# RFDA0066

## DIGITAL CONTROLLED VARIABLE GAIN AMPLIFIER 5MHz TO 1GHz, 12-BIT 0.5dB LSB CONTROL

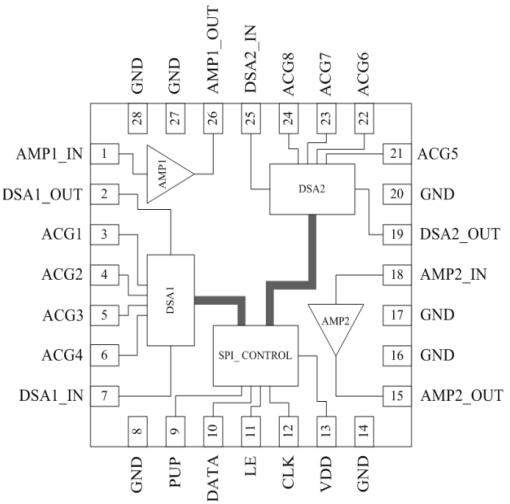
Package Style: MCM 28-Pin, 6.0mmx6.0mm


### Features

- Frequency Range 5MHz to 1GHz
- Dual 6-Bit Digital Step Attenuator
- SPI Serial Control Programming
- Max Gain=45dB at 100MHz
- Gain Control Range=63dB (0.5dB Step Size)
- High OIP3/P1dB=+39/22dBm
- +5V Supply for DSA and +8V for Amplifier with Drop Resistor
- Small 28-Pin, 6.0mmx6.0mm, MCM
- Power-up Programming

### Applications

- High Linearity Power Control
- CATV Drivers
- Transceiver IF DVA
- Cellular, PCS, GSM, UMTS
- Wireless Data, Satellite Terminals




Functional Block Diagram

### Product Description

RFMD's RFDA0066 is a digital controlled variable gain amplifier featuring high linearity over the entire gain control range with noise figure less than 3.5dB in its maximum gain state. The gain of dual 6-bit digital step attenuator is programmed with a 12-bit Serial Peripheral Interface (SPI). The RFDA0066 is packaged in a small 6.0mm x 6.0mm leadless laminate MCM, which contains plated through thermal vias for ultra-low thermal resistance. The module is easy to use with a few external DC blocks and RF chokes.

### Ordering Information

| | |
|---|---|
| RFDA0066SR | 7" Sample reel with 100 pieces |
| RFDA0066SQ | Sample bag with 25 pieces |
| RFDA0066TR7 | 7" Reel with 750 pieces |
| RFDA0066TR13 | 13" Reel with 2500 pieces |
| RFDA0066PCK-410 | 5MHz to 250MHz PCBA with 5-piece sample bag |
| RFDA0066PCK-411 | 400MHz to 1GHz 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 | ☐ LDMOS |





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## Absolute Maximum Ratings

| Parameter | Rating | Unit |
|---|---|---|
| Power Supply for DSA | +5.5V/20 | $V_{DC}$/mA |
| Power Supply for Amplifier | +5.5V/340 | $V_{DC}$/mA |
| Power Dissipation | 1980 | mW |
| Max RF Input Power, $Z_L$=50 Ω | +16 | dBm |
| Operating Temperature ($T_{CASE}$) | -40 to +85 | °C |
| Storage Temperature | -40 to +150 | °C |
| Junction Temperature | +150 | °C |
| ESD Rating (HBM) | 500 (Class 1B) | V |
| Moisture Sensitivity Level | MSL3 | |

**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. | | |
| **Overall** | | | | | $T_L$=25°C, $Z_S$=$Z_L$=50Ω, $V_{CC}$=8V (for AMPs) and $V_{DD}$=5V (for DSAs), 5MHz to 250MHz application circuit unless otherwise noted. |
| Frequency Range | 5 | | 1000 | MHz | |
| Max Gain | | 44.5 | | dB | Attenuation=0dB |
| Gain Control Range | | 63.0 | | dB | |
| Step Accuracy | | ±(0.1 +5% attenuation setting) | | dB | Major state error up to 250MHz |
| P1dB | | 22 | | dBm | Attenuation = 0dB |
| Output IP3 | | 39 | | dBm | $P_{OUT}$ = 0dBm/tone, 1MHz spacing |
| Control Interface | | 12 | | bit | SPI Interface |
| Settling Time | | 250 | | ns | $T_{ON}$, $T_{OFF}$(10%/90% RF) |
| Noise Figure | | 3.5 | | dB | Attenuation = 0dB |
| Impedance | | 50 | | Ω | |
| Input Return Loss | | 20 | | dB | At Maximum Gain |
| Output Return Loss | | 20 | | dB | At Maximum Gain |
| DSA Supply Voltage | 4.75 | 5.0 | 5.25 | V | |
| DSA Supply Current | 6 | 12 | 20 | mA | Include Two DSAs and SPI Control Circuit |
| Amplifier Supply Voltage | 4.7 | 5.0 | 5.3 | V | Test on Amplifier Bias Pin |
| Amplifier Supply Current | | 230 | | mA | Include Two Amplifiers |
| Thermal Resistance | | 70 | | °C/W | |

## Typical RF Performance at Key Operating Frequencies

| Parameter | Unit | 5MHz | 50MHz | 100MHz | 250MHz | 400MHz | 600MHz | 900MHz |
|---|---|---|---|---|---|---|---|---|
| Max Small Signal Gain | dB | 44.3 | 44.5 | 44.5 | 44.0 | 43.3 | 42.4 | 40.3 |
| Output P1dB | dBm | 22.2 | 22.4 | 22.5 | 22.4 | 22.2 | 22.1 | 21.8 |
| Output IP3 | dBm | 38.2 | 39.5 | 39.6 | 38.5 | 38.2 | 36.6 | 35.9 |
| Input Return Loss | dB | 23 | 25 | 25 | 21 | 23 | 23 | 28 |
| Output Return Loss | dB | 24 | 27 | 28 | 24 | 19 | 18 | 19 |
| Noise Figure[1] | dB | N/A | 3.5 | 3.5 | 3.5 | 3.7 | 3.7 | 3.8 |

Notes:
1. Noise Figure at 5MHz is not tested due to the limitation of test bench.


