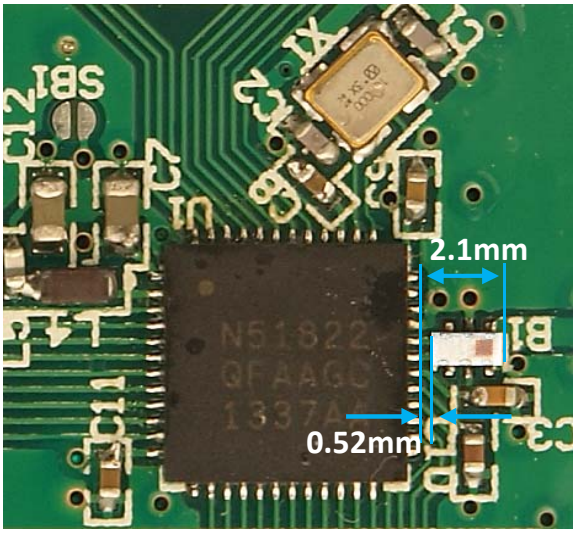
High Frequency Ceramic Solutions

Application Note: AN020 Date: 06/04/2014 M.Carmona/I.Johnson

Application Note for Nordic Semi's nRF51822-QFAA, nRF51422-QFAA, nRF51822-QFAB, nRF51422-QFAB, nRF51822-QFAC, and nRF51422-QFAC Integrated RF Front End Solution Using Johanson's 1.6x0.8mm Impedance Matched Balun Filter (BPF)



Abstract

The nRF51822 and nRF51422 devices from Nordic Semiconductor are powerful, highly flexible, multiprotocol SoCs designed for Bluetooth® low energy, ANT, and 2.4 GHz ultra-low power wireless applications. The devices are built around an ARM® Cortex™ CPU and integrate fully compliant Bluetooth low energy and ANT stacks. The devices also include a rich selection of analog and digital peripherals - such as ADC, serial interfaces, PWM, and quadrature demodulator - that can be used in a wide range of ultra-low power applications.

This application note describes how to use Johanson Technology's 2450BM14E0003 balun-filter, shares active measured results obtained with the chipsets, provides design files for ease of use on any PCB/Application environment and RF technical support contact info at Johanson Technology.

Introduction

In partnership with Nordic Semiconductor, Johanson Technology has developed an 6-pin EIA 0603 (1.6mmx0.8mmx0.7mm) ceramic passive device that contains the following functions:
-Differential complex impedance (X+jY) matching network for the nRF51822 and nRF51422
-Differential to 50Ω single-ended balun
-Specifically designed BPF to pair with the nRF chipsets for FCC/ETC (+Korea, Japan, China) emissions compliance

This front-end 6-pin device considerably reduces implementation size area by using smaller effective PCB real estate usage. Also, it reduces component count, eliminates RF variability (100% RF tested before T&R), and offers excellent temperature stability (4ppm). AEC-Q200 available.

Design/gerber/layout files

www.johansontechnology.com/nordic

Technical Support

http://www.johansontechnology.com/component/techquestion

JOHANSON TECHNOLOGY

www.johansontechnology.com

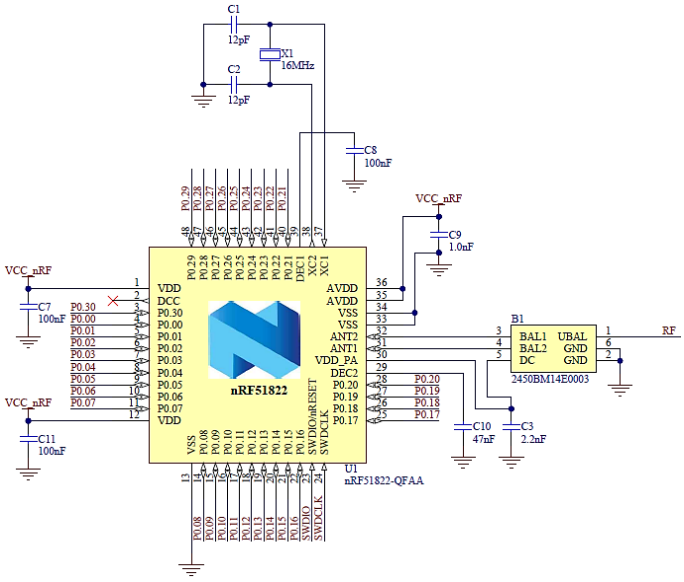
4001 Calle Tecate • Camarillo, CA 93012, USA • TEL +1.805.389.1166

