

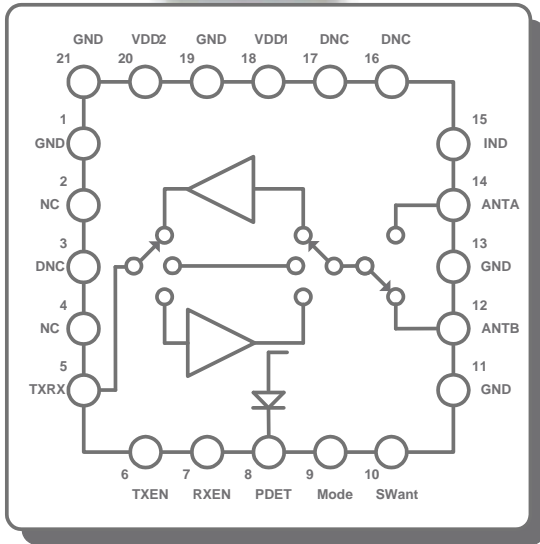


# **RFX2411 Single-Chip CMOS RFeIC with PA, LNA, Antenna Switch, Combined Tx/Rx Transceiver Port, Input Port to Antenna Ports Bypass Mode, and Diversity Switch**

## **Evaluation Board Results Summary & Technical Notes**



3x3x0.55mm  
20L QFN



## RFX2411 Differentiating Features

- Integration of PA, LNA, Tx-Rx Switching Circuitry, Associated Matching Network, Harmonic Filter, PA Power Detection Circuit and Diversity switch all in a Single-Chip, Single-Die pure CMOS Solution
- Greatly Reduced and Simplified Tx/Rx Control
- Low Current Mode for ultra low power consumption
- Low Voltage Battery Operation down to 2.0V
- 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 20L QFN Package

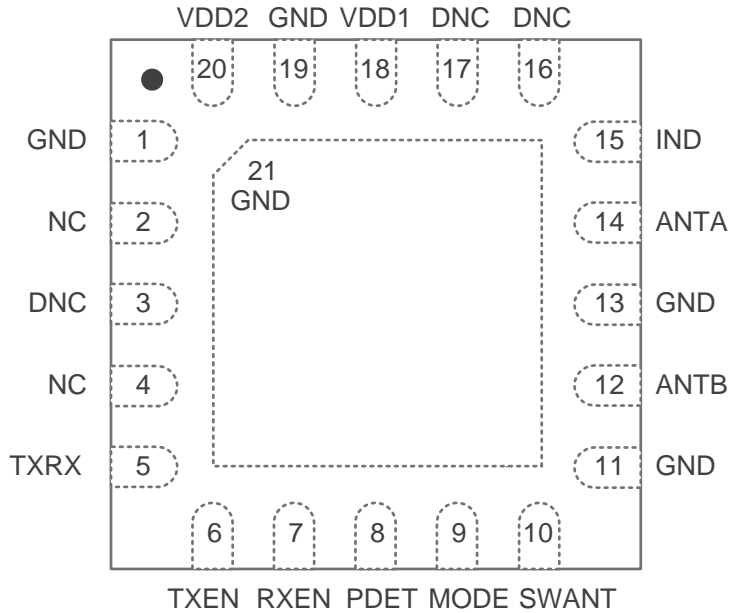
## APPLICATIONS

- 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

## RFX2411 Customer Benefits

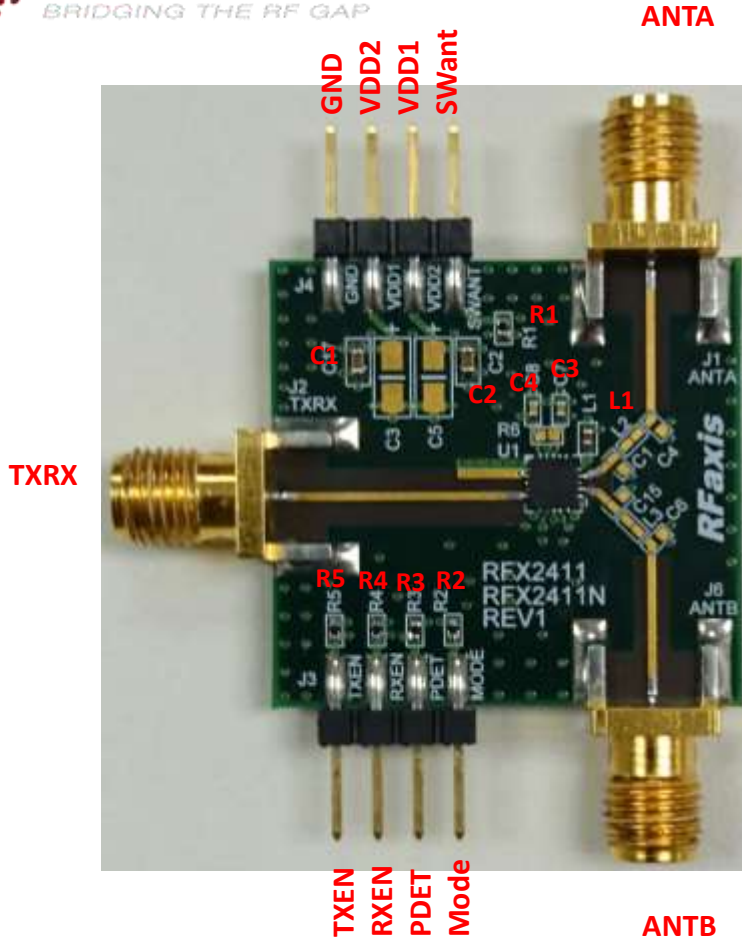
- Greatly Simplified, 50 Ohm “Plug & Play” PCB Implementation
- Small Form-Factor and Quick Design Cycle
- Simplest Approach to Improve Link Performance including Range and Receiver Sensitivity
- Very Low BOM Cost and Competitive Price

# RFX2411 Pin Description



Pin Number	Pin Name	Description
1, 11,13, 19, 21	GND	Ground – Must be connected to Ground in the Application Circuit
2, 4	NC	No Internal Connection
5	TXRX	RF signal to/from the Transceiver: DC shorted to GND
6	TXEN	CMOS Input to Control TX Enable
7	RXEN	CMOS Input to Control RX Enable
8	PDET	Analog Voltage Proportional to the PA Power Output
9	MODE	CMOS Input to control mode of operation
10	SWant	CMOS Input to select antenna for diversity
12	ANTB	RF Signal from the PA or RF Signal Applied to the LNA; DC Shorted to GND
14	ANTA	RF Signal from the PA or RF Signal Applied to the LNA; DC Shorted to GND
15	IND	Inductor to GND
3, 16, 17	DNC	Reserved – Do Not Connect in the Application Circuit
18	VDD1	Voltage Supply Connection
20	VDD2	Voltage Supply Connection

# RFX2411 Evaluation Board and Preliminary BOM



For VDD decoupling:  
 C1, C2=2.2uF  
 C3, C4=220pF

Detector Loading:  
 R3 = 10Kohm

Digital Control Protection:  
 R1 = R2 = R4 = R5 = 1Kohm (Recommended for control lines with voltage that may approach Vdd levels).

For Harmonic Suppression:  
 L1=1.2nH (Inductor value may need to be optimized in final application circuit since it is layout dependent)  
 Additional filtering may be required for compliance depending on system configuration and application.

Eval PCB Information:  
 - 4-Layer Stack, 10mil/40mil/10mil  
 - FR4 with  $\epsilon_r=4.5$ ,  $\tan \delta = 0.02$  (typ.)  
 - All trace losses have been de-embedded from the following Measurements.

Control Logic Truth Table

TXEN	RXEN	MODE	Mode of Operation
0	0	0	Shutdown Mode
0	0	1	Bypass Mode
1	X	0	Low Idq TX Mode
1	X	1	High Idq TX Mode
0	1	0	Low Noise Figure Receive Mode
0	1	1	Low Current Receive Mode

Note: "1" denotes high voltage state (> 1.2V) at Control Pins  
 "0" denotes low voltage state (< 0.3V) at Control Pins

SWant	Mode of Operation
1	ANTA port enabled
0	ANTB port enabled

## EVB Signal Loss De-Embedding

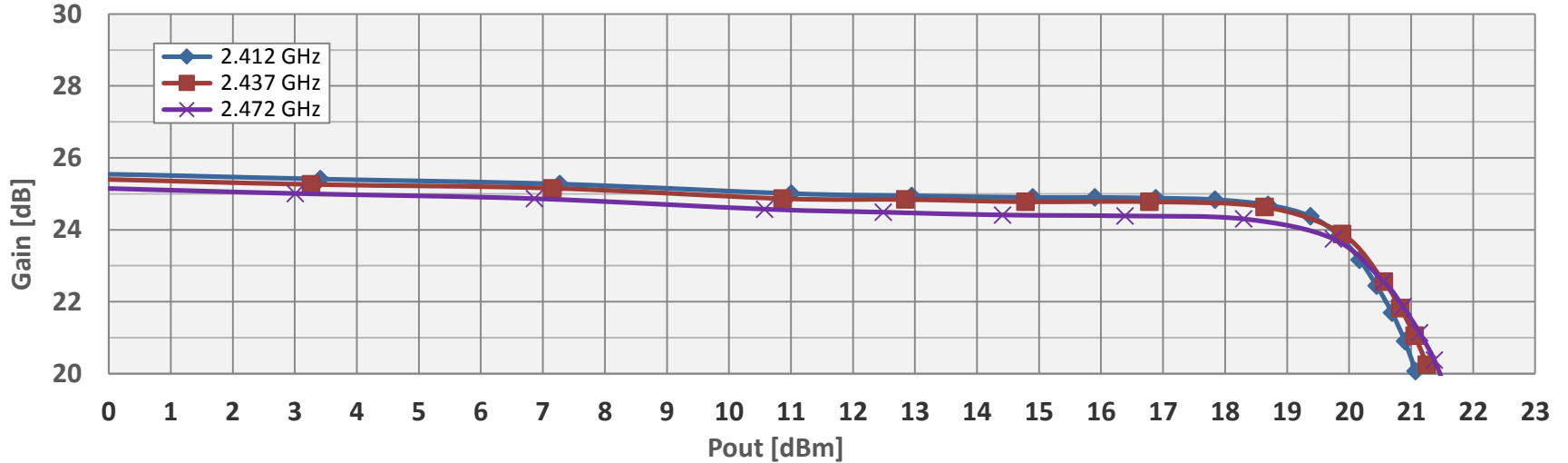
RF Signal	Loss
ANT	.22 dB
TX	.22 dB
RX	.22 dB

**Total EVB Loss Includes the Trace and Connector**

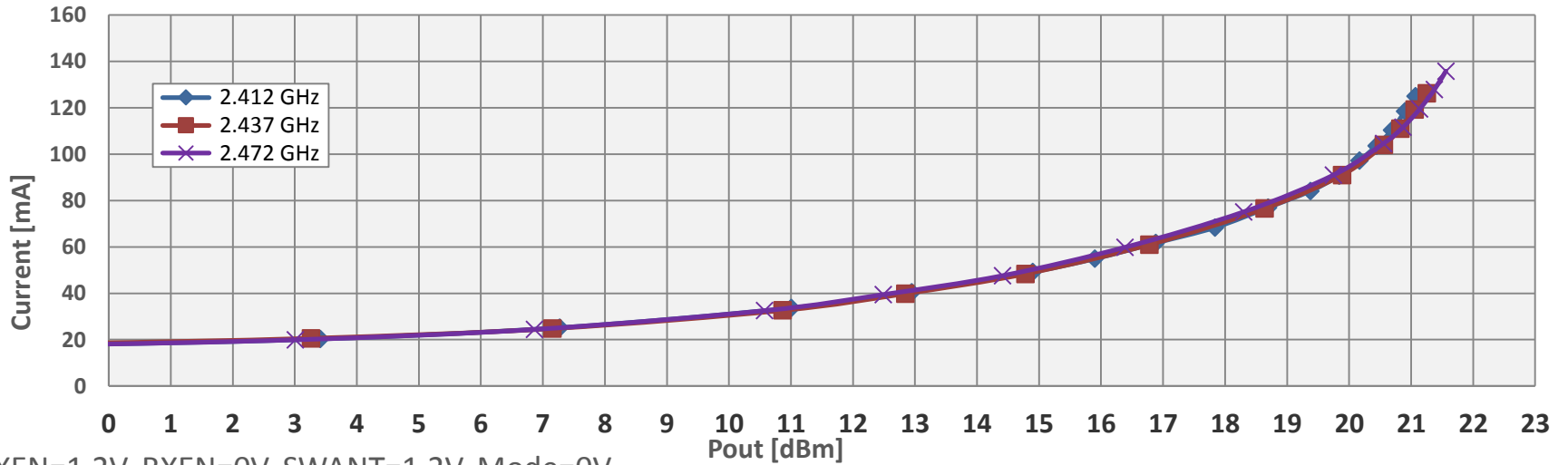
# TX Large Signal Gain & Current vs. Pout Across Frequency

## Antenna A, Low Idq Mode, CW Signal

Gain VDD = 3.3V Low Idq Mode



Max Current VDD = 3.3V Low Idq Mode

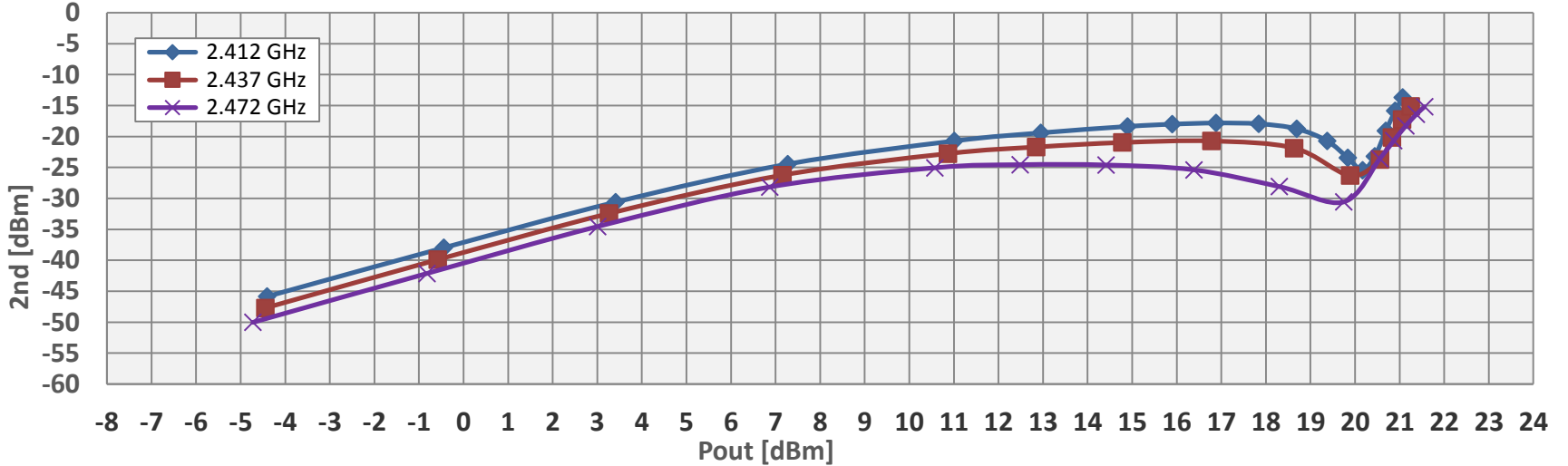


TXEN=1.2V, RXEN=0V, SWANT=1.2V, Mode=0V

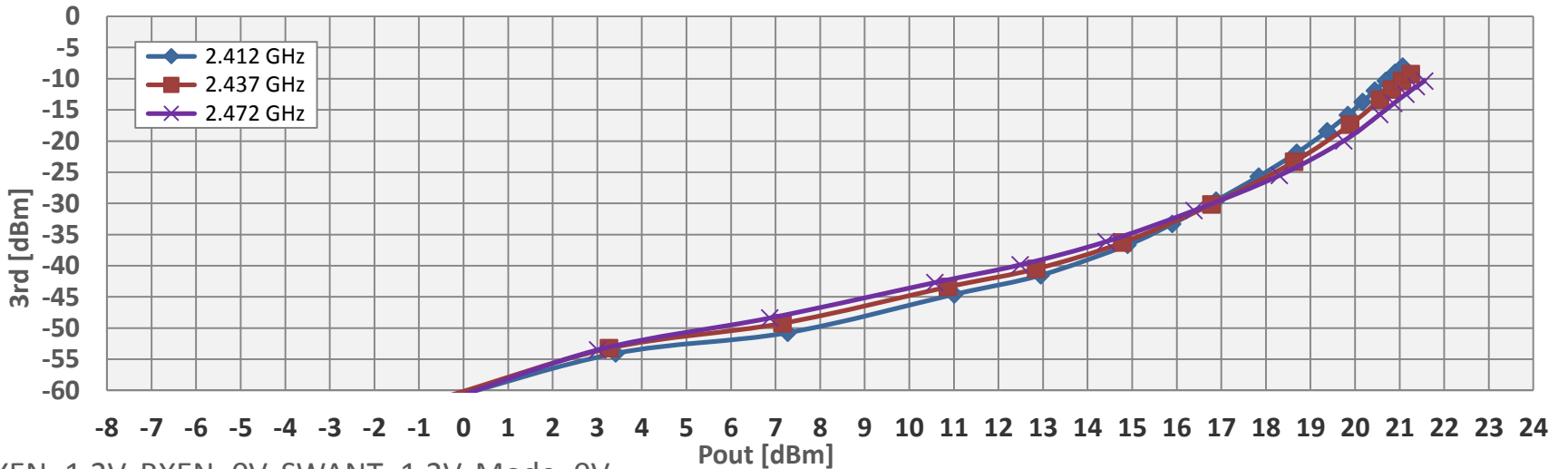
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# TX Large Signal 2<sup>nd</sup> and 3<sup>rd</sup> Harmonic Across Frequency Antenna A, Low Idq Mode, CW Signal

2nd Harmonic VDD = 3.3V Low Idq Mode



3rd Harmonic VDD = 3.3V Low Idq Mode



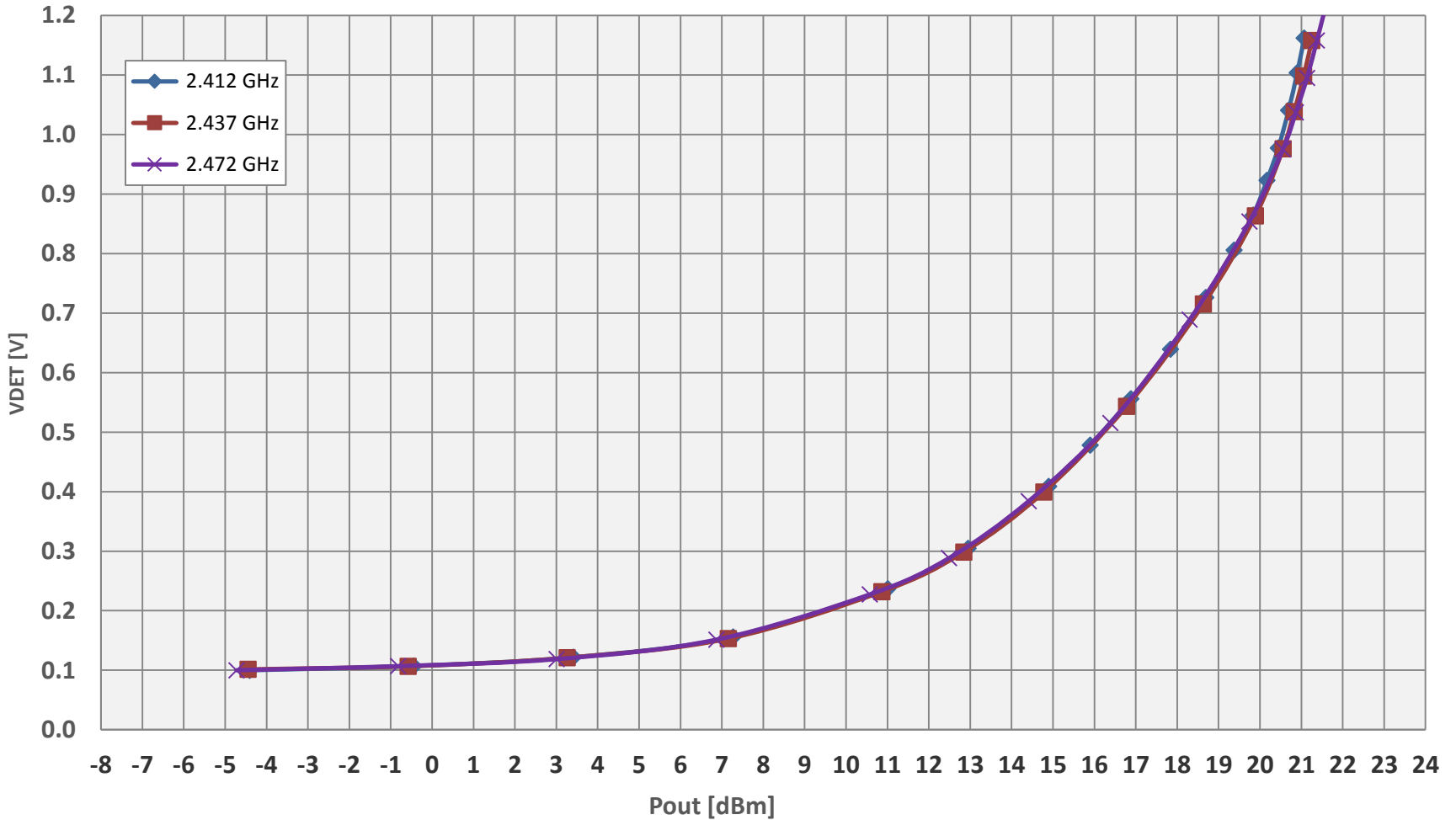
TXEN=1.2V, RXEN=0V, SWANT=1.2V, Mode=0V

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# TX Large Signal Detector Voltage vs. Pout Across Frequency