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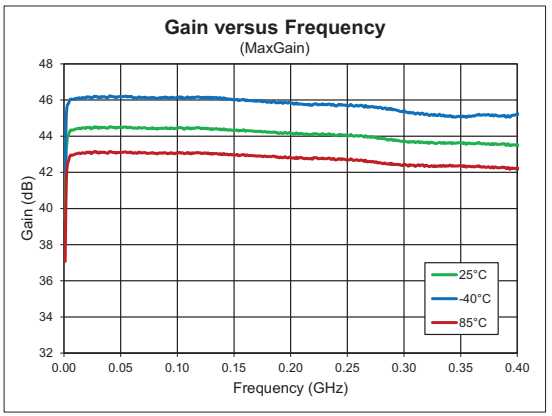
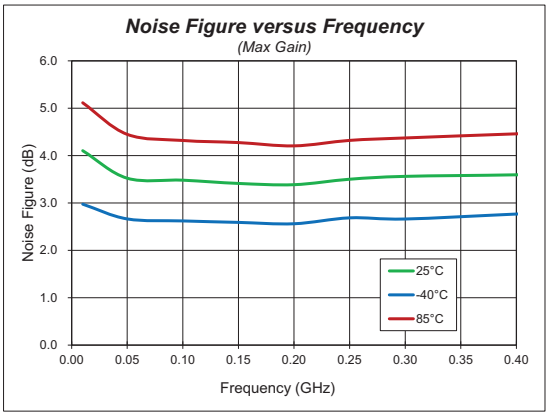
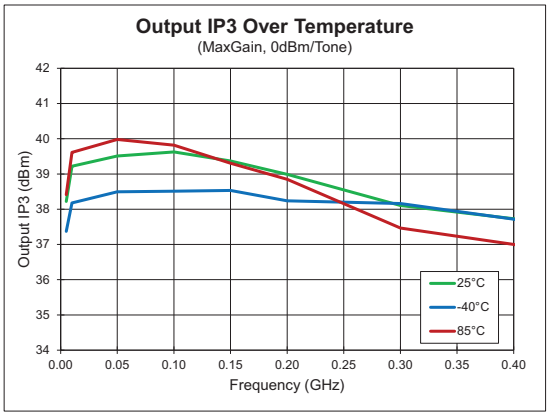
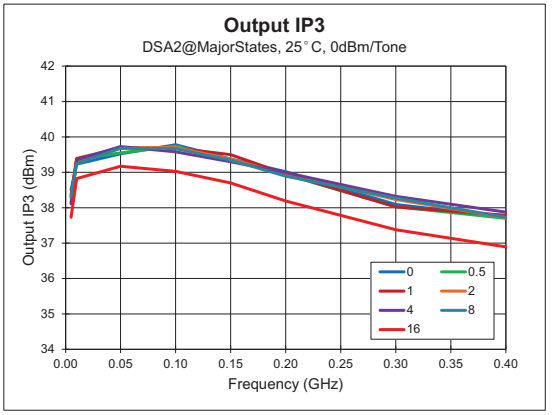
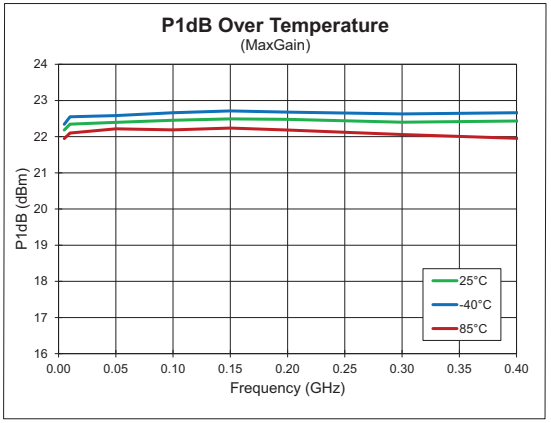
## Typical Performance - 5MHz to 250MHz Broadband Application Circuit

