METEORCOMM LLC

ITCR 1.0 EMI Intermod Testing Final Report

Document Revision: 0.1
Document Number: 00002521-A

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Revision history

Revision	Date	Summary of Changes
0.0	8/24/2011	Initial formatting and DCN - 00001482-A
0.1	11/15/2012	Template change disclaimer and footers FRA doc with new DCN 00002521-A

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Project Detail

Contract Number	FR-TEC-0003-11-01-00
Phase	1
Work Breakdown Number	
Dates of Survey	June 16th to August 1st, 2011
Locations	BNSF Interbay Locomotive Facility 47 39' 13.18 N LAT, 122 22' 55.62" W LON, elev. 31 ft
Test Engineer	Ramon Abelleyro
CONTRACT NUMBER	FR-TEC-0003-11-01-00

1. Executive Summary

This approach to deploying multiple antennas was developed by UP, consisting of two roof top boxes instead of the conventional antenna systems used by most other railroads. One of these antenna box systems has been installed on UP 4620, an SD-70M locomotive with DC traction motors.

The antenna box approach permits the deployment of multiple antennas with additional spacing between them, resulting in increased RF isolation. The antenna boxes are deployed along with a complete set of new coaxial antenna cables and several band pass filters, which also contribute to improve the performance of all on-board RF equipment. The mechanical design of the roof top boxes facilitates access, maintenance and addition of more antennas, if required.

The purpose of testing UP 4620 was to gather data on RF parameters including intermodulation, antenna isolation, VSWR and EMI noise.

The UP 4620 has not yet been equipped to operate with PTC or distributed power radios, but the antenna boxes are outfitted with PTC A, PTC B, DP A and DP B antennas, coax cables and filters. For the testing, Meteorcomm provided and operated a Meteorcomm PTC radio, and STI-CO provided and operated four radios in the 450 and 900 MHz bands to be used in lieu of on-board radios not yet installed or not possible to operate manually for testing, such as the HOT radio.

Intermodulation testing did not provide significant evidence of intermodulation products in the 220 MHz PTC band while transmitting simultaneously with several radios in different combinations.

For EMI testing the locomotive was configured for a fully loaded test, sending all electrical power generated to the dynamic brake resistors. During testing the engine was stepped from notch 1 to notch 8, staying on each notch for at least a minute as readings were taken using two instruments. No significant evidence of EMI interference was found in the 216 to 226 MHz PTC band.

2. Testing Detail

Upon completing the initial survey it was found that there were no DP A or DP B 450 MHz antennas installed, and there were antenna cables with uncrimped, unsoldered, and/or loose RF connectors. Union Pacific sent an RF engineer who resolved these issues in Interbay.

Testing on board UP 4620 required the use of a Meteorcomm PTC radio which can only operate from a 72 V DC power supply, but there were no 72 V DC outlets on UP 4620. It would have been necessary to open, cut, and splice 72 V DC locomotive cabling. This could not be done locally at the BNSF Interbay facility.

The alternative was to use a 12 V deep cycle marine battery with a DC-to-DC converter. The only company that offered this type of converters, ICT, only builds them on special order. It took three weeks to get the DC-to-DC converters from ICT, then testing with a Meteorcomm PTC radio started.

STI-CO provided two Kenwood 450 MHz mobile radios to be used as DP A and DP B radios during the testing. STI-CO also provided a Kenwood 450 MHz portable radio to be used as an HOT radio, and a Kenwood 900 MHz portable radio to be used as a SPEC 200 and Event Recorder radio.

Battery power on board the locomotive was also provided by STI-CO, using Optima deep cycle spiral cell 12 V 60 AH batteries, an automatic regulated 40 A charger and 600 watts sine wave 12 V DC to 120 V AC converter. To power the Meteorcomm PTC radio two ICT isolated 12 V DC-to-DC converters (one 24 V DC output and one 48 V DC output) were used in series, providing a total of regulated 72 V DC 5 A to power the Meteorcomm PTC radio.

Instruments used included an Agilent N6841A RF Sensor with N6820 Signal Analysis software suite, an Agilent N9912A Field Fox multi-function RF analyzer with all options installed, and an Anritsu S412E LMR Master multi-function RF analyzer with all options.

The Agilent N6841A RF Sensor is the main instrument, with the Agilent N9912A and Anritsu S412E used to complement the Agilent N6841A. During testing there were intermittent issues with the Agilent N9912A Field Fox, which had to be replaced by the Anritsu S412E.

The criteria for selecting the Agilent N6841A as the main instrument included resolution of 500,000 points, no-gap analysis of up to 20 MHz of bandwidth, and much faster speed than most other spectrum analyzers, in some cases up to 1,000 times faster.

All testing was done manually, with one person connecting and reconnecting the test cables to antennas and other locomotive RF equipment, while another person configured and monitored the instruments screens, and recorded on paper each measurement. The Meteorcomm PTC radio was operated using an XTERM application in a notebook PC controlling the PTC radio. The external DC-to-DC converter providing 72 V DC from a 12 V battery worked fine and the maximum load of 5 A was not exceeded.

The Kenwood mobile radios were operated with RJ-45 cables plugged into the front microphone socket, and equipped with a toggle switch to activate the PTT control of the radio.

All coaxial cables used had been specially built by STI-CO for this testing, with 220 MHz and 160 MHz cables cut to exact multiples of ½ wave length. All the cables were swept and checked with a transmission test set before starting to use them.

Open-Short-Load T-Calibration kits were used with the Agilent N9912A and with the Anritsu S412E, calibrating the instruments every time that testing parameters would change, such as the start and stop frequencies for the portion of spectrum being monitored.

The first step was to measure and record each radio transmitted power, which was done with the N9912A Agilent Field Fox connected to a USB RF power meter. These measurements were used later to determine other parameters such as antenna isolation.

To measure antenna isolation a signal would be transmitted for a brief period of time from each antenna, measuring the level of this signal at each of the other antennas. The difference between the transmitted level and the level measured at each of the other antennas was used to determine antenna isolation. If the level measured was positive, this number was subtracted from the transmitted power level. If it was negative, it was added to the level of the transmitted power level.

Standard procedures were used for other measurements such as VSWR and Intermodulation. It was not possible to reliably measure some of the filters installed, or to use the Agilent N9912A Field Fox for insertion loss testing due to its low transmitted power. Arrangements are being made to resolve these issues when testing the next locomotive.

3. Antenna Isolation Testing

For the antenna isolation test two instruments were used, an Agilent N6841A RF Sensor and an Anritsu S412E LMR Master portable RF Analyzer.

The RF Sensor was connected to a Discone multiband antenna 108 – 1500 MHz, which was placed outside the locomotive at 45 feet to the right and in front of the locomotive. With the tripod fully extended the top of the Discone antenna was at 10.5 feet above the ground. The RF Sensor bandwidth was set to 40 KHz, peak measurement, with 8 averages. The shape factor (Selectivity) was set to 9.00 : 1.

The Anritsu S412E was connected to a ¼ wave whip on a magnetic mount placed on a 17" X 17" ground plane plate on the floor of the radio room of the locomotive. Resolution and Video Bandwidth were both set to 30 KHz.

With both instruments monitoring spectrum, two separate tests were carried out, the first one with both instruments monitoring the PTC band from 216 MHz to 225 MHz, while operating the loaded locomotive generator (full load test using dynamic braking resistors) for at least one minute on each 1 notch, 2 notch, 3 notch, 4 notch, 5 notch, 6 notch, 7 notch and 8 notch. Both instruments were observed during the minute or longer that the engine remained on each notch, and both screens were captured and stored.
The second test was with both instruments monitoring spectrum from 20 to 1000 MHz, and again operating the loaded locomotive for at least one minute on each notch.

Both instruments were observed and there was no significant evidence of EMI generation being captured by the antenna system and monitoring instruments. The locomotive was a General Motors SD-70M, a DC locomotive, which when operating at full power was dissipating more than three megawatts of power through the loading resistors.

Screen captures of each instrument readings are provided in the following section.

4. EMI Testing – Instrument Screen Capture

Figure 1: One Notch Agilent N6841A 216 – 226 MHz Exterior Discone Antenna

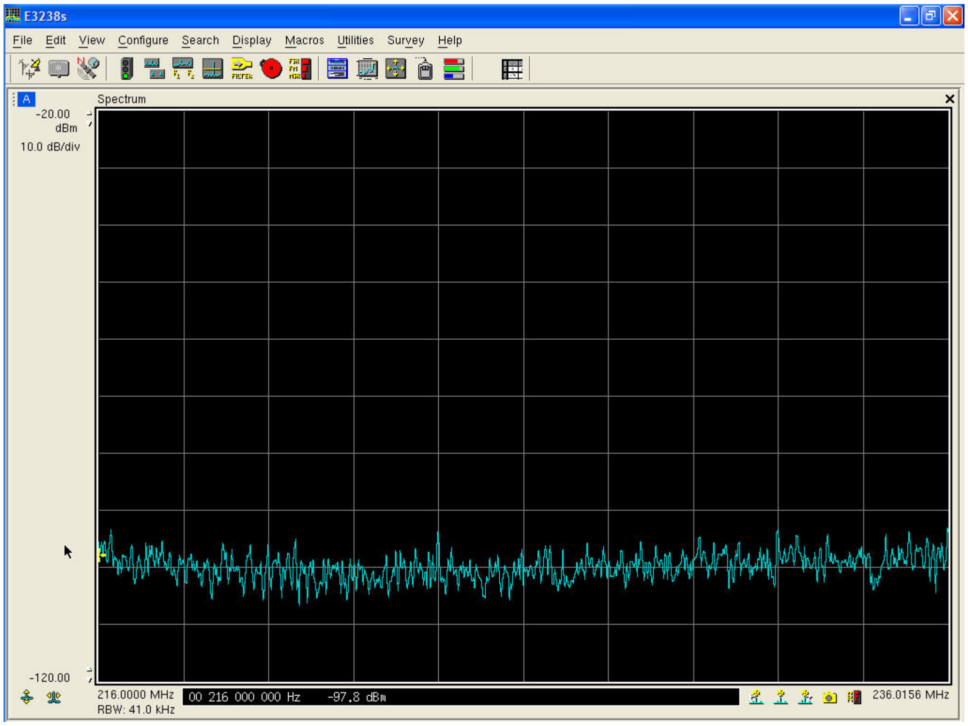


Figure 2: One Notch Agilent N6841A 216 – 226 MHz Exterior Discone Antenna

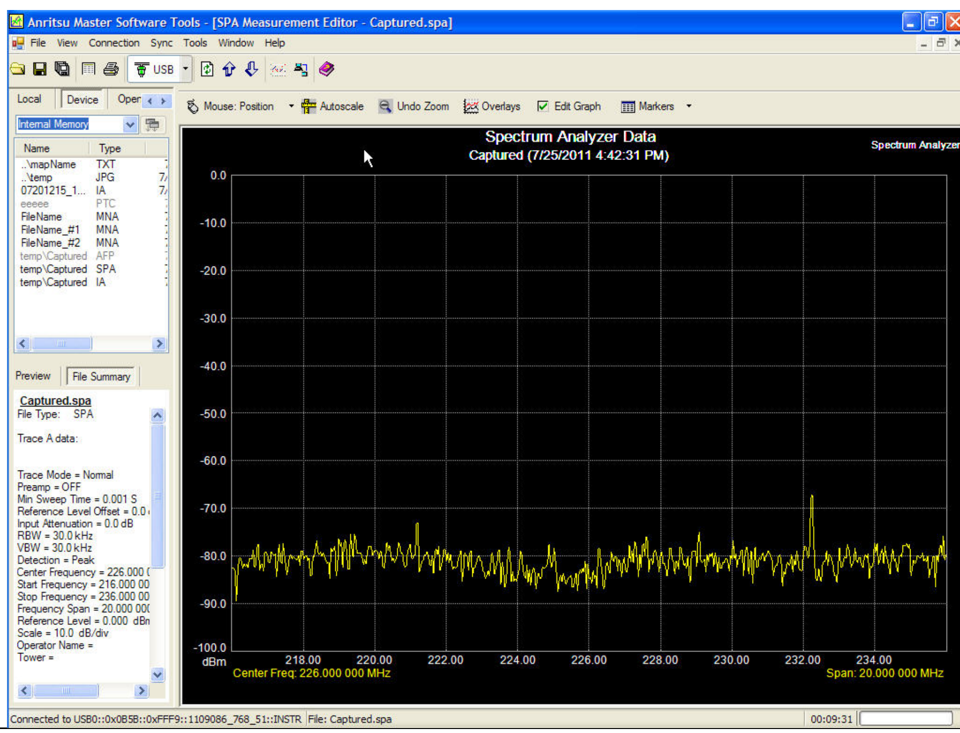


Figure 3: One Notch Anritsu S412E 216 – 236 MHz Interior ¼ Wave Antenna in Radio Room