High Frequency Ceramic Solutions

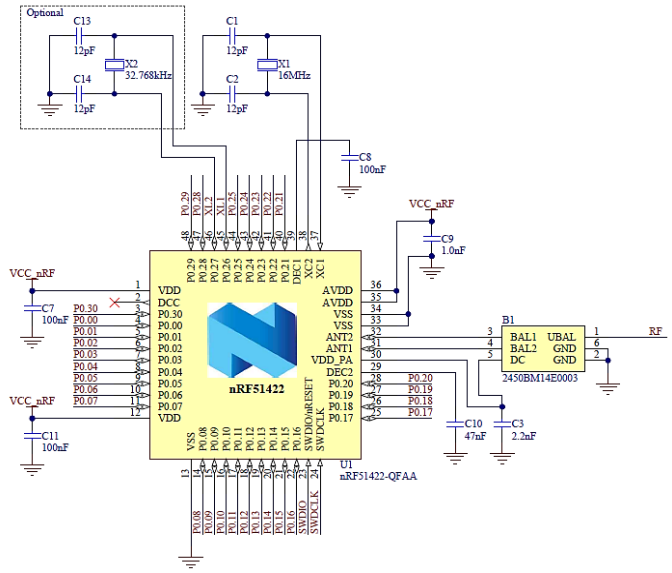
Application Note: AN020 Date: 06/04/2014 M.Carmona/I.Johnson

Application Note for Nordic Semi's nRF51822-QFAA, nRF51422-QFAA, nRF51822-QFAB, nRF51422-QFAB, nRF51822-QFAC, and nRF51422-QFAC Integrated RF Front End Solution Using Johanson's 1.6x0.8mm Impedance Matched Balun Filter (BPF)

Schematic nRF51822-QFAA & balun-filter 2450BM14E0003



Schematic nRF51422-QFAA & balun-filter 2450BM14E0003



More schematic examples, download the layout/gerber files, BOM, etc go to: www.johansontechnology.com/nordic

High Frequency Ceramic Solutions

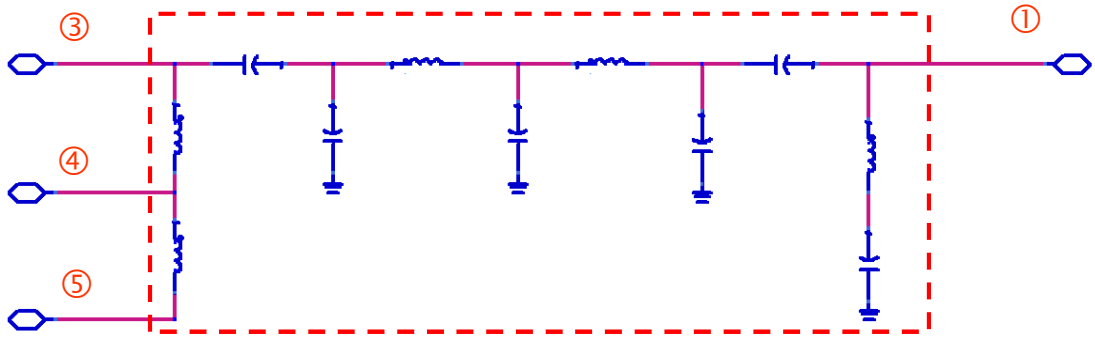
Application Note: AN020 Date: 06/04/2014 M.Carmona/I.Johnson

Application Note for Nordic Semi's nRF51822-QFAA, nRF51422-QFAA, nRF51822-QFAB, nRF51422-QFAB, nRF51822-QFAC, and nRF51422-QFAC Integrated RF Front End Solution Using Johanson's 1.6x0.8mm Impedance Matched Balun Filter (BPF)

Johanson 2450BM14E0003 component Description

Johanson uses 6/6 RoHS Green Low-Temperature-CoFired-Ceramic (LTCC) integrated passive technology in a 6-pin (Sn plated) monolithic structure. This component is 100% RF Tested, making it a more reliable system, impedance controlled environment, consistent-guaranteed RF

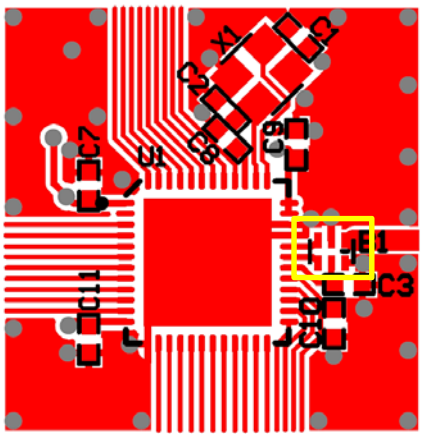
2450BM14E0003 *Internal* Representative Schematic