## Antenna A, Low Idq Mode, CW Signal

Vdet VDD = 3.3V Low Idq Mode

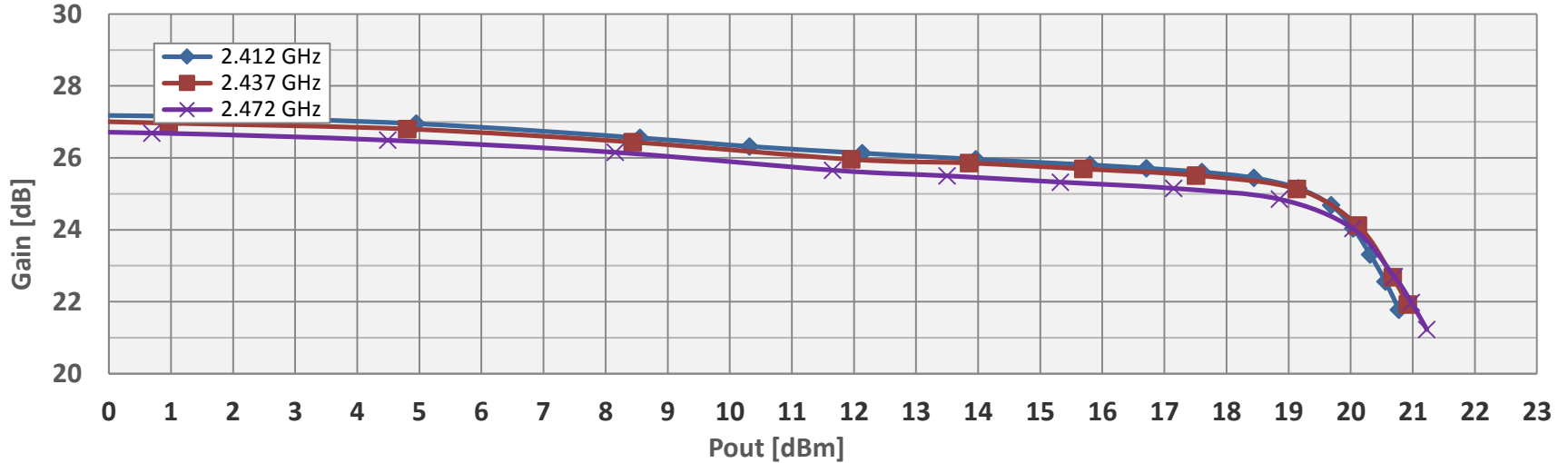




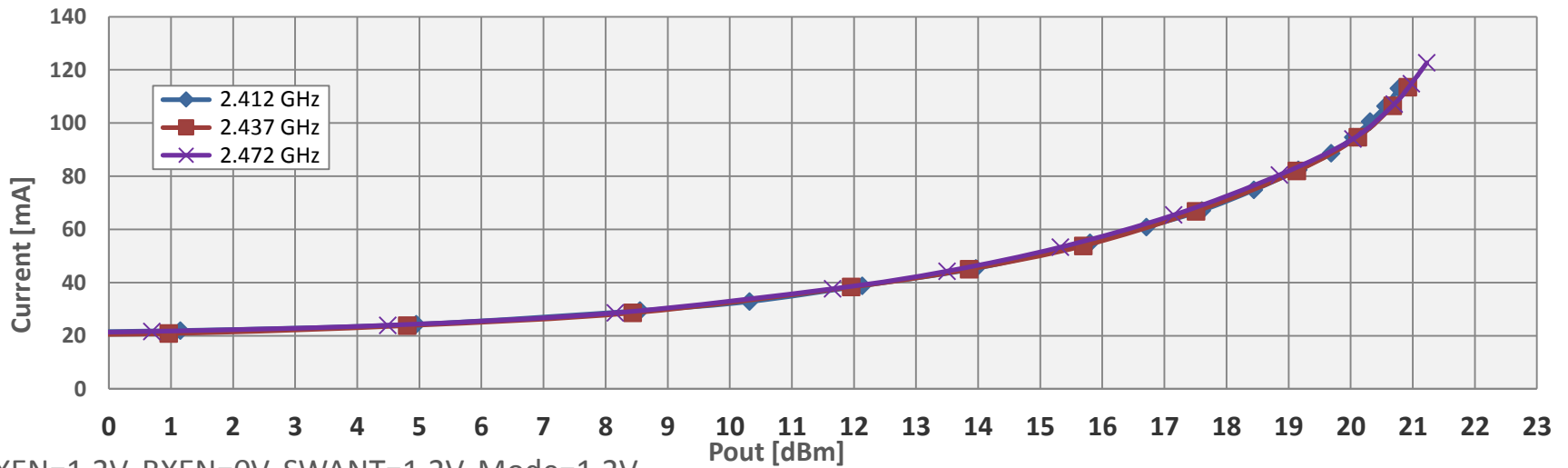
# TX Large Signal Gain & Current vs. Pout Across Frequency

