



ENGINEERING REPORT OF ATSC
TELEVISION TRANSMITTER PERFORMANCE CHARACTERISTICS

FOR

WRAL-DT
Raleigh North Carolina

ULXTED-120

Capitol Broadcasting
Raleigh
North Carolina

Measured by:



September 11, 2020



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FACILITIES AUTHORIZED IN CONSTRUCTION PERMIT:

Name of applicant: : Capitol Broadcasting
 Call letters: : WRAL-DT
 Channel number: : CH-17
 File number of license or CP: : BLANK-0000143682
 Center frequency: : 491 MHz
 Pilot frequency: : 488.309441 MHz

TRANSMITTER LOCATION:

State: : North Carolina
 Country: : United States of America
 City: : Garner
 Street: : 3201D
 GPS : 35° 40' 29" N 78° 31' 39" W (NAD 83)

TRANSMITTER MANUFACTURER:

Manufacturer : GatesAir
 Type: : ULXTED-120
 Serial Number: : TE10004069-018
 Type Acceptance File Number: : 
 Exciter Type: : XTE (x2)

TRANSMITTER POWER SUMMARY: (Average, Digital Power)

Amplifier (s) rated power : 0.627 kW (*120= 75.24 kW)
 Transmitter system rated power (Pre-filter) : 75.24 kW
 Transmitter power output (TPO-Post filter) : 69.34 kW
 Transmission line loss : 1.63 dB
 Antenna input power : 47.1 kW
 Antenna power gain (Max) : 12.43 dB.
 ERP (Ave.) : 833.7 kW

FILTER MANUFACTURER:

: ERI 8-pole, dual-reflective

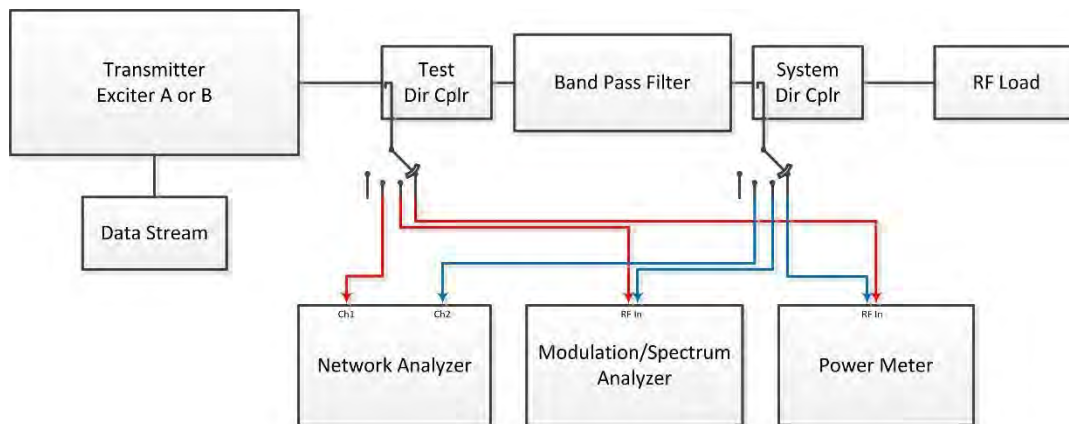
ANTENNA MANUFACTURER:

: ERI ATW25H4-ETO-17H

*Link to FCC Data <https://www.fccinfo.com/>

** Customer supplied power level (if applicable)

SIGNAL BLOCK DIAGRAM



TEST EQUIPMENT LIST:

<u>Test Equipment</u>	<u>Make</u>	<u>Model</u>	<u>S/N</u>
Network Analyzer	Copper Mountain	S5048	18097093
Spectrum Analyzer	Rohde & Schwarz	ETL	100682
Power Meter	Rohde & Schwarz	NRP-Z51	100260

METHOD FOR DETERMINING POWER OUTPUT

This describes the method of power output determining as described in the FCC rules and Regulations.

TPO measurement: With the transmitter adjusted to produce 100% (TPO); Average Power, was measured using a calibrated RF power meter connected to a precision directional coupler.

TPO *post filter* **69.34 kW** /-49.72 dB (coupler value)

- A Precision “Average” Power meter was used to calibrate output power & verify pre-filter levels.
- Pre & Post filter, forward and reflected data recorded & displayed in this report.

Efficiency measurement: A calibrated RF power meter; R&S NRP-Z51 (with a 10 dB pad) was used to measure a precision directional coupler(s) before the Mask filter in the RF system. In multi filter systems, the pre-filter power is additive as can be seen below.

- PRE-Filter coupling value(s) & Power: TX 1 Cab-1 51.31 dB ; 17.72 kW / Cab-2 51.60 dB; 17.25kw TX 2 Cab-1 51.64 dB; 17.73kW / Cab-2 51.88 dB ; 17.98 kw

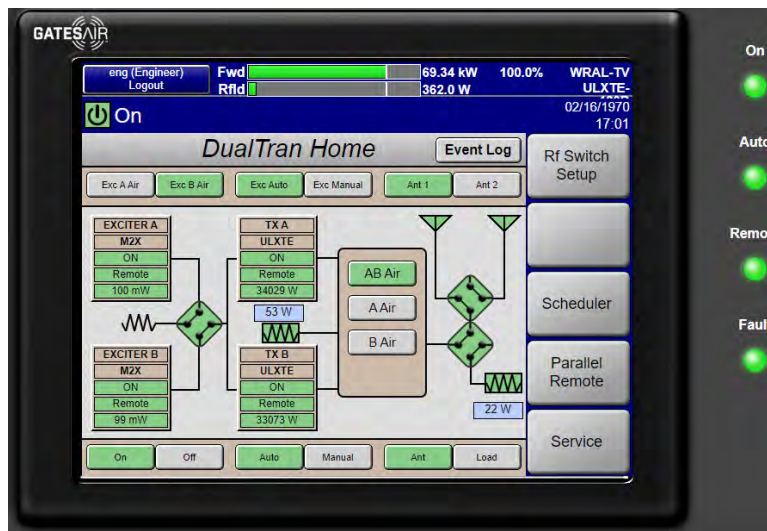
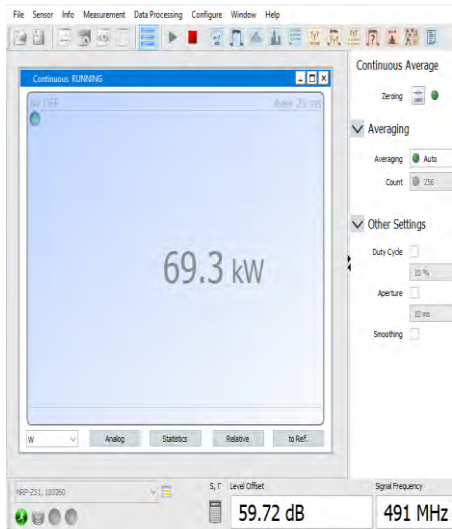
Average pre-filter power displayed from the power meter reading(s): 70.680 kW

PA EFFICIENCY

Total PA power supply current: 3436.3A
 Average PA power supply voltage: 47.9V
 Transmitter power in Watts: 70.68kW

PA Efficiency = Cabinet Average output power/input power X 100	
Total PA Current	3436.3
Average PA power supply voltage	47.9
Power in watts	70680
Transmitter efficiency	42.94%

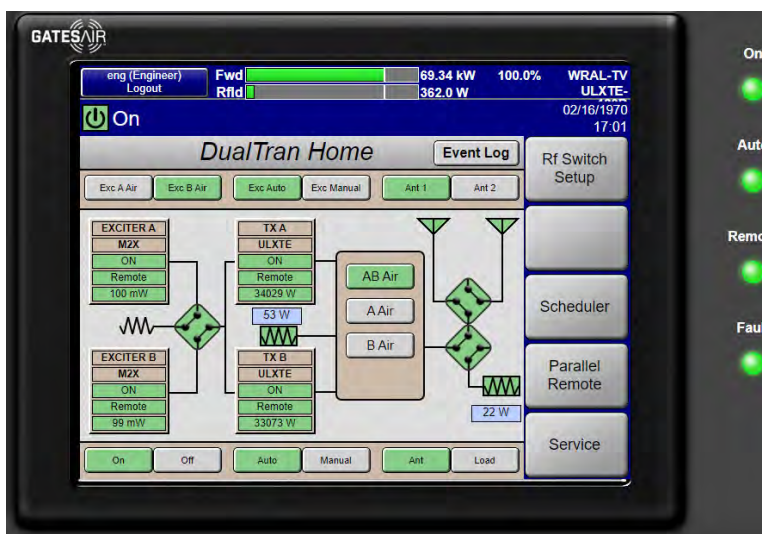
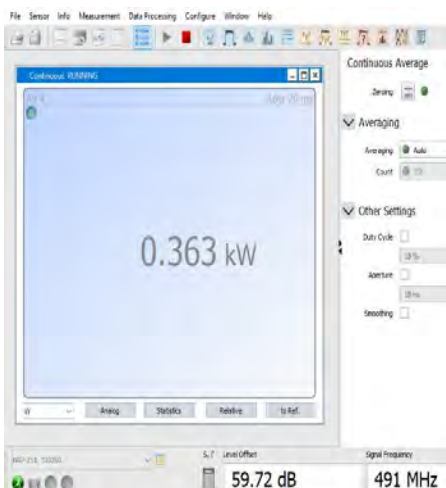
Screen capture below showing transmitter power display & POST-filter Forward power.



Screen capture showing transmitter power display & POST-filter Reflected power.

- NOTE Reflected power must be > 0 and less than 5% of forward power.
 - If reflected power is not within the above parameters further investigation is required. Test load, and all interconnecting coaxial line to be measured & investigated.
- Reflected power / Forward power * 100 = Reflected percentage.

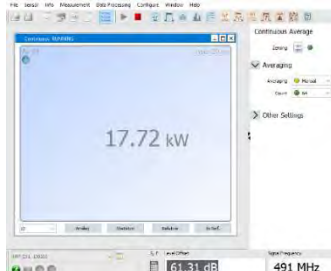
Reflected Power %	
Forward power	69340.00
Reflected power	363.00
Reflected power % < 5%	0.52
VSWR	1.16



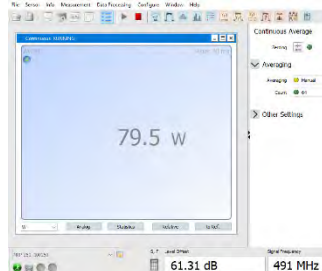
Transmitter A and B Pre-Filter Power Meter Readings.

NOTE; Prefilter requires a set of power meter measure for each Cabinet and/or filter.
Reflected power to be > 0 and less than 5% of forward power.

Screen capture showing PRE-filter Forward & Reflected TX A Cabinet-1

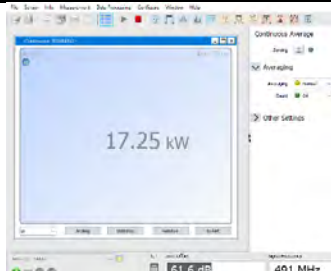


TX A Cab-1 Forward

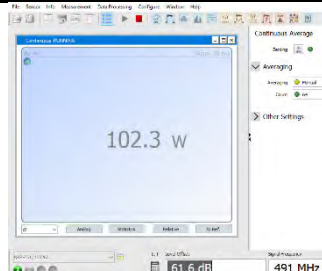


TX A Cab-1 Reflected

Screen capture showing PRE-filter Forward & Reflected TX A Cabinet-2

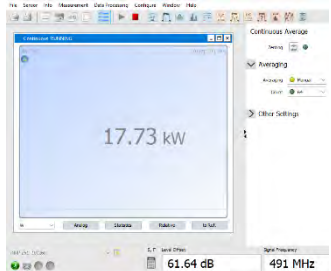


TX A Cab-2 Forward

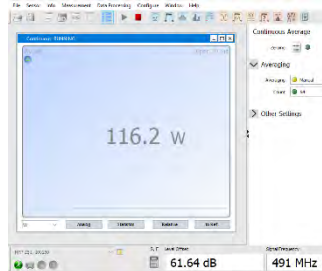


TX A Cab-2 Reflected

Screen capture showing PRE-filter Forward & Reflected TX B Cabinet-1

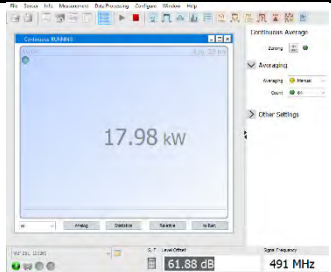


TX B Cab-1 Forward

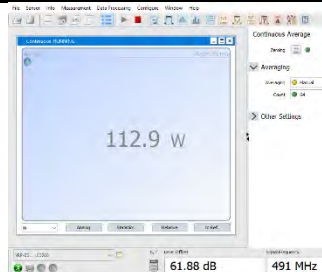


TX B Cab-1 Reflected

Screen capture showing PRE-filter Forward & Reflected TX B Cabinet-2



TX B Cab-2 Forward



TX B Cab-2 Reflected

FREQUENCY MEASUREMENT OF DIGITAL PILOT; POST FILTER-EXCITER A & B

FREQUENCY MEASUREMENTS OF THE DIGITAL CARRIER.

