RFSA4013 Temperature Compensating Attenuator

Product Overview

The RFSA4013 is a monolithic analog temperature compensating attenuator (TCA) featuring exceptional linearity. It is designed to offset the gain reduction of an RF component over temperature without the need for closed loop feedback. Three customer selectable temperature coefficients provide a flexible solution for RF lineups. The RFSA4013 incorporates revolutionary new circuit architecture to solve a long-standing industry problem with regards to attenuator architecture: high IP3, low DC current and broad bandwidth. Traditional approaches require expensive co-fired ceramics with temperature sensitive materials or current hungry PIN diodes with elaborate area consuming control circuits. This temperature compensating attenuator requires only a single supply voltage and two logic bits to set the slope of attenuation versus temperature.

The RFSA4013 draws about 1mA current. This attenuator is internally matched to 50Ω over frequency and working modes with no external matching required.

The RFSA4013 is packaged in a RoHS-compliant, compact 3 mm x 3 mm QFN package.

Functional Block Diagram





16-Pin mm x 3 mm leadless QFN Package

Key Features

- Patented Circuit Architecture
- 50 6000 MHz Frequency Range
- 3 Selectable Slopes of Attenuation vs. Temperature
- +55 dBm IIP3 Typical
- +85 dBm IIP2 Typical
- High P1dB, > +30 dBm
- Low Current Consumption, 1 mA Typical
- Single 5 Volt DC Supply

Applications

- Cellular Wireless Infrastructure
- WiBro, WiMax, LTE
- Microwave Radio
- High Linearity Level Control

Ordering Information

Part No.	Description
RFSA4013TR7	2500 pcs on 7" reel (standard)
RFSA4013PCK-410	50 MHz-6.0 GHz Evaluation Kit

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Absolute Maximum Ratings

Parameter	Rating
Storage Temperature	−65 to +150 °C
Supply Voltage (VDD)	-0.5 to +6.0 V
Mode Select Pin Voltage (MODE1 & 2)	-0.5 to +6.0 V
RF Input Power	+30 dBm
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Operation of this device outside the parameter ranges given above may cause permanent damage.

Recommended Operating Conditions

Parameter	Min	Тур	Max	Units
VDD	+4.75	+5	+5.25	V
Operating Temperature	-40		+85	°C
RF Input Power			+27	dBm
Tj, MTTF > 1e5 hours			+125	°C

Electrical specifications are measured at specified test conditions. Specifications are not guaranteed over all recommended operating conditions. Temperature reference point is 3mm from the corner between pins 16 and 17 on the PCB copper.

Electrical Specifications

Test conditions unless otherwise noted: VDD = +5V, Temp = +25 °C on Qorvo EVB, 50Ω system.

Parameter	Conditions	Min	Тур	Max	Units
Operating Frequency		50		6000	MHz
Test Frequency			2000		MHz
	MODE1 Low and MODE2 High		0.043		dB/°C
Attenuation Slope	MODE1 High and MODE2 High		0.058		dB/°C
	MODE1 High and MODE2 Low		0.066		dB/°C
	MODE1 Low and MODE2 High		5.40		dB
Nominal Attenuation at +25°C	MODE1 High and MODE2 High		6.35		dB
	MODE1 High and MODE2 Low		7.40		dB
Relative Insertion Phase			3		Deg
Return Loss	Input and Output		20		dB
Input P1dB			30		dBm
Input IP3	PIN + IMD3(dBc)/2	45	55		dBm
Input IP2	PIN + IMD2(dBc); IMD2 at F1+F2		85		dBm
Input IH2	PIN + H2(dBc); H2-Second order Harmonic		87		dBm
Input IH3	PIN + H3(dBc)/2; H3-Third order Harmonic		59		dBm
Made Central Threshold Voltages	MODE1 and MODE2 Logic Low			+0.4	V
wode Control Threshold Voltages	MODE1 and MODE2 Logic High	+1.0			V