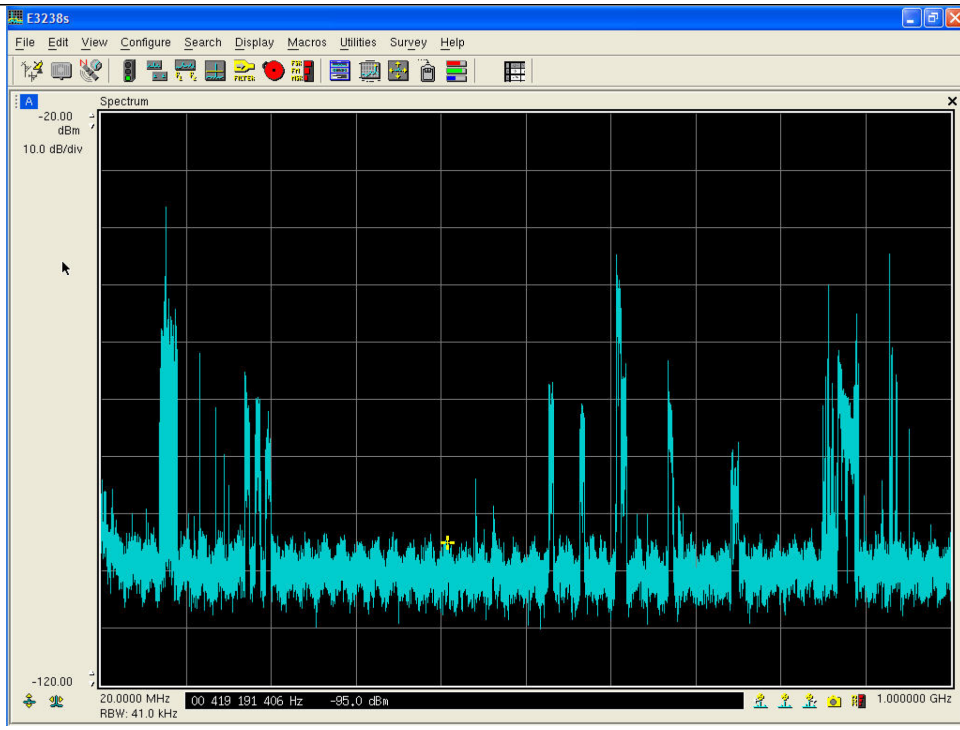


Figure 4: One Notch Agilent N6841A 20 – 1000 MHz Exterior Discone Antenna

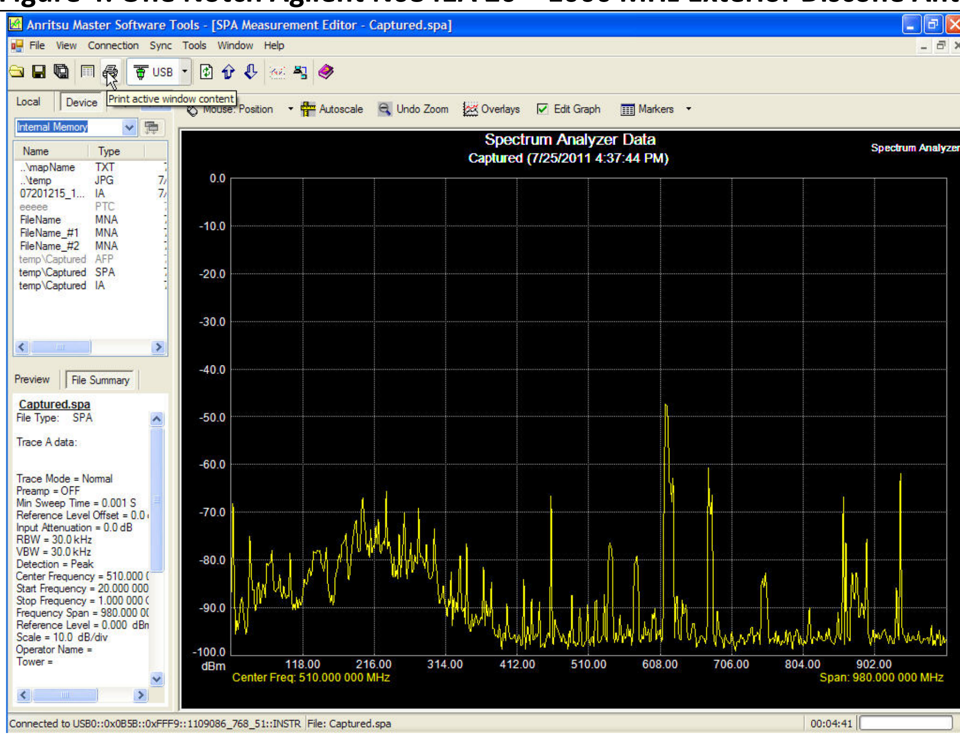


Figure 5: One Notch Anritsu S412E 20 – 1000 MHz Interior ¼ Wave Antenna in Radio Room

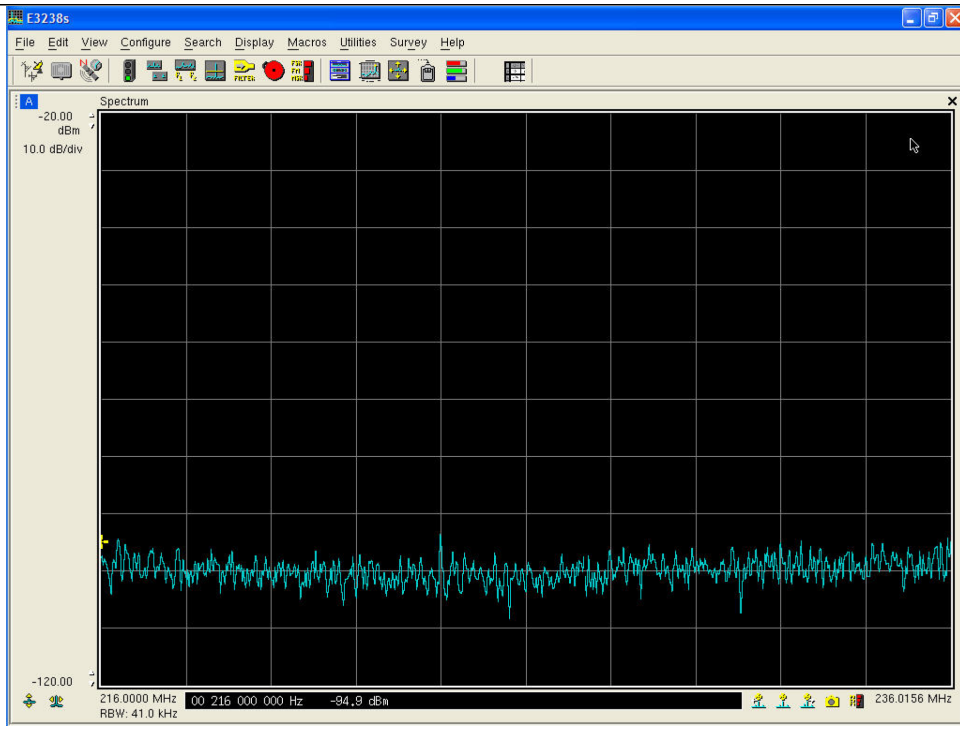


Figure 6: Two Notch Agilent N6841A 216 – 226 MHz Exterior Discone Antenna

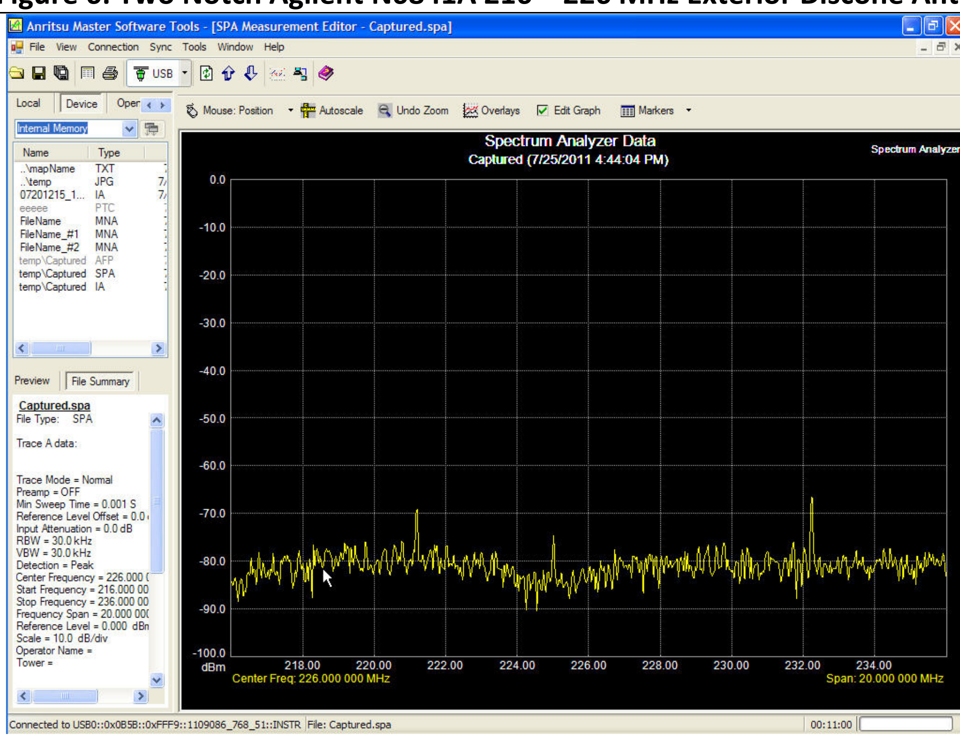


Figure 7: Two Notch Anritsu S412E 216 – 236 MHz Interior ¼ Wave Antenna in Radio Room

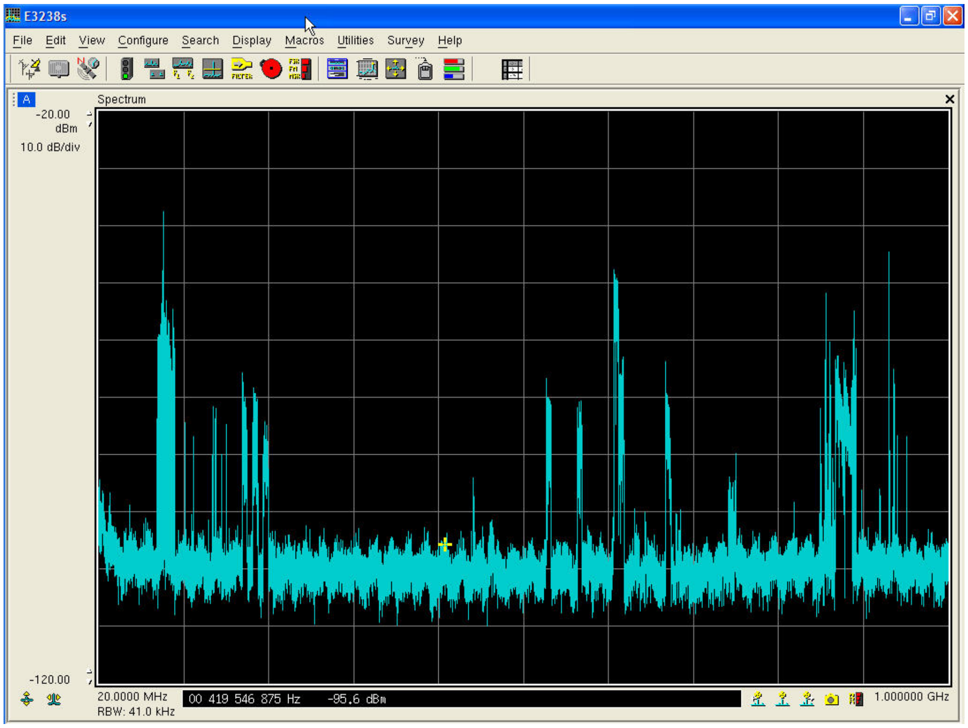


Figure 8: Two Notch Agilent N6841A 20 – 1000 MHz Exterior Discone Antenna

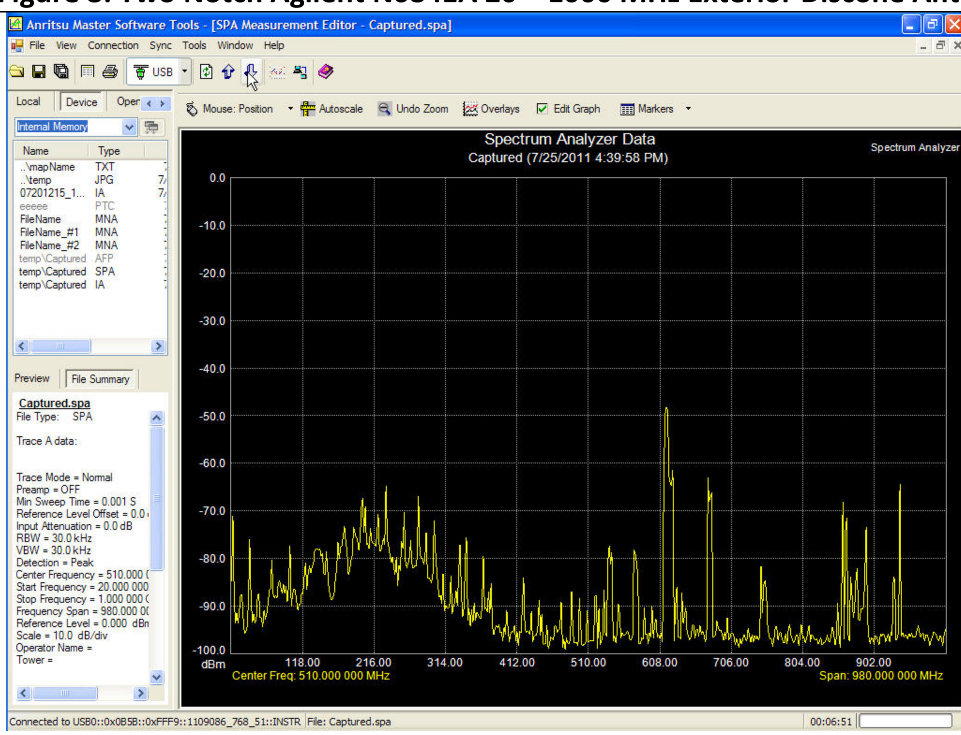


Figure 9: Two Notch Anritsu S412E 20 – 1000 MHz Interior ¼ Wave Antenna in Radio Room

