CIG Measured Antenna Data Package

Performance Data & Compliance

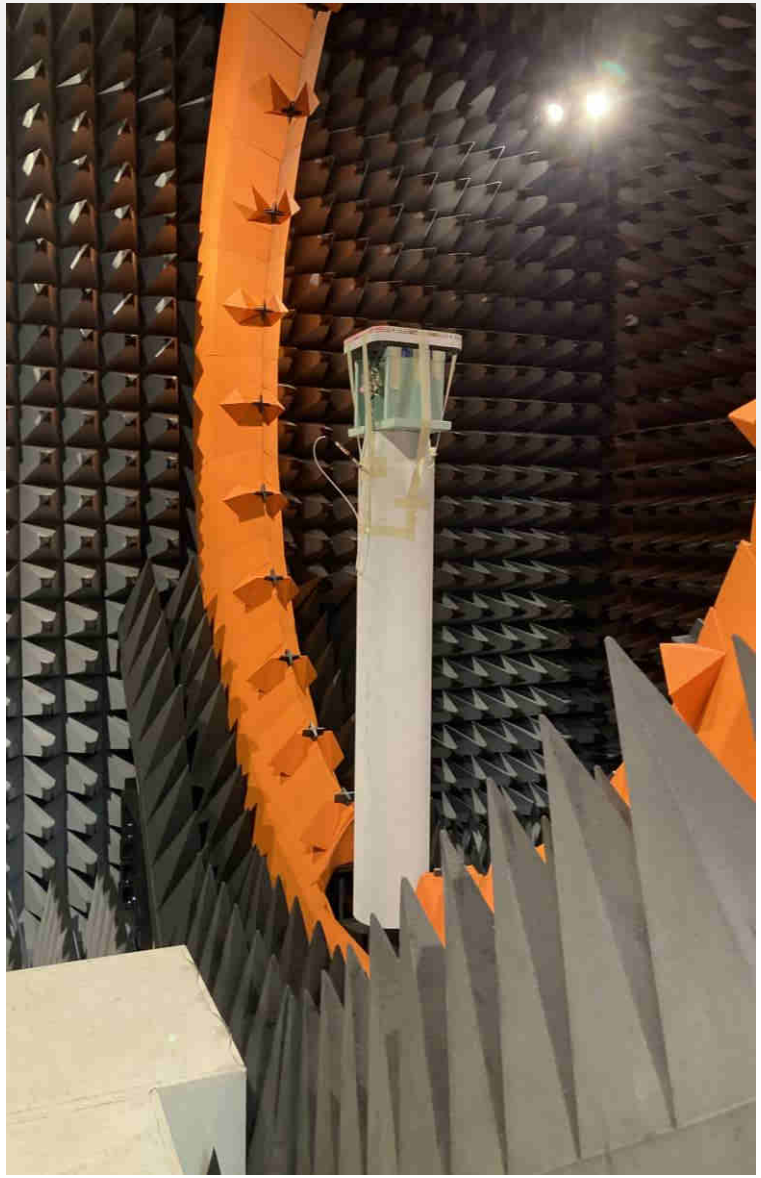
September 14, 2022

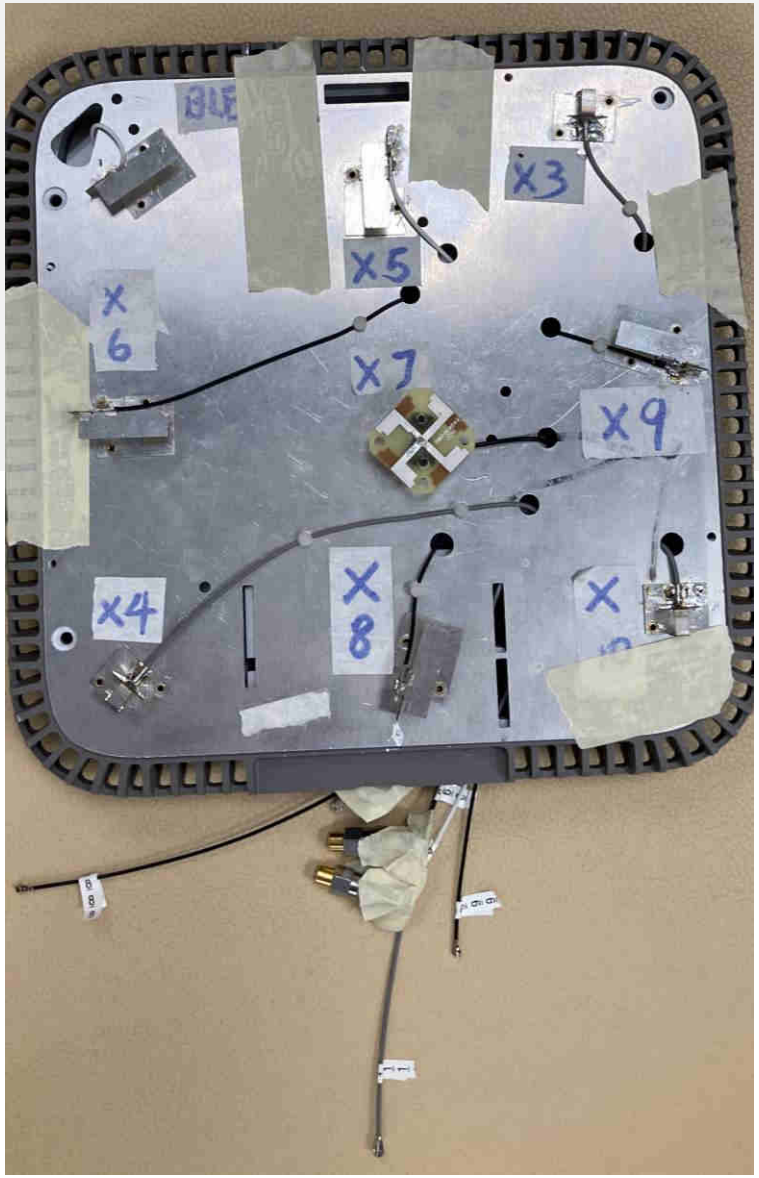
Rev 5

PCTEL®

Measurement Equipment, Port Assignments, & Cable Management

- S-parameters measured on Keysight E5071C network analyzer and radiation patterns measured in MVG SG-24 anechoic chamber
- Antenna cables lengthened to route out the ethernet ports on the bottom of the access point; this means that the efficiency data is “worst-case”





Single-Band Antenna Data

Single-Band Antenna 6 GHz Data Summary

Antenna	Detail	X3: 6G			X4: 6G			X7: 6G			X10: 6G		
Frequency	2.4G-2.5G	5.925G	6.525G	7.125G	5.925G	6.525G	7.125G	5.925G	6.525G	7.125G	5.925G	6.525G	7.125G
Efficiency	%	65	66	65	64	63	64	54	59	53	66	66	66
Peak Gain	dBi	6.6	5.9	4.8	6.2	5.4	4.8	3.0	3.3	3.2	6.1	5.3	4.9
S11	<-10dB	-14	-13	-15	-13	-12	-13	-11	-14	-14	-15	-13	-14

Frequency	5.925G	6.525G	7.125G
Max. Uncorrelated Gain	3.1 dBi	2.8 dBi	2.6 dBi
Max. Correlated Gain	*8.8 dBi*	*8.6 dBi*	*8.4 dBi*

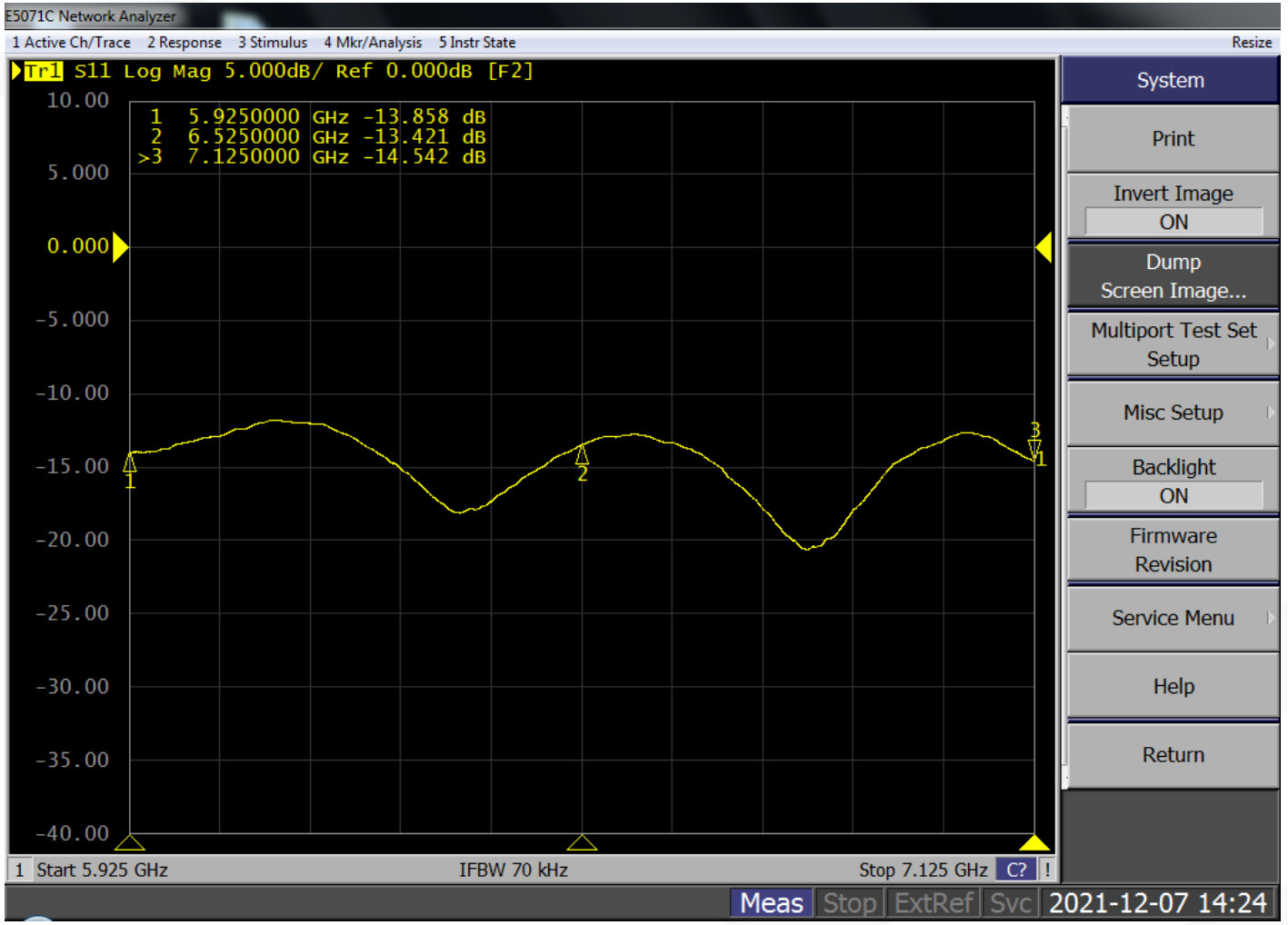
$$\text{Correlated Gain} = 10\log[(10^{G1/20} + 10^{G2/20} + \ldots + 10^{GN/20})^2 / N_{ANT}]\ \text{dBi}$$

$$\text{Uncorrelated Gain} = 10\log[(10^{G1/10} + 10^{G2/10} + \ldots + 10^{GN/10}) / N_{ANT}]\ \text{dBi}$$

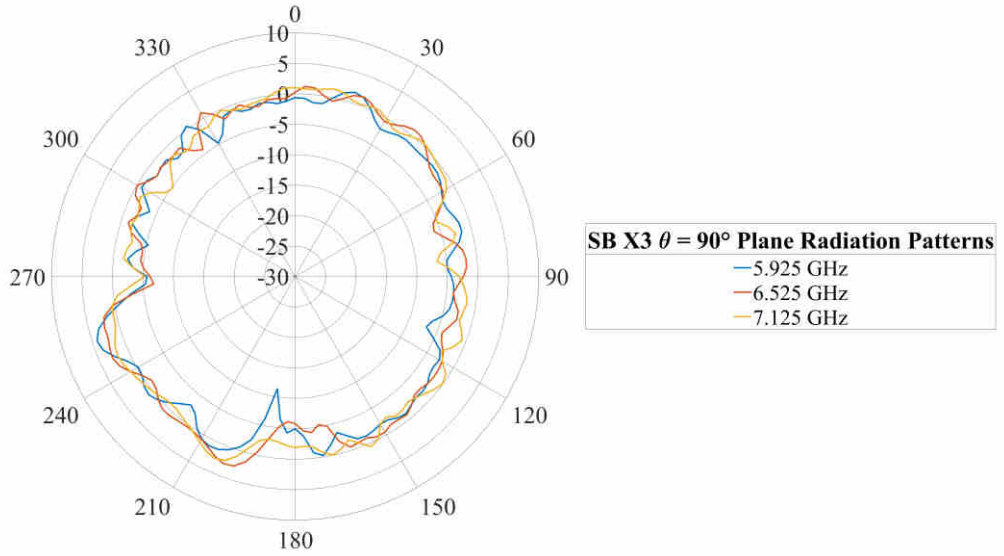
Updated at Rev. 5

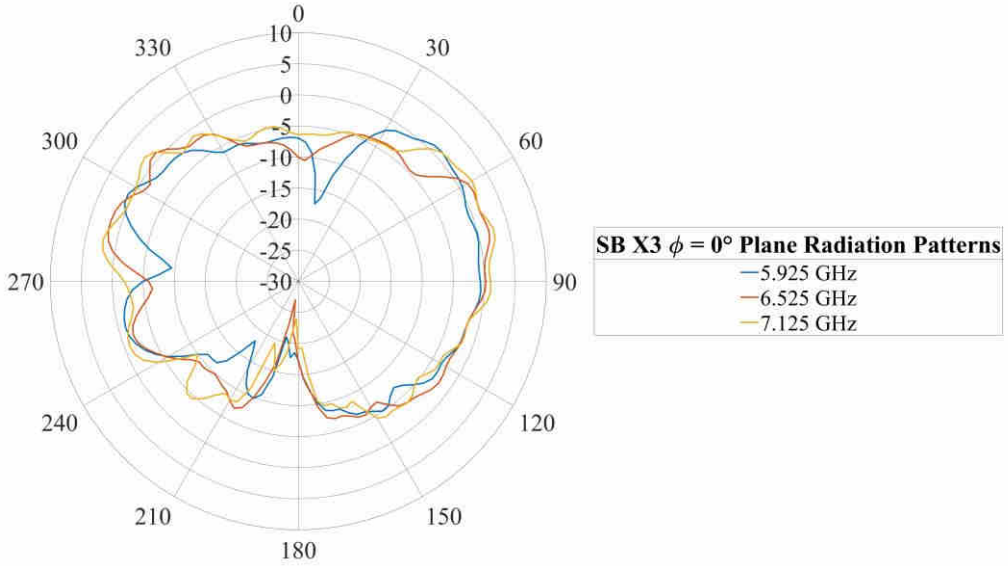
Note: Details refer to Correlated Gain Calculation-Wi-Fi 6G and Uncorrelated Gain Calculation-Wi-Fi 6G files.

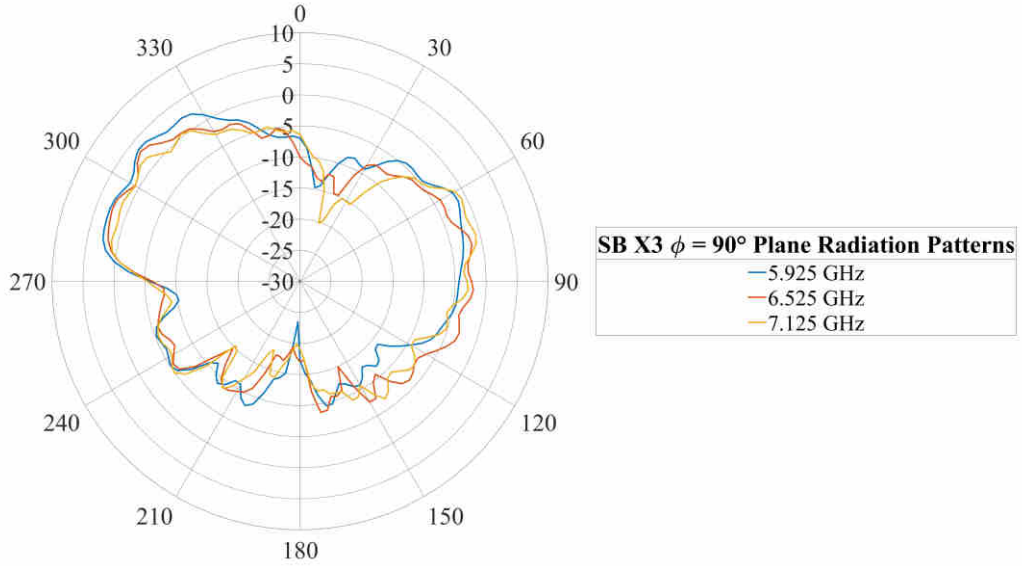
X3 Return Loss



X3 Radiation Patterns

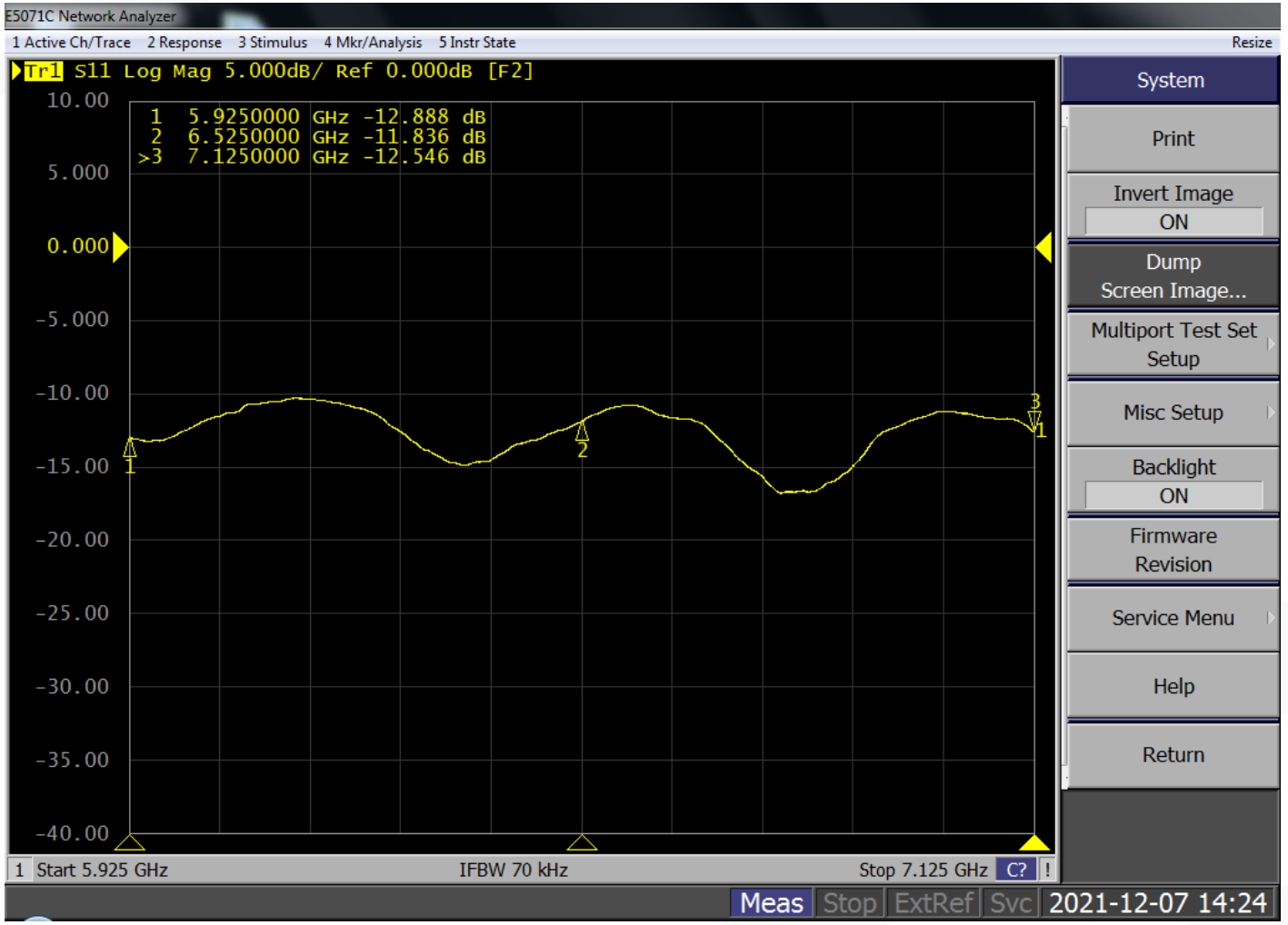




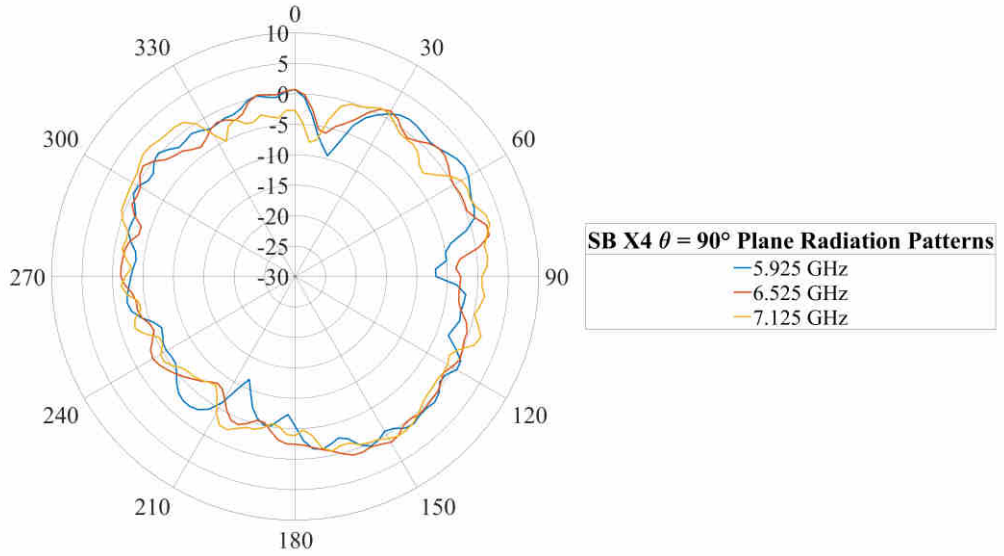


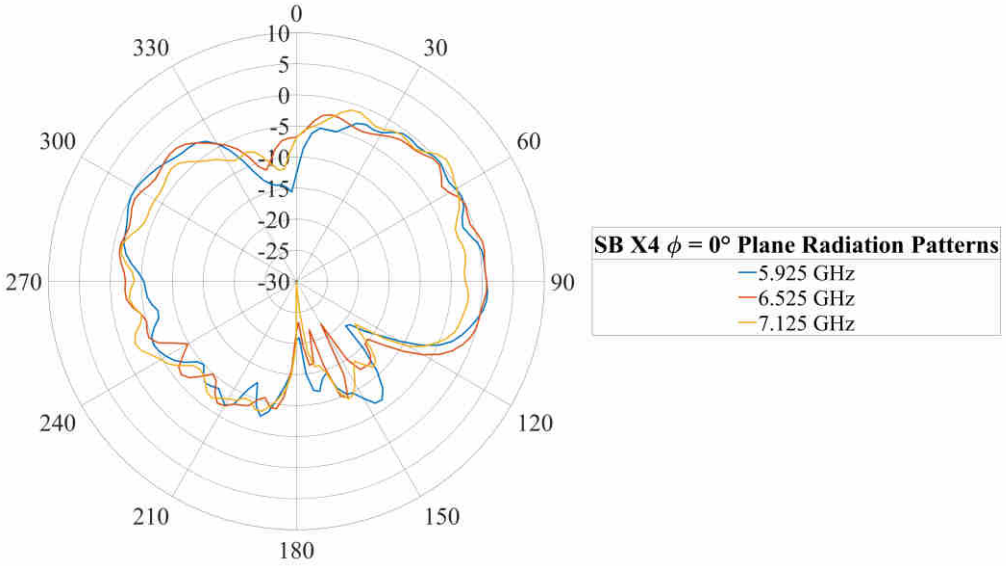
X3 Efficiency and Peak Gain Over Frequency