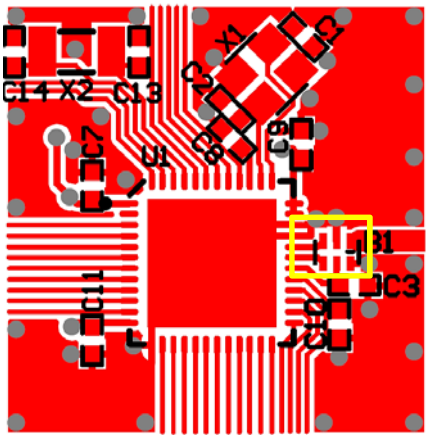
To perfrom parametric simulations with our balun-filter, download the touchstone file at: www.johansontechnology.com/nordic

Layout of nRF & balun-filter 2450BM14E0003

nRF51822 reference design



nRF51422 reference design



More schematic examples, download the layout/gerber files, BOM, etc go to: www.johansontechnology.com/nordic

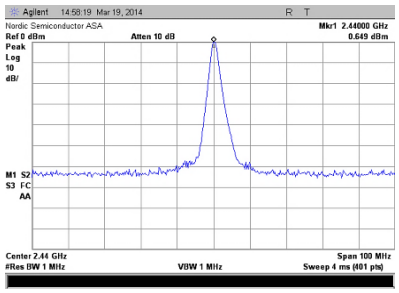
Contact our RF Applications Engineers to revise your layout at: http://www.johansontechnology.com/component/techquestion

Application Note: AN020 Date: 06/04/2014 M.Carmona/I.Johnson

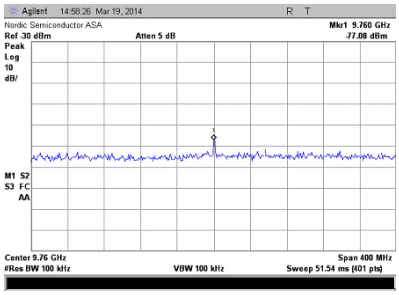
Application Note for Nordic Semi's nRF51822-QFAA, nRF51422-QFAA, nRF51822-QFAB, nRF51422-QFAB, nRF51822-QFAC, and nRF51422-QFAC Integrated RF Front End Solution Using Johanson's 1.6x0.8mm Impedance Matched Balun Filter (BPF)

Measured Conductive measurements of nRF51822 + 2450BM14E0003 on Reference Design PCB

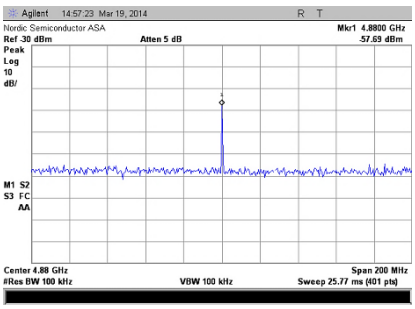
0dBm, 2440MHz (Mid)



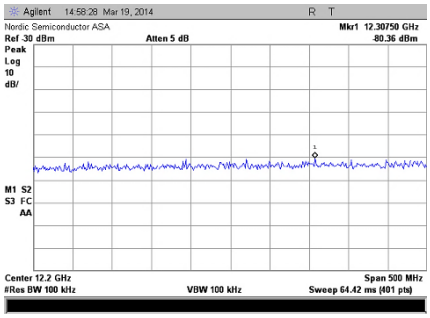
Mid 0dBm Fundamental



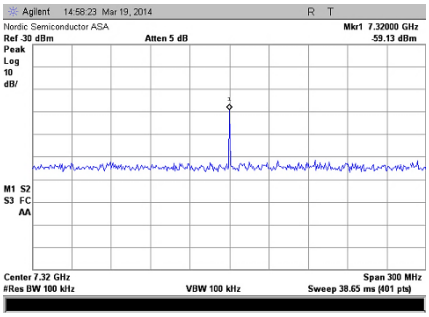
Mid 0dBm 4th harmonic



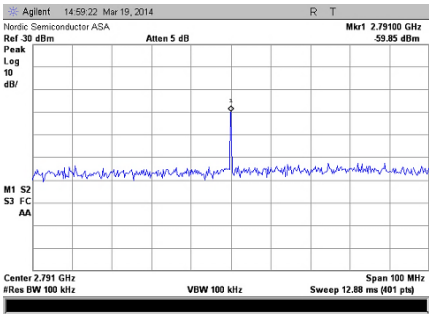
Mid 0dBm 2nd harmonic



Mid 0dBm 5th harmonic



Mid 0dBm 3rd harmonic



Mid 0dBm Local Oscillator

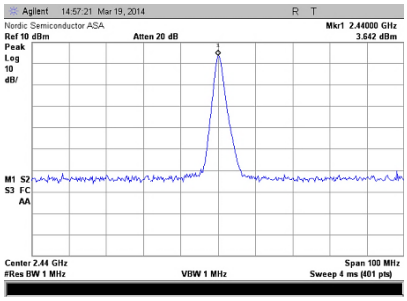
Contact our RF Applications Engineers to revise your layout at:
www.johansontechnology.com/component/techquestion

