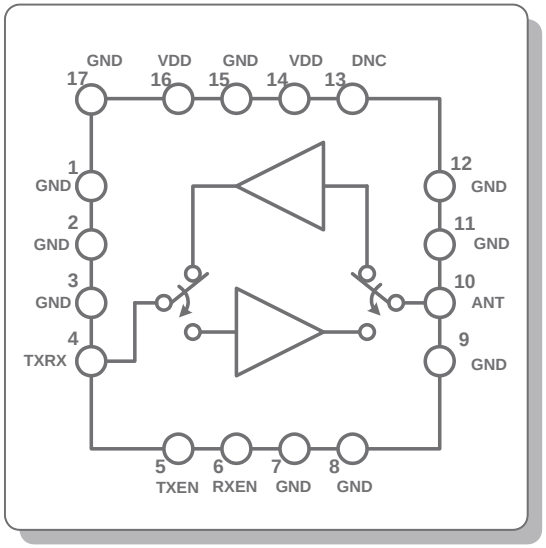
RFX2401C Single-Chip CMOS RFeIC with PA, LNA, Antenna Switch and Combined Tx/Rx Transceiver Port

Eval Board Test Summary & Technical Notes

RFX2401C RFeIC Key Features and Benefits

(3x3x0.55mm
16L QFN)



RFX2401C Differentiating Features

- Integration of PA, LNA, Tx-Rx Switching Circuitry, Associated Matching Network and Harmonic Filter all into a Single-Chip, Single-Die pure CMOS Solution
- Greatly Reduced and Simplified Tx/Rx Control
- Low Voltage Battery Operation down to 2.7V
- Digital Logic with 1.2V Turn-On Voltage
- No Vref Regulator for Biasing
- Common Tx/Rx Port Saves Additional SPDT
- Requires Minimal External Components
- Small, Ultra-Thin 3x3x0.55mm 16L QFN Package

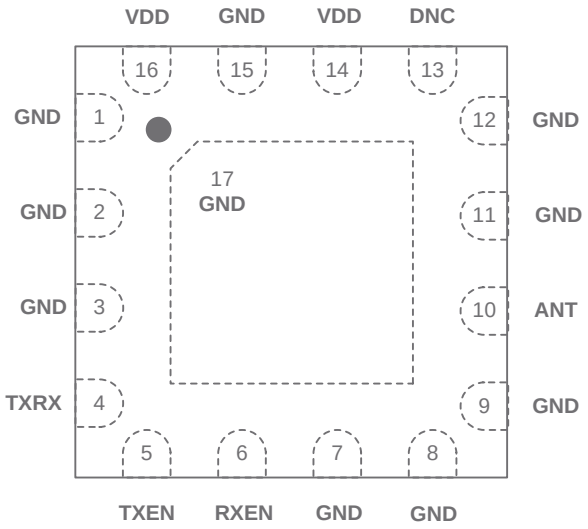
APPLICATIONS

- 802.15.4 ZigBee Extended Range Devices
- ZigBee Smart Power
- ZigBee Home Area Network
- RF4CE Remote Control
- Wireless Sensor Networks
- Other 2.4GHz ISM Band Systems

RFX2401C Customer Benefits

- Greatly Simplified, 50 Ohm “Plug & Play” PCB Implementation
- Small Form-Factor and Quick Design Cycle
- Simplest Approach to Improve Link Performance including Range and Receiver Sensitivity
- Very Low BOM Cost and Competitive Price

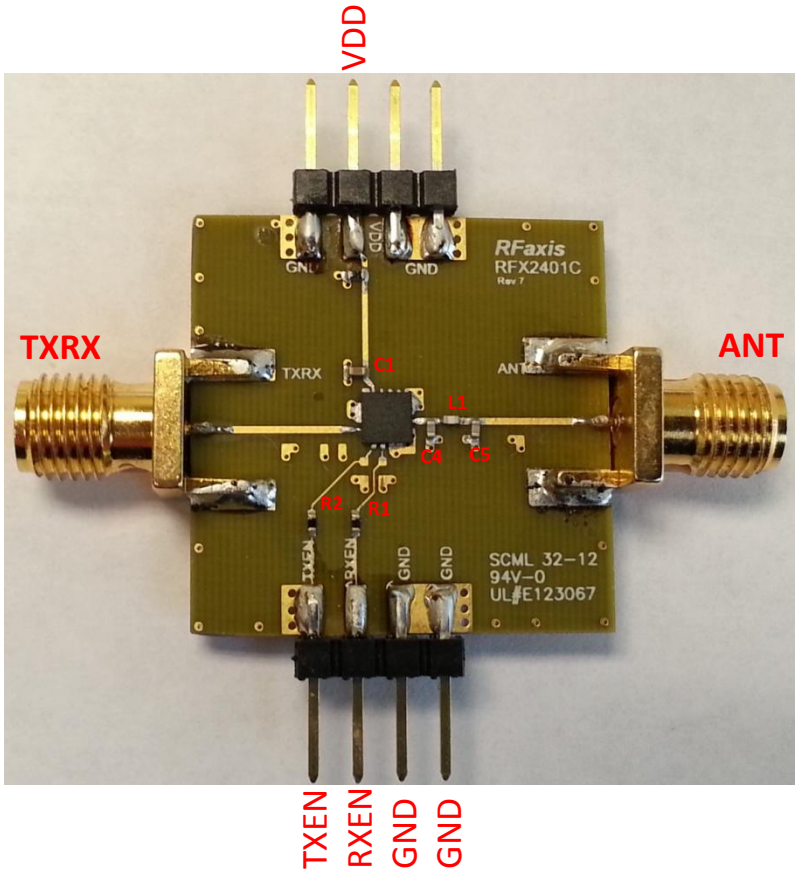
RFX2401C Internal Block Diagram and Pin Description



(Top "See-Through" View)

Pin Number	Pin Name	Description
4	TXRX	RF signal to/from the Transceiver: DC shorted to GND
5	TXEN	CMOS Input to Control TX Enable
6	RXEN	CMOS Input to Control RX Enable
10	ANT	RF Signal from the PA or RF Signal Applied to the LNA; DC Shorted to GND
1, 2, 3, 7, 8, 9, 11, 12, 15, 17	GND	Ground – Must be connected to Ground in the Application Circuit
13	DNC	Reserved – Do Not Connect in the Application Circuit
14	VDD	Alternative Voltage Supply Pin, internally connected to Pin 16, no connection needed
16	VDD	Voltage Supply Connection

RFX2401C Eval Board and Recommended BOM



Recommended BOM:

For VDD decoupling:

- C1=1uF

For Harmonic Filtering only (not required otherwise):

- C4=C5=2pF
- L1=1.5nH only TDK part# MLG1005S1N5S
  or 1.8nH ACX part # HI1005-1C1N8SMT

For Control Line:

- R1 = 1KΩ
- R2 = 1KΩ

R1 and R2 are for evaluation purpose only. They not needed in application schematic

DC Bias & Tx/Rx Logic Control:

VDD=3.3V nominal (1.8~3.6V operational)

For Transmit Mode (TX):

- TXEN=High (>1.2V)
- RXEN= Don't Care

For Receive Mode (RX):

- RXEN=High(>1.2V)
- TXEN=Low (<0.3V)

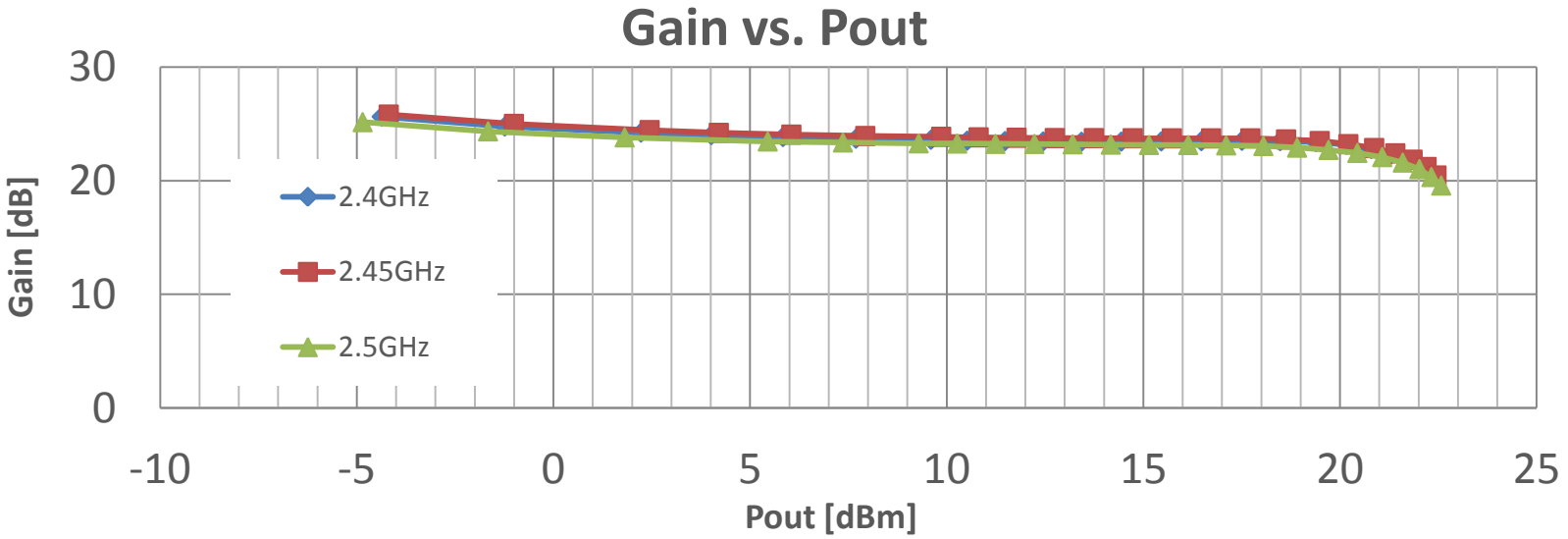
Eval PCB Information:

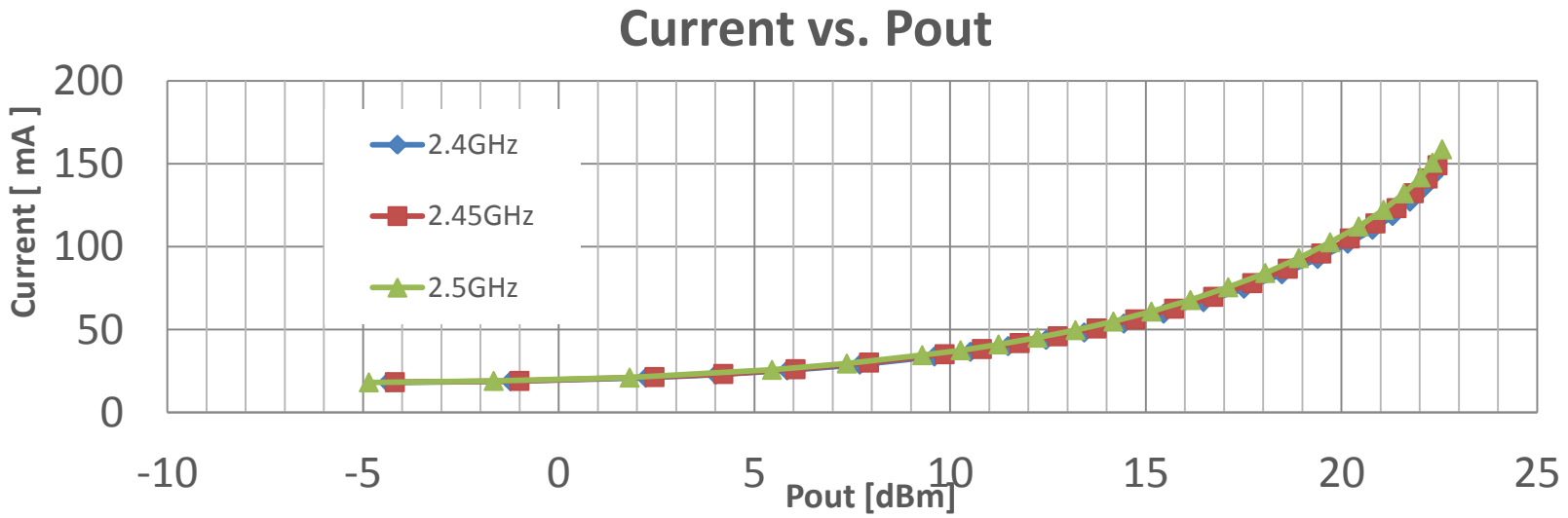
- 4-Layer Stack, 10mil/40mil/10mil
- FR4 with εr=4.5, tan δ = 0.02 (typ.)

Control Logic Truth Table

TXEN	RXEN	Operating Conditions
1	X	TX Active
0	1	RX Active
0	0	Chip is Shut-down

Tx CW Gain and Current vs Pout & Frequency without External Harmonic Filter (VDD=3.3V)

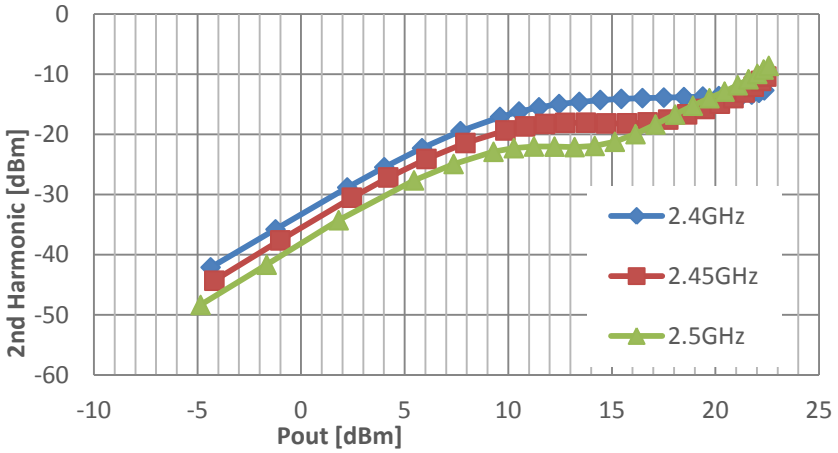




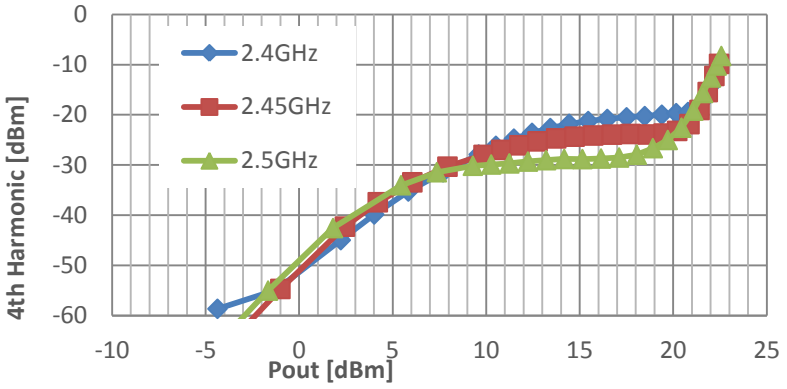
Note: Output power measured at antenna, without external harmonic filter.

Tx Harmonics vs Pout & Frequency
Without External Harmonic Filter (VDD=3.3V)