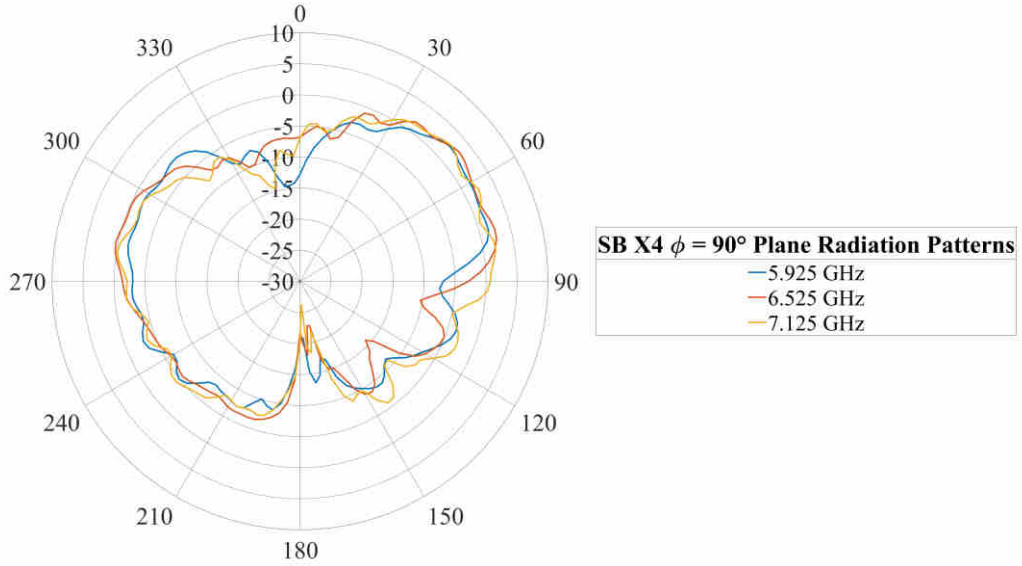
X4 Return Loss



X4 Radiation Patterns

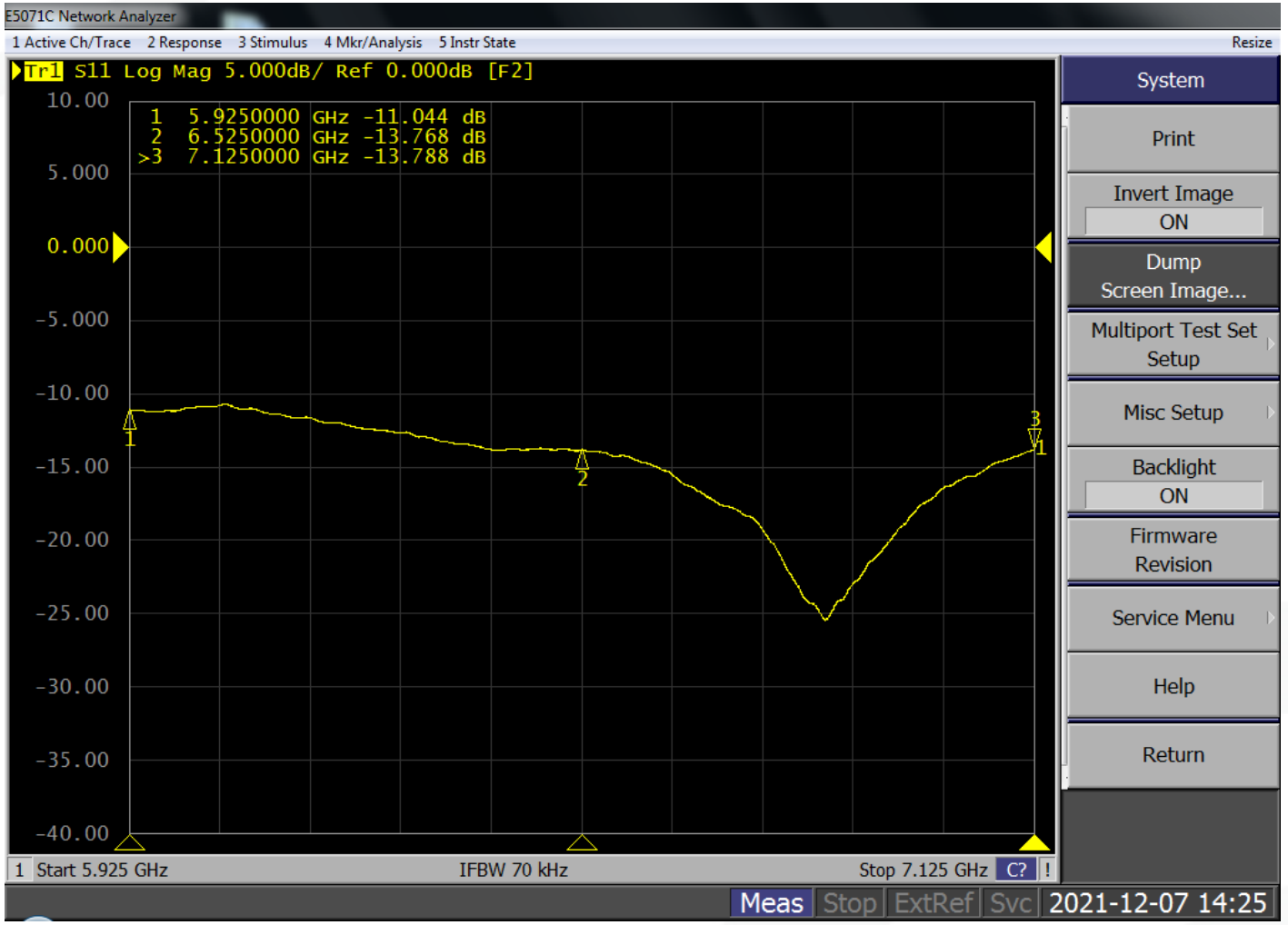




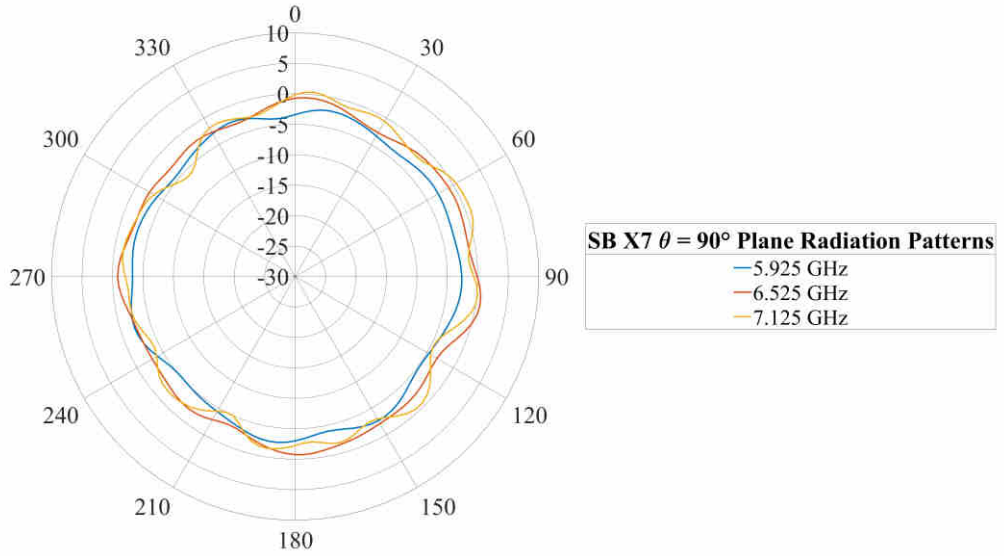


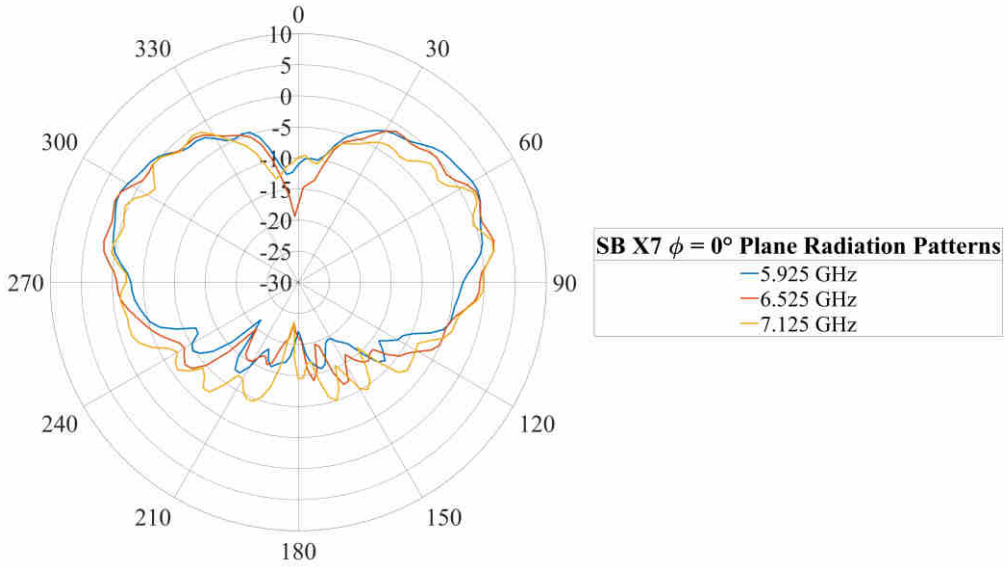
X4 Efficiency and Peak Gain Over Frequency

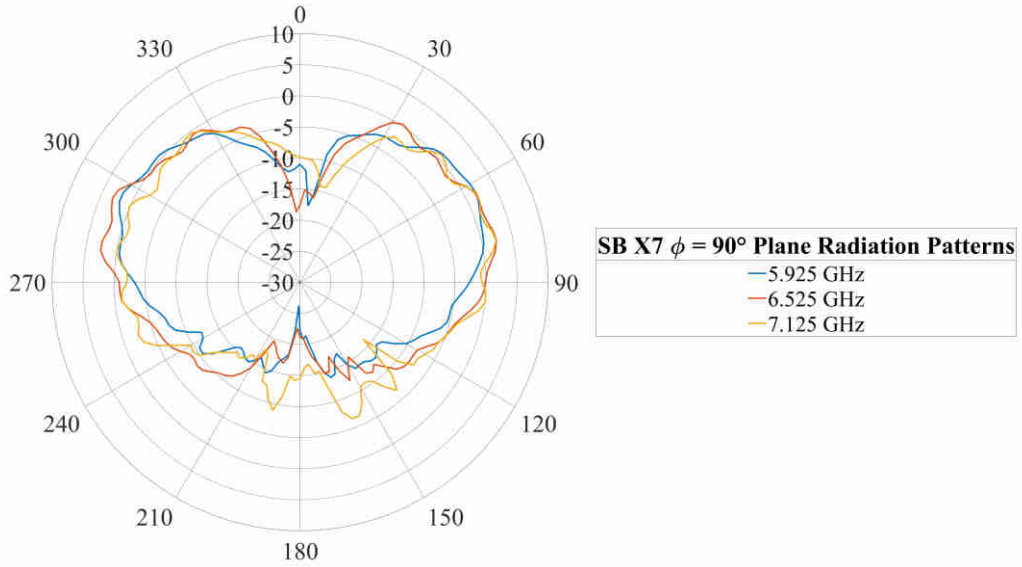
X7 Return Loss



X7 Radiation Patterns

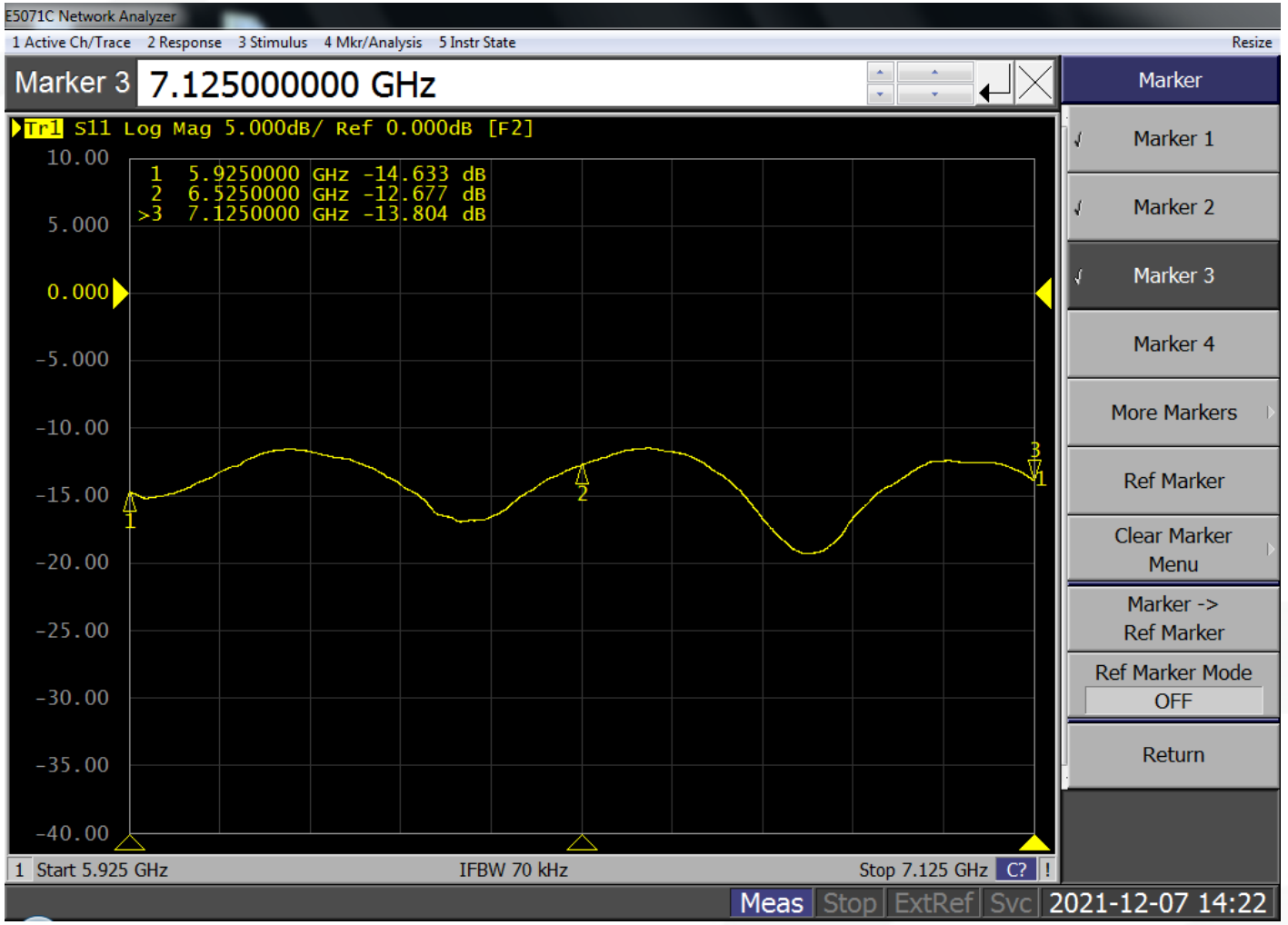




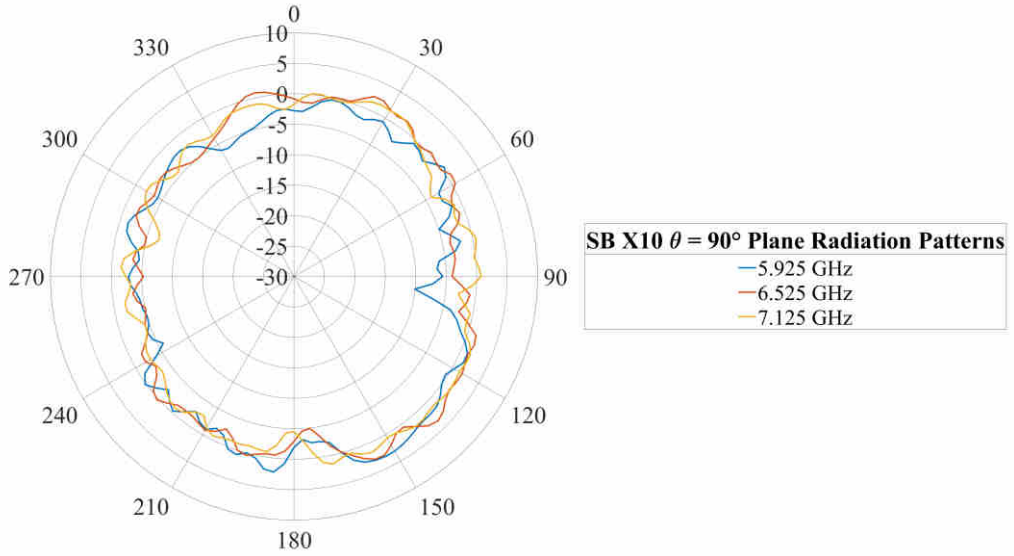


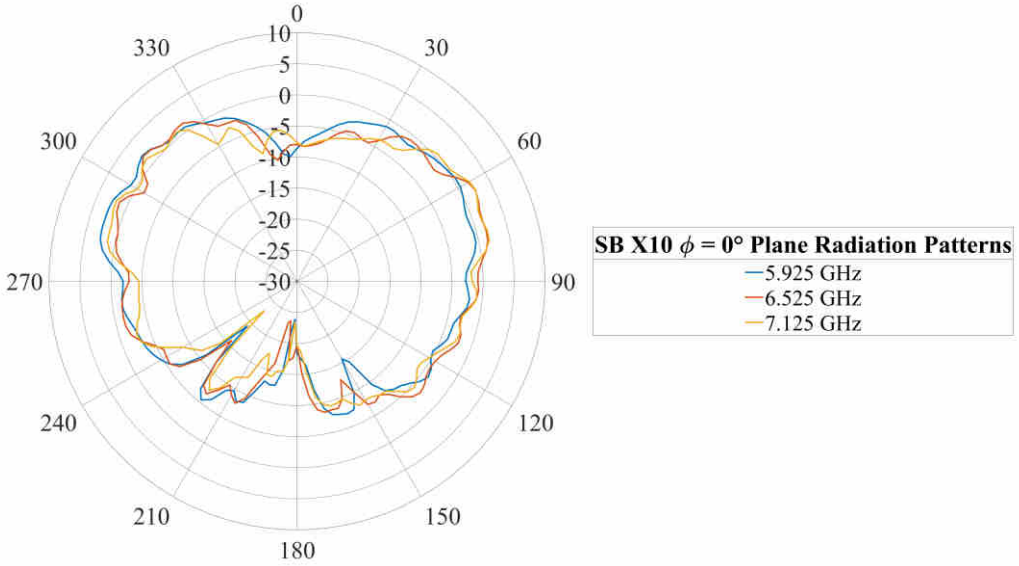
X7 Efficiency and Peak Gain Over Frequency

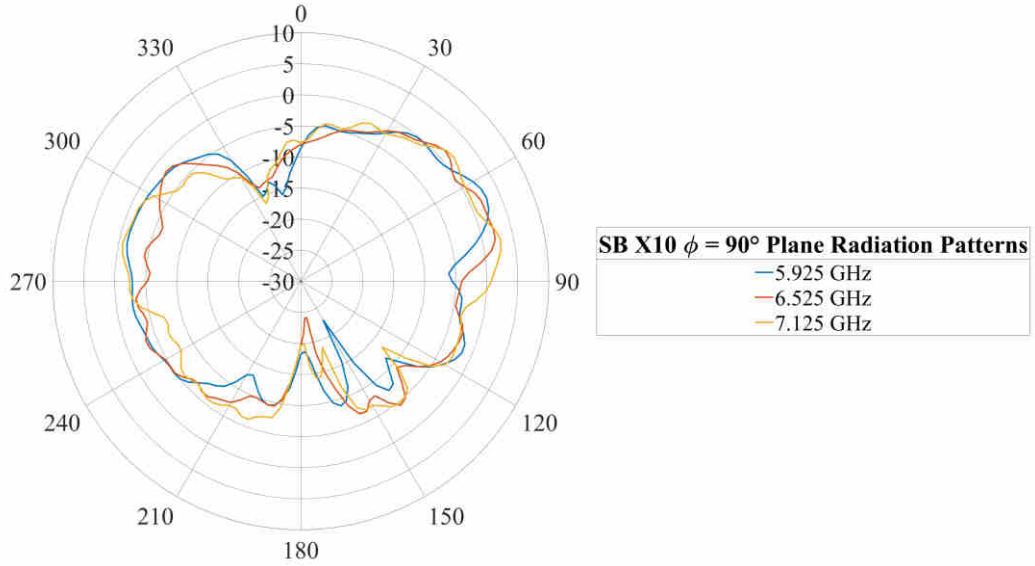
X10 Return Loss



X10 Radiation Patterns







X10 Efficiency and Peak Gain Over Frequency

Dual-Band Antenna Data

Dual-Band Antenna 2.4 GHz Data Summary

Antenna	Detail	X5: 2.4G			X6: 2.4G			X8: 2.4G			X9: 2.4G		
Frequency	2.4G-2.5G	2.4G	2.44G	2.484G	2.4G	2.44G	2.484G	2.4G	2.44G	2.484G	2.4G	2.44G	2.484G
Efficiency	%	70	71	71	67	66	62	67	69	70	67	71	70
Peak Gain	dBi	3.3	3.7	4.1	3.1	3.2	2.9	4.4	4.0	4.1	3.4	3.7	3.6
S11	<-10dB	-19	-24	-18	-16	-15	-13	-15	-16	-15	-14	-15	-15

Frequency	2.4G	2.44G	2.484G
Max. Uncorrelated Gain	2.3 dBi	2.2 dBi	2.1 dBi
Max. Correlated Gain	8.3 dBi	8.1 dBi	8.0 dBi

$$\text{Correlated Gain} = 10\log[(10^{G1/20} + 10^{G2/20} + \ldots + 10^{GN/20})^2 / N_{ANT}]\ \text{dBi}$$

$$\text{Uncorrelated Gain} = 10\log[(10^{G1/10} + 10^{G2/10} + \ldots + 10^{GN/10}) / N_{ANT}]\ \text{dBi}$$

Note: Details refer to Correlated Gain Calculation-Wi-Fi 2.4G & 5G and Uncorrelated Gain Calculation-Wi-Fi 2.4G & 5G files.

Dual-Band Antenna 5 GHz Data Summary

Antenna	Detail	X5: 5G			X6: 5G			X8: 5G			X9: 5G		
Frequency	2.4G-2.5G	5.17G	5.5G	5.835G	5.17G	5.5G	5.835G	5.17G	5.5G	5.835G	5.17G	5.5G	5.835G
Efficiency	%	61	67	66	63	60	56	60	59	58	63	62	57
Peak Gain	dBi	4.4	4.4	4.2	4.2	3.5	3.6	3.7	3.2	3.1	4.1	3.6	3.0
S11	<-10dB	-15	-20	-23	-21	-17	-13	-15	-16	-14	-16	-17	-14

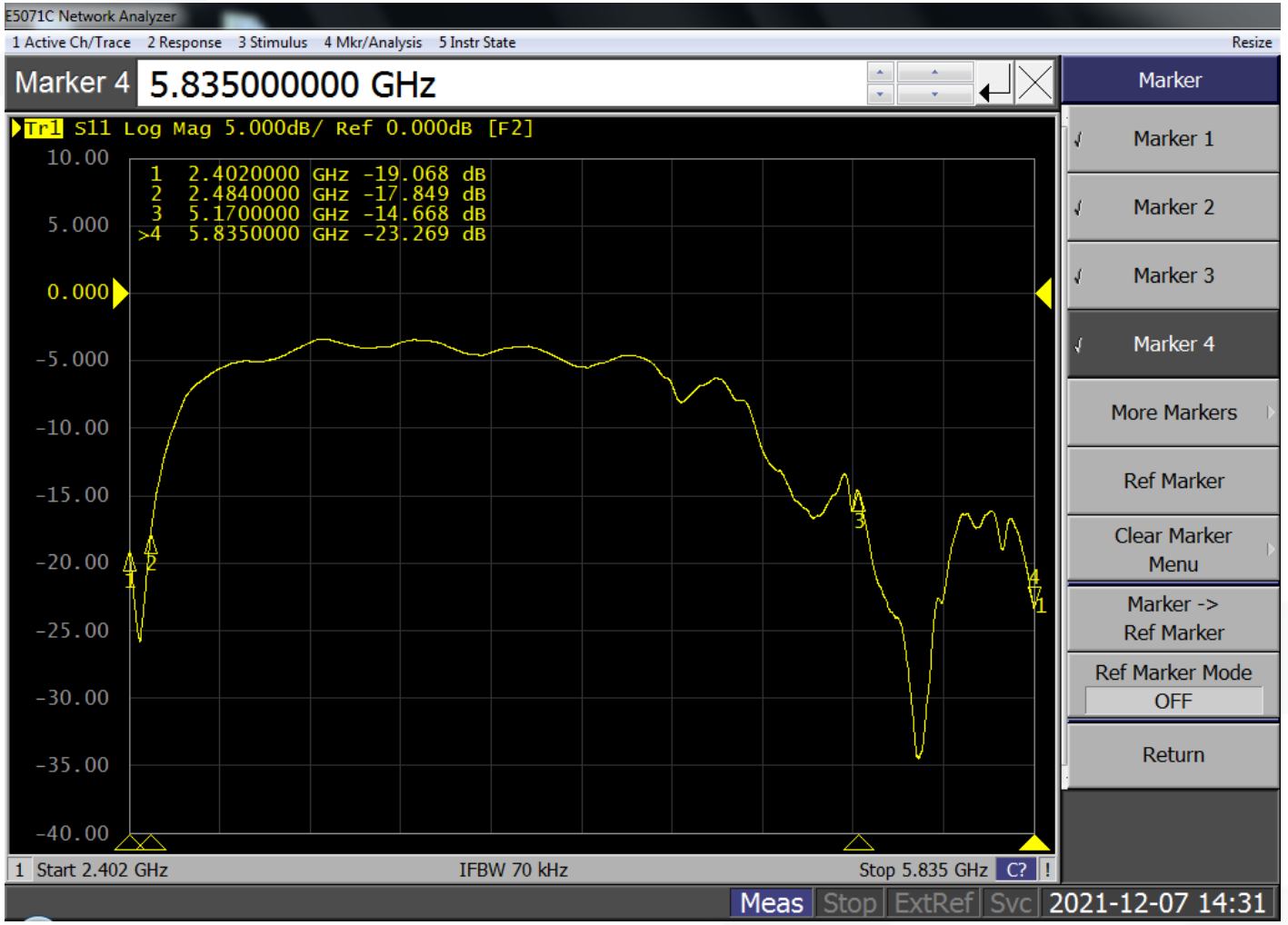
Frequency	5.17G	5.5G	5.835G
Max. Uncorrelated Gain	3.0 dBi	2.4 dBi	1.4 dBi
Max. Correlated Gain	9.0 dBi	8.4 dBi	7.2 dBi

$$\text{Correlated Gain} = 10\log[(10^{G1/20} + 10^{G2/20} + \ldots + 10^{GN/20})^2 / N_{ANT}]\ \text{dBi}$$

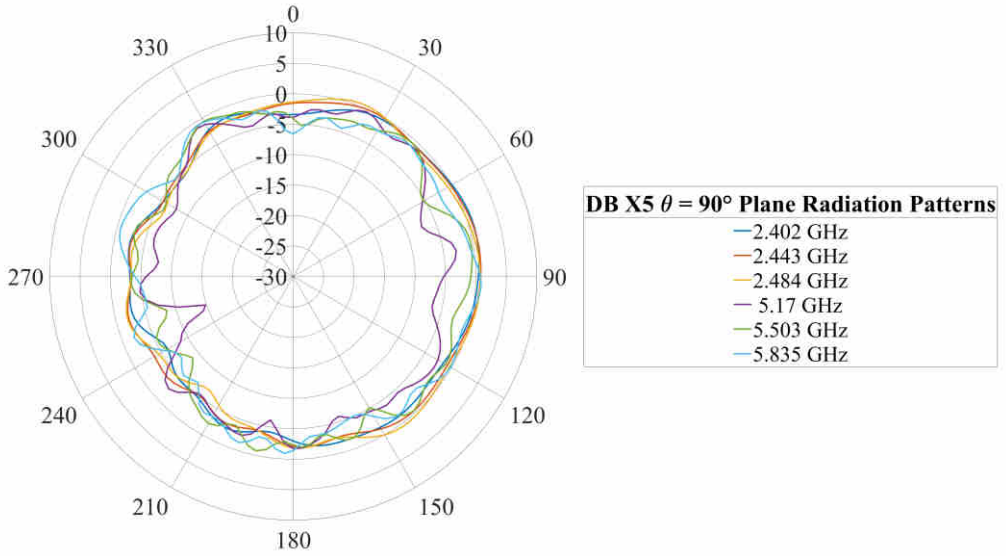
$$\text{Uncorrelated Gain} = 10\log[(10^{G1/10} + 10^{G2/10} + \ldots + 10^{GN/10}) / N_{ANT}]\ \text{dBi}$$

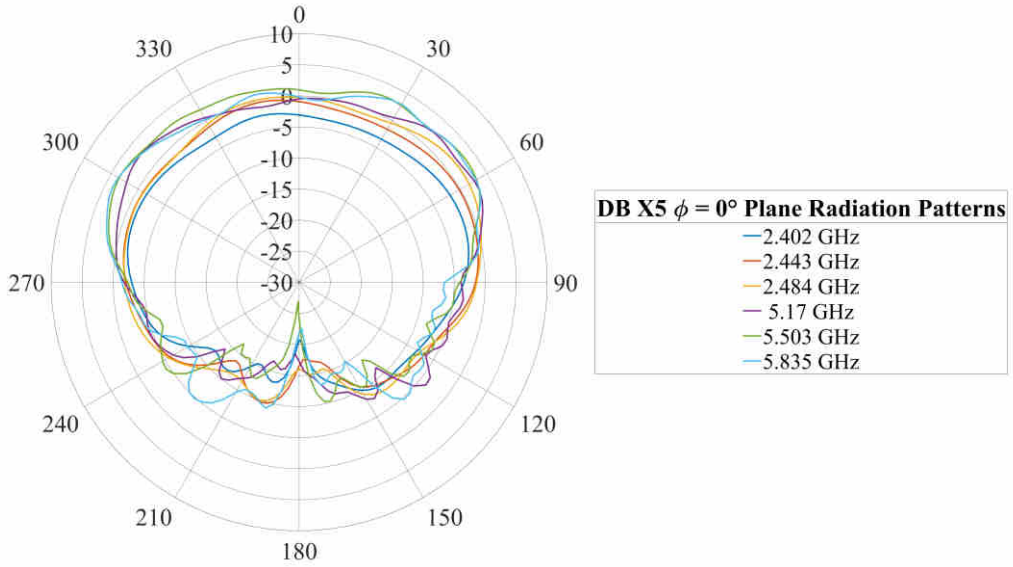
Note: Details refer to Correlated Gain Calculation-Wi-Fi 2.4G & 5G and Uncorrelated Gain Calculation-Wi-Fi 2.4G & 5G files.

