Appendix

Main Test Instruments

Conducted Emission					
Test Equipment	**Manufacturer**	**Model No.**	**Inventory No.**	**Cal. date**	**Cal.Duedate**
				(yyyy-mm-dd)	**(yyyy-mm-dd)**
Shielding Room	ZhongYu Electron	GB-88	SEM001-06	2017/5/10	2020/5/9
LISN	Rohde & Schwarz	ENV216	SEM007-01	2018/9/2	2019/9/2
LISN	ETS-LINDGREN	Feb-16	SEM007-02	2019/4/1	2020/3/31
Measurement Software	AUDIX	e3 V5.4.1221d	N/A	N/A	N/A
Coaxial Cable	SGS	N/A	SEM024-01	2019/6/12	2020/6/11
2 Line ISN	Fischer Custom Communications Inc.	FCC-TLISN-T2-02	EMC0122	2019/2/11	2020/2/10
EMI Test Receiver	Rohde & Schwarz	ESCI	SEM004-02	2019/3/2	2020/3/1

RF conducted test					
Test Equipment	**Manufacturer**	**Model No.**	**Inventory No.**	**Cal. date**	**Cal.Duedate**
				(yyyy-mm-dd)	**(yyyy-mm-dd)**
DC Power Supply	Agilent Technologies Inc	66311B	W009-09	2018/9/15	2019/9/15
Signal Analyzer	Rohde & Schwarz	FSV	W025-05	2019/1/13	2020/1/12
Coaxial Cable	SGS	N/A	SEM031-01	2019/6/12	2020/6/11
Attenuator	Weinschel Associates	WA41	SEM021-09	N/A	N/A
Signal Generator	KEYSIGHT	N5173B	SEM006-05	2018/9/2	2019/9/2
Temperature Chamber	GIANT FORCE	ICT-150-40-CP-AR	W027-03	2018/11/27	2019/11/27
Power Meter	Rohde & Schwarz	NRVS	SEM014-02	2018/9/2	2019/9/2

Measurement Uncertainty

No.	Item	Measurement Uncertainty
1	Total RF power, conducted	±0.75dB
2	RF power density, conducted	±2.84dB
3	Spurious emissions, conducted	±0.75dB
4	Conduct emission test	±3.12 dB (9KHz- 30MHz)
5	Temperature test	±1°C
6	Humidity test	±3%
7	DC and low frequency voltages	±0.5%

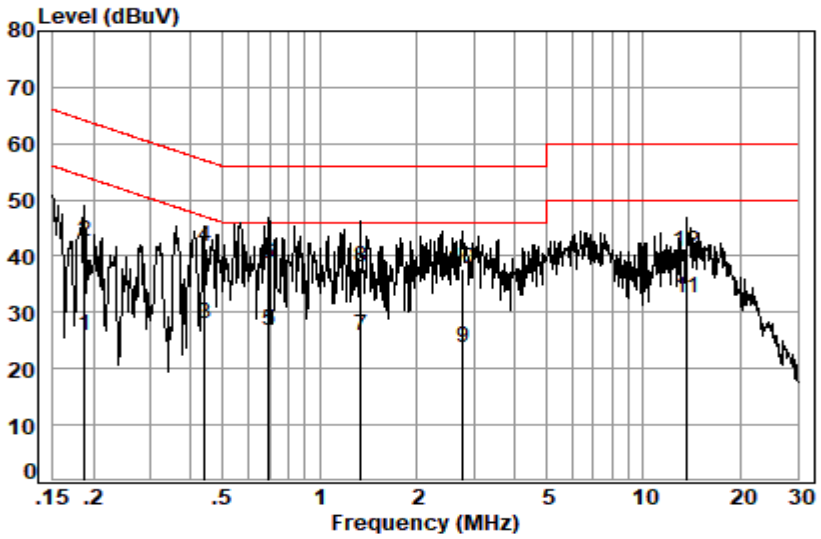
AC Power Line Conducted Emissions

Measurement Data

An initial pre-scan was performed on the live and neutral lines with peak detector.

Quasi-Peak and Average measurement were performed at the frequencies with maximized peak emission were detected.

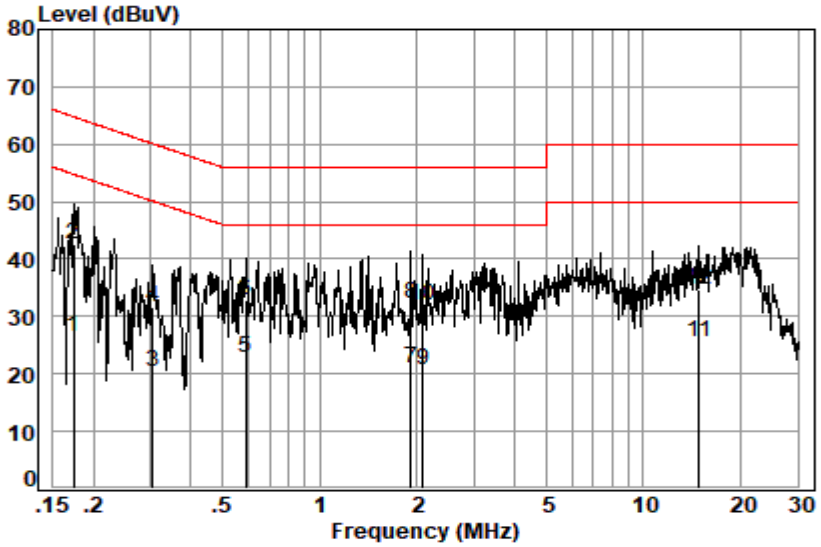
Live line:



Site : Shielding Room
Condition: Line
Job No. : 16976CR
Test mode: d

	Freq	Cable Loss	LISN Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB	dB	dBuV	dBuV	dBuV	dB	
1	0.1884	0.02	9.66	16.31	25.99	54.11	-28.12	Average
2	0.1884	0.02	9.66	32.99	42.67	64.11	-21.44	QP
3	0.4421	0.06	9.67	18.27	28.00	47.02	-19.02	Average
4	0.4421	0.06	9.67	32.04	41.77	57.02	-15.25	QP
5	0.6973	0.07	9.68	17.04	26.79	46.00	-19.21	Average
6	0.6973	0.07	9.68	28.97	38.72	56.00	-17.28	QP
7	1.3379	0.12	9.73	16.10	25.95	46.00	-20.05	Average
8	1.3379	0.12	9.73	28.07	37.92	56.00	-18.08	QP
9	2.7794	0.16	9.71	13.81	23.68	46.00	-22.32	Average
10	2.7794	0.16	9.71	27.99	37.86	56.00	-18.14	QP
11	13.6228	0.20	10.23	22.19	32.62	50.00	-17.38	Average
12	13.6228	0.20	10.23	30.41	40.84	60.00	-19.16	QP

Neutral line:



Site : Shielding Room
Condition: Neutral
Job No. : 16976CR
Test mode: d

	Freq	Cable Loss	LISN Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB	dB	dBuV	dBuV	dBuV	dB	
1	0.1740	0.02	9.64	16.85	26.51	54.77	-28.26	Average
2	0.1740	0.02	9.64	32.80	42.46	64.77	-22.31	QP
3	0.3051	0.04	9.64	10.61	20.29	50.10	-29.81	Average
4	0.3051	0.04	9.64	22.00	31.68	60.10	-28.42	QP
5	0.5916	0.07	9.64	12.97	22.68	46.00	-23.32	Average
6	0.5916	0.07	9.64	23.05	32.76	56.00	-23.24	QP
7	1.9182	0.16	9.69	11.04	20.89	46.00	-25.11	Average
8	1.9182	0.16	9.69	22.46	32.31	56.00	-23.69	QP
9	2.0768	0.16	9.69	10.83	20.68	46.00	-25.32	Average
10	2.0768	0.16	9.69	22.05	31.90	56.00	-24.10	QP
11	14.9068	0.21	10.37	14.90	25.48	50.00	-24.52	Average
12	14.9068	0.21	10.37	23.99	34.57	60.00	-25.43	QP

Remarks:

1. The following Quasi-Peak and Average measurements were performed on the EUT:

2. Final Test Level =Receiver Reading + LISN Factor + Cable Loss.

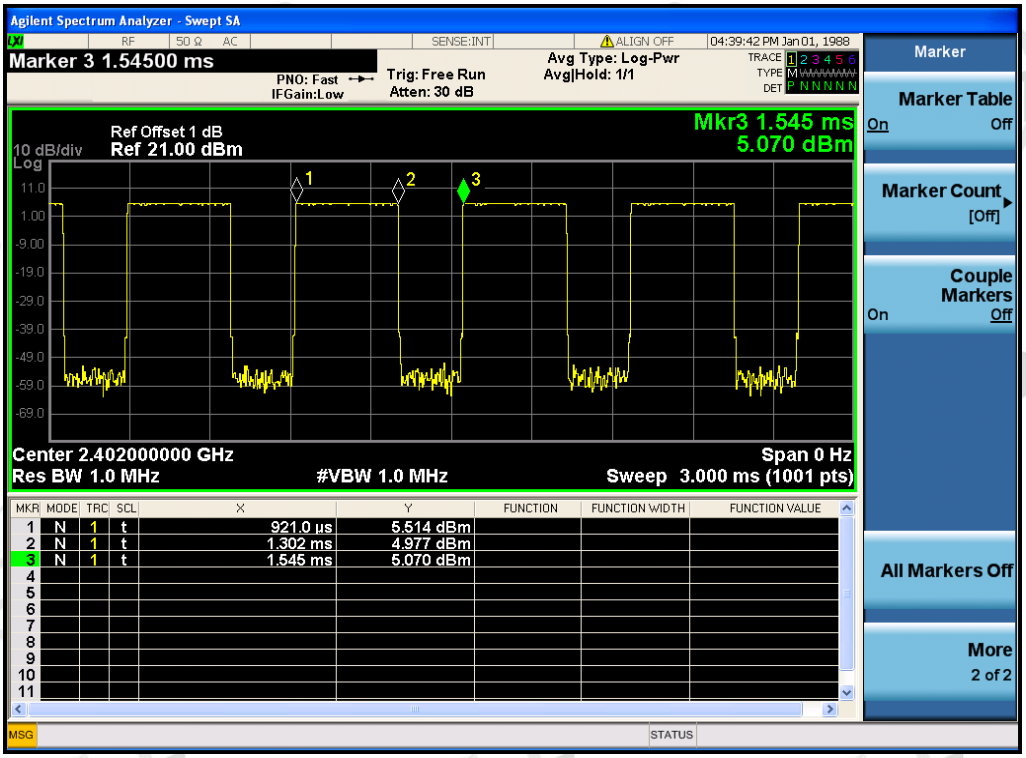
Duty Cycle

Test Results

Test Mode	TX Freq. [MHz]	Duty cycle [%]
BLE	CH0	61.06

Test Plots

BLE



Conducted Output Power

Test Results

Measurement Data of Peak Power:

GFSK mode			
Test channel	Peak Output Power (dBm)	Limit (dBm)	Result
Lowest	11.18	30.00	Pass
Middle	12.44	30.00	Pass
Highest	11.76	30.00	Pass

Test plots:

GFSK _Lowest Channel

GFSK _Middle Channel

GFSK _Highest Channel

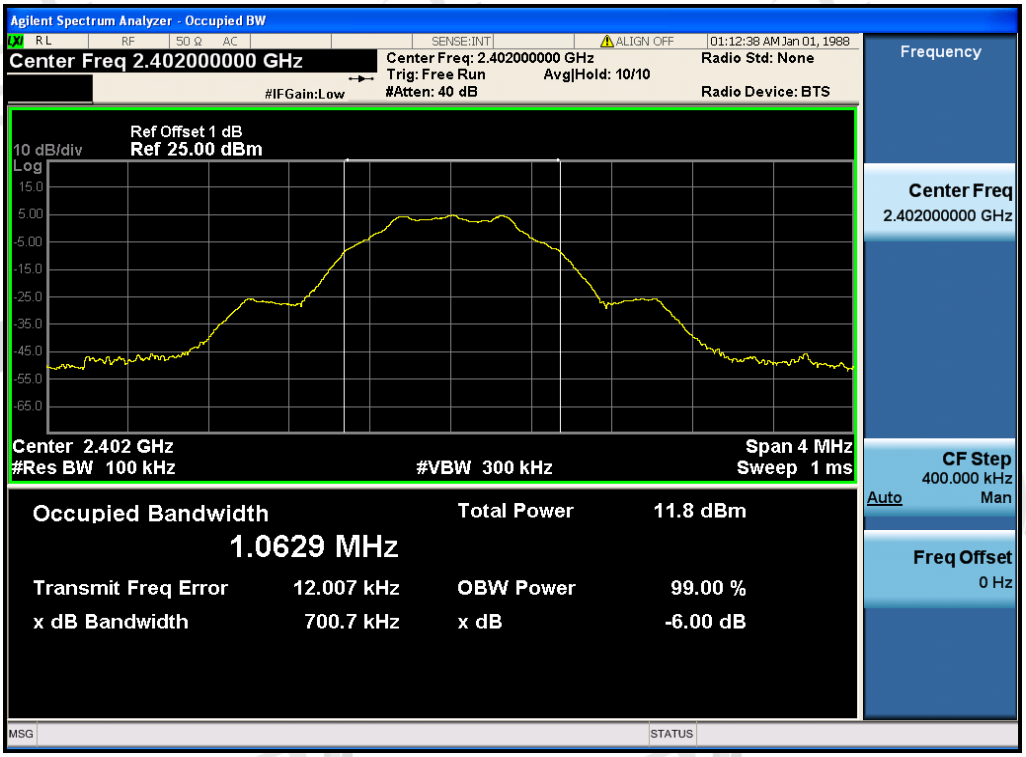
DTS (6 dB) Bandwidth & 99% Occupied Bandwidth

Test Results

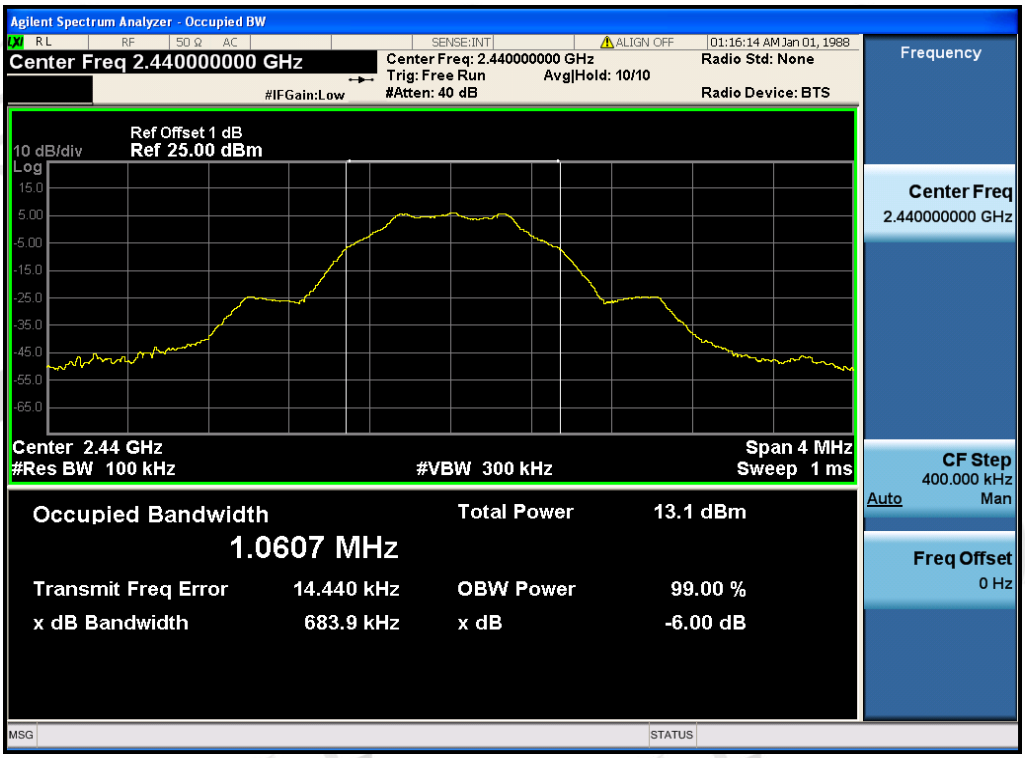
Mode	Test Channel	99% Occupied Bandwidth (MHz)	6dB Emission Bandwidth (MHz)	Limit (kHz)	Result
GFSK	Lowest	1.05	1.06	≥500	Pass
	Middle	1.04	1.06	≥500	Pass
	Highest	1.04	1.06	≥500	Pass