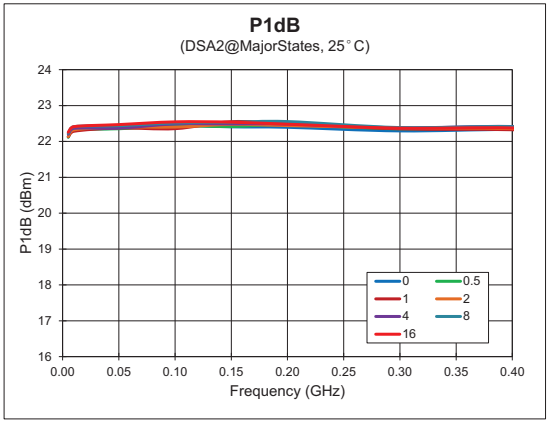


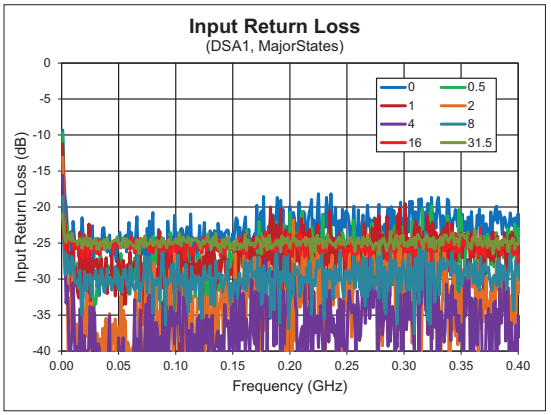



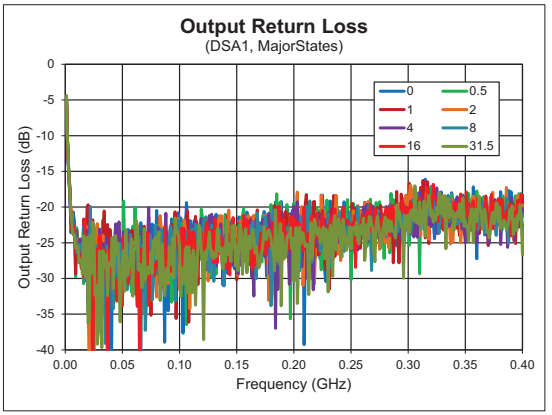



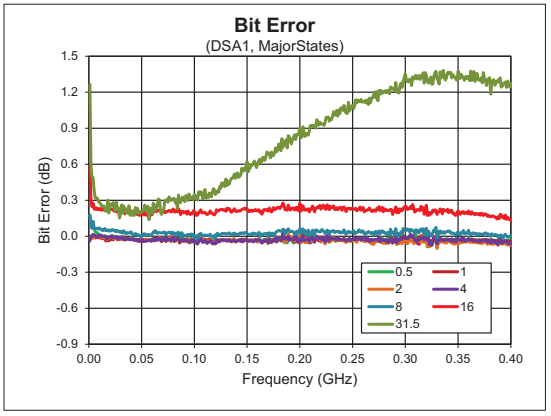



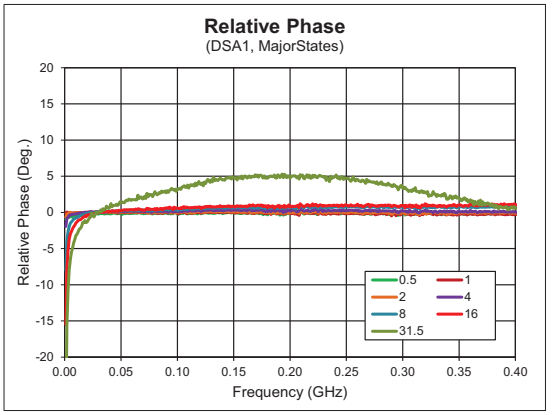



## Test Conditions: Changing DSA1 setting, with DSA2 at 0dB Attenuation (25°C)





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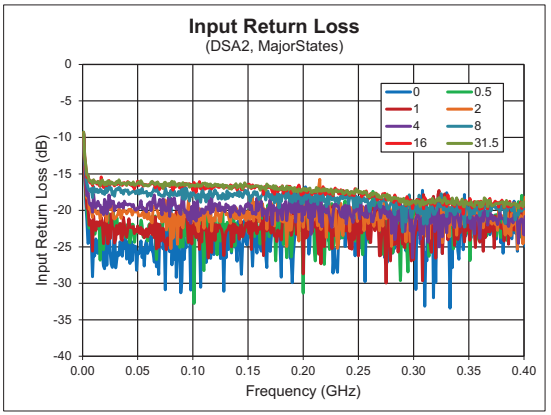
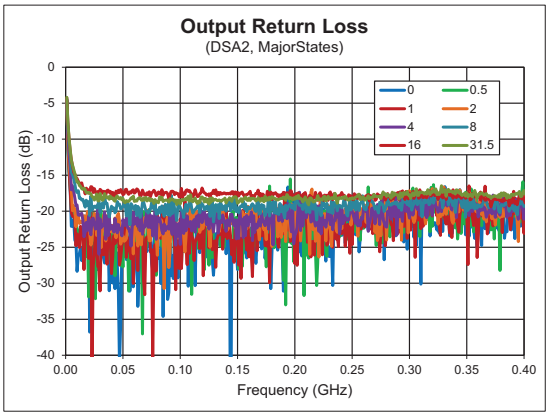
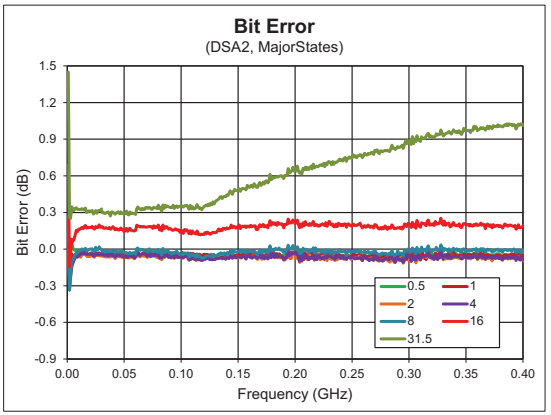
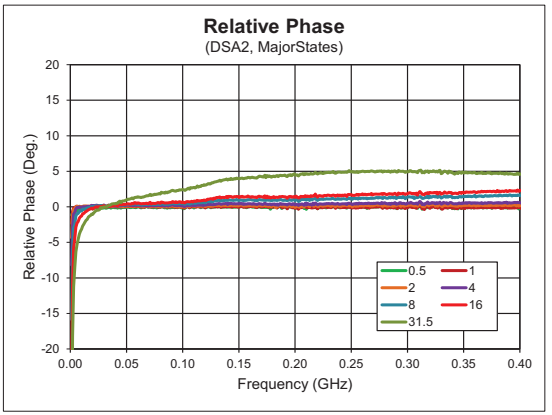
## Test Conditions: Changing DSA2 setting, with DSA1 at 0dB Attenuation (25°C)