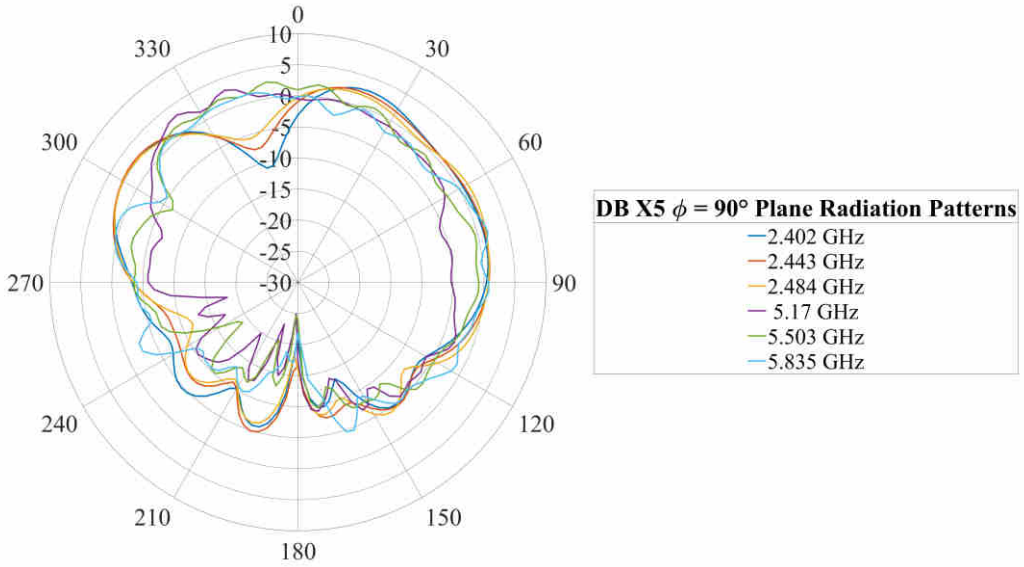
X5 Return Loss



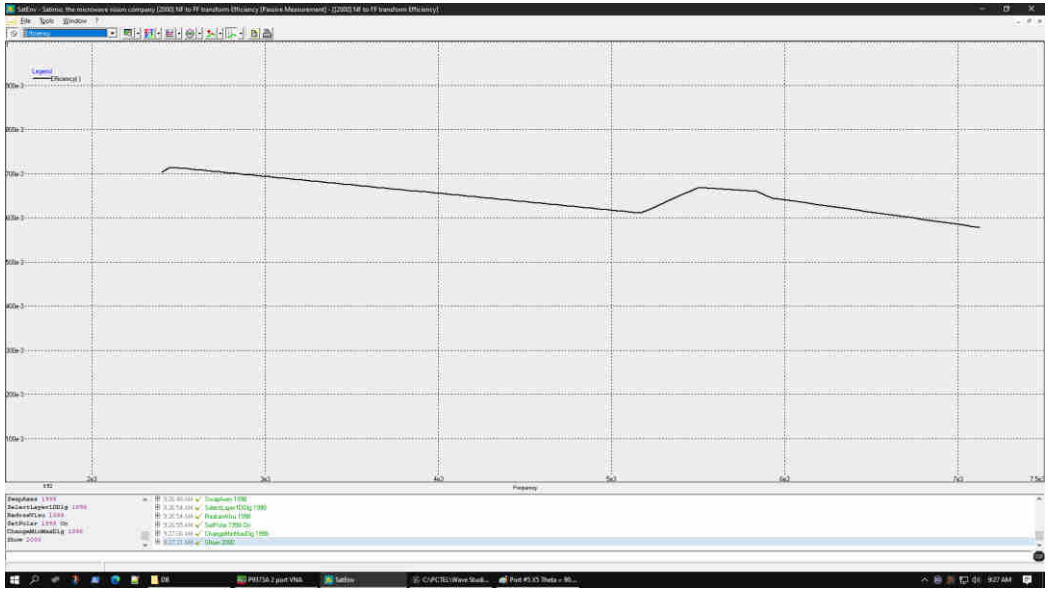
X5 Radiation Patterns





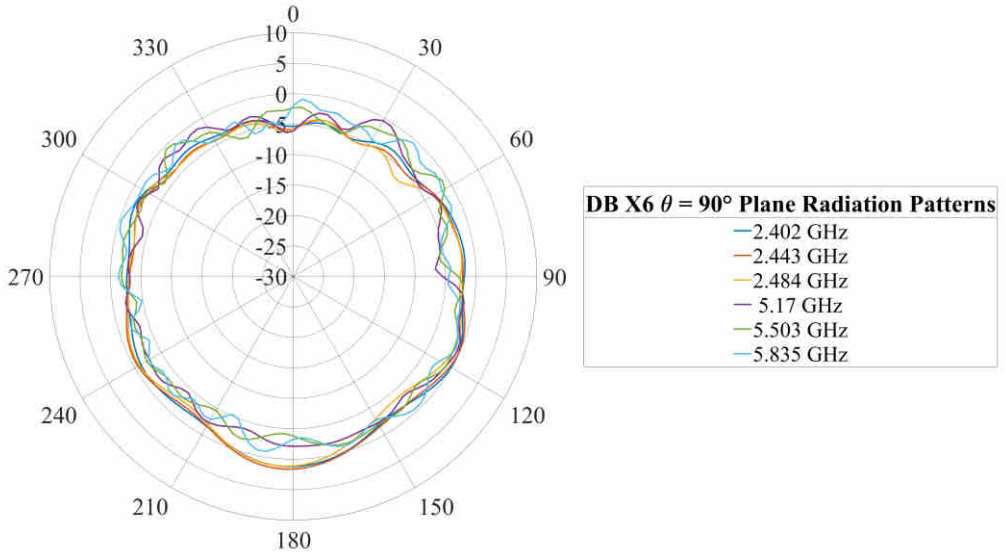


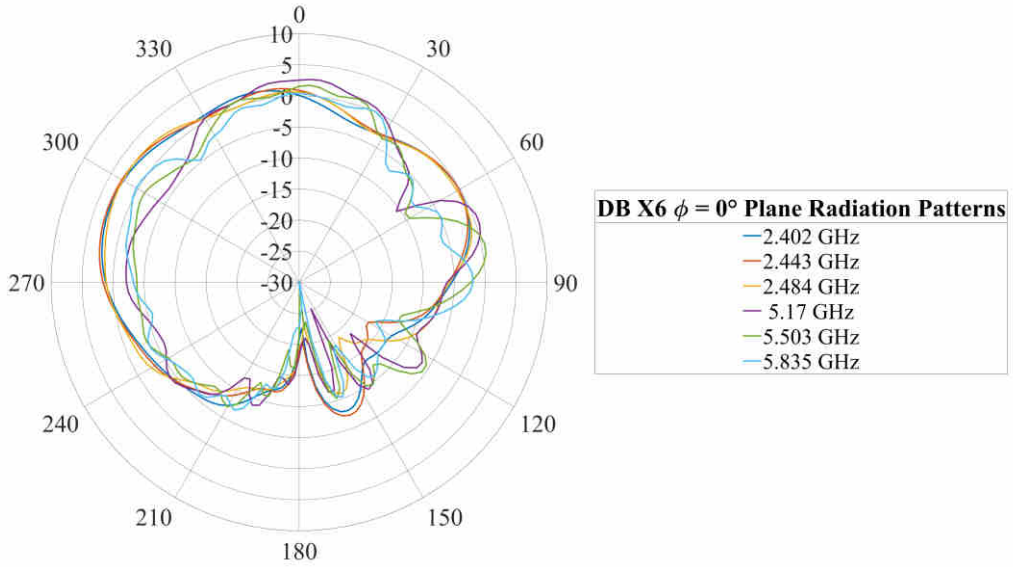
X5 Efficiency and Peak Gain Over Frequency

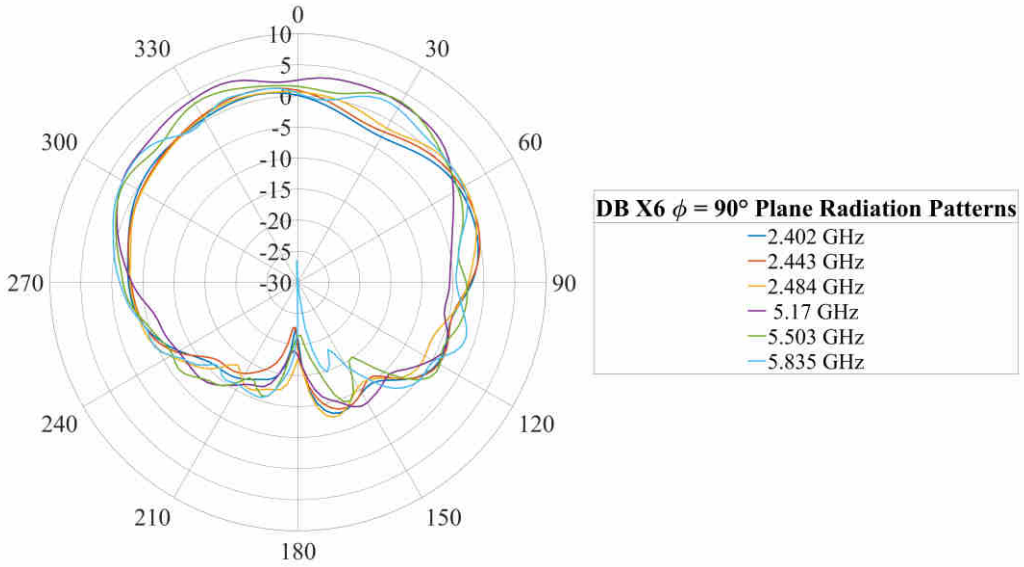


X6 Return Loss

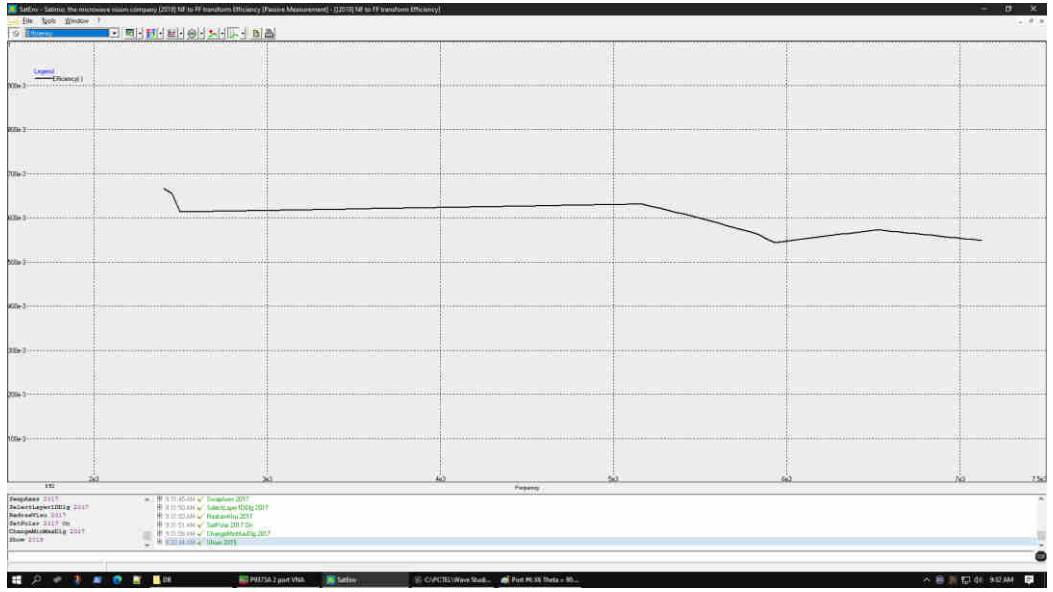
X6 Radiation Patterns





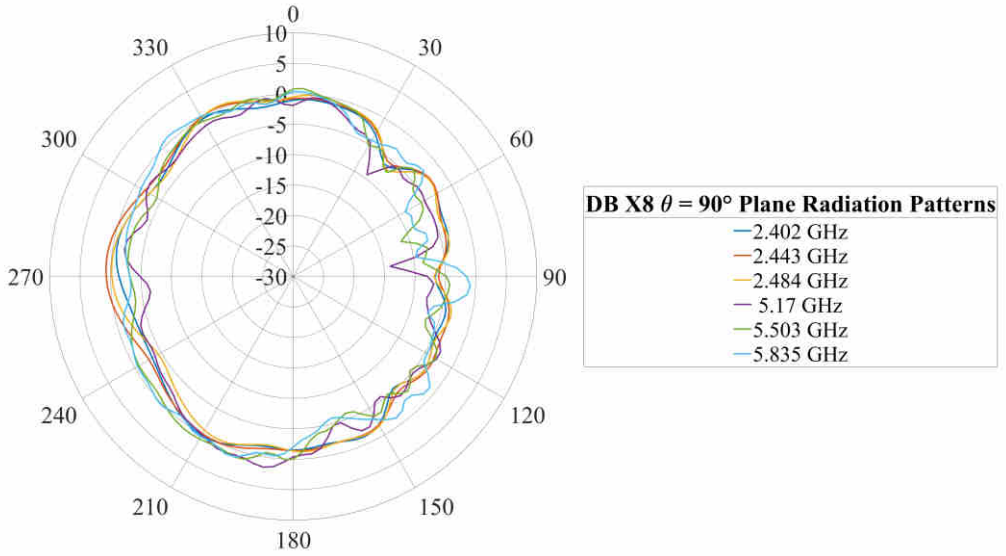


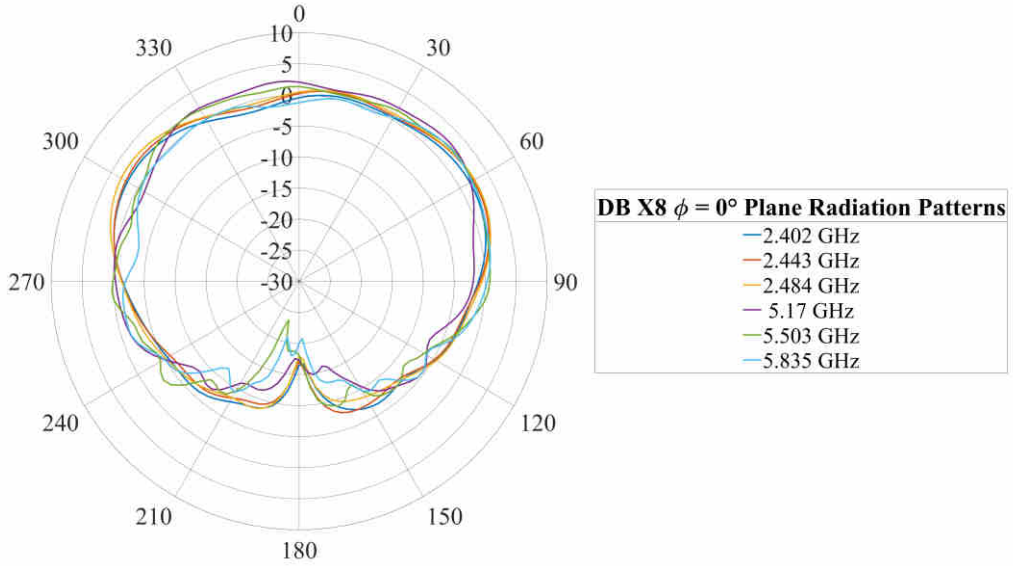
X6 Efficiency and Peak Gain Over Frequency

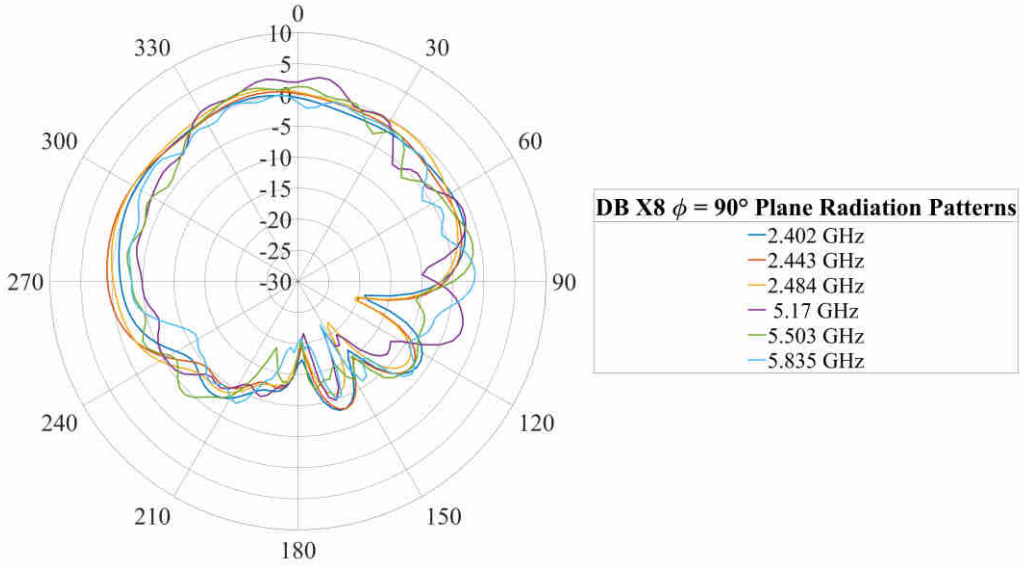


X8 Return Loss

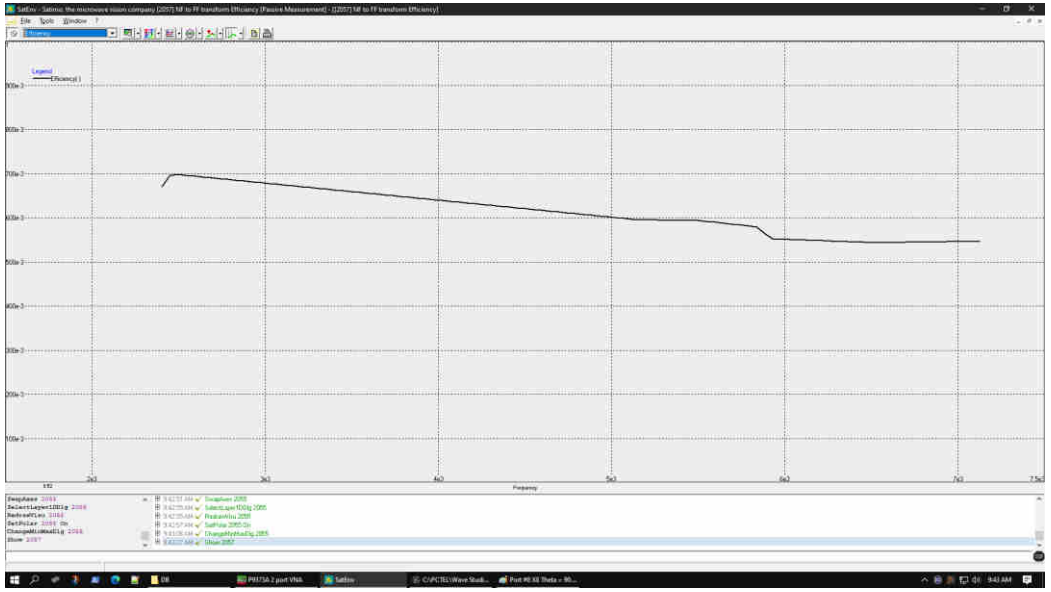
X8 Radiation Patterns





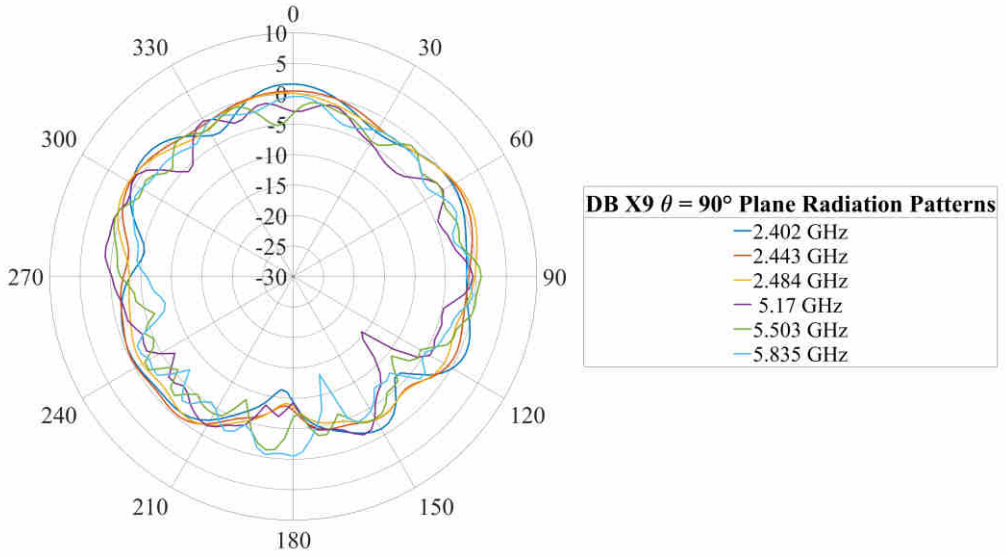


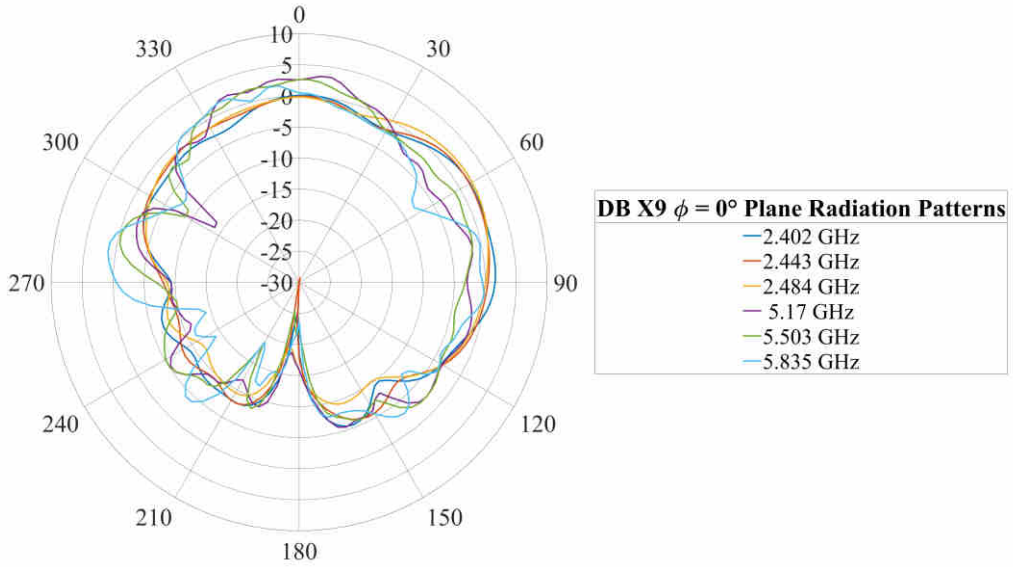
X8 Efficiency and Peak Gain Over Frequency