Test plots

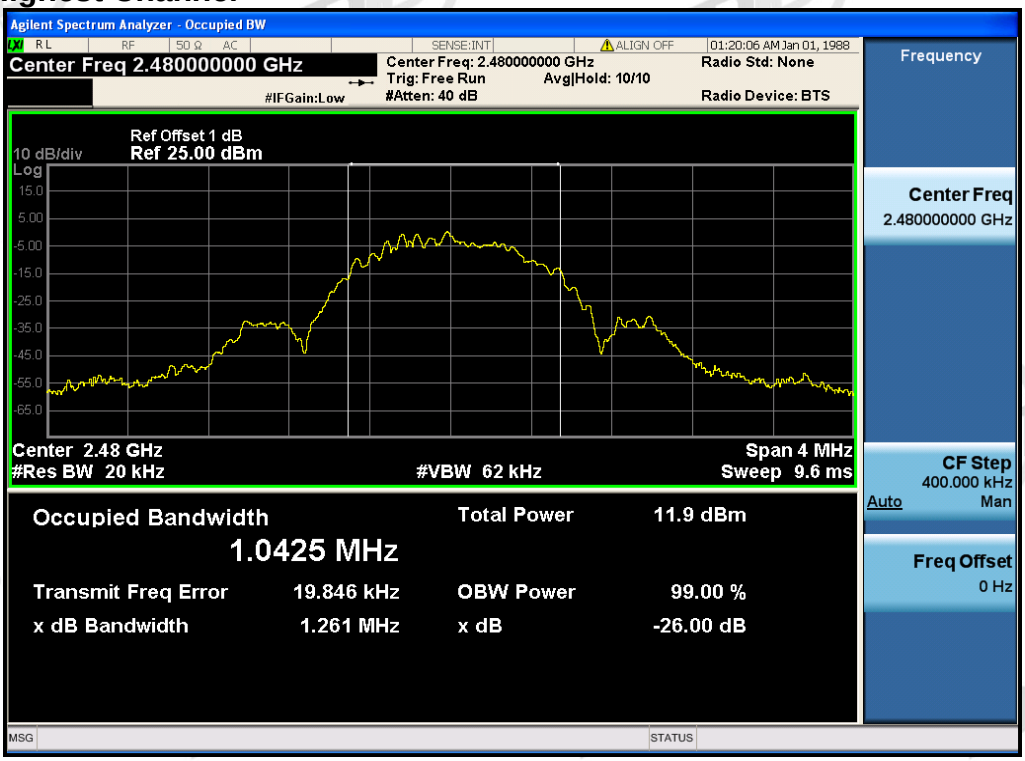
GFSK _Lowest Channel

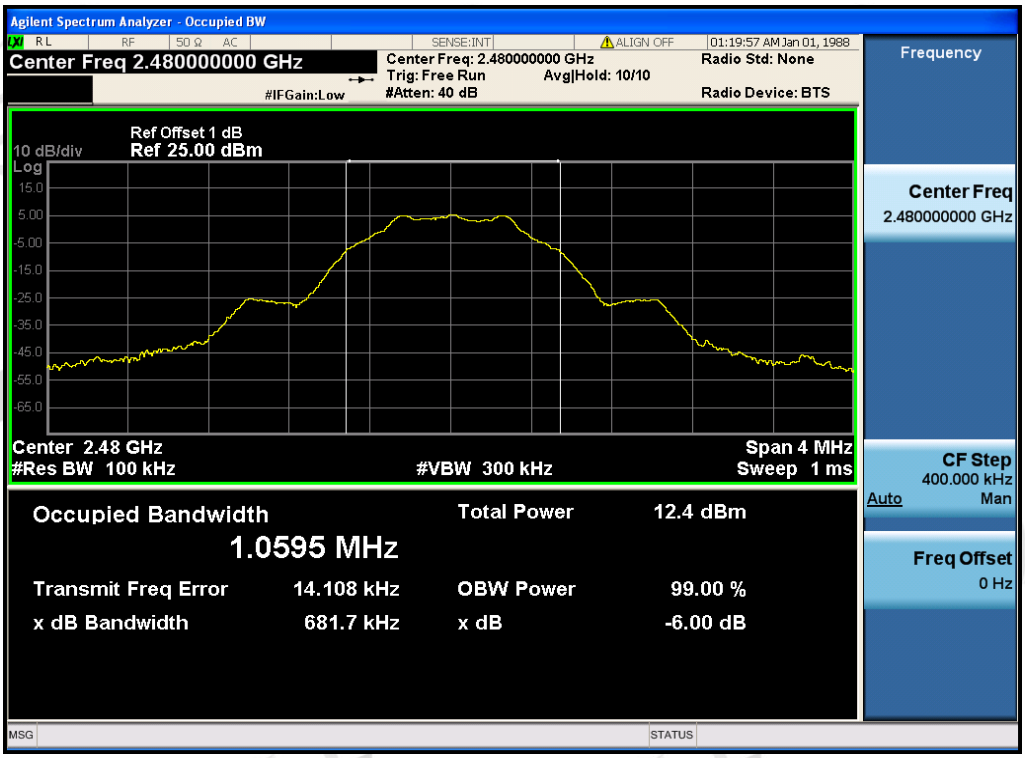


GFSK _Middle Channel



GFSK _Highest Channel





Power Spectral Density

Test Results

Mode	Test Channel	Power Spectral Density (dBm/3kHz)	Limit (dBm/3kHz)	Result
GFSK	Lowest	-9.40	≤8.00	Pass
	Middle	-8.07	≤8.00	Pass
	Highest	-8.82	≤8.00	Pass