[Section 73.1545 © (1) and (2)] Frequency measurements were made of the pilot carrier frequency using the following equipment;

Rohde & Schwarz ETL, SN: 100682

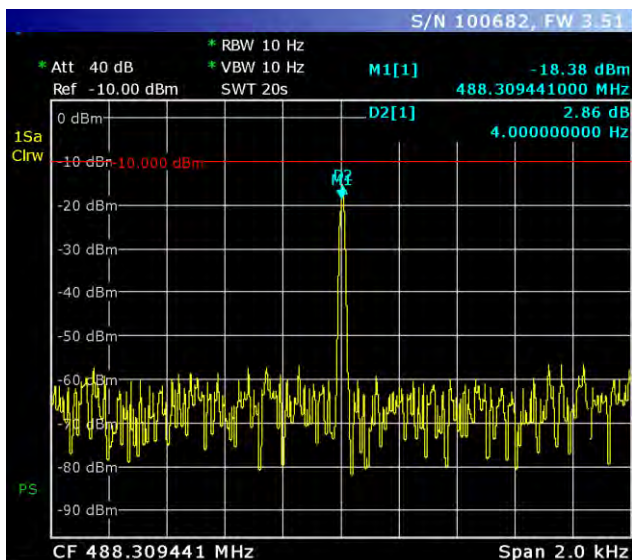
Pilot Frequency= Lower 6 MHz side band plus 0.309441 MHz

*Set parameters as listed below;

- Span=2 kHz, RBW=10HZ, VBW=10 HZ for N-1
- Span=100HZ, RBW=10 HZ, VBW=10 HZ for DTV-DTV & N+1
 - (10mhz EXT reference should be used for 100HZ span)

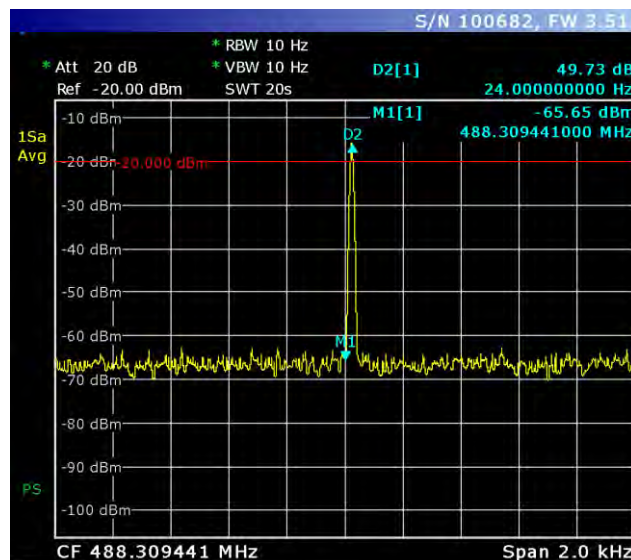
*Place center frequency and marker 1, on Pilot; For Marker 2 use peak search to find peak.

**NOTE the pilot can be adjusted from each exciter “FTR OCXO, OCXO%” for the System Reference “manual” mode.



Date: 24.SEP.2020 15:14:44

Exciter A: 488,309,445 Hz



Date: 24.SEP.2020 10:29:56

Exciter B: 488,309,475 Hz

FCC limit +/- 1000 Hz from assigned carrier frequency. (N-1) *typical*
 FCC limit +/- 10 Hz from assigned carrier frequency. (DTV to DTV) *Close Channel*
 FCC limit +/- 3 Hz from assigned carrier frequency. (N+1) *SFN type network*

HARMONIC MEASUREMENTS-POST FILTER--EXCITER A

The capacitive samples were connected to the spectrum analyzer through a notch filter or high pass filter tuned to reduce the carrier, to prevent overloading.

The characteristics of the cable used is accounted for at each required frequency. The characteristics of the high pass filter(s), or notch filter(s), used are accounted for at each required frequency.

Copper Mountain: S5048 Network Analyzer, SN: 18097093

Spectrum analyzer model: Rohde & Schwarz ETL, SN: 100682

Cable type: Times Microwave Armored Cable Length: 15 ft. Filter used: (2) NHP-1000+ High Pass filters

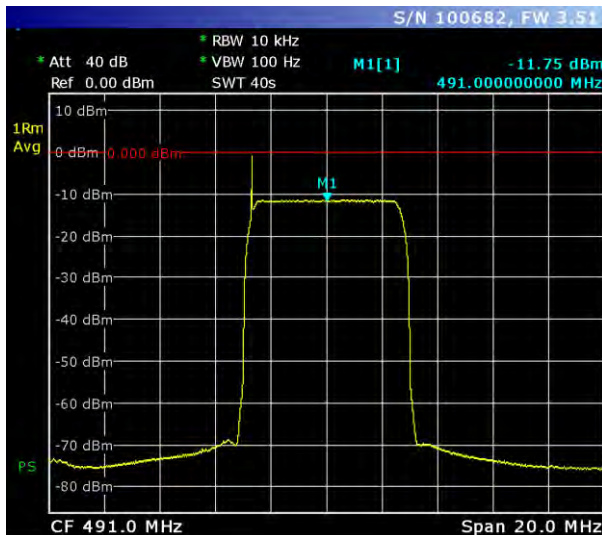
****NOTE; review document "Harmonic Measurement Instructions-ATSC-Rev B" prior to measure"**
Measurements to be taken with Spectrum Analyzer set for 10 kHz resolution bandwidth, and 10 kHz or less video bandwidth. * Set span to 20- 30 MHz*****

NOTE, only required to measure to the 3rd harmonic due to moding

***GatesAir, Inc. Moding document attached at the end of this report.**

WRAL Harmonic Measurements Exciter A													
Frequency	Measured Level	Losses (dB)				Loss Correction	Measurement RBW (kHz)	RBW Correction	TPO Reference Measurement After Corrections	dBc	FCC Limit	FCC Margin	
		Coupler	Cable	Signal Pad	Inline Filter								
Fundamental	491.00MHz	-11.000dBm	-49.720dB	1.000dB	0.000dB	50.720dB	10kHz	27.782dB	67.502dBm	0.0dBc	0.000dBc	0.0dB	
2nd Harmonic	982.00MHz	-123.990dBm	-43.940dB	2.093dB	0.680dB	46.713dB	10kHz	16.990dB	-60.287dBm	-127.8dBc	-110.000dBc	17.8dB	
3rd Harmonic	1473.00MHz	-108.870dBm	-37.930dB	3.099dB	0.450dB	41.479dB	10kHz	16.990dB	-50.401dBm	-117.9dBc	-110.000dBc	7.9dB	

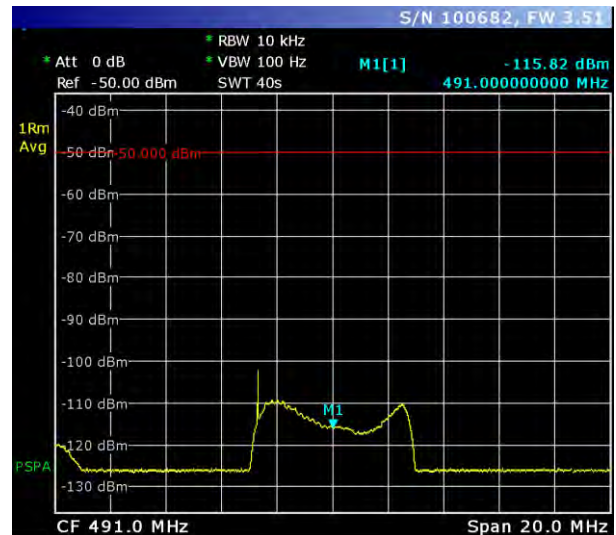
Exciter A:



Date: 24.SEP.2020 14:32:17

Exciter A:

Input level verified below 30dBm using external power meter, internal attenuation set at 50dB

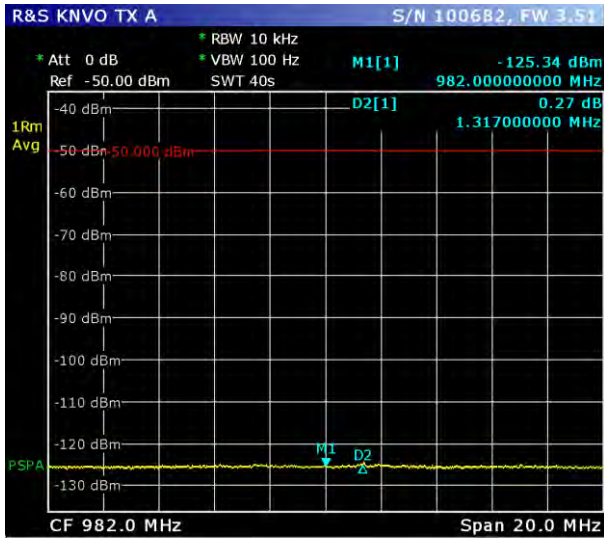


Date: 24.SEP.2020 14:36:23

Exciter A:

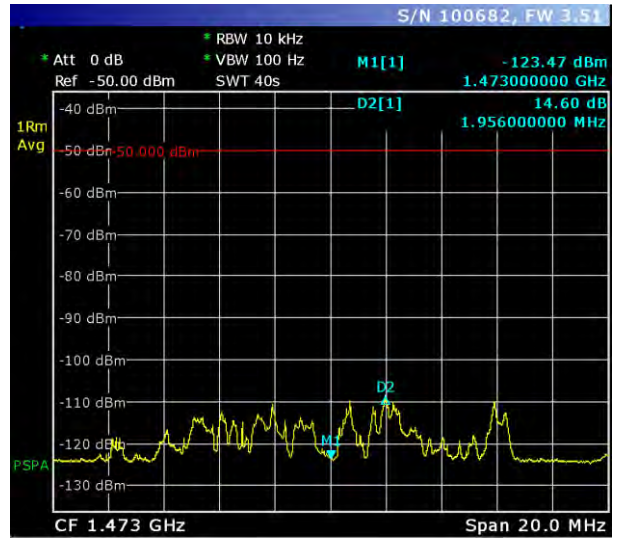
2 High Pass filters added to system, internal attenuation set at 0dB, pre-amp turned on.

HARMONIC MEASUREMENTS-POST FILTER--EXCITER A



Date: 21.OCT.2020 15:31:10

Exciter A:
 2nd harmonic with 2 HP filters in series



Date: 24.SEP.2020 14:41:01

Exciter A:
 3rd harmonic with 2 HP filters in series

Notes:

HARMONIC MEASUREMENTS-POST FILTER--EXCITER B

The capacitive samples were connected to the spectrum analyzer through a notch filter or high pass filter tuned to reduce the carrier, to prevent overloading.

The characteristics of the cable used is accounted for at each required frequency. The characteristics of the high pass filter(s), or notch filter(s), used are accounted for at each required frequency.