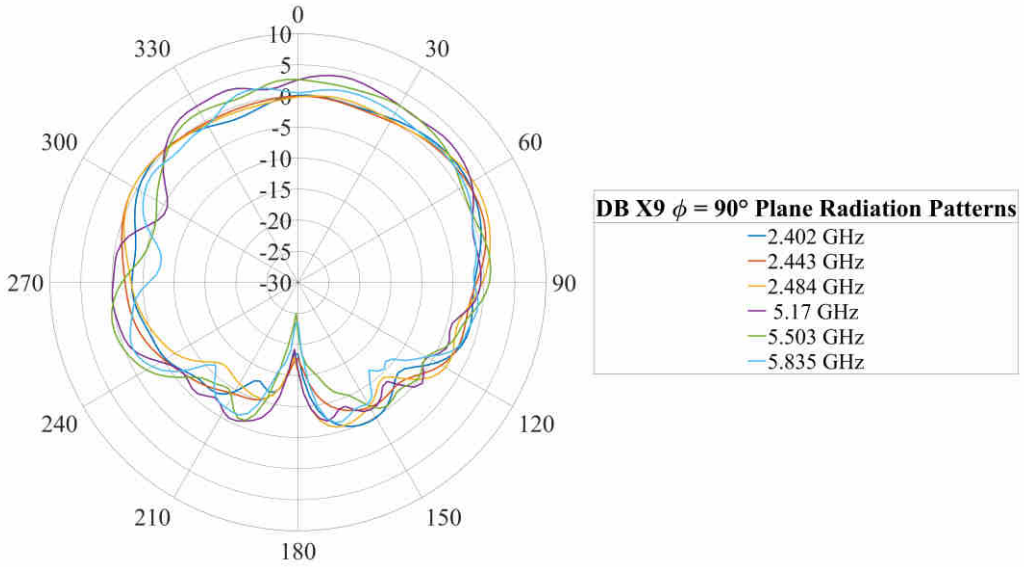


X9 Return Loss

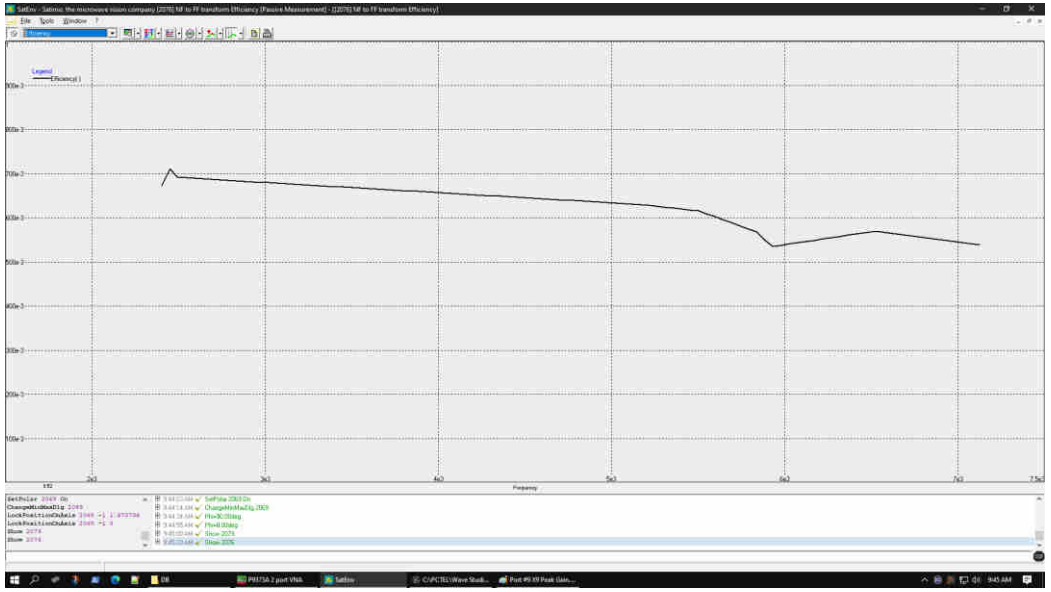
X9 Radiation Patterns

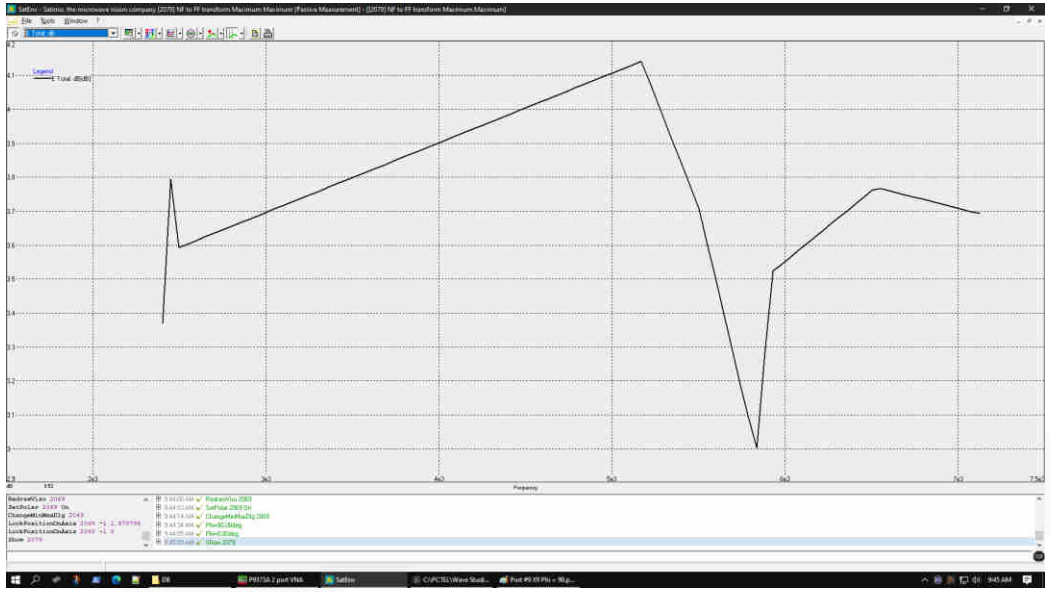






X9 Efficiency and Peak Gain Over Frequency



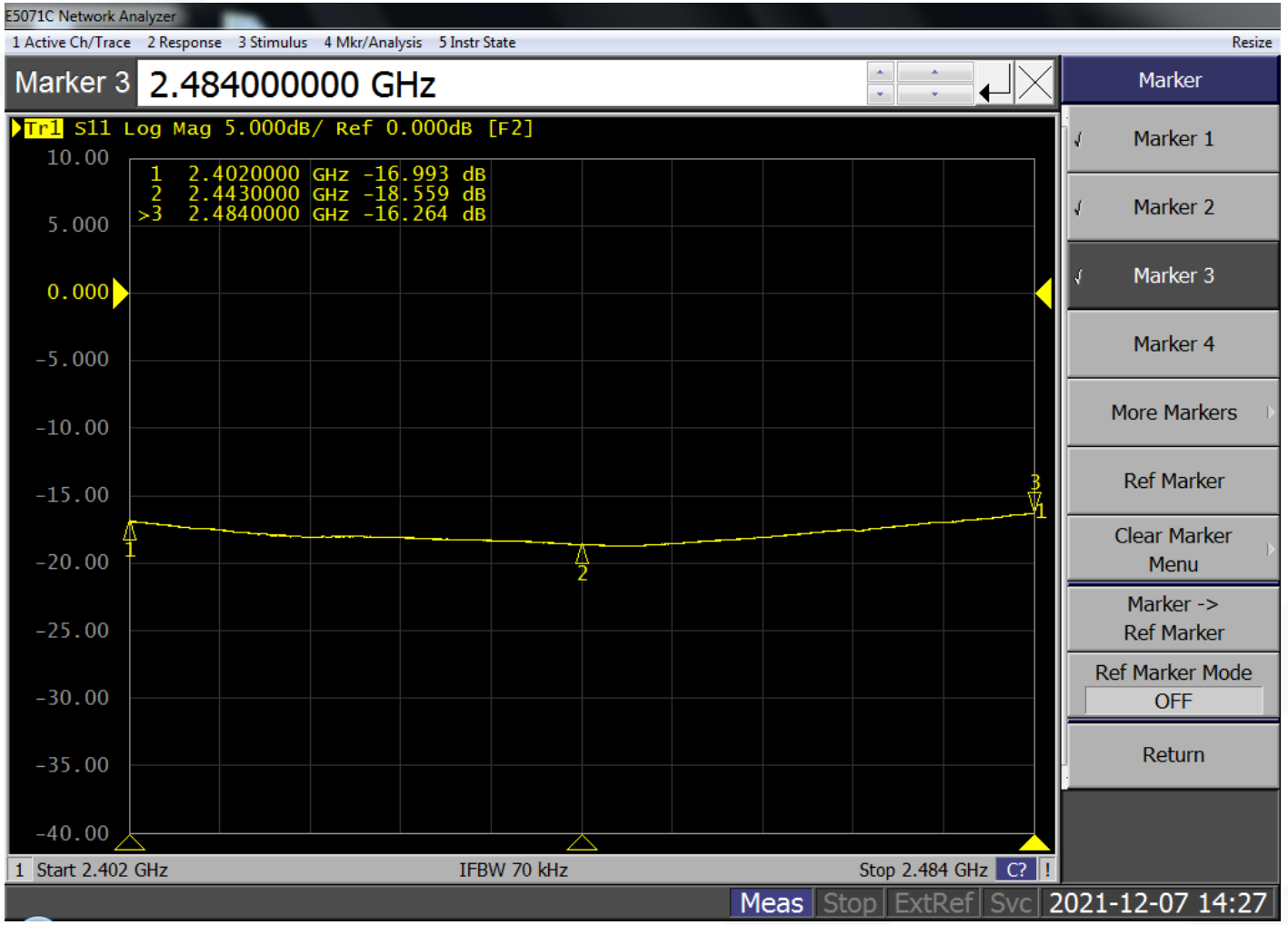


Bluetooth Antenna Data

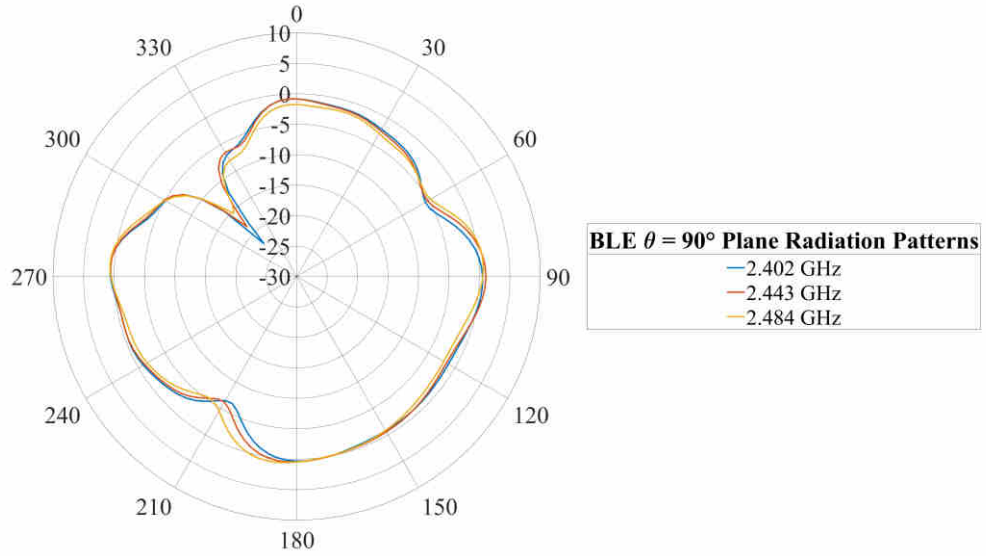
Bluetooth Antenna Data Summary

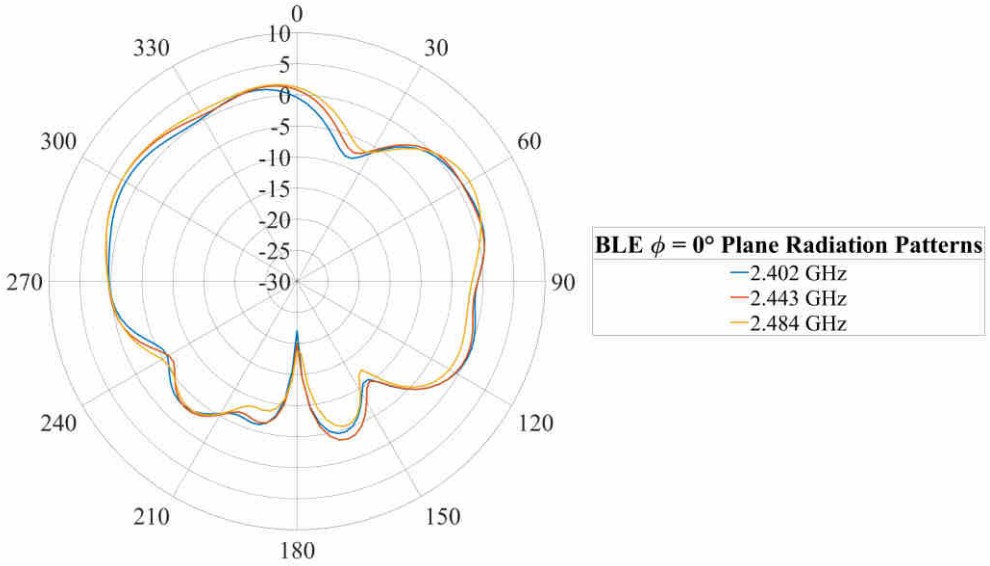
Antenna	Detail	X15: ble		
Frequency	2.4G-2.5G	2.4G	2.44G	2.484G
Efficiency	%	68	70	71
Peak Gain for 3D	dBi	4.1	4.2	4.0
S11	<-10dB	-17	-19	-16

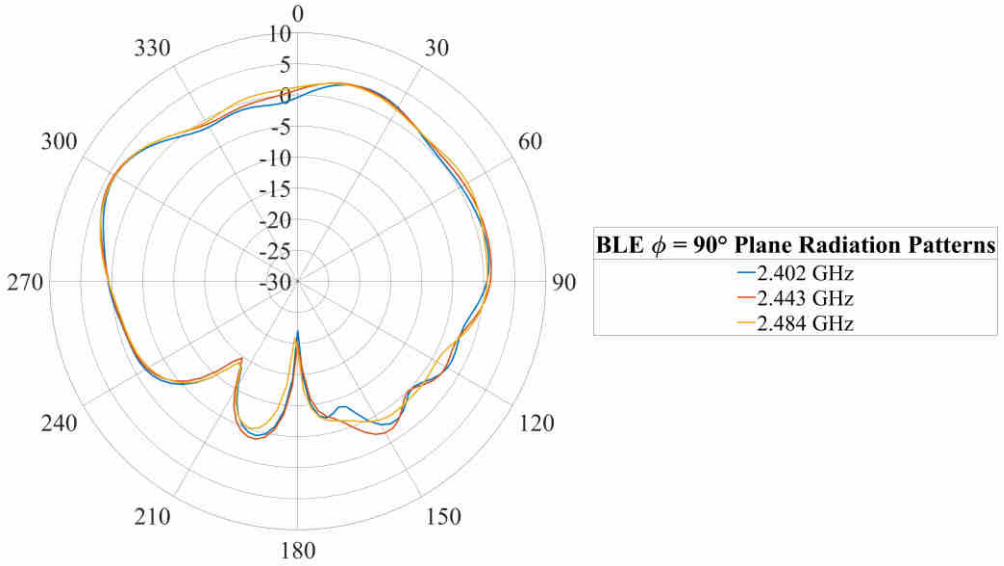
Bluetooth Return Loss



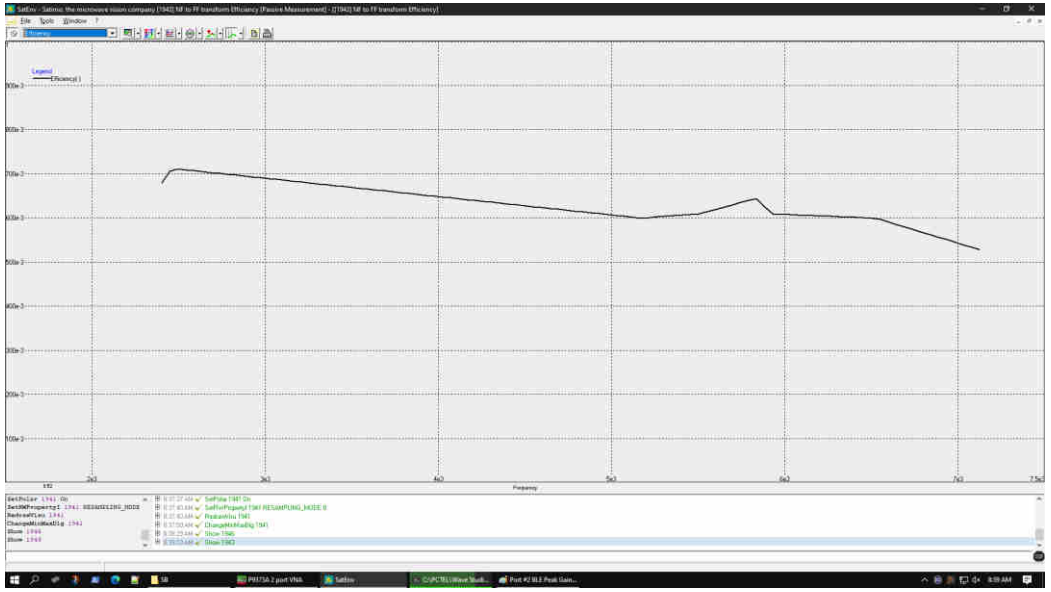
Bluetooth Radiation Patterns







Bluetooth Efficiency and Peak Gain Over Frequency



Summary of Isolation Data

Isolation in 2.4 GHz band

Isolation	X5: 2.4+5G	X6: 2.4+5G	X8: 2.4+5G	X9: 2.4+5G	X3: 6G	X4: 6G	X7: 6G	X10: 6G	X15: BLE
X5: 2.4+5G	\	-24	-21	-22	-29	-37	-39	-40	-17
X6: 2.4+5G	\	\	-24	-25	-37	-31	-36	-37	-17
X8: 2.4+5G	\	\	\	-23	-46	-32	-56	-33	-30
X9: 2.4+5G	\	\	\	\	-28	-40	-38	-30	-28
X3: 6G	\	\	\	\	\	-55	-59	-50	-33
X4: 6G	\	\	\	\	\	\	-61	-50	-34
X7: 6G	\	\	\	\	\	\	\	-60	-45
X10: 6G	\	\	\	\	\	\	\	\	-42
X15: BLE	\	\	\	\	\	\	\	\	\

Isolation in 5 GHz band

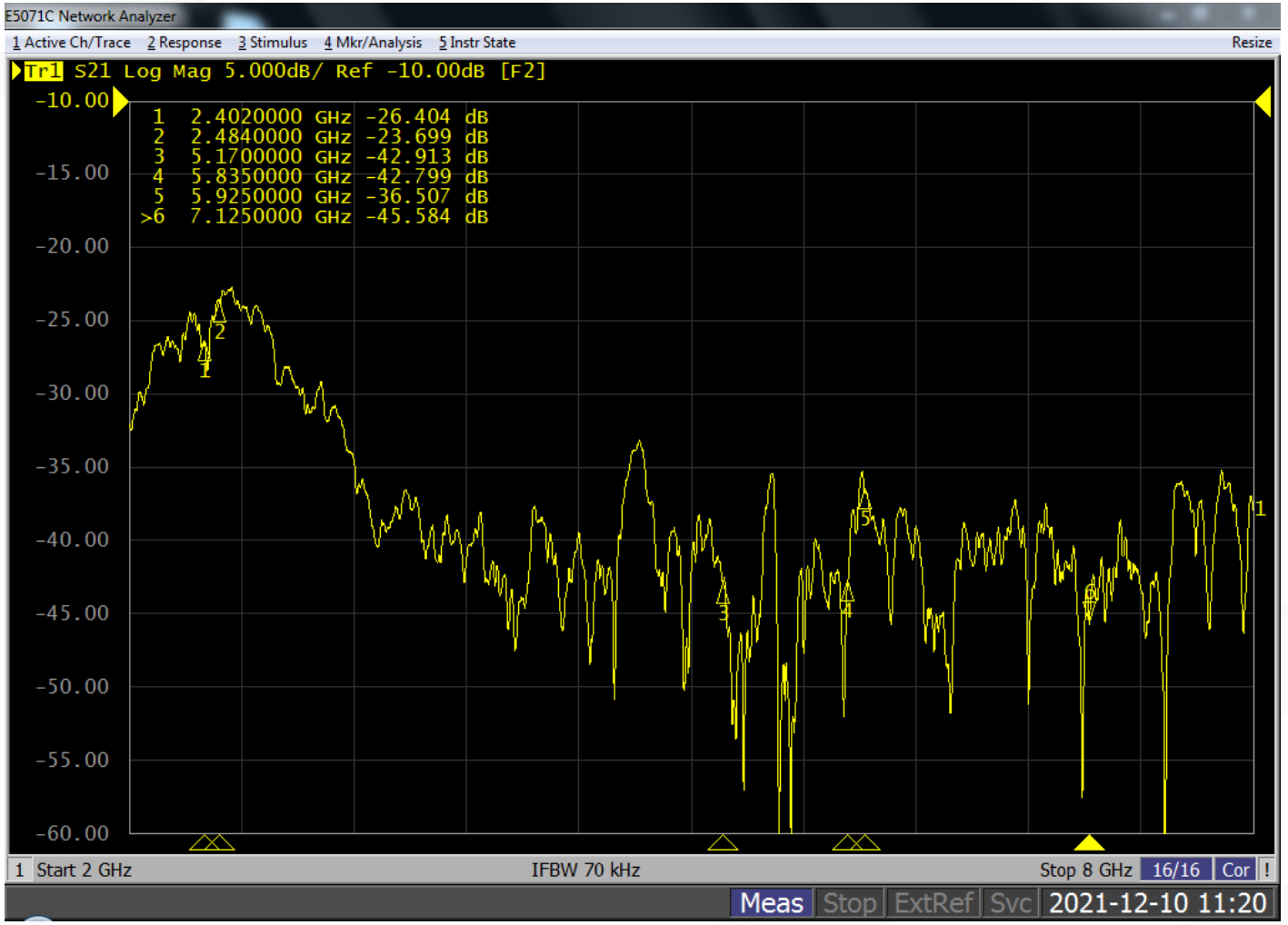
Isolation	X5: 2.4+5G	X6: 2.4+5G	X8: 2.4+5G	X9: 2.4+5G	X3: 6G	X4: 6G	X7: 6G	X10: 6G	X15: BLE
X5: 2.4+5G	\	-35	-32	-33	-26	-31	-34	-30	-24
X6: 2.4+5G	\	\	-35	-34	-32	-28	-39	-30	-28
X8: 2.4+5G	\	\	\	-32	-32	-30	-32	-27	-38
X9: 2.4+5G	\	\	\	\	-30	-32	-31	-33	-38
X3: 6G	\	\	\	\	\	-29	-37	-30	-35
X4: 6G	\	\	\	\	\	\	-37	-30	-35
X7: 6G	\	\	\	\	\	\	\	-38	-33
X10: 6G	\	\	\	\	\	\	\	\	-28
X15: BLE	\	\	\	\	\	\	\	\	\

Isolation in 6 GHz band

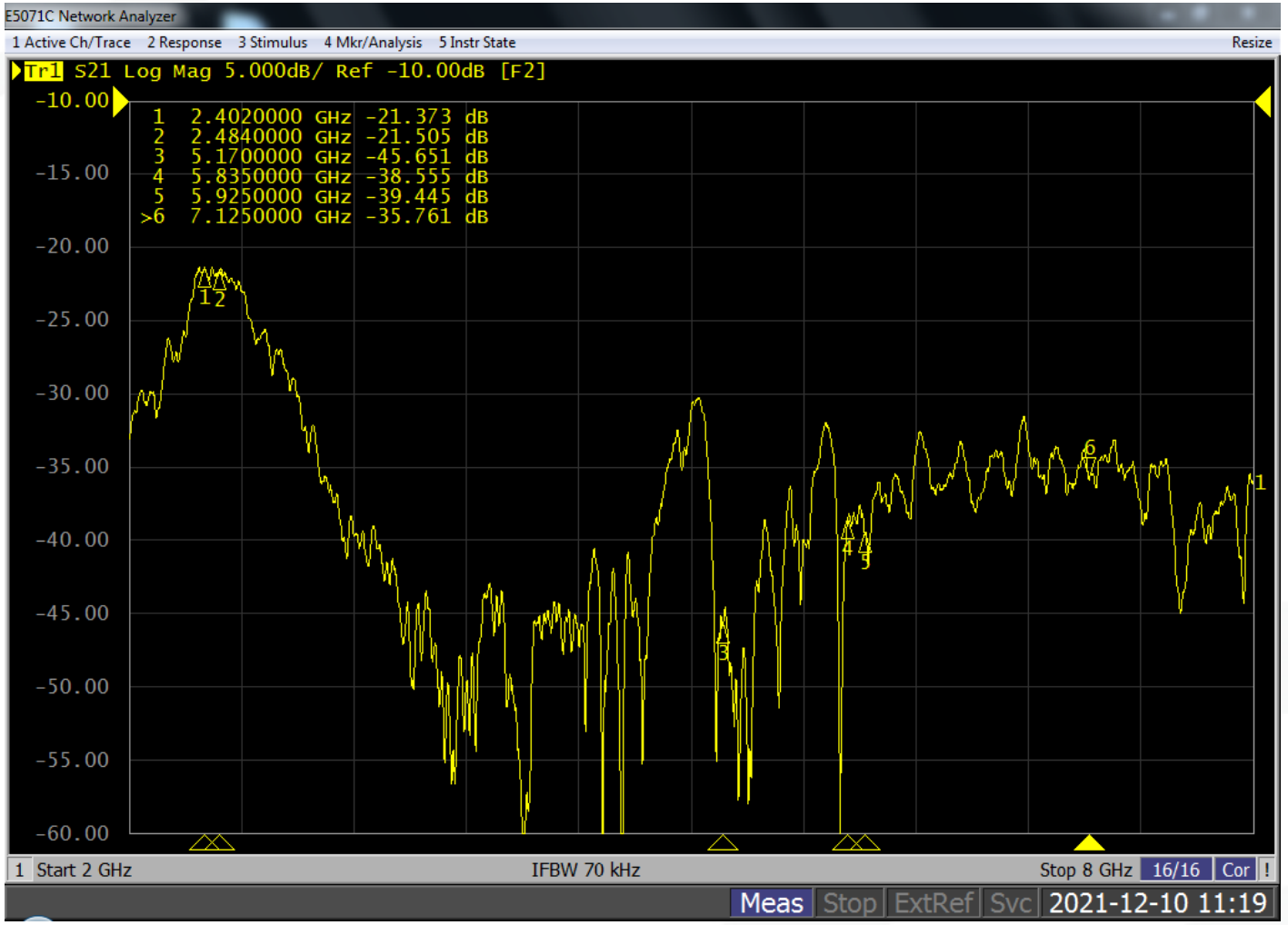
Isolation	X5: 2.4+5G	X6: 2.4+5G	X8: 2.4+5G	X9: 2.4+5G	X3: 6G	X4: 6G	X7: 6G	X10: 6G	X15: BLE
X5: 2.4+5G	\	-36	-31	-33	-25	-30	-31	-32	-25
X6: 2.4+5G	\	\	-32	-34	-29	-27	-36	-31	-27
X8: 2.4+5G	\	\	\	-32	-31	-28	-33	-26	-38
X9: 2.4+5G	\	\	\	\	-29	-33	-32	-28	-38
X3: 6G	\	\	\	\	\	-29	-40	-30	-31
X4: 6G	\	\	\	\	\	\	-40	-31	-30
X7: 6G	\	\	\	\	\	\	\	-35	-32
X10: 6G	\	\	\	\	\	\	\	\	-30
X15: BLE	\	\	\	\	\	\	\	\	\