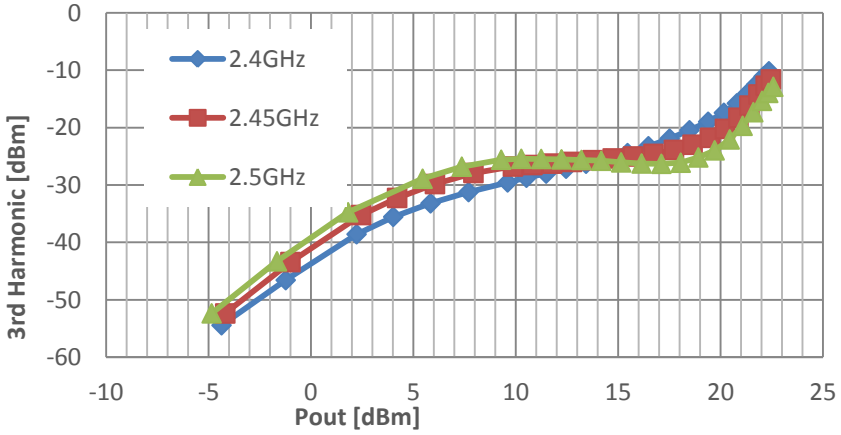
2nd Harmonic vs. Pout



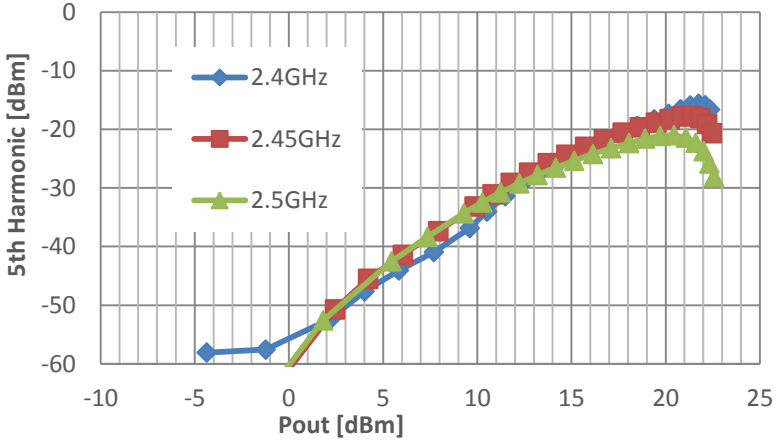
4th Harmonic vs. Pout



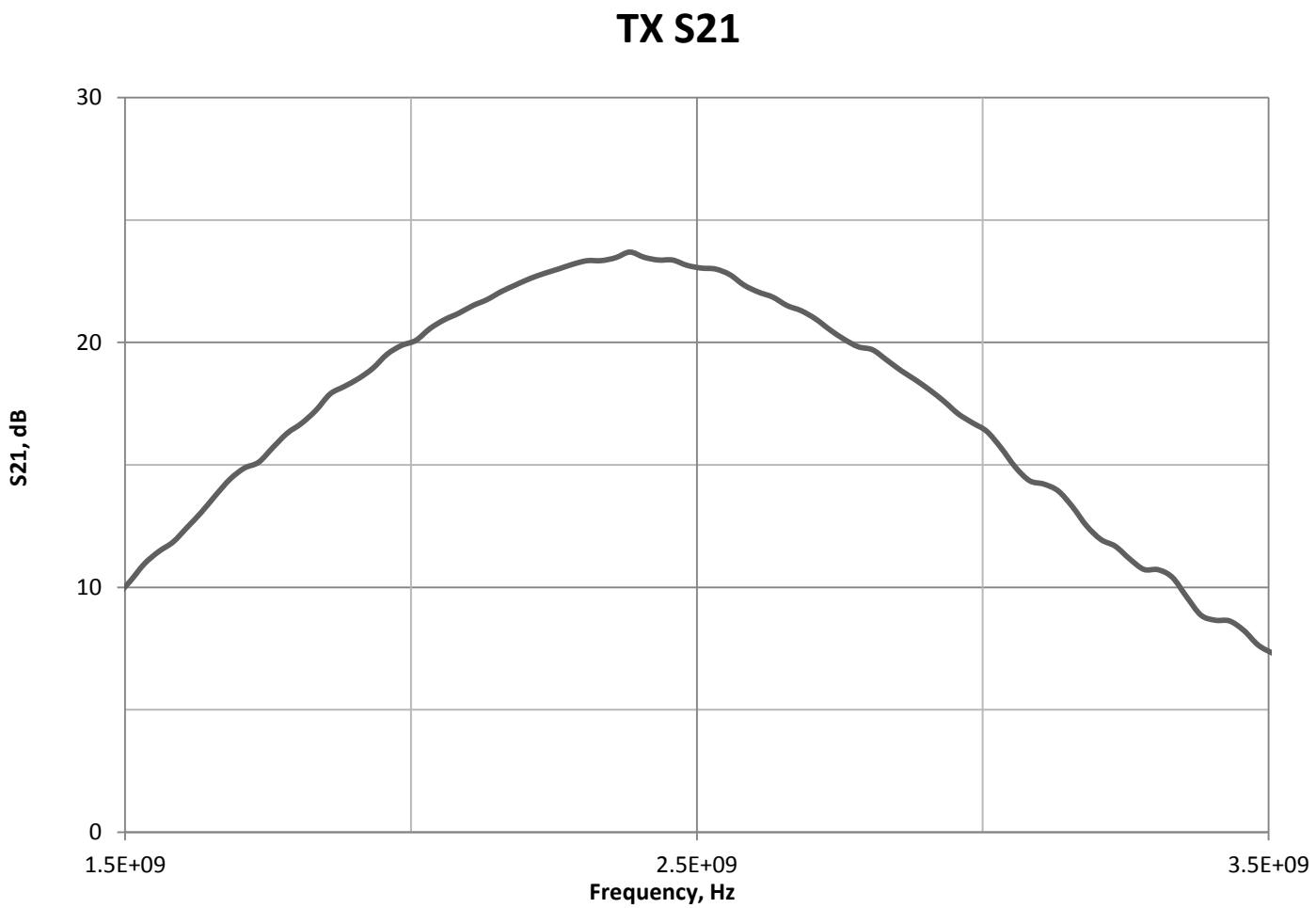
3rd Harmonic vs. Pout



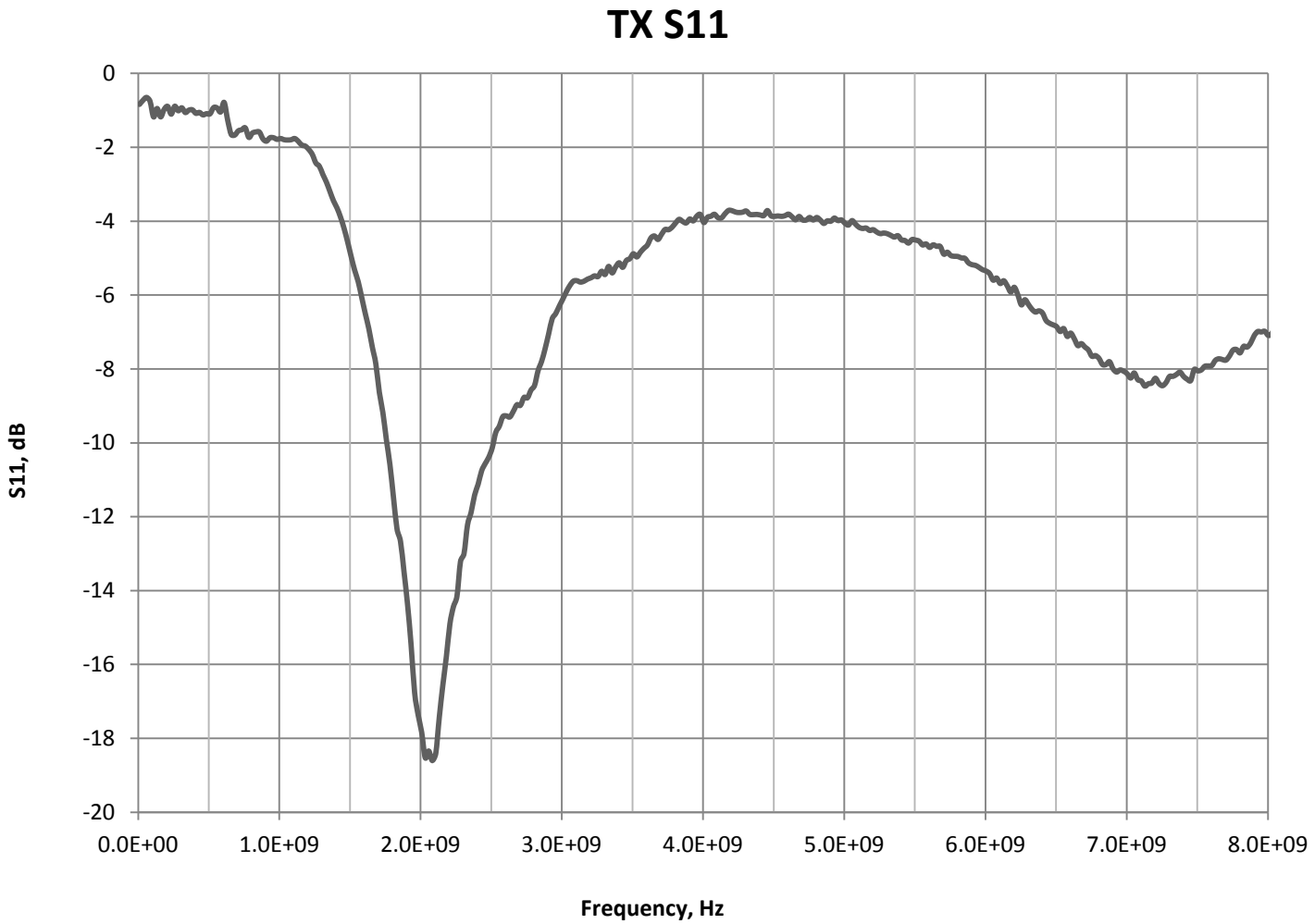
5th Harmonic vs. Pout



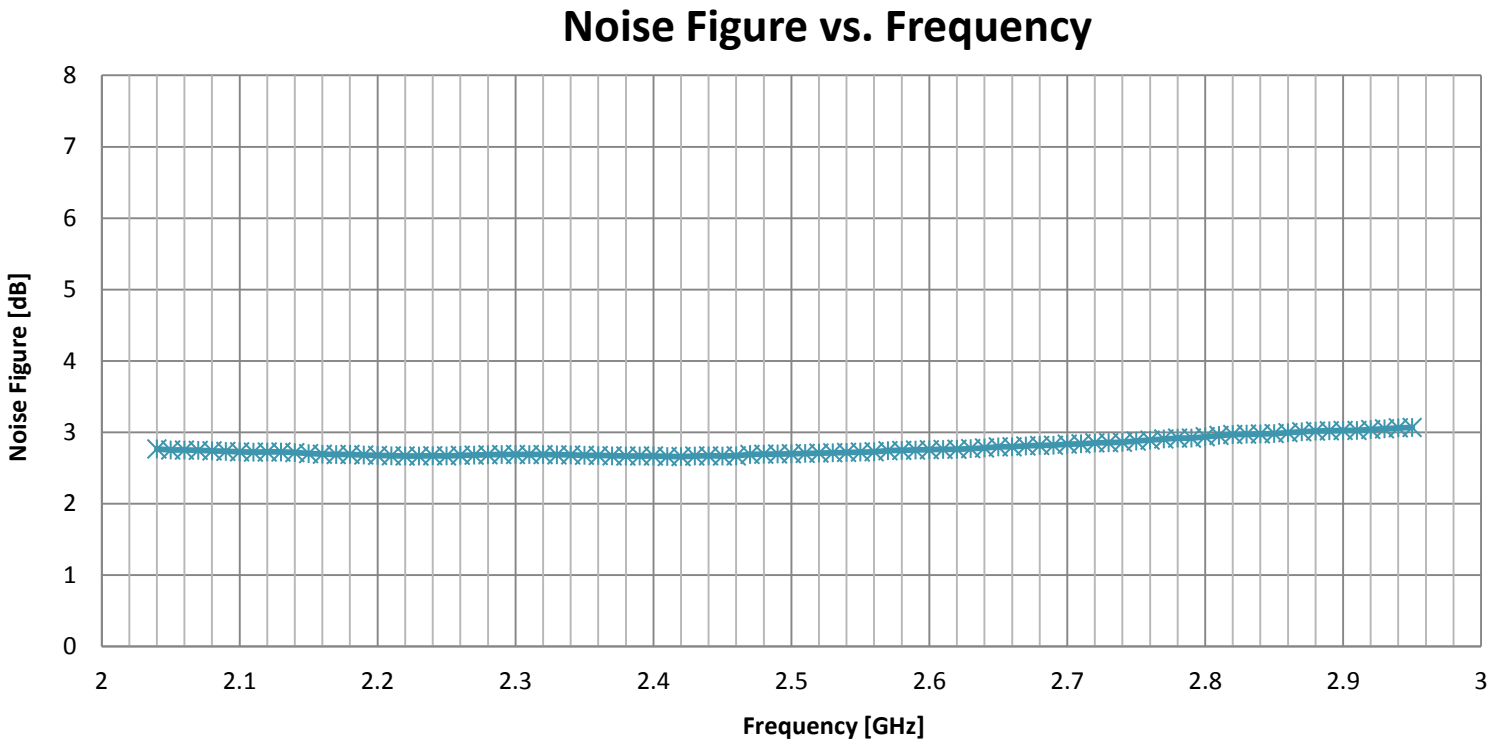
Measured Tx Small-Signal Gain (S21) Without External Harmonic Filter (VDD=3.3V)