## Antenna A, High Idq Mode, CW Signal

Gain VDD = 3.3V High Idq Mode



Max Current VDD = 3.3V High Idq Mode

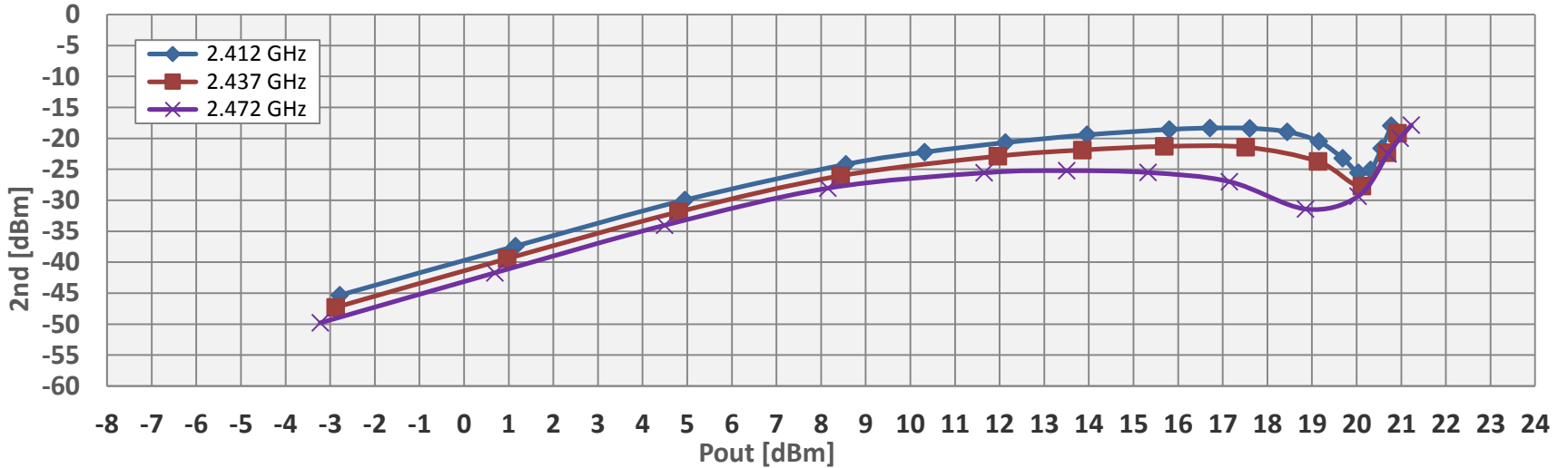


TXEN=1.2V, RXEN=0V, SWANT=1.2V, Mode=1.2V

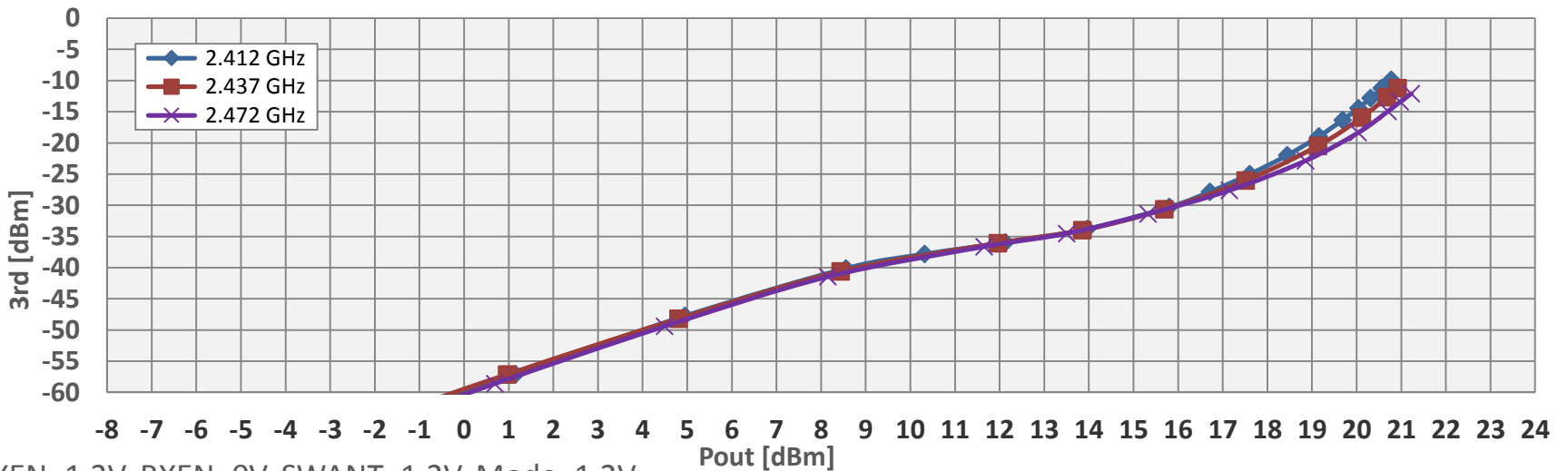
7/13/2015

# TX Large Signal 2<sup>nd</sup> and 3<sup>rd</sup> Harmonic Across Frequency Antenna A, High Idq Mode, CW Signal

2nd Harmonic VDD = 3.3V High Idq Mode



3rd Harmonic VDD = 3.3V High Idq Mode

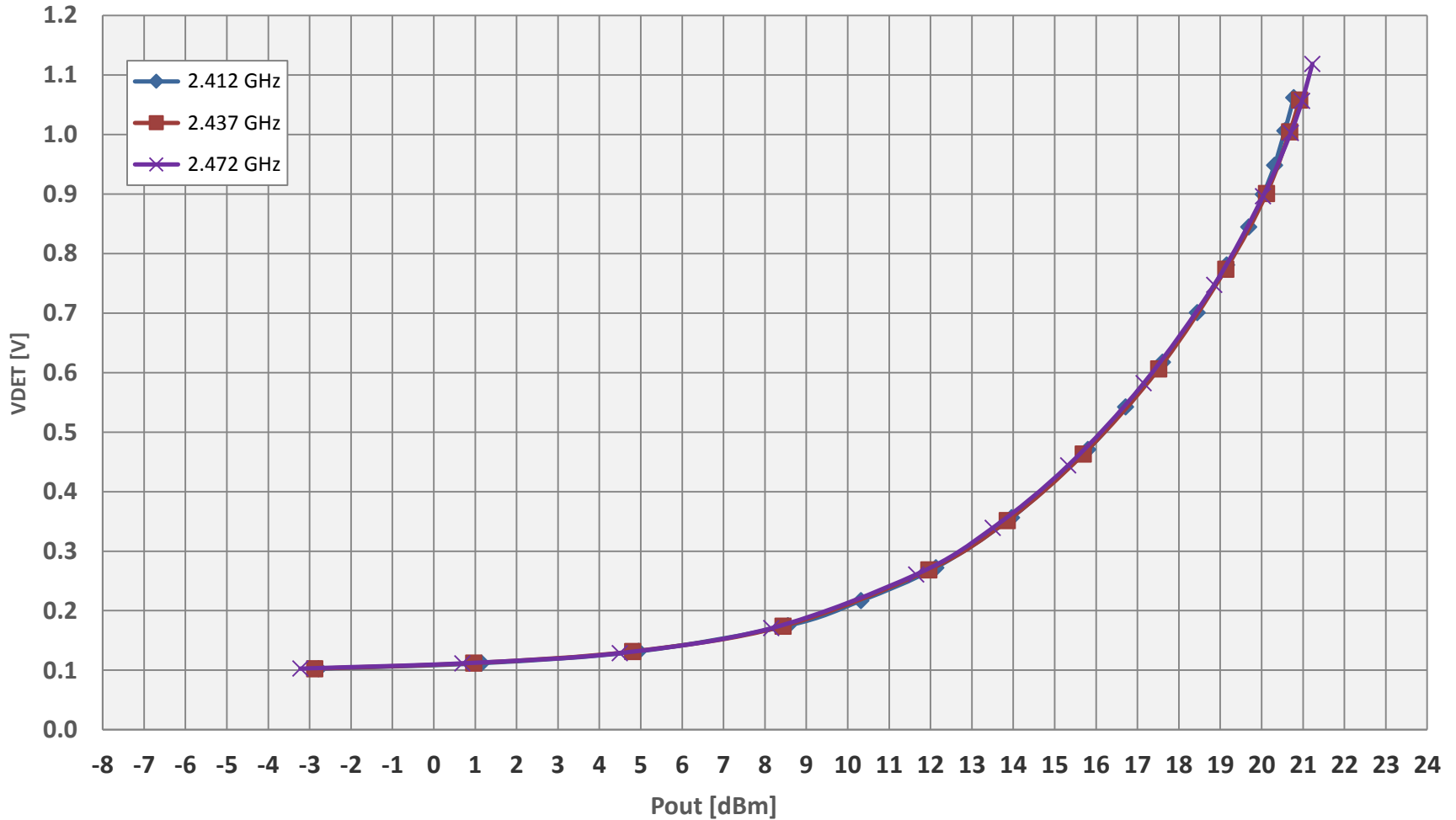


TXEN=1.2V, RXEN=0V, SWANT=1.2V, Mode=1.2V

# TX Large Signal Detector Voltage vs. Pout Across Frequency

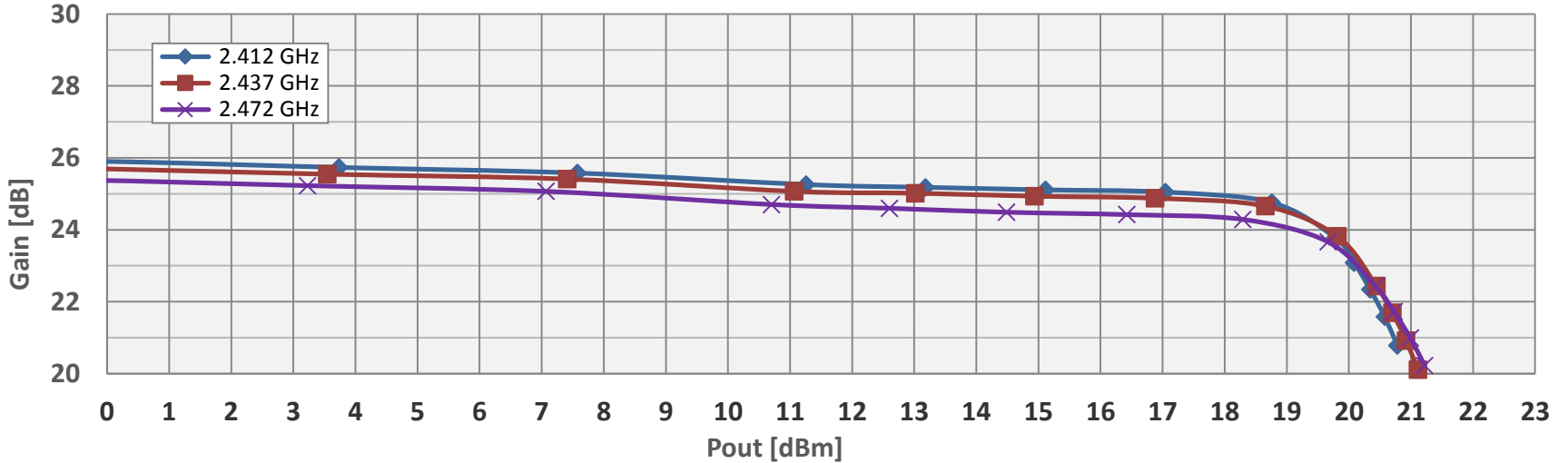
## Antenna A, High Idq Mode, CW Signal

Vdet VDD = 3.3V High Idq Mode

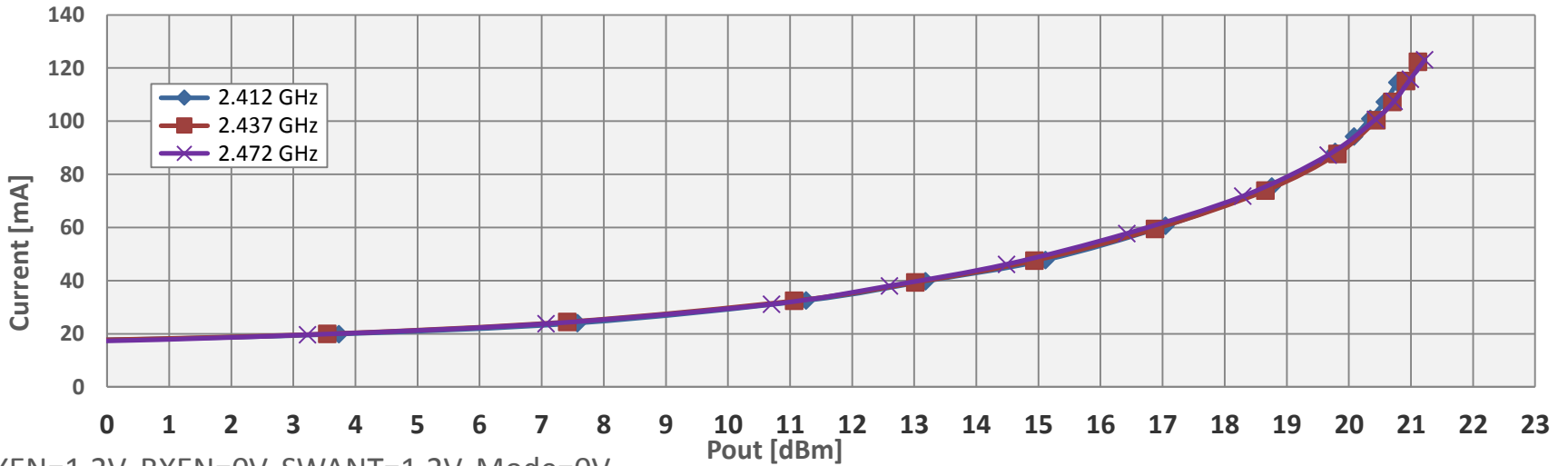


# TX Large Signal Gain & Current vs. Pout Across Frequency Antenna B, Low Idq Mode, CW Signal

Gain VDD = 3.3V Low Idq Mode



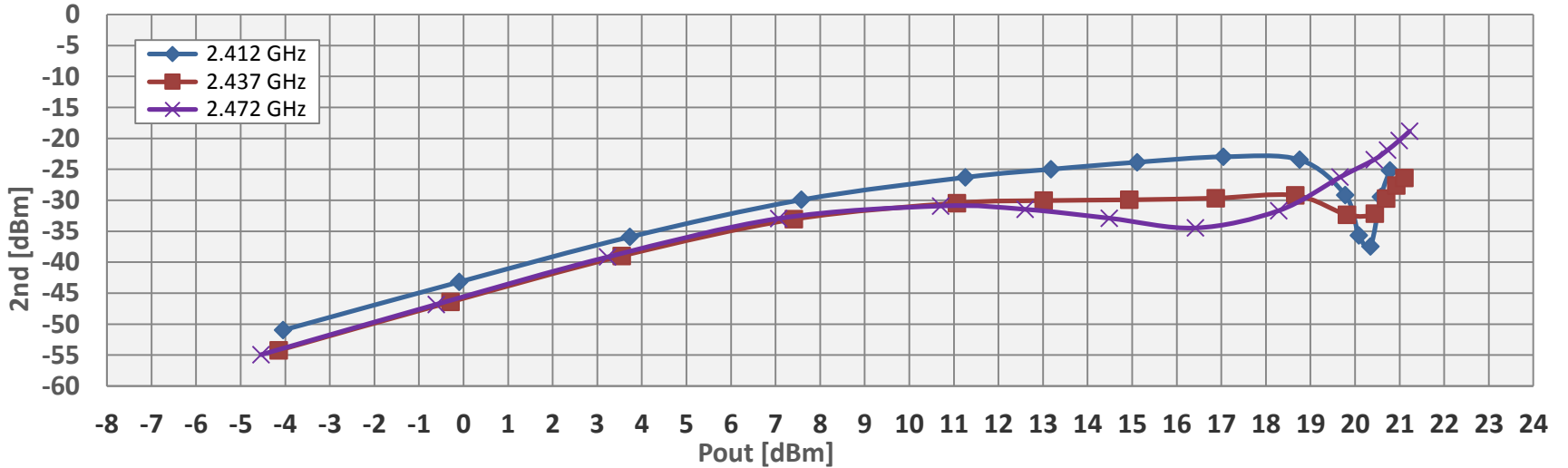
Max Current VDD = 3.3V Low Idq Mode



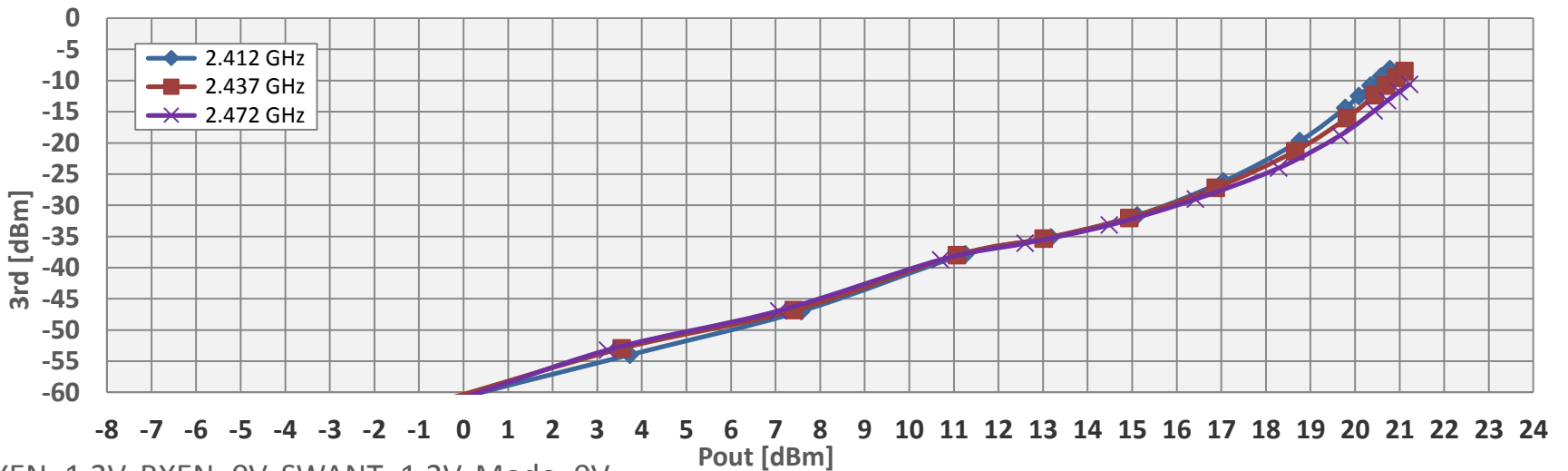
TXEN=1.2V, RXEN=0V, SWANT=1.2V, Mode=0V

# TX Large Signal 2<sup>nd</sup> and 3<sup>rd</sup> Harmonic Across Frequency Antenna B, Low Idq Mode, CW Signal

2nd Harmonic VDD = 3.3V Low Idq Mode



3rd Harmonic VDD = 3.3V Low Idq Mode

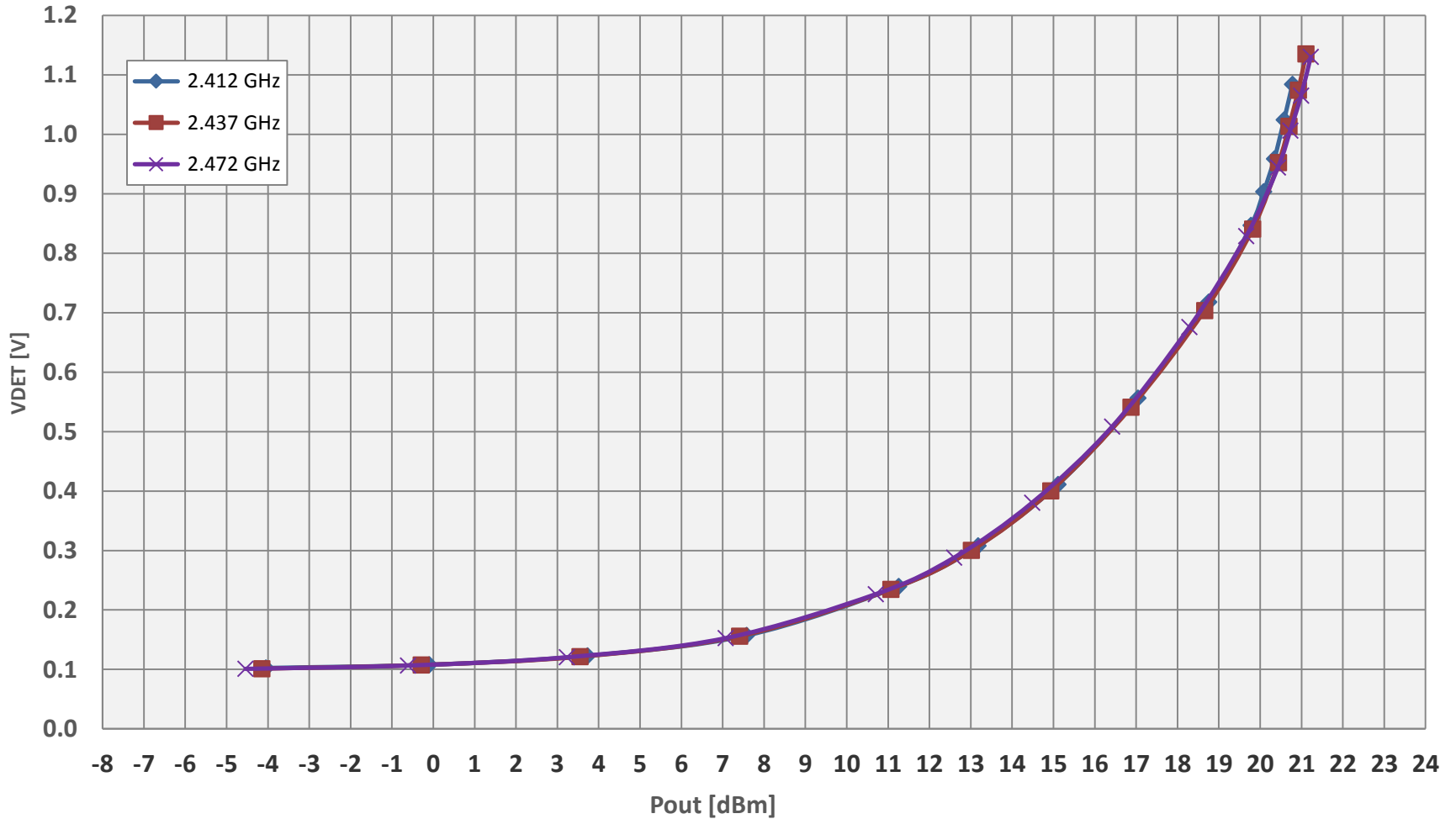


TXEN=1.2V, RXEN=0V, SWANT=1.2V, Mode=0V

# TX Large Signal Detector Voltage vs. Pout Across Frequency

## Antenna B, Low Idq Mode, CW Signal

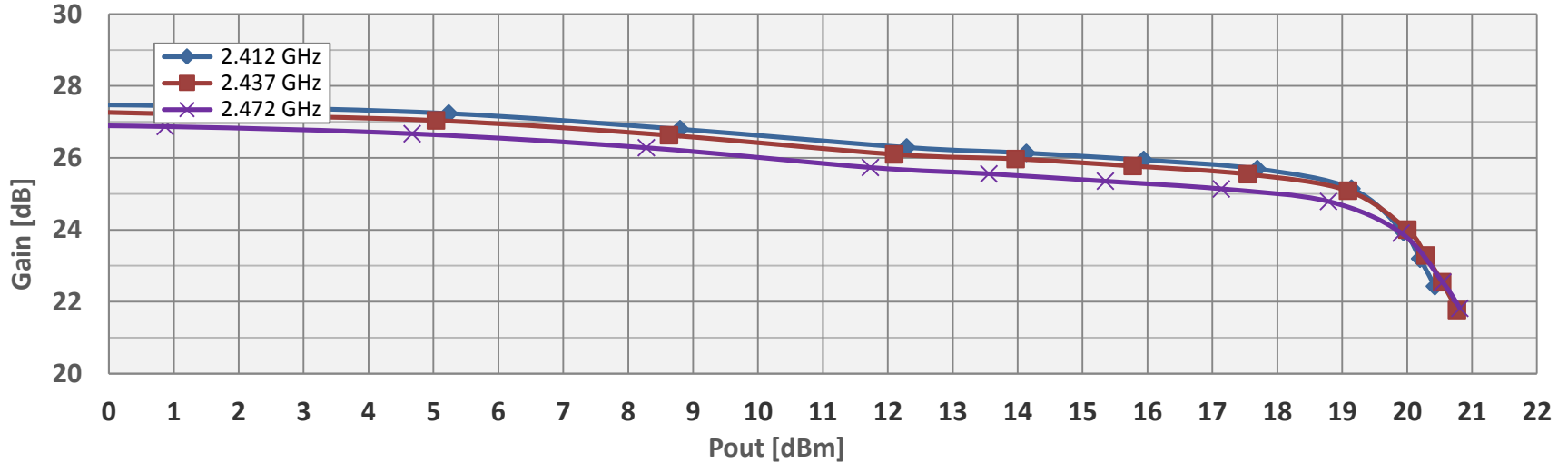
Vdet VDD = 3.3V Low Idq Mode



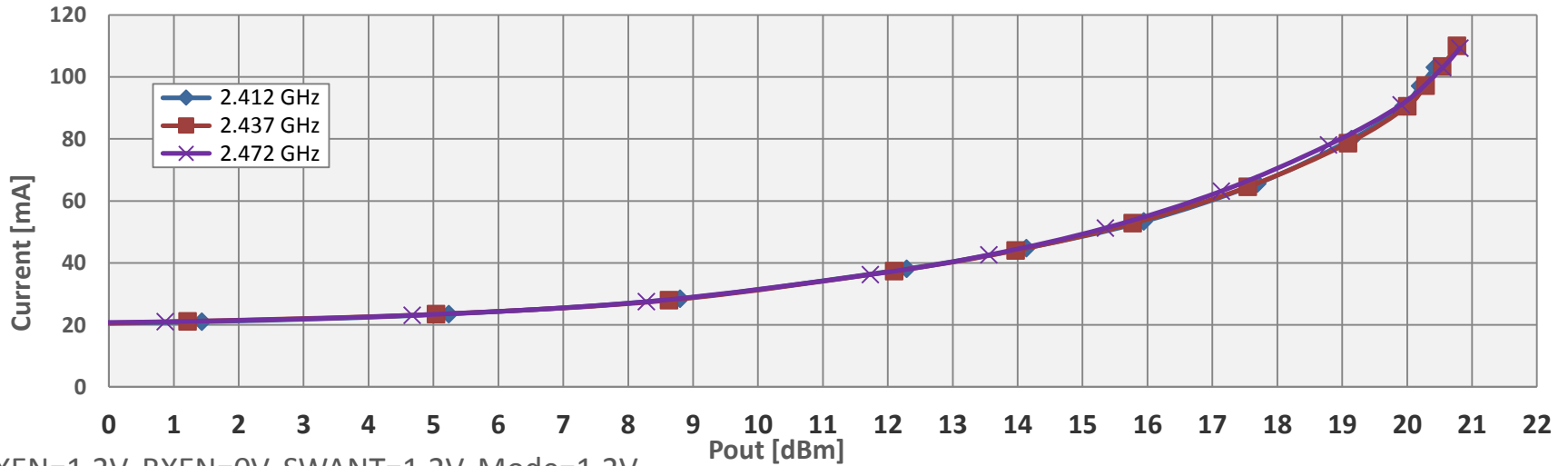
# TX Large Signal Gain & Current vs. Pout Across Frequency

## Antenna B, High Idq Mode, CW Signal

Gain VDD = 3.3V High Idq Mode



Max Current VDD = 3.3V High Idq Mode

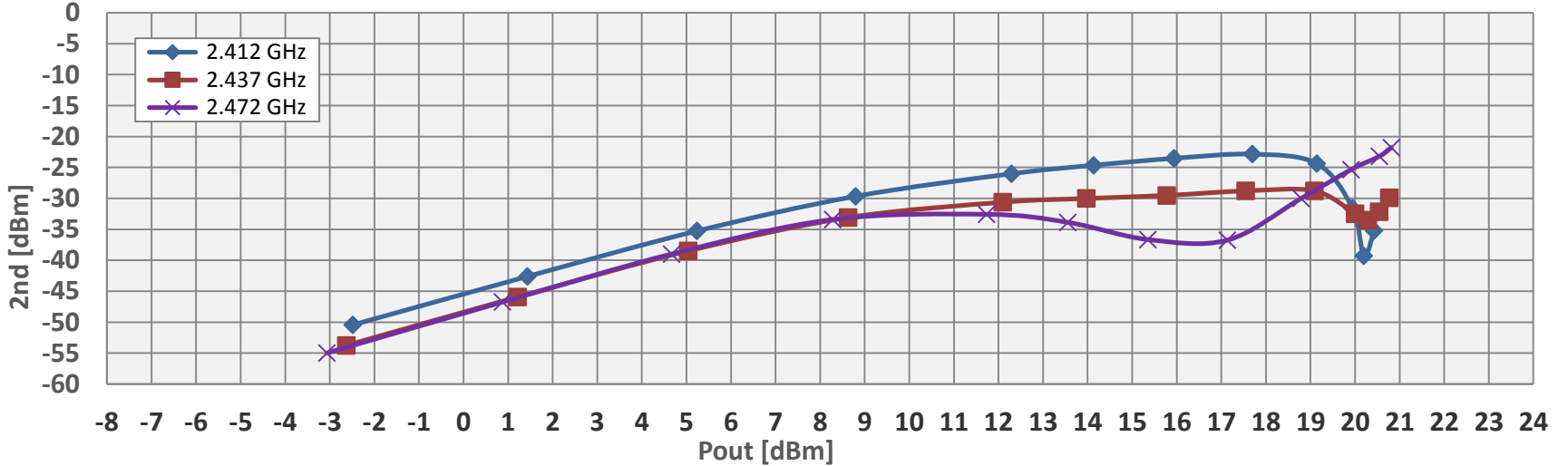


TXEN=1.2V, RXEN=0V, SWANT=1.2V, Mode=1.2V

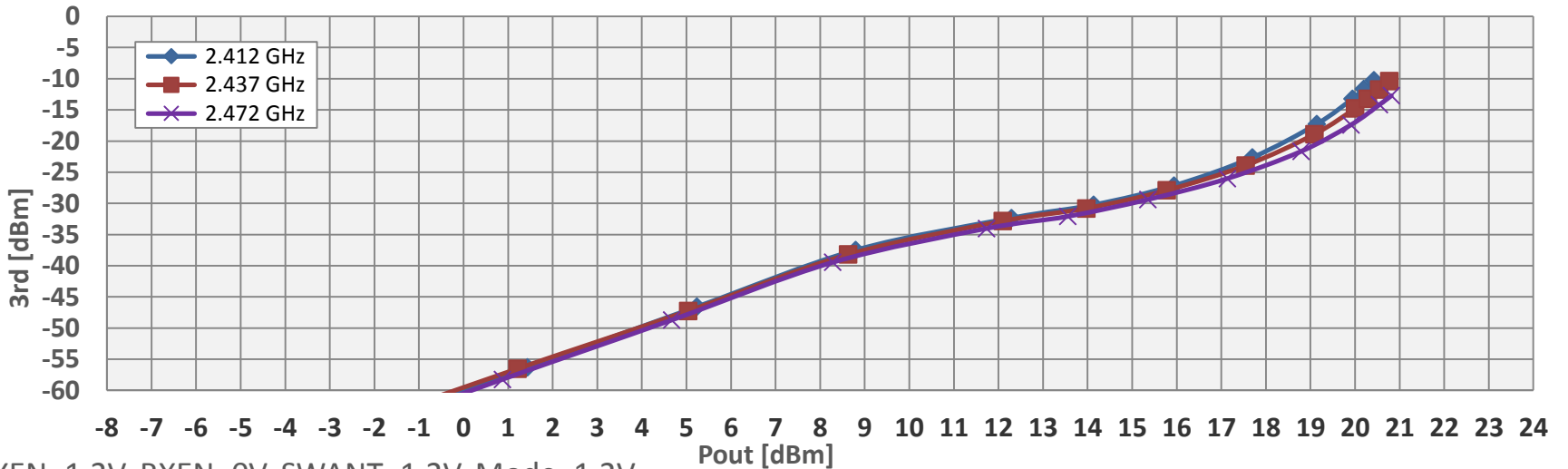
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# TX Large Signal 2<sup>nd</sup> and 3<sup>rd</sup> Harmonic Across Frequency Antenna B, High Idq Mode, CW Signal

## 2nd Harmonic VDD = 3.3V High Idq Mode



## 3rd Harmonic VDD = 3.3V High Idq Mode



TXEN=1.2V, RXEN=0V, SWANT=1.2V, Mode=1.2V

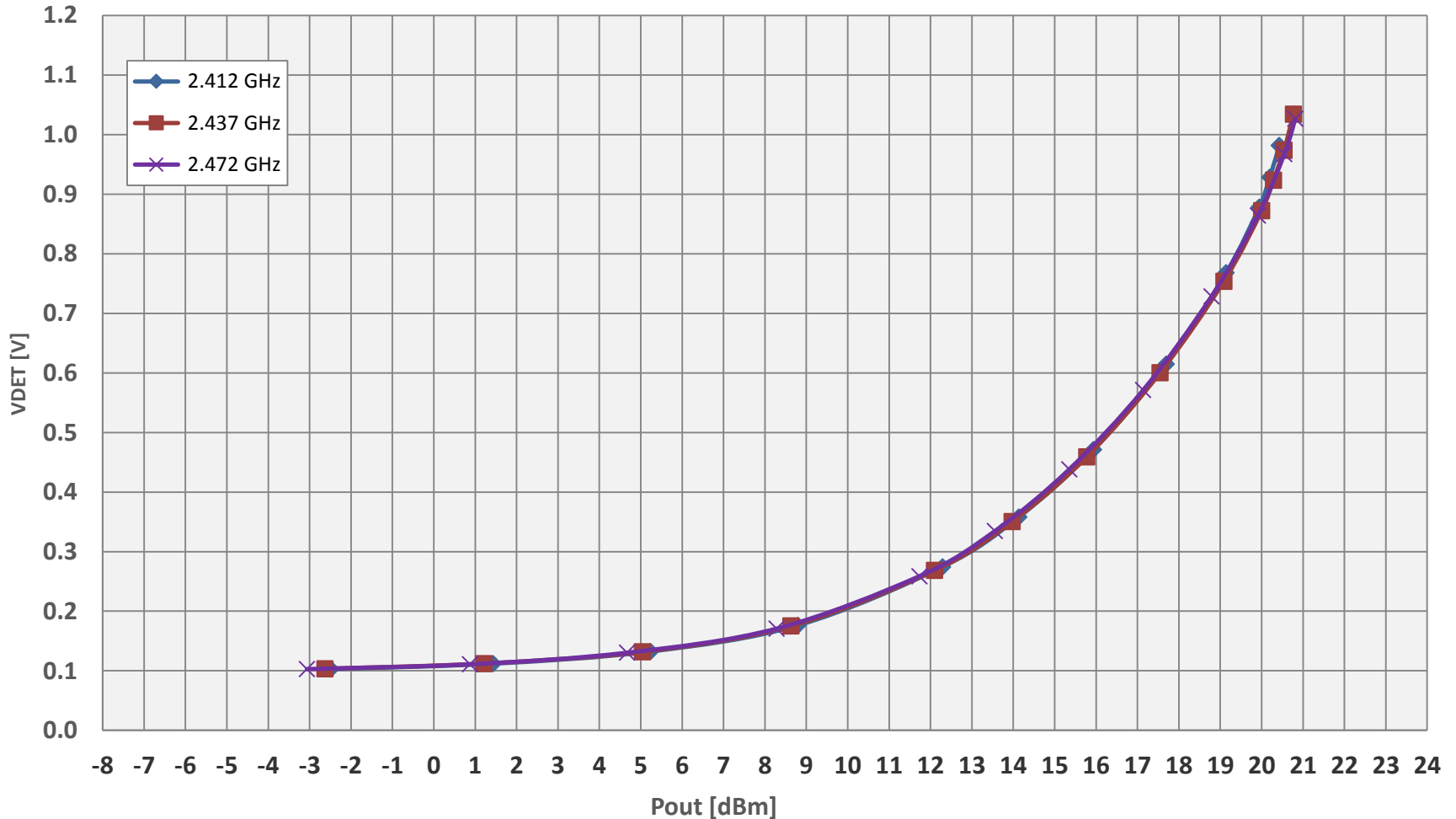
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# TX Large Signal Detector Voltage vs. Pout Across Frequency