Isolation Between Dual-Band Antennas

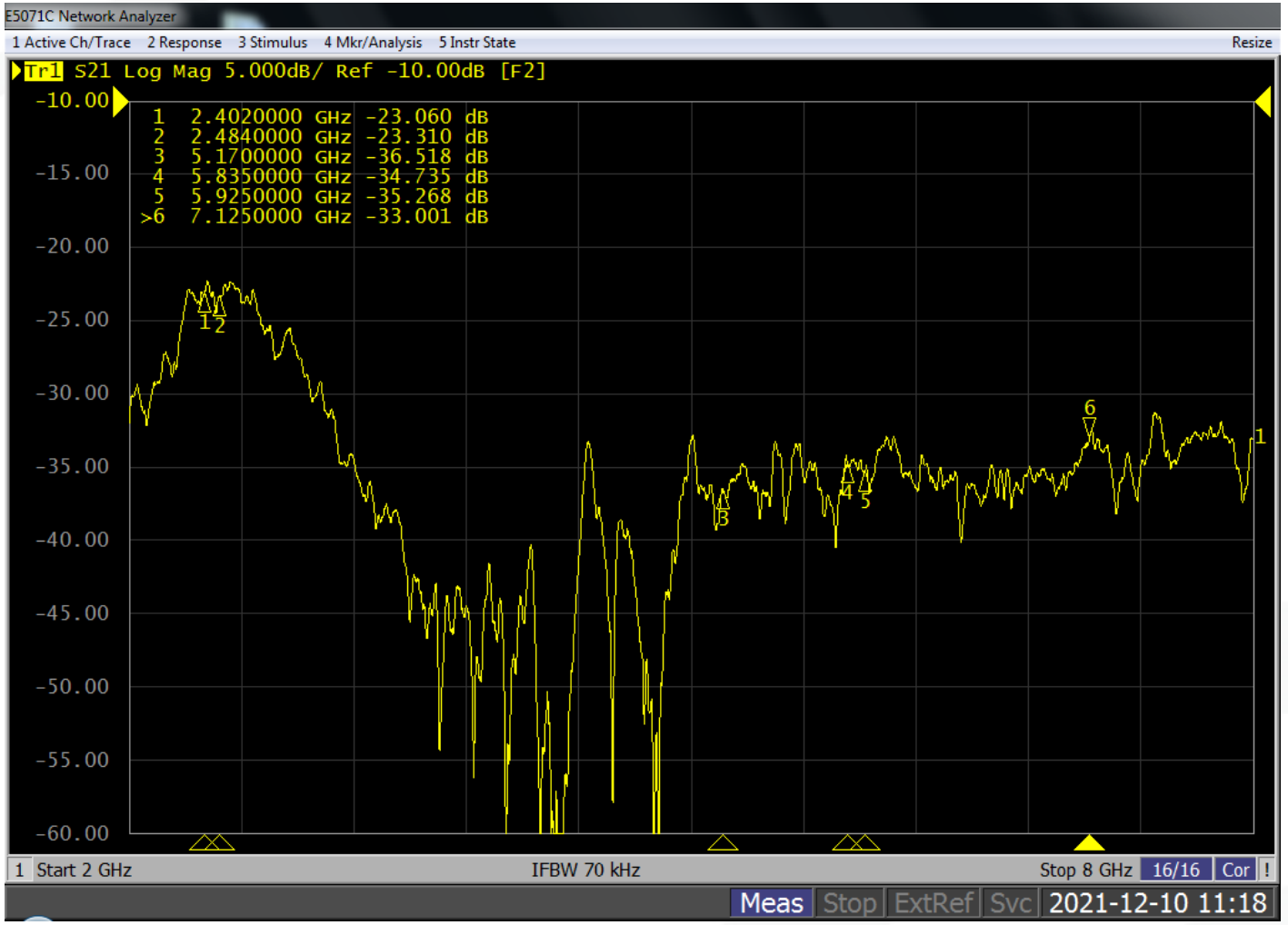
X5, X6 Isolation



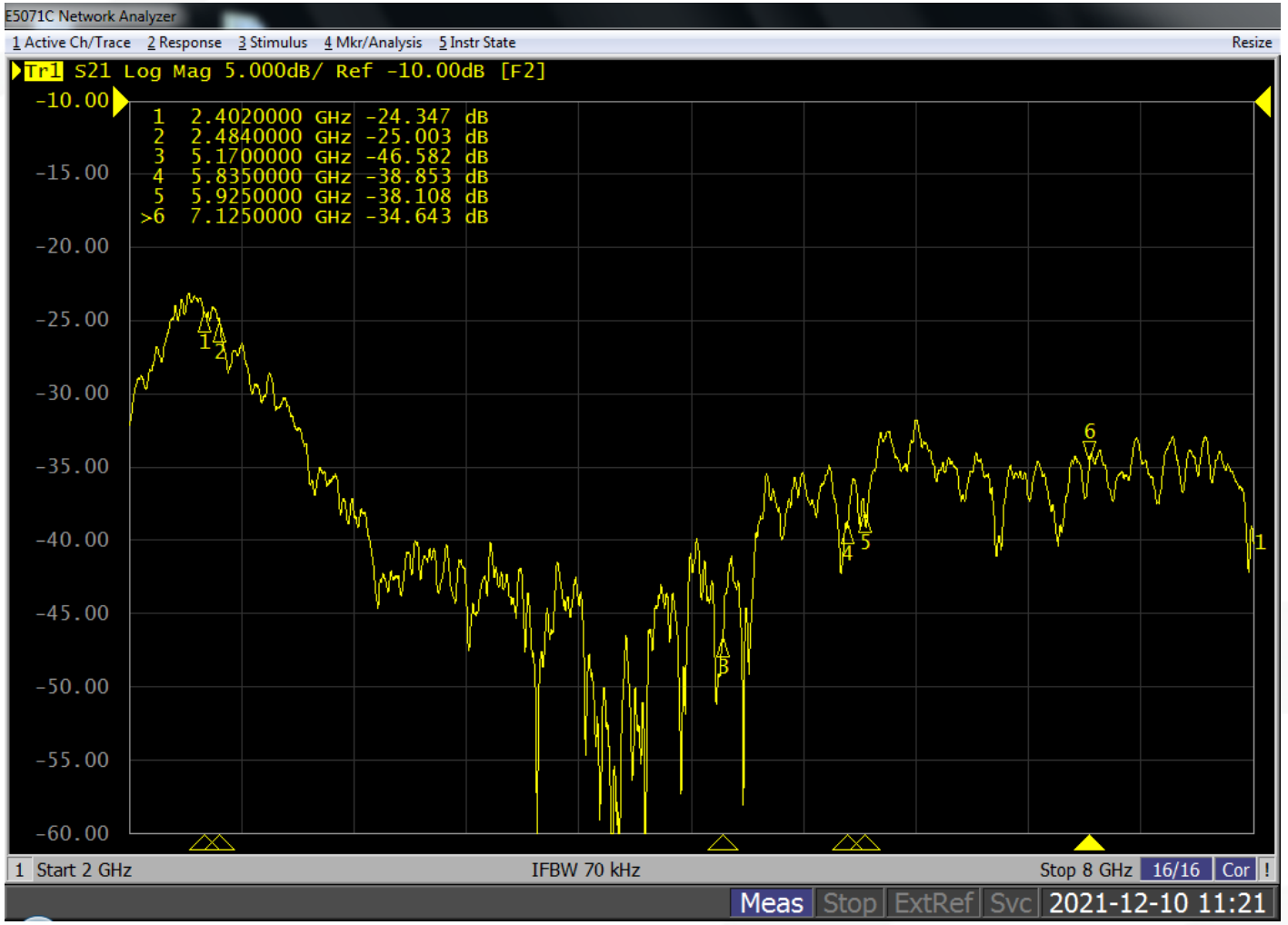
X5, X8 Isolation



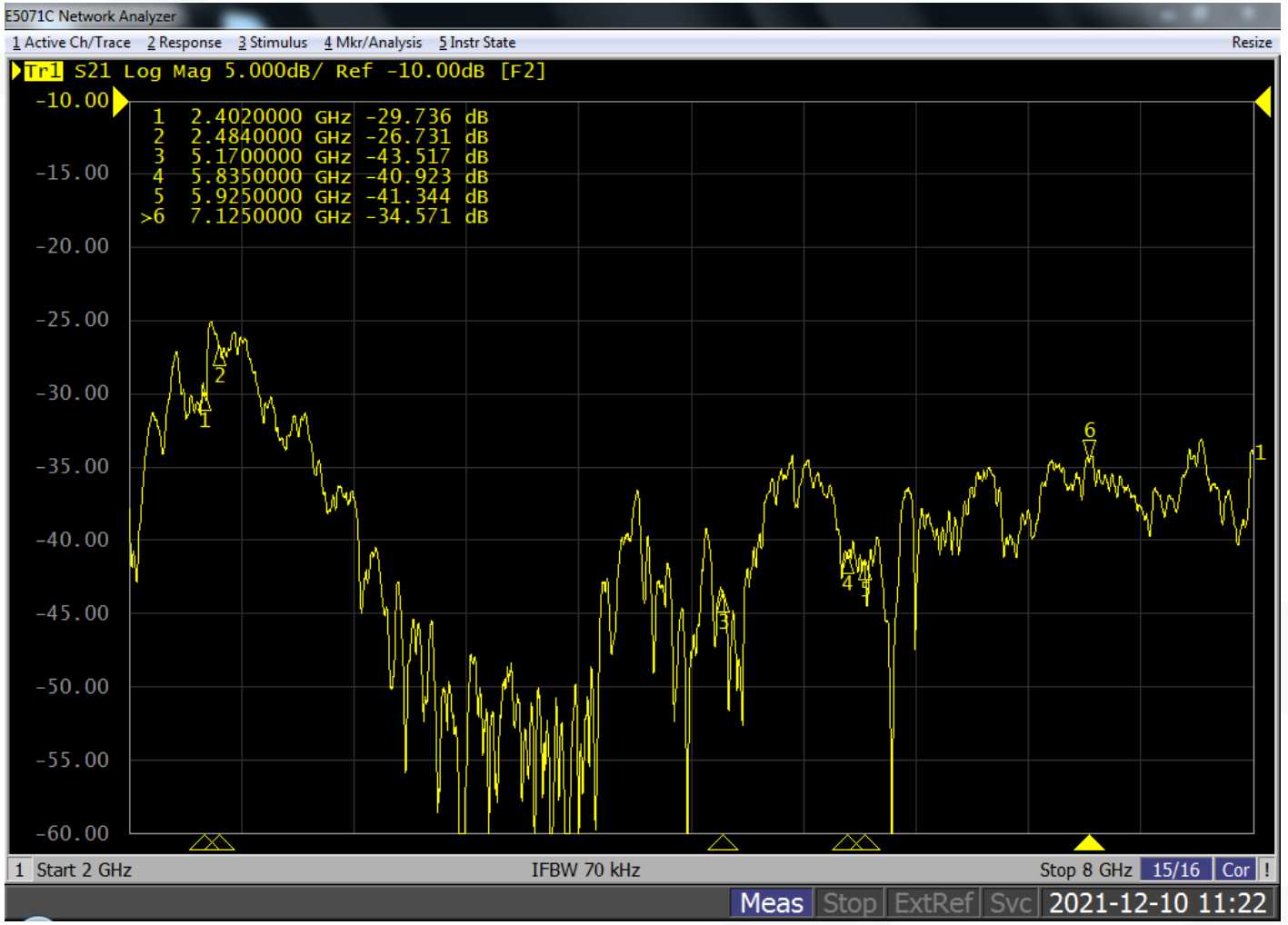
X5, X9 Isolation



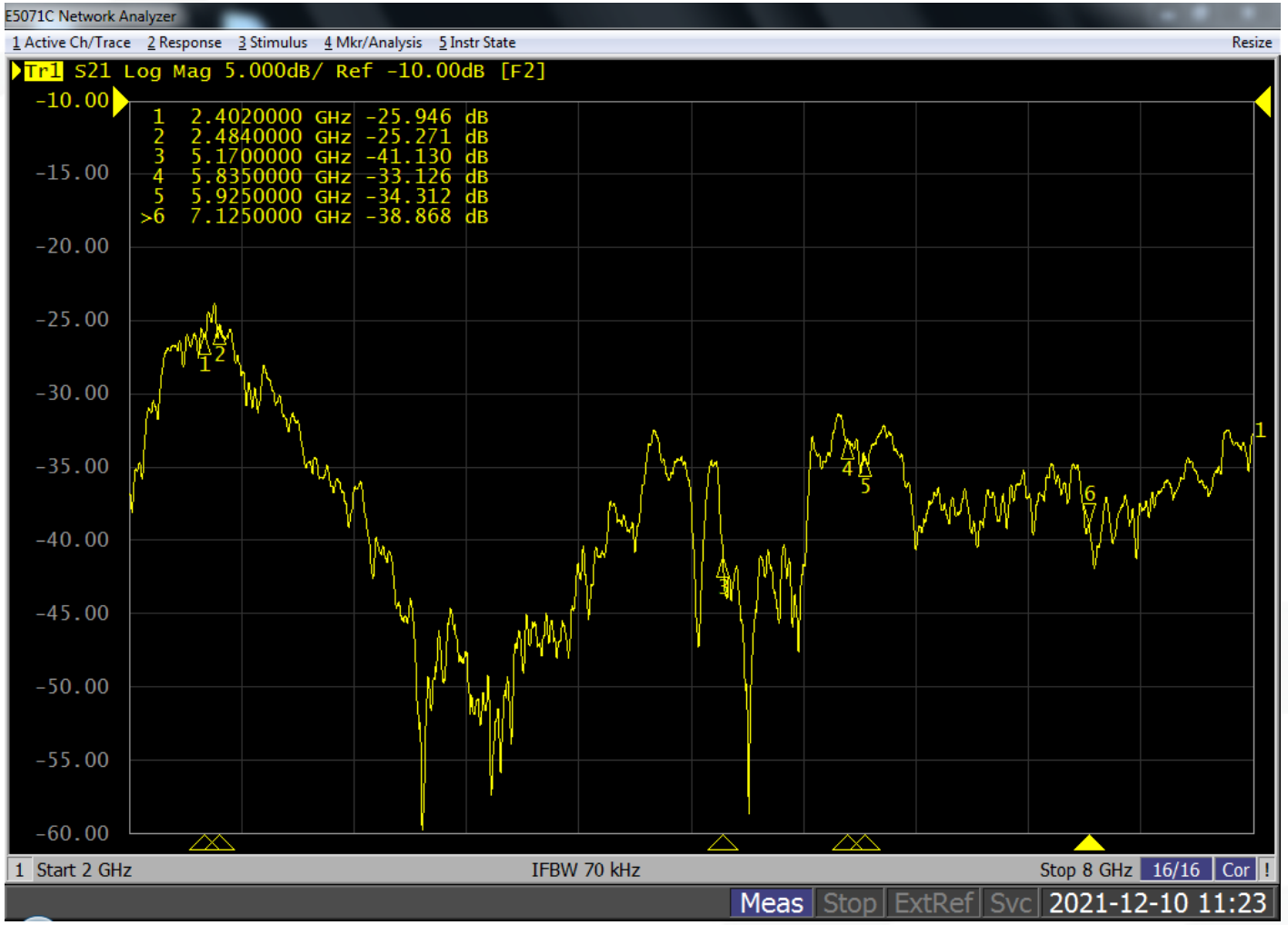
X6, X8 Isolation



X6, X9 Isolation

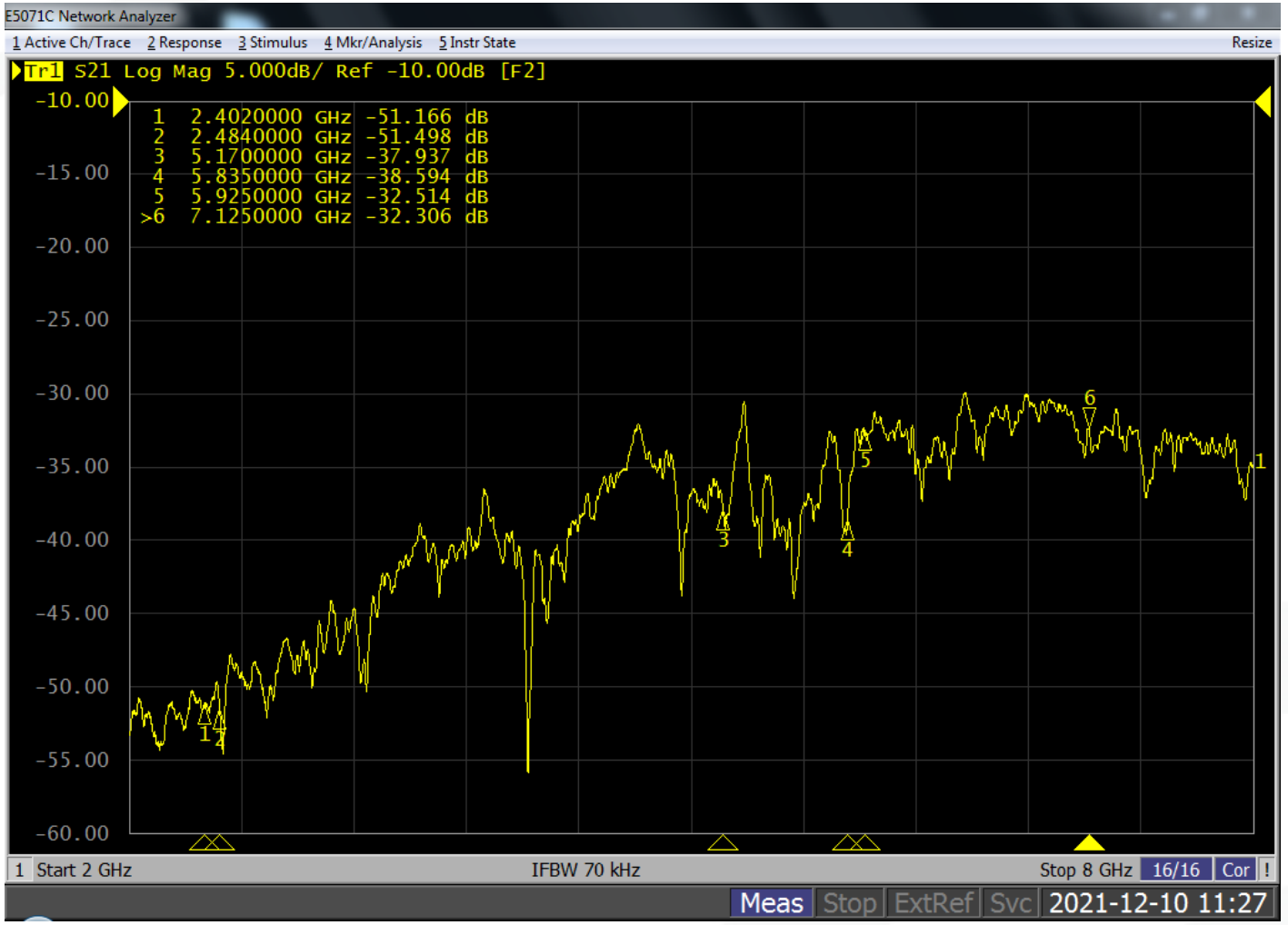


X8, X9 Isolation

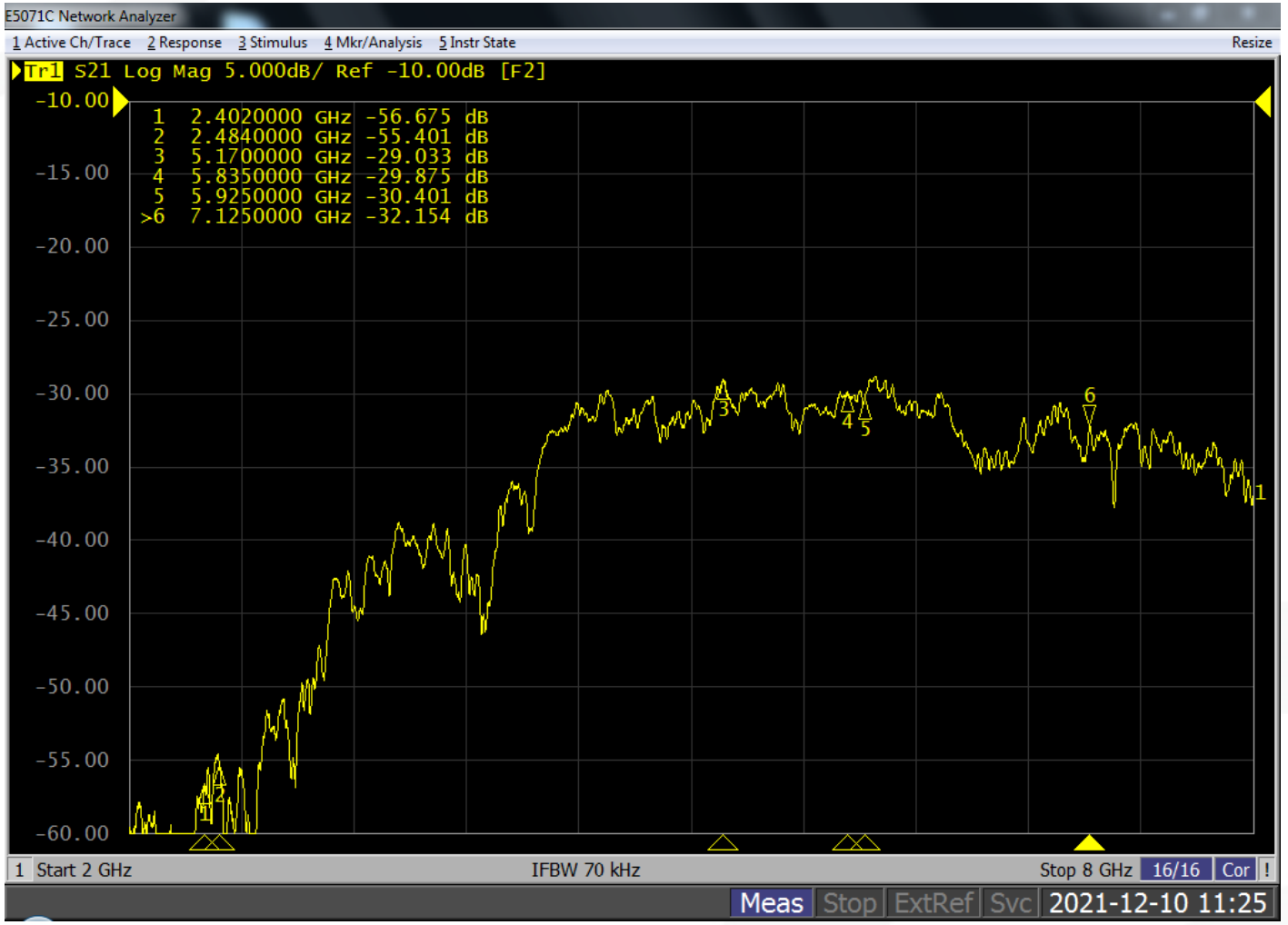


Isolation Between Single-Band Antennas

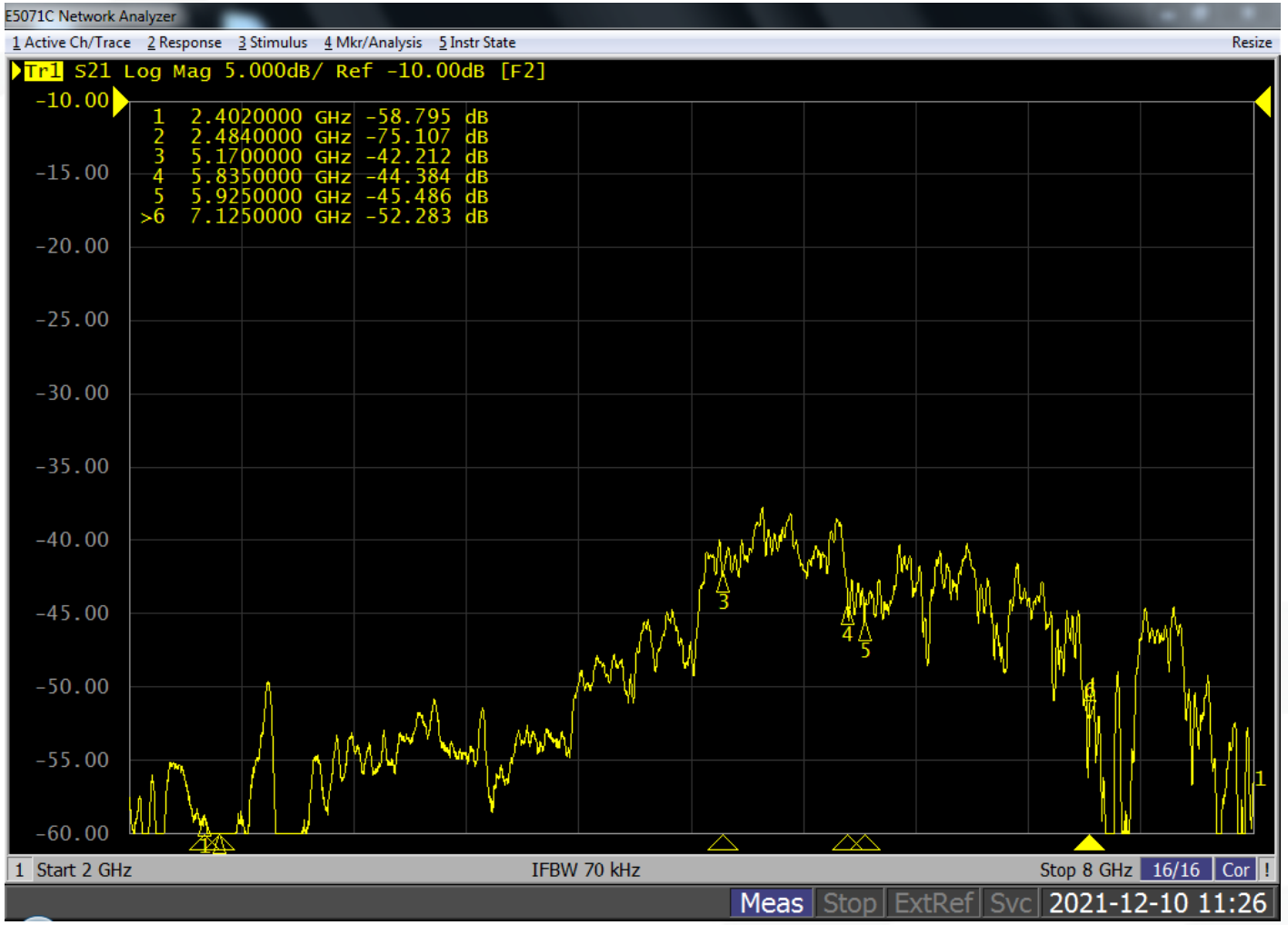
X3, X1 Isolation



X3, X4 Isolation

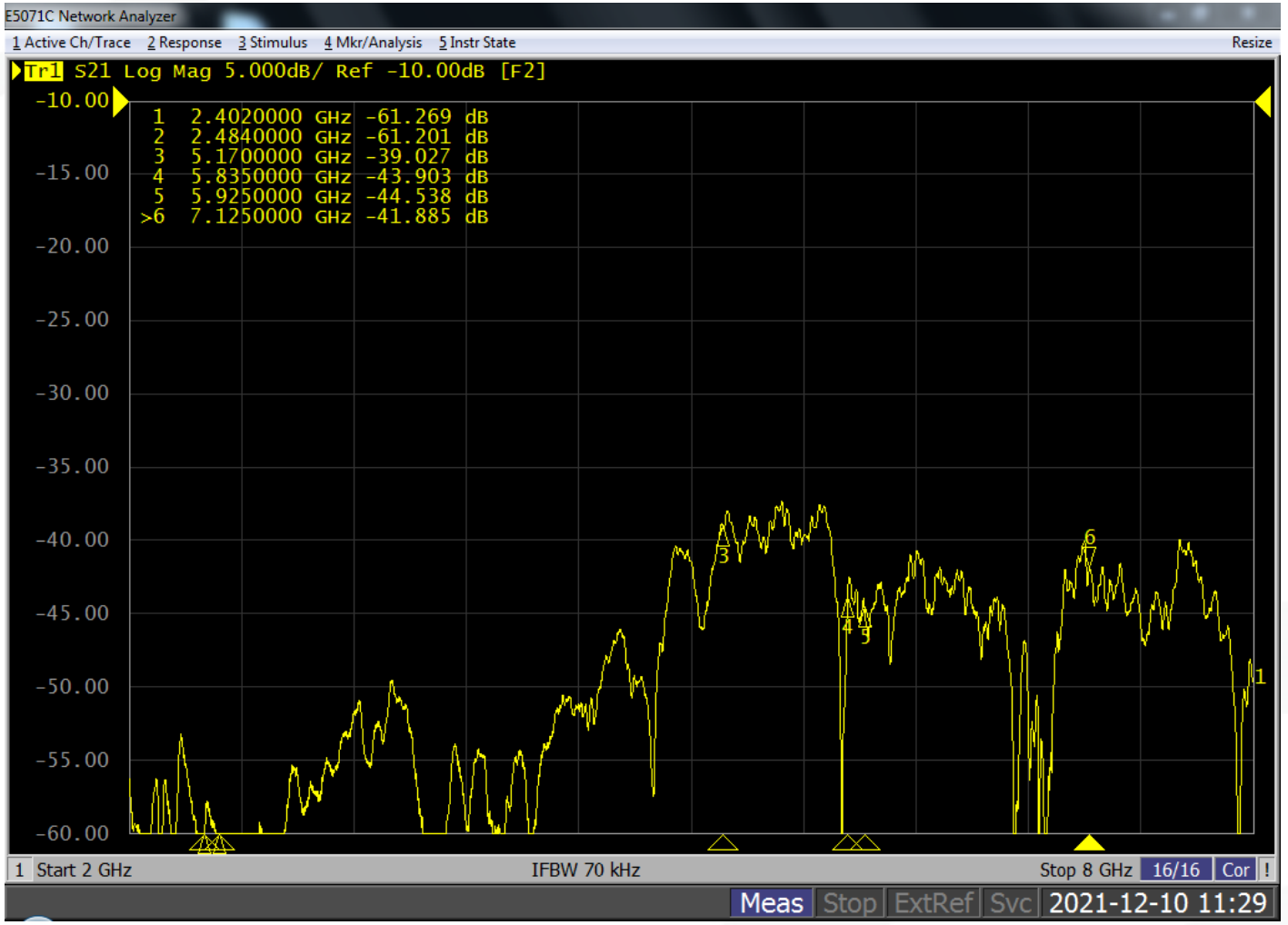


X3, X7 Isolation



X4, X1 Isolation

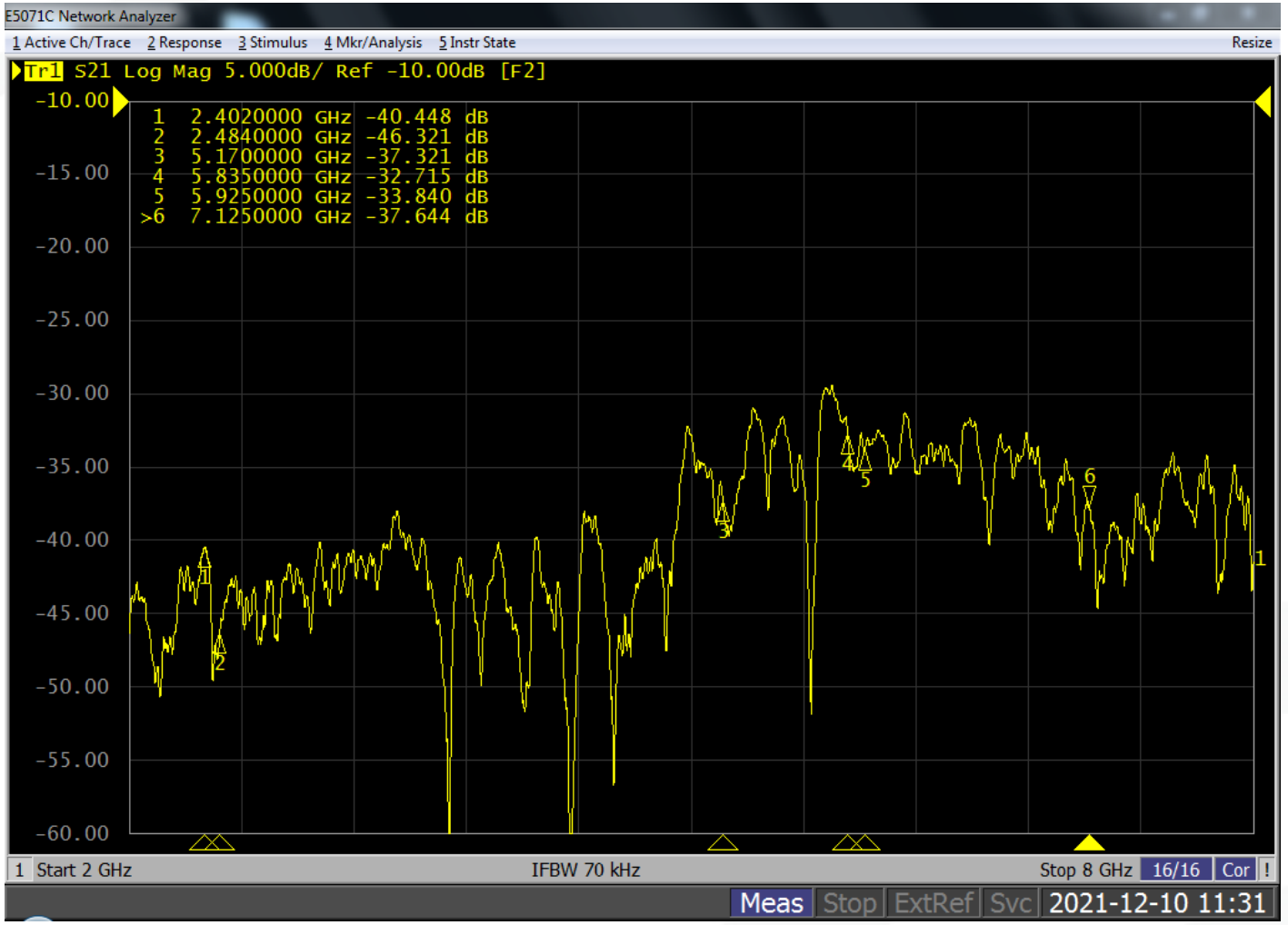
X4, X7 Isolation



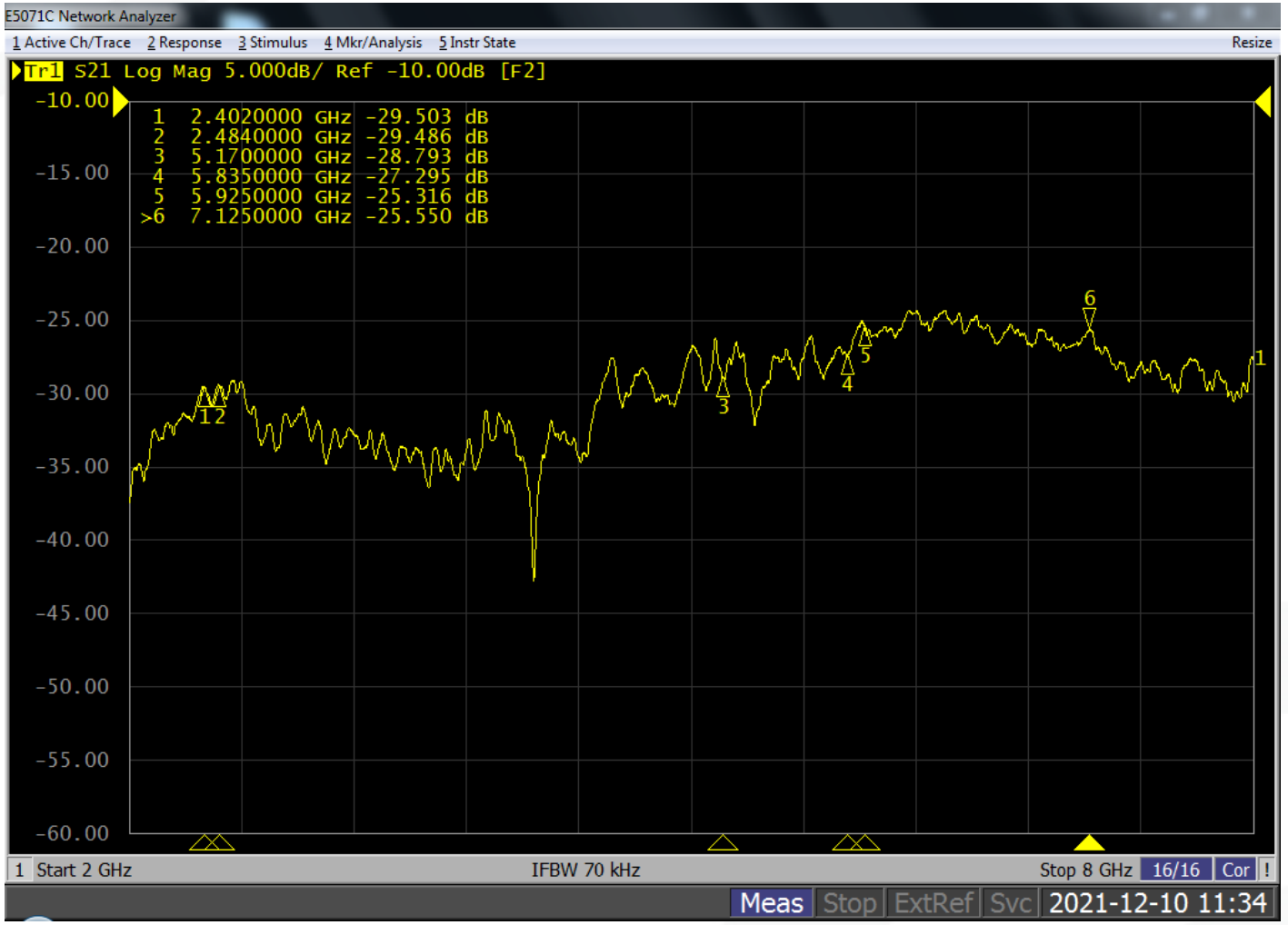
X7, X1 Isolation

Isolation Between Dual & Single-Band Antennas

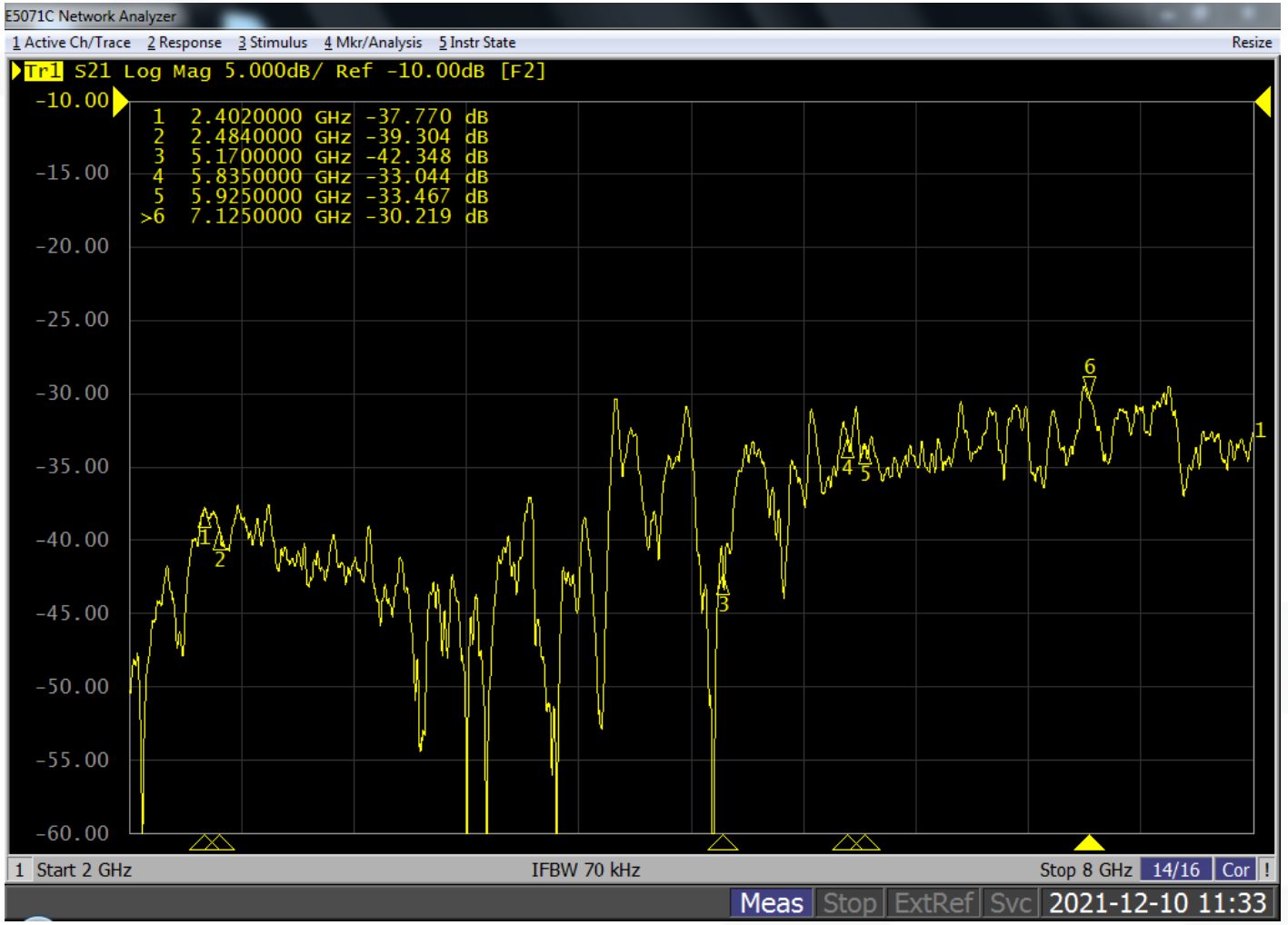
X5, X1 Isolation



X5, X3 Isolation

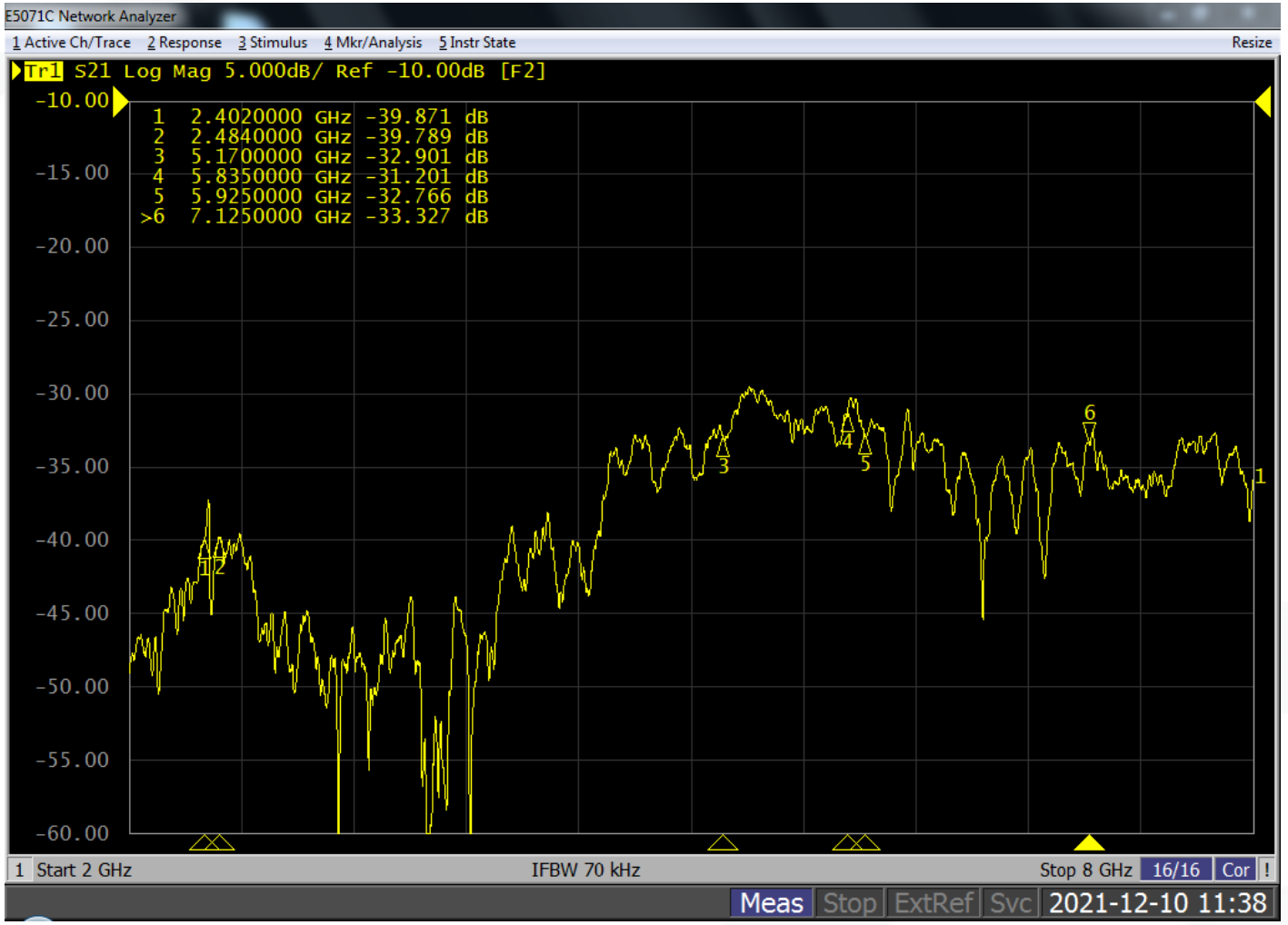


X5, X4 Isolation

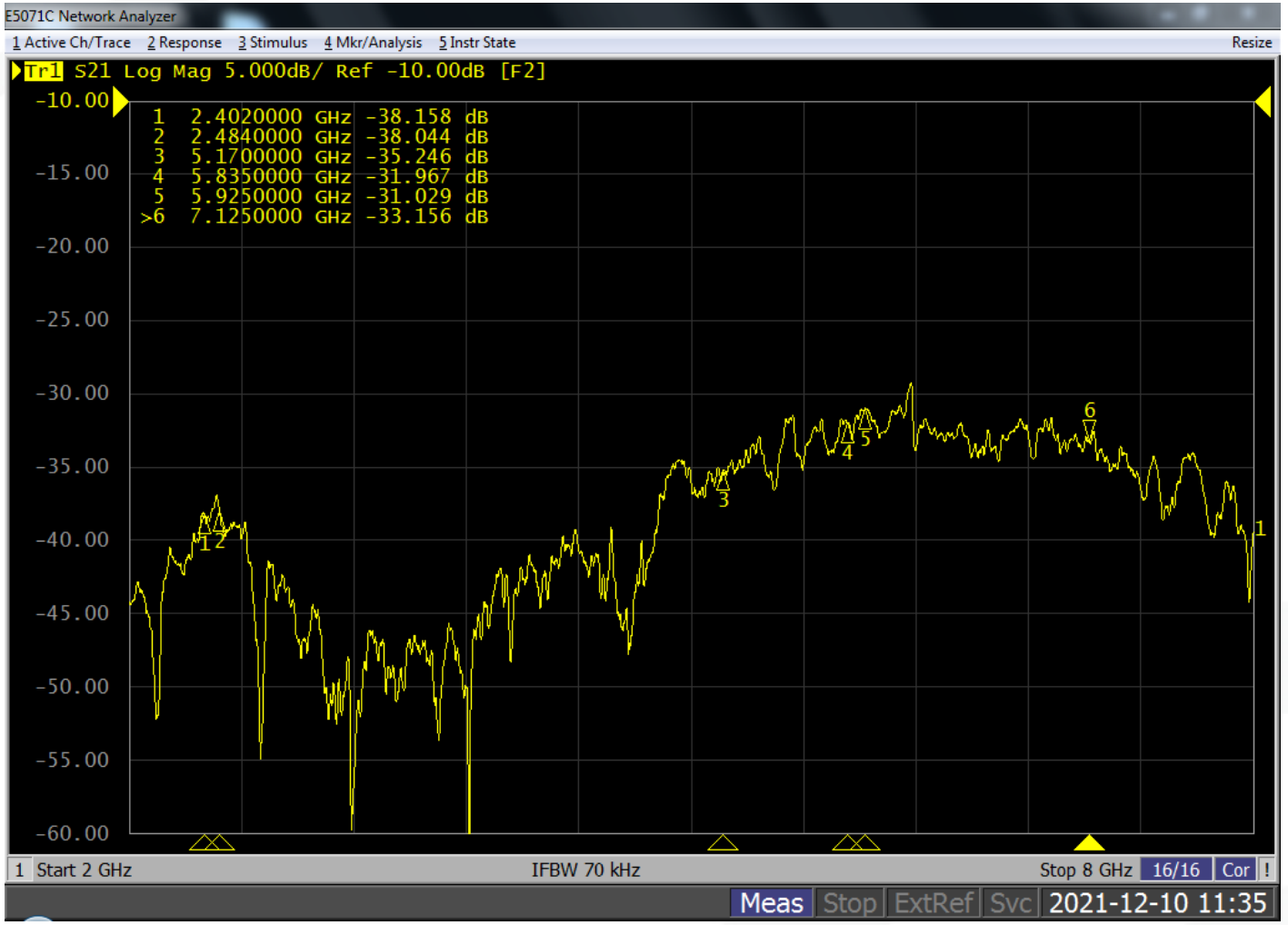


X5, X7 Isolation

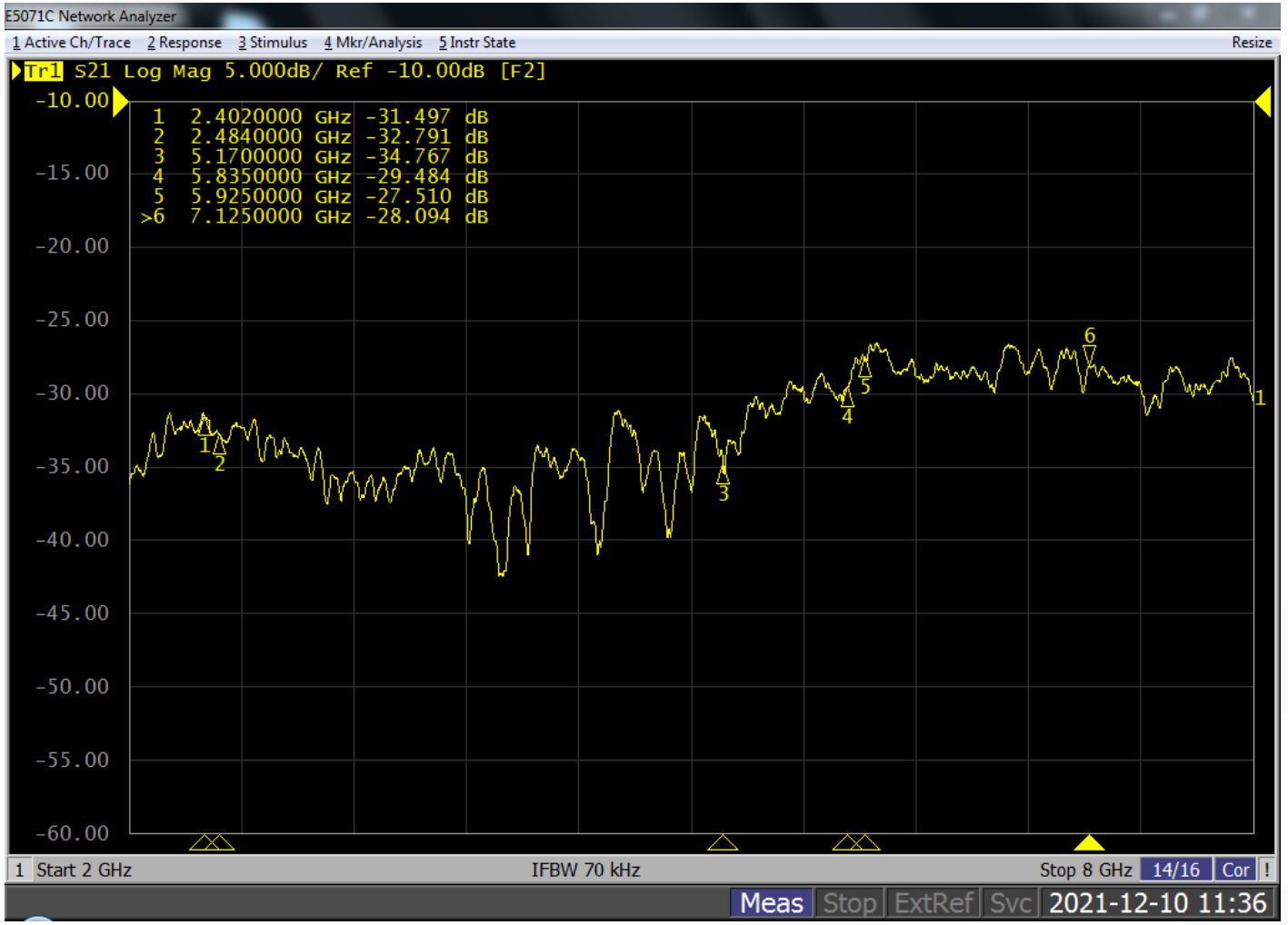
X6, X1 Isolation



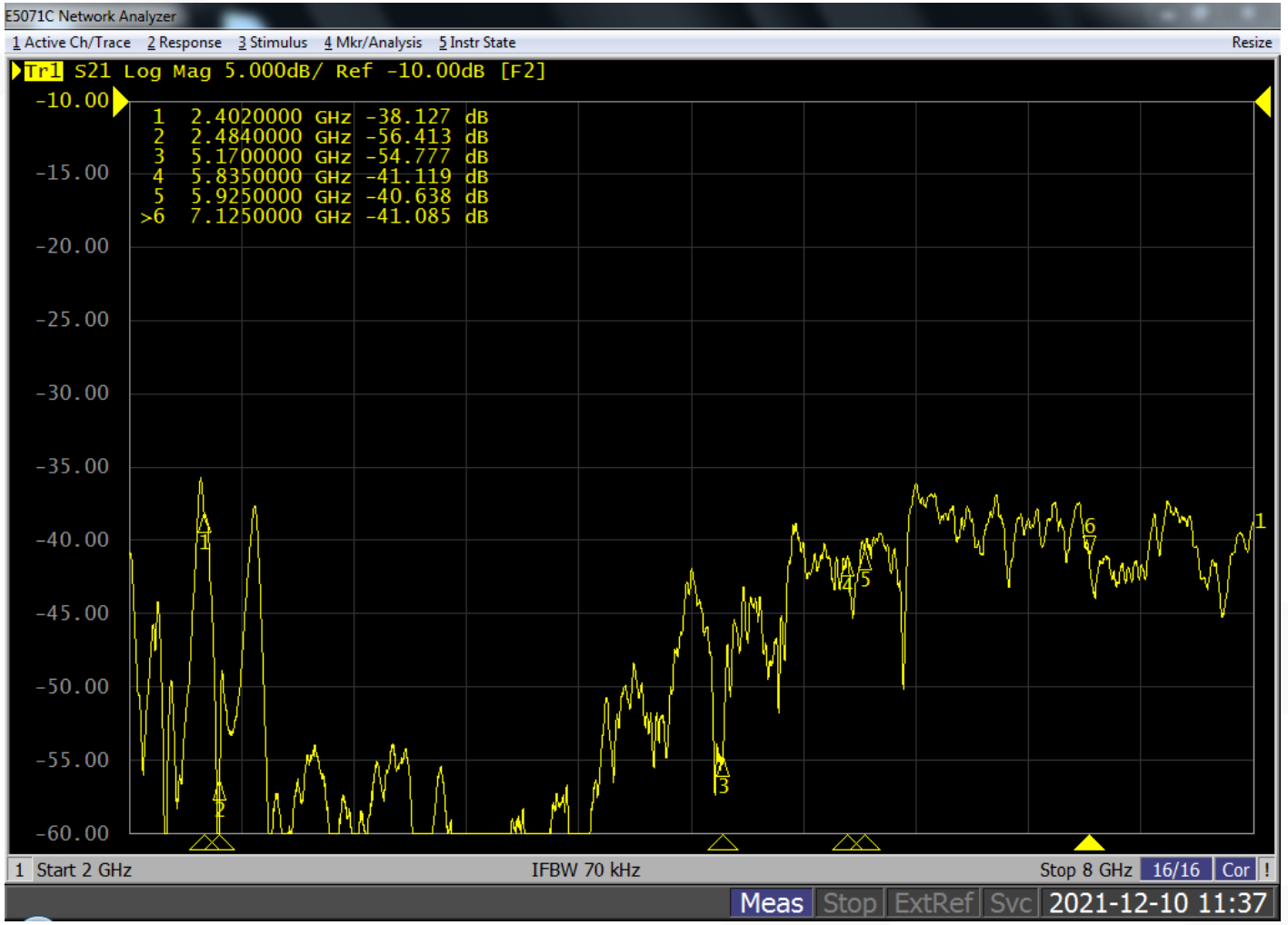
X6, X3 Isolation



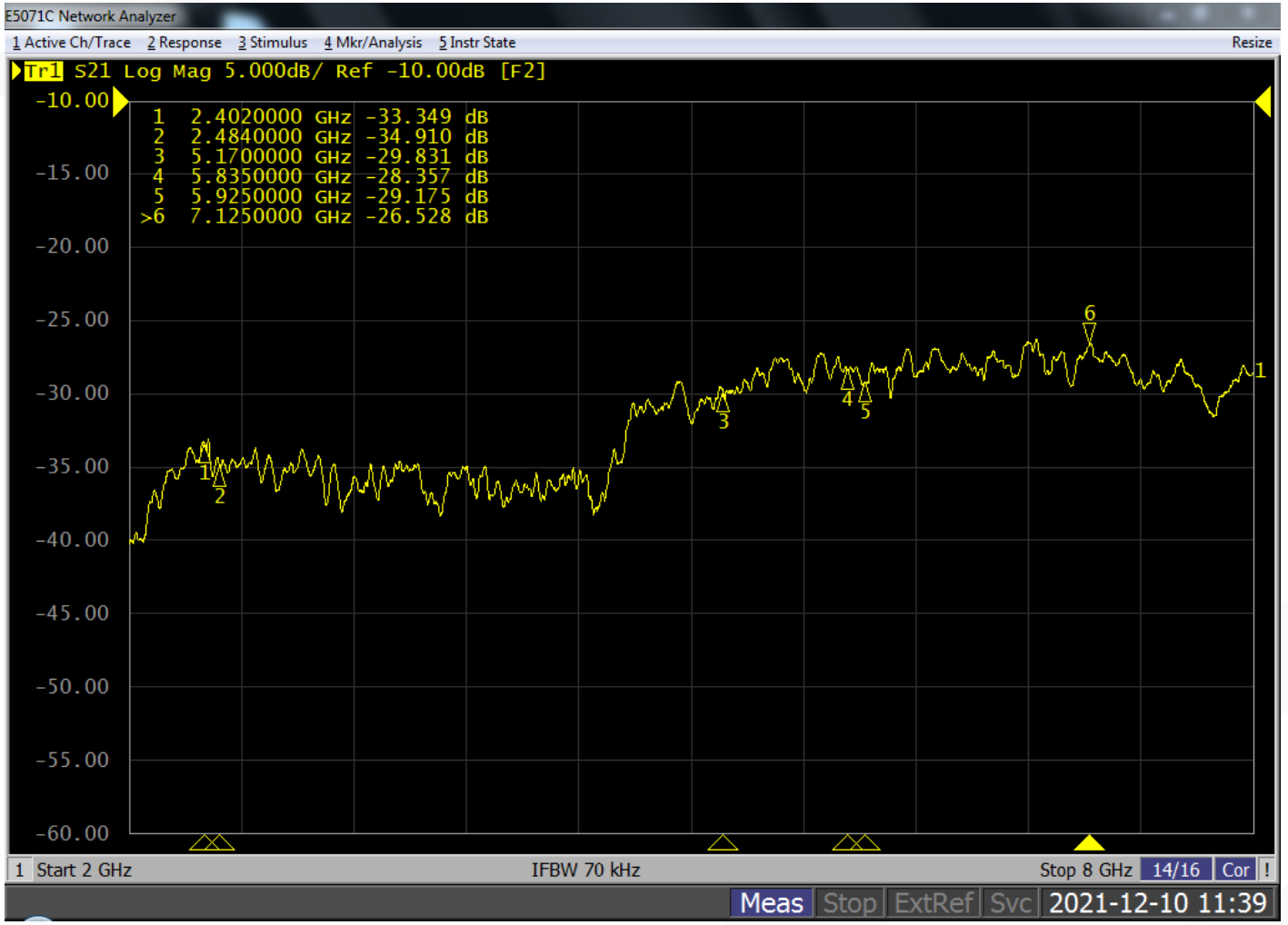
X6, X4 Isolation



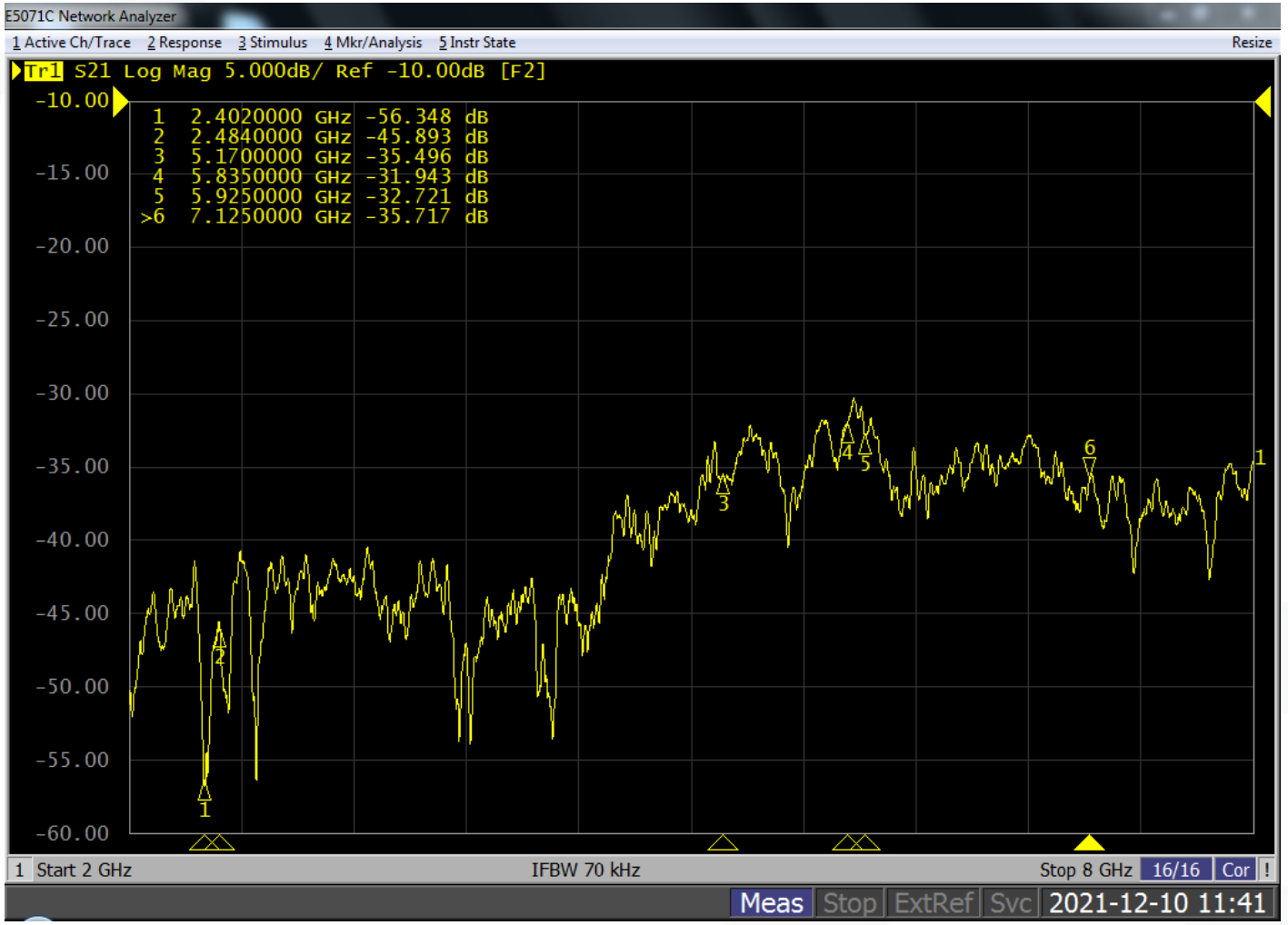
X6, X7 Isolation



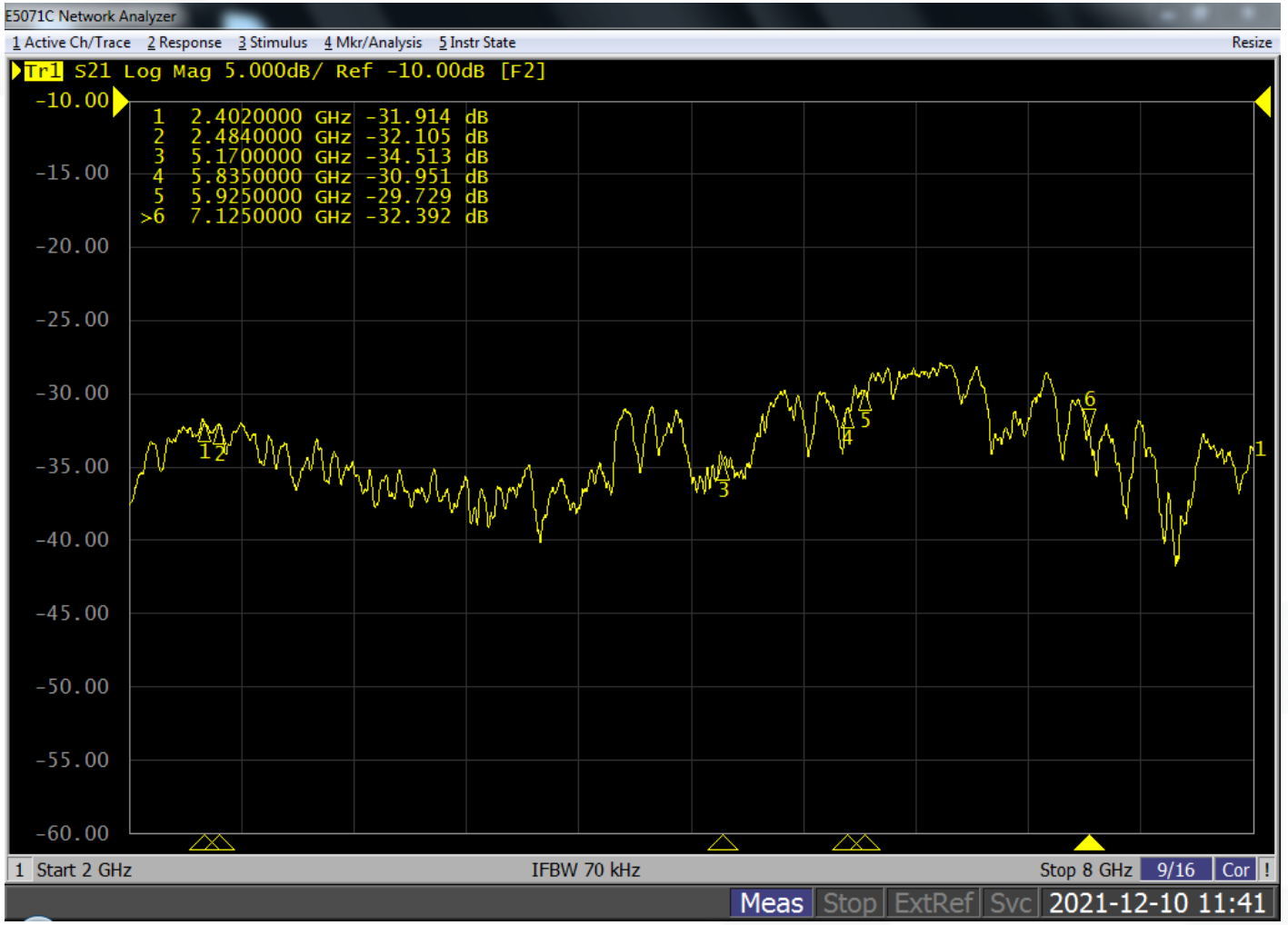
X8, X1 Isolation



X8, X3 Isolation

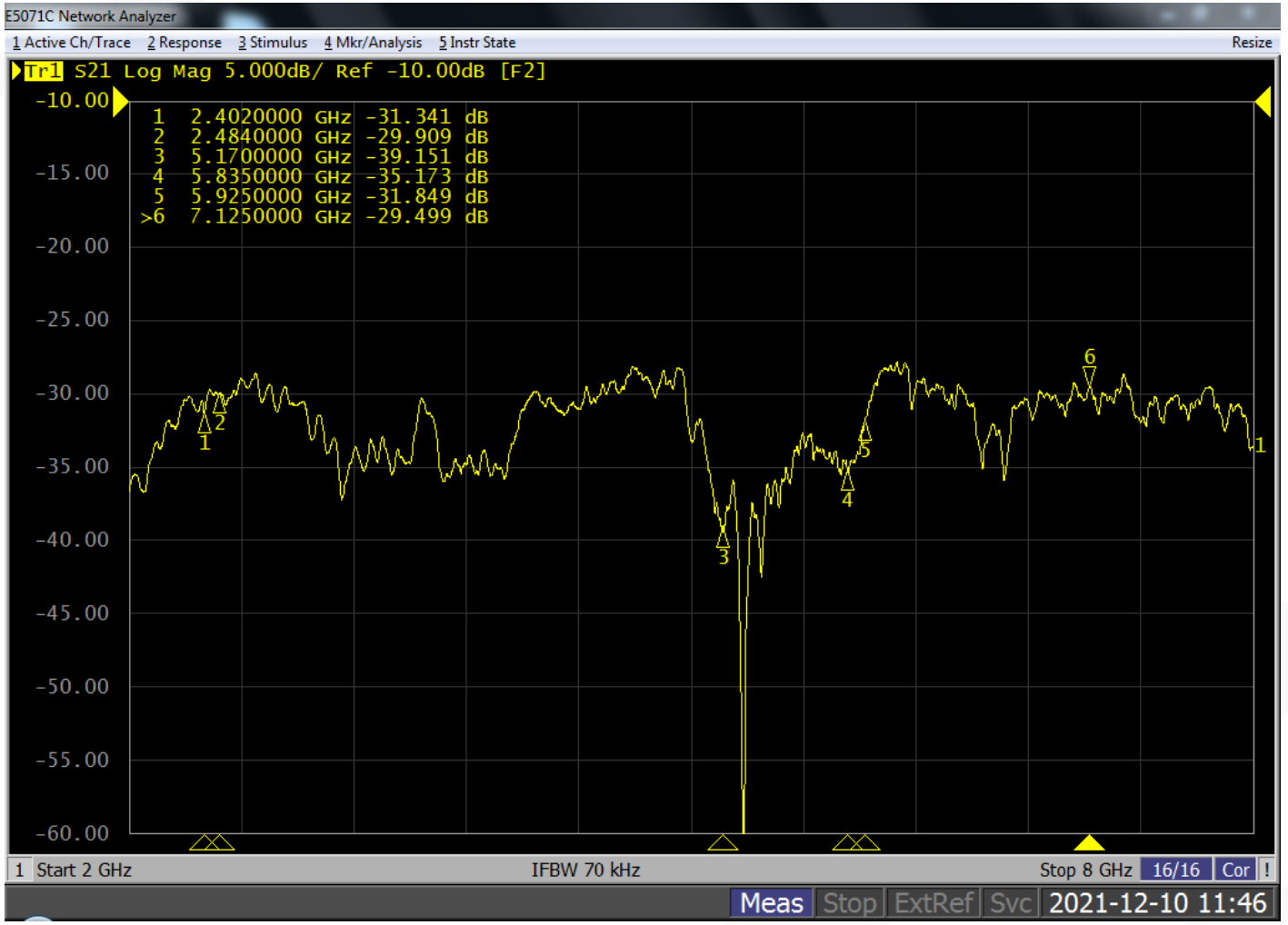


X8, X4 Isolation

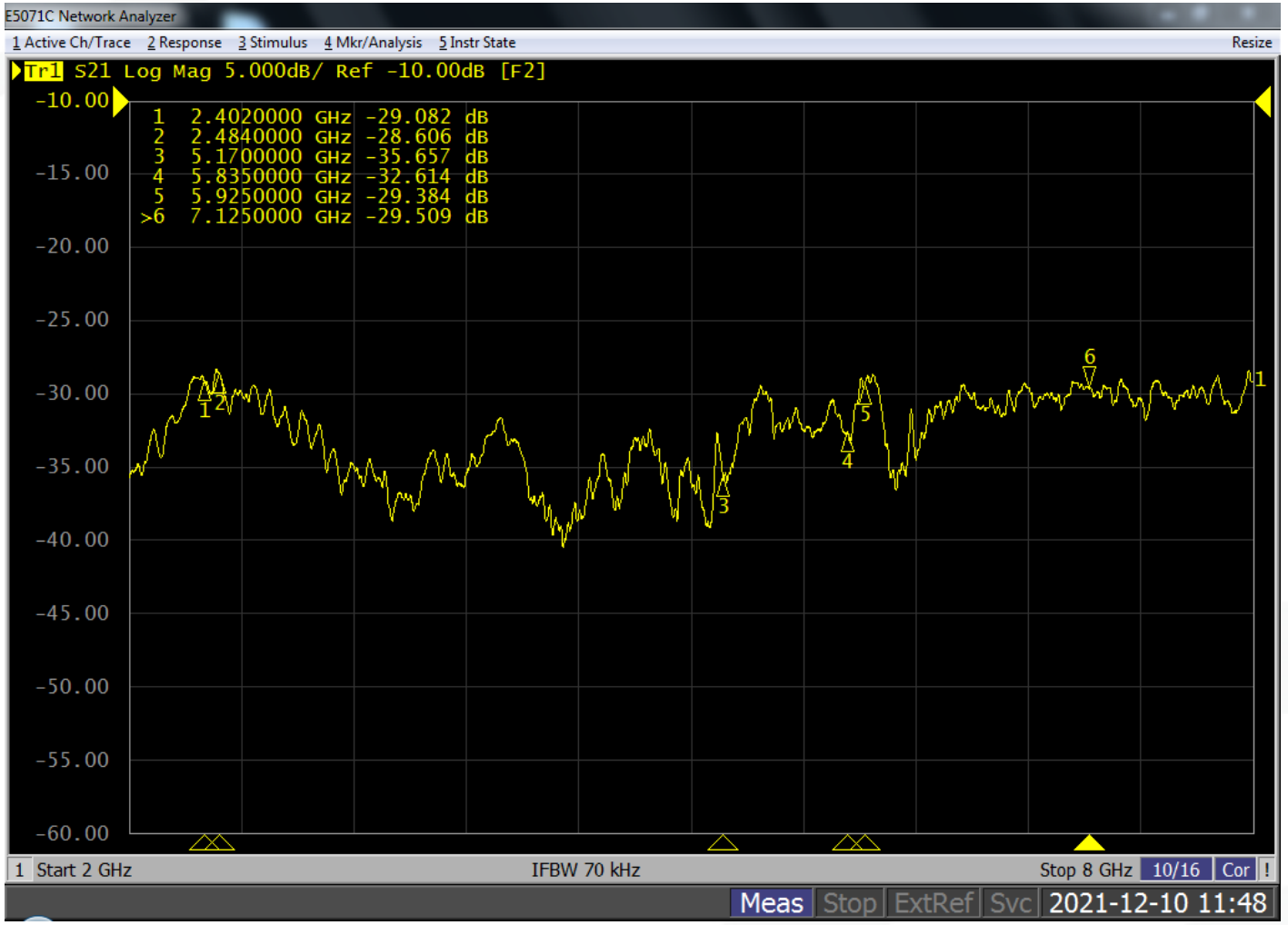


X8, X7 Isolation