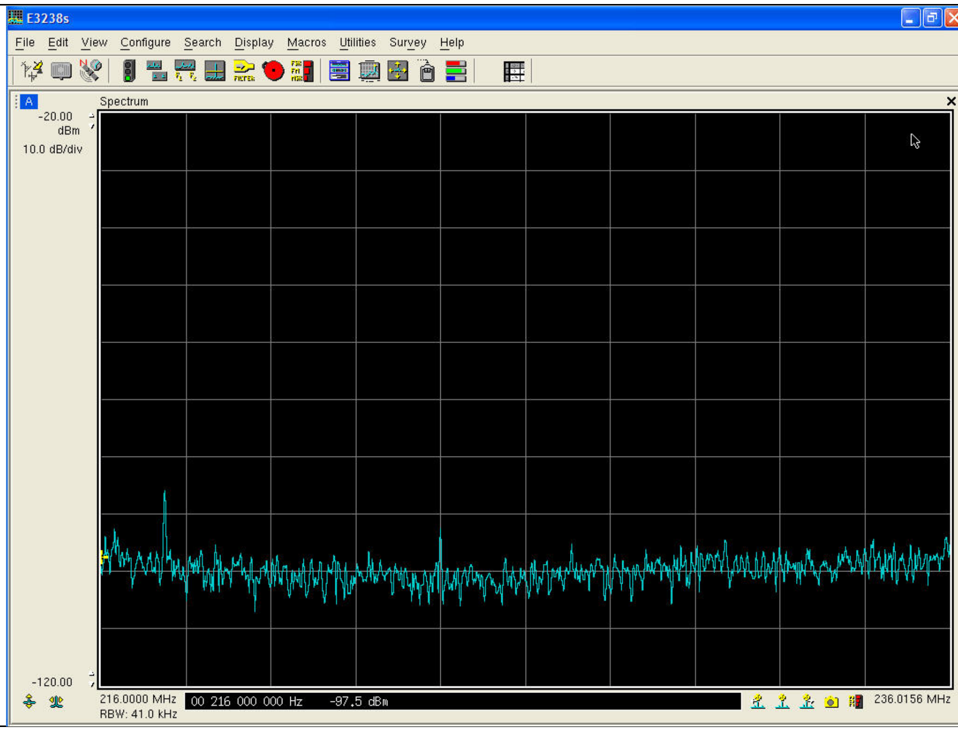


Figure 10: Three Notch Agilent N6841A 216 – 226 MHz Exterior Discone Antenna

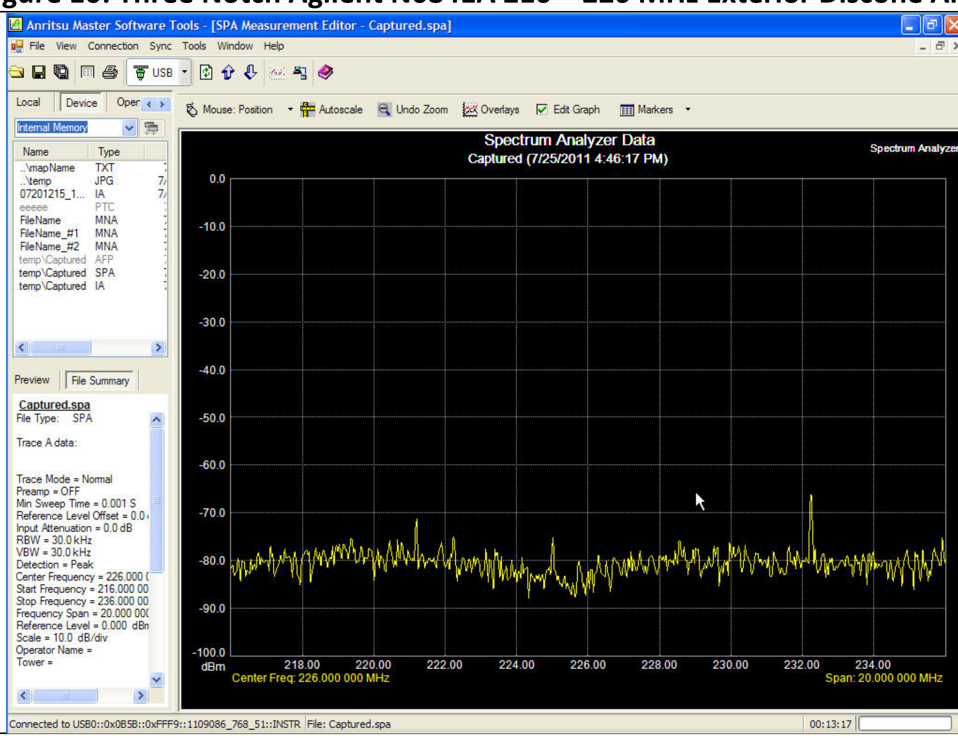


Figure 11: Three Notch Anritsu S412E 216 – 236 MHz Interior ¼ Wave Antenna in Radio Room

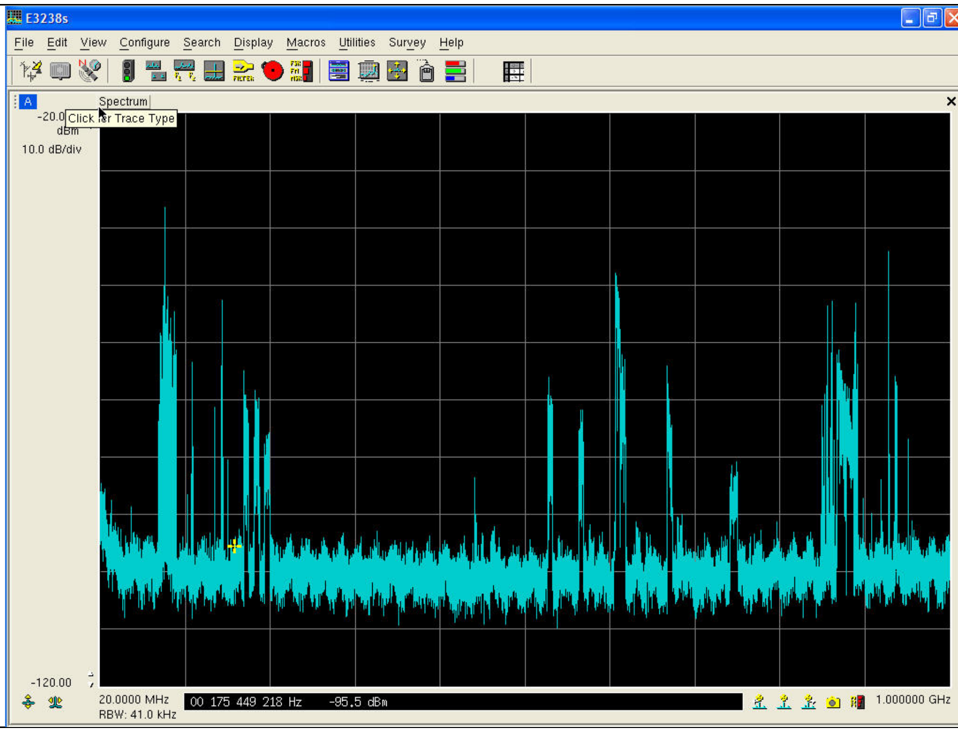


Figure 12: Three Notch Agilent N6841A 20 – 1000 MHz Exterior Discone Antenna

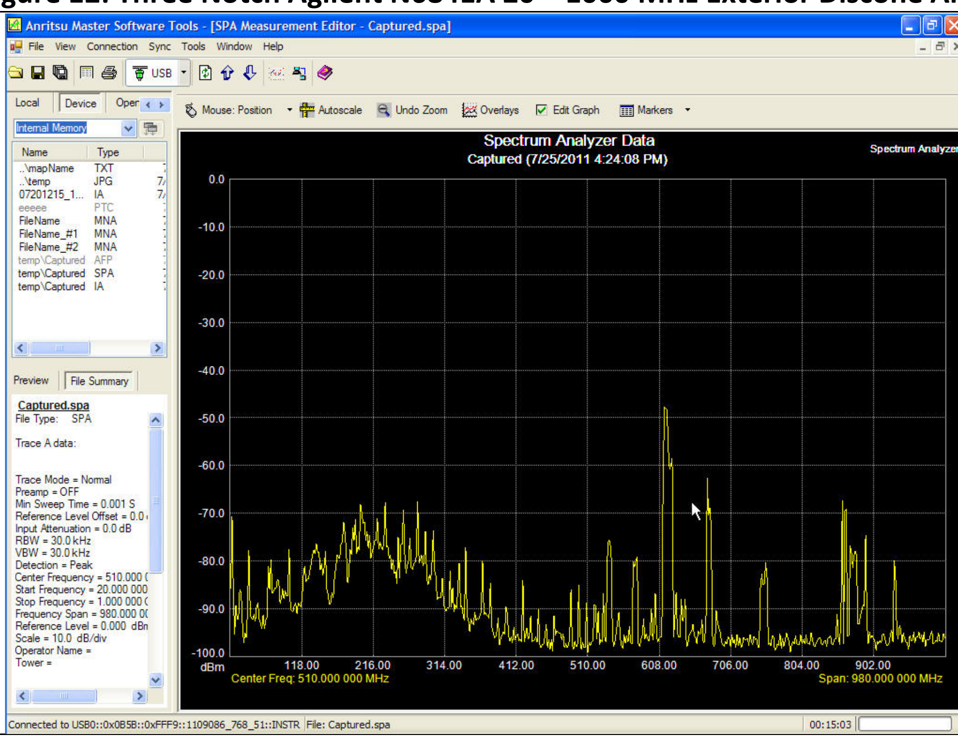


Figure 13: Three Notch Anritsu S412E 20 – 1000 MHz Interior ¼ Wave Antenna in Radio Room

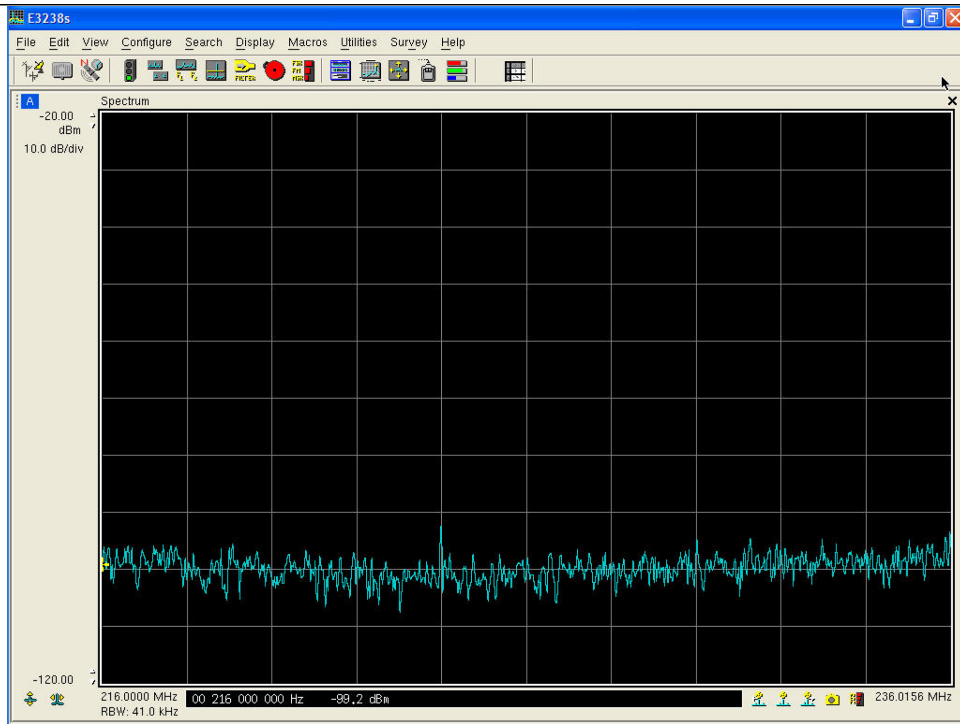


Figure 14: Four Notch Agilent N6841A 216 – 226 MHz Exterior Discone Antenna

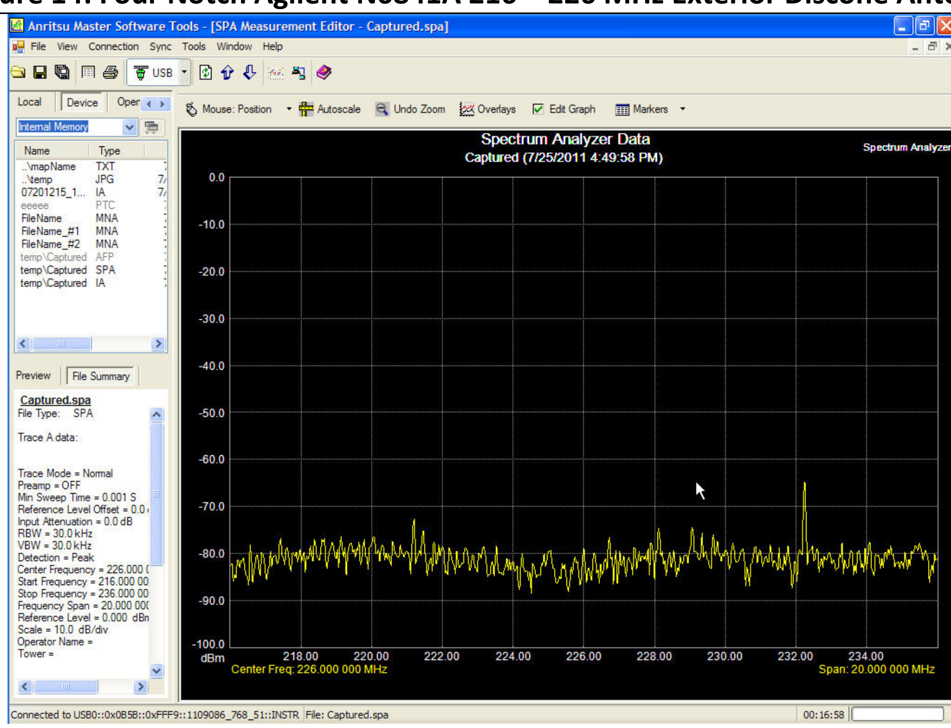


Figure 15: Four Notch Anritsu S412E 216 – 236 MHz Interior ¼ Wave Antenna in Radio Room