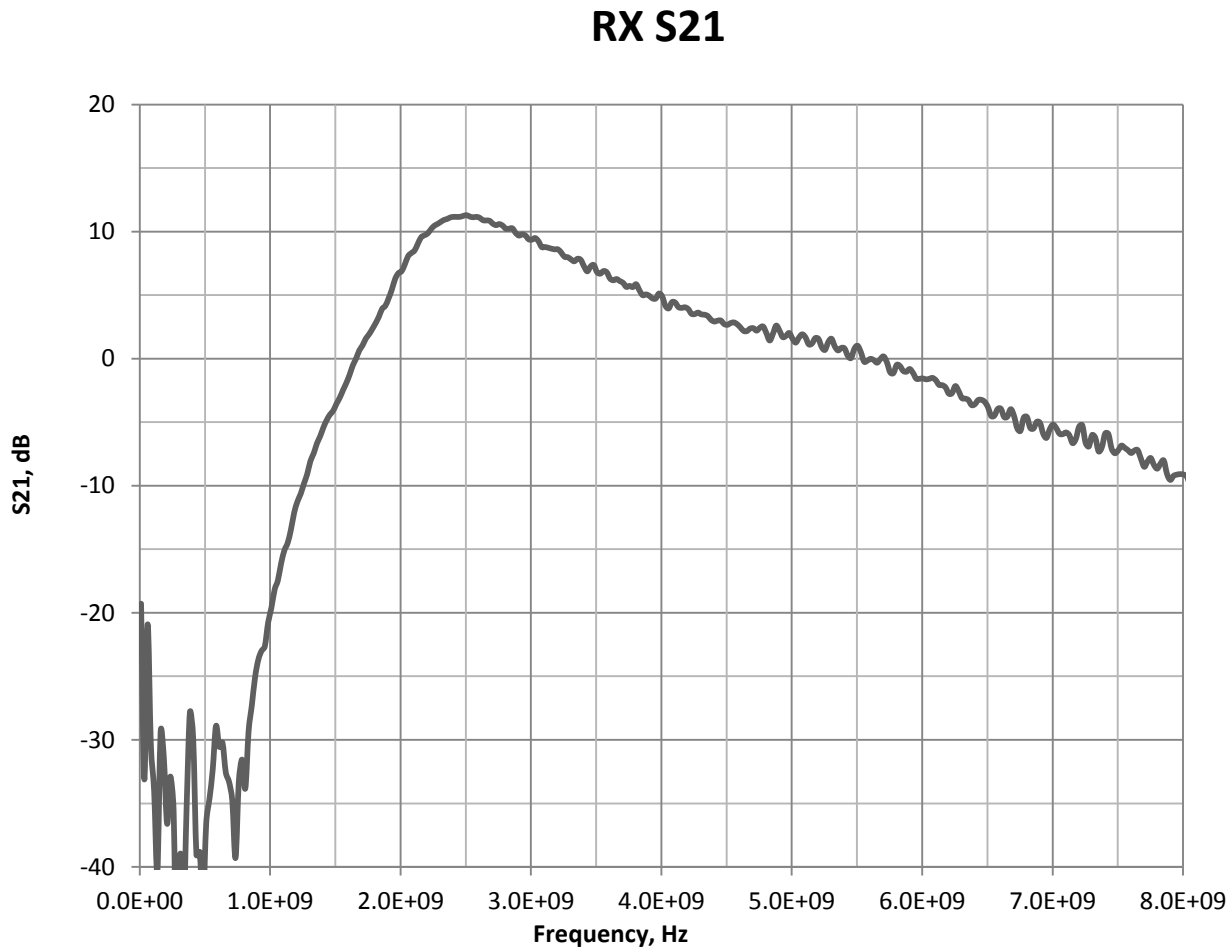
Measured Tx S11 (VDD=3.3V) Without External Harmonic Filter



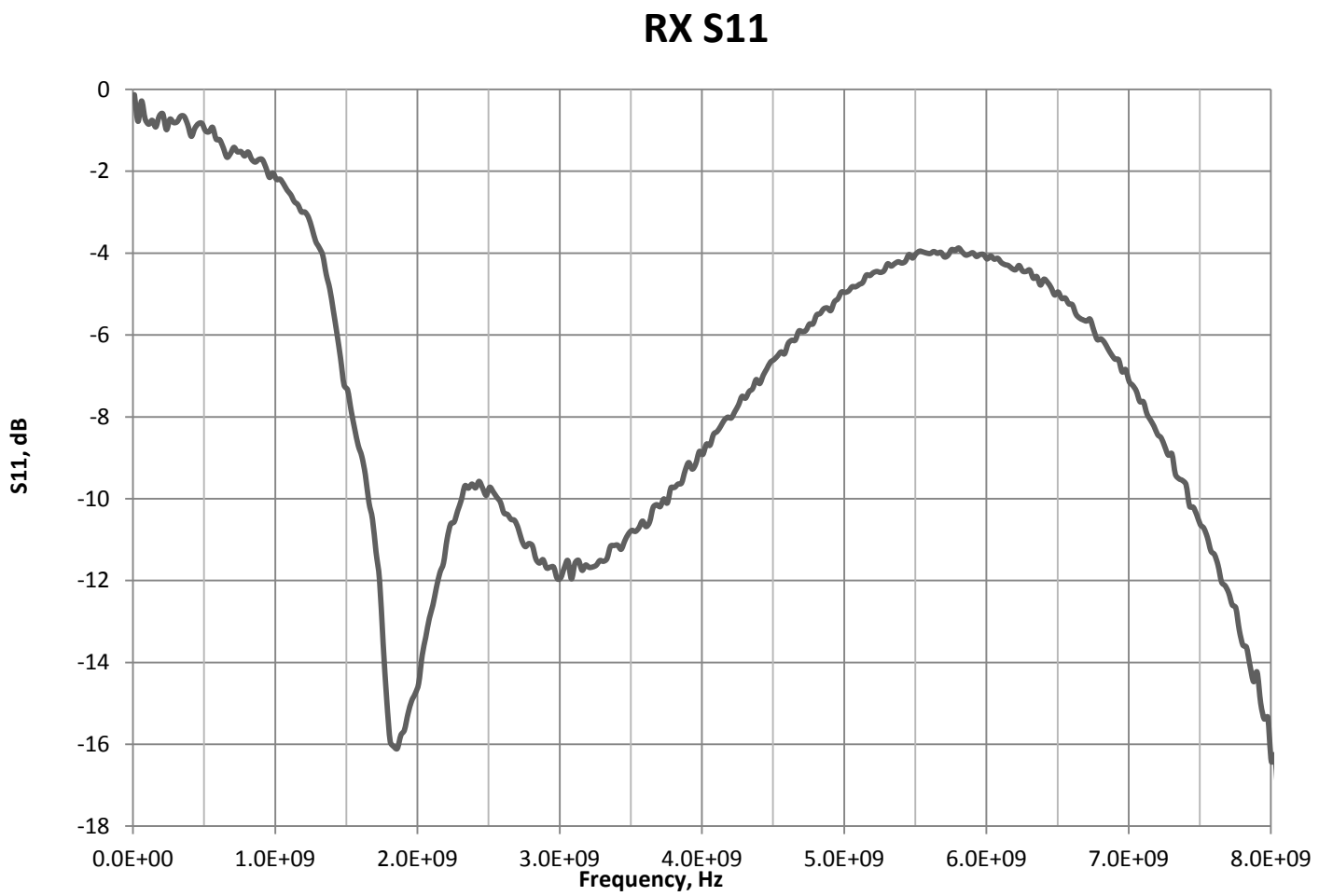
Measured Rx Noise Figure (VDD=3.3V) Without External Harmonic Filter



Measured Rx Small-Signal Gain (S21) (VDD=3.3V) Without External Harmonic Filter



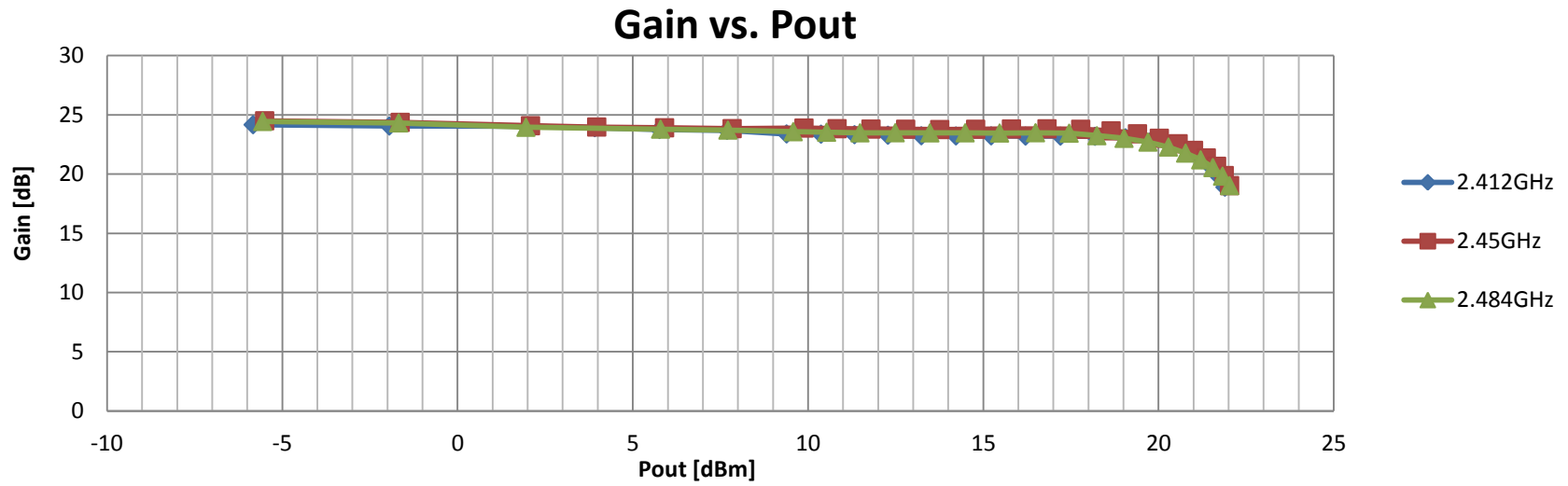
Measured Rx S11 (VDD=3.3V) Without External Harmonic Filter