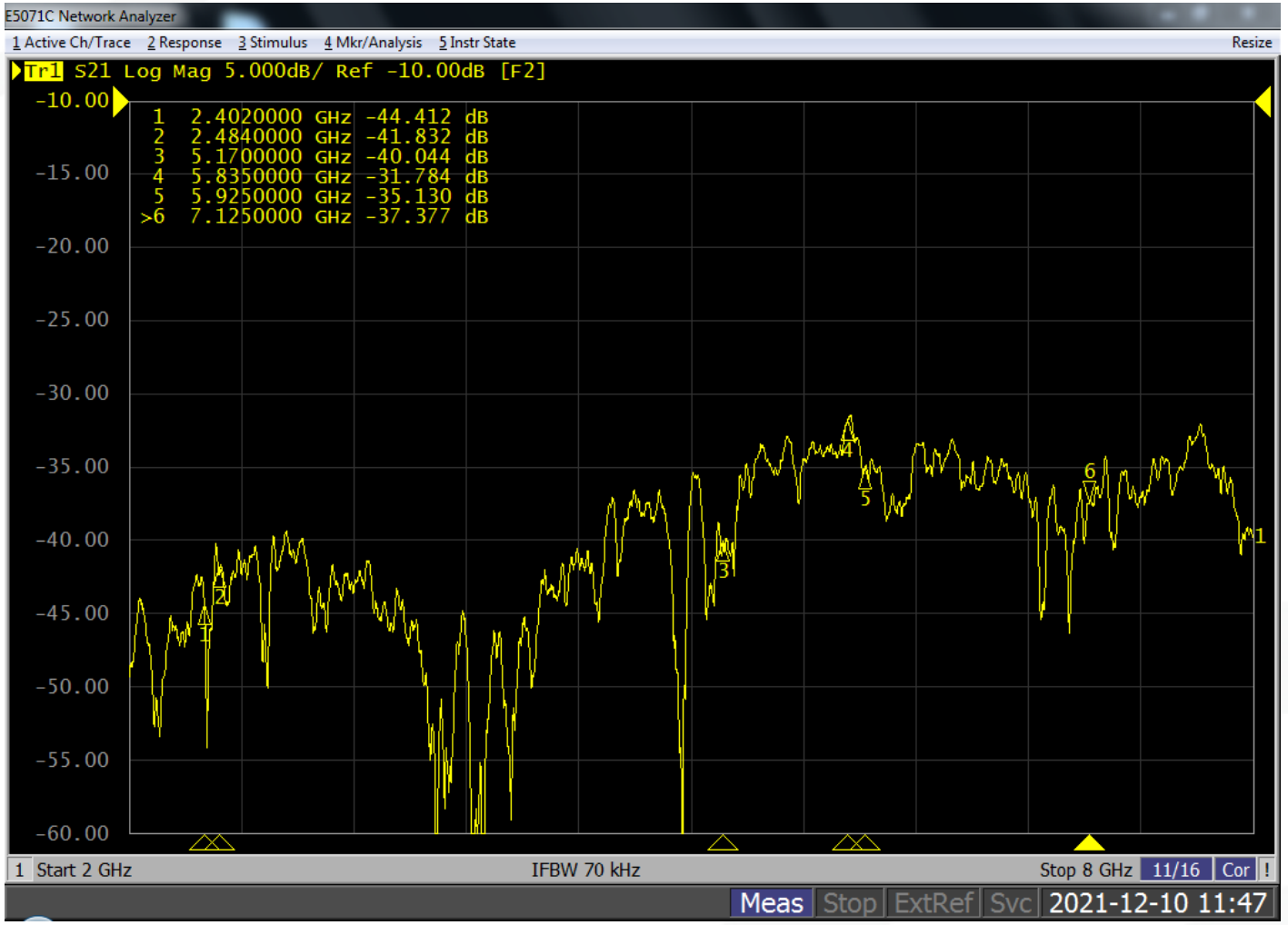
X9, X1 Isolation



X9, X3 Isolation



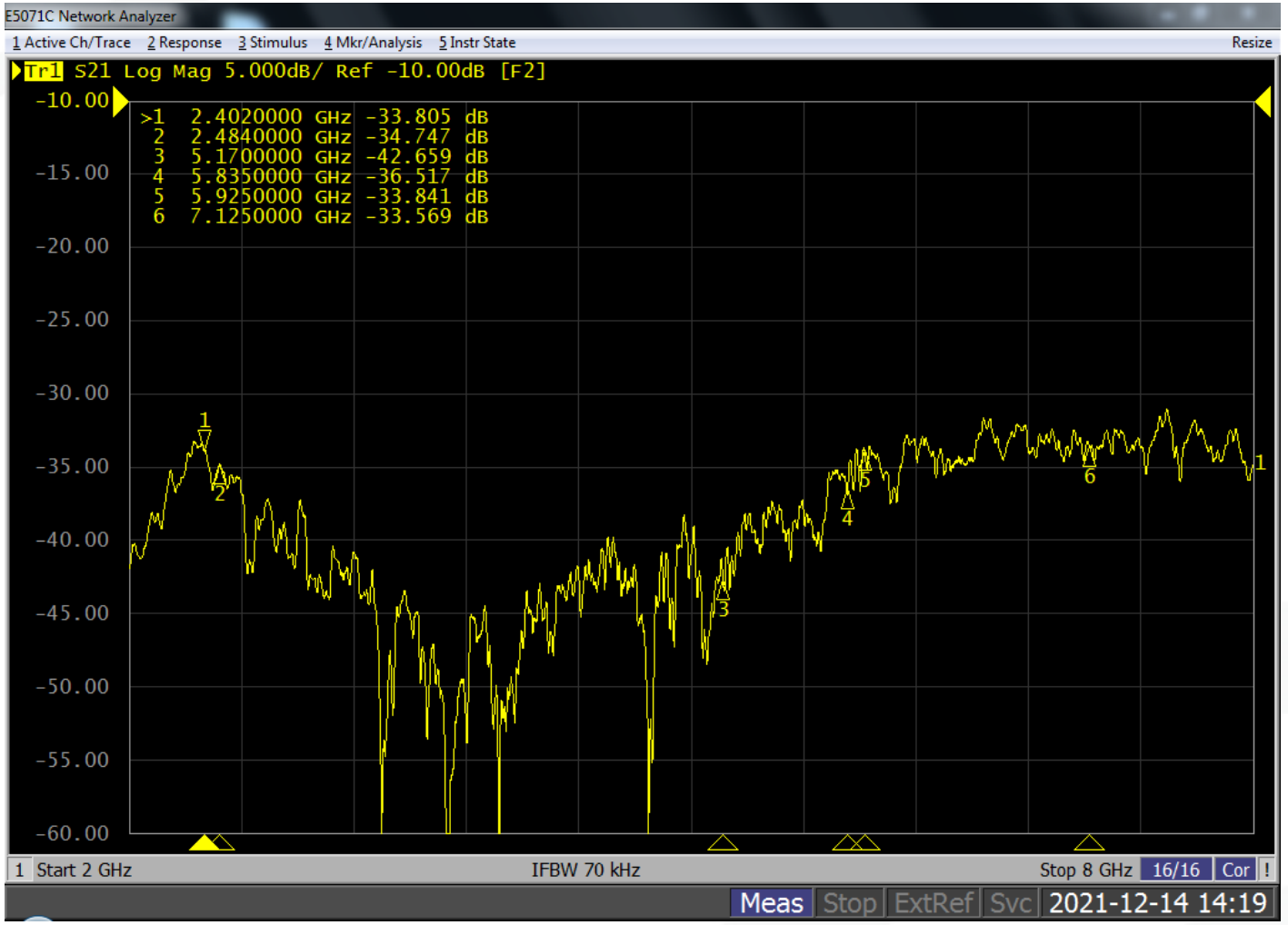
X9, X4 Isolation



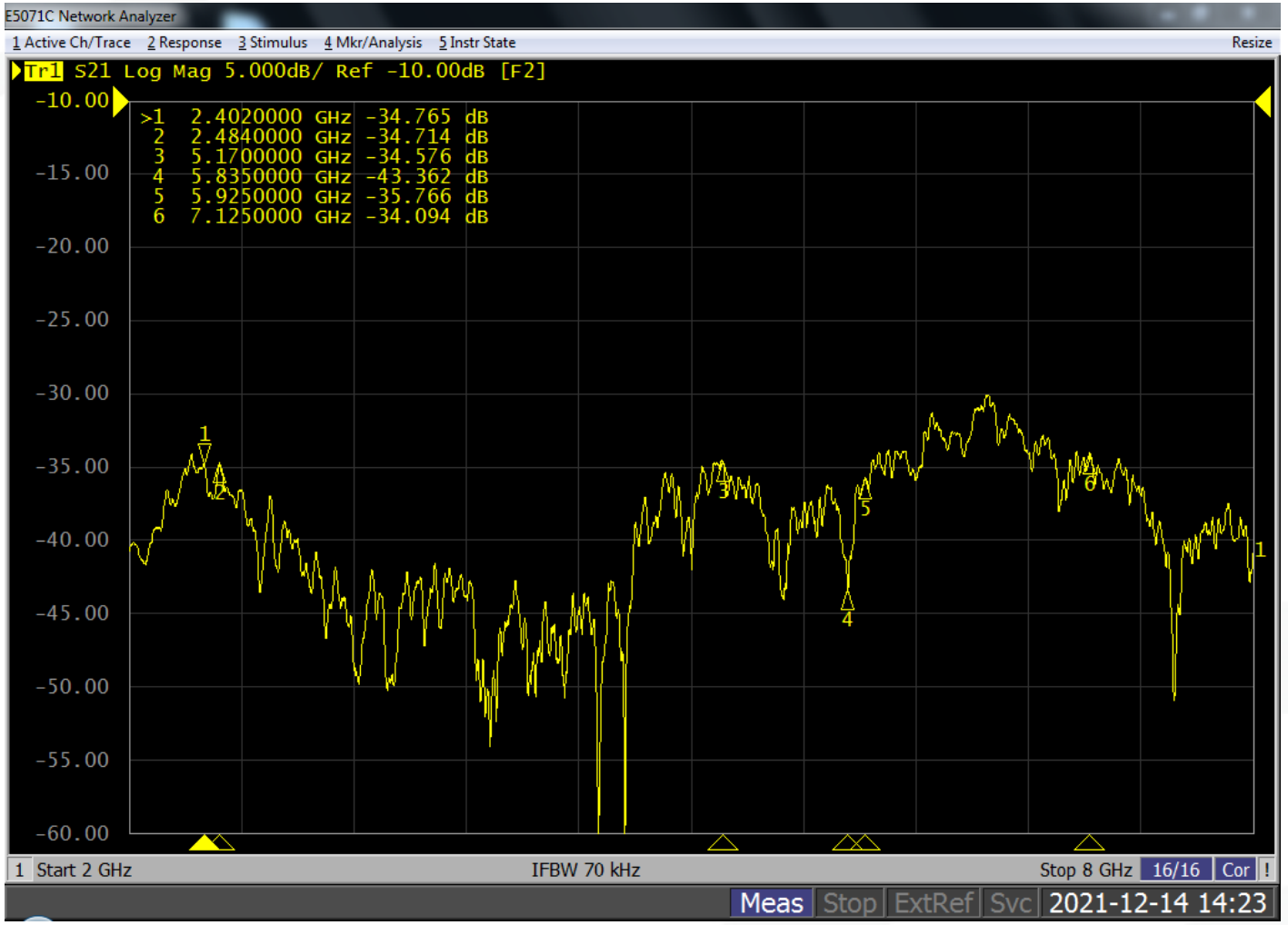
X9, X7 Isolation

Isolation Between Wi-Fi Antennas and Bluetooth Antenna

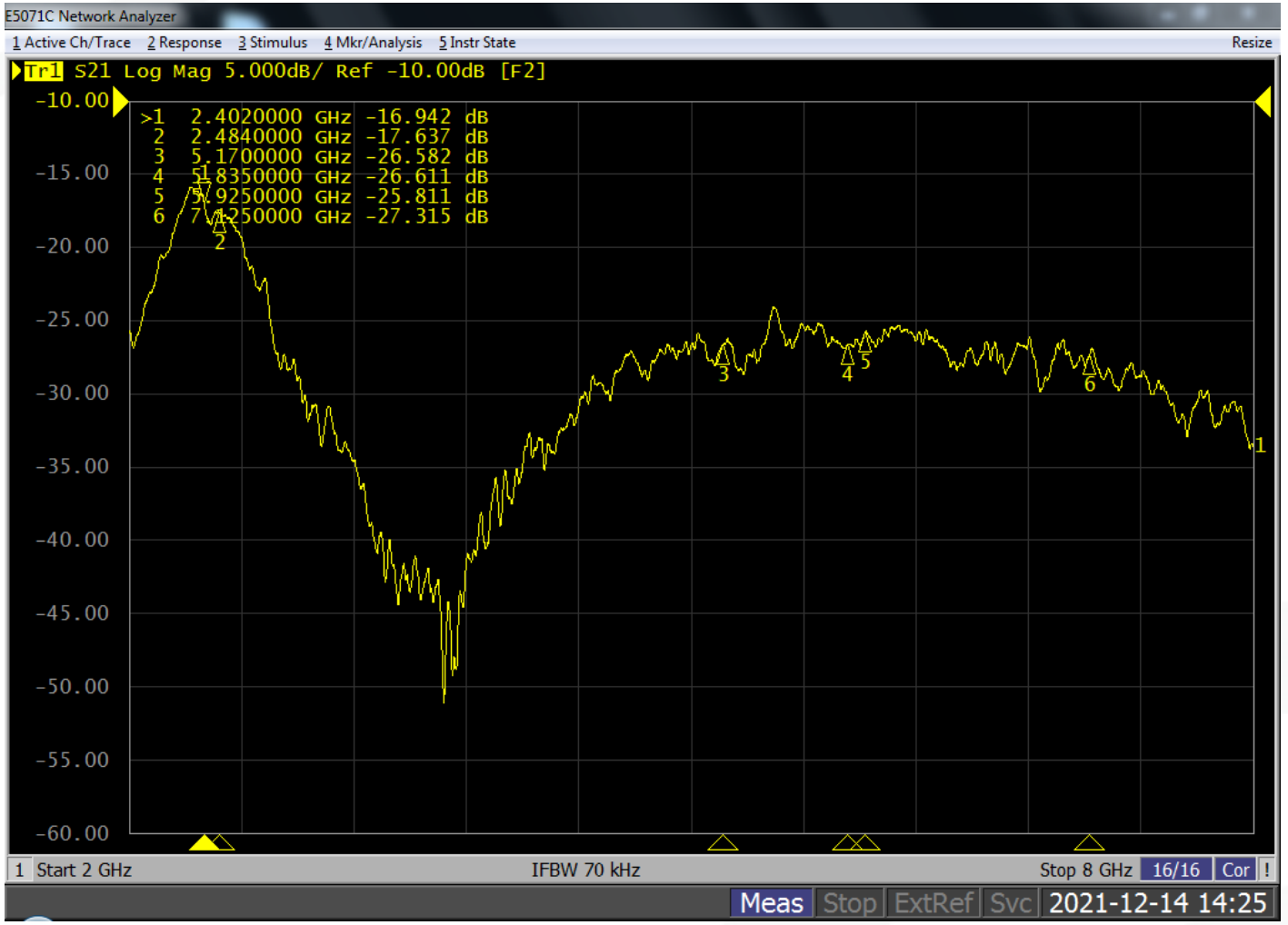
X3, BLE Isolation



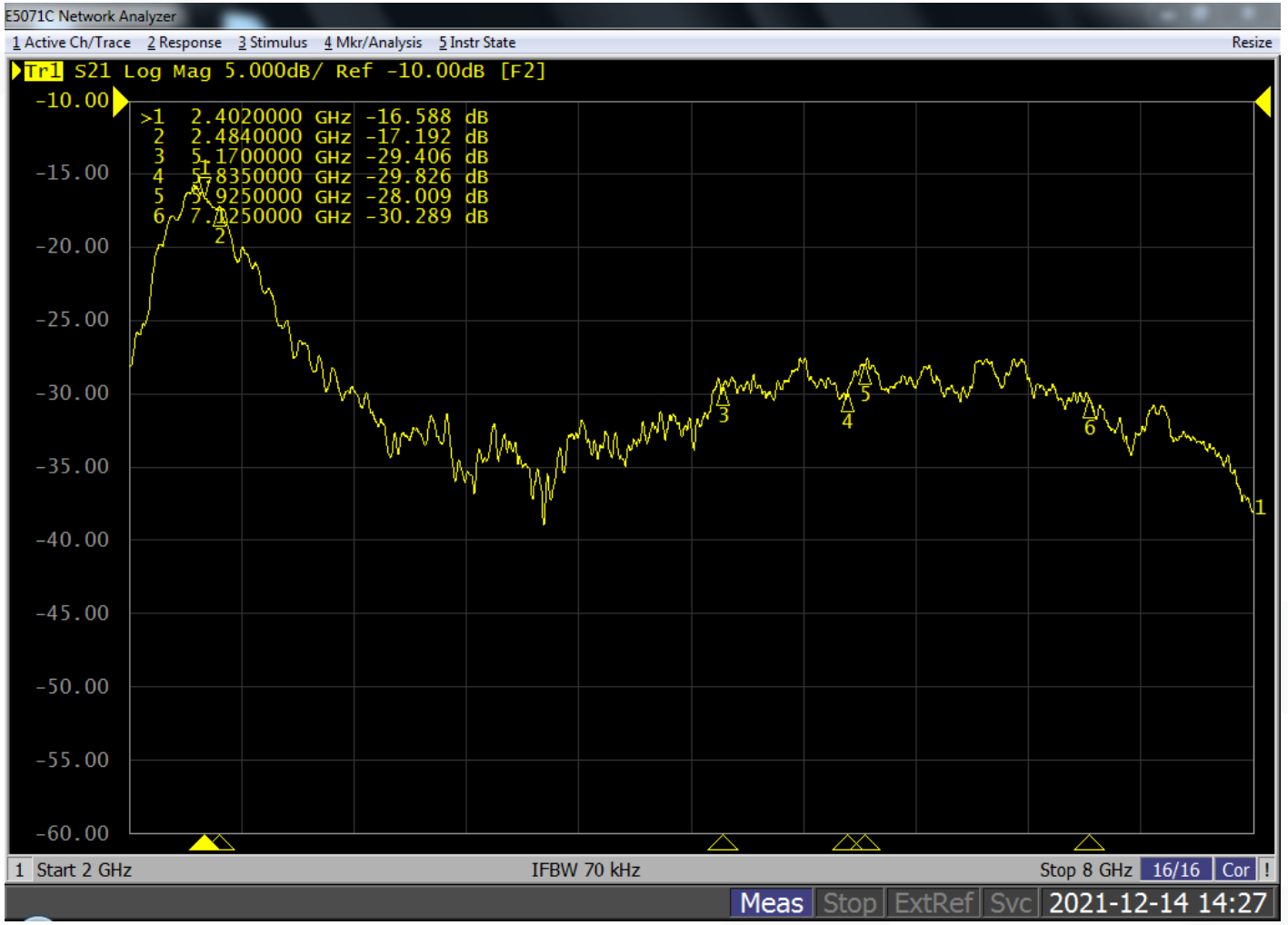
X4, BLE Isolation



X5, BLE Isolation

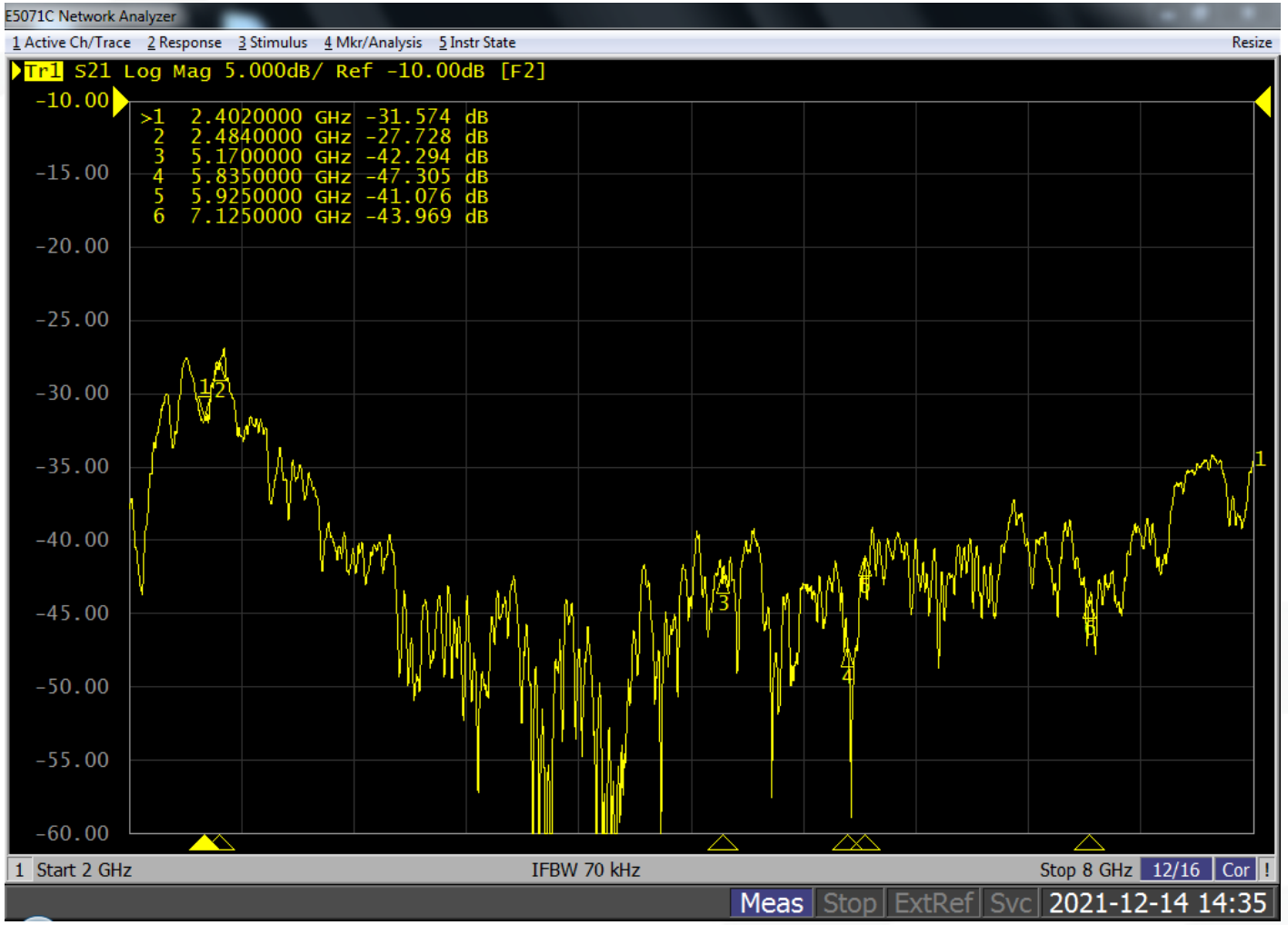


X6, BLE Isolation

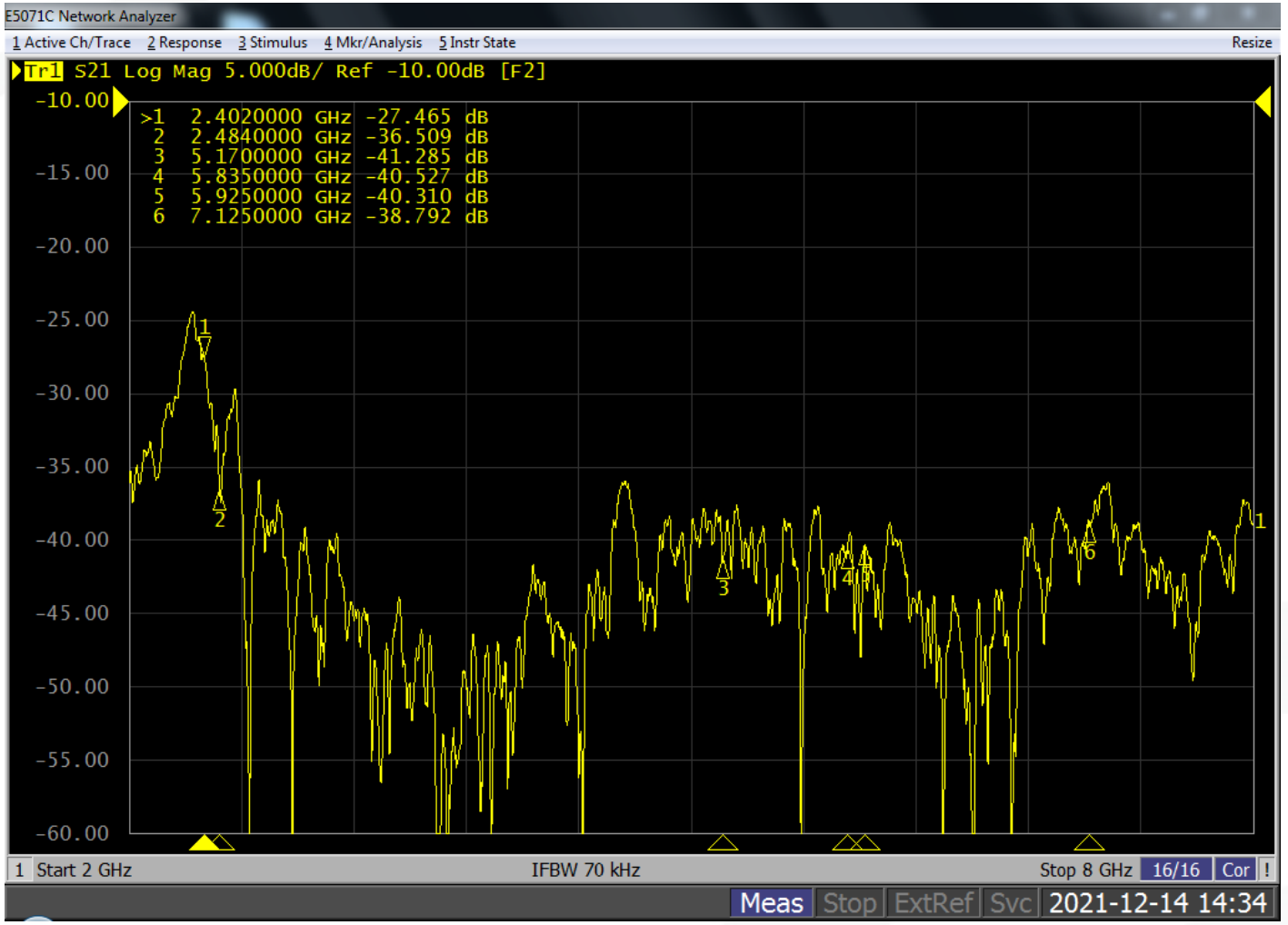


X7, BLE Isolation

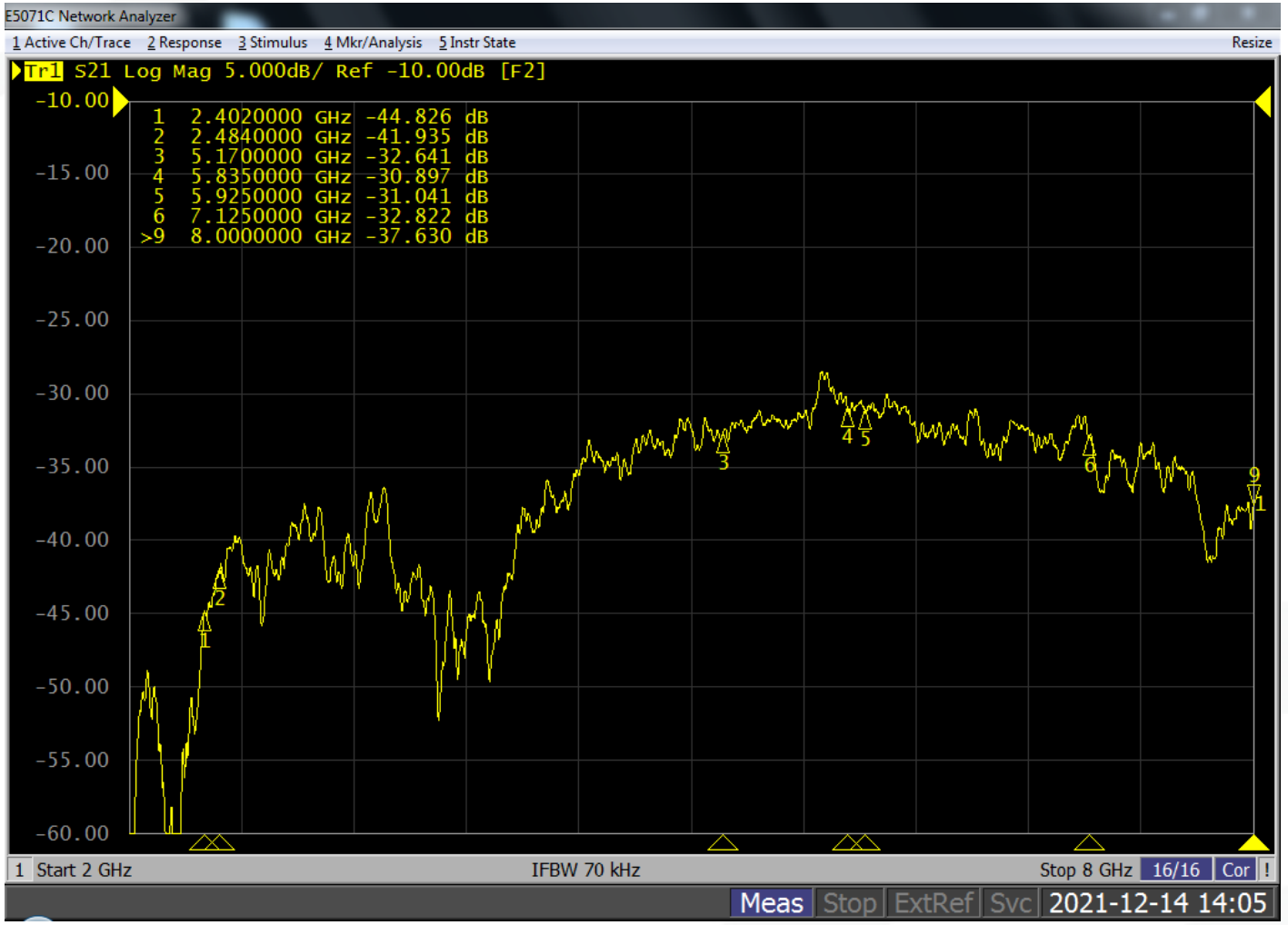
X8, BLE Isolation



X9, BLE Isolation



X10, BLE Isolation



Compliance

Single-Band Antenna Compliance Matrix

Design Parameter	Specification	Comply?				Comment
Frequency Range	5925 – 7125 MHz	Yes				-
Ports	4	Yes				-
Cable/Connector/Feed	Micro-coax/IPEX/Direct Solder	Yes				-
In-Group Isolation	≥ 20 dB	Yes				-
DB & 6G Isolation	≥ 25 dB	*Almost!*				(X3, X5) pair has 24.5 dB isolation right around 6 GHz; every other pair has a couple dB of margin over the 6 GHz band
Return Loss	<-10 dB	Yes				With respect to 50 Ω reference impedance
		X3: -13 dB	X4: -12 dB	X7: -11 dB	X10: -13 dB	
Peak Gain	Not specified	X3: 6.6 dBi	X4: 6.2 dBi	X7: 3.3 dBi	X10: 6.1 dBi	Overall Peak Gain = 6.6 dBi
Efficiency	Not specified	X3: 65%	X4: 64%	X7: 55%	X10: 66%	63% typical
Polarization	Not specified	-				3 vertical; 1 horizontal
