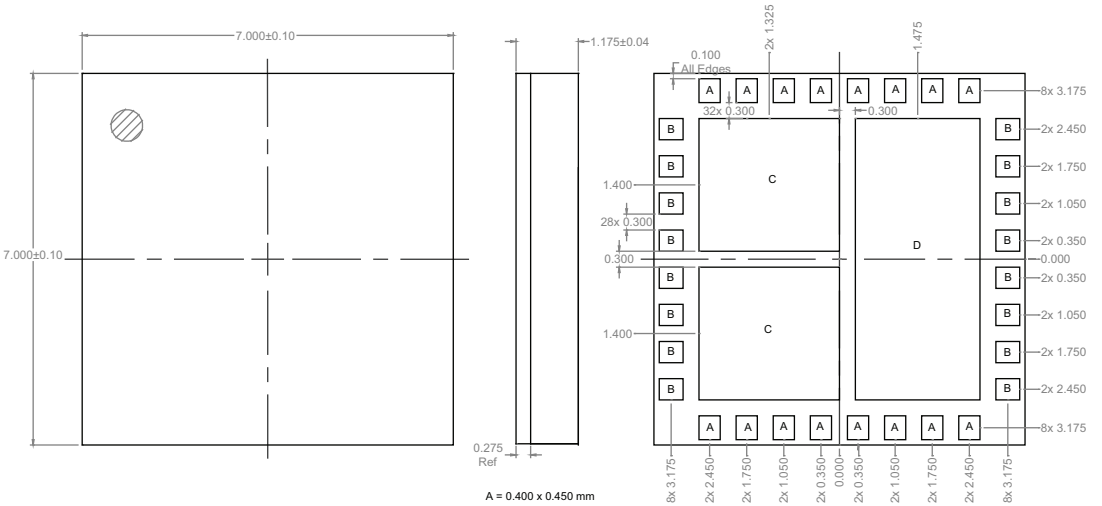





7628 Thorndike Road, Greensboro, NC 27409-9421 · For sales or technical support, contact RFMD at (+1) 336-678-5570 or customerservice@rfmd.com.

## Package Drawing

7.0mm x 7.0mm Laminate Module




Notes:
1. Shaded area represents Pin 1 location

A = 0.400 x 0.450 mm
B = 0.450 x 0.400 mm
C = 2.650 x 2.500 mm
D = 2.350 x 5.300 mm


7628 Thorndike Road, Greensboro, NC 27409-9421 · For sales or technical support, contact RFMD at (+1) 336-678-5570 or customerservice@rfmd.com.