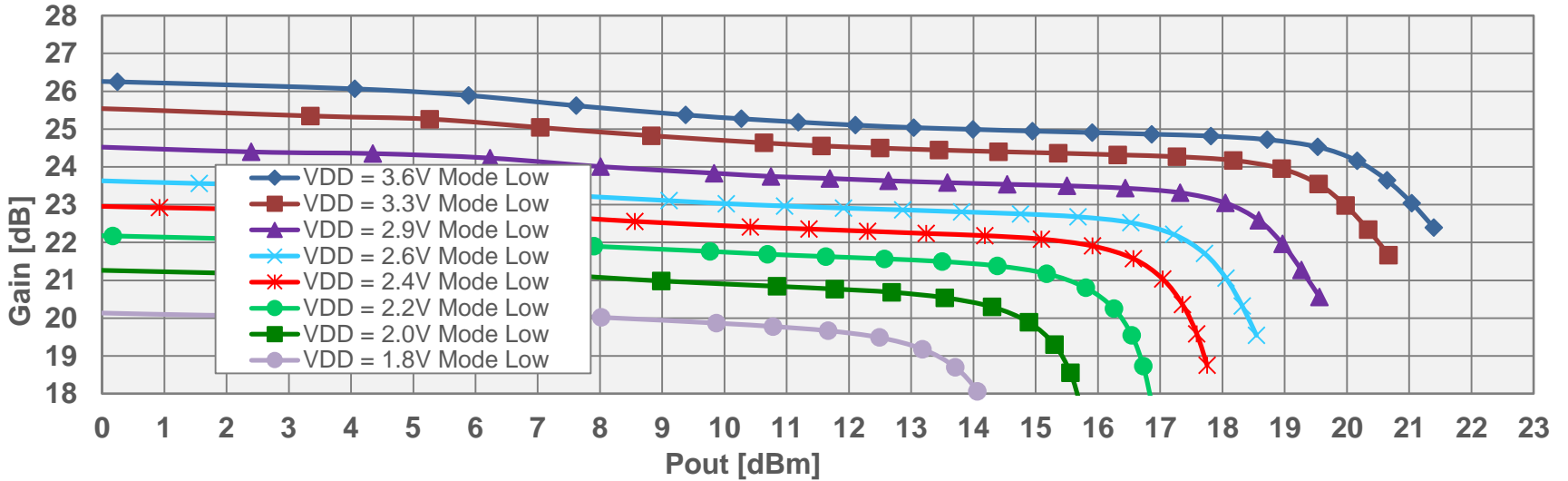
## Antenna B, High Idq Mode, CW Signal

Vdet VDD = 3.3V High Idq Mode

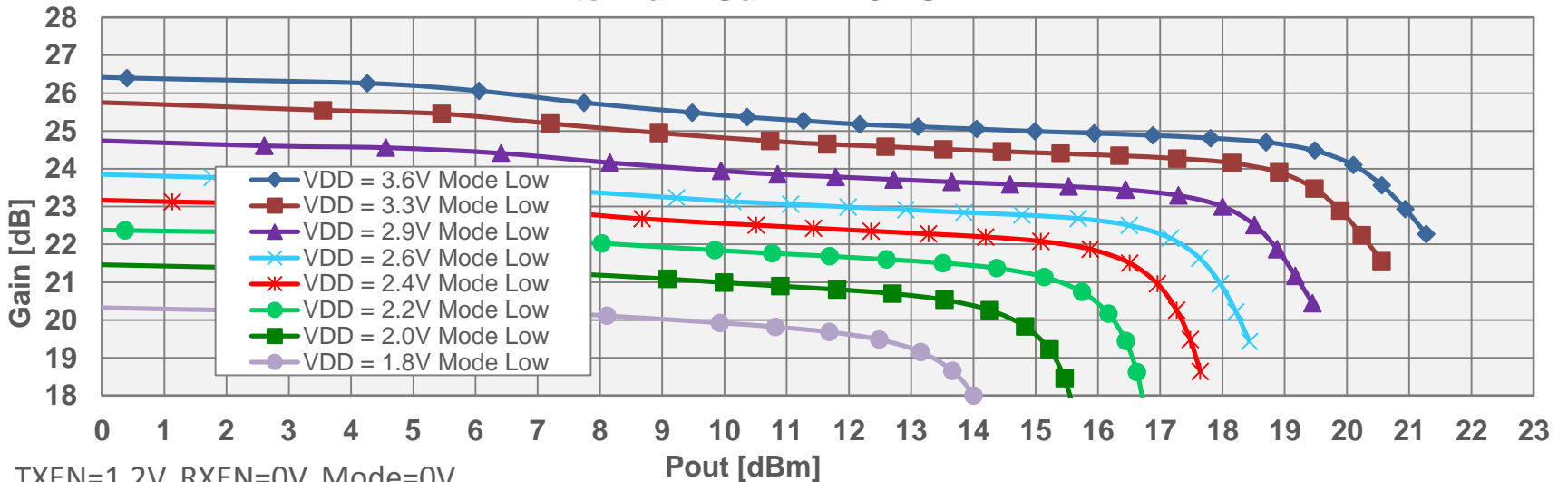


# TX Large Signal Gain & Current vs. Pout Across VDD 2.437 GHz, Low Idq Mode, CW Signal

## Antenna A Gain 2.437 GHz



## Antenna B Gain 2.437 GHz

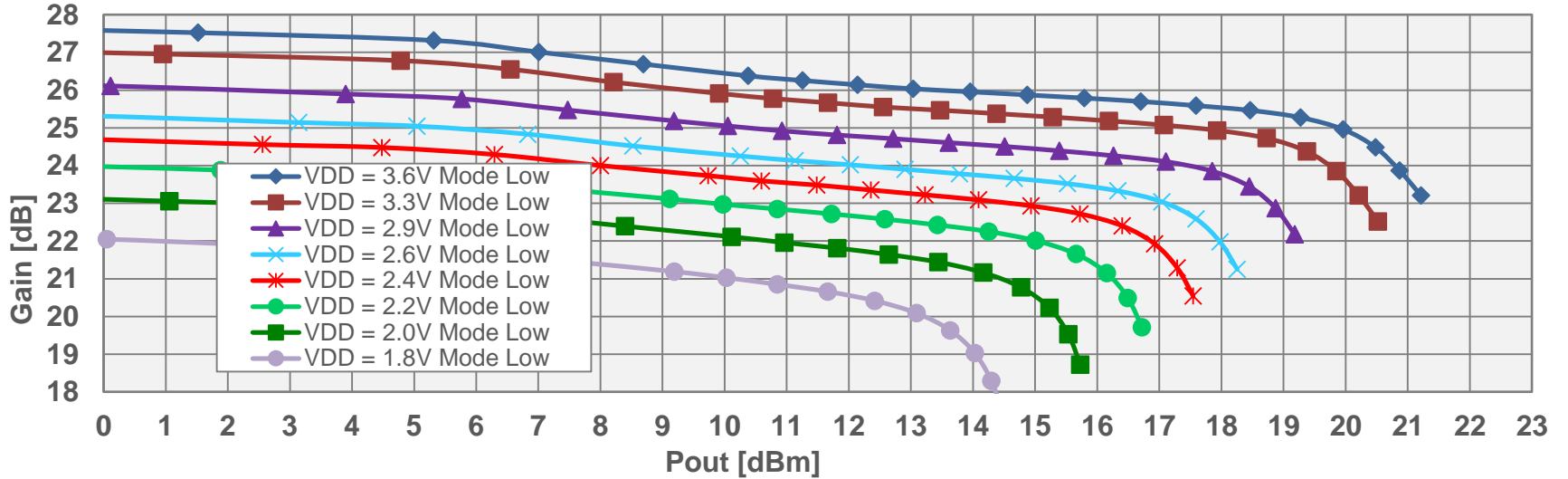


TXEN=1.2V, RXEN=0V, Mode=0V

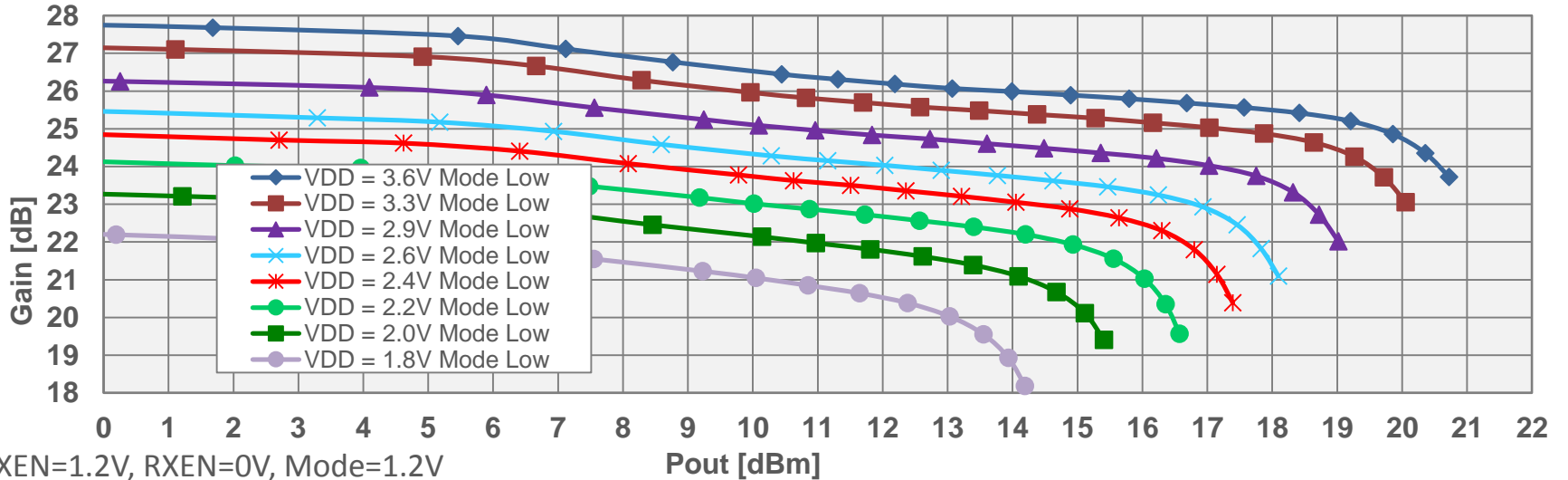
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# TX Large Signal Gain & Current vs. Pout Across VDD 2.437 GHz, High Idq Mode, CW Signal