Test plots

GFSK _Lowest Channel

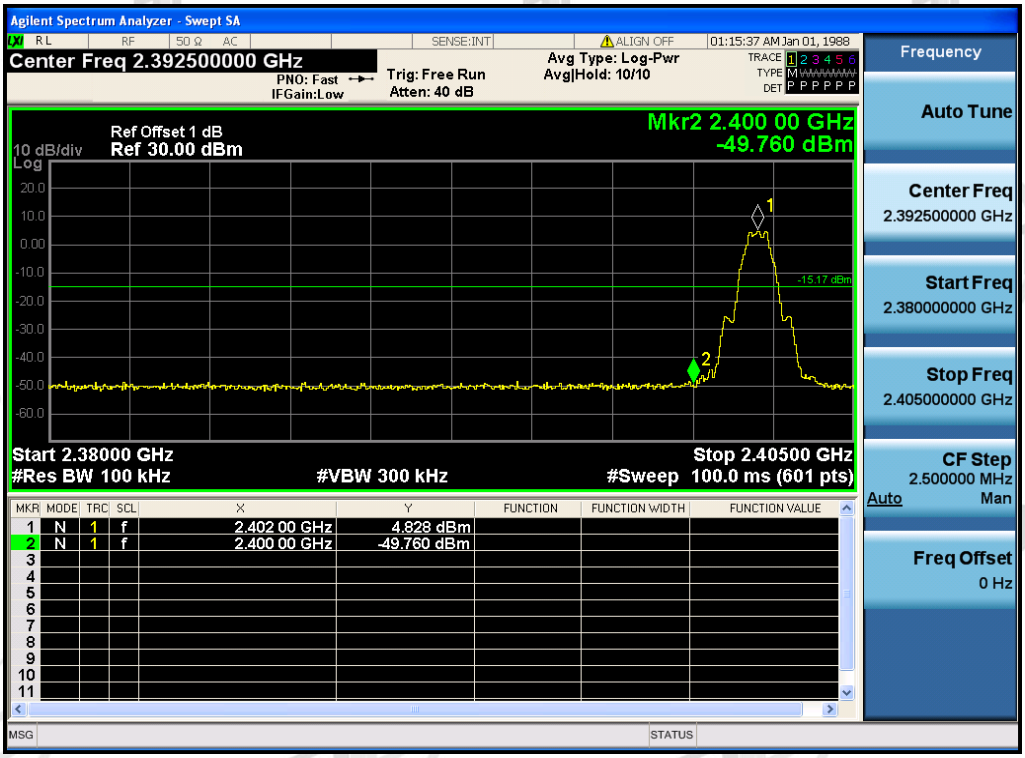
GFSK _Middle Channel

GFSK _Highest Channel

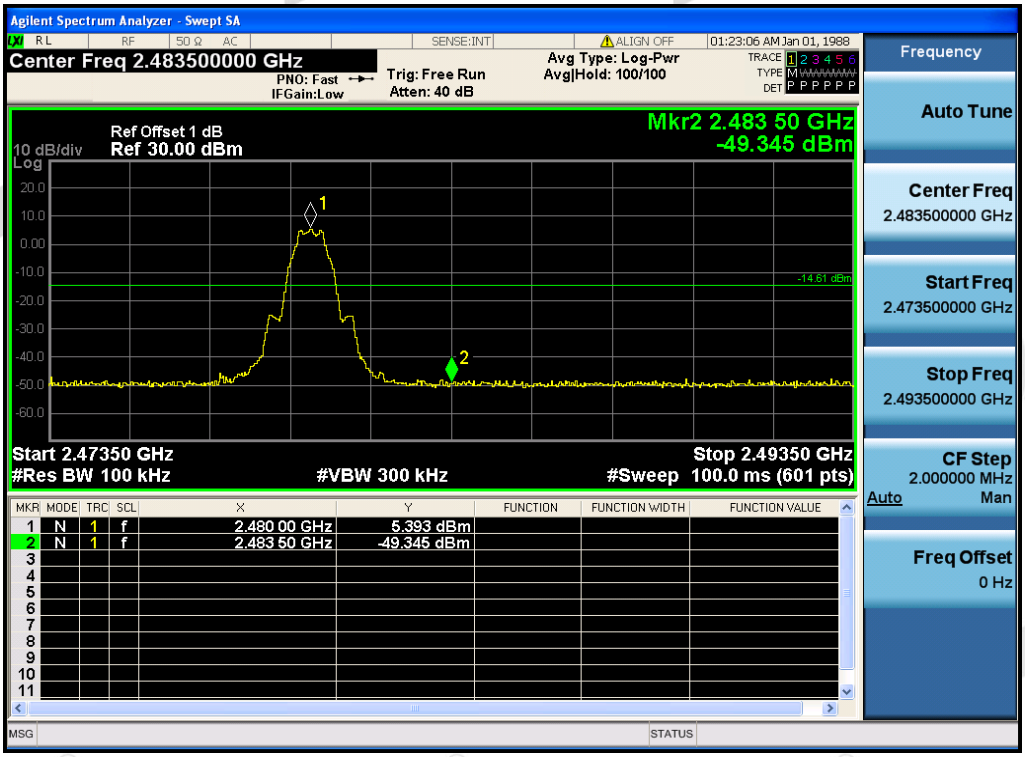
Band-edge for RF Conducted Emissions

Test plots

GFSK _Lowest Channel



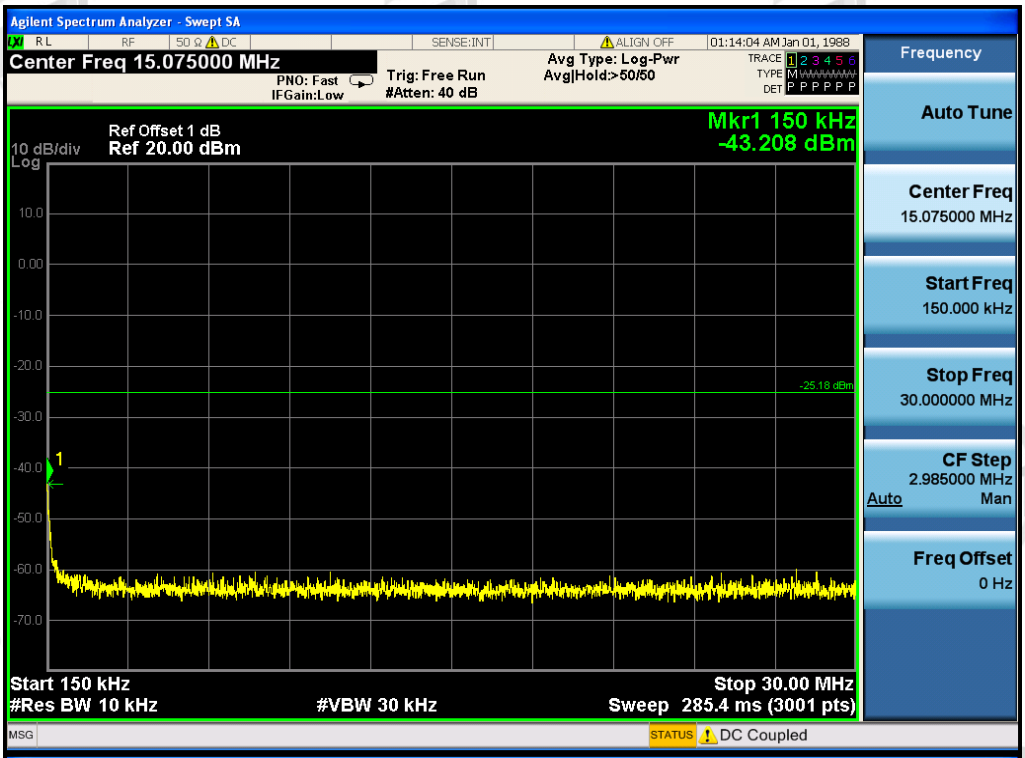
GFSK _Highest Channel

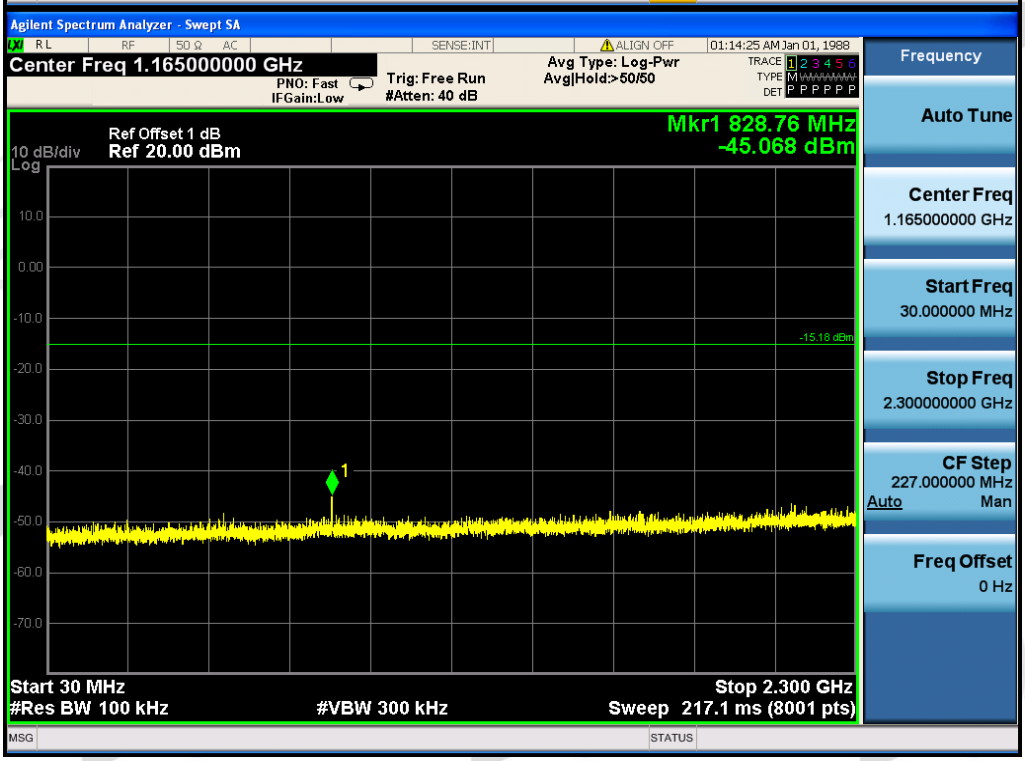


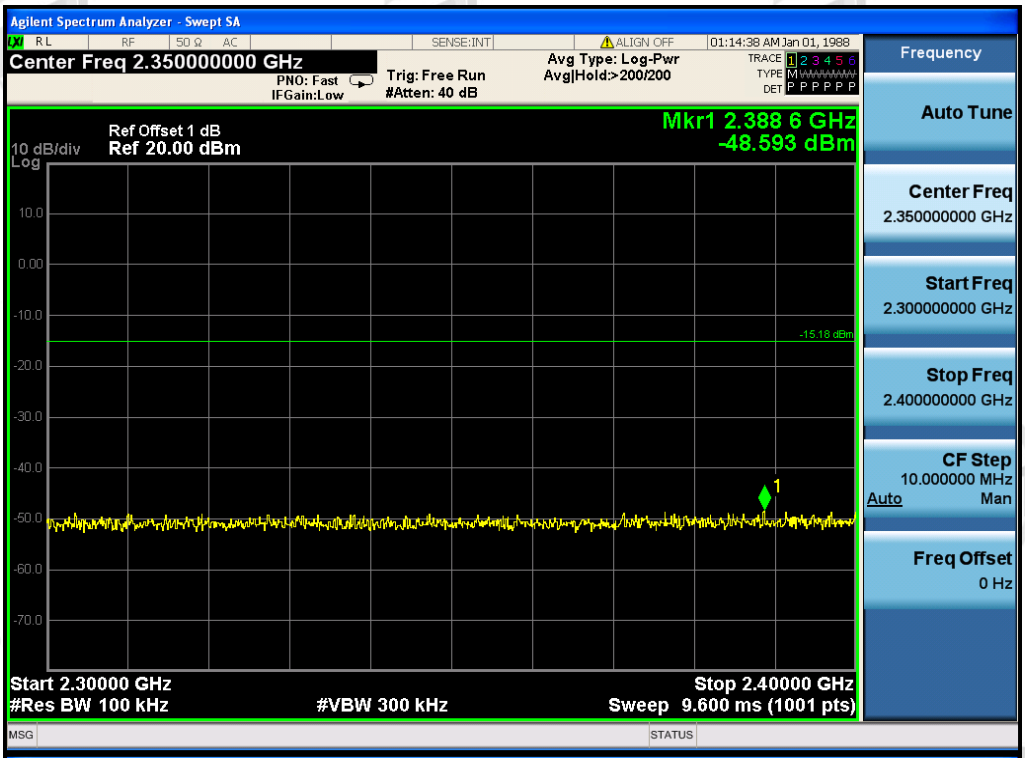
Spurious RF Conducted Emissions

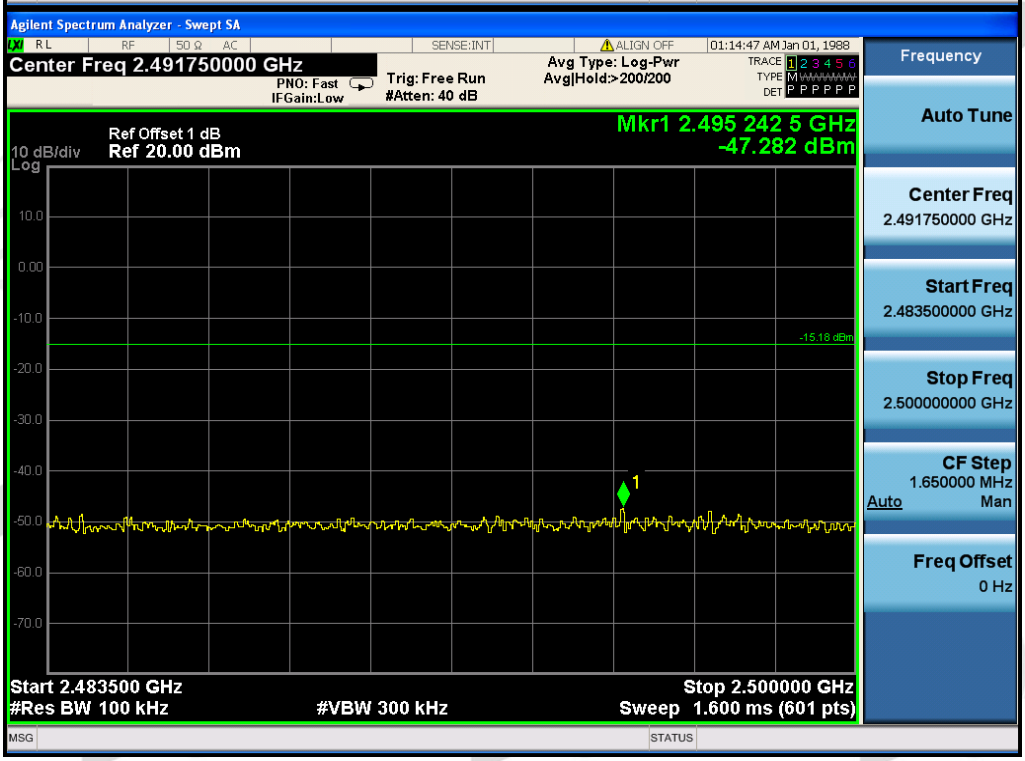
Test plots:

GFSK _Lowest Channel


Agilent Spectrum Analyzer - Swept SA
Center Freq 15.075000 MHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 40 dB
Avg Type: Log-Pwr
Avg|Hold:>50/50
01:14:04 AM Jan 01, 1988
Ref Offset 1 dB
10 dB/div
Log
Ref 20.00 dBm
Mkr1 150 kHz
-43.208 dBm
-25.18 dBm
Start 150 kHz
#Res BW 10 kHz
#VBW 30 kHz
Stop 30.00 MHz
Sweep 285.4 ms (3001 pts)
DC Coupled
Frequency
Auto Tune
Center Freq
15.075000 MHz
Start Freq
150.000 kHz
Stop Freq
30.000000 MHz
CF Step
2.985000 MHz
Auto
Man
Freq Offset
0 Hz

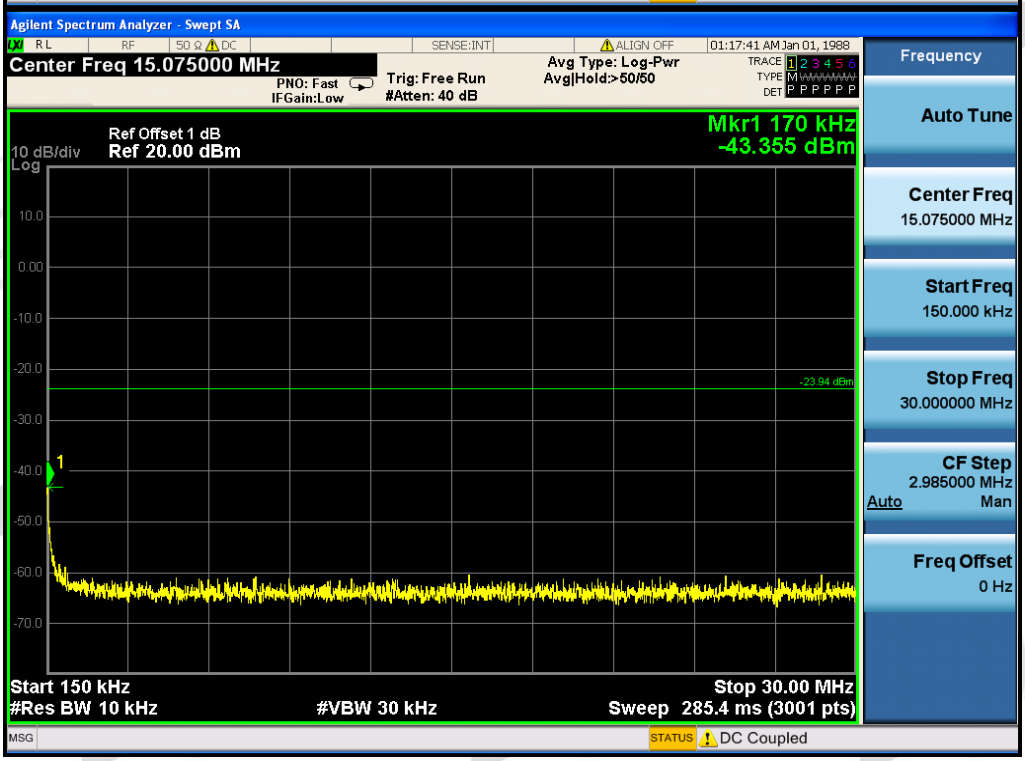