Application Note: AN020 Date: 06/04/2014 M.Carmona/I.Johnson

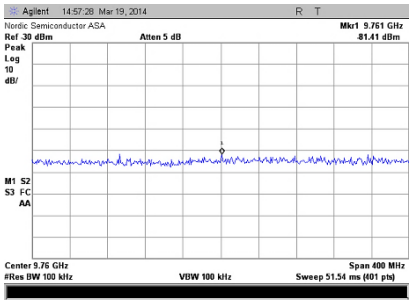
Application Note for Nordic Semi's nRF51822-QFAA, nRF51422-QFAA, nRF51822-QFAB, nRF51422-QFAB, nRF51822-QFAC, and nRF51422-QFAC Integrated RF Front End Solution Using Johanson's 1.6x0.8mm Impedance Matched Balun Filter (BPF)

Measured Conductive measurements of nRF51822 + 2450BM14E0003 on Reference Design PCB

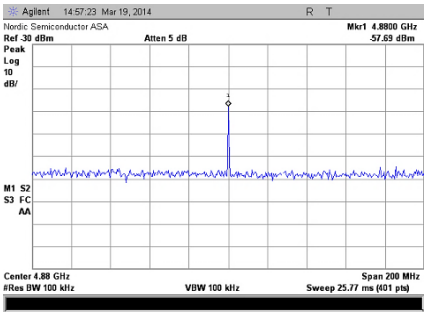
+4dBm, 2440MHz (Mid)



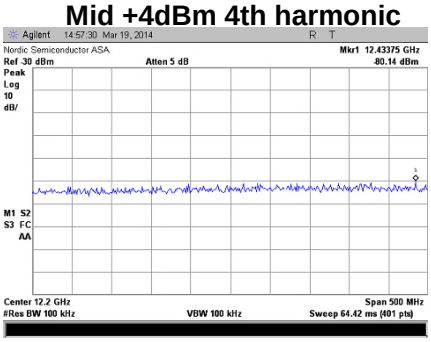
Mid +4dBm Fundamental



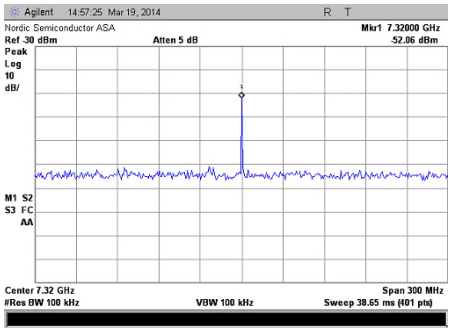
Mid +4dBm 4th harmonic



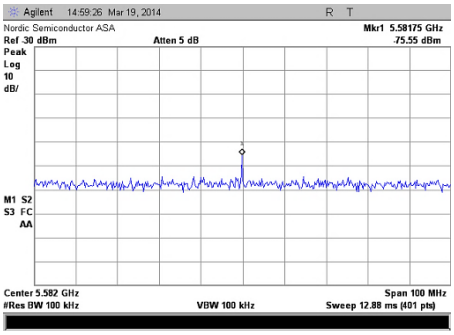
Mid +4dBm 2nd harmonic



Mid +4dBm 5th harmonic



Mid +4dBm 3rd harmonic



Mid +4dBm 2X(Local Oscillator)

Contact our RF Applications Engineers to revise your layout at:
www.johansontechnology.com/component/techquestion

Application Note: AN020 Date: 03/19/2015 M.Carmona/I.Johnson

Application Note for Nordic Semi's nRF51822-QFAA, nRF51422-QFAA, nRF51822-QFAB, nRF51422-QFAB, nRF51822-QFAC, and nRF51422-QFAC Integrated RF Front End Solution Using Johanson's 1.6x0.8mm Impedance Matched Balun Filter (BPF)

Measured Conductive measurements of 2450BM14E0003 + nRF51x22-QxAx CSP family chipsets on Reference Design PCB