Copper Mountain: S5048 Network Analyzer, SN: 18097093

Spectrum analyzer model: Rohde & Schwarz ETL, SN: 100682

Cable type: Times Microwave Armored Cable Length: 15 ft. Filter used: (2) NHP-1000+ HP Pass filters

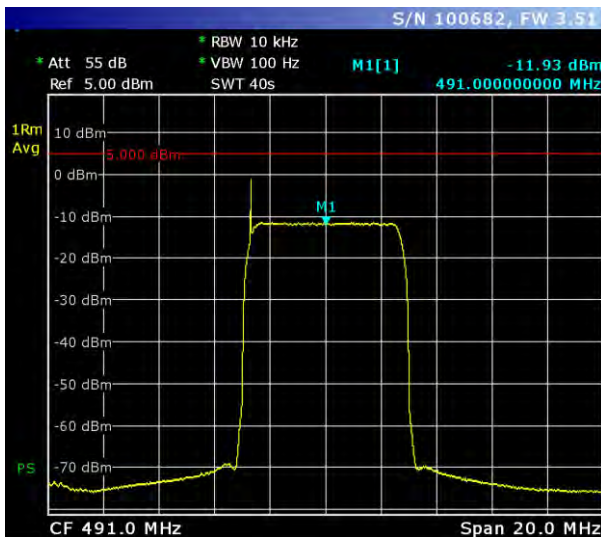
****NOTE; review document "Harmonic Measurement Instructions-ATSC-Rev B" prior to measure" Measurements to be taken with Spectrum Analyzer set for 10 kHz resolution bandwidth, and 10 kHz or less video bandwidth. *** Set span to 20-30 MHz*****

NOTE, only required to measure to the 3rd harmonic due to moding

**GatesAir, Inc. Moding document attached at the end of this report.*

WRAL Harmonic Measurements Exciter B													
	Frequency	Measured Level	Losses (dB)				Loss Correction	Measurement RBW (kHz)	RBW Correction	Measurement After Corrections	dBc	FCC Limit	FCC Margin
			Coupler	Cable	Signal Pad	Inline Filter							
Fundamental	491.00MHz	-11.930dBm	-49.720dB	1.000dB	0.000dB		50.720dB	10kHz	27.782dB	66.572dBm	0.0dBc	0.000dBc	0.0dB
2nd Harmonic	982.00MHz	-124.220dBm	-43.940dB	2.093dB	0.000dB	0.680dB	46.713dB	10kHz	16.990dB	-60.517dBm	-127.1dBc	-110.000dBc	17.1dB
3rd Harmonic	1473.00MHz	-108.730dBm	-37.930dB	3.099dB	0.000dB	0.450dB	41.479dB	10kHz	16.990dB	-50.261dBm	-116.8dBc	-110.000dBc	6.8dB

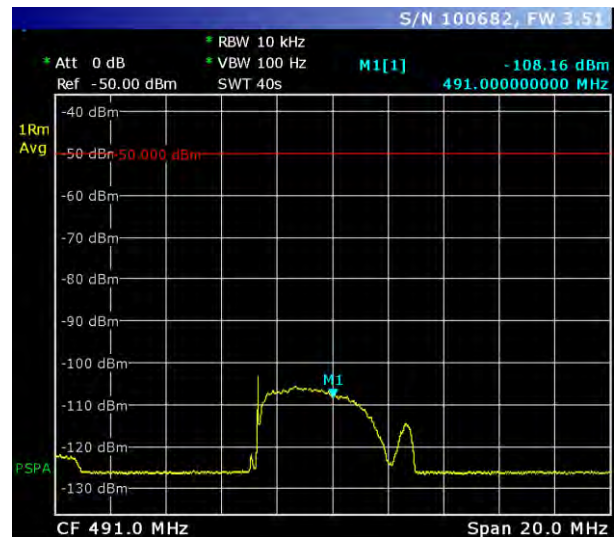
Exciter B:



Date: 24.SEP.2020 10:59:48

Exciter B:

Input level verified below 30dBm using external power meter, internal attenuation set at 55dB

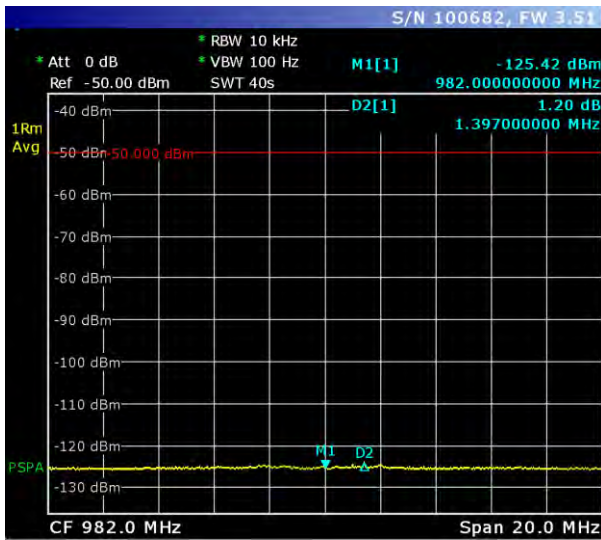


Date: 24.SEP.2020 10:53:32

Exciter B:

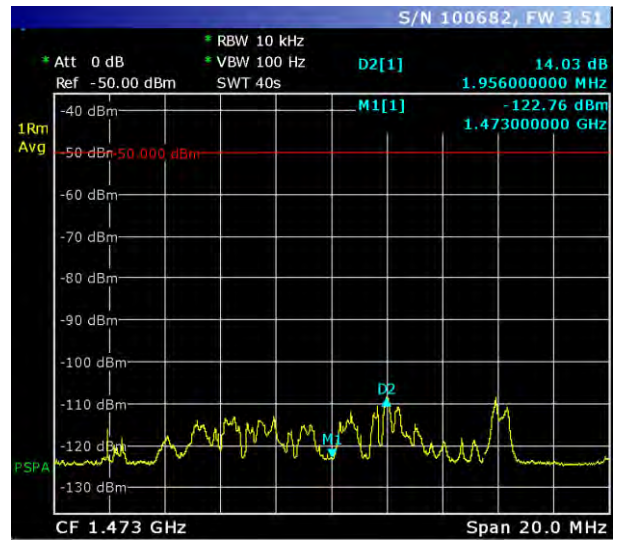
2 High Pass filters added to system, internal attenuation set at 0dB, pre-amp turned on.

HARMONIC MEASUREMENTS-POST FILTER--EXCITER B



Date: 24.SEP.2020 10:51:40

Exciter B:
 2nd harmonic with 2 HP filters in series



Date: 24.SEP.2020 10:48:44

Exciter B:
 3rd harmonic with 2 HP filters in series

Notes:

RESPONSE AND GROUP DELAY-POST FILTER-EXCITER A & B

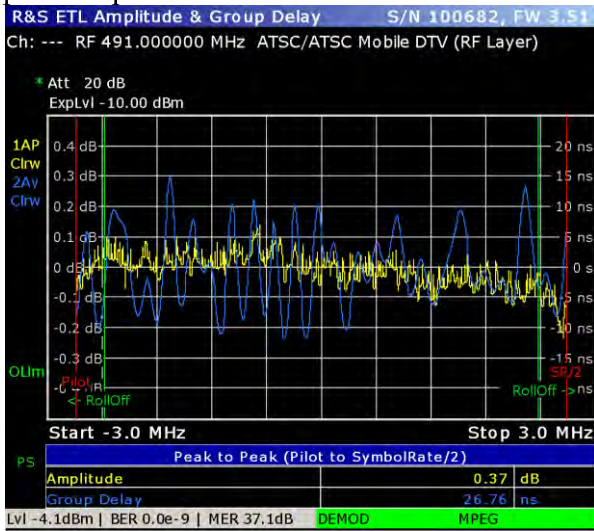
The Response and Group Delay was measured using the “Rhode and Swartz ETL Television Analyzer”. *Channel Analysis for ETL*

*Note if Amplitude is skewed, often can be adjusted via the exciter (typically not required).
RTAC>Calibration>Down Converter Tilt Compensation Enabled “yes”>

- Tilt factor .5 dB Steps (+/- 3 dB adjustment range) if more is required contact service.
- NOTE from this same screen PROFLE allows access for critical filter profile (i.e., Ch-14)

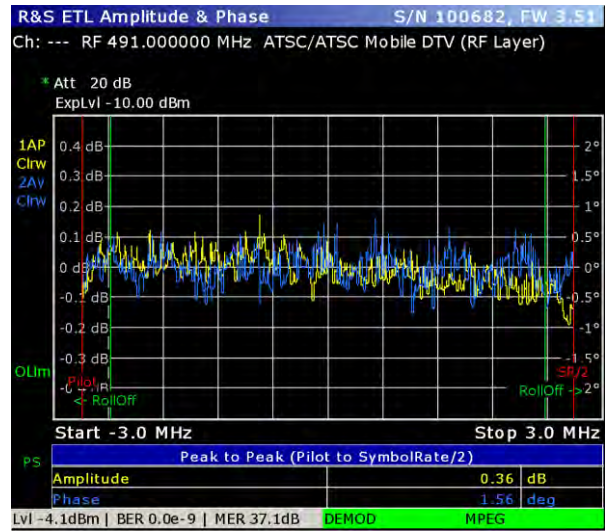
Rohde & Schwarz ETL, SN: 100682

*Spec: Amplitude variation < 1dB



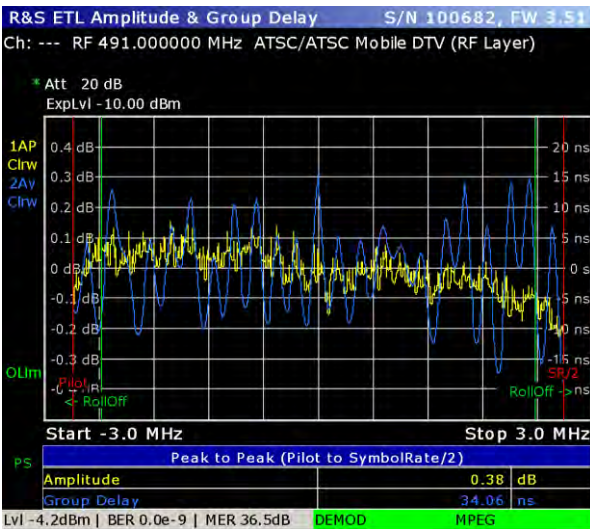
Date: 24.SEP.2020 14:24:34

Exciter A – Amplitude & Group Delay



Date: 24.SEP.2020 14:25:15

Exciter A – Amplitude & Phase



Date: 24.SEP.2020 11:05:30

Exciter B – Amplitude & Group Delay



Date: 24.SEP.2020 11:06:21

Exciter B – Amplitude & Phase

ERROR VECTOR MAGNITUDE-POST FILTER-EXCITER A

The Error Vector Magnitude was measured using the Rhode and Swartz ETL Television analyzer

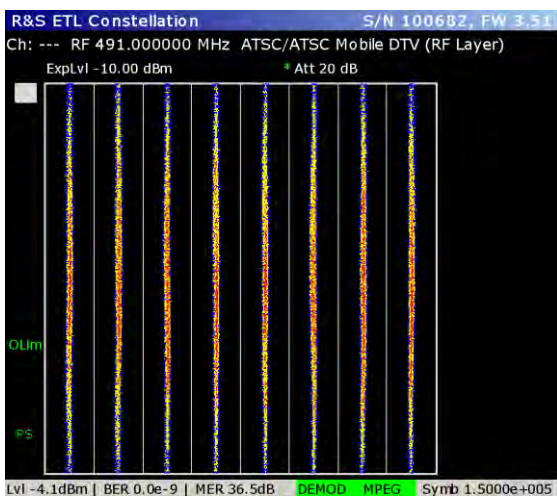
Menu-digital TV for ETL* *Zoom-select EVM for overview screen