Agilent Spectrum Analyzer - Swept SA
Center Freq 1.165000000 GHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 40 dB
Avg Type: Log-Pwr
Avg|Hold:>50/50
01:14:25 AM Jan 01, 1988
Ref Offset 1 dB
10 dB/div
Log
Ref 20.00 dBm
Mkr1 828.76 MHz
-45.068 dBm
-15.18 dBm
Start 30 MHz
#Res BW 100 kHz
#VBW 300 kHz
Stop 2.300 GHz
Sweep 217.1 ms (8001 pts)
Frequency
Auto Tune
Center Freq
1.165000000 GHz
Start Freq
30.000000 MHz
Stop Freq
2.300000000 GHz
CF Step
227.000000 MHz
Auto
Man
Freq Offset
0 Hz


Agilent Spectrum Analyzer - Swept SA
Center Freq 2.350000000 GHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 40 dB
Avg Type: Log-Pwr
Avg|Hold:>200/200
01:14:38 AM Jan 01, 1988
Ref Offset 1 dB
10 dB/div
Log
Ref 20.00 dBm
Mkr1 2.388 6 GHz
-48.593 dBm
-15.18 dBm
Start 2.30000 GHz
#Res BW 100 kHz
#VBW 300 kHz
Stop 2.40000 GHz
Sweep 9.600 ms (1001 pts)
Frequency
Auto Tune
Center Freq
2.350000000 GHz
Start Freq
2.300000000 GHz
Stop Freq
2.400000000 GHz
CF Step
10.000000 MHz
Auto
Man
Freq Offset
0 Hz
MSG
STATUS