+4 dBm Setting		nRF51822-QFAAGC		nRF51822-QFAAHA		nRF51822-QFABCB		nRF51422-QFACAB	
Board identifier		Board 3	Board 4	Board 5	Board 6	Board 9	Board 10	Board 11	Board 12
	Frequency	2450BM14E0003	2450BM14E0003	2450BM14E0003	2450BM14E0003	2450BM14E0003	2450BM14E0003	2450BM14E0003	2450BM14E0003
Fundamental	2,402.00	4.13	3.90	3.75	3.93	3.71	3.65	3.51	3.84
2nd harmonic	4,804.00	-48.90	-47.47	-57.85	-51.25	-51.36	-53.63	-50.67	-56.63
3rd harmonic	7,206.00	-53.63	-51.92	-55.06	-53.68	-52.41	-55.91	-56.26	-51.10
4th harmonic	9,608.00	-69.85	-69.60	-75.20	-70.76	-81.18	-80.54	-80.79	-81.33
5th harmonic	12,010.00	-79.86	-80.27	-80.19	-79.45	-79.66	-80.31	-78.80	-79.17
LO	2,747.43	-58.19	-57.45	-56.71	-57.08	-56.16	-56.84	-57.30	-57.10
LO/2	1,373.71	-76.47	-77.37	-80.76	-79.37	-79.52	-78.34	-76.85	-78.44
2LO	5,494.86	-75.16	-74.64	-75.75	-75.18	-76.01	-77.82	-76.16	-75.30
Fundamental Hi	2,480.00	4.17	4.02	3.71	3.92	3.87	3.85	3.69	3.92
2nd harmonic	4,960.00	-46.40	-44.54	-52.84	-49.43	-56.99	-53.67	-54.07	-58.21
3rd harmonic	7,440.00	-44.28	-43.86	-46.54	-45.00	-48.82	-48.88	-49.57	-47.14
4th harmonic	9,920.00	-68.95	-71.11	-80.62	-75.67	-80.71	-79.67	-79.43	-78.16
5th harmonic	12,400.00	-78.56	-79.04	-79.25	-79.24	-78.13	-79.94	-79.45	-78.61
LO	2,836.57	-60.55	-59.57	-59.53	-59.76	-58.61	-59.21	-59.99	-59.92
LO/2	1,418.29	-77.44	-77.30	-81.17	-78.08	-78.33	-78.01	-78.08	-77.32
2LO	5,673.14	-76.12	-75.11	-77.05	-76.29	-76.81	-77.60	-77.95	-75.22
Fundamental Mid	2,440.00	4.23	4.08	3.85	4.10	3.91	3.94	3.76	3.94
2nd harmonic	4,880.00	-56.82	-53.82	-62.29	-62.45	-50.12	-47.45	-47.96	-49.83
3rd harmonic	7,320.00	-51.08	-49.45	-50.82	-50.61	-47.92	-49.70	-51.99	-46.09
4th harmonic	9,760.00	-80.32	-80.44	-80.01	-80.41	-71.25	-67.13	-76.64	-70.67
5th harmonic	12,200.00	-78.91	-79.16	-79.43	-79.48	-78.20	-78.94	-78.84	-78.63
LO	2,790.86	-58.95	-58.11	-57.42	-58.04	-57.01	-57.58	-58.30	-57.92
LO/2	1,395.43	-77.57	-77.05	-83.73	-80.87	-79.32	-80.47	-79.33	-78.58
2LO	5,581.71	-74.58	-74.01	-74.43	-75.10	-74.91	-75.68	-75.30	-74.66

0 dBm Setting		nRF51822-QFAAGC		nRF51822-QFAAHA		nRF51822-QFABCB		nRF51422-QFACAB	
Board identifier		Board 3	Board 4	Board 5	Board 6	Board 9	Board 10	Board 11	Board 12
	Frequency	2450BM14E0003	2450BM14E0003	2450BM14E0003	2450BM14E0003	2450BM14E0003	2450BM14E0003	2450BM14E0003	2450BM14E0003
Fundamental	2,402.00	1.02	0.95	0.20	0.83	0.30	0.61	0.32	0.61
2nd harmonic	4,804.00	-37.85	-36.08	-38.38	-37.50	-36.73	-38.71	-35.59	-38.63
3rd harmonic	7,206.00	-69.37	-65.56	-65.81	-68.30	-62.41	-67.59	-66.10	-60.23
4th harmonic	9,608.00	-76.26	-74.36	-77.55	-74.48	-77.49	-74.12	-76.11	-74.08
5th harmonic	12,010.00	-78.80	-78.74	-80.06	-80.13	-79.81	-79.73	-80.37	-79.80
LO	2,747.43	-58.19	-57.45	-56.71	-57.08	-56.21	-56.83	-57.39	-57.01
LO/2	1,373.71	-76.47	-77.37	-80.76	-79.37	-80.02	-79.94	-77.94	-78.59
2LO	5,494.86	-75.16	-74.64	-75.75	-75.18	-76.94	-76.92	-76.17	-76.22
Fundamental Hi	2,480.00	1.26	1.25	0.36	1.01	0.69	0.99	0.62	0.89
2nd harmonic	4,960.00	-45.50	-43.94	-45.67	-44.70	-42.86	-44.72	-41.88	-44.27
3rd harmonic	7,440.00	-53.32	-52.46	-54.63	-53.07	-55.41	-55.89	-55.66	-53.35
4th harmonic	9,920.00	-80.05	-79.05	-78.29	-76.54	-76.19	-77.67	-78.02	-74.74
5th harmonic	12,400.00	-78.90	-79.26	-79.07	-79.14	-80.22	-78.66	-79.17	-78.44
LO	2,836.57	-60.55	-59.57	-59.53	-59.76	-58.65	-59.11	-60.04	-59.77
LO/2	1,418.29	-77.44	-77.30	-81.17	-78.08	-78.16	-79.84	-77.49	-78.64
2LO	5,673.14	-76.12	-75.11	-77.05	-76.29	-77.57	-77.91	-76.56	-75.41
Fundamental Mid	2,440.00	1.23	1.25	0.48	1.11	0.65	0.95	0.60	0.92
2nd harmonic	4,880.00	-40.27	-38.52	-40.81	-39.70	-39.94	-42.07	-38.61	-41.54
3rd harmonic	7,320.00	-58.15	-55.60	-56.51	-57.34	-60.66	-65.78	-63.92	-58.44
4th harmonic	9,760.00	-75.99	-74.46	-74.19	-71.84	-76.05	-74.50	-75.73	-75.11
5th harmonic	12,200.00	-79.13	-79.32	-78.78	-79.11	-80.14	-79.57	-80.07	-79.02
LO	2,790.86	-58.95	-58.11	-57.42	-58.04	-56.98	-57.58	-58.43	-58.11
LO/2	1,395.43	-77.57	-77.05	-83.73	-80.87	-80.49	-79.48	-78.07	-79.50
2LO	5,581.71	-74.58	-74.01	-74.43	-75.10	-75.21	-77.14	-77.05	-75.01