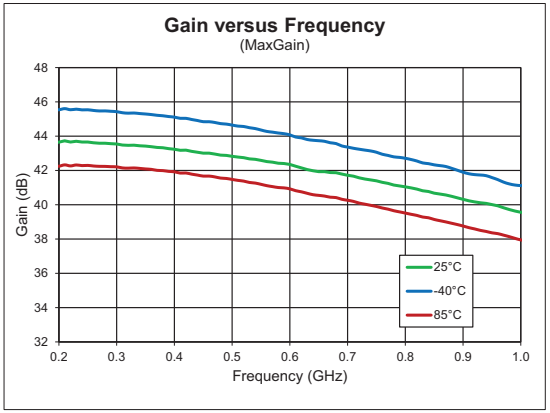


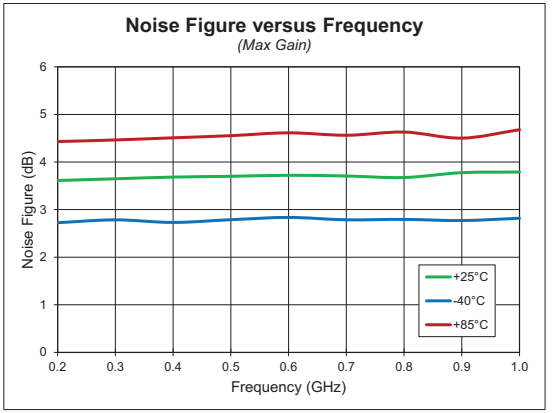



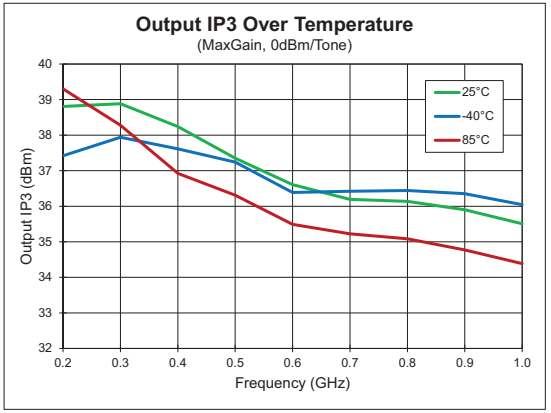



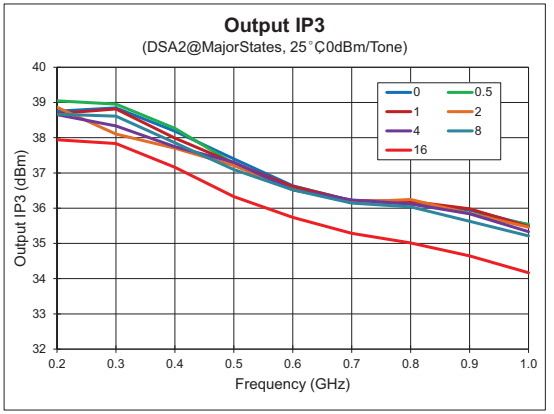



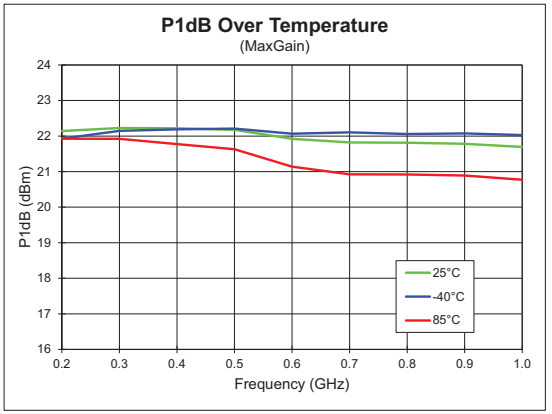
## Typical Performance - 400MHz to 1GHz Broadband Application Circuit

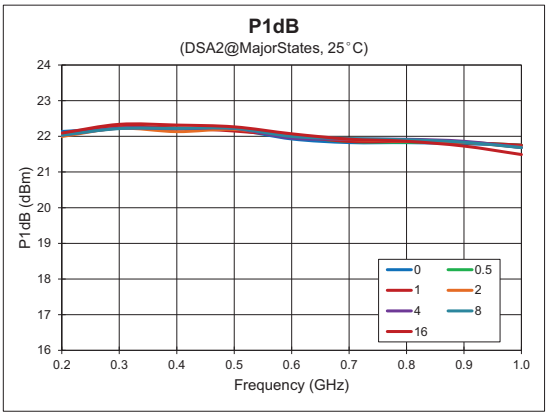


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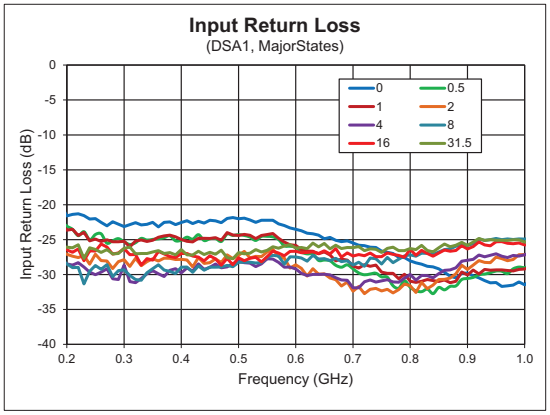
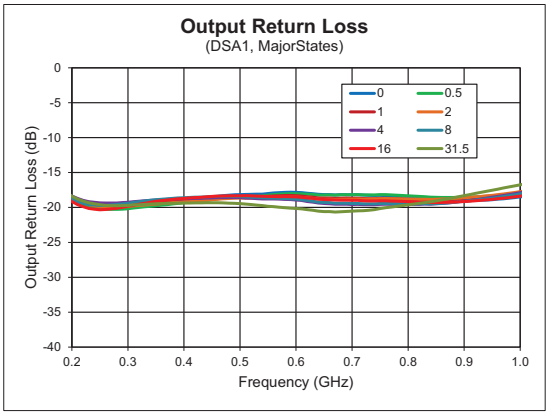
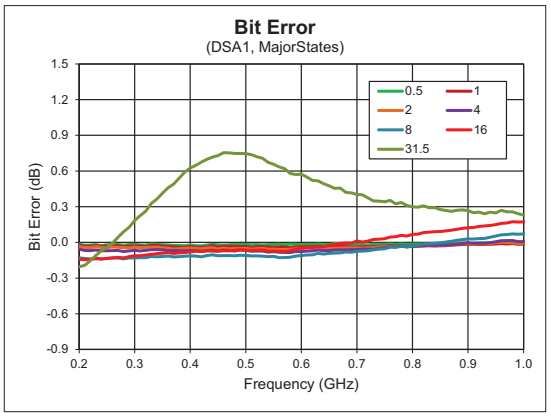
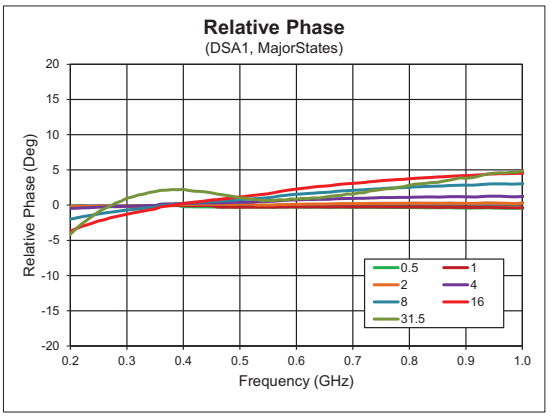
## Test Conditions: Changing DSA1 setting, with DSA2 at 0dB Attenuation (25°C)