Attenuation Temperature Coefficient Table

MODE1	MODE2	Attn. Slope	Attn. @ +25°C	
0	1	0.043 dB/°C	5.40 dB	
1	1	0.058 dB/°C	6.35 dB	
1	0	0.066 dB/°C	7.40 dB	
0	0	Not Supported		

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Evaluation Board and Schematic – RFSA4013EVB-01



Bill of Material – RFSA4013EVB-01

Reference Des.	Value	Description	Manuf.	Part Number
U1	-	TCA, 50 to 4000MHz, 5V, SOI	Qorvo	RFSA4013
PCB	-	PCB, SA2013	Qorvo	SA2013-410(A)
C1, C2, C7, C8, C9	1000 pF	CAP, 1000 pF 10%, 50V, X7R, 0402	Murata	GRM155R71H102KA01D
C4	1 µF	CAP, 1 µF 10%, 16V, X7R, 1206	Murata	GRM31MR71E105KC01L
R5	100 Ω	RES, 100 Ω, 5%, 1/16W, 0402	Various	-
J1, J2	SMA	CON, SMA, EL MINI, 0.068"	Aliner	20-001CF-T
P1, P2	-	CON, HDR ST, 4-PIN, 0.100", T/H	MOLEX	22-28-4043
C3, C5, C6, R1, R2, R3, R4	DNP	-	-	-

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Performance Plots – RFSA4013PCK-410



Insertion Loss versus Frequency Mode 1=High, Mode 2=High, V_{DD}=5V







Insertion Loss versus Frequency Mode 1=Low, Mode 2=High, V_{DD}=5V





Input Return Loss versus Frequency

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Performance Plots – RFSA4013PCK-410 (continued 1)



Output Return Loss versus Temperature RF 2GHz, V_{DD}=5V







Output Return Loss versus Frequency Mode 1=High, Mode 2=Low, V_{DD}=5V





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Performance Plots – RFSA4013PCK-410 (continued 2)







Input IP3 versus Temperature V_{DD}=5V, Mode 1=High, Mode 2=High, Pin=+20dBm/Tone





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Performance Plots – RFSA4013PCK-410 (continued 3)

Test conditions unless otherwise noted: VDD = +5.0 V, Temp = +25°C, on Qorvo EVB.







Input IP2 versus Temperature V_{pp}=5V, Mode 1=High, Mode 2=High, Pin=+20dBm/Tone





Datasheet Rev F, January 25, 2024 | Subject to change without notice

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Performance Plots – RFSA4013PCK-410 (continued 4)

Test conditions unless otherwise noted: VDD = +5.0 V, Temp = +25°C, on Qorvo EVB.







3rd Harmonic IH3 versus Temperature V_{DD}=5V, Mode 1=High, Mode 2=High, Pin=+20dBm



3rd Harmonic IH3 versus Temperature V_{DD}=5V, Mode 1=Low, Mode 2=High, Pin=+20dBm



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Performance Plots – RFSA4013PCK-410 (continued 5)

Test conditions unless otherwise noted: VDD = +5.0 V, Temp = +25°C, on Qorvo EVB.





2nd Harmonic IH2 versus Attenuation RF 2GHz, V_{DD}=5V, Pin=+20dBm 120 110 100 90 80 70 IH2 (dBm) 60 50 40 30 Mode1=High Mode2=Low 20 -Mode1=High Mode2=High 10 Mode1=Low Mode2=High 0 -14 -12 -10 -2 -8 -6 0 Attenuation (dB)

2nd Harmonic IH2 versus Temperature V_{DD}=5V, Mode 1=High, Mode 2=High, Pin=+20dBm





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Performance Plots – RFSA4013PCK-410 (continued 6)



Relative Insertion Phase versus Attenuation V_{pp}=5V, Mode 1=Low, Mode 2=High











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Performance Plots – RFSA4013PCK-410 (continued 7)

Test conditions unless otherwise noted: VDD = +5.0 V, Temp = +25°C, on Qorvo EVB.