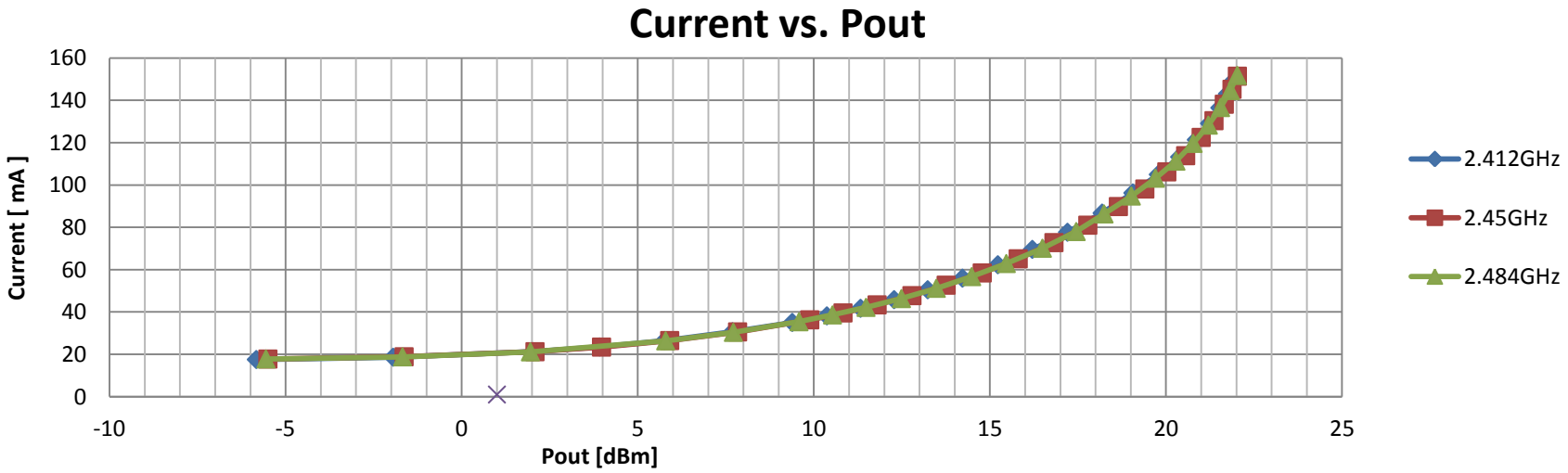


RFX2401C
With External Harmonic Filter

Eval Board Test Summary & Technical Notes

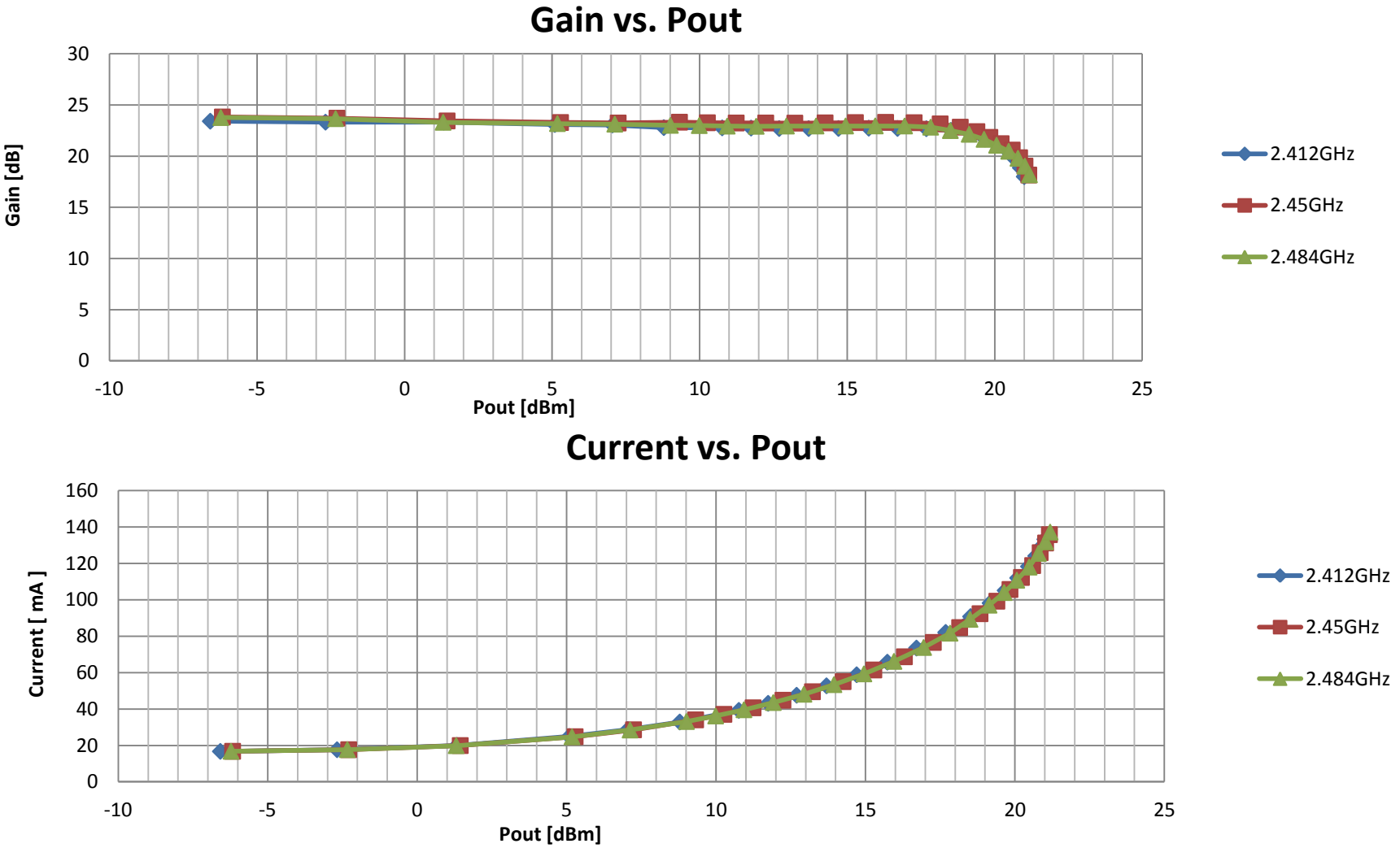
Tx CW Gain and Current vs. Pout & Frequency (VDD=3.3V) With External Harmonic Filter





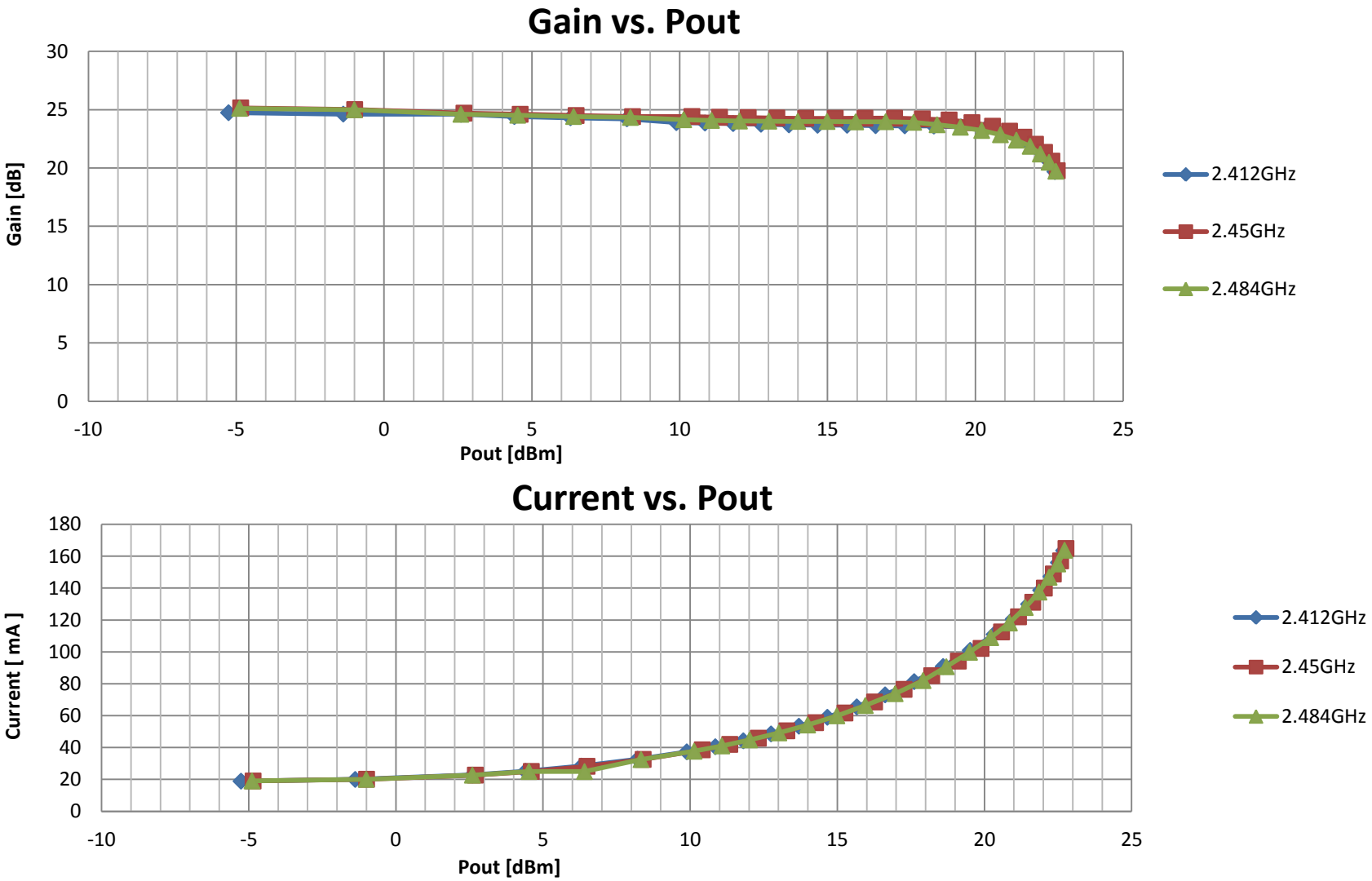
Note: Output power measured at antenna, after the harmonic filter which has ~0.5dB insertion loss.

Tx CW Gain and Current vs. Pout & Frequency (VDD=3.0V) With External Harmonic Filter



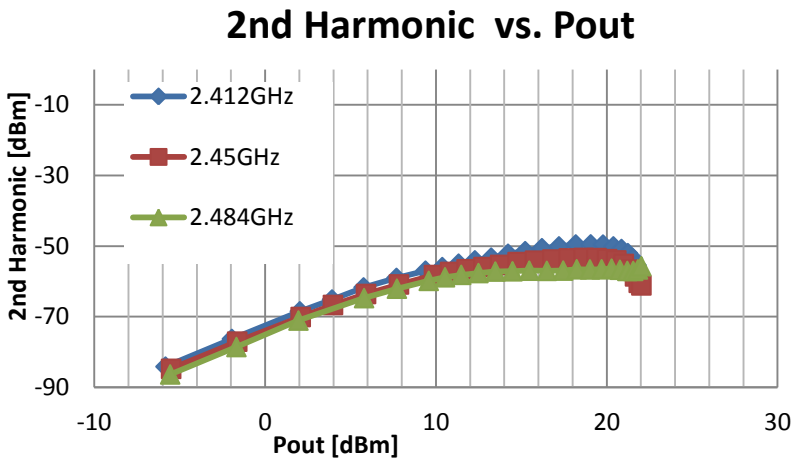
Note: Output power measured at antenna, after the harmonic filter which has ~0.5dB insertion loss.