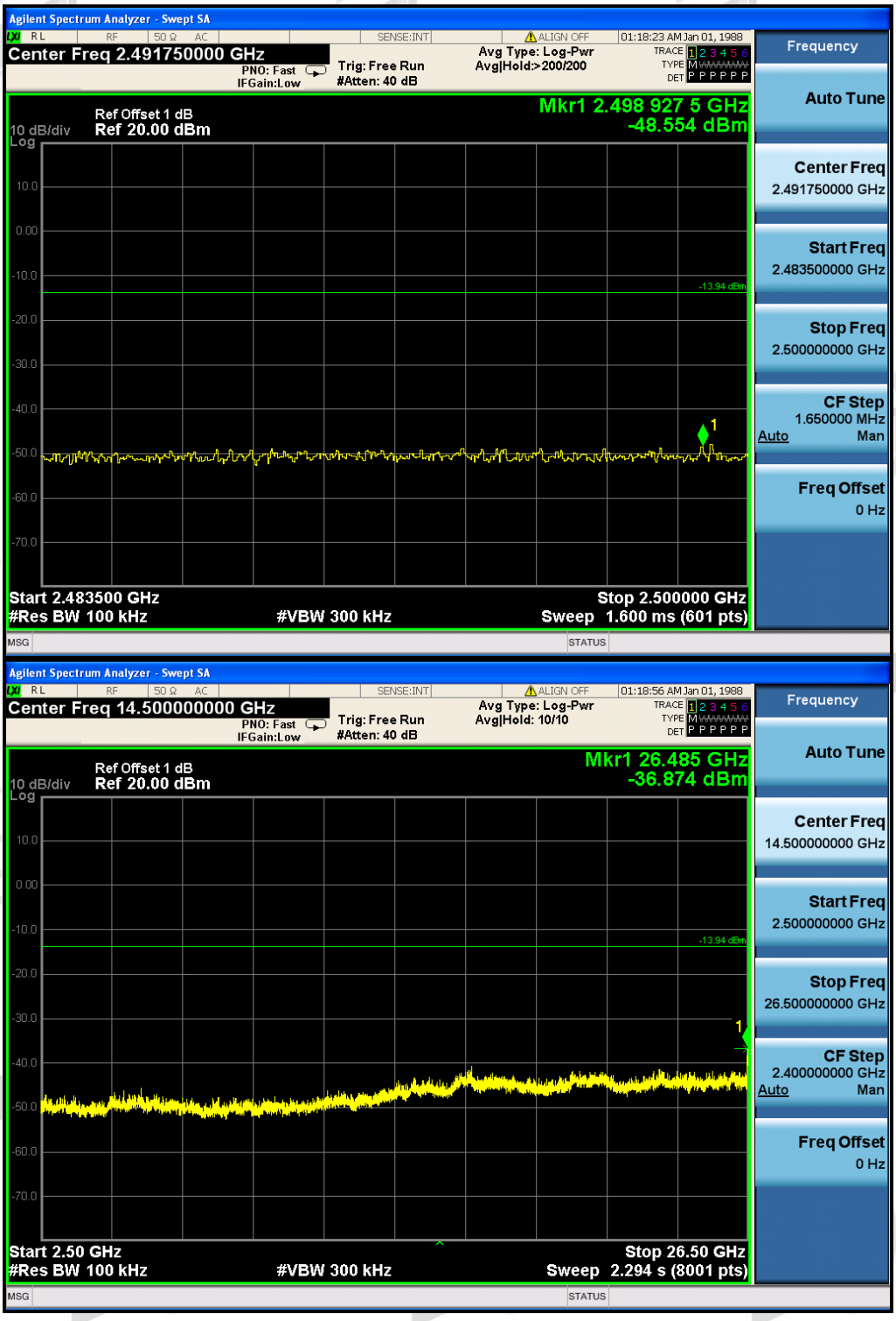

Agilent Spectrum Analyzer - Swept SA
Center Freq 2.491750000 GHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 40 dB
Avg Type: Log-Pwr
Avg|Hold:>200/200
01:14:47 AM Jan 01, 1988
Ref Offset 1 dB
10 dB/div
Log
Ref 20.00 dBm
Mkr1 2.495 242 5 GHz
-47.282 dBm
-15.18 dBm
Start 2.483500 GHz
#Res BW 100 kHz
#VBW 300 kHz
Stop 2.500000 GHz
Sweep 1.600 ms (601 pts)
Frequency
Auto Tune
Center Freq
2.491750000 GHz
Start Freq
2.483500000 GHz
Stop Freq
2.500000000 GHz
CF Step
1.650000 MHz
Auto
Man
Freq Offset
0 Hz
MSG
STATUS

GFSK _Middle Channel

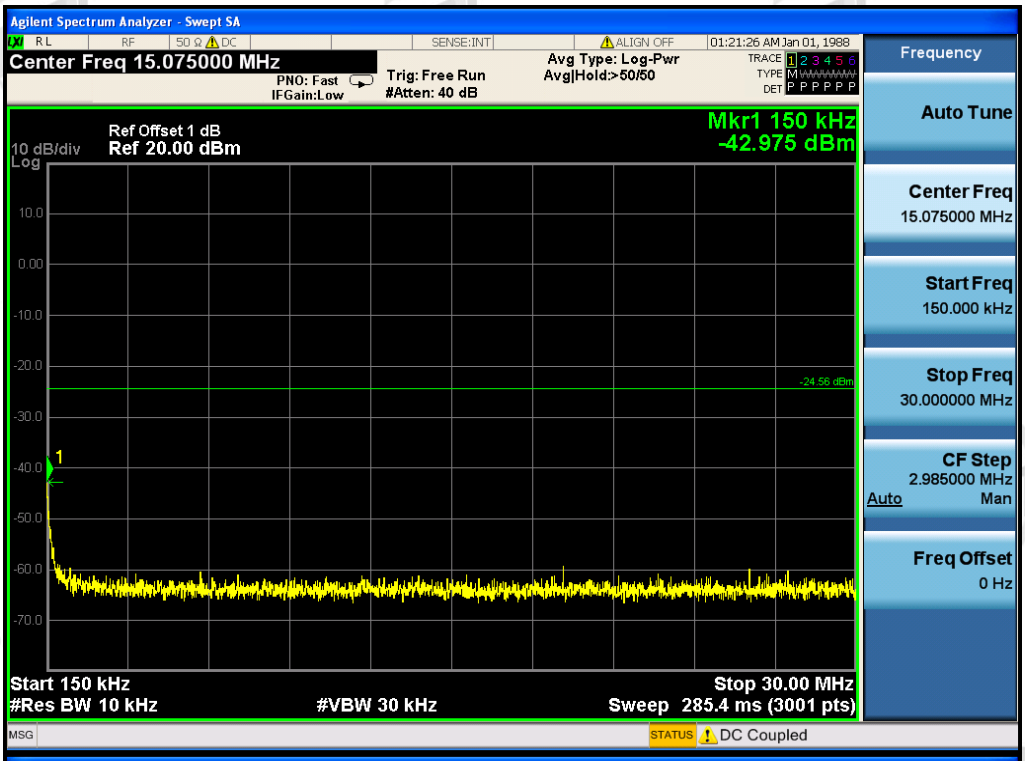

Agilent Spectrum Analyzer - Swept SA
Center Freq 79.500 kHz
PNO: Wide
IFGain:Low
Trig: Free Run
#Atten: 26 dB
Avg Type: Log-Pwr
Avg|Hold:>50/50
01:17:19 AM Jan 01, 1988
Ref Offset 1 dB
10 dB/div
Log
Ref 0.00 dBm
Mkr1 9.235 kHz
-51.875 dBm
-33.94 dBm
Start 9.00 kHz
#Res BW 1.0 kHz
#VBW 3.0 kHz
Stop 150.00 kHz
Sweep 134.8 ms (601 pts)
DC Coupled
Frequency
Auto Tune
Center Freq
79.500 kHz
Start Freq
9.000 kHz
Stop Freq
150.000 kHz
CF Step
14.100 kHz
Auto
Man
Freq Offset
0 Hz