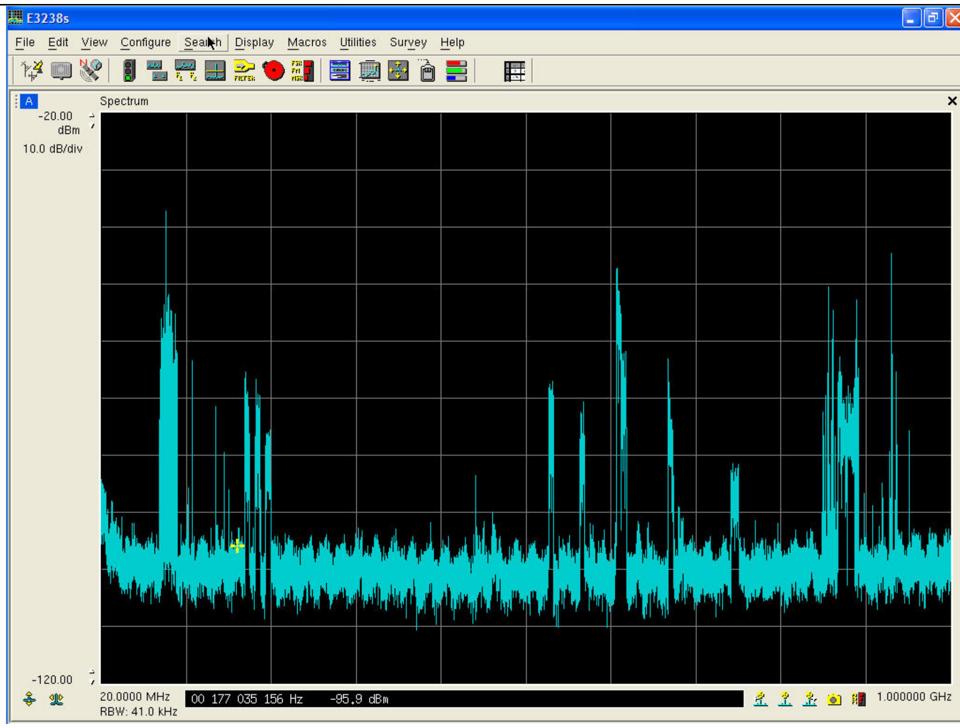


Figure 16: Four Notch Agilent N6841A 20 – 1000 MHz Exterior Discone Antenna

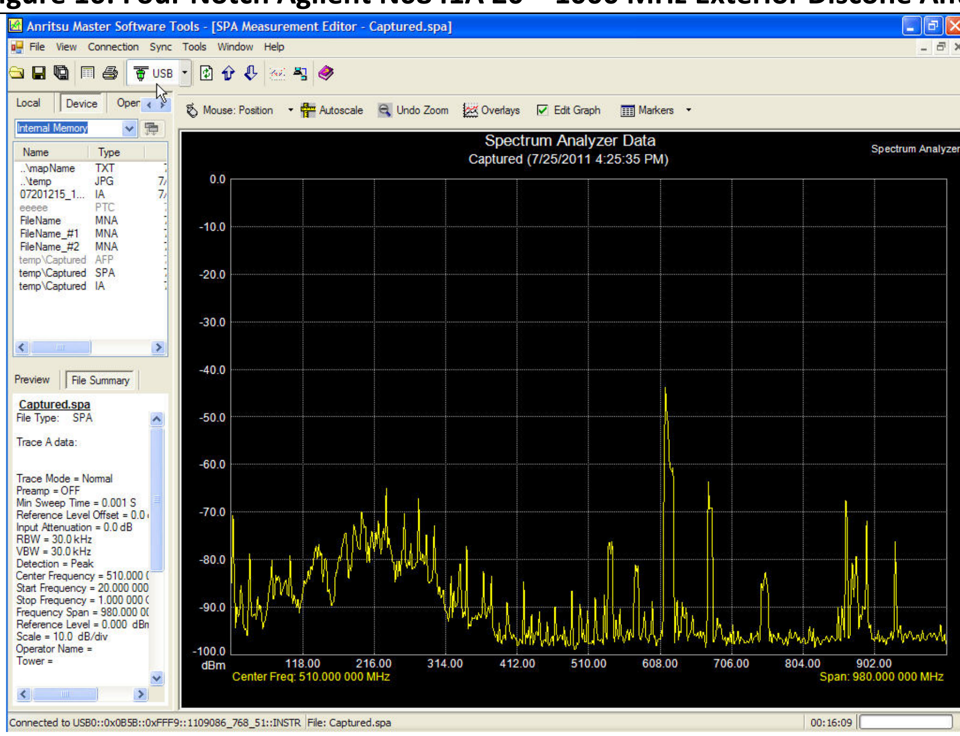


Figure 17: Four Notch Agilent N6841A 20 – 1000 MHz Exterior Discone Antenna

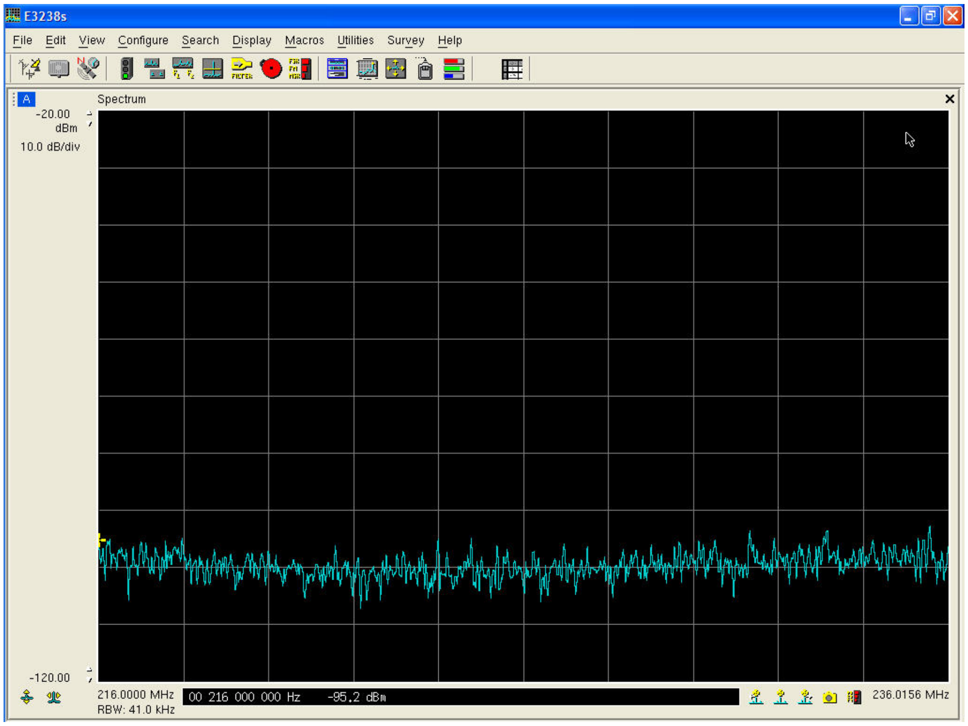


Figure 18: Four Notch Anritsu S412E 20 – 1000 MHz Interior ¼ Wave Antenna in Radio Room

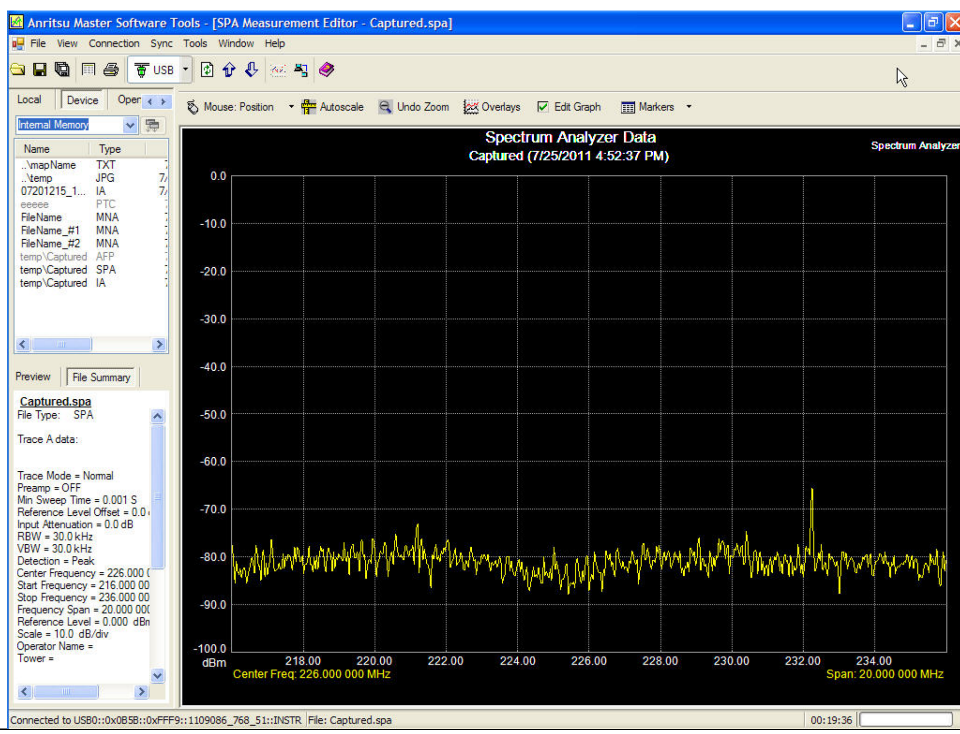


Figure 19: Five Notch Agilent N6841A 216 – 226 MHz Exterior Discone Antenna

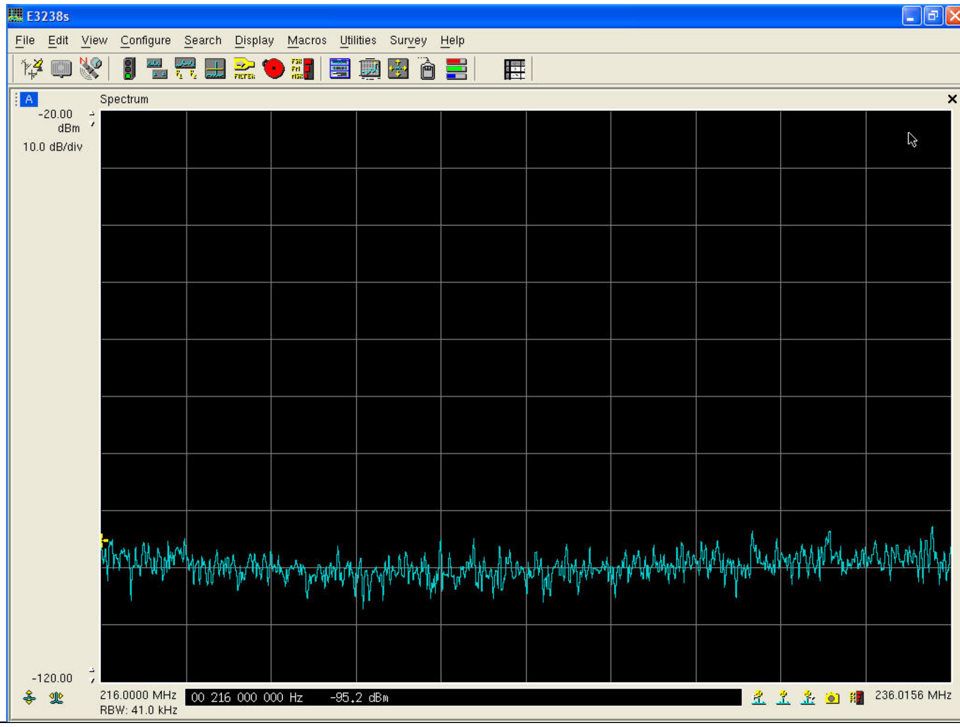


Figure 20: Five Notch Anritsu S412E 216 – 236 MHz Interior ¼ Wave Antenna in Radio Room

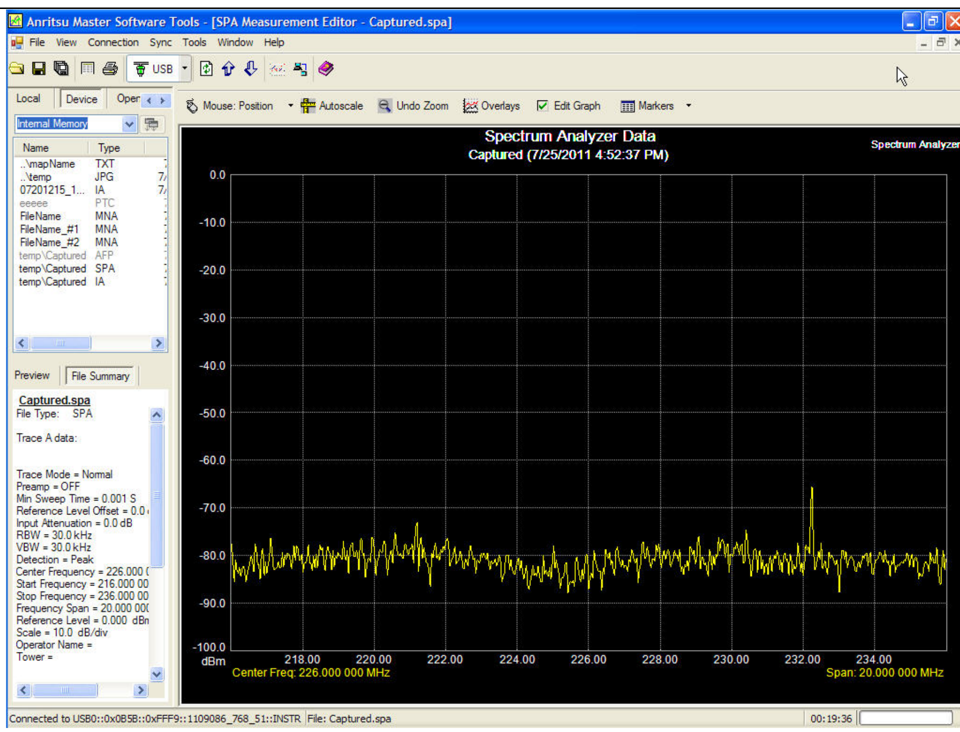


Figure 21: Five Notch Agilent N6841A 20 – 1000 MHz Exterior Discone Antenna

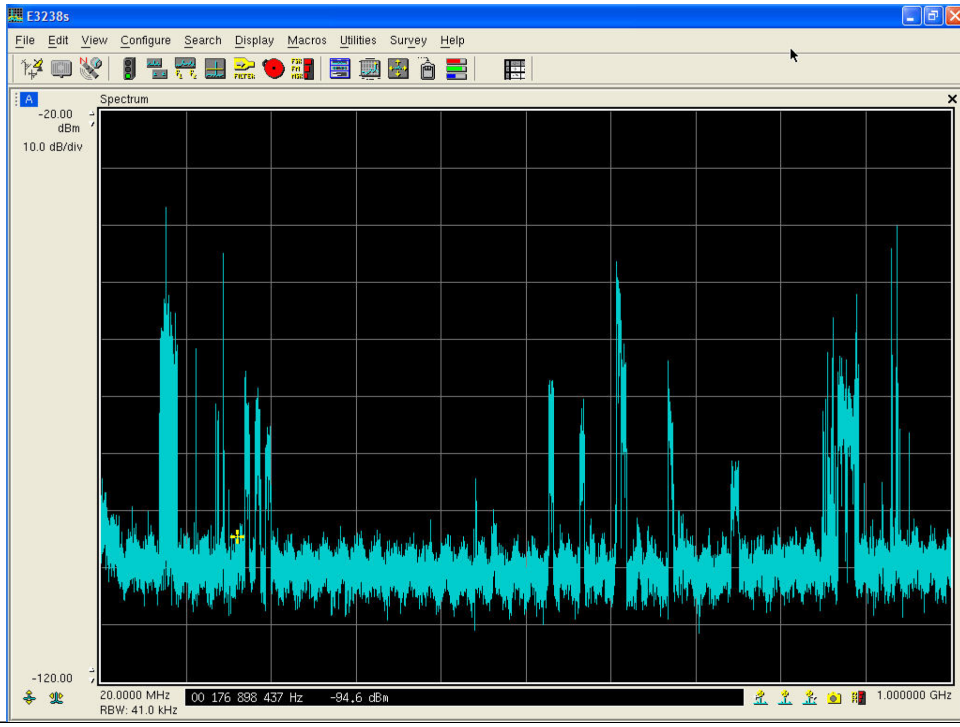


Figure 22: Five Notch Anritsu S412E 20 – 1000 MHz Interior ¼ Wave Antenna in Radio Room