Contact our RF Applications Engineers to revise your layout at:
www.johansontechnology.com/component/techquestion

High Frequency Ceramic Solutions

2.45GHz Impedance Matched Balun + Band Pass Filter: Optimized for Nordic's Chipsets: nRF51822-QFAA, nRF51422-QFAA, nRF51822-QFAB, nRF51422-QFAB, nRF51822-QFAC, and nRF51422-QFAC **P/N 2450BM14E0003**

Detail Specification: 3/20/2015

For the Full App Note and Layout Files, go to: www.johansontechnology.com/nordic

General Specifications

Part Number	2450BM14E0003
Frequency (MHz)	2400 - 2500
Unbalanced Impedance	50 Ω (single ended)
Differential Balanced Impedance	Impedance matched to Nordic Semi nRF51822-QFAx and nRF51422-QFAx chipsets
Average Insertion Loss when connected to the nRF51XX chipset (Active OP)	0.9dB Typ@25C 1.5dB max. (-45 to +85C)
Insertion Loss when component measured by itself (passive insertion loss)	2.1dB typ. @25C 2.5dB max. (-45 to +85C)

Attenuation Differential mode (dB):		**Return Loss (dB)**	15 typ. 9.5 min.
800-928 MHz	15 typ.@25°C 10 min.	**Amplitude Difference**	150 ± 15deg
1200-1500 MHz	14 typ.@25°C 10 min.	**Reel Quantity**	4,000 pcs
4800~5000MHz	35 typ.@25°C 20 min.	**Operating Temperature**	-40 to +85°C
7200~7500MHz	21 typ.@25°C 18 min.	**Recommended Storage Conditions for unused T&R product**	+5 to +35°C, Humidity: 45-75%RH, 18 mos. Max
Attenuation Common mode (dB):			
4800~5000MHz	44 typ.@25°C 20 min.	**Power Capacity**	1W max.(CW)

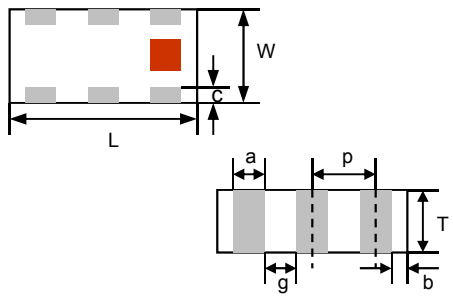
You can download measured s-parameters of this component at: www.johansontechnology.com/nordic

Part Number Explanation

P/N Suffix	**Packaging Style**	Bulk	Suffix = S	Eg. 2450BM14E0003S
		T & R	Suffix = T	Eg. 2450BM14E0003T
	Termination Style	100% Tin	Suffix = None	Eg. 2450BM14E0003(T or S)

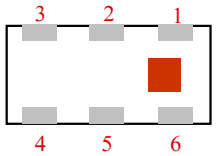
Mechanical Dimensions

	In	mm
L	0.063 ± 0.004	1.60 ± 0.10
W	0.031 ± 0.004	0.80 ± 0.10
T	0.024 ± 0.004	0.60 ± 0.10
a	0.008 ± 0.004	0.20 ± 0.10
b	0.008 +.004/-.006	0.20 +0.1/-0.15
c	0.006 ± 0.004	0.15 ± 0.10
g	0.012 ± 0.004	0.30 ± 0.10
p	0.020 ± 0.002	0.50 ± 0.05



Terminal Configuration

No.	Function
1	Unbalanced Port
2	GND
3	Balanced Port
4	Balanced Port
5	DC Feed
6	GND



Johanson Technology, Inc. reserves the right to make design changes without notice.
All sales are subject to Johanson Technology, Inc. terms and conditions.