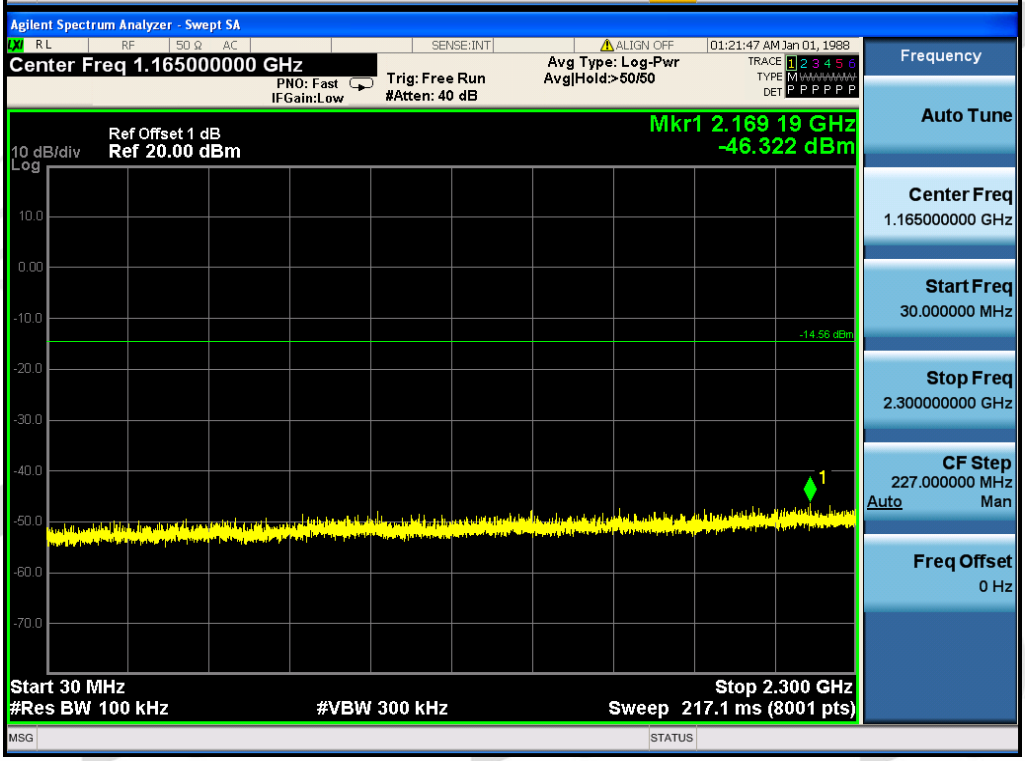

Agilent Spectrum Analyzer - Swept SA
Center Freq 15.075000 MHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 40 dB
Avg Type: Log-Pwr
Avg|Hold:>50/50
01:17:41 AM Jan 01, 1988
Ref Offset 1 dB
10 dB/div
Log
Ref 20.00 dBm
Mkr1 170 kHz
-43.355 dBm
-23.94 dBm
Start 150 kHz
#Res BW 10 kHz
#VBW 30 kHz
Stop 30.00 MHz
Sweep 285.4 ms (3001 pts)
DC Coupled
Frequency
Auto Tune
Center Freq
15.075000 MHz
Start Freq
150.000 kHz
Stop Freq
30.000000 MHz
CF Step
2.985000 MHz
Auto
Man
Freq Offset
0 Hz

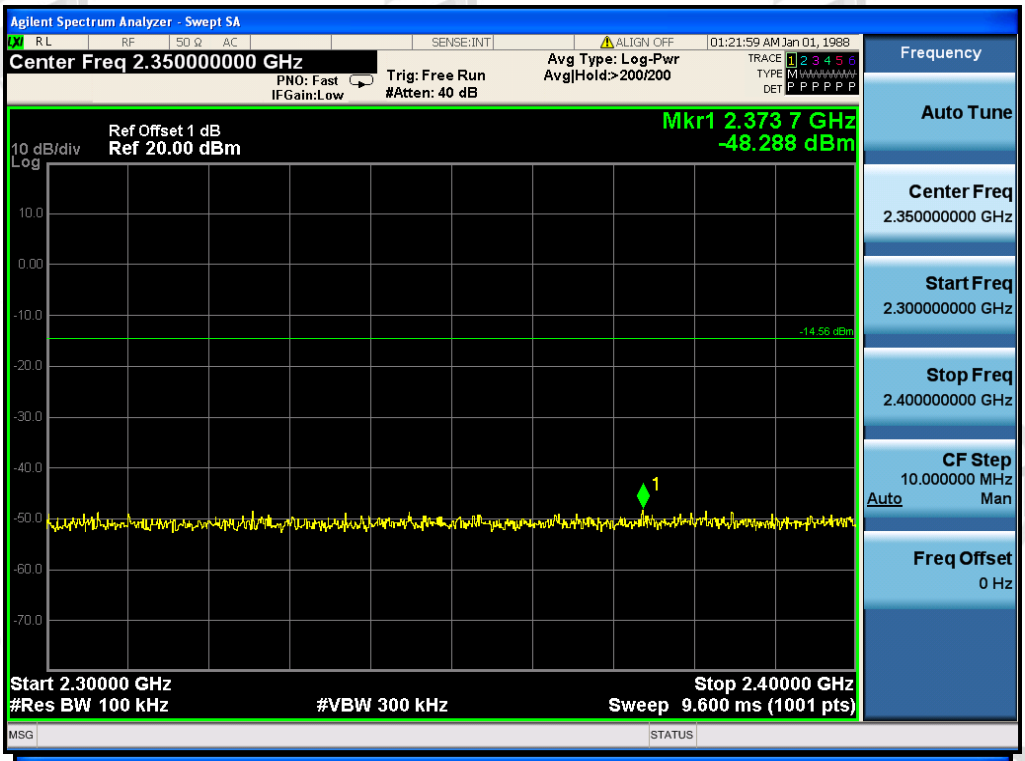

Agilent Spectrum Analyzer - Swept SA
Center Freq 1.165000000 GHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 40 dB
Avg Type: Log-Pwr
Avg|Hold:>50/50
01:18:02 AM Jan 01, 1988
Ref Offset 1 dB
10 dB/div
Log
Ref 20.00 dBm
Mkr1 2.240 41 GHz
-46.292 dBm
-13.94 dBm
Start 30 MHz
#Res BW 100 kHz
#VBW 300 kHz
Stop 2.300 GHz
Sweep 217.1 ms (8001 pts)
Frequency
Auto Tune
Center Freq
1.165000000 GHz
Start Freq
30.000000 MHz
Stop Freq
2.300000000 GHz
CF Step
227.000000 MHz
Auto
Man
Freq Offset
0 Hz
MSG
STATUS
Agilent Spectrum Analyzer - Swept SA
Center Freq 2.350000000 GHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 40 dB
Avg Type: Log-Pwr
Avg|Hold:>200/200
01:18:13 AM Jan 01, 1988
Ref Offset 1 dB
10 dB/div
Log
Ref 20.00 dBm
Mkr1 2.392 8 GHz
-48.507 dBm
-13.94 dBm
Start 2.30000 GHz
#Res BW 100 kHz
#VBW 300 kHz
Stop 2.40000 GHz
Sweep 9.600 ms (1001 pts)
Frequency
Auto Tune
Center Freq
2.350000000 GHz
Start Freq
2.300000000 GHz
Stop Freq
2.400000000 GHz
CF Step
10.000000 MHz
Auto
Man
Freq Offset
0 Hz
MSG
STATUS