Uncorrelated Antenna Gain	≤ 6 dBi	Yes				Overall Peak Uncorrelated Gain = 3.1 dBi
Correlated Antenna Gain	Not specified	-				8.8 dBi max.; 8.6 dBi typ.

Dual-Band Antenna 2.4 GHz Compliance Matrix

Design Parameter	Specification	Comply?				Comment
Frequency Range	2402 – 2484 & 5170 – 5835 MHz	Yes				-
Ports	4	Yes				-
Cable/Connector/Feed	Micro-coax/IPEX/Direct Solder	Yes				-
In-Group Isolation	≥ 20 dB	Yes				-
DB & 6G Isolation	≥ 25 dB	Yes				(X3, X9) pair has 28 dB isolation over 2.4 GHz; this is the maximum isolation between DB and 6G antennas over the 2.4 GHz band
Return Loss	<-10 dB	Yes				With respect to 50 Ω reference impedance
		X5: -18 dB	X6: -13 dB	X8: -15 dB	X9: -14 dB	
Peak Gain	Not specified	X5: 4.1 dBi	X6: 3.2 dBi	X8: 4.4 dBi	X9: 3.7 dBi	Overall Peak Gain = 4.4 dBi
Efficiency	Not specified	X5: 71 %	X6: 65%	X8: 69%	X9: 69%	69% typical
Polarization	Not specified	-				Mixed
Uncorrelated Antenna Gain	≤ 6 dBi	Yes				Overall Peak Uncorrelated Gain = 2.3 dBi
Correlated Antenna Gain	Not specified	-				8.3 dBi max.; 8.1 dBi typ.

Dual-Band Antenna 5 GHz Compliance Matrix

Design Parameter	Specification	Comply?				Comment
Frequency Range	2402 – 2484 & 5170 – 5835 MHz	Yes				-
Ports	4	Yes				-
Cable/Connector/Feed	Micro-coax/IPEX/Direct Solder	Yes				-
In-Group Isolation	≥ 20 dB	Yes				-
DB & 6G Isolation	≥ 25 dB	Yes				(X3, X9) pair has 26 dB isolation over 5 GHz; this is the maximum isolation between DB and 6G antennas over the 5 GHz band