## Antenna A Gain 2.437 GHz

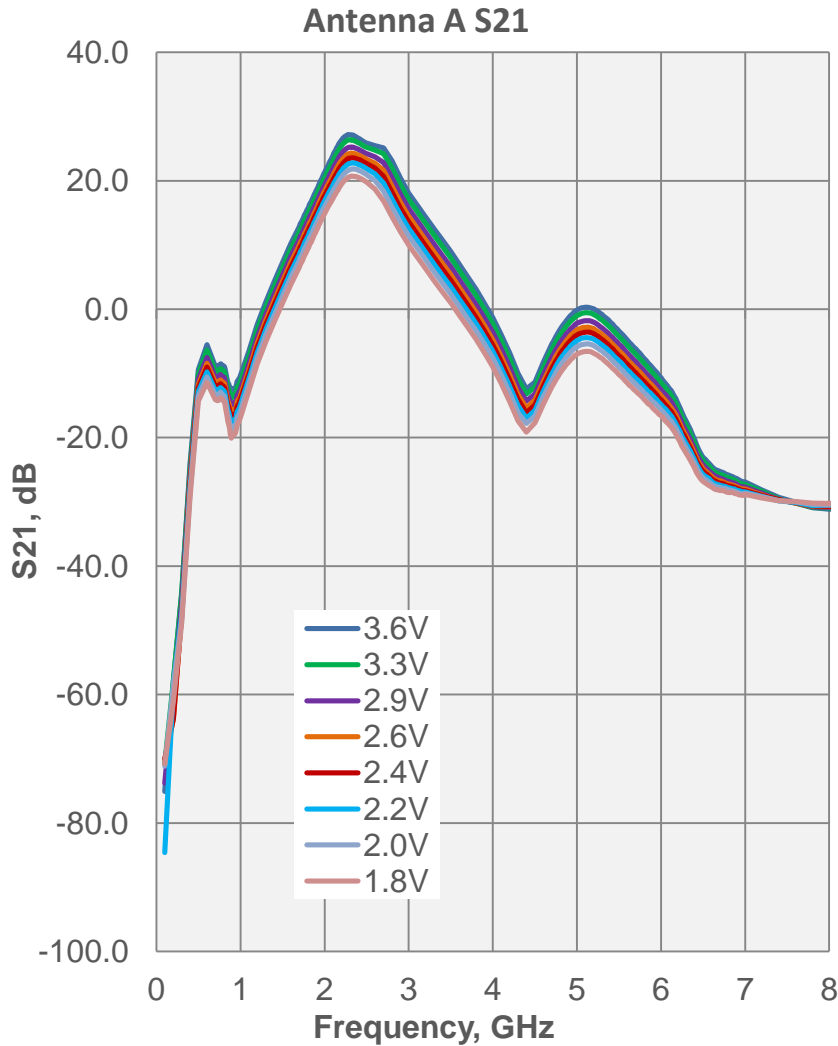


## Antenna B Gain 2.437 GHz

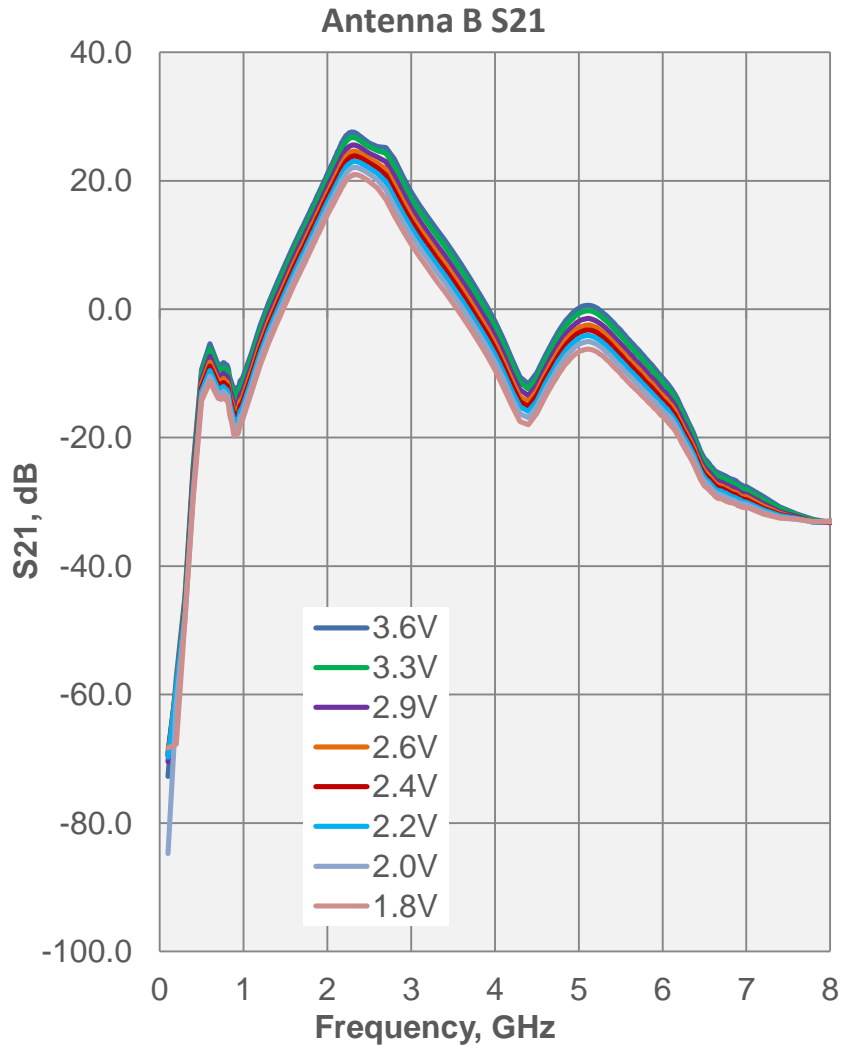


TXEN=1.2V, RXEN=0V, Mode=1.2V

# TX S-Parameters Across Voltage Antenna A and B, Low Idq Mode

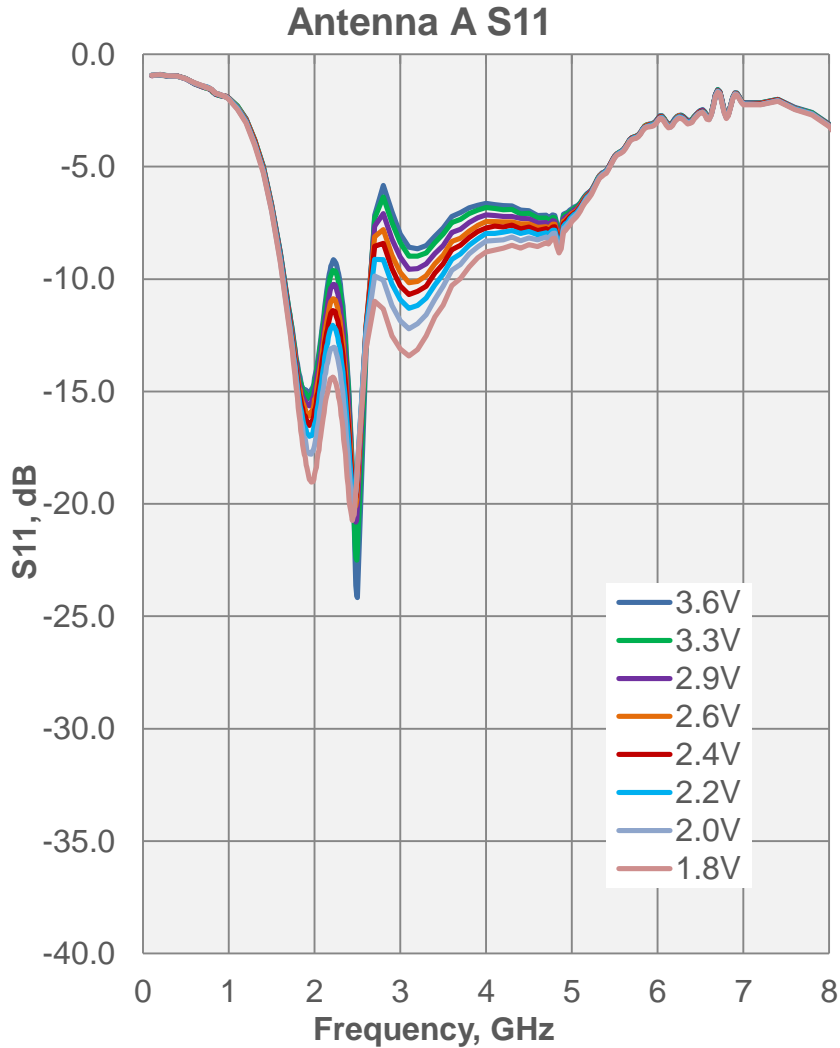


Idq ~ 15mA

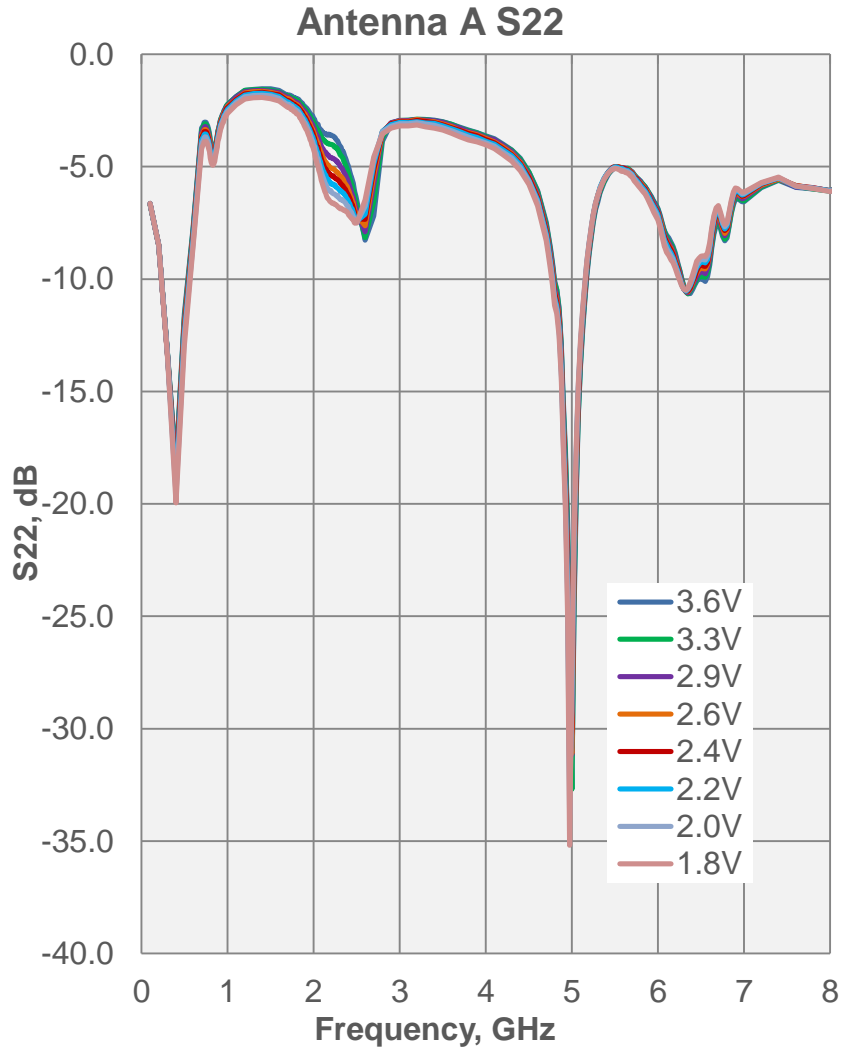


# TX S-Parameters Across Voltage

## Antenna A S11 and S22, Low Idq Mode

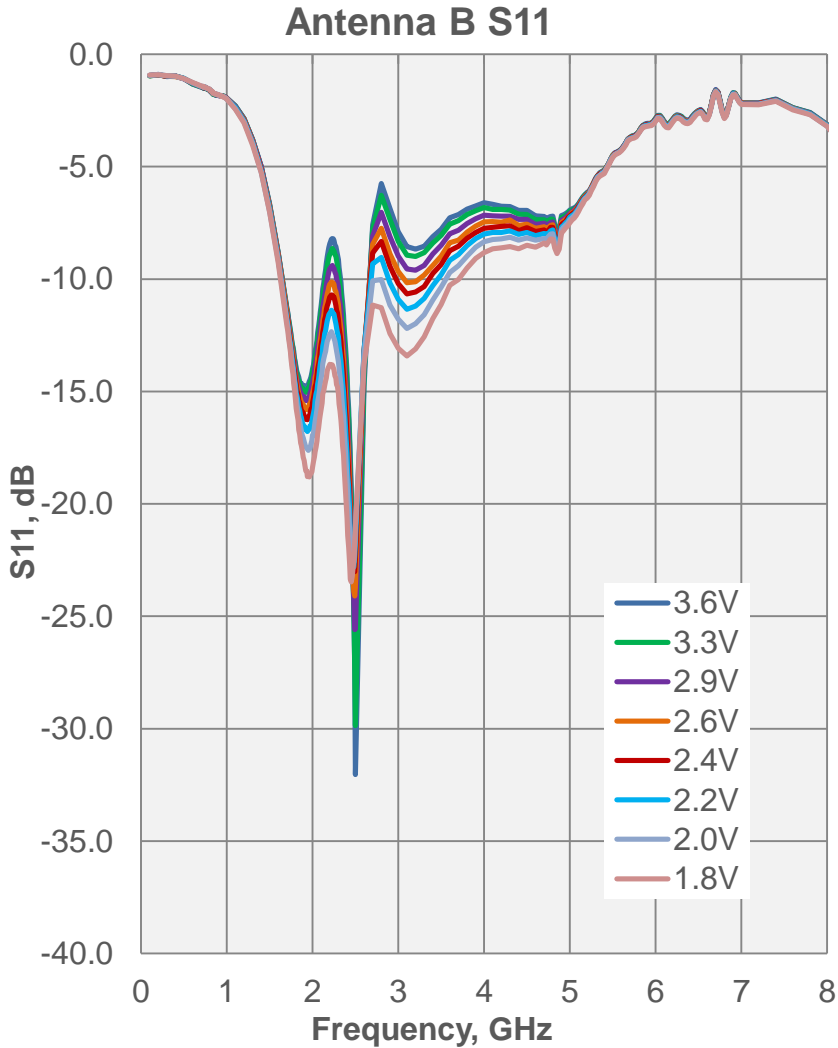


Idq ~ 15mA

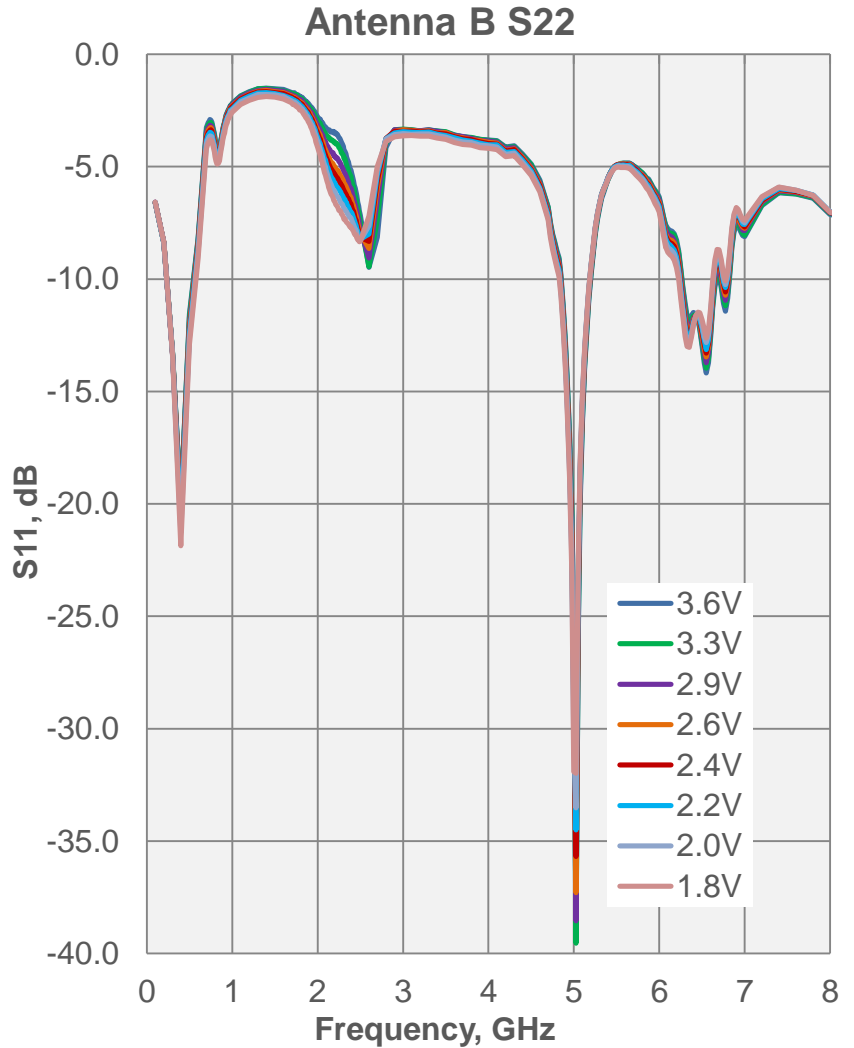


# TX S-Parameters Across Voltage

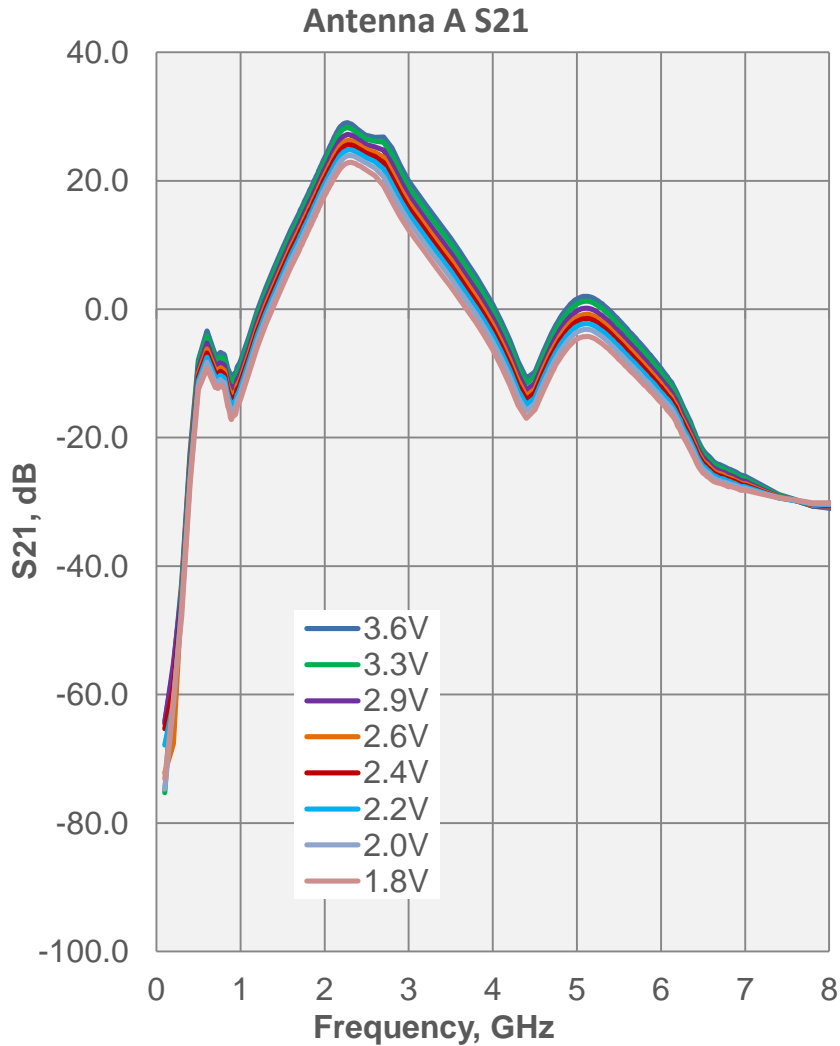
## Antenna B S11 and S22, Low Idq Mode



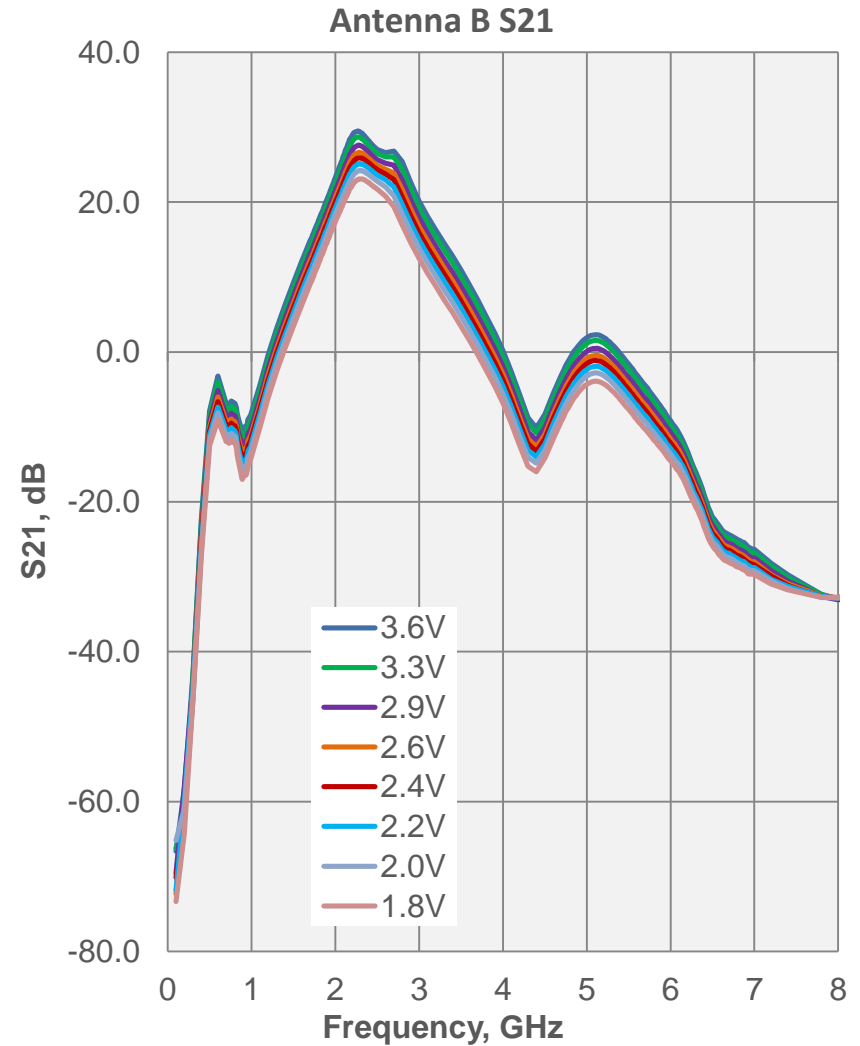
Idq ~ 15mA



# TX S-Parameters Across Voltage Antenna A and B, High Idq Mode

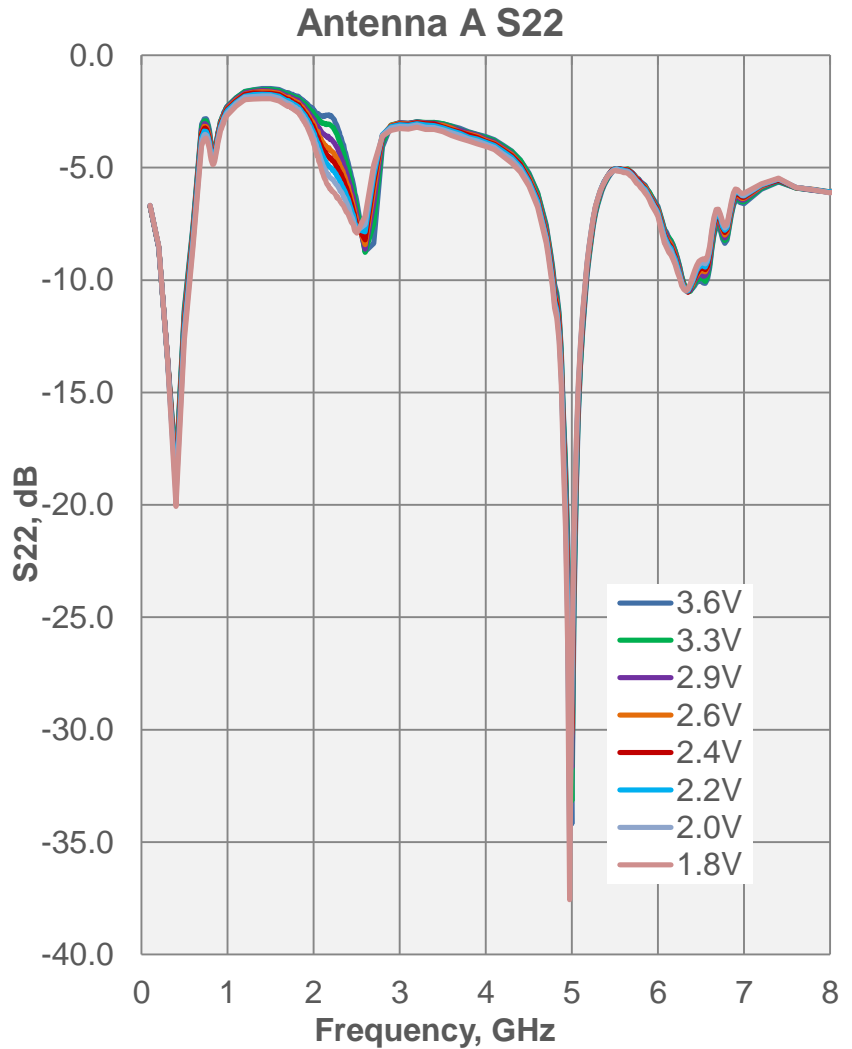
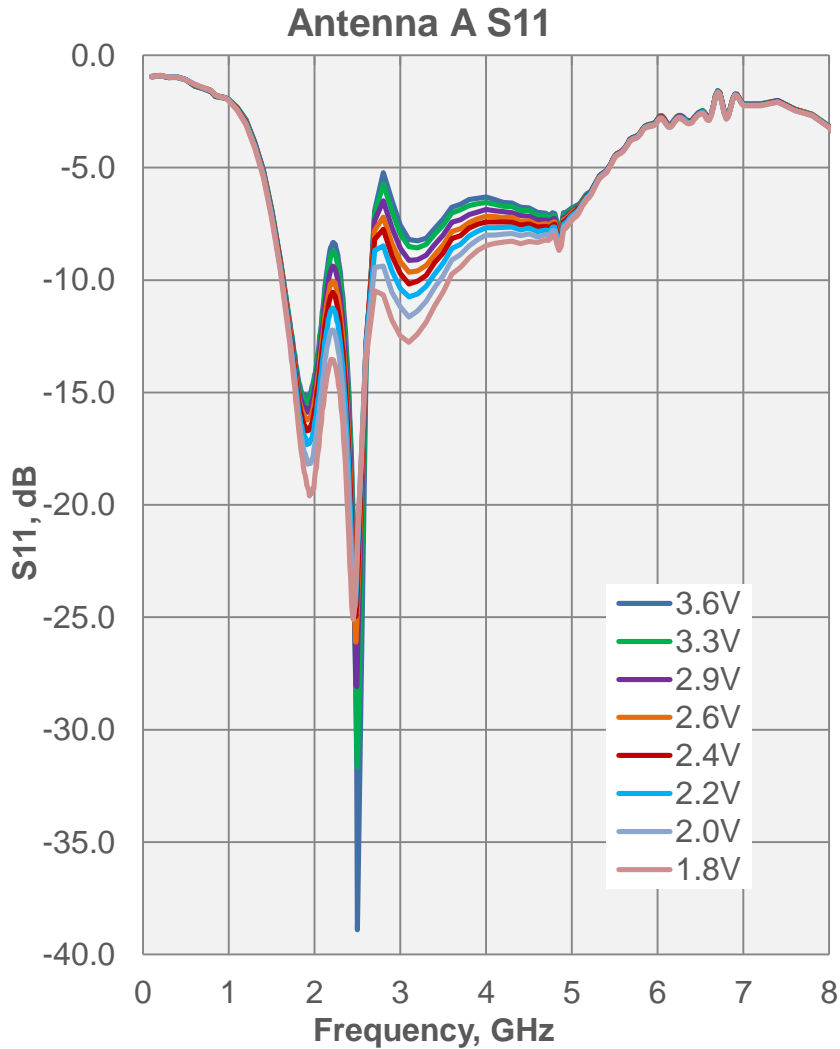


Idq ~ 18mA



# TX S-Parameters Across Voltage

## Antenna A S11 and S22, High Idq Mode

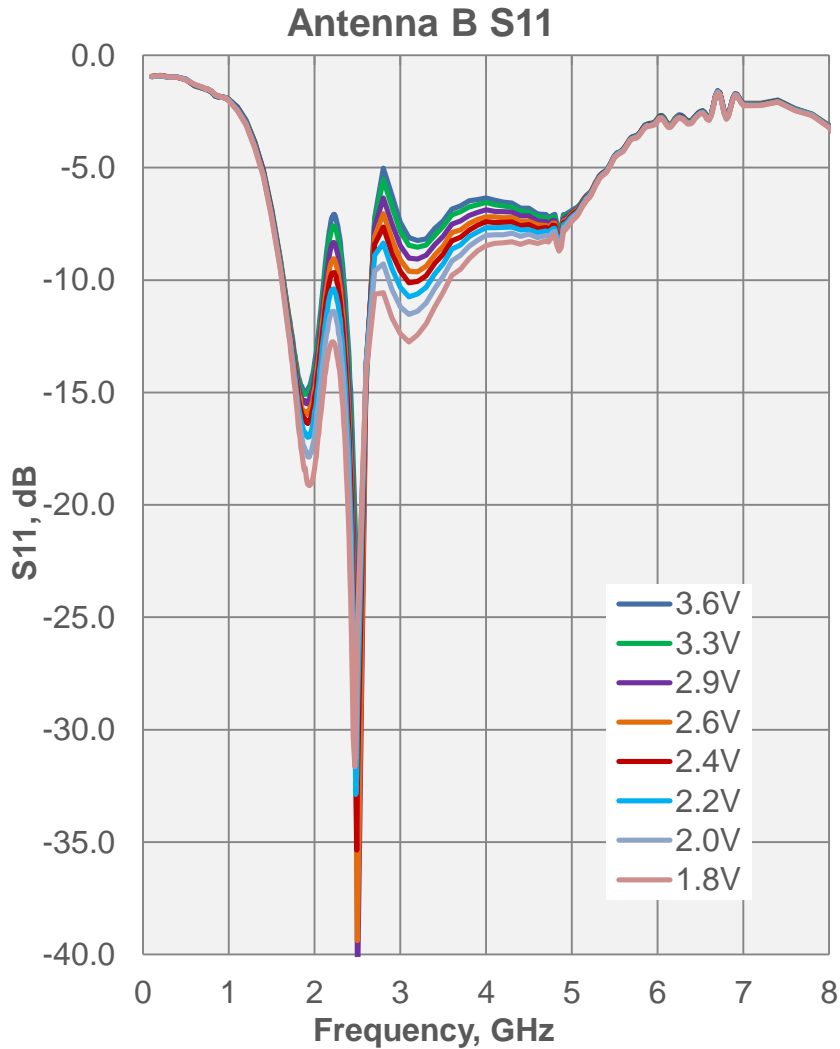


Idq ~ 18mA

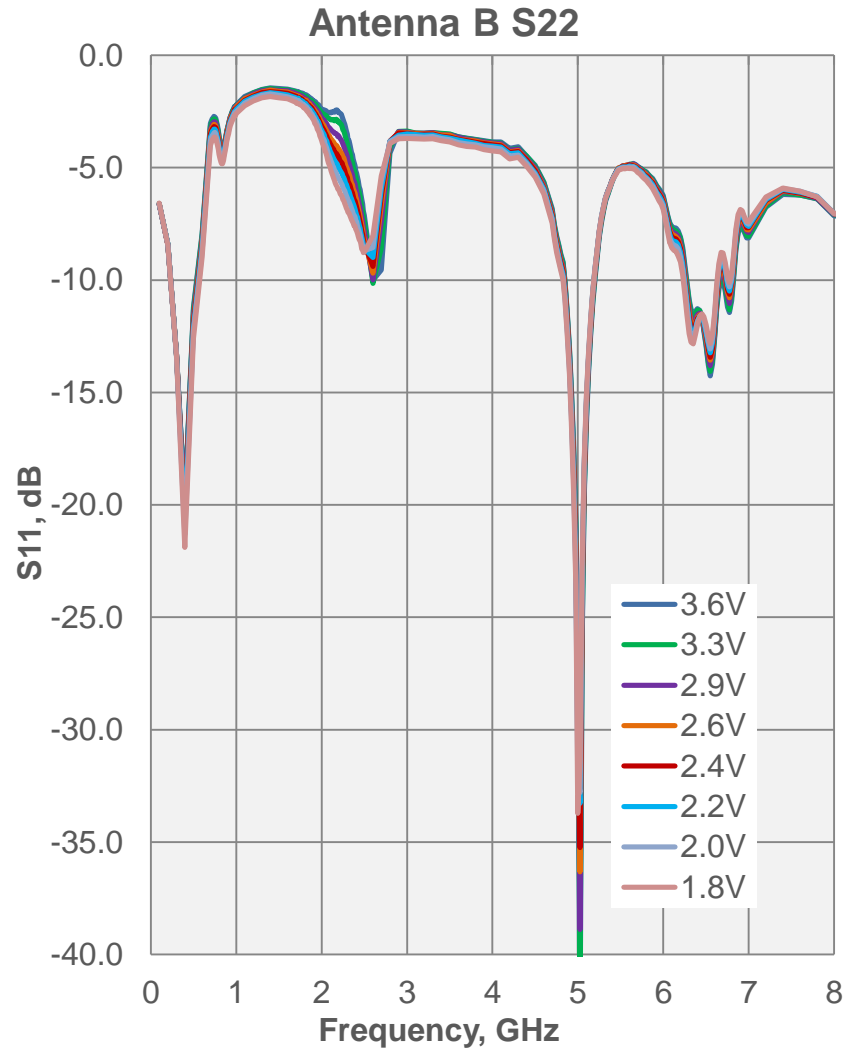


# TX S-Parameters Across Voltage

## Antenna B S11 and S22, High Idq Mode

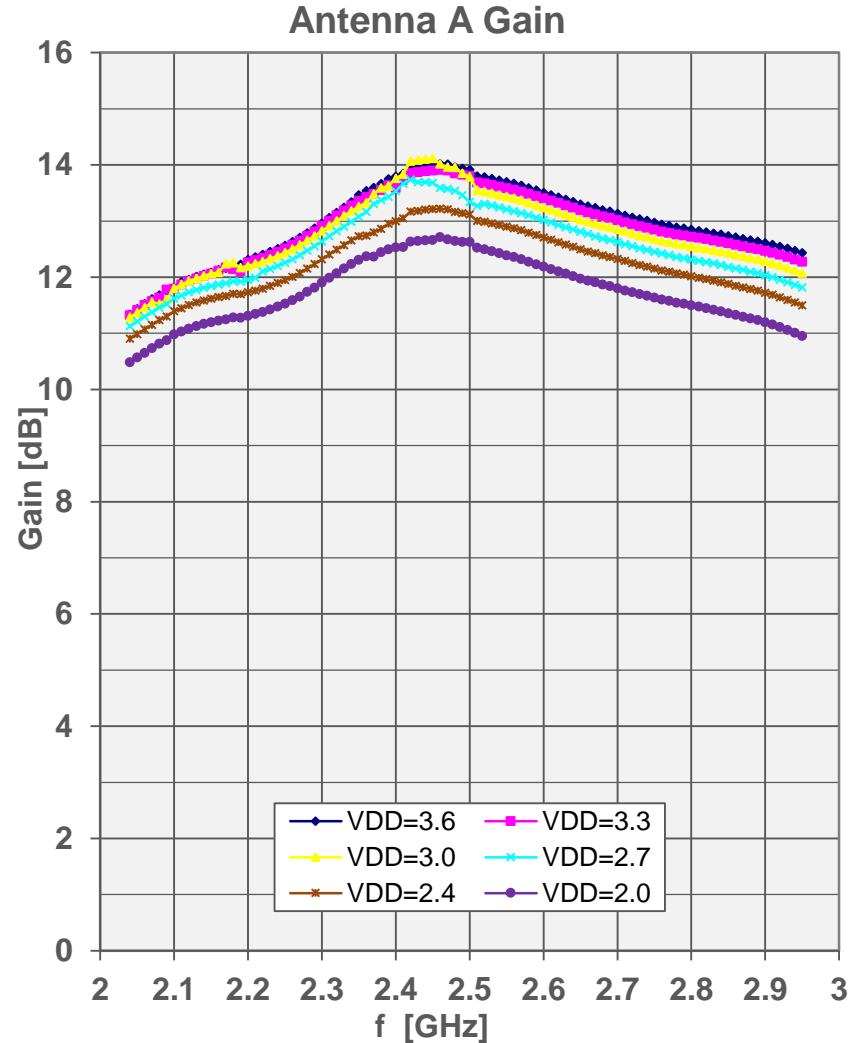
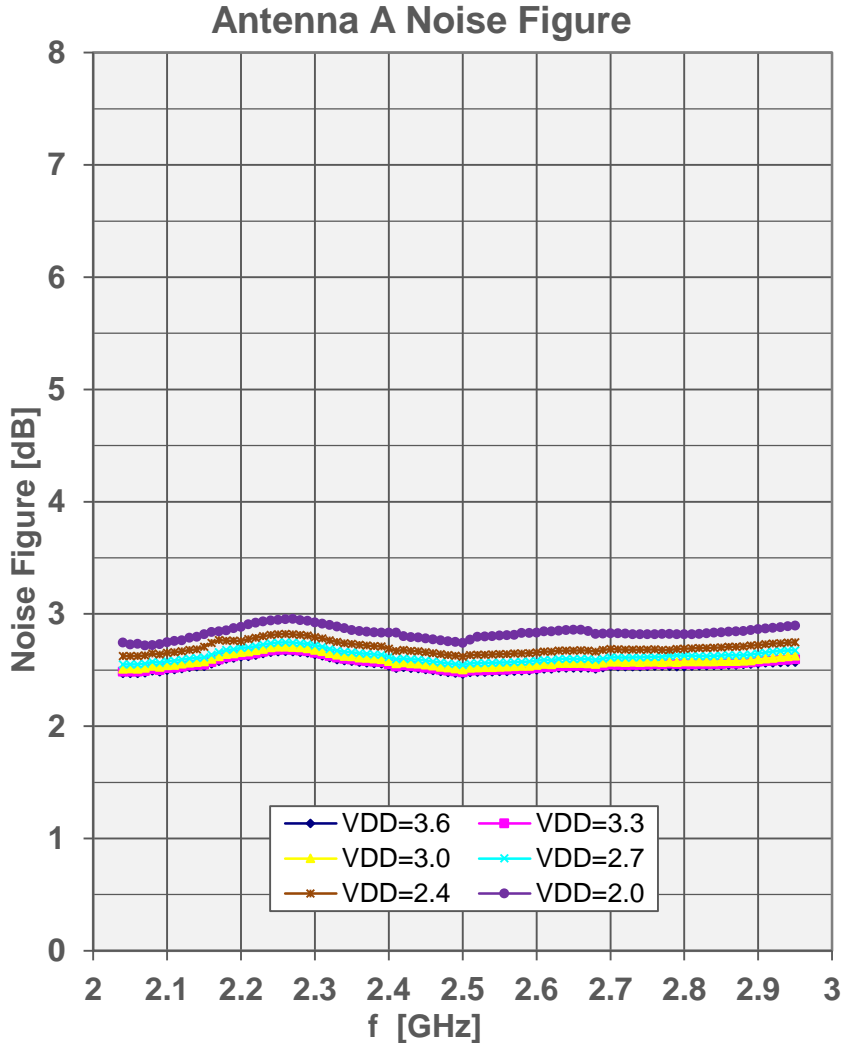