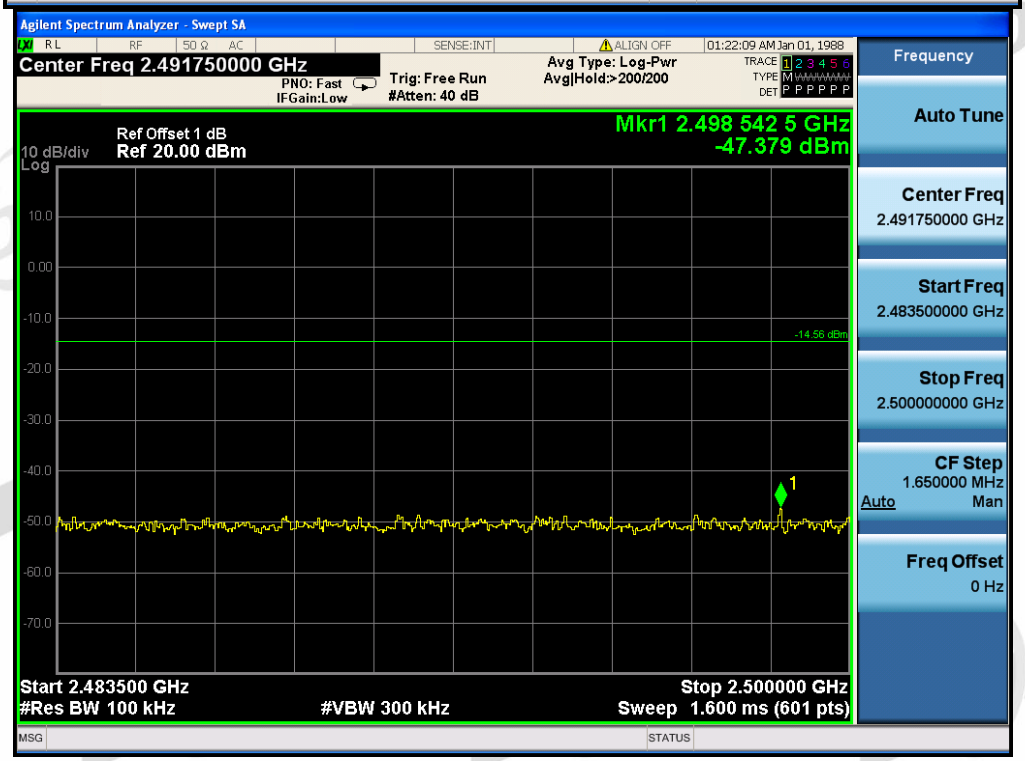

Agilent Spectrum Analyzer - Swept SA
Center Freq 2.491750000 GHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 40 dB
Avg Type: Log-Pwr
Avg|Hold:>200/200
01:18:23 AM Jan 01, 1988
Ref Offset 1 dB
10 dB/div
Log
Ref 20.00 dBm
Mkr1 2.498 927 5 GHz
-48.554 dBm
-13.94 dBm
Start 2.483500 GHz
#Res BW 100 kHz
#VBW 300 kHz
Stop 2.500000 GHz
Sweep 1.600 ms (601 pts)
Frequency
Auto Tune
Center Freq
2.491750000 GHz
Start Freq
2.483500000 GHz
Stop Freq
2.500000000 GHz
CF Step
1.650000 MHz
Auto
Man
Freq Offset
0 Hz
MSG
STATUS
Agilent Spectrum Analyzer - Swept SA
Center Freq 14.500000000 GHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 40 dB
Avg Type: Log-Pwr
Avg|Hold: 10/10
01:18:56 AM Jan 01, 1988
Ref Offset 1 dB
10 dB/div
Log
Ref 20.00 dBm
Mkr1 26.485 GHz
-36.874 dBm
-13.94 dBm
Start 2.50 GHz
#Res BW 100 kHz
#VBW 300 kHz
Stop 26.50 GHz
Sweep 2.294 s (8001 pts)
Frequency
Auto Tune
Center Freq
14.500000000 GHz
Start Freq
2.500000000 GHz
Stop Freq
26.500000000 GHz
CF Step
2.400000000 GHz
Auto
Man
Freq Offset
0 Hz
MSG
STATUS

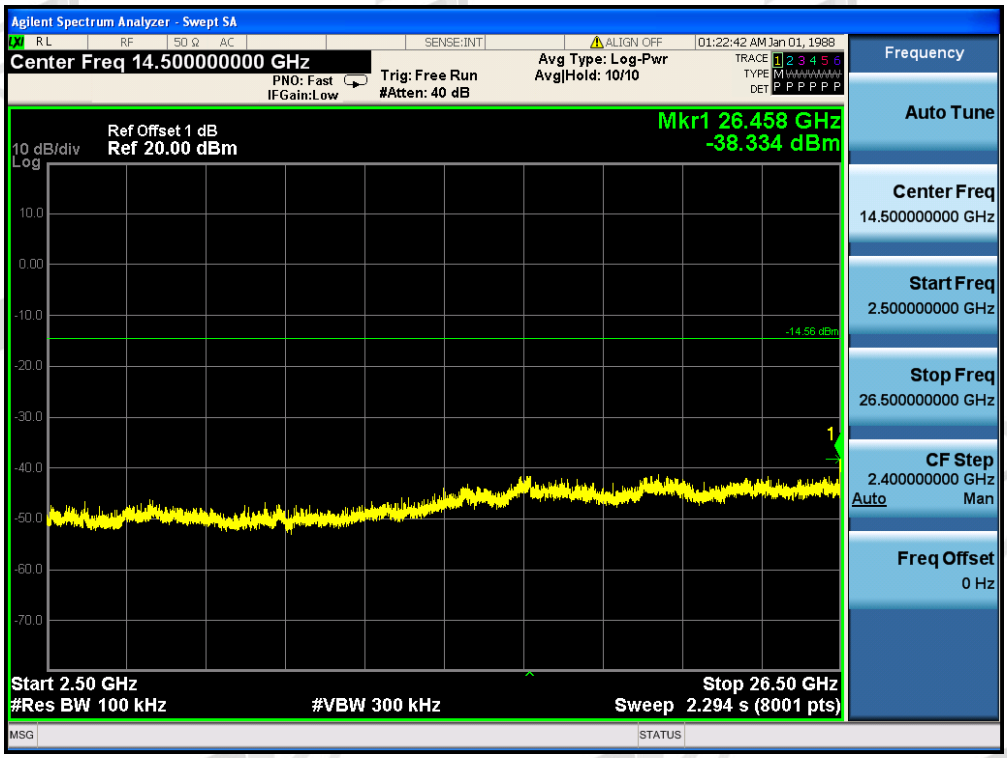
GFSK _Highest Channel


Agilent Spectrum Analyzer - Swept SA
Center Freq 15.075000 MHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 40 dB
Avg Type: Log-Pwr
Avg|Hold:>50/50
01:21:26 AM Jan 01, 1988
Ref Offset 1 dB
10 dB/div
Log
Ref 20.00 dBm
Mkr1 150 kHz
-42.975 dBm
-24.56 dBm
Start 150 kHz
#Res BW 10 kHz
#VBW 30 kHz
Stop 30.00 MHz
Sweep 285.4 ms (3001 pts)
DC Coupled
Frequency
Auto Tune
Center Freq
15.075000 MHz
Start Freq
150.000 kHz
Stop Freq
30.000000 MHz
CF Step
2.985000 MHz
Auto
Man
Freq Offset
0 Hz


Agilent Spectrum Analyzer - Swept SA
Center Freq 1.165000000 GHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 40 dB
Avg Type: Log-Pwr
Avg|Hold:>50/50
01:21:47 AM Jan 01, 1988
Ref Offset 1 dB
10 dB/div
Log
Ref 20.00 dBm
Mkr1 2.169 19 GHz
-46.322 dBm
-14.56 dBm
Start 30 MHz
#Res BW 100 kHz
#VBW 300 kHz
Stop 2.300 GHz
Sweep 217.1 ms (8001 pts)
Frequency
Auto Tune
Center Freq
1.165000000 GHz
Start Freq
30.000000 MHz
Stop Freq
2.300000000 GHz
CF Step
227.000000 MHz
Auto
Man
Freq Offset
0 Hz


Agilent Spectrum Analyzer - Swept SA
RL
RF
50 Ω AC
SENSE:INT
ALIGN OFF
01:21:59 AM Jan 01, 1988
Center Freq 2.350000000 GHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 40 dB
Avg Type: Log-Pwr
Avg|Hold:>200/200
TRACE 1 2 3 4 5 6
TYPE M
DET P P P P P P
Ref Offset 1 dB
10 dB/div
Log
Ref 20.00 dBm
Mkr1 2.373 7 GHz
-48.288 dBm
10.0
0.00
-10.0
-20.0
-30.0
-40.0
-50.0
-60.0
-70.0
-14.56 dBm
1
Start 2.30000 GHz
#Res BW 100 kHz
#VBW 300 kHz
Stop 2.40000 GHz
Sweep 9.600 ms (1001 pts)
MSG
STATUS
Frequency
Auto Tune
Center Freq
2.350000000 GHz
Start Freq
2.300000000 GHz
Stop Freq
2.400000000 GHz
CF Step
10.000000 MHz
Auto
Man
Freq Offset
0 Hz


Agilent Spectrum Analyzer - Swept SA
RL
RF
50 Ω AC
SENSE:INT
ALIGN OFF
01:22:09 AM Jan 01, 1988
Center Freq 2.491750000 GHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 40 dB
Avg Type: Log-Pwr
Avg|Hold:>200/200
TRACE 1 2 3 4 5 6
TYPE M
DET P P P P P P
Ref Offset 1 dB
10 dB/div
Log
Ref 20.00 dBm
Mkr1 2.498 542 5 GHz
-47.379 dBm
10.0
0.00
-10.0
-20.0
-30.0
-40.0
-50.0
-60.0
-70.0
-14.56 dBm
1
Start 2.483500 GHz
#Res BW 100 kHz
#VBW 300 kHz
Stop 2.500000 GHz
Sweep 1.600 ms (601 pts)
MSG
STATUS
Frequency
Auto Tune
Center Freq
2.491750000 GHz
Start Freq
2.483500000 GHz
Stop Freq
2.500000000 GHz
CF Step
1.650000 MHz
Auto
Man
Freq Offset
0 Hz



Remark:

Scan from 9kHz to 25GHz, the disturbance between 9KHz to 30MHz was very low, and the above harmonics were the highest point could be found when testing, The amplitude of spurious emissions from the radiator which are attenuated more than 20dB below the limit need not be reported.

The End