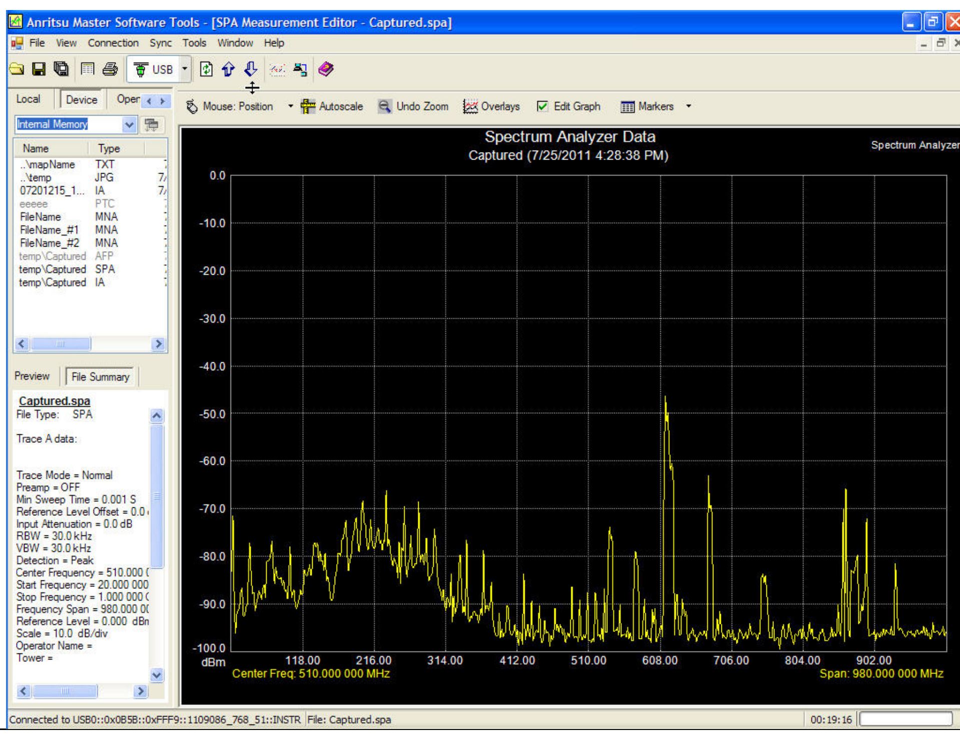


Figure 23: Six Notch Agilent N6841A 216 – 226 MHz Exterior Discone Antenna

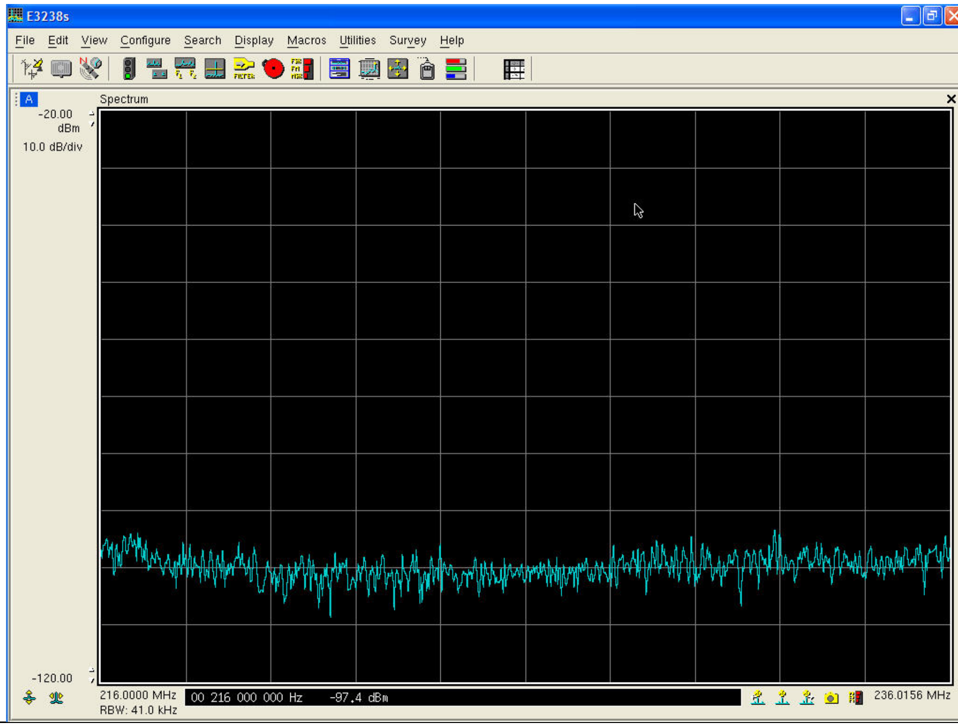


Figure 24: Six Notch Anritsu S412E 216 – 236 MHz Interior ¼ Wave Antenna in Radio Room

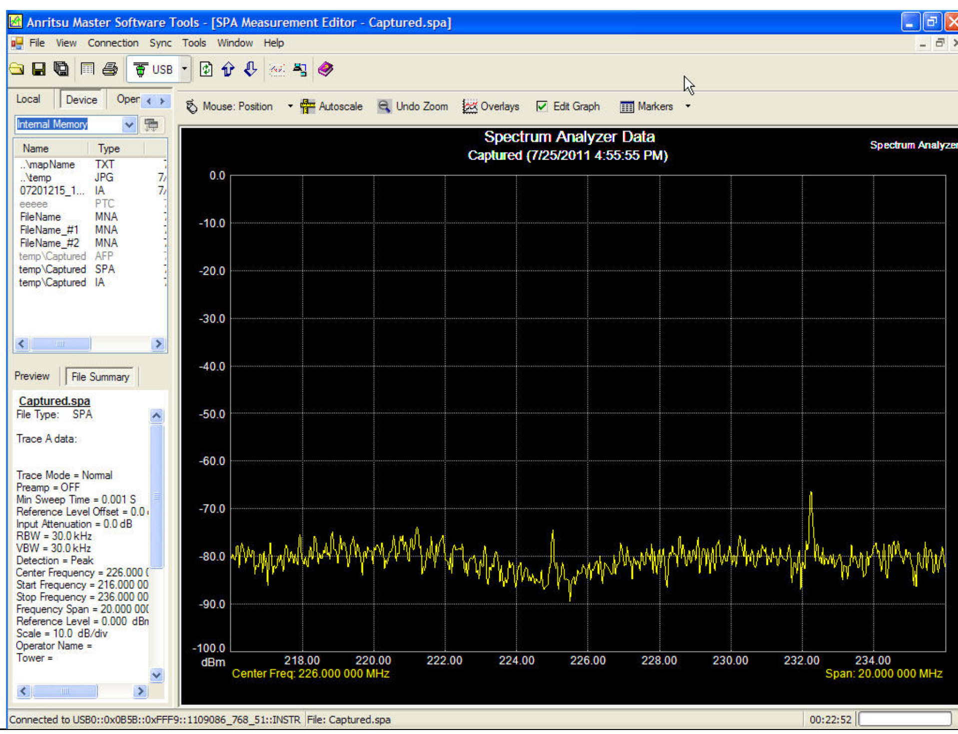


Figure 25: Six Notch Agilent N6841A 20 – 1000 MHz Exterior Discone Antenna

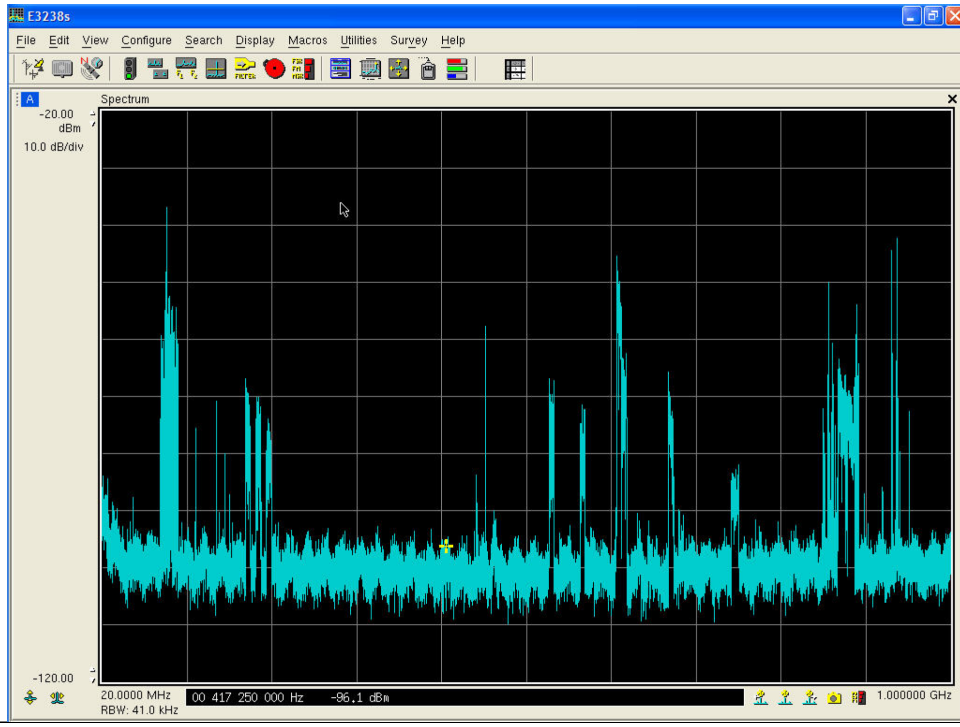


Figure 26: Six Notch Anritsu S412E 20 – 1000 MHz Interior ¼ Wave Antenna in Radio Room

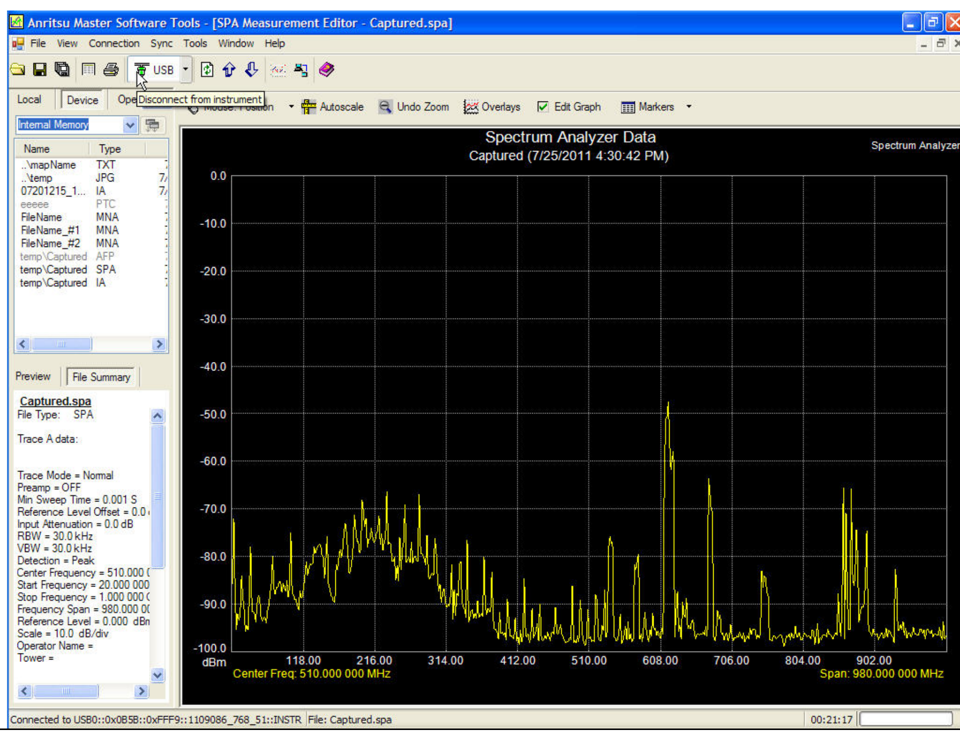


Figure 27: Seven Notch Agilent N6841A 216 – 226 MHz Exterior Discone Antenna

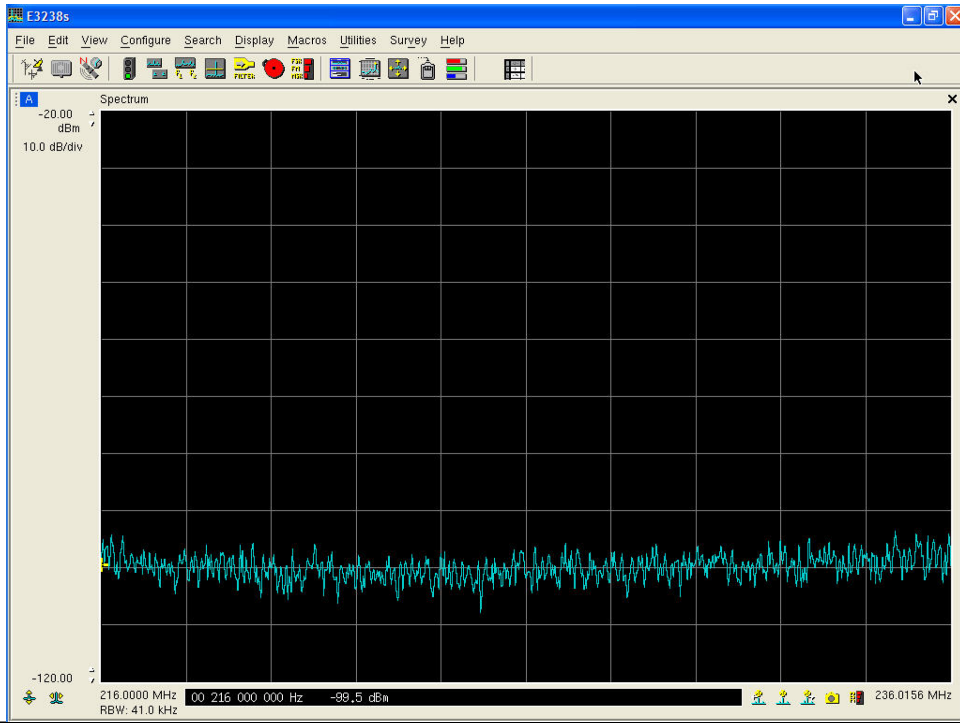


Figure 28: Seven Notch Anritsu S412E 216 – 236 MHz Interior ¼ Wave Antenna in Radio Room