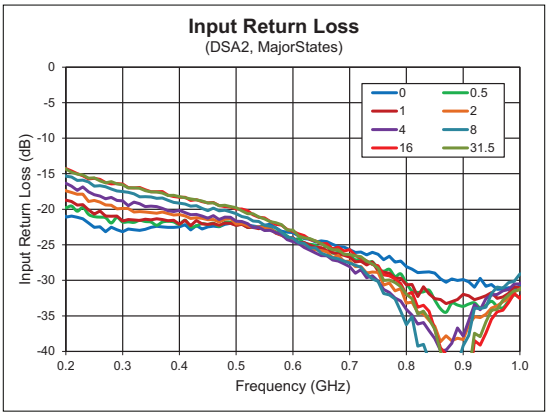


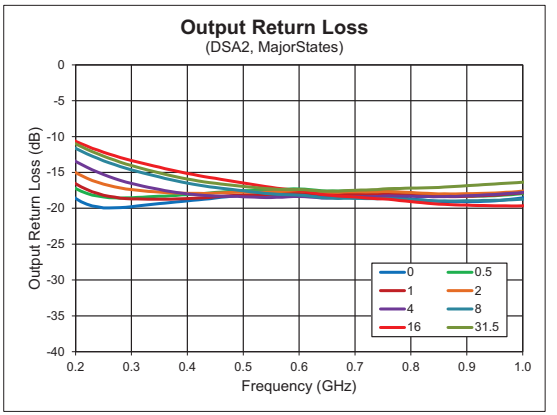



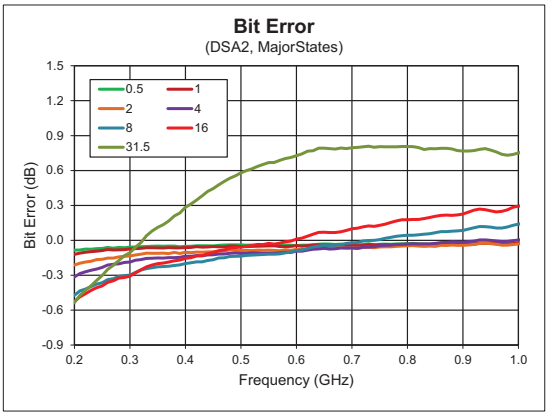



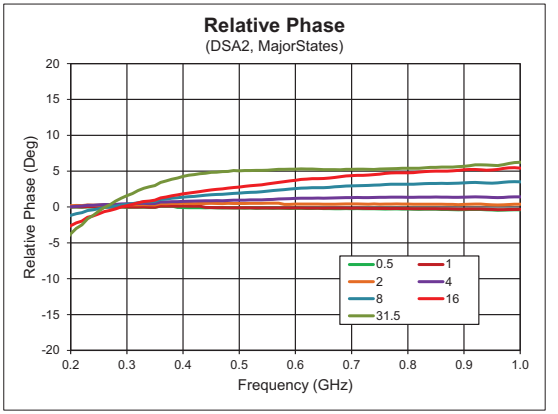



## Test Conditions: Changing DSA2 setting, with DSA1 at 0dB Attenuation (25°C)



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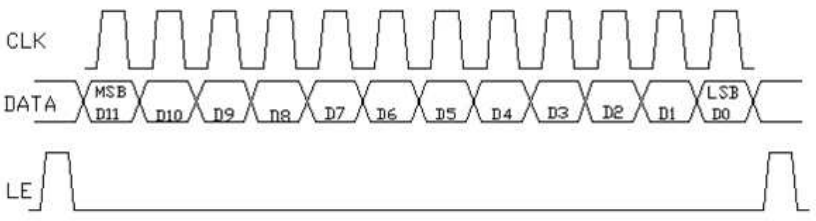
## Truth Table

| DSA1 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 |

| DSA2 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 |

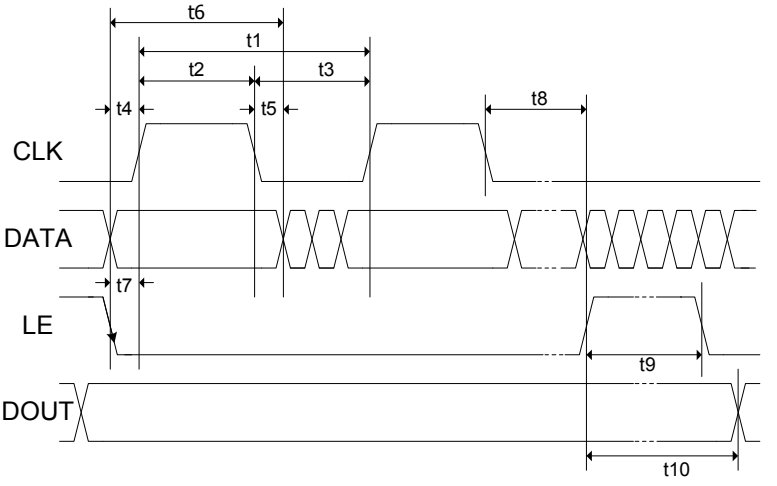
Programming Example - 12 Bit



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

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

## SPI Timing Diagram




## 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 |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## Pin Names and Description

| Pin | Function | Description |
|---|---|---|
| 1 | AMP1_IN | AMP1 Input |
| 2 | DSA1_OUT | DSA1 Output |
| 3 | ACG1 | AC Ground Connection |
| 4 | ACG2 | AC Ground Connection |
| 5 | ACG3 | AC Ground Connection |
| 6 | ACG4 | AC Ground Connection |
| 7 | DSA1_IN | DSA1 Input |
| 8 | GND | RF/DC Ground Connection |
| 9 | PUP | Power Up Programming pin |
| 10 | DATA | Serial Data Input |
| 11 | LE | Serial Latch Enable |
| 12 | CLK | Serial Clock Input |
| 13 | VDD | Supply Voltage for DSA and SPI Control |
| 14 | GND | RF/DC Ground Connection |
| 15 | AMP2_OUT | AMP2 OUT and Bias pin |
| 16 | GND | RF/DC Ground Connection |
| 17 | GND | RF/DC Ground Connection |
| 18 | AMP2_IN | AMP2 Input |
| 19 | DSA2_OUT | DSA2 Output |
| 20 | GND | RF/DC Ground Connection |
| 21 | ACG5 | AC Ground Connection |
| 22 | ACG6 | AC Ground Connection |
| 23 | ACG7 | AC Ground Connection |
| 24 | ACG8 | AC Ground Connection |
| 25 | DSA2_IN | DSA2 Input |
| 26 | AMP1_OUT | AMP1 Output and Bias pin |
| 27 | GND | RF/DC Ground Connection |
| 28 | GND | RF/DC Ground Connection |