Rohde & Schwarz ETL, SN: 100682

R&S ETL Digital Overview		S/N 100682, FW 3.51	
Ch: --- RF 491.000000 MHz ATSC/ATSC Mobile DTV (RF Layer)			
* Att 20 dB ExpLvl -10.00 dBm			
EVM (rms)			0.94 %
ATSC Parameters			
Pass	Limit	< Results	< Limit Unit
Level	-60.0	-4.1	10.0 dBm
Constellation		8VSB / Normal	
MER (rms)	24.0	36.9	---- dB
MER (peak)	10.0	13.7	---- dB
EVM (rms)	----	0.94	4.40 %
EVM (peak)	----	13.50	22.00 %
OLim	BER before RS	0.0e-9(10%/1e10)	2.0e-4
	BER after RS	0.0e-7(61%/1e6)	1.0e-10
	Packet Error Ratio	0.0e-5(61%/1e6)	1.0e-8
PS	Packet Errors	0	1 /s
	Carrier Freq Offset	-30000.0	326.9 30000.0 Hz
	Symbol Rate Offset	-10000.0	7.2 10000.0 Symb/s
	MPEG Ts Bitrate		19.392671 MBit/s
Lvl -4.1dBm BER 0.0e-9 MER 36.9dB DEMOD MPEG			

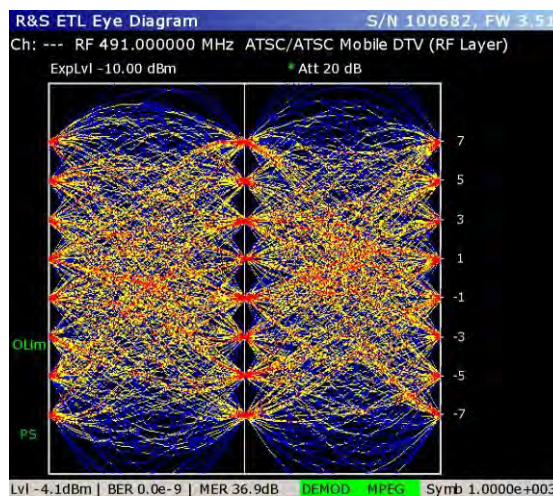
Date: 24.SEP.2020 14:22:08

Overview *EVM Spec <4%*



Date: 24.SEP.2020 14:22:59

Exciter A: Constellation



Date: 24.SEP.2020 14:23:30

Exciter A: Eye Pattern

ERROR VECTOR MAGNITUDE-POST FILTER-EXCITER B

The Error Vector Magnitude was measured using the Rhode and Swartz ETL Television analyzer

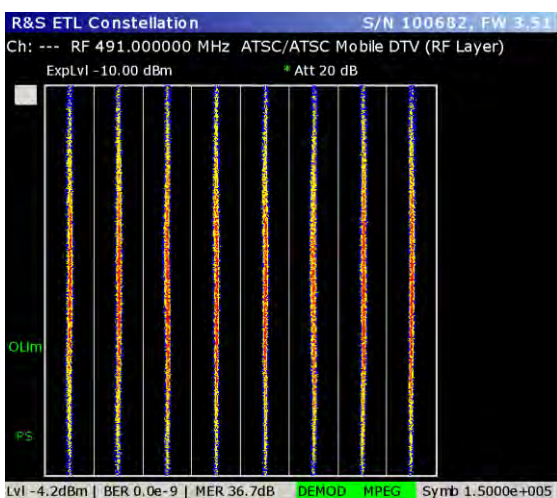
Menu-digital TV for ETL* *Zoom-select EVM for overview screen

Rohde & Schwarz ETL, SN: 100682



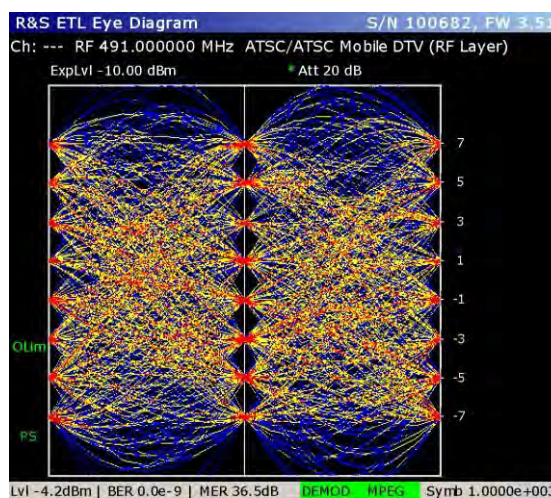
Date: 24.SEP.2020 11:07:32

Overview *EVM Spec <4%*



Date: 24.SEP.2020 11:07:54

Exciter B: Constellation



Date: 24.SEP.2020 11:08:20

Exciter B: Eye Pattern

SYSTEM SIDEBAND ENERGY +/- 3.25 MHz FROM CENTER, POST-FILTER-EXCITER A

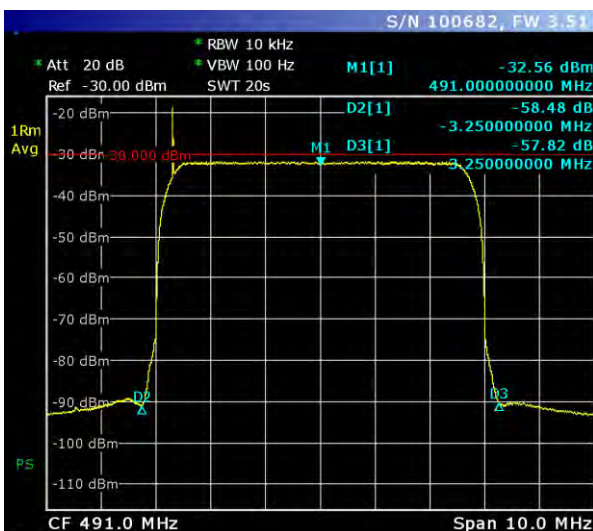
Specification= -37 dB.*

*Note for standard spectrum analyzers, -10.63 dB will need to be added to the spectrum analyzer marker values. Adding -10.63 dB accounts for the {flat portion or "head" of an ideal 8-VSB signal "IEEE P1631"}. The marker delta, plus the "flat portion" -10.63 value, must be less than -47 dB to meet specification. Note screen below to the left.

*Some analyzers have built in software that automatically adds the -10.63dB {flat portion or head of an ideal 8-VSB signal} to the overall measurement such as an ETL. Screen below to the right shows a pre-configured screen. (When using pre-configured screens, it is typically not required to add the -10.63 value).

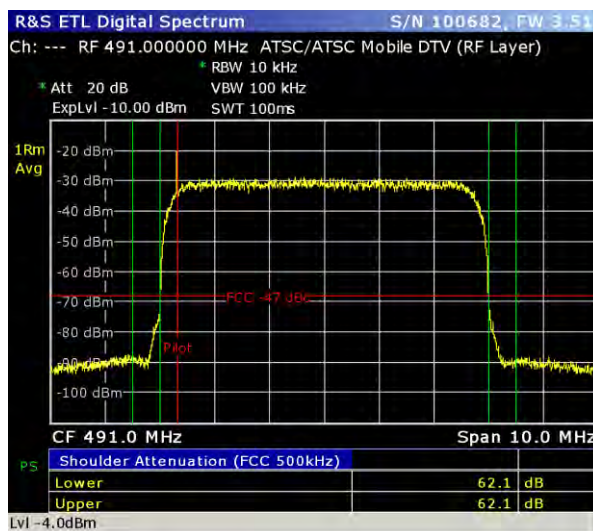
Measurements to be taken with Spectrum Analyzer set for 10 kHz resolution bandwidth, and 10 kHz or less video bandwidth, 10MHz span. Post-Filter. *NOTE, if Spectrum Analyzer does not have the preconfigured set up, those screen shots can be omitted.

Rohde & Schwarz ETL, SN: 100682



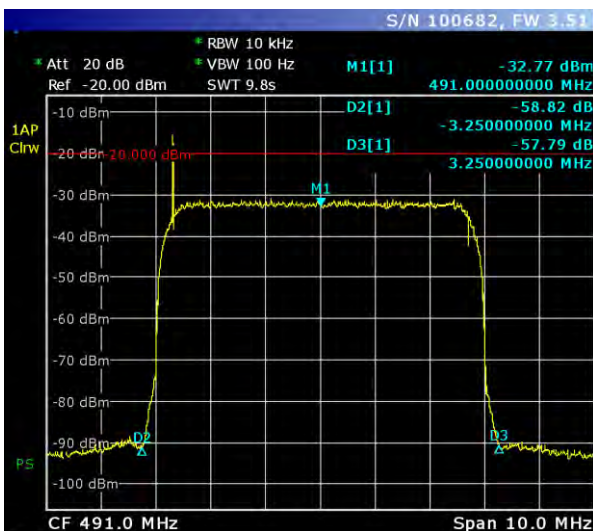
Date: 24.SEP.2020 14:19:35

Exciter A: Standard Spectral Screen



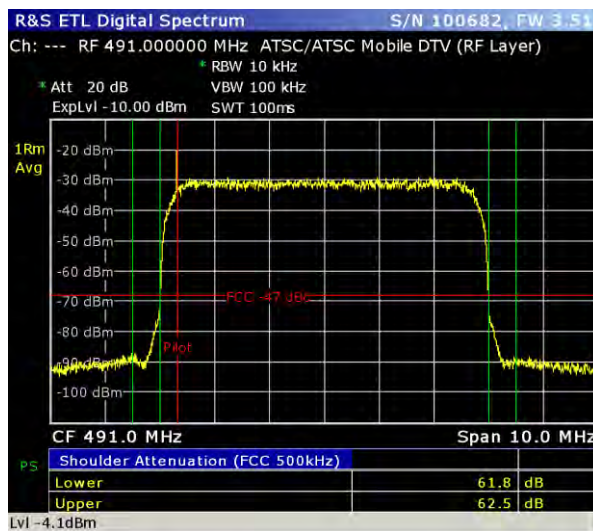
Date: 24.SEP.2020 14:21:00

Exciter A: ETL Pre-Configured Screen



Date: 24.SEP.2020 11:12:40

Exciter B: Standard Spectral Screen



Date: 24.SEP.2020 11:10:16

Exciter B: ETL Pre-Configured Screen



DIGITAL TRANSMITTER AMPLITUDE RESPONSE --EXCITER A

The following chart shows the addition of the Band Pass Filter and the Transmitter response, (Net Response). The Net Response is then compared to the FCC Mask. A negative number in the last column indicates exceeding the FCC specifications. References for these measurements are from the ATSC Standard Document A64.

*Screen capture below is a summary sheet (Net Response). Proof folder must include excel work sheet with all values for each filter sweep and pre-filter coupler measurements to validate compliance.

WRAL Exc A Summary Bandpass Data Calculated (2 mask filters)									
Frequency	Summary Filter Response			Transmitter Response before filter			Net Response	FCC Mask Response	Negative # Is out of FCC Specifications
	Analyzer Reading	Center Freq. Reference	Filter Response	Analyzer Reading	Center Freq. Reference	Transmitter Response			
482.00	-77.466	-0.184	-77.28	-42.190	0.000	-42.19	-119.47	-99.40	20.07
483.00	-86.227	-0.184	-86.04	-41.670	0.000	-41.67	-127.71	-88.60	39.11
484.00	-68.292	-0.184	-68.11	-41.145	0.000	-41.15	-109.25	-77.10	32.15
485.00	-54.282	-0.184	-54.10	-40.730	0.000	-40.73	-94.83	-65.60	29.23
486.00	-41.241	-0.184	-41.06	-40.175	0.000	-40.18	-81.23	-54.10	27.13
486.50	-34.476	-0.184	-34.29	-39.890	0.000	-39.89	-74.18	-48.40	25.78
487.00	-27.624	-0.184	-27.44	-39.545	0.000	-39.55	-66.98	-42.60	24.38
487.50	-24.544	-0.184	-24.36	-38.930	0.000	-38.93	-63.29	-36.40	26.89
487.75	-32.007	-0.184	-31.82	-38.760	0.000	-38.76	-70.58	-36.40	34.18
494.25	-25.839	-0.184	-25.66	-38.620	0.000	-38.62	-64.28	-36.40	27.88
494.50	-27.563	-0.184	-27.38	-39.175	0.000	-39.18	-66.55	-36.40	30.15
495.00	-29.674	-0.184	-29.49	-39.300	0.000	-39.30	-68.79	-42.60	26.19
495.50	-36.026	-0.184	-35.84	-39.490	0.000	-39.49	-75.33	-48.40	26.93
496.00	-42.541	-0.184	-42.36	-39.715	0.000	-39.72	-82.07	-54.10	27.97
497.00	-55.629	-0.184	-55.45	-40.230	0.000	-40.23	-95.68	-65.60	30.08
498.00	-71.095	-0.184	-70.91	-40.530	0.000	-40.53	-111.44	-77.10	34.34
499.00	-79.405	-0.184	-79.22	-41.040	0.000	-41.04	-120.26	-88.60	31.66
500.00	-75.594	-0.184	-75.41	-41.495	0.000	-41.50	-116.91	-99.40	17.51