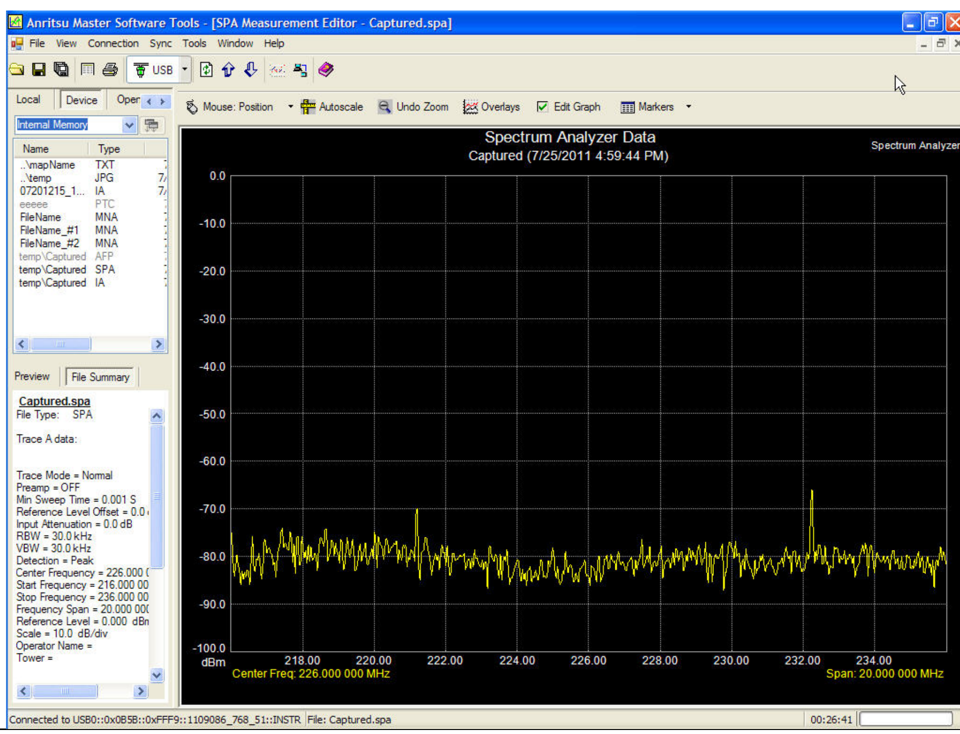


Figure 29: Seven Notch Agilent N6841A 20 – 1000 MHz Exterior Discone Antenna

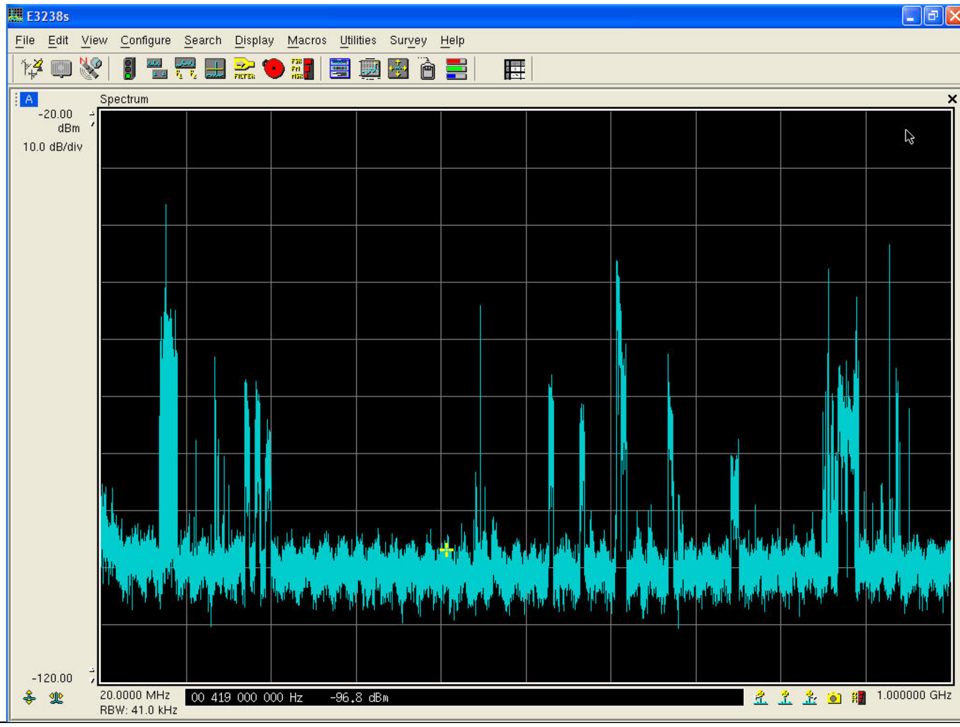


Figure 30: Seven Notch Anritsu S412E 20 – 1000 MHz Interior ¼ Wave Antenna in Radio Room

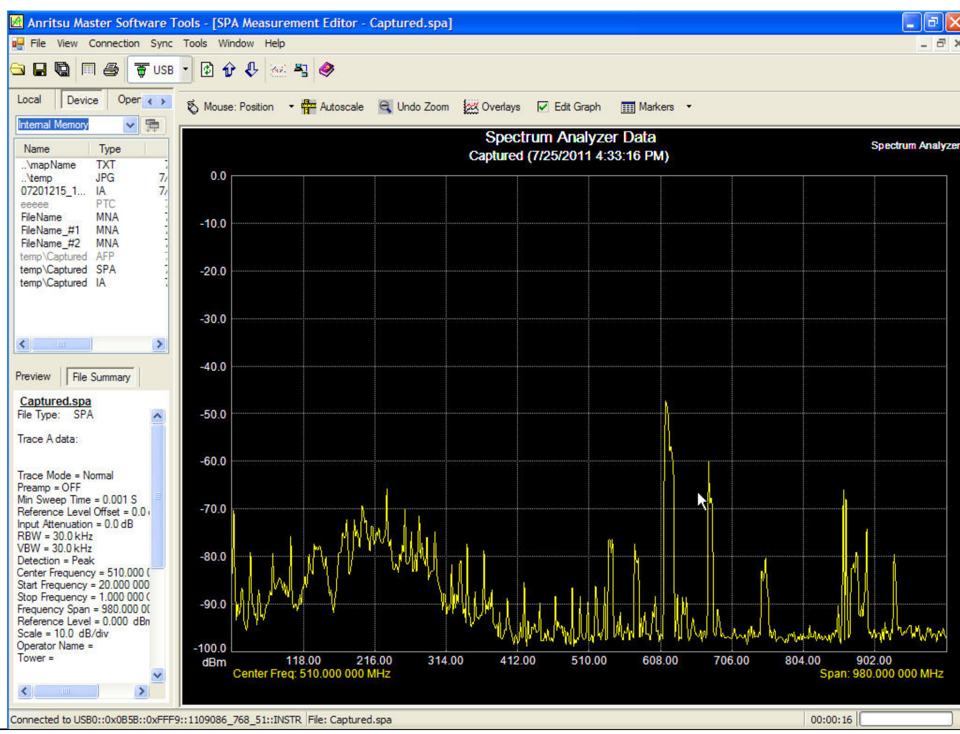


Figure 31: Eight Notch Agilent N6841A 216 – 226 MHz Exterior Discone Antenna

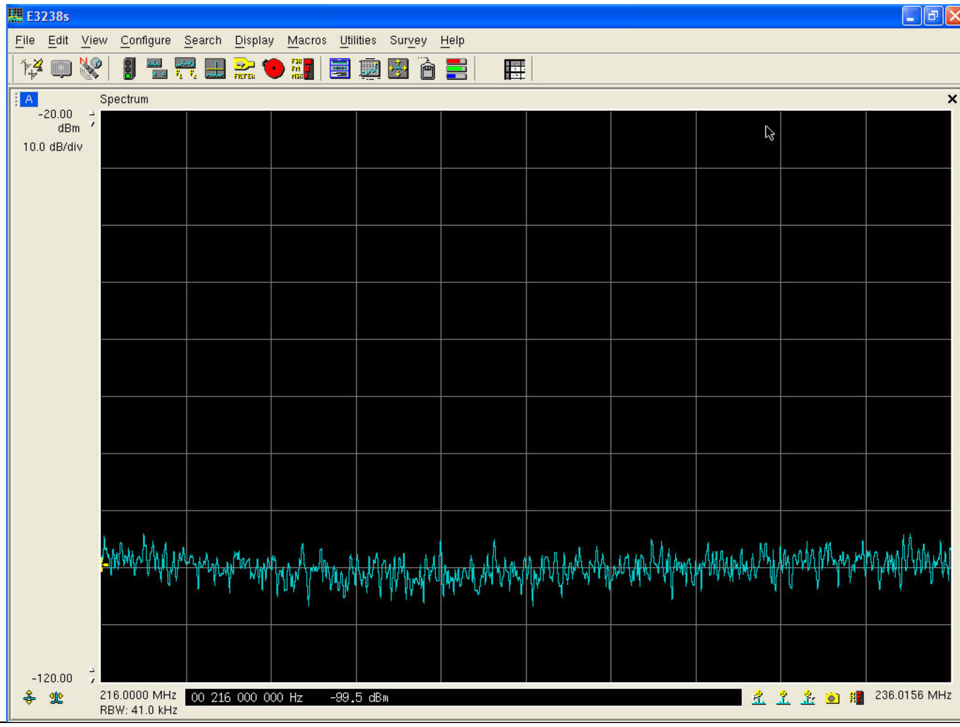


Figure 32: Eight Notch Anritsu S412E 216 – 236 MHz Interior ¼ Wave Antenna in Radio Room