V_{DD}=5V, F=12.001Hz, Pin=+10dBm/Tone 100 95 90 85 80 g 2 75 nd 70 65 Mode1=High Mode2=Low 60 Mode1=High Mode 2=High 55 Mode1=Low Mode2=High 50 -14 -13 -12 -7 -8 -11 -10 Attenuation (dB) -9 -6 Temperature (°C)

Input IP2 versus Attenuation

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Performance Plots – RFSA4013PCK-410 (continued 8)







3rd Harmonic IH3 versus Attenuation V_{DD}=5V, F=6GHz, Pin=+10dBm/tone







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Pin Configuration and Description



Top View

Pin No.	Label	Description
1, 5, 8, 12, 13, 14, 16	GND	RF/DC ground connection
2, 4, 9, 11	NC	No Connection internally, NC on evaluation PCB, can be connected to GND externally
3	RFIN	RF Input, External DC blocking require
6	MODE1	Logic control Input 1, Attenuation temperature coefficient slope selection
7	MODE2	Logic control Input 2, Attenuation temperature coefficient slope selection
10	RFOUT	RF Output, External DC blocking require
15	VDD	DC supply voltage input
Backside Paddle	GND	RF & DC Ground. Use recommended via hole pattern to minimize inductance and thermal resistance. See PCB Mounting Pattern for suggested footprint.

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Package Marking and Dimensions



Notes:

- 1. All dimensions are in mm. Angles are in degrees.
- 2. Dimension and tolerance formats conform to ASME Y14.4M-1994.

3. The terminal #1 identifier and terminal numbering conform to JESD 95-1 SPP-012.



PCB Mounting Pattern

Notes:

- 1. All dimensions are in mm. Angles are in degrees.
- 2. A heat sink underneath the area of the PCB for the mounted device is recommended for proper thermal operation.
- 3. Ground / thermal via holes on center slug are critical for the proper performance of this device. Via holes should use a .35mm (#80 / .0135") diameter drill and have a final plated through diameter of .25 mm (.010").
- 4. Add as much copper as possible to inner and outer layers near the part to ensure optimal thermal performance.

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Tape and Reel Information – Carrier and Cover Tape Dimensions



Feature	Measure	Symbol	Size (in)	Size (mm)
	Length	A0	0.125	3.20
Covity	Width	B0	0.125	3.20
Cavity	Depth	K0	0.040	1.00
	Pitch	P1	0.157	4.00
Cantarlina Distance	Cavity to Perforation - Length Direction	P2	0.079	2.00
Centenine Distance	Cavity to Perforation - Width Direction	F	0.217	5.50
Cover Tape	Width (Reference Only)	С	0.362	9.20
Carrier Tape	Width	W	0.472	12.0

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Tape and Reel Information – Reel Dimensions

Standard T/R size = 2,500 pieces on a 7" reel.



Feature	Measure	Symbol	Size (in)	Size (mm)
	Diameter	A	6.969	177.0
Flange	Thickness	W2	0.717	18.2
	Space Between Flange	W1	0.504	12.8
Hub	Outer Diameter	N	2.283	58.0
	Arbor Hole Diameter	С	0.512	13.0
	Key Slit Width	В	0.079	2.0
	Key Slit Diameter	D	0.787	20.0

Tape and Reel Information – Tape Length and Label Placement



Notes:

- 1. Empty part cavities at the trailing and leading ends are sealed with cover tape. See EIA 481-1-A.
- 2. Labels are placed on the flange opposite the sprockets in the carrier tape.

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Handling Precautions

Parameter	Rating	Standard	
ESD-Human Body Model (HBM)	Class 1C	ANSI / ESDA / JEDEC JS-001	Caution!
ESD-Charged Device Model (CDM)	Class C5	ANSI / ESDA / JEDEC JS-002	ESD-Sensitive Device
MSL-Moisture Sensitivity Level	Level 1	IPC/JEDEC J-STD-020	

Solderability

Compatible with both lead-free (260°C max. reflow temp.) and tin/lead (245°C max. reflow temp.) soldering processes. Solder profiles available upon request.

Contact plating: Matte Sn (*Thickness: 8 µm ~ 23 µm*)

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 (C₁₅H₁₂Br₄0₂) Free
- PFOS Free
- SVHC Free

Contact Information

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

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