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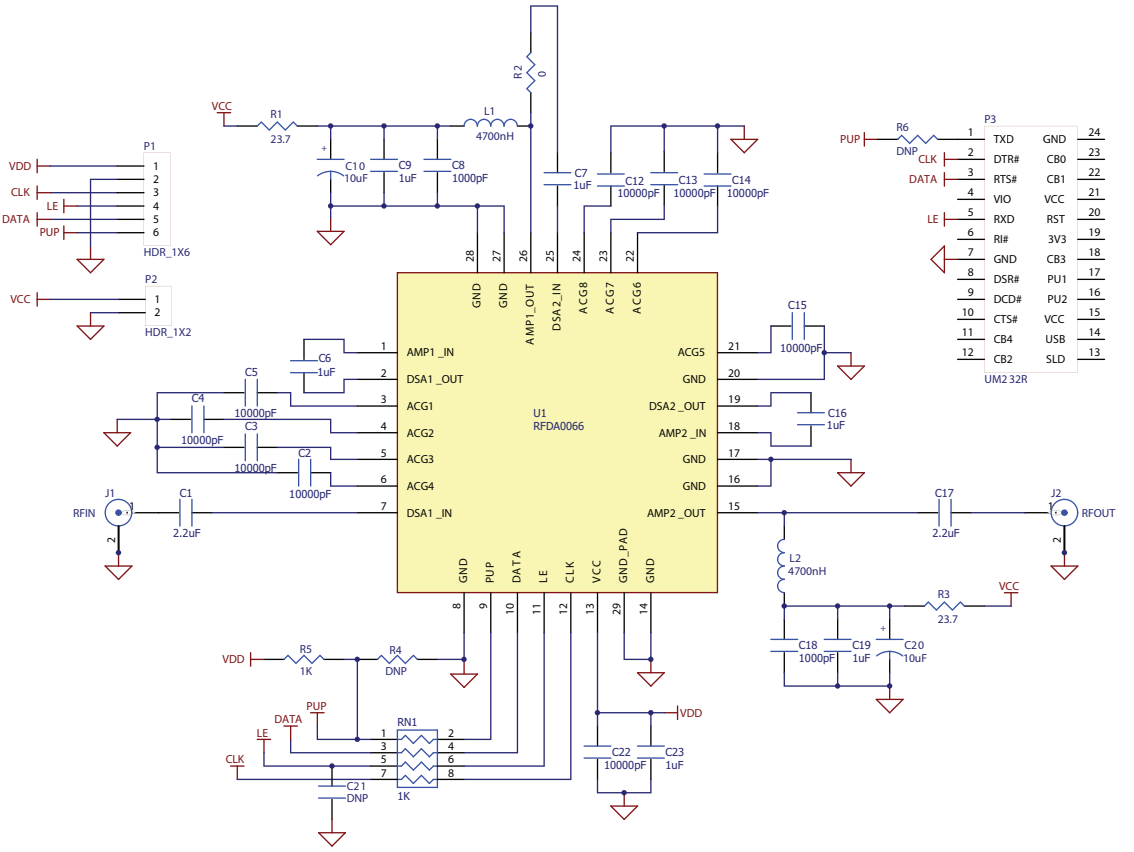
## Evaluation Board Schematic

5MHz to 250MHz Application Circuit




***Required Bias Resistance for $I_{CC}$ =115mA (one Amplifier)**

Bias Resistance = $R_{BIAS}$ + $R_{CHOKE}$ = ( $V_{CC}$ -$V_D$ ) / $I_{CC}$

( $V_{CC}$: Supply Voltage; $V_D$: Voltage on the device, ~4.9-5.0V; $R_{BIAS}$: Bias Resistor; $R_{CHOKE}$: DCR of choke)

### Bias Resistance

| Supply Voltage | 7V | 8V | 9V | 12V |
|---|---|---|---|---|
| Bias Resistance | 19Ω | 27.5Ω | 36Ω | 63Ω |



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## Evaluation Board Build of Materials (BOM)

5MHz to 250MHz Application Circuit

| Description | Reference Designator | Manufacturer | Manufacturer's P/N |
|---|---|---|---|
| Evaluation Board | | RFMD | RFDA0066410(B) |
| Digital Controlled Variable Gain Amplifier | U1 | RFMD | RFDA0066SB |
| CAP, 2.2µF, 10%, 10V, X5R, 0603 | C1, C17 | Murata Electronics | GRM188R61A225KE34D |
| CAP, 10000pF, 10%, 16V, X7R, 0402 | C2-C5, C12-C15, C22 | Taiyo Yuden (USA), Inc. | RM EMK105BJ103KV-F |
| CAP, 1µF, 10%, 6.3V, X5R, 0402 | C6-C7, C9, C16, C19, C23 | Taiyo Yuden (USA), Inc. | RM JMK105BJ105KVLF |
| CAP, 1000pF, 10%, 50V, X7R, 0402 | C8, C18 | Taiyo Yuden (USA), Inc. | RM UMK105BJ102KV-F |
| CAP, 10µF, 10%, 16V, TANT-B | C10, C20 | AVX Corporation | TAJB106K016R |
| IND, 4700nH, 10%, W/W, 1008 | L1-L2 | Coilcraft, Inc. | 1008CS-472XKBC |
| CONN, HDR, ST, 6-PIN, 0.100" | P1 | SAMTEC INC. | TSW-106-07-G-S |
| CONN, HDR, ST, 2-PIN, 0.100" | P2 | SAMTEC INC. | TSW-102-07-G-S |
| CONN, SKT, 24-PIN DIP, .600", T/H | P3 | Aries Electronics, Inc. | 24-6518-10 |
| CONN, SMA, END LNCH, RND PIN, 0.059" | J1-J2 | GIGALANE CO., LTD. | PSF-S01-006 |
| RES, 23.7Ω, 1%, 3/4W, 2010 | R1, R3 | PANASONIC INDUSTRIAL CO | ERJ12SF23R7U |
| JMPR, 0Ω, 0603 | R2 | PANASONIC INDUSTRIAL CO | ERJ-3GEY0R00 |
| RES, 1K, 1%, 1/16W, 0603 | R5 | PANASONIC INDUSTRIAL CO | ERJ-3EKF1001V |
| RES ARRAY, 4-ELEM, 1K, 5%, SMD 4x0402 | RN1 | KOA Speer Electronics, Inc. | CN1E4KTTD102J |
| DNI | C11, C21, R4, R6, J3 | | |