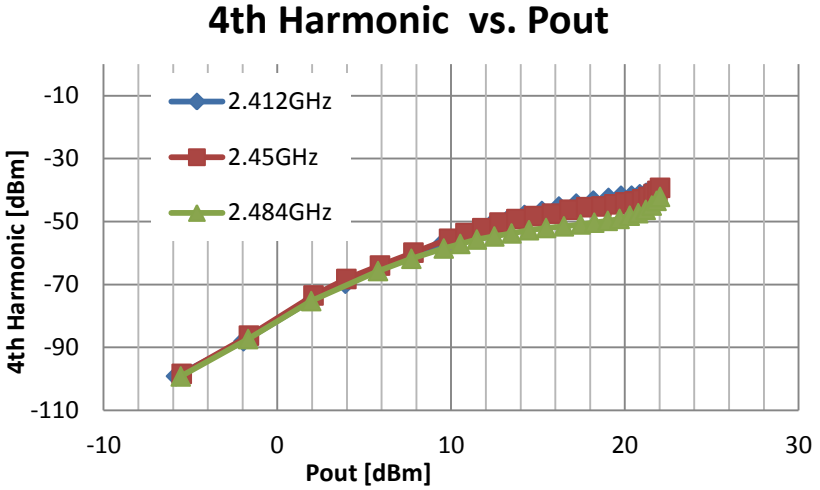
Tx CW Gain and Current vs. Pout & Frequency (VDD=3.6V) With External Harmonic Filter

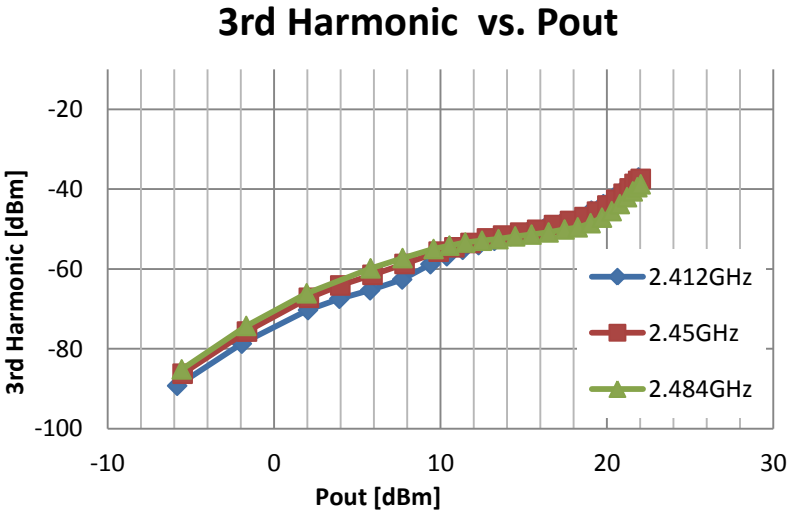


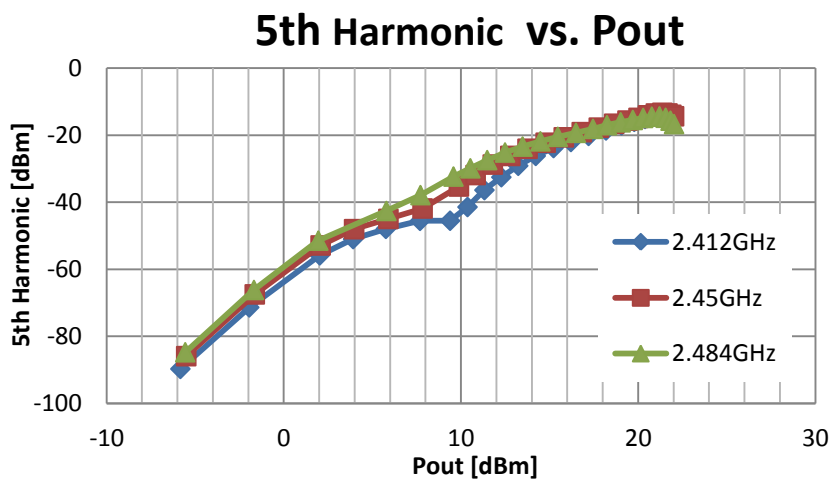
Note: Output power measured at antenna, after the harmonic filter which has ~0.5dB insertion loss.

Tx Harmonics vs Pout & Frequency (VDD=3.3V) With External Harmonic Filter



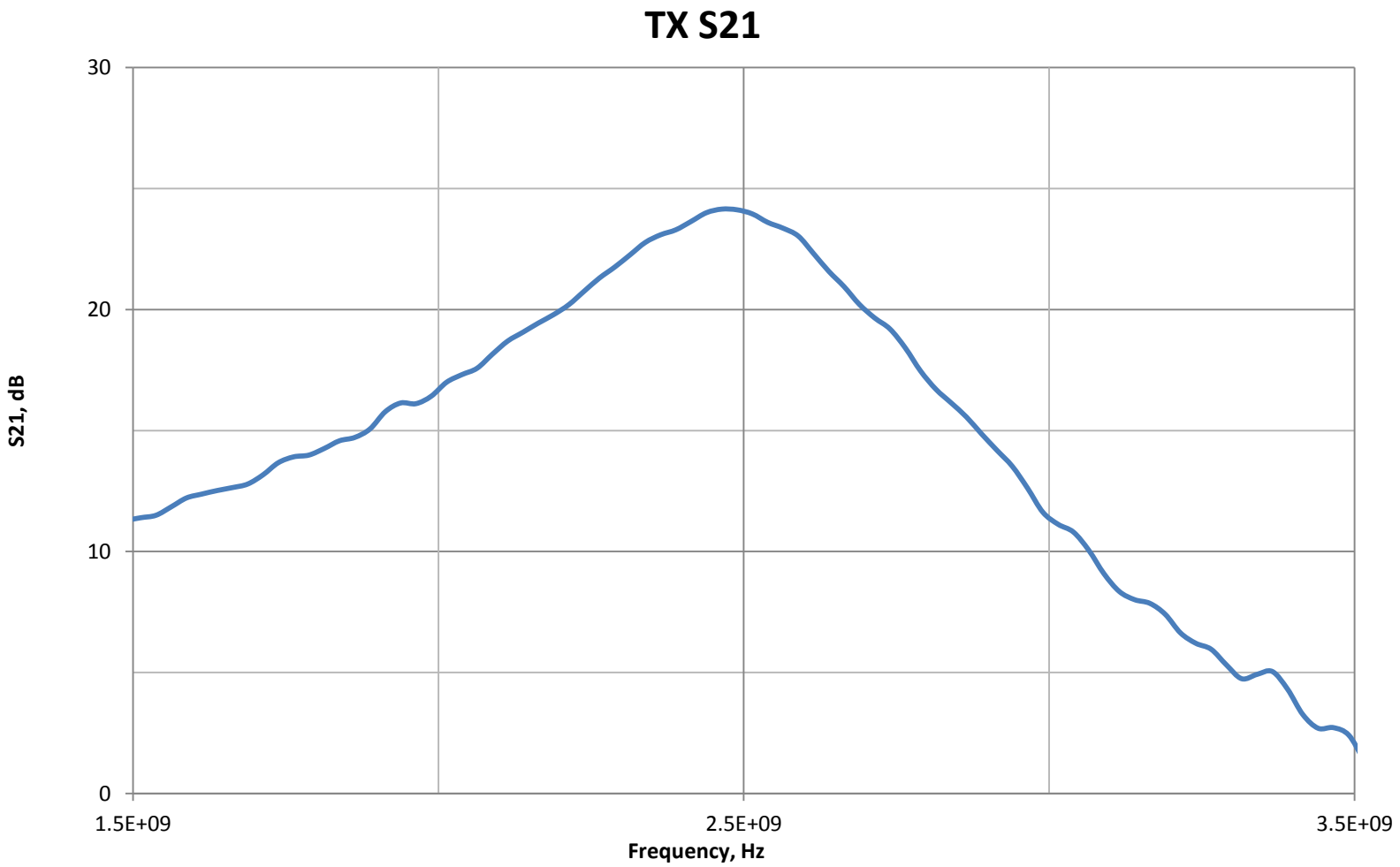




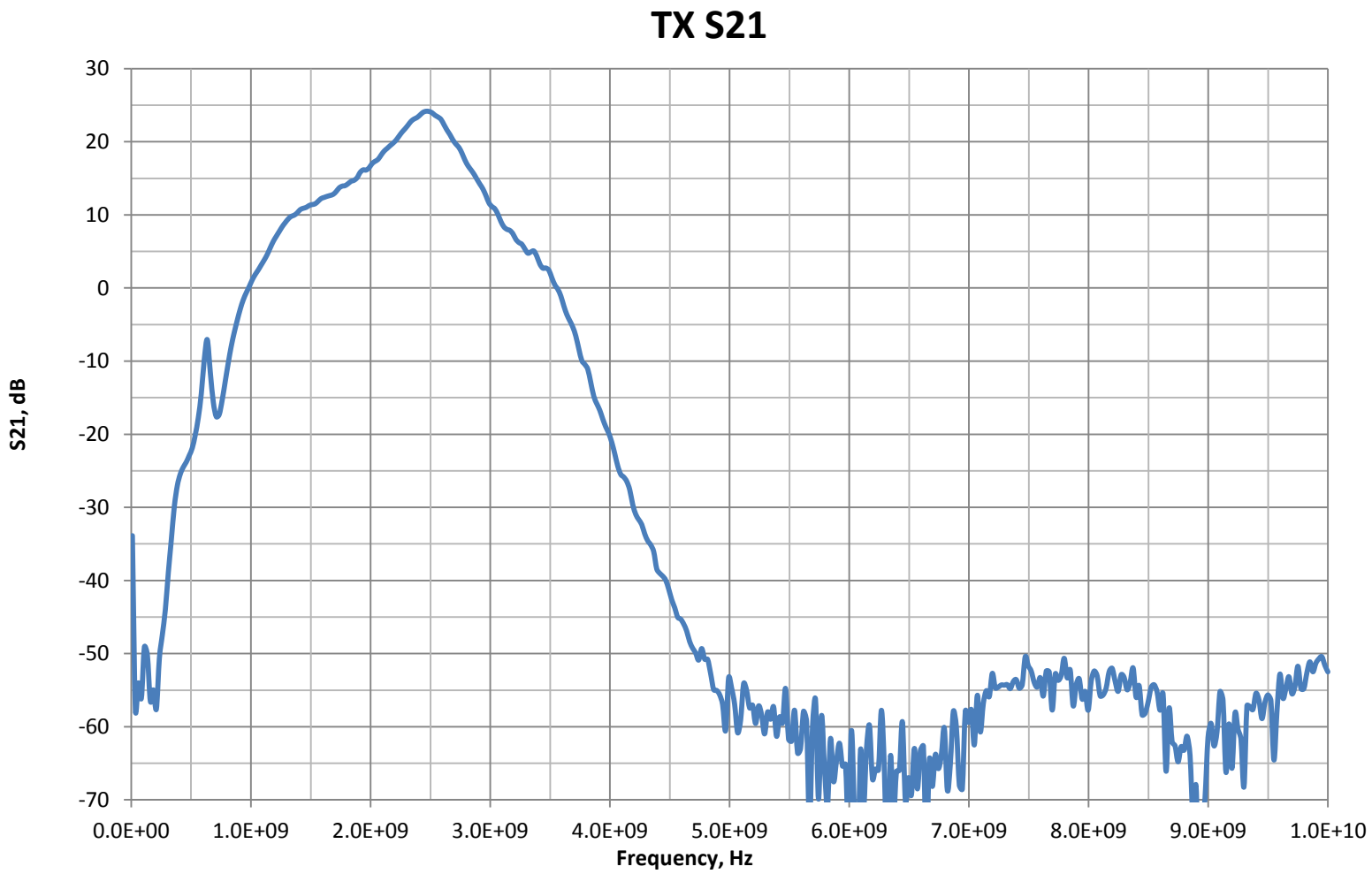


Note: RFX2401C can achieve FCC harmonic compliance with only one simple pi-filter.