Idq ~ 18mA



# RX Noise Figure and Gain

## Antenna A, Low Noise Figure Mode

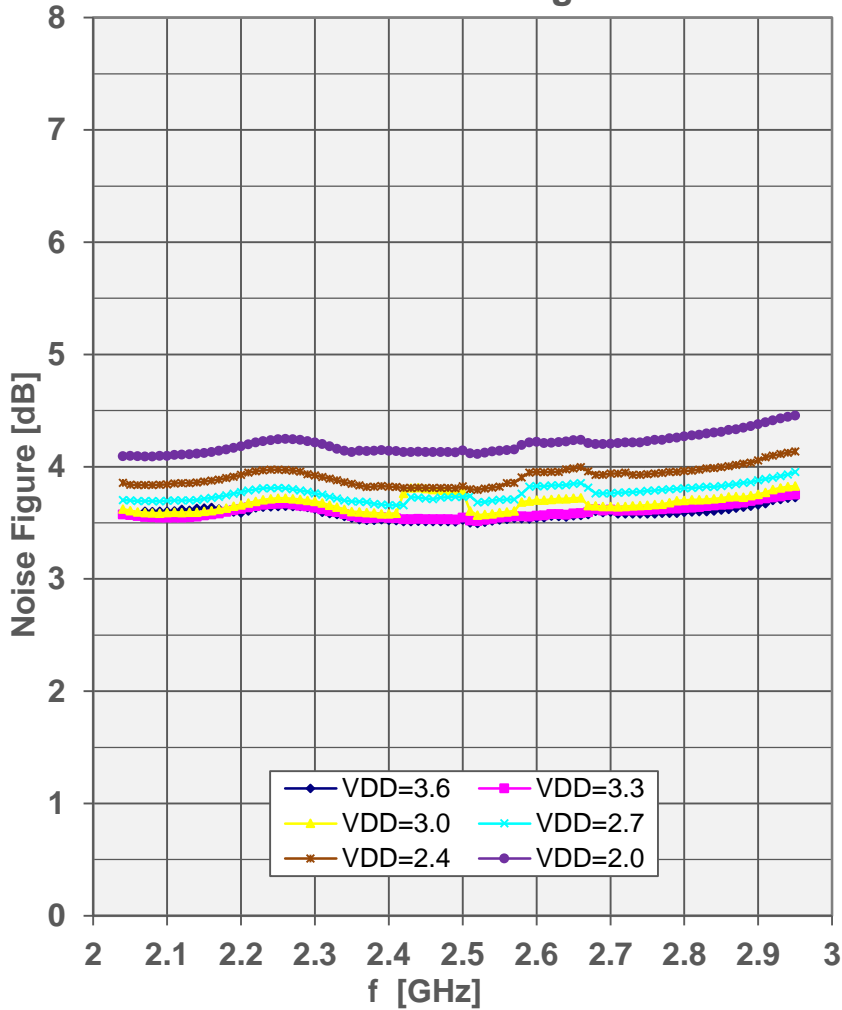


TXEN=0V, RXEN=1.2V, SWANT=1.2V, Mode=0V, Idq= 9 mA

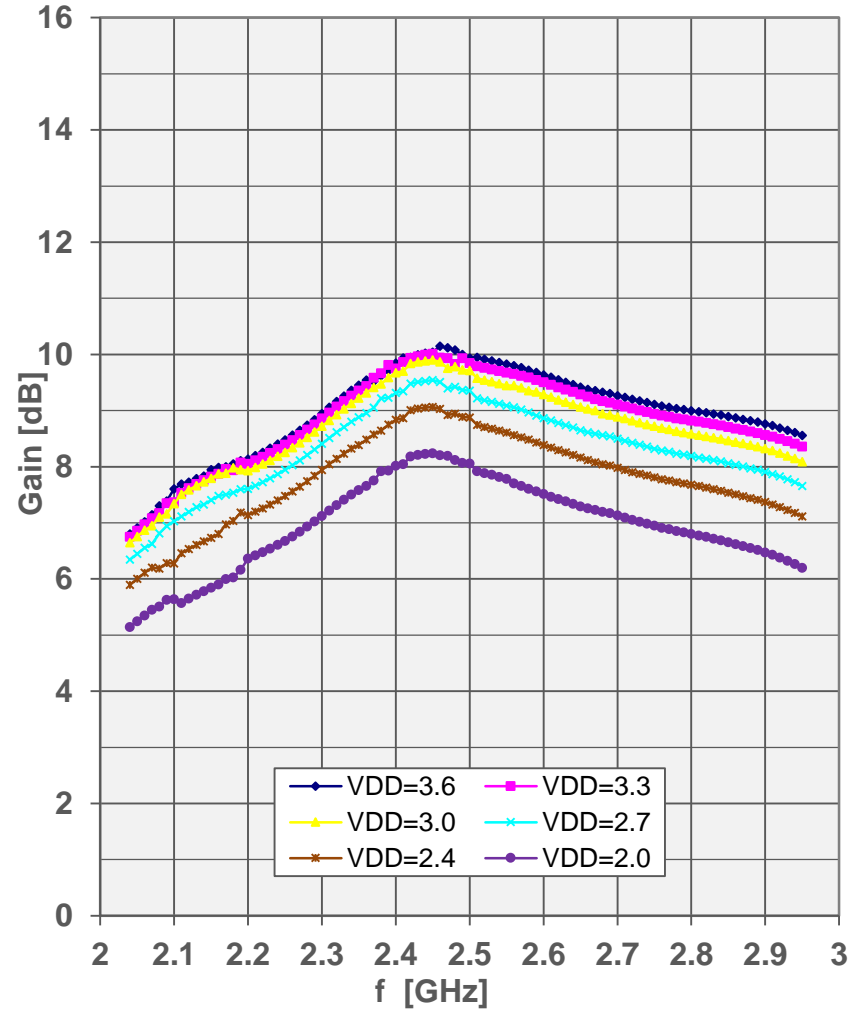
# RX Noise Figure and Gain

## Antenna A, Low Current Mode

### Antenna A Noise Figure



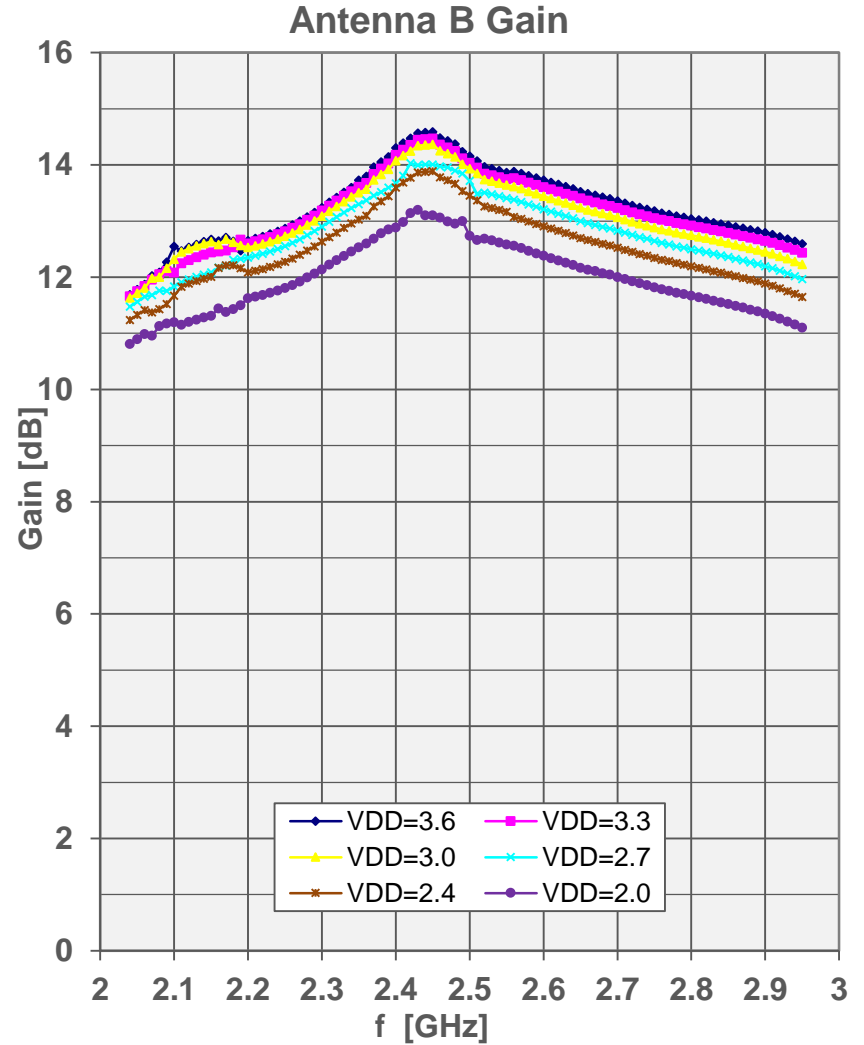
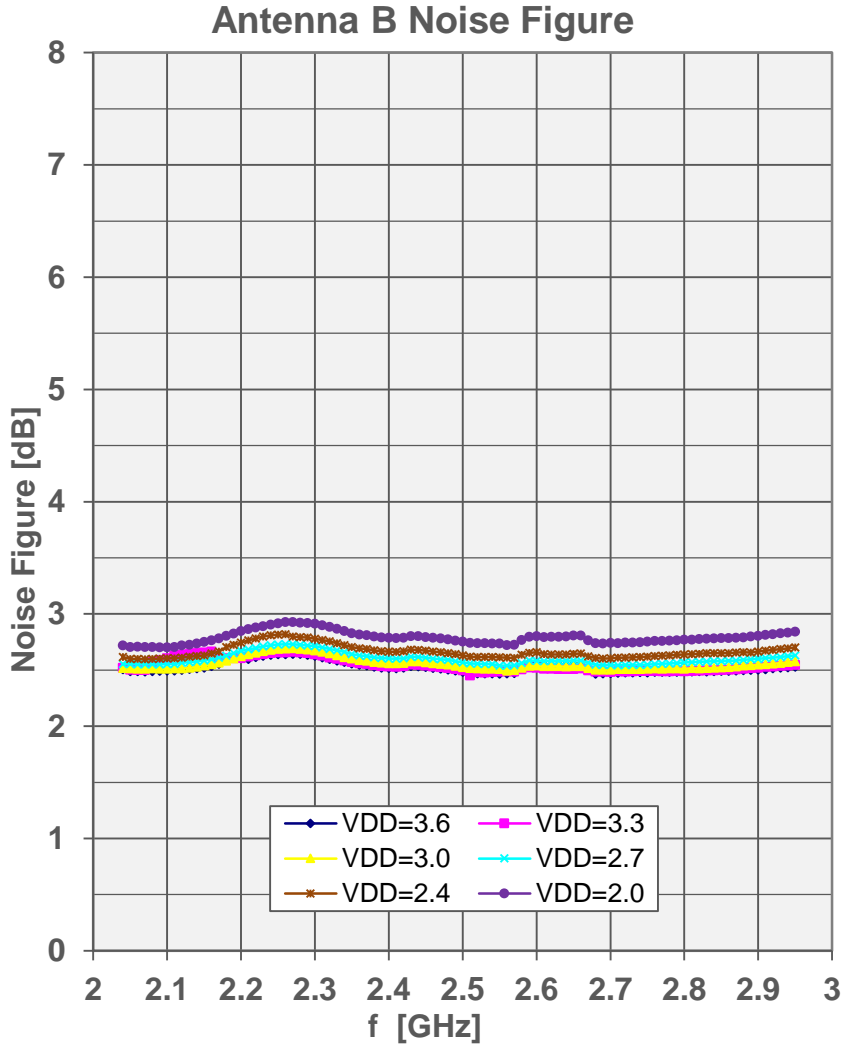
### Antenna A Gain



TXEN=0V, RXEN=1.2V, SWANT=1.2V, Mode=1.2V Idq= 3 mA

# RX Noise Figure and Gain

## Antenna B, Low Noise Figure Mode

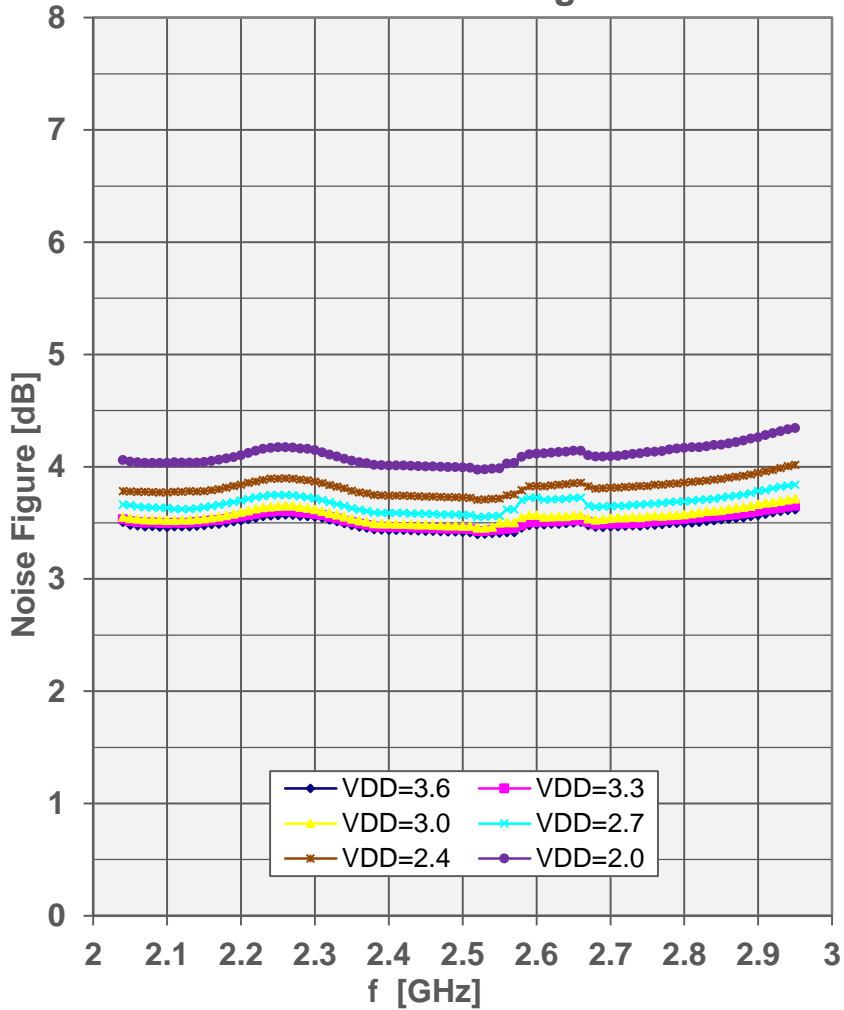


TXEN=0V, RXEN=1.2V, SWANT=1.2V, Mode=0V, Idq= 9 mA

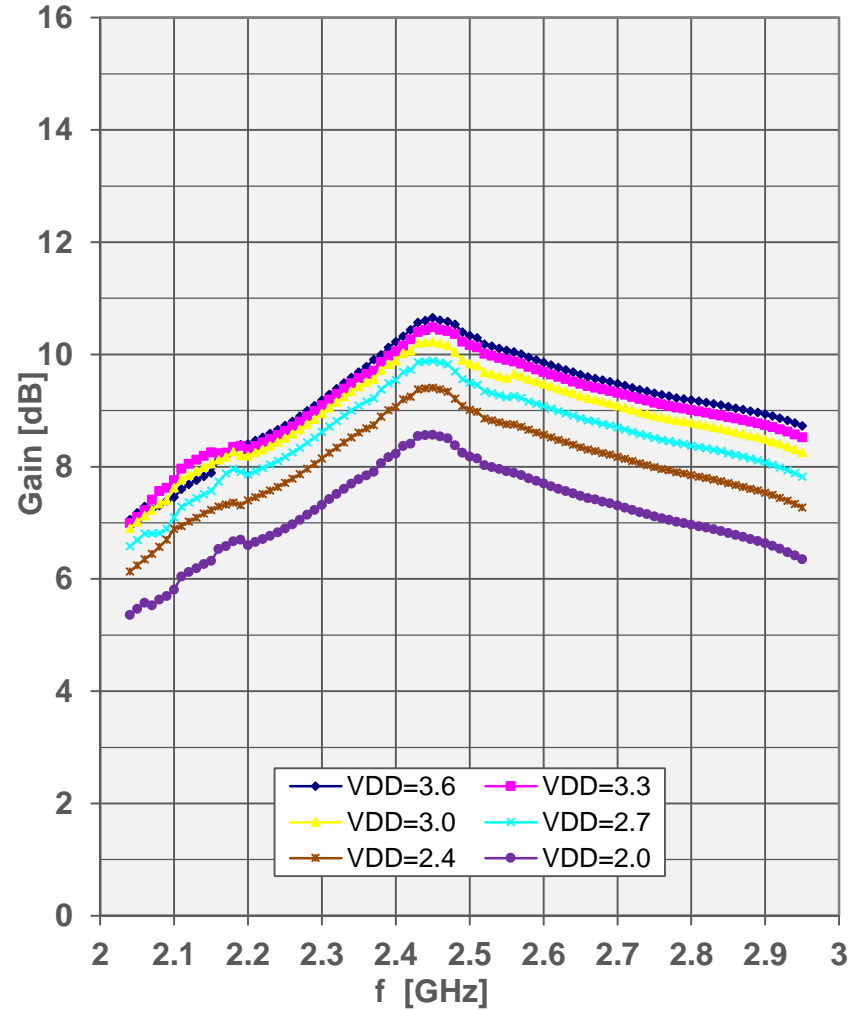
# RX Noise Figure and Gain

## Antenna A, Low Current Mode

### Antenna B Noise Figure



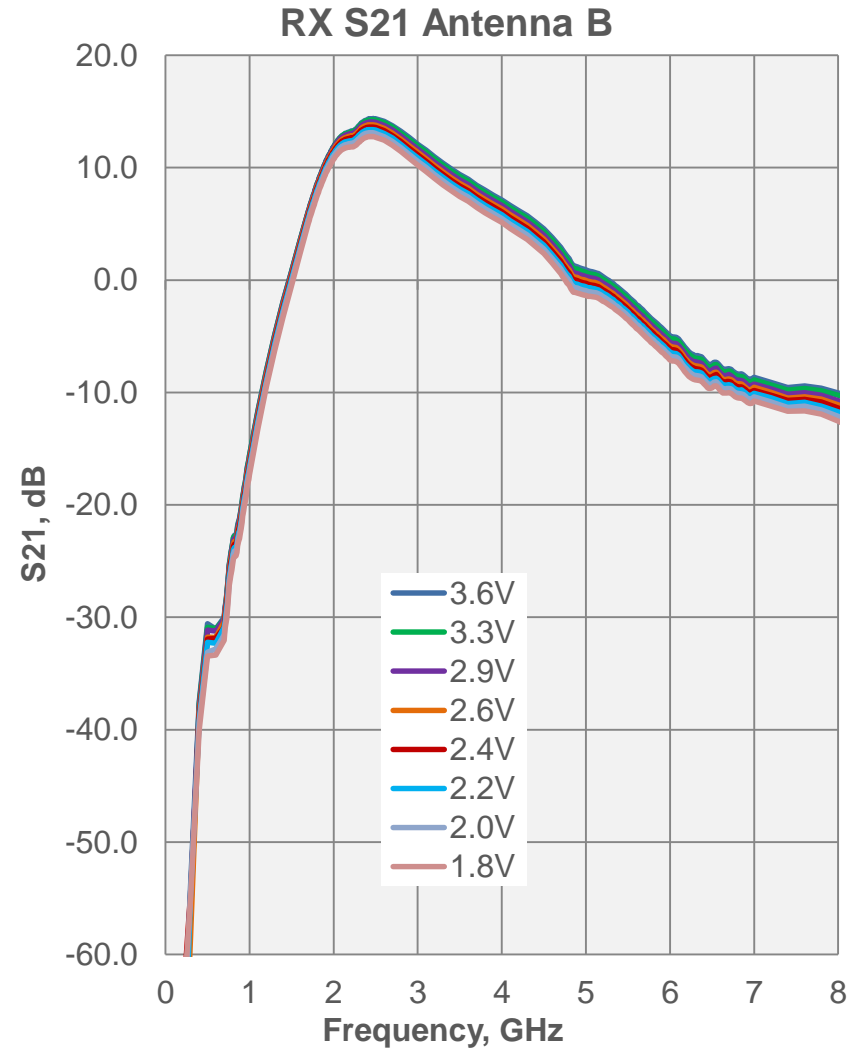
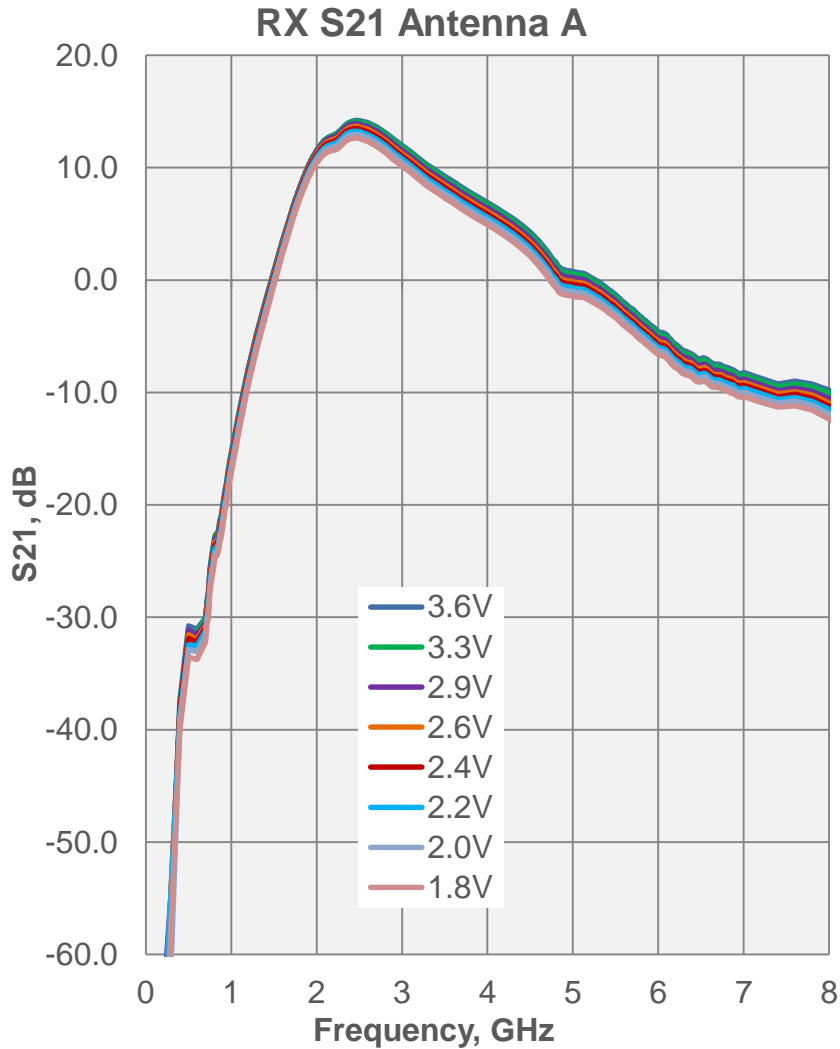
### Antenna B Gain