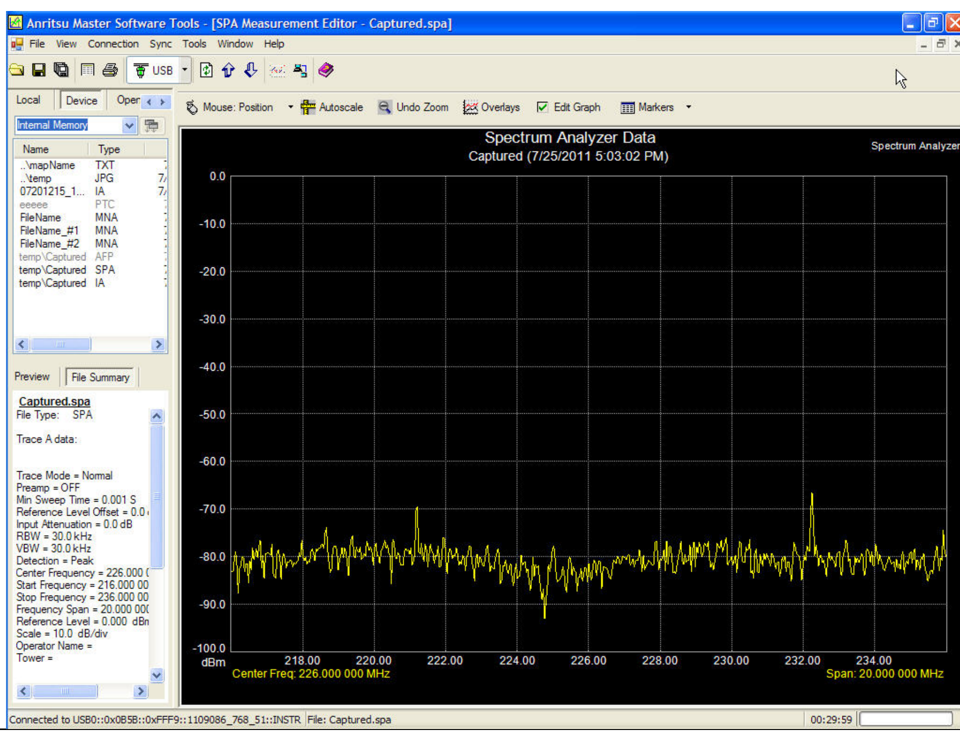


Figure 33: Eight Notch Agilent N6841A 20 – 1000 MHz Exterior Discone Antenna

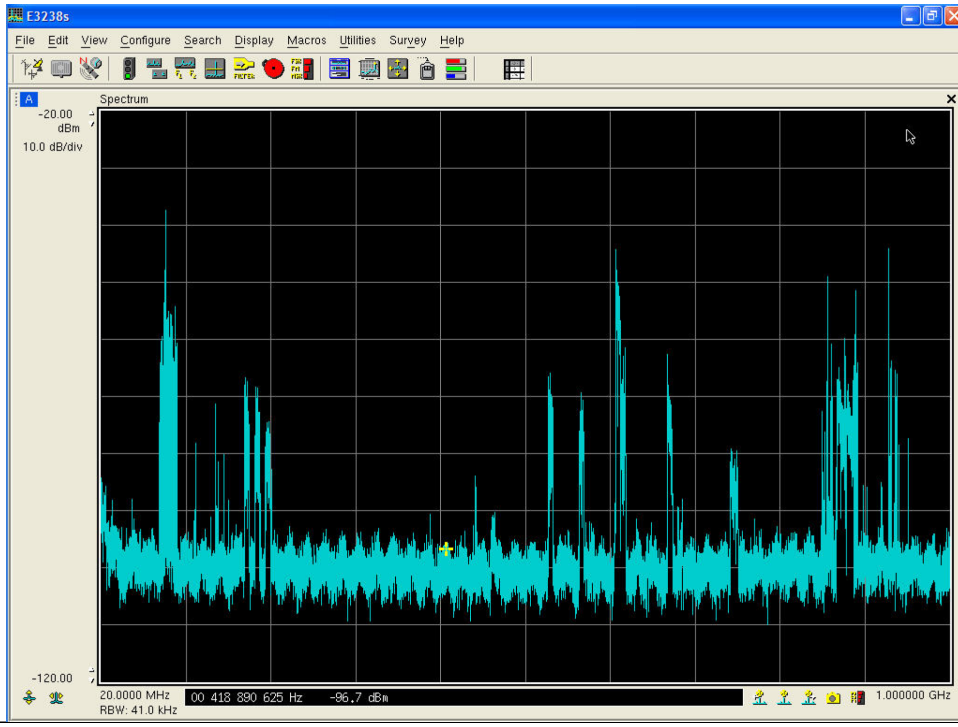
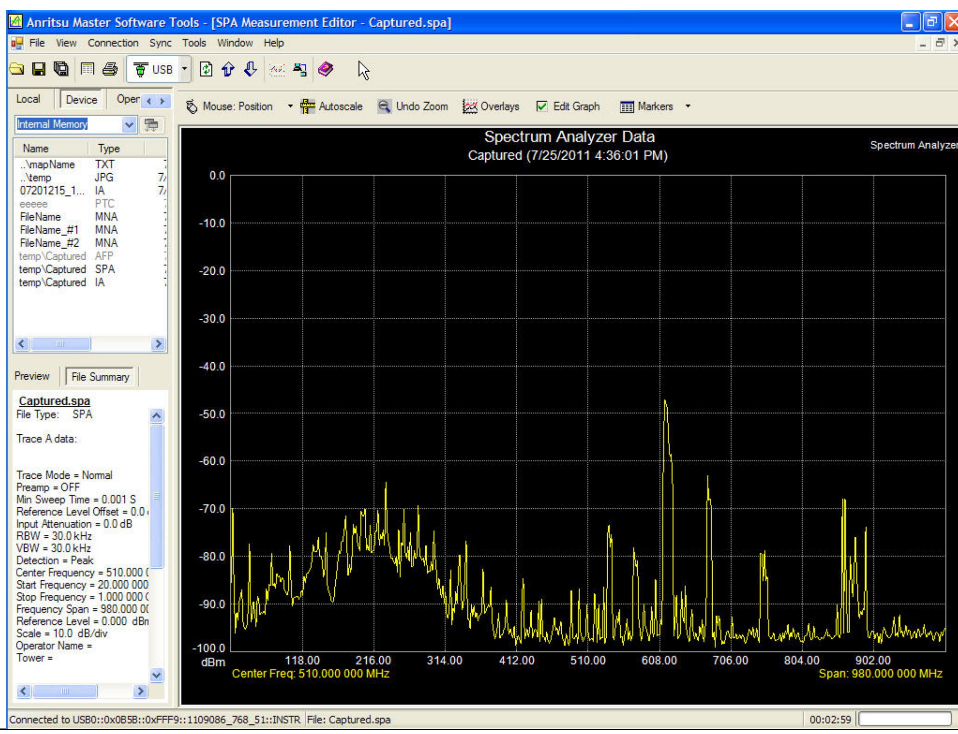


Figure 34: Eight Notch Anritsu S412E 20 1000 MHz Interior ¼ Wave Antenna in Radio Room



5. Conclusions

The testing of several RF and EMI parameters of UP 4620 did not provide significant evidence of Intermodulation products or EMI interference.

There were several procedural and instrument issues that will be resolved. Also, the method used required a long time to perform a few of the tests, and some instruments might need to be replaced.

The locomotive UP 4620 was only partially equipped with radio systems, and had no PTC radios or other PTC equipment on-board. It was necessary to improvise on a best effort basis. It would have been preferable to work on a fully equipped locomotive with all the radios and PTC equipment.

The issues found after the survey have served to plan a better approach to surveying a locomotive to be tested, only starting to work on a locomotive when there are no outstanding problems to resolve that could delay the testing process.

A better way to connect and reconnect all testing cables and instruments should be developed. It takes a large amount of time to connect and reconnect all RF cables when testing multiple RF sub-systems, increasing the potential for mechanical/electrical failures or connection degradation, and the probability that human error could produce incorrect testing results.

6. Action Items

Define a more comprehensive pre-screening of the locomotive before surveying and starting evaluation, ensuring that all antennas, PTC, and radio systems are installed and operational, and that there are no electrical or mechanical issues with antenna cables or connectors. Verify that there is a working 72 V DC power outlet on board to power Meteorcomm PTC radios.

Develop a method to streamline testing, possibly incorporating a more automated approach where measurements are logged by an instrument such as the Agilent N65841A RF Sensor, instead of manually recording measurements on paper.

Use one set of well calibrated mobile radios on a rugged portable enclosure to do all testing, instead of trying to operate the radios installed on board the locomotive, some of which cannot be controlled to transmit using a PTT command for testing purposes. These installed radios may be off-calibration and not be able to produce the nominal output RF power, which can also affect the measurements results.

Possibly install the Agilent N6841A RF Sensor in a protective enclosure, along with switchable attenuators, limiters and filters to provide a variable parameter front-end for the instrument.

Appendix A: On Board Radio Equipment Report

Locomotive Type	**SD-70M**	**Technician**	**R. Abelleyro**
Locomotive Number	UP 4620	Date	July 2011
Location (Address)	BNSF Interbay, Seattle, WA	GPS Coordinates	47 39' 13.18 N 122 22' 55.62" W

Transceiver Equipment

Manufacturer	Model Number	Serial Number	Operating Frequency	Description
Motorola Spectra	-	-	160 MHz	Voice Dispatch Radio
N/A	N/A	UP ID 104378	450 MHz	Head of Train Radio
NEXTERNA	304 W2	-	800 MHz	Cell Modem
-	-	-	900 MHz	SPEC 200 radio
-	-	-	900 MHz	Event Recorder radio

Filters

Manufacturer	Model Number	Serial Number	Operating Frequency	Description
Networks International	OBA69 C-1079 DC 1109	064	160 MHz	Band pass
Networks International	OBA69-C-1080 DC 1109	049	220 MHz	Band pass
Networks International	OBA 69 C-1080 DC 1109	053	220 MHz	Band pass
Networks International	OBA 69 C-1082 DC 1109	070	455 MHz	Band pass
Networks International	OBA 69 C-1081 DC 1110	059	916 MHz	Band pass
Networks International	OBA 69 C-1081	058	916 MHz	Band pass

Locomotive Type	**SD-70M**	**Technician**	**R. Abelleyro**
Locomotive Number	UP-4620	Date	July 2011
Location (Address)	BNSF Interbay, Seattle, WA	GPS Coordinates	47 39' 13.18 N 122 22' 55.62" W

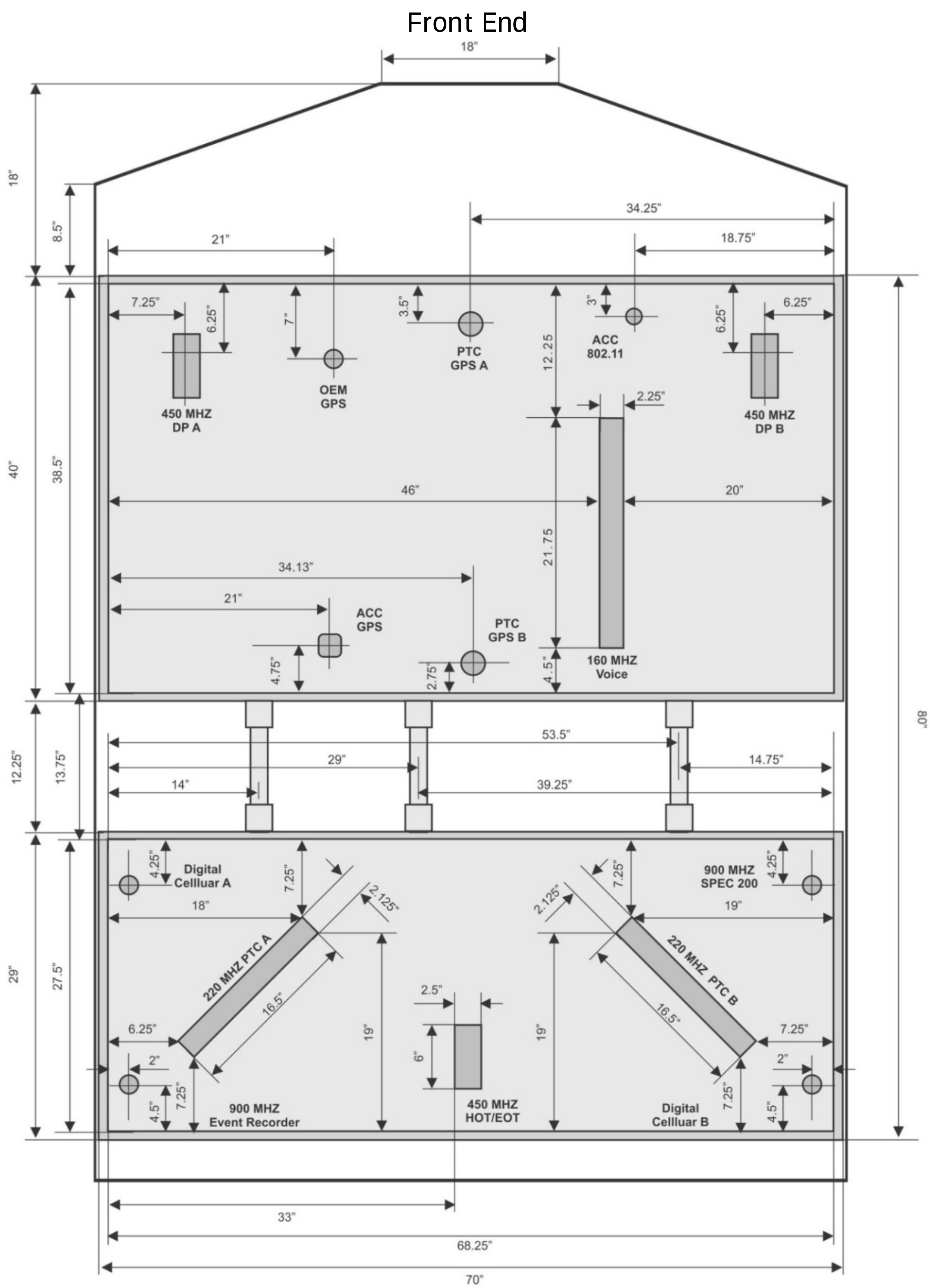
Antenna Equipment

Manufacturer	Model Number	Frequency Range	Photograph Taken	Description
Sinclair	-	160 MHz	Y	Voice radio
Sinclair	-	220 MHz	Y	PTC A
Sinclair	-	220 MHz	Y	PTC B
Sinclair	-	450 MHz	Y	DP A
Sinclair	-	450 MHz	Y	DP B
Sinclair	-	450 MHz	Y	HOT
-	-	900 MHz	Y	Event Recorder
-	-	900 MHz	Y	SPEC 200
-	-	800/1900 MHz	Y	Digital Cellular A
-	-	800/1900 MHz	Y	Digital Cellular B
-	-	1500 MHz	Y	GPS A
-	-	1500 MHz	Y	GPS B
-	-	1500 MHz	Y	ACC GPS
-	-	1500 MHz	Y	OEM GPS
-	-	2.4 GHz	Y	ACC 802.11

RF Cable

Connector Antenna End	Cable Type	Connector Equipment End	Approximate Length	Notes
-	LMR-400	N Female	10 - 20Feet	Solid core, difficult to flex