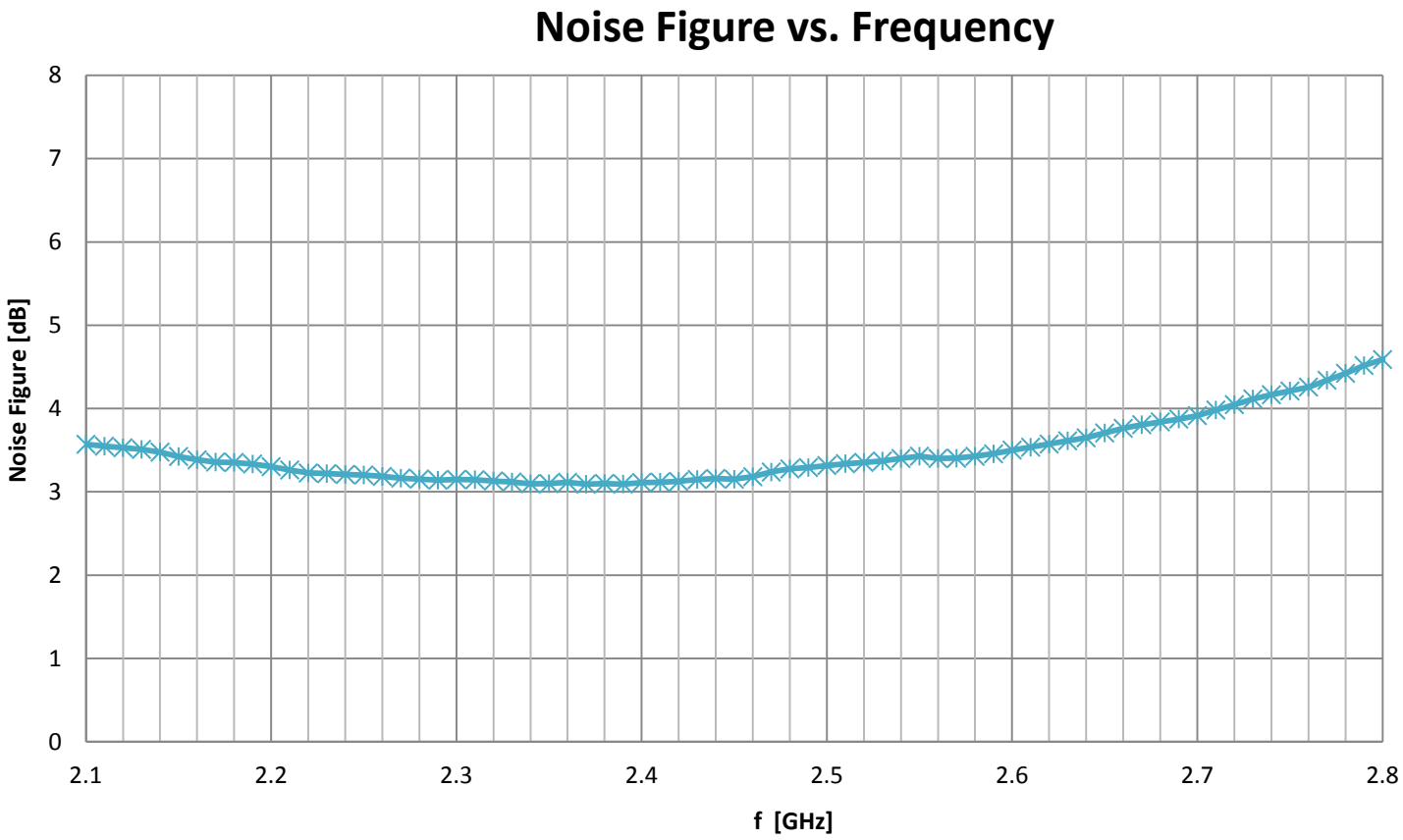
Measured Tx Small-Signal Gain (S21) (VDD=3.3V) With External Harmonic Filter



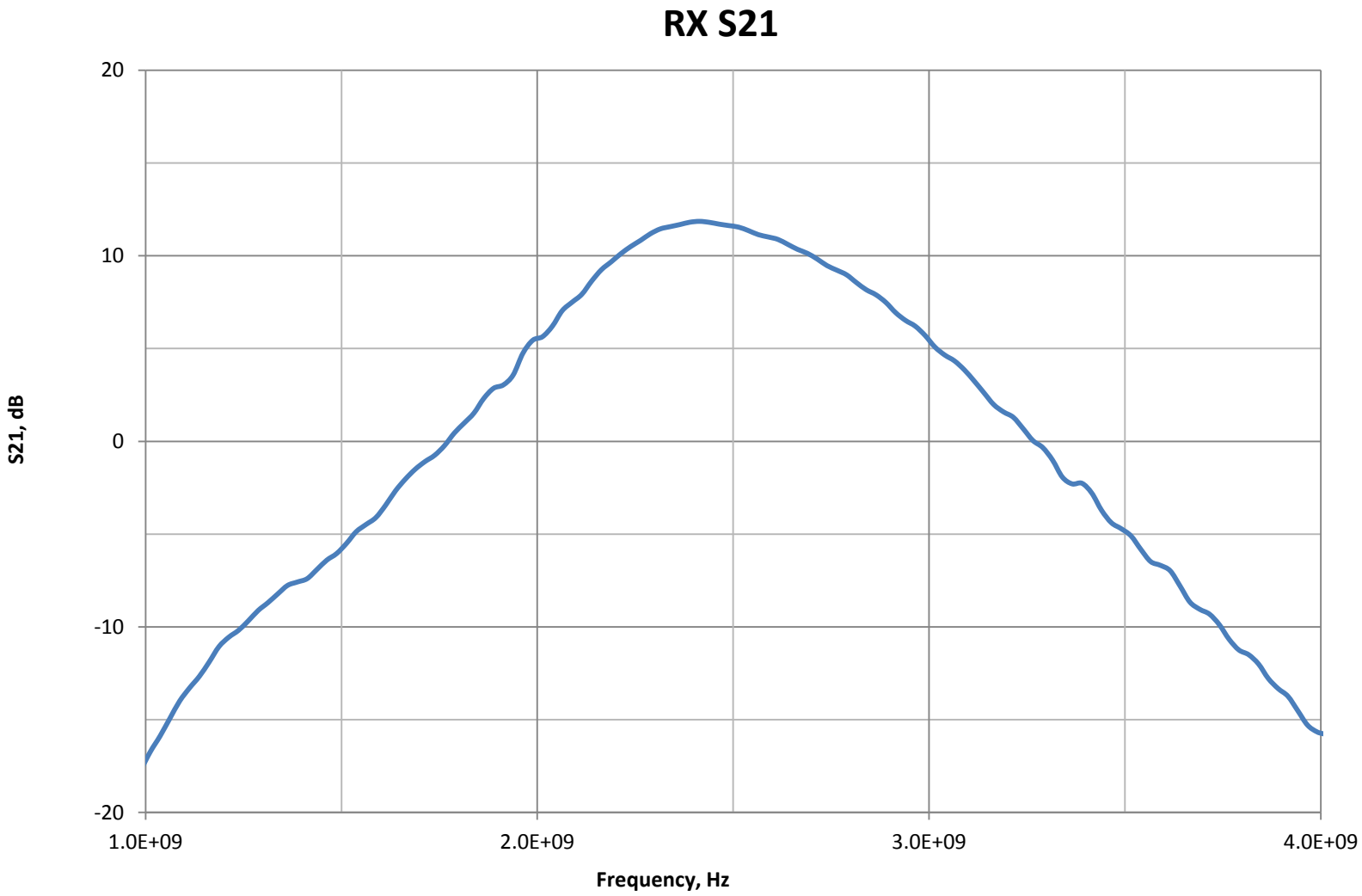
Measured Tx Wideband Small-Signal S21 (VDD=3.3V) With External Harmonic Filter