JOHANSON TECHNOLOGY

www.johansontechnology.com

4001 Calle Tecate • Camarillo, CA 93012, USA • TEL +1.805.389.1166

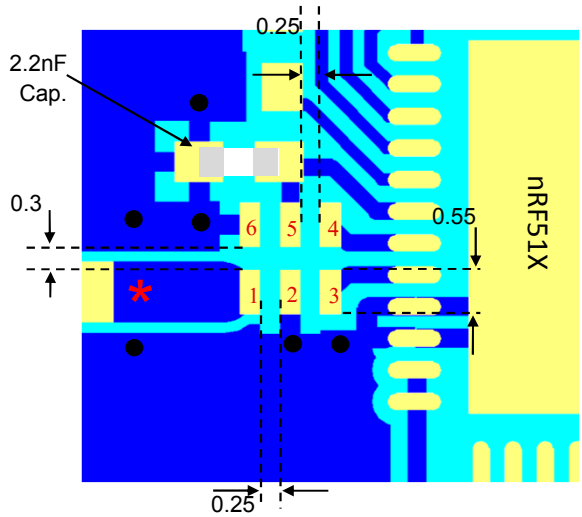
Ver 2.0

High Frequency Ceramic Solutions

2.45GHz Impedance Matched Balun + Band Pass Filter: Optimized for Nordic's Chipsets: nRF51822-QFAA, nRF51422-QFAA, nRF51822-QFAB, nRF51422-QFAB, nRF51822-QFAC, and nRF51422-QFAC **P/N 2450BM14E0003**

Detail Specification: 3/20/2015

Mounting Considerations



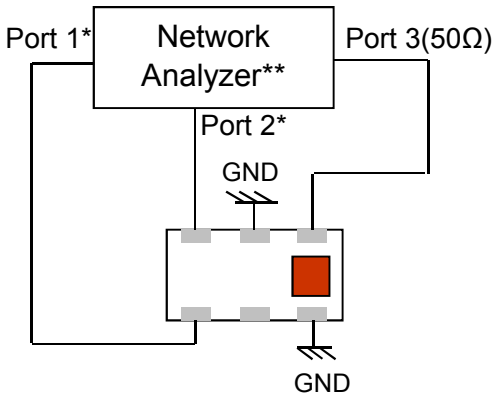
Land

Via Through

*Line width should be designed to match 50Ω characteristic impedance, depending on PCB material and thickness.

Do you need the layout/gerber files of the above? Go to: www.johansontechnology.com/nordic or send us a message to review your layout at: www.johansontechnology.com/component/techquestion

Solo-Component Characterization Scheme



Port 3: Unbalanced Port
Ports 1 and 2: Balanced Port
IL=S_{ds21}, Att_DM=S_{ds21}, Att_CM=S_{cs21}
RL=S_{ss11}
Amp_balance = dB(S(1,3)/S(2,3))
Phase_balance = Phase(S(1,3)/S(2,3))

*Impedance for ports 1 and 2
= Conjugate to Balanced Impedance/2
**E5071B from Agilent

JOHANSON TECHNOLOGY

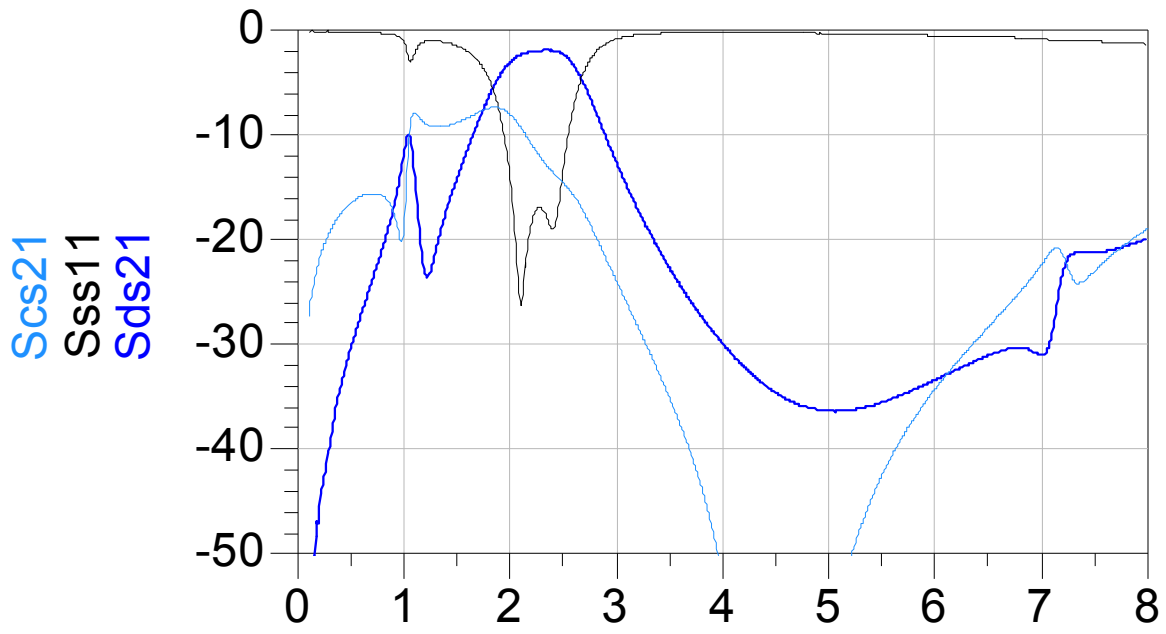
www.johansontechnology.com
4001 Calle Tecate • Camarillo, CA 93012, USA • TEL +1.805.389.1166