Appendix B: Locomotive Roof Diagram

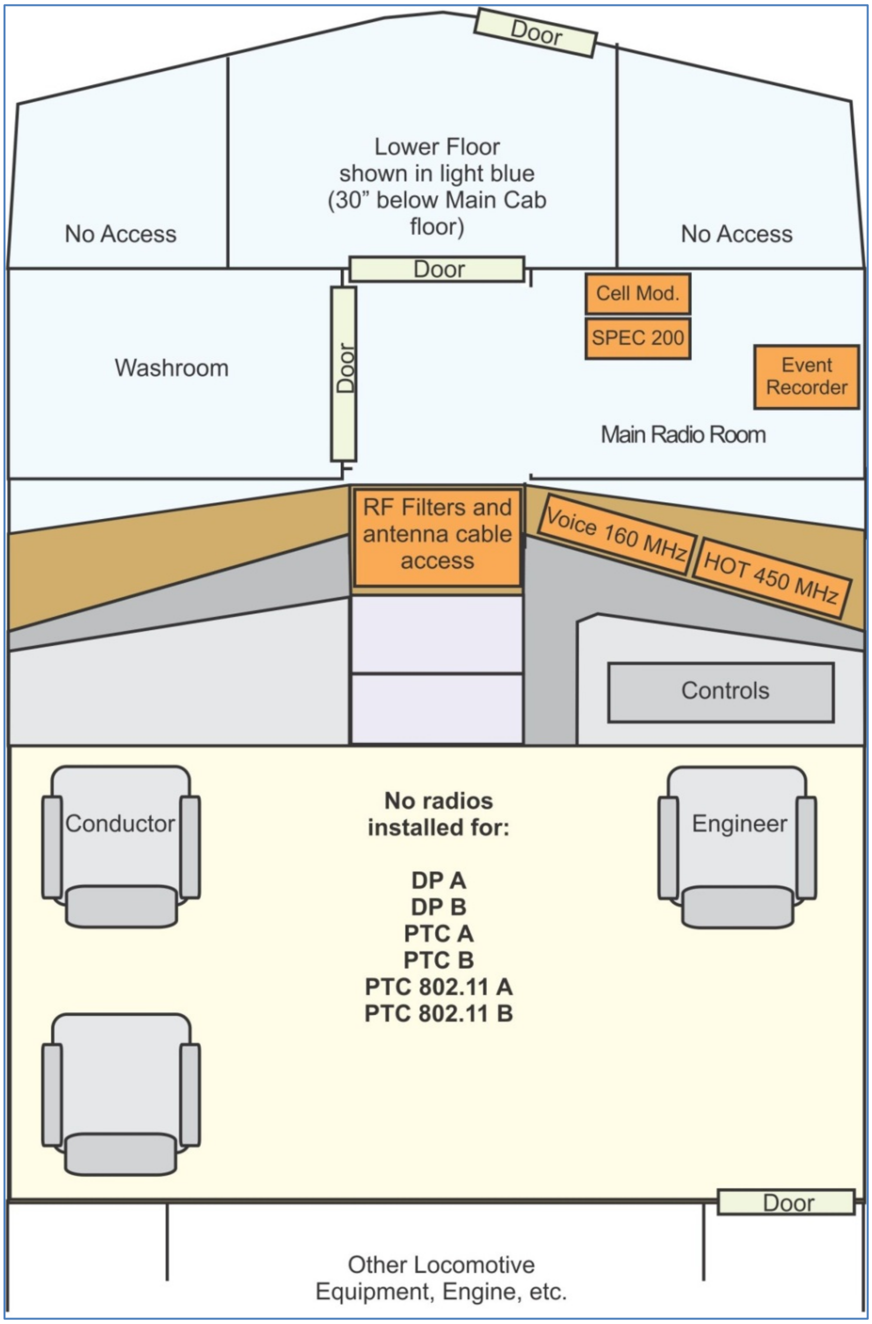


Item	**Measure X**	**Measure Y**
	(Inches)	(Inches)
Flat Roof Area (approximate LXW)	80”	70”
VHF Antenna	21.75”	2.25”
End of Train 450 MHz	6”	2.5”
Distributed Power A	6”	2.5”
Distributed Power B	6”	2.5”
220 MHz PTC Engineer	16.5”	2.125”
220 MHz PTC Conductor	16.5”{	2.125
Cell A Engineer	-	-
Cell B Engineer	1.75”	1.75”
Cell A Conductor	1.75”	1.75”
Cell B Conductor	-	-
WIFI Engineer	1.5”	1.5”
WIFI Conductor	-	-
PTC GPS A	2.25”	2.25”
PTC GPS B	2.25”	2.25”
ACC GPS	2.5”	2.5”
OEM GPS	1.25”	1.25”

Locomotive Type	**SD-70M**	**Technician**	**R. Abelleyro**
Locomotive Number	UP 4620	Date	July 2011
Location (Address)	BNSF Interbay, Seattle, WA	GPS Coordinates	47 39’ 13.18 N 122 22’ 55.62” W

Appendix C: Locomotive Cab Diagram

Locomotive Type	**SD-70M**	**Technician**	**R. Abelleyro**
Locomotive Number	UP 4620	Date	July 2011
Location (Address)	BNSF Interbay, Seattle, WA	GPS Coordinates	47 39' 13.18 N 122 22' 55.62" W



Appendix D: Intermodulation Test Data Report

Transmitting Band	VHF 161	VHF 161 FILTER	220 ENG	220 ENG FILT	220 CON	220 CON FILTER	EOT 450	Dist. Power A	Dist. Power B	WABTEC DL 900
Tx Frequency (MHz)										
Forward Power (W)										
Reverse Power (W)										
Receiving Band	(dBm)	(dBm)	(dBm)	(dBm)	(dBm)	(dBm)	(dBm)	(dBm)	(dBm)	(dBm)
VHF 161	TB									
VHF 161 Filter		TB								
220 ENG			TB							
220 ENG Filter				TB						
220 CON					TB					
220 CON Filter						TB				

- Not completed -

(Current instruments and equipment have to be modified and upgraded, and a new testing process is required to carry out this test.)

Until the new equipment and testing process are ready, intermodulation was preliminarily measured by monitoring the 216 – 225 MHz PTC band while operating several transmitters in other bands, alone and in some combinations. These transmitters included 160 MHz 35 W voice radio, 450 MHz 20 W DP radio, 450 MHz 4 W HOT radio, and 900 MHz 2 W radio.
Using this basic approach, no significant intermodulation products could be observed when one or more radios were operated while monitoring the PTC 216 to 225 MHz band

NF = Noise Floor

Locomotive Type	SD-70M	Technician	R. Abelleyro
Locomotive Number	UP-4620	Date	July 2011
Location (Address)	BNSF Interbay Locomotive Facility, Seattle, WA	GPS Coordinates	47 39’ 13.18 N 122 22’ 55.62” W

Appendix E: Test Equipment Report

Locomotive Type	**SD-70M**	**Technician**	**R. Abelleyro**
Locomotive Number	UP 4620	Date	July 2011
Location (Address)	BNSF Interbay, Seattle, WA	GPS Coordinates	47 39' 13.18 N 122 22' 55.62" W

Test Equipment

Manufacturer	Model Number	Serial Number	Calibration Date	Description
Agilent	N9912A	US48310137	-	Field Fox multifunction RF Analyzer
Agilent	N6841A	US49120085	N/A	RF Sensor 20 MHz to 6 GHz
Agilent	N6820A	-	N/A	Signal Analysis Software for RF Sensor
Agilent	U2000A	MY48000478	-	RF Power measuring sensor
Anritsu	S412E	1109220	-	LMR Master multifunction RF Analyzer
Agilent	1250-3607	002140	-	T-calibration kit
Panasonic	CF-30	7HKYA62828	N/A	Rugged notebook PC
Bird	4304A	100901662	-	5-500 W Wattmeter, 25 to 1,000 MHz
Fluke	117 True RMS	15680912	-	Digital hand held multimeter
Kenwood	TK 481	80100214	N/A	900 MHz FM hand-held radio
Kenwood	TK-3180	81100304	N/A	450 MHz FM hand-held radio
Kenwood	TK-8180	70500036	N/A	450 MHz FM mobile radio
Kenwood	NX-800	00200053	N/A	450 MHz FM/NXDN mobile radio
STI-CO	IOAK-DC-ANT	-	N/A	Discone Antenna, 108-1500 MHz
Mini-circuits	VLM-33+	-	N/A	50 Ohm broadband limiter, SMA 2 W

Manufacturer	**Model Number**	**Serial Number**	**Calibration Date**	**Description**
Mini-circuits	BW-N10W5+	-	N/A	Attenuator 10 db N-type, DC-18 GHz 5 watt
Mini-circuits	BW-N20W5+	-	N/A	Attenuator 20 db N-type, DC-18 GHz 5 watt
Mini-circuits	BW-N20W5+	-	N/A	Attenuator 20 db N-type, DC-18 GHz 5 watt
Mini-circuits	BW-N40W5+	-	N/A	Attenuator 40 db N-type, DC-18 GHz 5 watt

Manufacturer	Model Number	Serial Number	Calibration Date	Description
STI-CO	FILT-NB-220-MIL	-	-	220 MHz band-pass filter 1 of 2
STI-CO	FILT-NB-220-MIL	-	-	220 MHz band-pass filter 2 of 2.
STI-CO	FILT-NB-160-MIL	-	-	160 MHz band-pass filter
Various	Various	-	-	RF adaptors, N, UHF, TNC, SMA, etc.
Various	Various	-	-	Field technicians tool kit

Locomotive Type	**SD-70M**	**Technician**	**R. Abelleyro**
Locomotive Number	UP-4620	Date	July 2011
Location (Address)	BNSF Interbay Locomotive Facility, Seattle, WA	GPS Coordinates	47 39' 13.18 N 122 22' 55.62" W

Appendix F: VSWR Return Loss Report Form

Antenna	Frequency	VSWR Low	VSWR Mid	VSWR High
VHF 161	**150 – 200 MHz**	M1 177.750 1.22	M2 163.375 1.27	M3 150.375 1.35
220 A Cond	**200 – 250 MHz**	M1 220..875 1.02	M2 234.625 1.11	M3 240.750 1.20
220 B Eng	**200 – 250 MHz**	M1 220.625 1.02	M2 233.125 1.09	M3 240.000 1.19
HOT 450	**425 – 475 MHz**	M1 461.250 1.01	M2 444.500 1.08	M3 425.000 1.18
DP A 450	**425 – 475 MHz**	M1 460.750 1.02	M2 436.625 1.12	M3 427.500 1.22
DP B 450	**425 – 475 MHz**	M1 461.625 1.02	M2 437.625 1.12	M3 428.000 1.22
ARC 900	**850 – 950 MHz**	M1 858.500 1.16	M2 864.500 1.21	M3 890.250 1.26
ER 900	**850 – 950 MHz**	M1 935.250 1.01	M2 893.500 1.07	M3 851.500 1.14
SPEC 900	**850 – 950 MHz**	M1 897.500 1.00	M2 893.500 1.06	M3 858.500 1.11
Cell A	**650 – 1000 MHz**	M1 880.125 1.01	M2 848.625 1.07	M3 659.625 1.17
Cell A PCS	**1700 – 2700**	M1 1865.0 1.01	M2 1965.0 1.09	M3 2112.5 1.18
Cell B	**650 – 1000 MHz**	M1 872.250 1.03	M2 909.000 1.12	M3 998.250 1.19
Cell B PCS	**1700 - 2700**	M1 1925.0 1.01	M2 2015.0 1.08	M3 2110 1.19
802.11	**2350 – 2550**	M1 2527.0 1.03	M2 2534.0 1.08	M3 2542.0 1.13

Locomotive Type	**SD-70M**	**Technician**	**R. Abelleyro**
Locomotive Number	UP-4620	Date	July 2011
Location (Address)	BNSF Interbay Locomotive Facility, Seattle, WA	GPS Coordinates	47 39’ 13.18 N 122 22’ 55.62” W

Appendix G: Insertion Loss Isolation Report Form

	Insertion Loss	Insertion Loss	Insertion Loss	Plots Recorded	Isolation	Isolation	Isolation	Isolation	Isolation	Plots Recorded
	Low	Mid	High		Marker 1	Marker 2	Marker 3	Marker 4	Marker 5	
Frequency Band	(DB)	(DB)	(DB)	(Y / N)	(DB)	(DB)	(DB)	(DB)	(DB)	(Y / N)
VHF 161 Cable										
VHF 161 Filter										
220 ENG Cable										
220 ENG Filter										
220 CON Cable										
220 CON Filter										
EOT 450 Cable										
Dist. Power A Cable										
Dist. Power B Cable										
WABTEC DL 900 Cable										
CEL A ENG Cable										
CEL B CON Cable										
CEL A ENG Cable										
CEL B CON Cable										
WIFI ENG Cable										
WIFI CON Cable										

\- **Not Completed** -

+5 dBm output power of Agilent N9912A Field Fox not sufficient power to carry out this test, a new test setup and testing process will be required

Locomotive Type	**SD-70M**	**Technician**	**R. Abelleyro**
Locomotive Number	UP-4620	Date	July 2011
Location (Address)	BNSF Interbay Locomotive Facility, Seattle, WA	GPS Coordinates	47 39' 13.18 N 122 22' 55.62" W

Appendix H: Antenna Isolation Report Form

Transmitting Band	VHF 161	VHF 161 FILT	220 ENG	220 ENG FILT	220 CON	220 CON FILT	HOT 450	Dist. PWR A	Dist. PWR B	ER 900	SPEC 900	CEL A	CEL B	802.11		
Receiving Band	(dBm)	(dBm)	(dBm)	(dBm)	(dBm)	(dBm)	(dBm)	(dBm)	(dBm)	(dBm)	(dBm)	(dBm)	(dBm)	(dBm)	(dBm)	(dBm)
VHF 161	TB	N/A	64.9	-	61.0	-	58.2	51.5	56.6	67.2	61.3	-	-	-	-	-
VHF 161 FILT	N/A	TB	-	-	-	-	-	-	-	-	-	-	-	-	-	-
220 CON	42.6	-	TB	N/A	18.2	-	40.7	47.2	43.2	21.0	44.7	-	-	-	-	-
220 CON FILT	-	-	N/A	TB	-	-	-	-	-	-	-	-	-	-	-	-
220 ENG	35.6	-	17.7	-	TB	N/A	39.5	42.9	45.6	40.2	27.7	-	-	-	-	-
220 ENG FILT	-	-	-	-	N/A	TB	-	-	-	-	-	-	-	-	-	-
HOT 450	74.3	-	37.7	-	37.3	-	TB	33.0	30.7	40.1	52.8	-	-	-	-	-
Dist. Power A	49.3	-	48.3	-	42.6	-	32.2	TB	49.0	55.5	46.5	-	-	-	-	-
Dist. Power B	55.4	-	42.7	-	48.1	-	29.9	48.0	TB	49.3	53.0	-	-	-	-	-
ER 900	54.3	-	28.2	-	45.0	-	37.6	53.3	49.2	TB	49.5	-	-	-	-	-
SPEC 900	49.2	-	47.9	-	34.3	-	45.7	41.5	52.6	48.4	TB	-	-	-	-	-
CEL A	58.4	-	40.4	-	64.3	-	47.6	57.3	49.3	26.1	40.0	TB	-	-	-	-
CEL B	55.4	-	49.8	-	32.4	-	42.9	55.4	63.5	38.6	26.6	-	TB	-	-	-
802.11	42.1	-	38.3	-	56.6	-	45.2	38.3	39.7	65.4	50.8	-	-	TB	-	-
															TB	-
																TB

TB = Transmitting Band NA = Not Applicable

Locomotive Type		Technician	
Locomotive Number		Date	
Location (Address)		GPS Coordinates	