Measured Rx Noise Figure (VDD=3.3V) With External Harmonic Filter

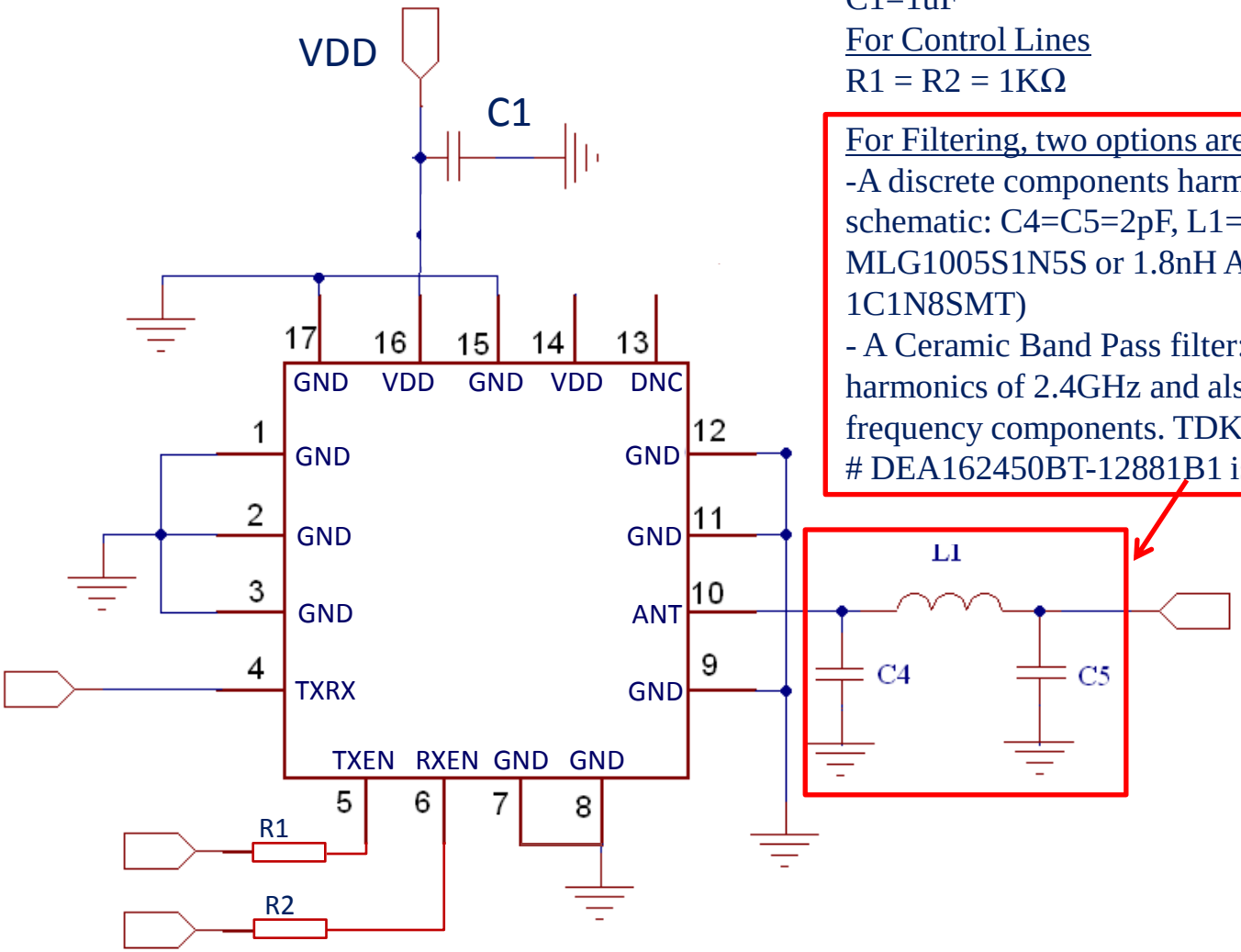


Measured Rx Small-Signal Gain (S21) (VDD=3.3V) With External Harmonic Filter



RFX2401C Application Schematic & BOM

Typical Application Schematic



Recommended BOM:

For VDD Decoupling

C1=1uF

For Control Lines

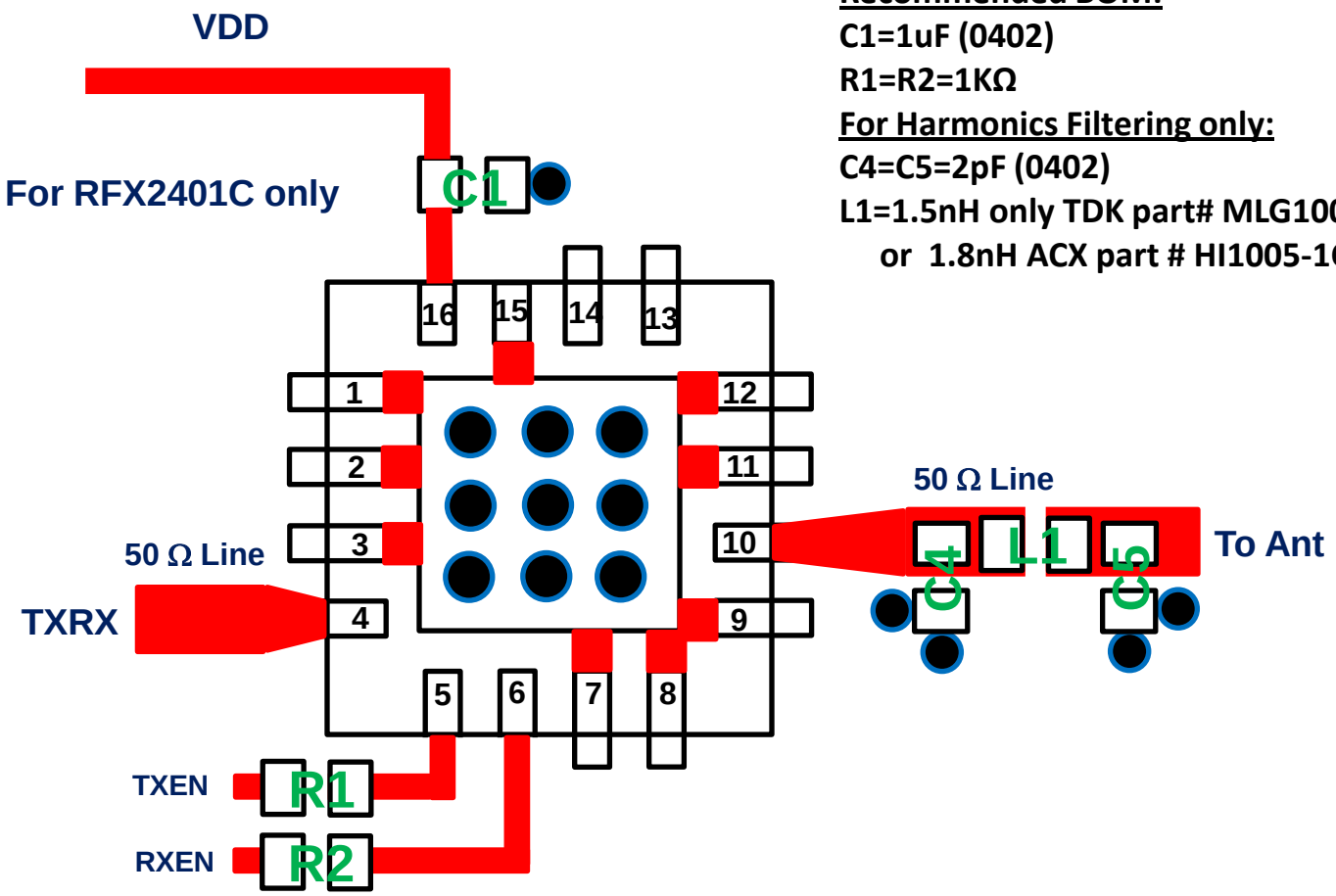
R1 = R2 = 1KΩ

For Filtering, two options are presented:

-A discrete components harmonic as shown in the schematic: C4=C5=2pF, L1=1.5nH (TDK part# MLG1005S1N5S or 1.8nH ACX part # HI1005-1C1N8SMT)

- A Ceramic Band Pass filter: This will filter the harmonics of 2.4GHz and also suppress low frequency components. TDK Band pass filter part # DEA162450BT-12881B1 is recommended

RFX2401C PCB Layout Recommendation



Recommended BOM:

C1=1uF (0402)

R1=R2=1KΩ

For Harmonics Filtering only:

C4=C5=2pF (0402)

L1=1.5nH only TDK part# MLG1005S1N5S

or 1.8nH ACX part # HI1005-1C1N8SMT

Notes:

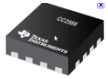
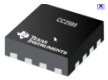
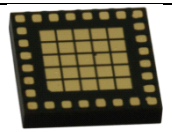
-Tie all unused pins to center ground paddle

-For best RF performance please place 9 vias under the center ground paddle

-Place vias immediately next to each shunt cap (C1,C4, C5) if possible

-Pin 14 is an alternative supply pin and can be left open

RFX2401C Competitive Analysis

Vendor		RFaxis	TI	TI	SiGe	Atmel	NEC/Renesas	UBEC	Maxi-AMP	Skyworks	Skyworks
P/N		RFX2401C	CC2590	CC2591	SE2431L	T7024	uPG2253T6S	UP2268	MCP03	SKY65336	SKY65352
	Process	Pure CMOS	SiGe BiCMOS	SiGe BiCMOS	SiGe BiCMOS	SiGe BiCMOS	GaAs FET	GaAs	GaAs	GaAs	GaAs
	Package Size	3x3x0.5	4x4x0.9	4x4x0.9	3x4x0.9	5x5x0.9	3x3x0.75	3x3x0.6	4x4x0.75	8x8x1.3	6x6x1.3
	Package Pin Count	16	16	16	24	20	16	16	20	28	20
	Package Image										
	Nominal Vcc(V)	3.3	3.0	3.0	3.0	3.0	3.0	3.3	3.3	3.0	3.3
Tx	Icq(mA)	17	8	40	30	125	36	9		50	70
Tx	Gain(dB)	25	14	22	24	30	19	11	22	17	20
Tx	Psat(dBm)	22	13.8	20.6	20.0	23	20	15 P1dB	19.1 P1dB	20	21
Tx	Current (mA)@Pout	100@20	22@12.2	112@20.6	120@20	165@23	90@19	23@14	65	145@20	110@20
Rx	Gain(dB)	12	11.4	11.0	12.5	16	No LNA	17	12	10.5	10
Rx	NF(dB)	2.5	4.6	4.8	2	2.1		2.3	2.6	2	2
Rx	Icq(mA)	10	3.4	3.4	5	8		6.5	7	8	7
Rx	Input P1dB(dBm)	-8	-21	-17	-8	-22		-6		-11	N/A

RFX2401C is the industry's first and only complete single-chip/single-die RF Front-end Integrated Circuit (RFeIC) in pure CMOS. It meets/beats SiGe and GaAs designs in performance, while providing the smallest and most cost-competitive solution for ZigBee, Smart Energy, Home Automation, Wireless Sound & Audio, Wireless Sensor Networks, and/or any other 2.4GHz ISM band applications on the market today.