ETL or Spectrum Mask Markers

Center Frequency =	491.00 MHz				
	<u>Markers</u>		<u>Lower</u>		<u>Upper</u>
Adj = ±	3.25	MHz	487.75	MHz	494.25 MHz
Alt01 = ±	3.50	MHz	487.50	MHz	494.50 MHz
Alt02 = ±	4.00	MHz	487.00	MHz	495.00 MHz
Alt03 = ±	4.50	MHz	486.50	MHz	495.50 MHz
Alt04 = ±	5.00	MHz	486.00	MHz	496.00 MHz
Alt05 = ±	6.00	MHz	485.00	MHz	497.00 MHz
Alt06 = ±	7.00	MHz	484.00	MHz	498.00 MHz
Alt07 = ±	8.00	MHz	483.00	MHz	499.00 MHz
Alt08 = ±	9.00	MHz	482.00	MHz	500.00 MHz

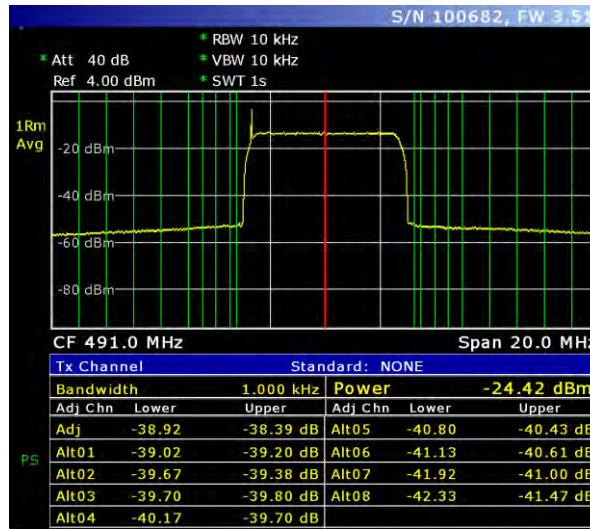
DIGITAL TRANSMITTER AMPLITUDE RESPONSE--EXCITER A

The test equipment was connected as shown in the Block Diagram. The response was measured **at the pre-filter coupler** on the transmitter output. The results are recorded below.

*Example below is multi/chart-screen, other screens or chart type data is acceptable as well.

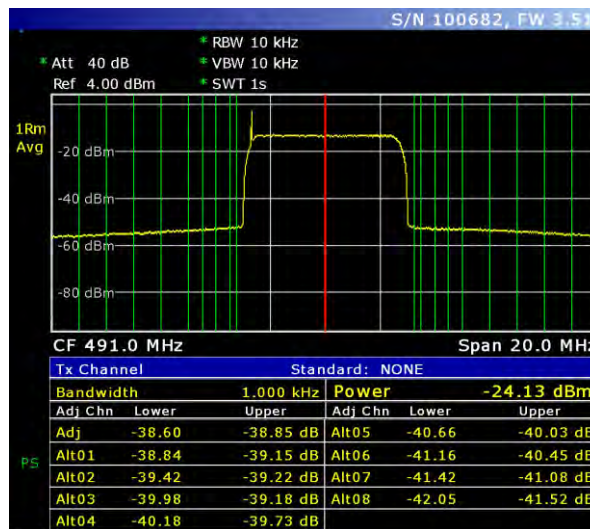
Measurements to be taken with Spectrum Analyzer set for 10 kHz resolution bandwidth, and 10 kHz or less video bandwidth. Span to be set to 20 MHz

Rohde & Schwarz ETL, SN: 100682



Date: 24.SEP.2020 12:04:21

TX A Exc A Pre-Filter



Date: 24.SEP.2020 12:01:24

TX B Exc A Pre-Filter

DIGITAL TRANSMITTER AMPLITUDE RESPONSE --EXCITER B

The following chart shows the addition of the Band Pass Filter and the Transmitter response, (Net Response). The Net Response is then compared to the FCC Mask. A negative number in the last column indicates exceeding the FCC specifications. References for these measurements are from the ATSC Standard Document A64.

WRAL Exc B Summary Bandpass Data Calculated (2 mask filters)									
Frequency	Summary Filter Response			Transmitter Response before filter			Net Response	FCC Mask Response	Negative # Is out of FCC Specifications
	Analyzer Reading	Center Freq. Reference	Filter Response	Analyzer Reading	Center Freq. Reference	Transmitter Response			
482.00	-77.466	-0.184	-77.28	-42.350	0.000	-42.35	-119.63	-99.40	20.23
483.00	-86.227	-0.184	-86.04	-41.815	0.000	-41.82	-127.86	-88.60	39.26
484.00	-68.292	-0.184	-68.11	-41.260	0.000	-41.26	-109.37	-77.10	32.27
485.00	-54.282	-0.184	-54.10	-40.675	0.000	-40.68	-94.77	-65.60	29.17
486.00	-41.241	-0.184	-41.06	-39.975	0.000	-39.98	-81.03	-54.10	26.93
486.50	-34.476	-0.184	-34.29	-39.750	0.000	-39.75	-74.04	-48.40	25.64
487.00	-27.624	-0.184	-27.44	-39.470	0.000	-39.47	-66.91	-42.60	24.31
487.50	-24.544	-0.184	-24.36	-39.030	0.000	-39.03	-63.39	-36.40	26.99
487.75	-32.007	-0.184	-31.82	-38.825	0.000	-38.83	-70.65	-36.40	34.25
494.25	-25.839	-0.184	-25.66	-38.945	0.000	-38.95	-64.60	-36.40	28.20
494.50	-27.563	-0.184	-27.38	-39.180	0.000	-39.18	-66.56	-36.40	30.16
495.00	-29.674	-0.184	-29.49	-39.520	0.000	-39.52	-69.01	-42.60	26.41
495.50	-36.026	-0.184	-35.84	-39.915	0.000	-39.92	-75.76	-48.40	27.36
496.00	-42.541	-0.184	-42.36	-39.600	0.000	-39.60	-81.96	-54.10	27.86
497.00	-55.629	-0.184	-55.45	-40.360	0.000	-40.36	-95.81	-65.60	30.21
498.00	-71.095	-0.184	-70.91	-40.685	0.000	-40.69	-111.60	-77.10	34.50
499.00	-79.405	-0.184	-79.22	-41.135	0.000	-41.14	-120.36	-88.60	31.76
500.00	-75.594	-0.184	-75.41	-41.600	0.000	-41.60	-117.01	-99.40	17.61

ETL or Spectrum Mask Markers

Center Frequency =	491.00	MHz				
	<u>Markers</u>		<u>Lower</u>		<u>Upper</u>	
Adj = ±	3.25	MHz	487.75	MHz	494.25	MHz
Alt01 = ±	3.50	MHz	487.50	MHz	494.50	MHz
Alt02 = ±	4.00	MHz	487.00	MHz	495.00	MHz
Alt03 = ±	4.50	MHz	486.50	MHz	495.50	MHz
Alt04 = ±	5.00	MHz	486.00	MHz	496.00	MHz
Alt05 = ±	6.00	MHz	485.00	MHz	497.00	MHz
Alt06 = ±	7.00	MHz	484.00	MHz	498.00	MHz
Alt07 = ±	8.00	MHz	483.00	MHz	499.00	MHz
Alt08 = ±	9.00	MHz	482.00	MHz	500.00	MHz

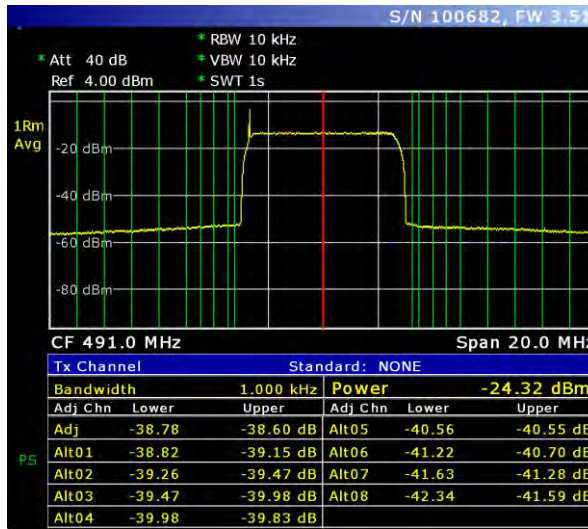
DIGITAL TRANSMITTER AMPLITUDE RESPONSE--EXCITER B

The test equipment was connected as shown in the Block Diagram. The response was measured **at the pre-filter coupler** on the transmitter output. The results are recorded below.

*Example below is multi/chart-screen, other screens or chart type data is acceptable as well.

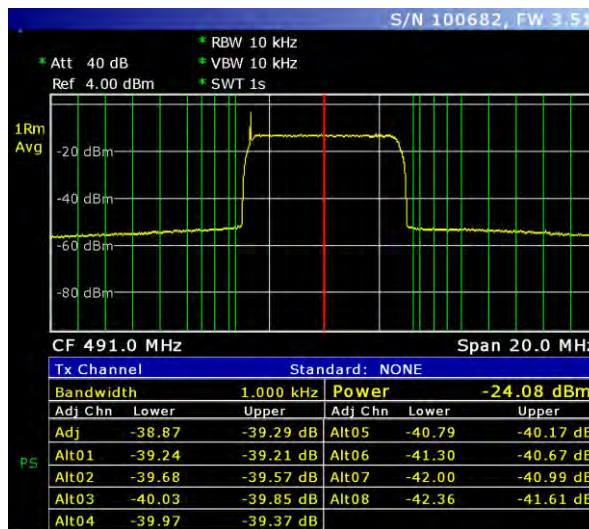
Measurements to be taken with Spectrum Analyzer set for 10 kHz resolution bandwidth, and 10 kHz or less video bandwidth. Span to be set to 20 MHz