TXEN=0V, RXEN=1.2V, SWANT=1.2V, Mode=1.2V Idq= 3 mA

# RX S-Parameters Across Voltage

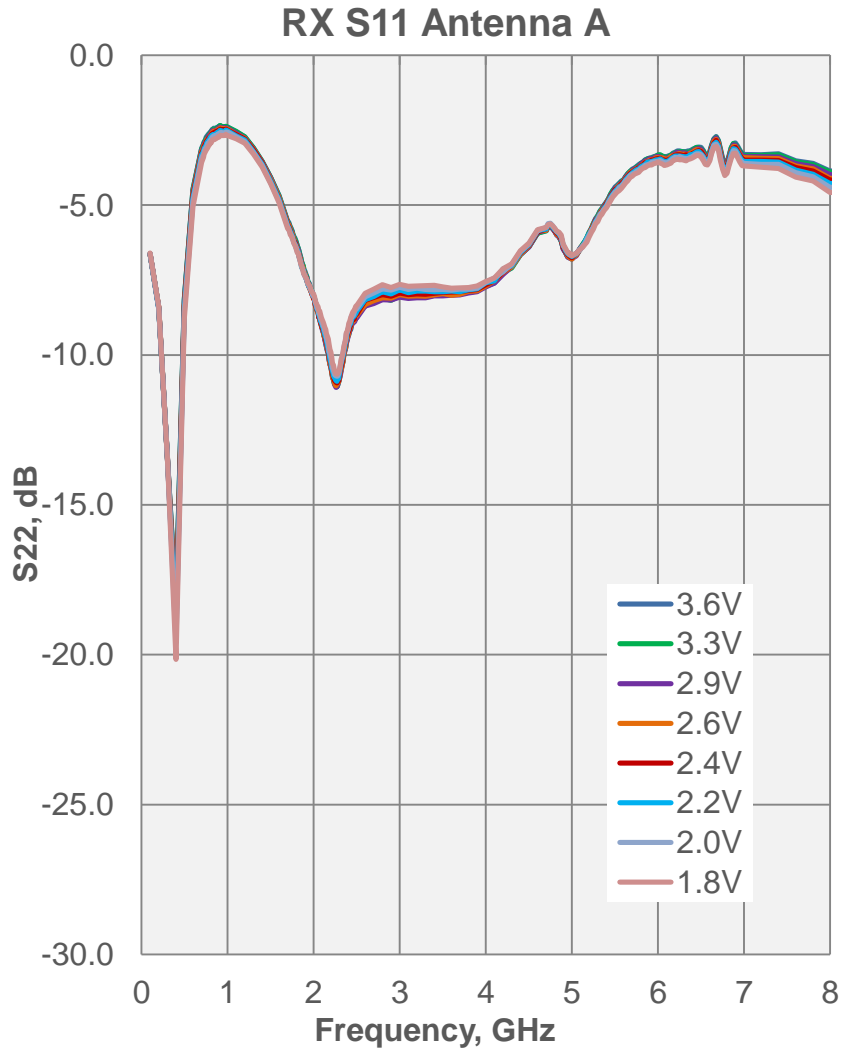
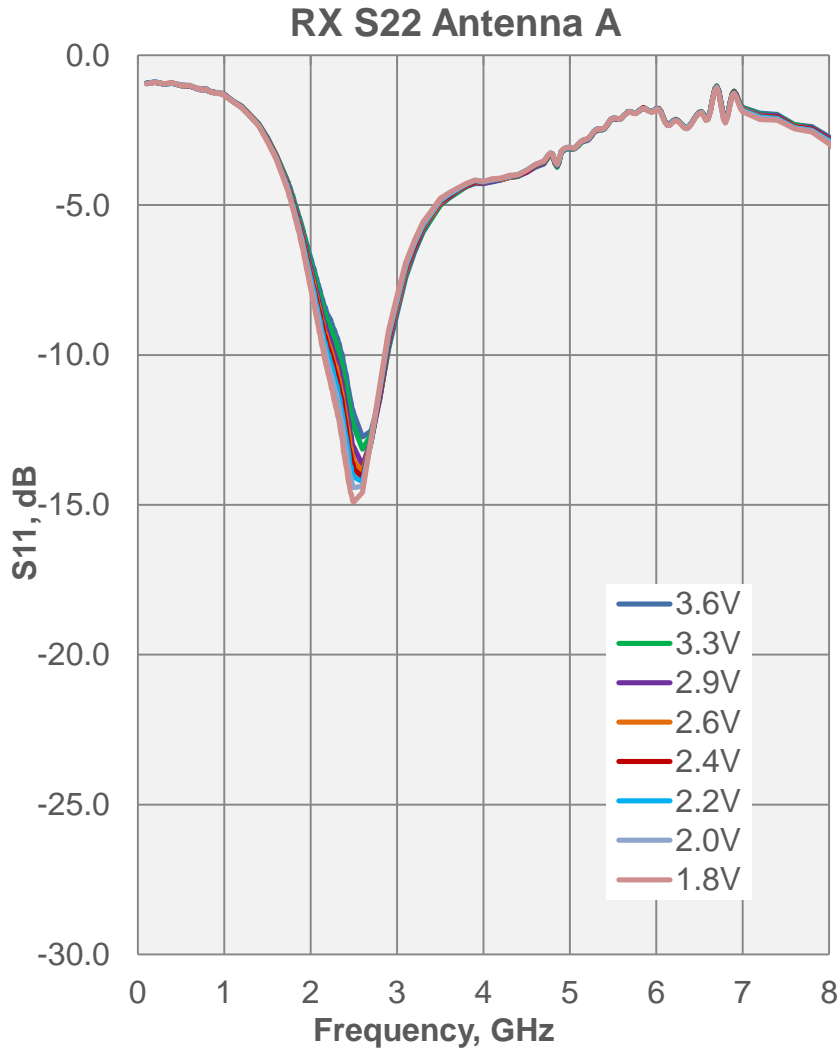
## Antenna A and B, Low Noise Figure Mode



$I_{dq} \sim 9\text{mA}$

# RX S-Parameters Across Voltage

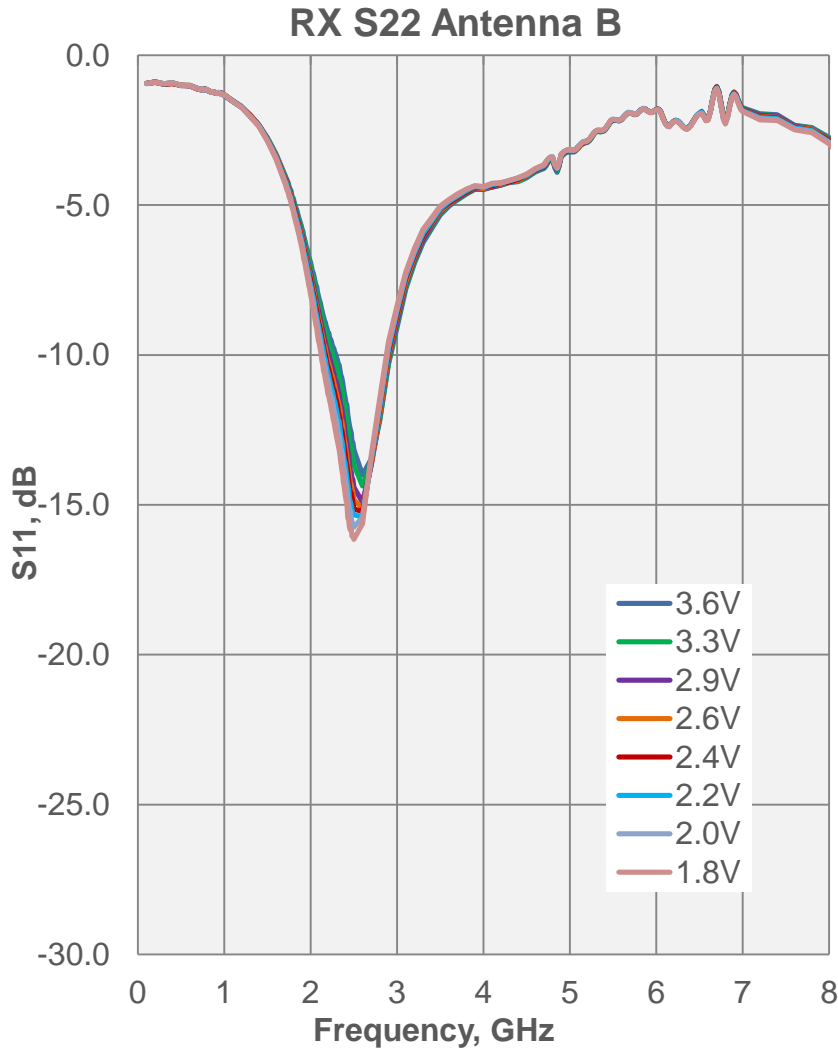
## Antenna A S11 and S22, Low Noise Figure Mode