Return Loss	<-10 dB	Yes				With respect to 50 Ω reference impedance
		X5: -15 dB	X6: -13 dB	X8: -14 dB	X9: -14 dB	
Peak Gain	Not specified	X5: 4.4 dBi	X6: 4.2 dBi	X8: 3.7 dBi	X9: 4.1 dBi	Overall Peak Gain = 4.4 dBi
Efficiency	Not specified	X5: 65%	X6: 60%	X8: 59%	X9: 61%	61% typical
Polarization	Not specified	-				Mixed
Uncorrelated Antenna Gain	≤ 6 dBi	Yes				Overall Peak Uncorrelated Gain = 3.0 dBi
Correlated Antenna Gain	Not specified	-				9 dBi max.; 8.2 dBi typ.

Bluetooth Antenna Compliance Matrix

Design Parameter	Specification	Comply?	Comment
Frequency Range	2402 – 2484 MHz	Yes	-
Ports	1	Yes	-
Cable/Connector/Feed	Micro-coax/IPEX/Direct Solder	Yes	-
Return Loss	<-10 dB	Yes; -16 dB	With respect to 50 Ω reference impedance
Peak Gain	Not specified	4.2 dBi	Overall Peak Gain = 4.2 dBi
Efficiency	Not specified	70%	70% typical
Polarization	Not specified	-	Mixed

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Performance Critical

Thank You!

Revision History

Rev 1: Added tables summarizing performance, BLE isolation data, and tabulated isolation data

Rev 2: Revised compliance tables & regenerated radiation patterns for viewability

Rev 3: Added correlated antenna gains to data summary and compliance tables

Rev 4: Added calculation formulas for correlated and uncorrelated gains

Rev 5: Updated SB antenna max. correlated gains with correct values