Rohde & Schwarz ETL, SN: 100682



Date: 24.SEP.2020 11:36:23

TX A Exc B Filter



Date: 24.SEP.2020 11:40:06

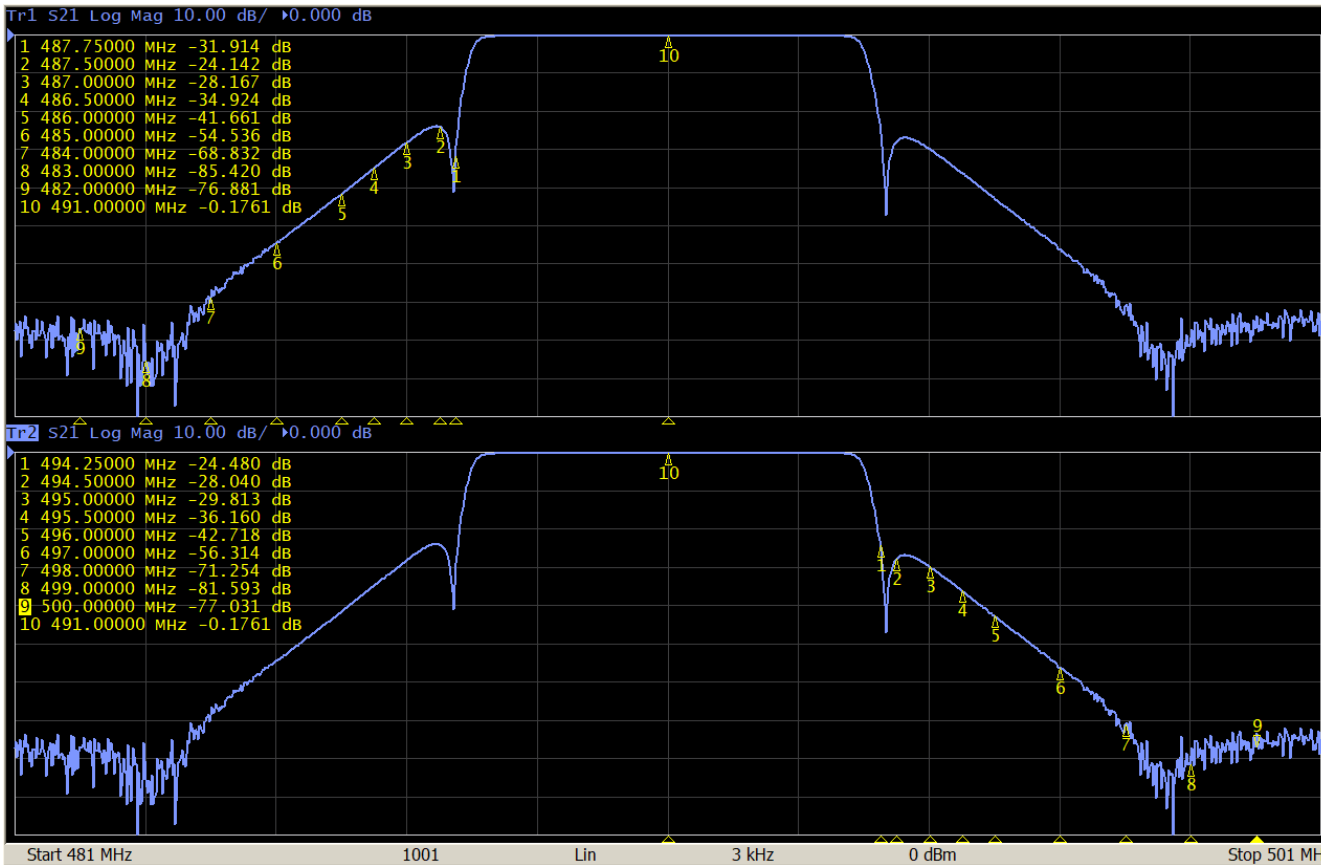
TX B Exc B Filter

DIGITAL TRANSMITTER AMPLITUDE RESPONSE -TX A BANDPASS FILTER

The response of the Band Pass Filter was measured using S21 parameters, the results are recorded below.

*Span to be a minimum of 18 MHz, no more than 30 MHz
 Points of measure to align with amplitude response chart.*

Copper Mountain: S5048 Network Analyzer, SN: 18097093

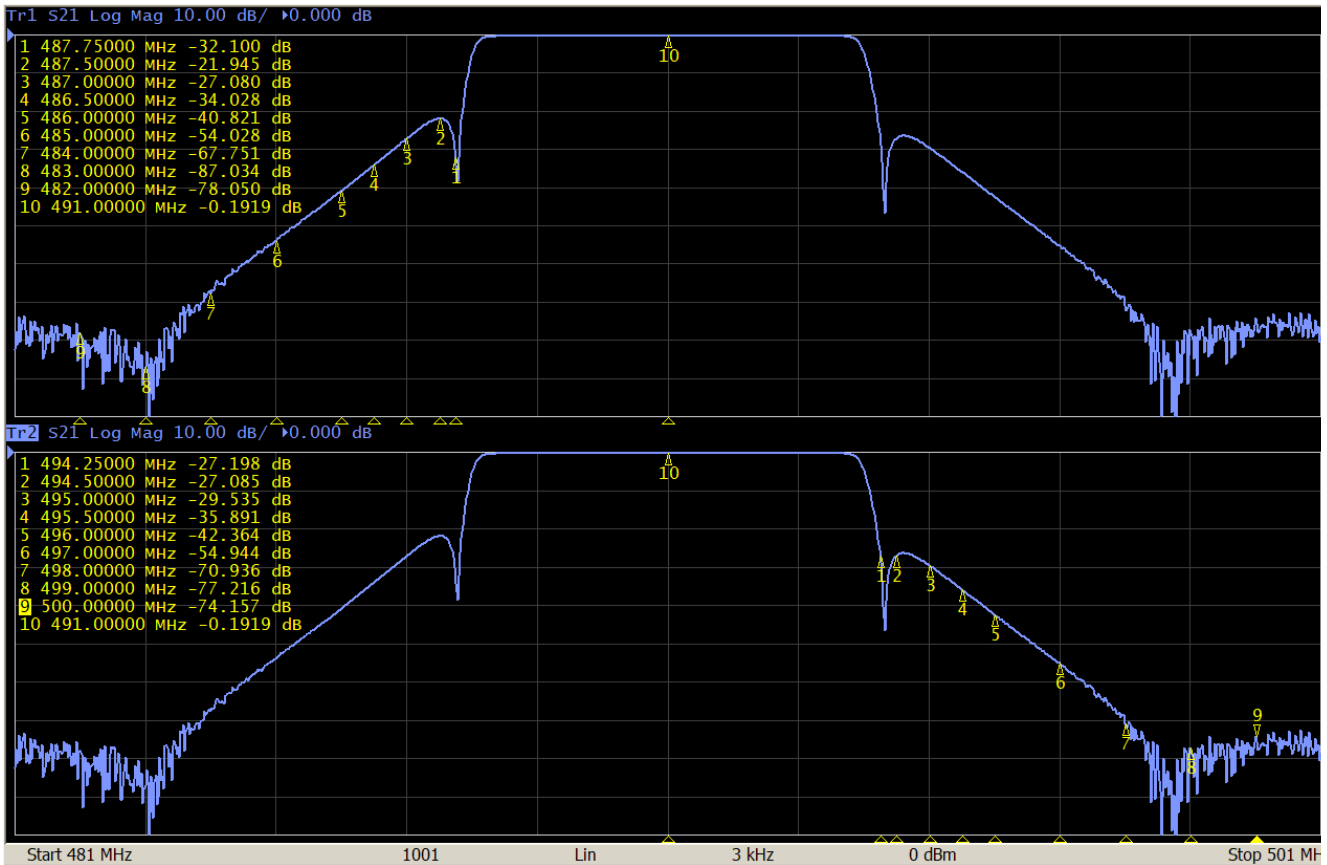


DIGITAL TRANSMITTER AMPLITUDE RESPONSE -TX B BANDPASS FILTER

The response of the Band Pass Filter was measured using S21 parameters, the results are recorded below.

*Span to be a minimum of 18 MHz, no more than 30 MHz
 Points of measure to align with amplitude response chart.*

Copper Mountain: S5048 Network Analyzer, SN: 18097093



TRANSMITTER MSC SCREENS

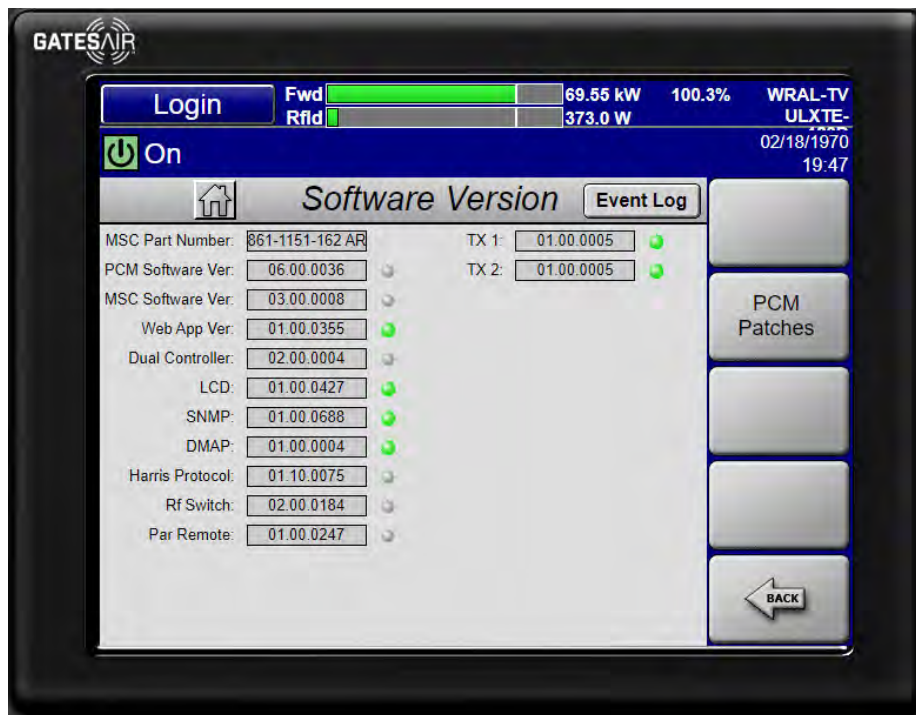
System Home Screen

The screenshot shows the 'DualTran Home' interface. At the top, it displays the user 'gates (Engineer)' with a 'Logout' button. Power status is shown as 'Fwd' at 69.75 kW (100.6%) and 'Rfid' at 377.0 W. The station is identified as 'WRAL-TV ULXTE-' with a date of '03/09/1970' and time '20:07'. The system is 'On'. Below this, there are buttons for 'Exc A Air', 'Exc B Air', 'Exc Auto', 'Exc Manual', 'Ant 1', and 'Ant 2'. The main area contains a schematic diagram of the transmitter system with components like 'EXCITER A', 'TX A', 'TX B', and 'AB Air'. A power meter shows '23 W' and another shows '0 W'. On the right side, there are buttons for 'Rf Switch Setup', 'Scheduler', 'Parallel Remote', and 'Service'. At the bottom, there are control buttons for 'On', 'Off', 'Auto', 'Manual', 'Ant', and 'Load'.

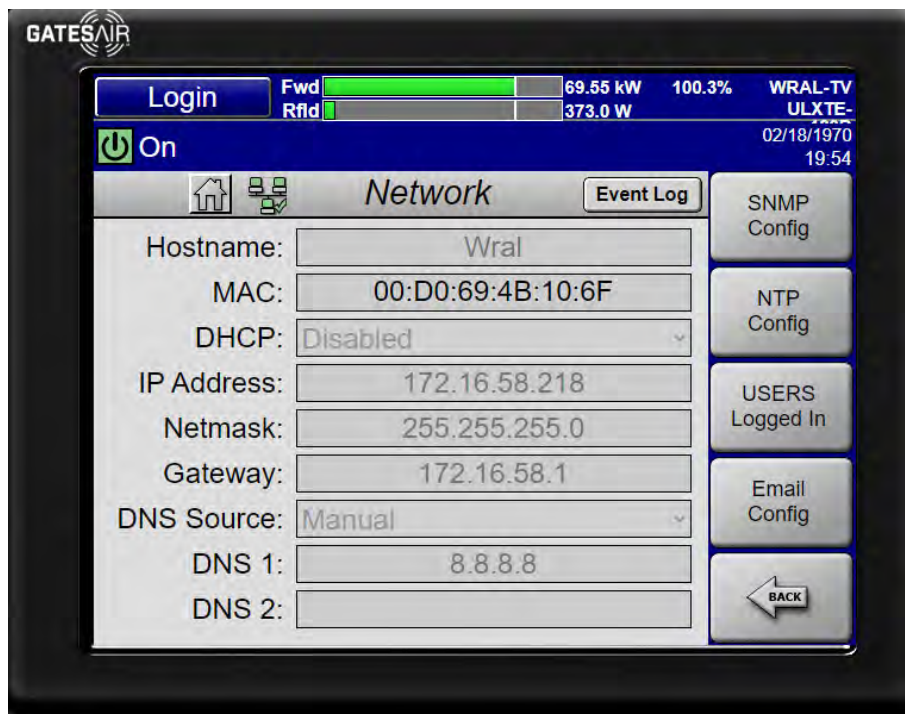
System Service

The screenshot shows the 'System Service' configuration screen. It features the same top header as the previous screen. The main area contains several input fields: 'Station Name' (WRAL-TV), 'Model Number' (ULXTE-120D), 'Serial Number' (TE10004069-018), 'Display Format' (MM/DD/YYYY), and 'Offset from UTC' (-05:00 hrs:min). A date and time section shows 'Date (MM/DD/YYYY): 10/13/2020' and 'Time (24 Hour): 14 49', with a note '(Disabled by NTP): Set Time'. On the right side, there are buttons for 'System Setup', 'Version', 'Network', 'Software Update', and a 'BACK' button.