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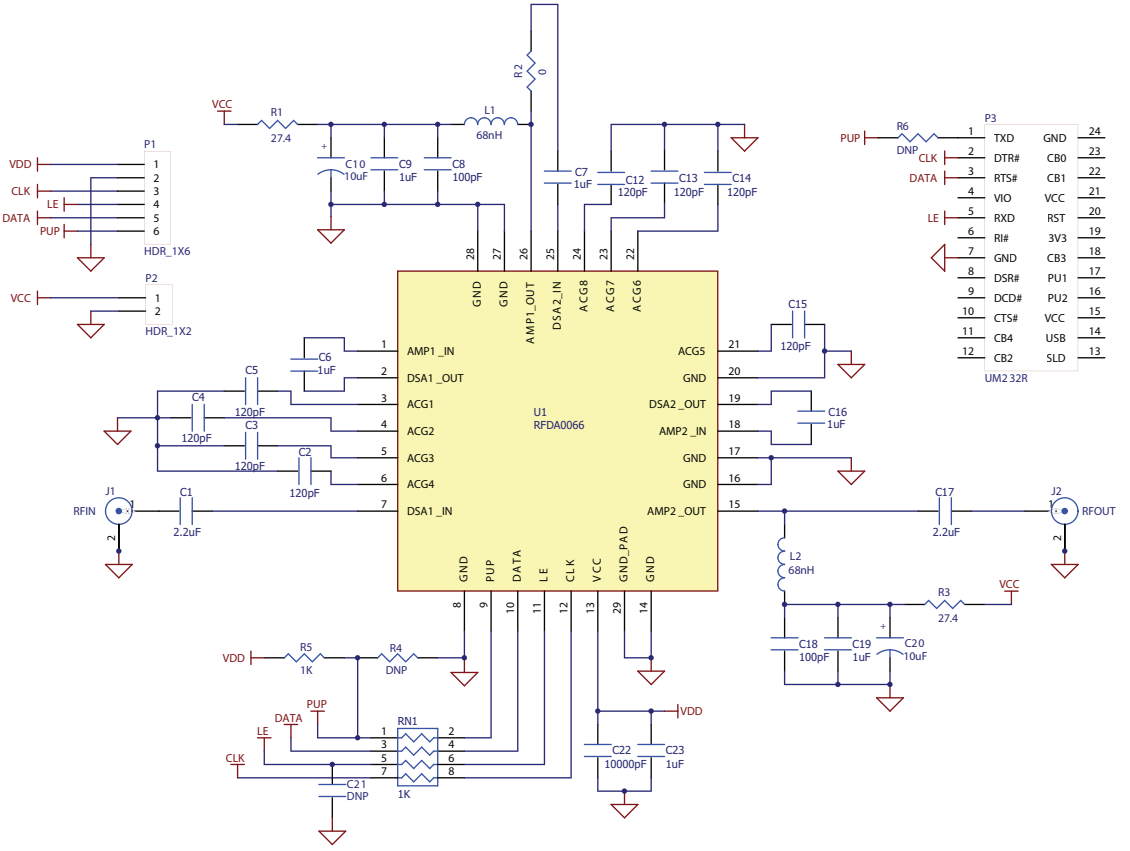
## Evaluation Board Schematic

400MHz to 1GHz Application Circuit



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## Evaluation Board Build of Materials (BOM)

400MHz to 1GHz Application Circuit

| Description | Reference Designator | Manufacturer | Manufacturer's P/N |
|---|---|---|---|
| Evaluation Board | | RFMD | RFDA0066410(B) |
| Digital Controlled Variable Gain Amplifier | U1 | RFMD | RFDA0066SB |
| CAP, 2.2µF, 10%, 10V, X5R, 0603 | C1, C17 | Murata Electronics | GRM188R61A225KE34D |
| CAP, 10000pF, 10%, 16V, X7R, 0402 | C22 | Taiyo Yuden (USA), Inc | RM EMK105BJ103KV-F |
| CAP, 120pF, 5%, 50V, CG, 0402 | C2-C5, C12-C15 | Taiyo Yuden (USA), Inc | RM UMK105CG121JV-F |
| CAP, 1µF, 10%, 6.3V, X5R, 0402 | C6-C7, C9, C16, C19, C23 | Taiyo Yuden (USA), Inc | RM JMK105BJ105KVLF |
| CAP, 100pF, 5%, 50V, C0G, 0402 | C8, C18 | Taiyo Yuden (USA), Inc | RM UMK105CG101JV-F |
| CAP, 10µF, 10%, 16V, TANT-B | C10, C20 | AVX Corporation | TAJB106K016R |
| IND, 68nH, 5%, W/W, 1008 | L1-L2 | Coilcraft, Inc. | 1008CS-680XJBC |
| CONN, HDR, ST, 6-PIN, 0.100" | P1 | SAMTEC INC. | TSW-106-07-G-S |
| CONN, HDR, ST, 2-PIN, 0.100" | P2 | SAMTEC INC. | TSW-102-07-G-S |
| CONN, SKT, 24-PIN DIP, .600", T/H | P3 | Aries Electronics, Inc. | 24-6518-10 |
| CONN, SMA, END LNCH, RND PIN, 0.059" | J1-J2 | GIGALANE CO., LTD. | PSF-S01-006 |
| RES, 27.4Ω, 1%, 3/4W, 2010 | R1, R3 | PANASONIC INDUSTRIAL CO | ERJ12SF27R4U |
| JMPR, 0Ω, 0603 | R2 | PANASONIC INDUSTRIAL CO | ERJ-3GEY0R00 |
| RES, 1K, 1%, 1/16W, 0603 | R5 | PANASONIC INDUSTRIAL CO | ERJ-3EKF1001V |
| RES ARRAY, 4-ELEM, 1K, 5%, SMD 4x0402 | RN1 | KOA Speer Electronics, Inc. | CN1E4KTTD102J |
| DNI | C11, C21, R4, R6, J3 | | |