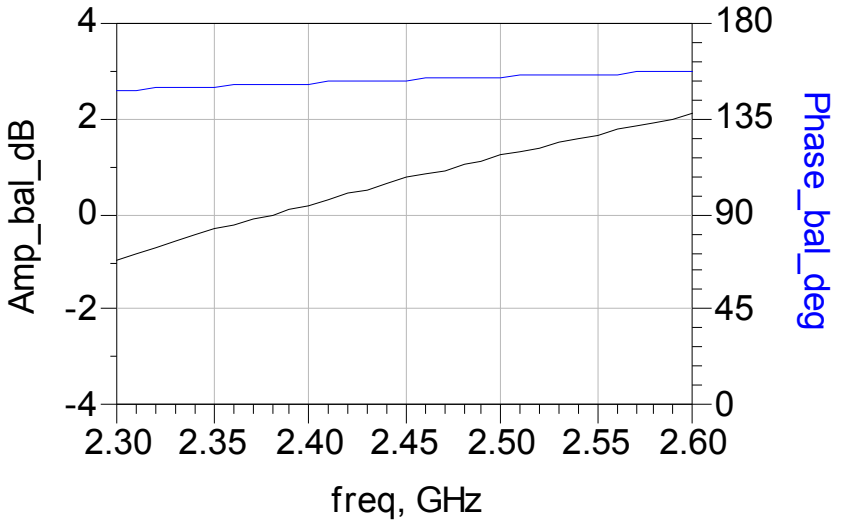
High Frequency Ceramic Solutions

2.45GHz Impedance Matched Balun + Band Pass Filter: Optimized for Nordic's Chipsets: nRF51822-QFAA, nRF51422-QFAA, nRF51822-QFAB, nRF51422-QFAB, nRF51822-QFAC, and nRF51422-QFAC **P/N 2450BM14E0003**

Detail Specification: 3/20/2015

Typical Electrical Characteristics (T=25°C)





JOHANSON TECHNOLOGY

www.johansontechnology.com
4001 Calle Tecate • Camarillo, CA 93012, USA • TEL +1.805.389.1166

High Frequency Ceramic Solutions

2.45GHz Impedance Matched Balun + Band Pass Filter: Optimized for Nordic's Chipsets: nRF51822-QFAA, nRF51422-QFAA, nRF51822-QFAB, nRF51422-QFAB, nRF51822-QFAC, and nRF51422-QFAC **P/N 2450BM14E0003**

Detail Specification: 3/20/2015

Application Notes, Layout Files, and more
www.johansontechnology.com/nordic

Packaging information
www.johansontechnology.com/ipcpackaging.html

Soldering Information
www.johansontechnology.com/ipcsoldering-profile

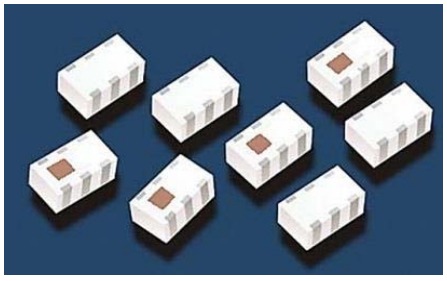
MSL Info
www.johansontechnology.com/technical-notes/msl-rating.html

Recommneded Storage Condition and Max Shelf Life
www.johansontechnology.com/ipcstorage-shelflife

RoHS Compliance
www.johansontechnology.com/technical-notes/rohs-compliance.html

Antenna layout and tuning techniques
www.johansontechnology.com/tuning

Antenna layout review, tuning, and characterization services
www.johansontechnology.com/ipcantennaservices



www.johansontechnology.com
4001 Calle Tecate • Camarillo, CA 93012, USA • TEL +1.805.389.1166