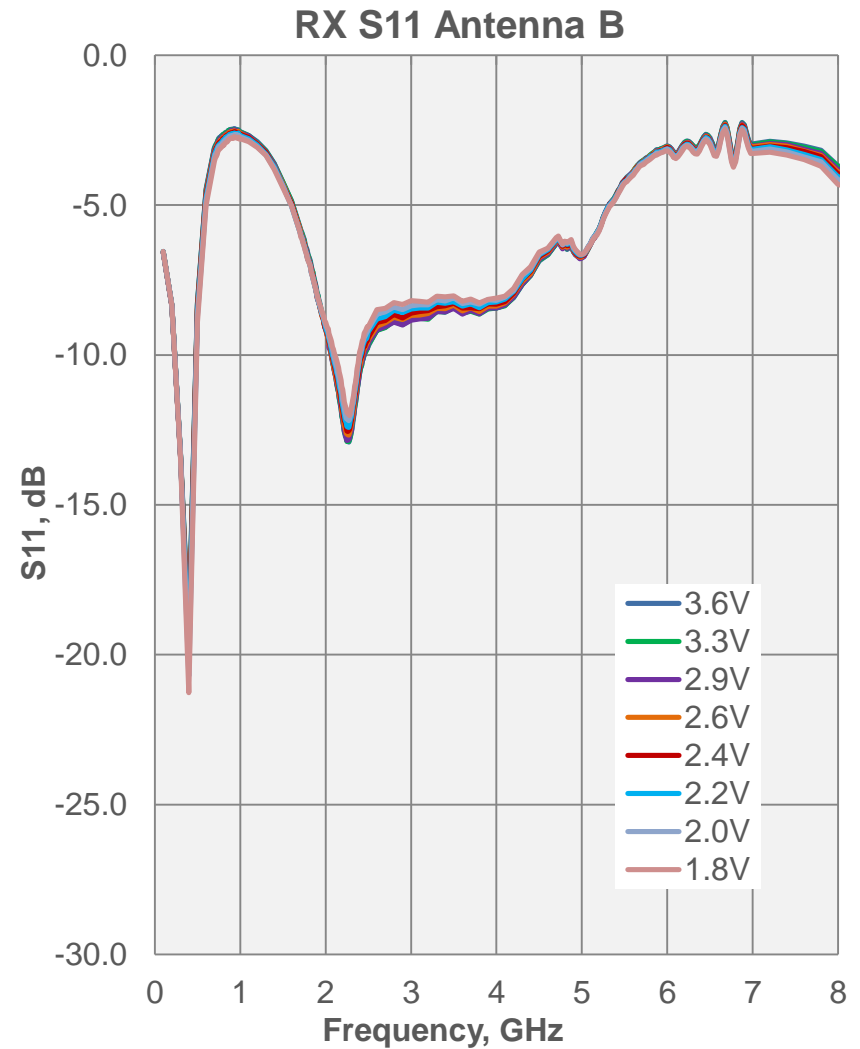
Idq ~ 9mA

# RX S-Parameters Across Voltage

## Antenna B S11 and S22, Low Noise Figure Mode



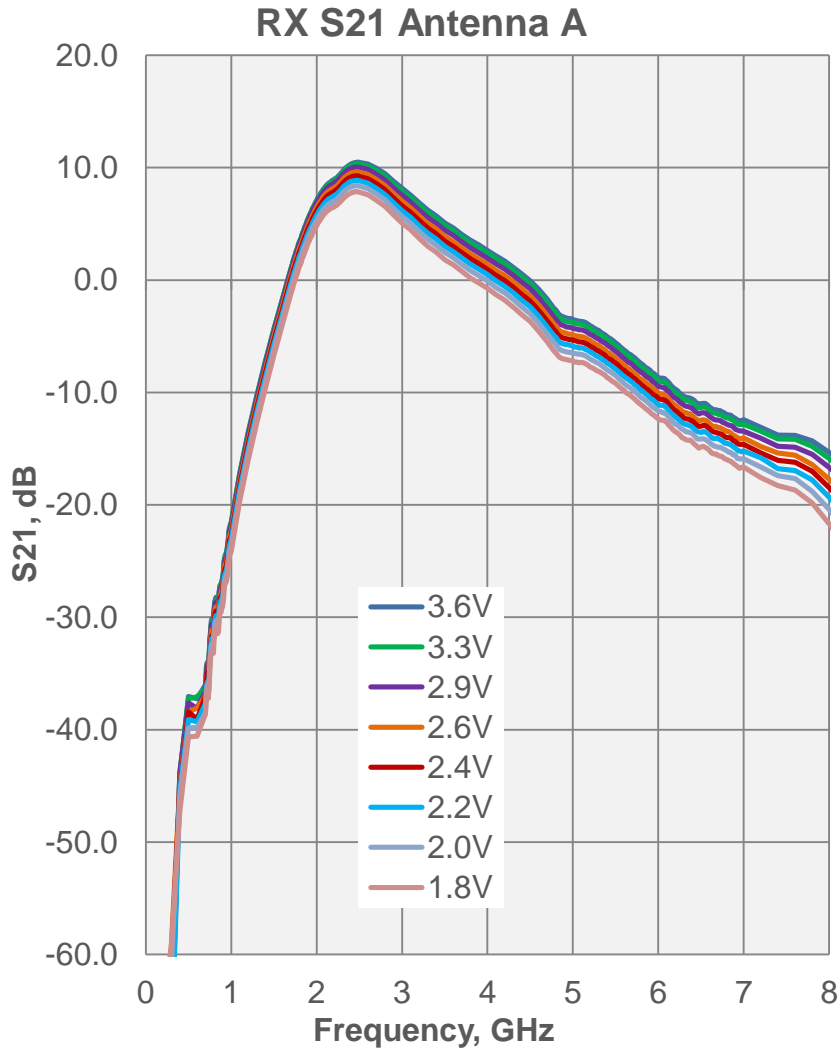
$I_{dq} \sim 9\text{mA}$



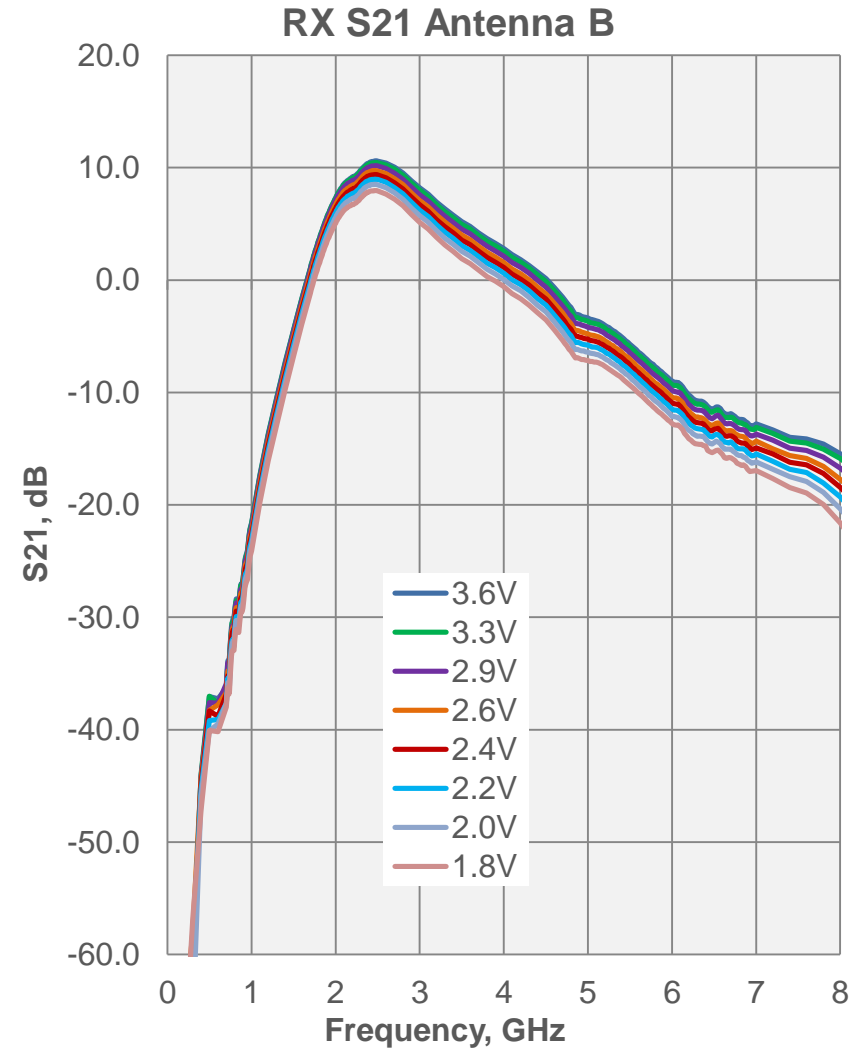


# RX S-Parameters Across Voltage

## Antenna A and B, Low Current Mode

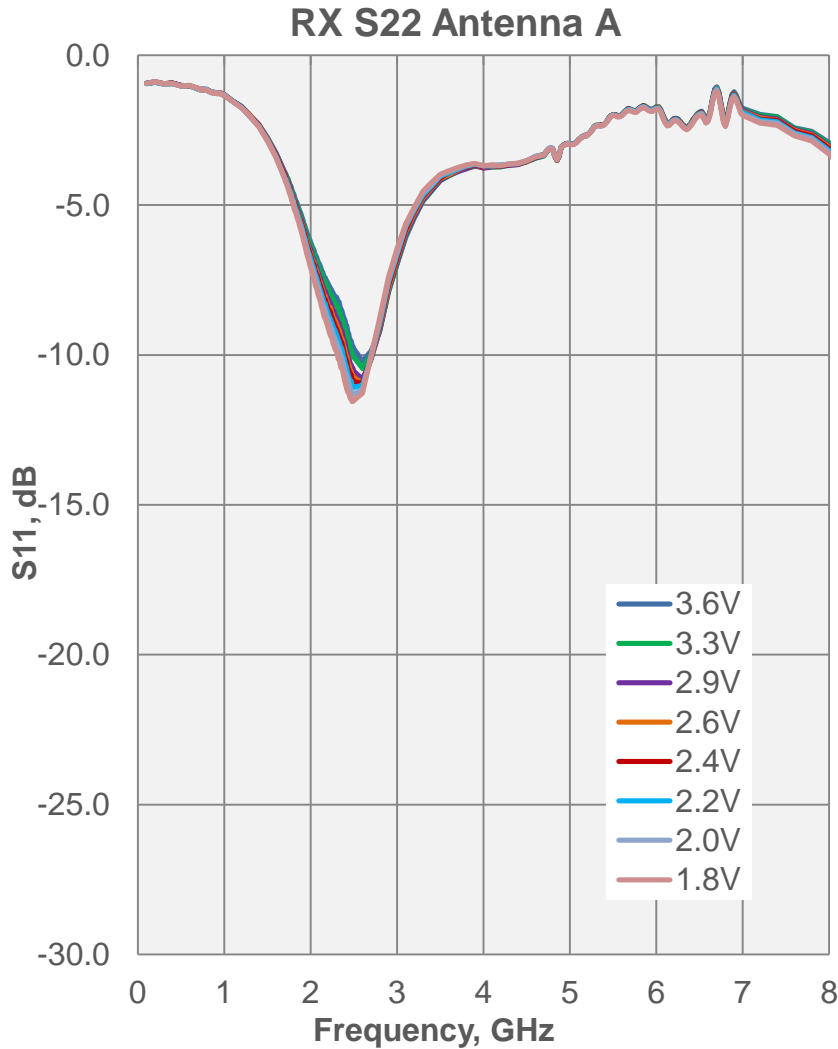


$I_{dq} \sim 3\text{mA}$

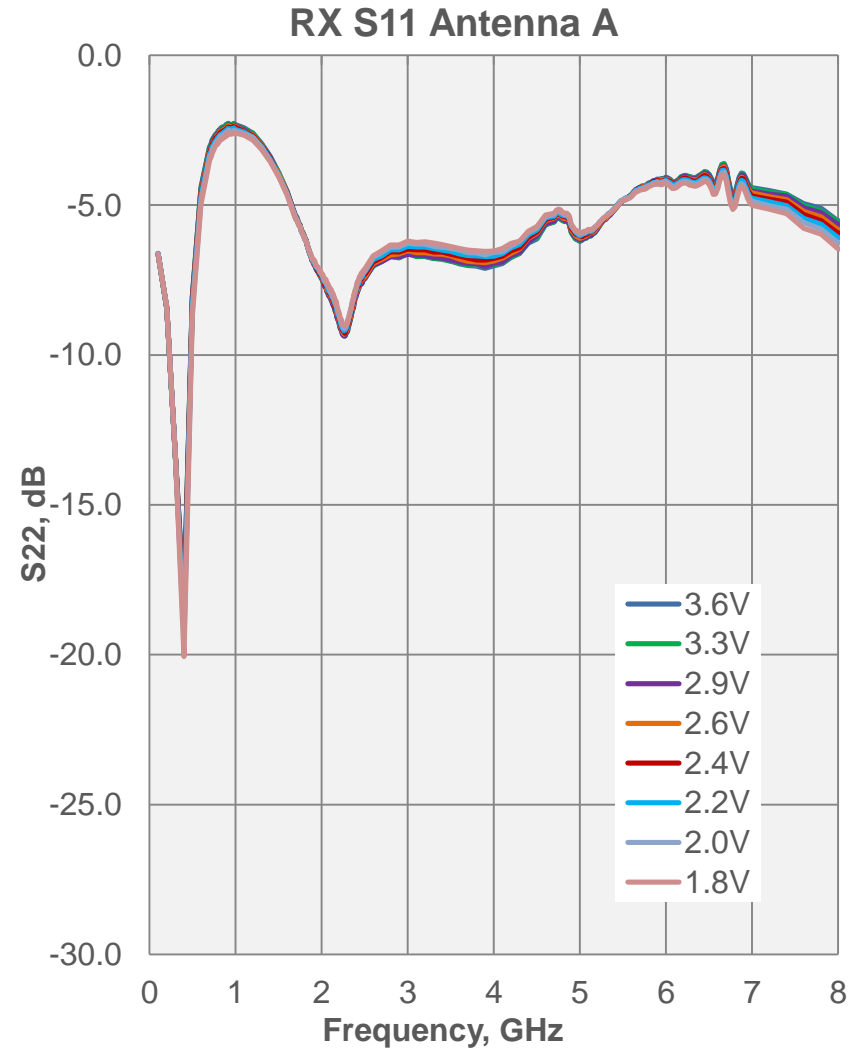


# RX S-Parameters Across Voltage

## Antenna A S11 and S22, Low Current Mode

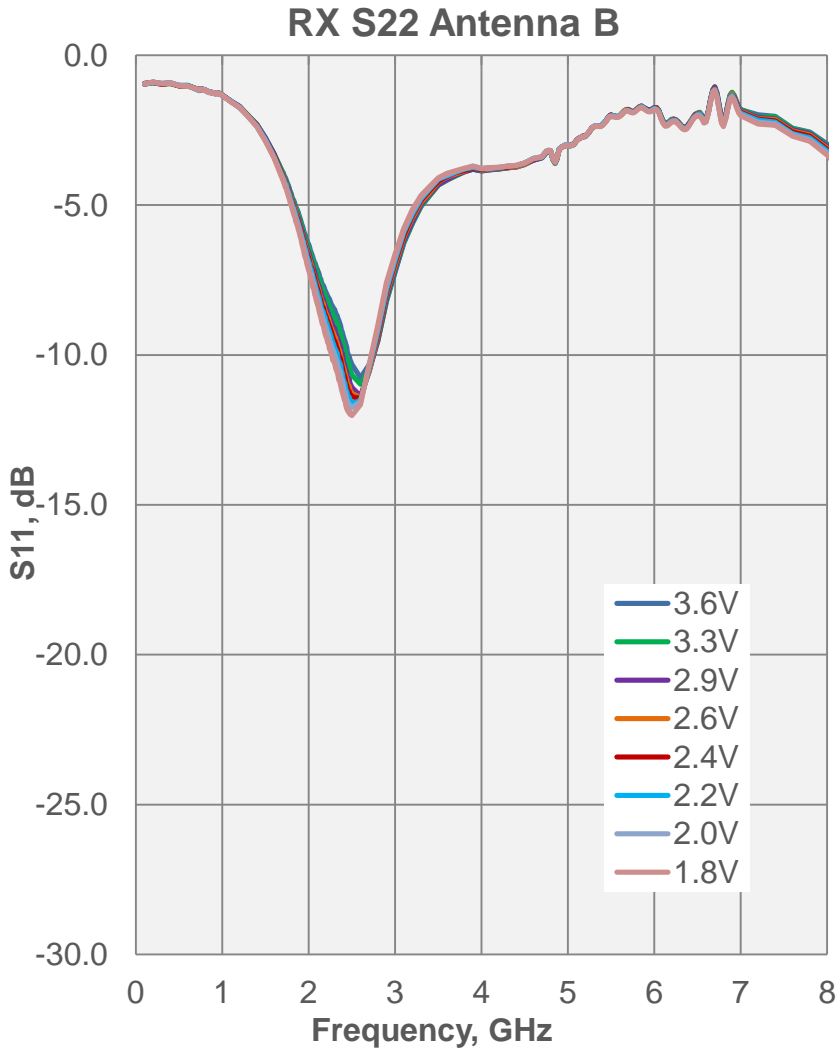


$I_{dq} \sim 3\text{mA}$

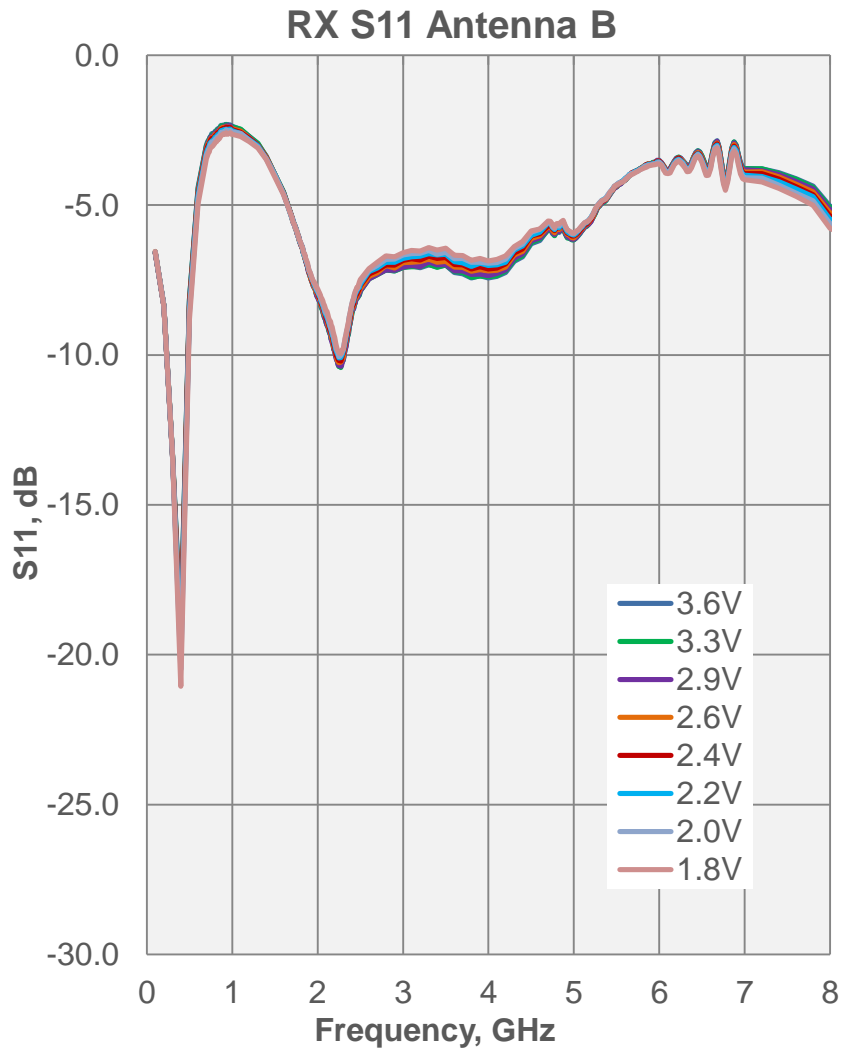


# RX S-Parameters Across Voltage

## Antenna B S11 and S22, Low Current Mode

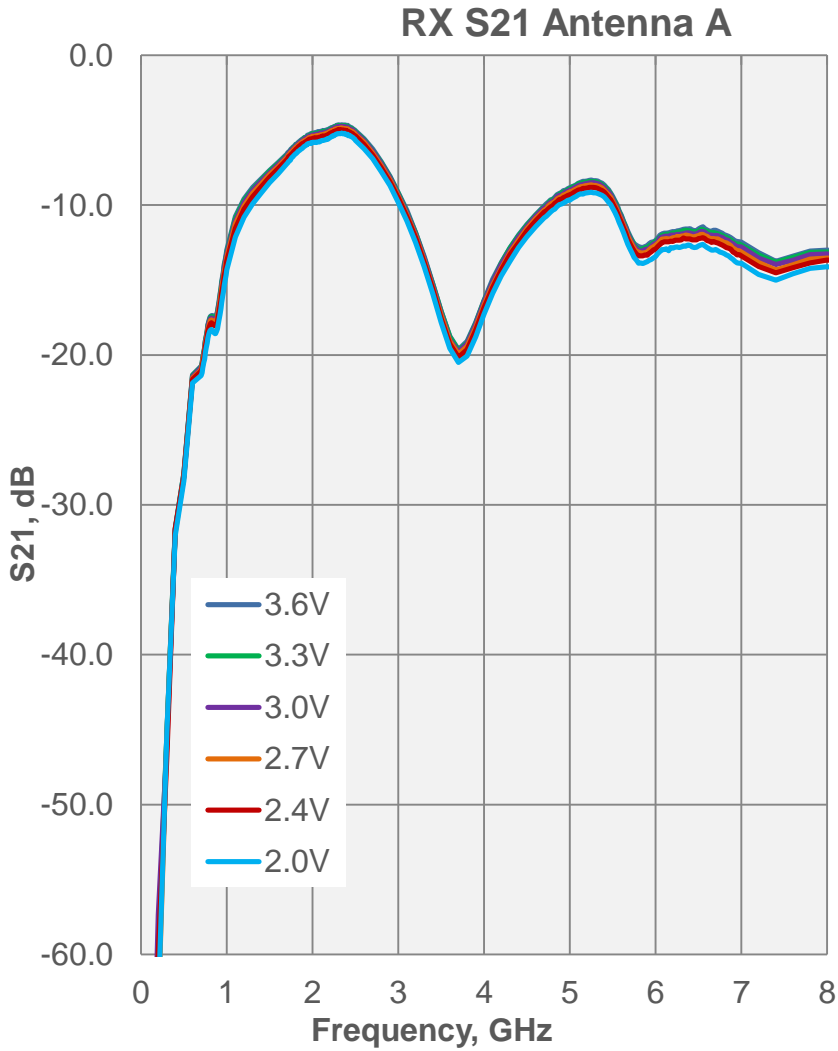


$I_{dq} \sim 3\text{mA}$

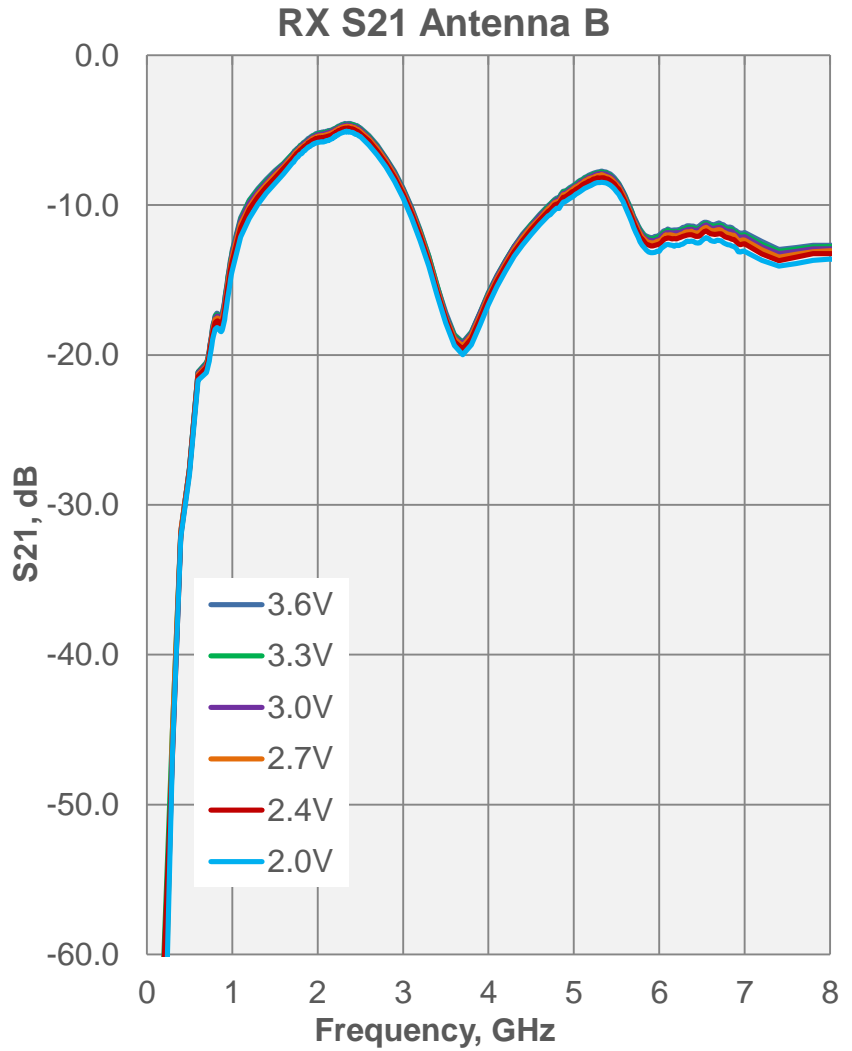


# Bypass S-Parameters Across Voltage

## Antenna A and B

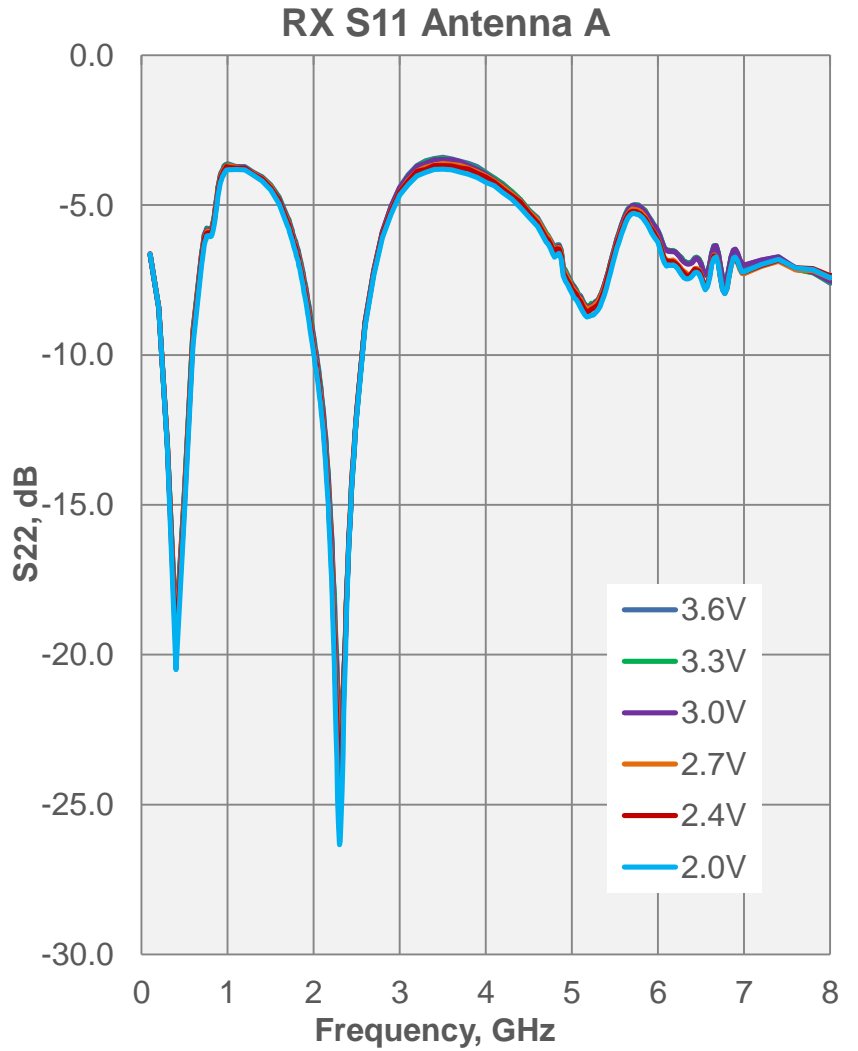
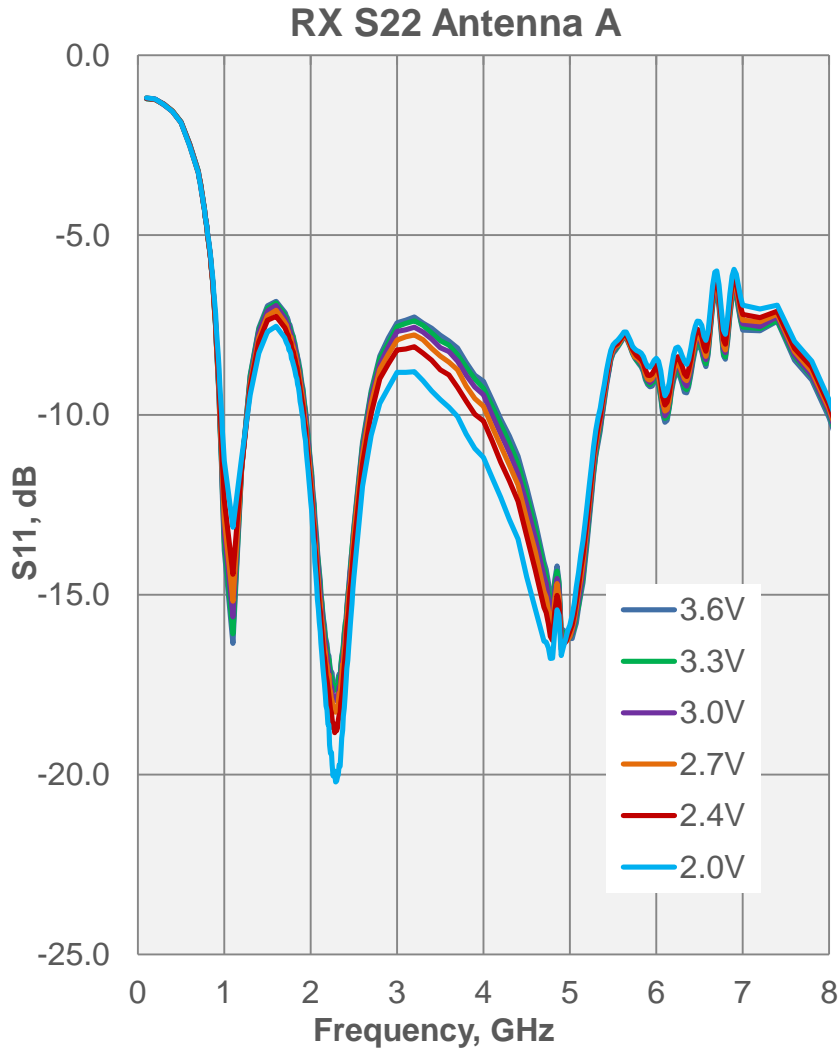


$I_{dq} \sim 1\mu A$



# Bypass S-Parameters Across Voltage

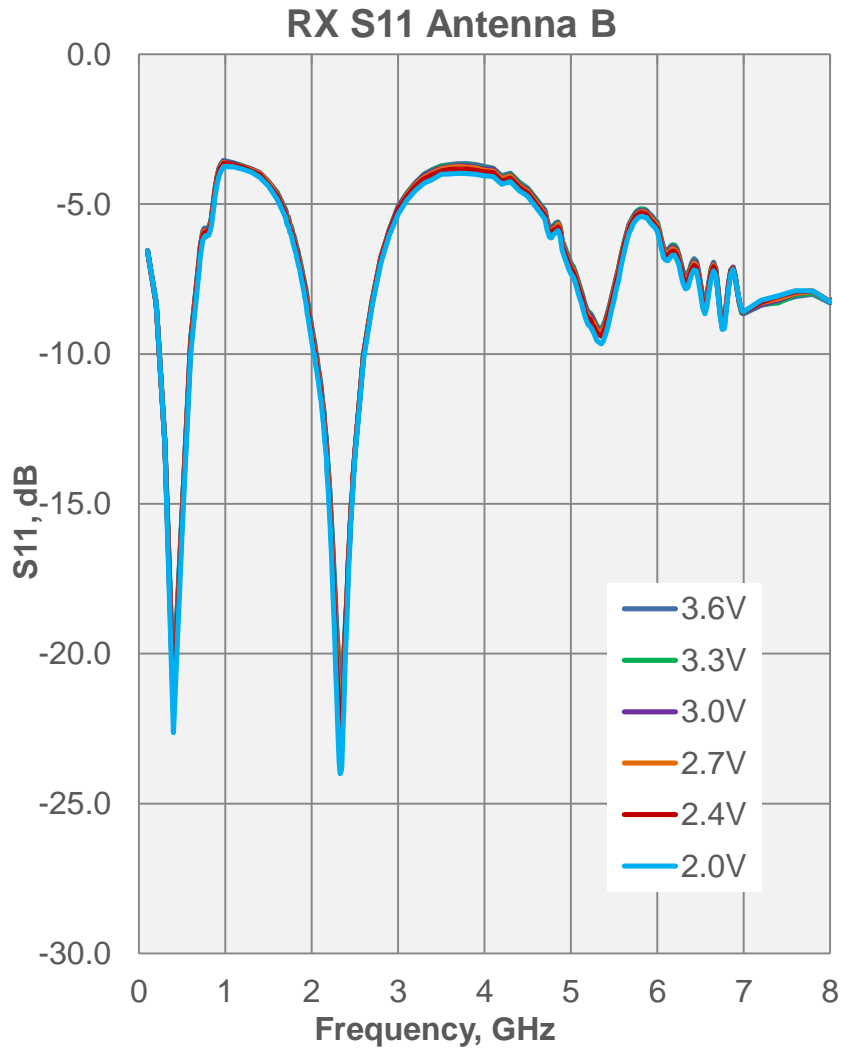
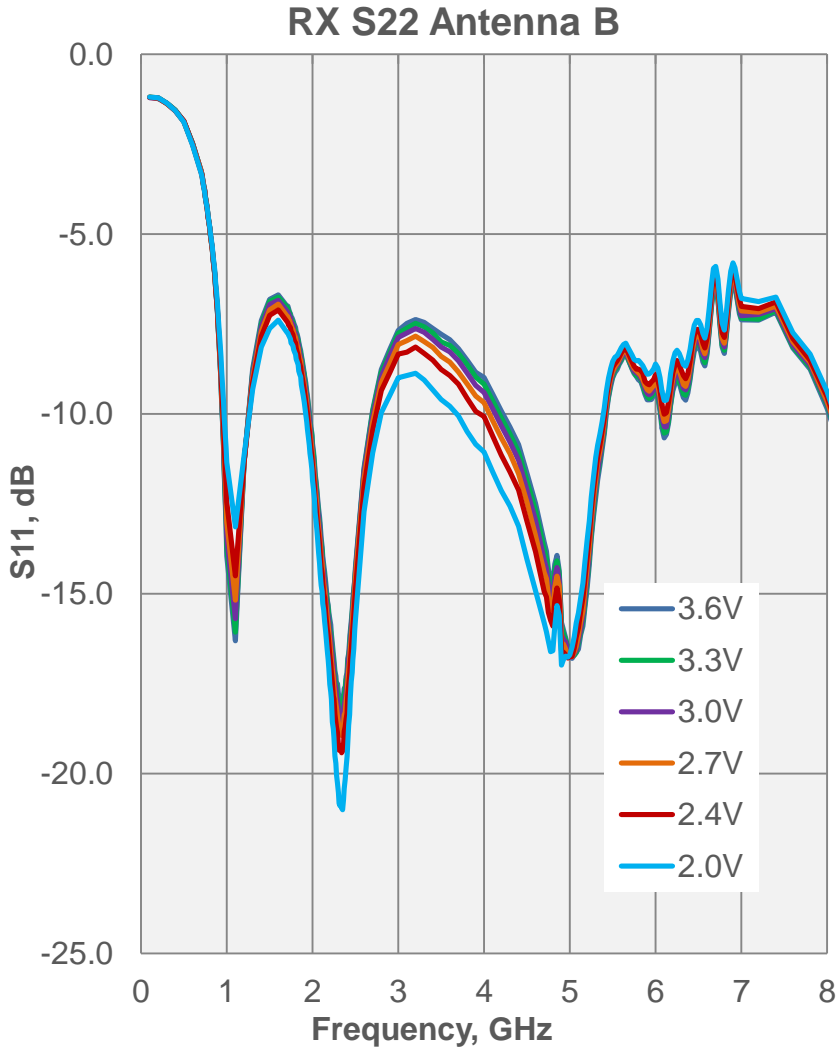
## Antenna A S11 and S22



Idq ~ 1uA

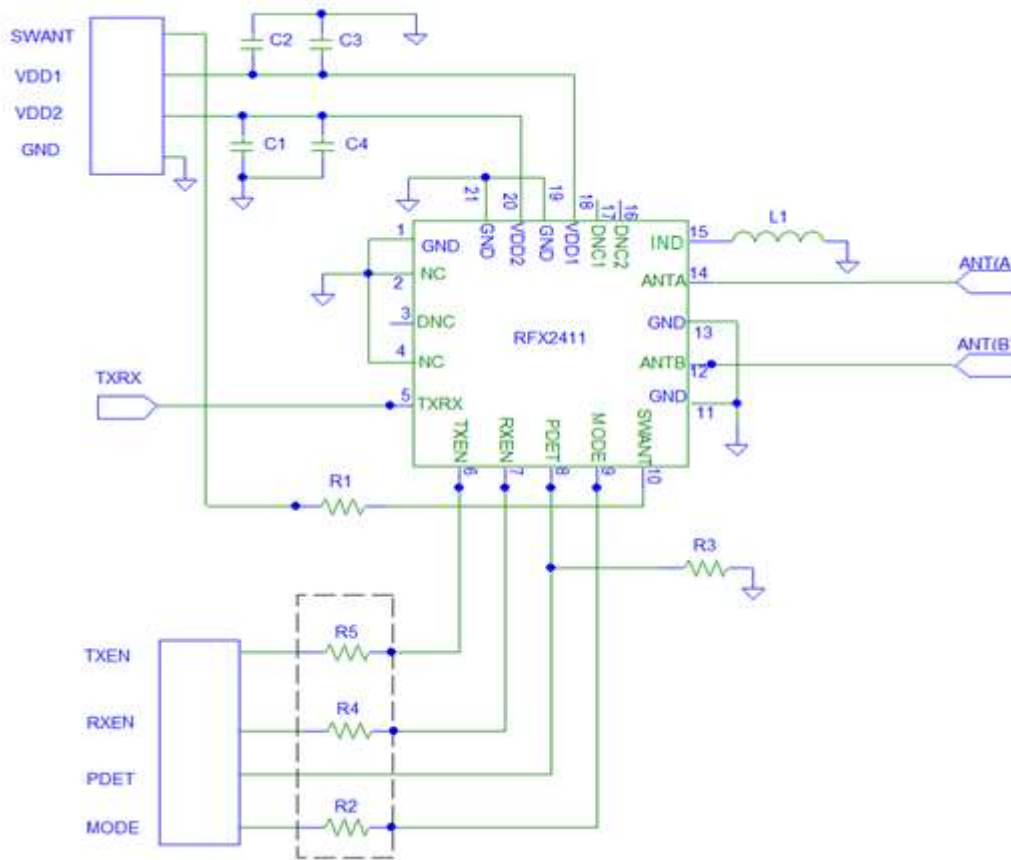
# RX S-Parameters Across Voltage

## Antenna B S11 and S22



Idq ~ 1uA

# RFX2411 Application Schematic



## Recommended BOM:

- R3=10K
- R1=R2=R4=R5=1K
- C1=C2=2.2uF
- C3=C4=220pF
- L1=1.2nH

## Notes:

R1, R2, R4, R5 on the control lines are for standalone EVBs, and are recommended in actual system implementation when the control line voltage will approach VDD