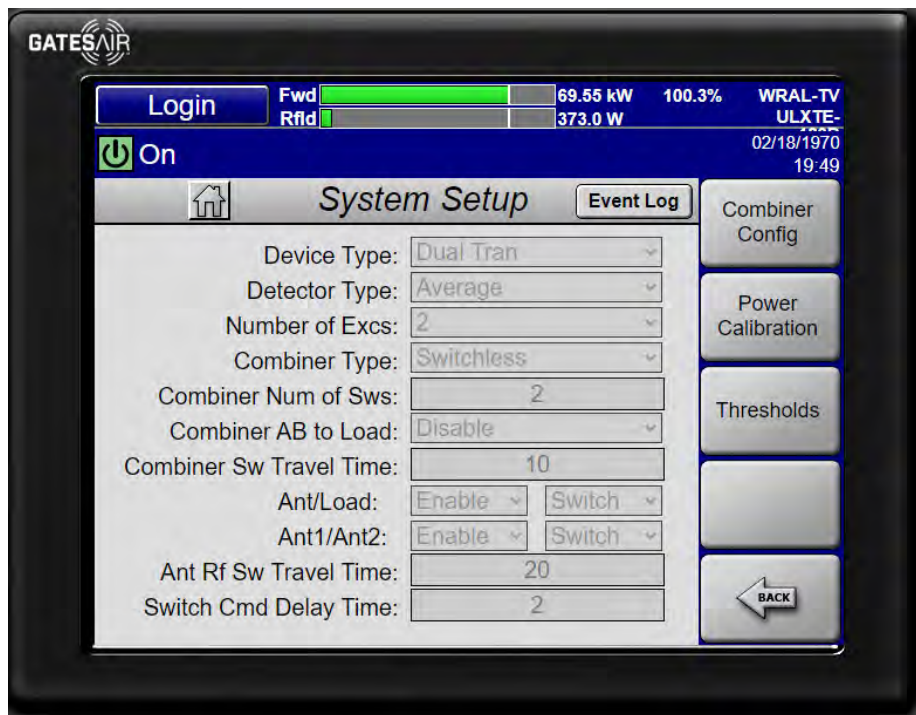
System Version



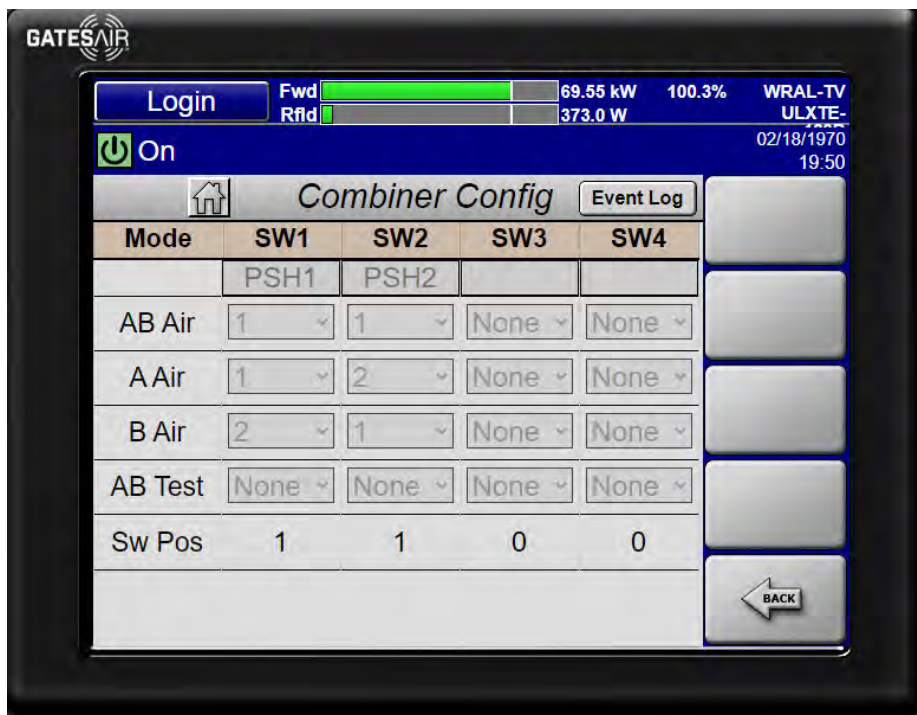
System Network



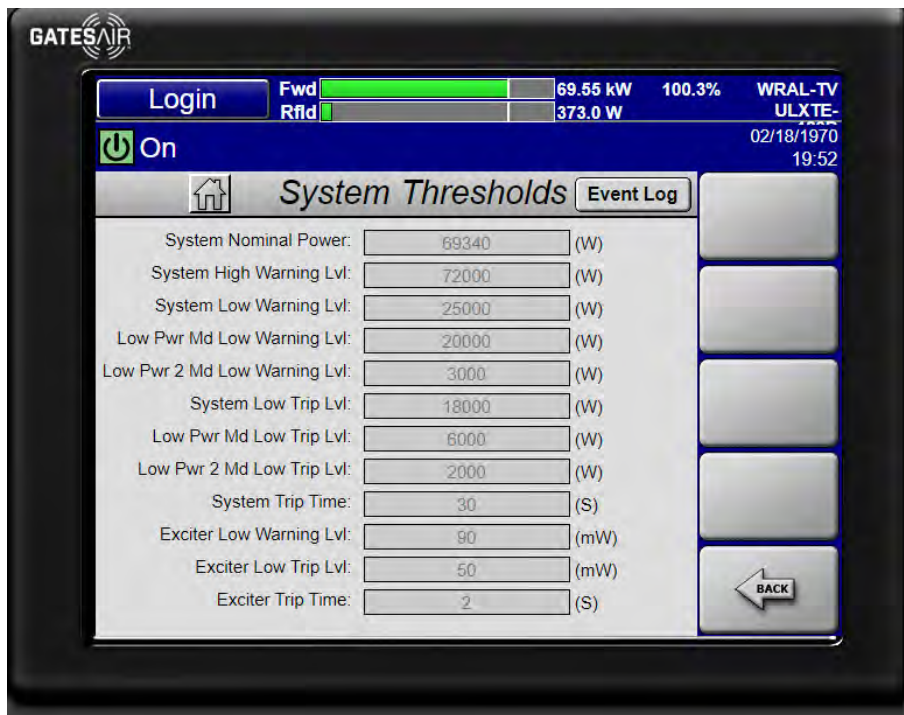
System Setup



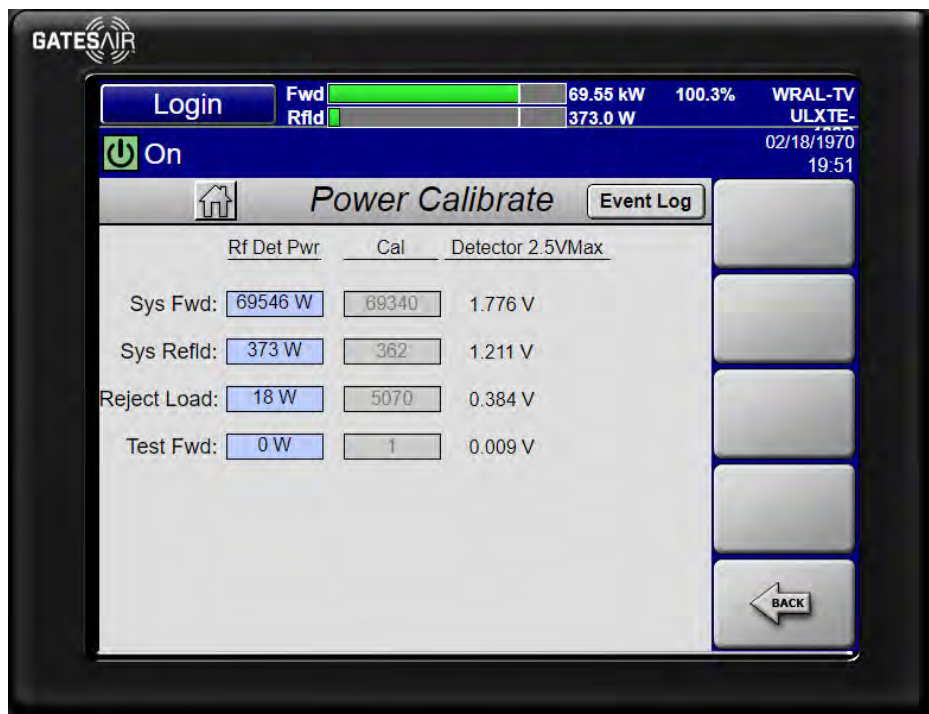
Combiner Config



System Thresholds



Power Calibration Screen



TRANSMITTER A STM SCREENS

System Home Screen

System Service

System Version

WRAL TX A **ULXTE-60 N/A** **Maxiva™**

Forward 35.3 kW 101%
Reflected 194 W

491.00 MHz 09/24/2020 16:08

Version Back

Release Version: A09
Software Part Number: 8611162042
Bootloader Software: 0035, Mar 29 2010, 14:51:06
Application Software: 1029, Feb 13 2020, 14:49:27
GUI Software: V1.0.9
STM CPLD Firmware: 0017
BOM PBC Software: 0280
BOM PAM Software: 0099
Monitor Board: C.0
Micro Module: D.0
LS Board Rev: E.0

Exciter Output
Drive Chain System
Power Amp Mute
Power Supply Remote Enabled

PA Voltage: 47.9V
System Current: 1721.2A
AC Mains OK:
Cable Interlock:
Safety Interlock:
Mute Interlock:
RF Hours: 9355

Power Block

System Network

WRAL TX A **ULXTE-60 N/A** **Maxiva™**

Forward 34.9 kW 100%
Reflected 194 W

491.00 MHz 09/24/2020 16:08

Network IP Addressing Back

Rear Front

Address Type: Static Static

Address: 192.168.67.11 192.168.117.88

Subnet Mask: 255.255.254.0 255.255.255.0

Gateway: 192.168.67.1

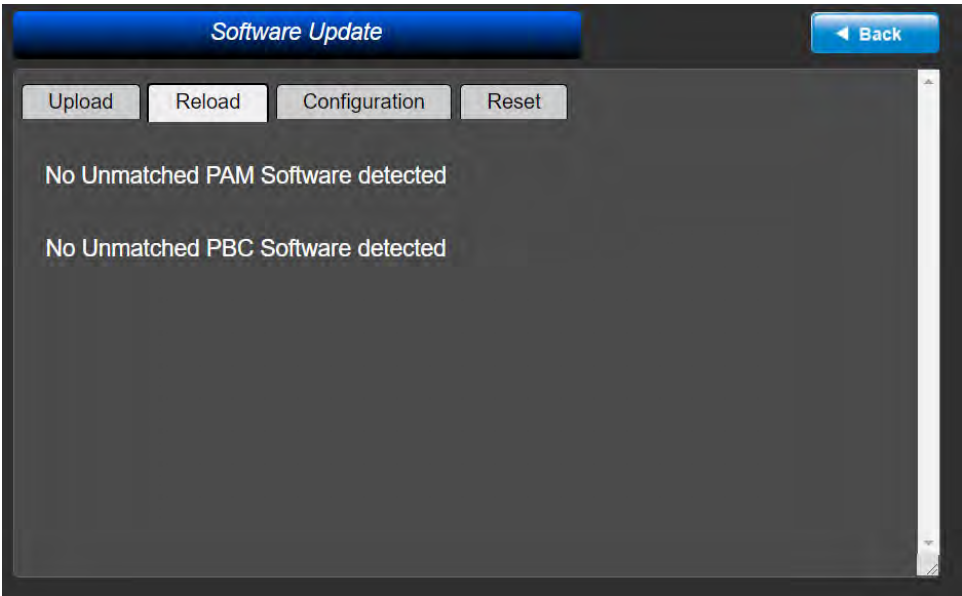
DNS Server: 172.23.4.10

HTTP Port: 80

ENET Interface Date/Time
SNMP

PA Voltage: 47.9V
System Current: 1720.8A
AC Mains OK:
Cable Interlock:
Safety Interlock:
Mute Interlock:
RF Hours: 9355