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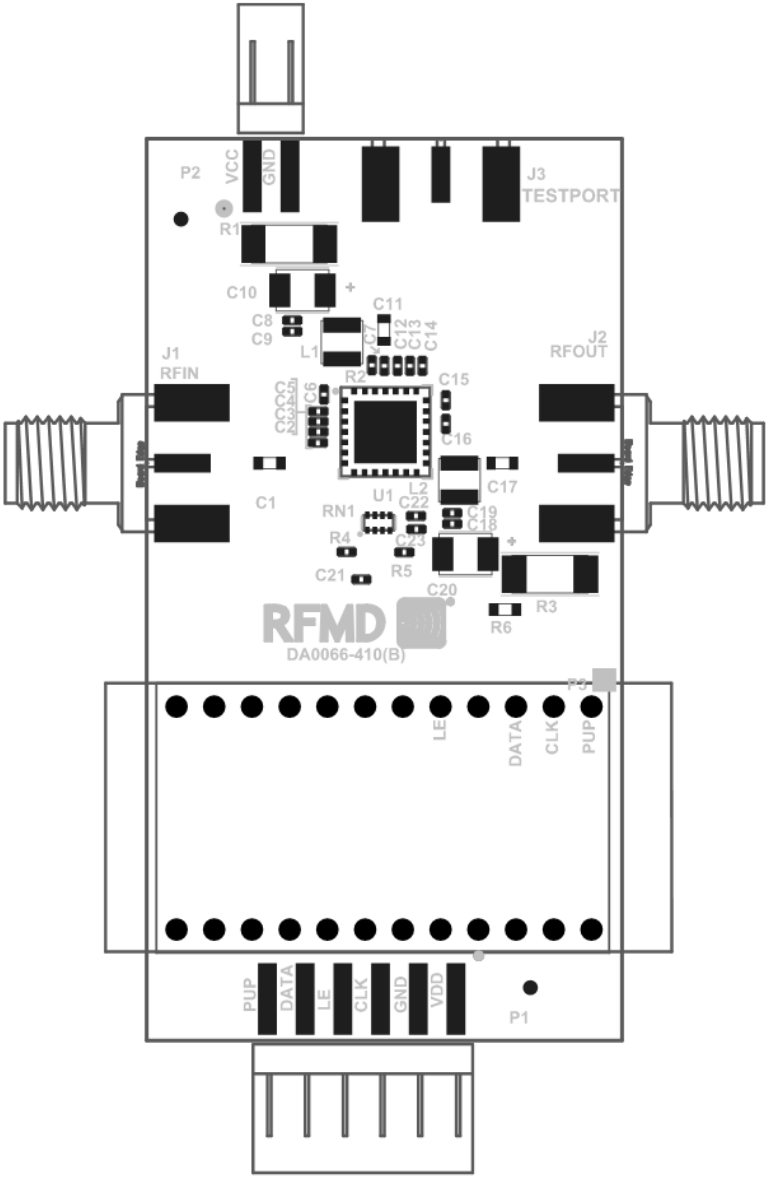
## Evaluation Board Assembly Drawing



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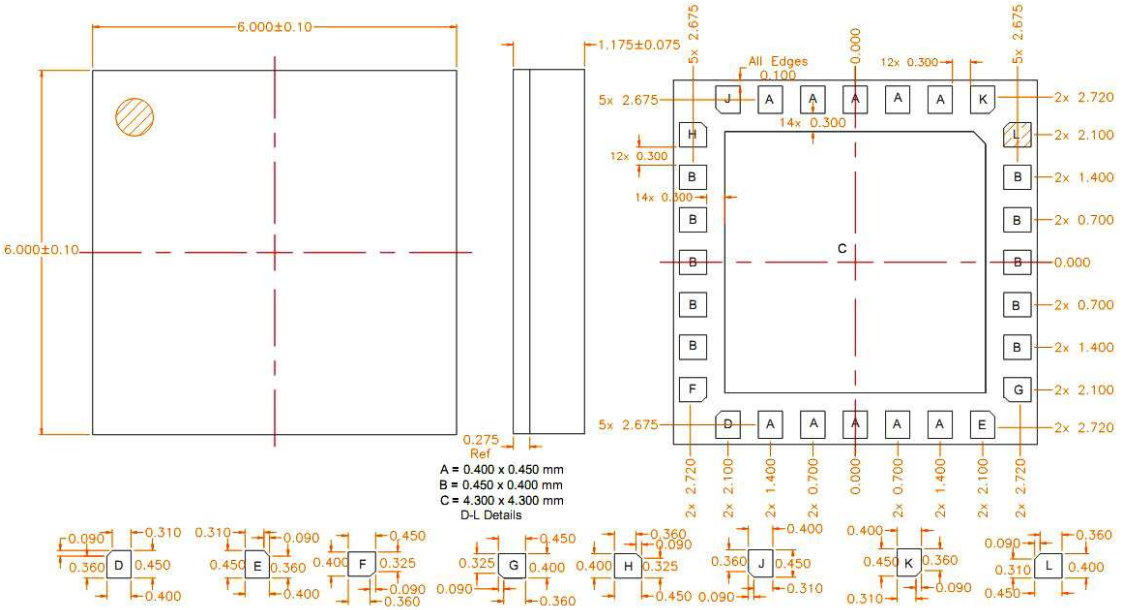
## Package Drawing

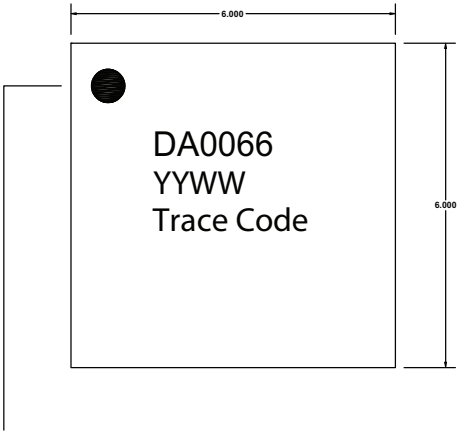
6.0mmx6.0mm Laminate Module




Notes:
1. Shaded area represents Pin 1 location.

The module thickness tolerance is: +/- .04mm. All other dim tolerances are +/- .075mm unless otherwise noted.

## Branding Diagram




Pin 1 Indicator

Fill in the YYWW Notation with the Date Code
YY = Year
WW = Week

Trace Code to be assigned by SubCon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