Software Management Reload Page



Tx A System Phase A



TX A System Phase B



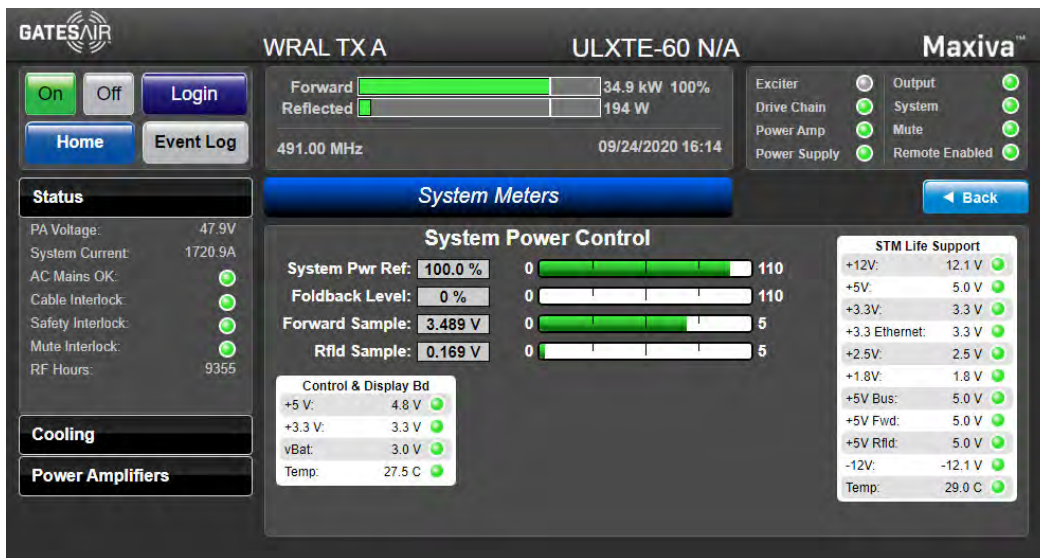
TX A System Gain A



TX A System Gain B



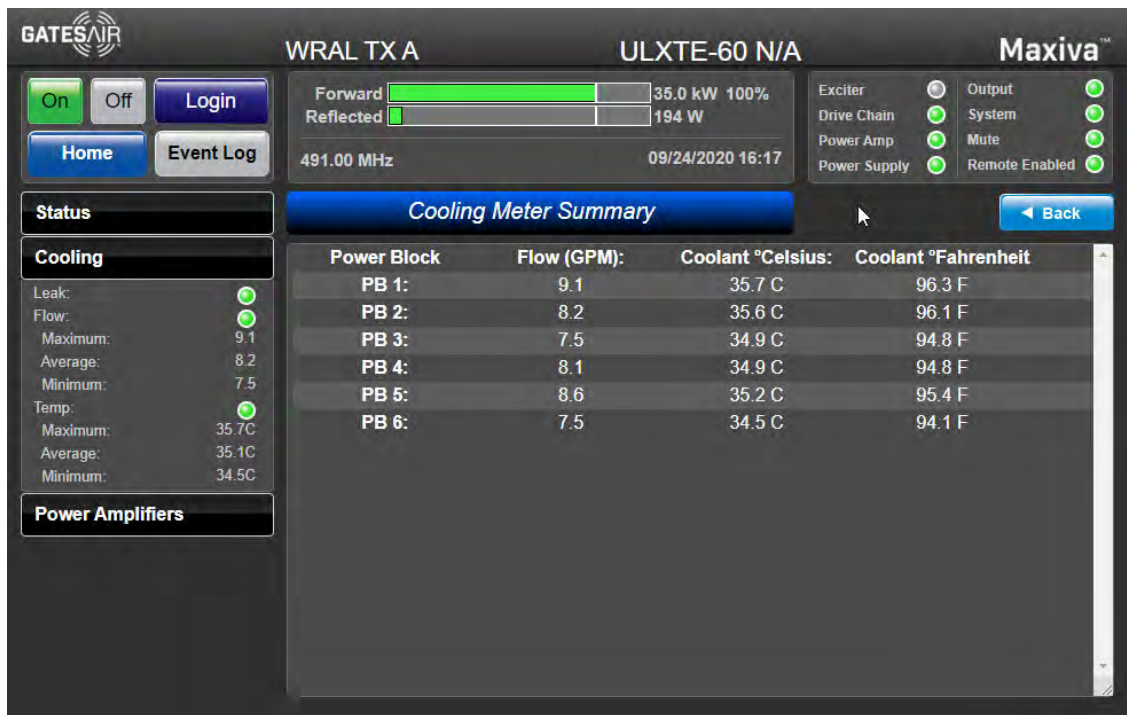
TX A System Meters



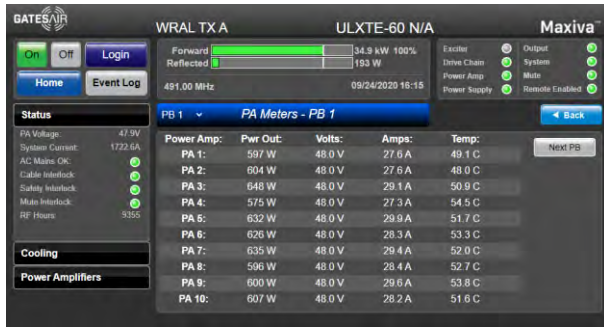
System Output Overview



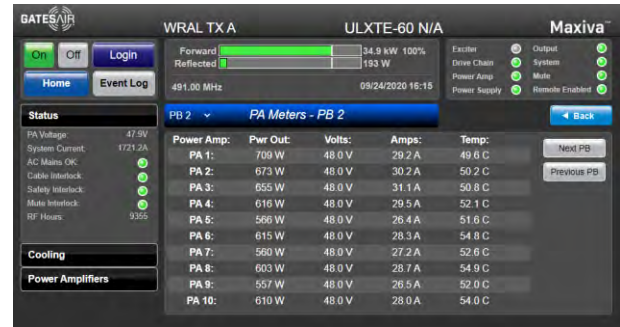
Cooling Meter Summary



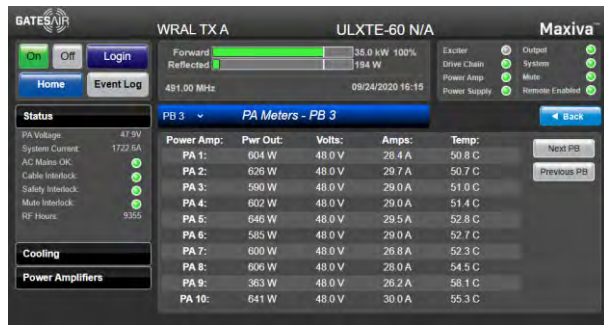
TX A Block PA Meters



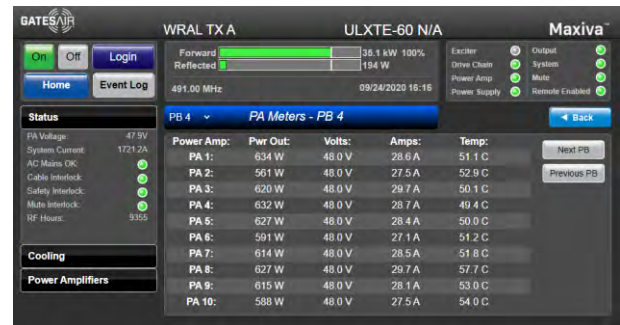
Power Block 1



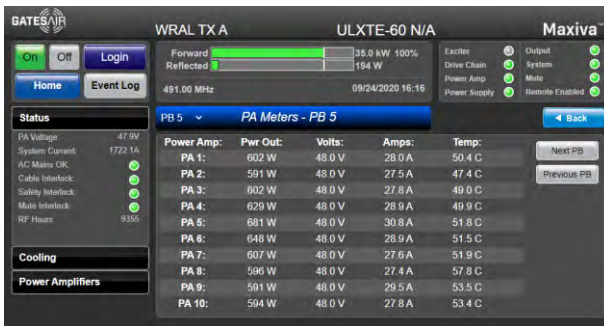
Power Block 2



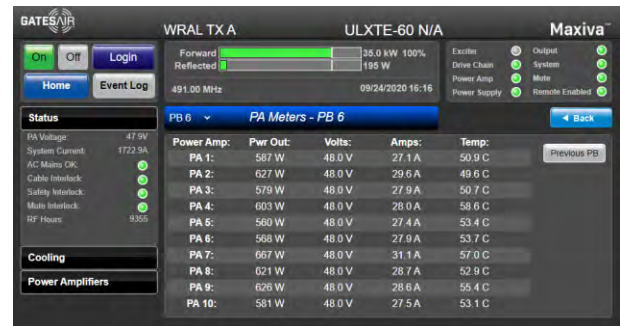
Power Block 3



Power Block 4

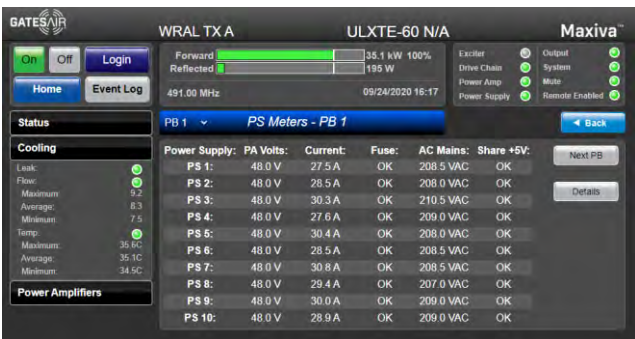


Power Block 5

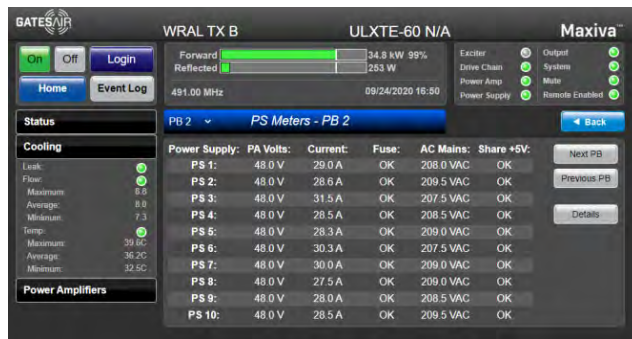


Power Block 6

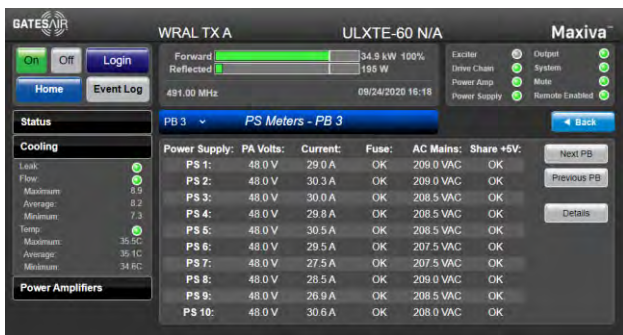
TX A Power Block PS Meters



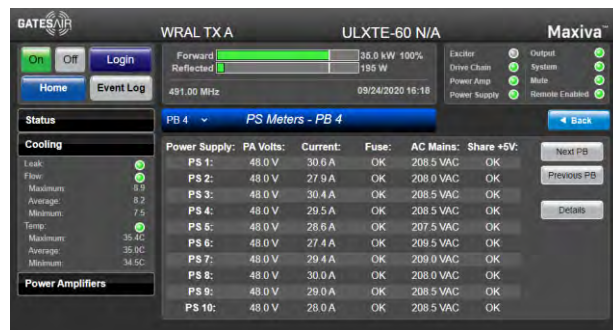
Power Block 1



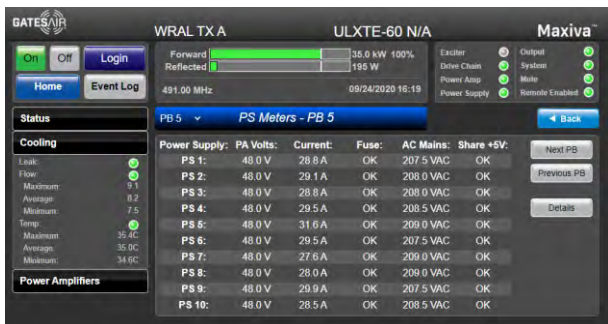
Power Block 2



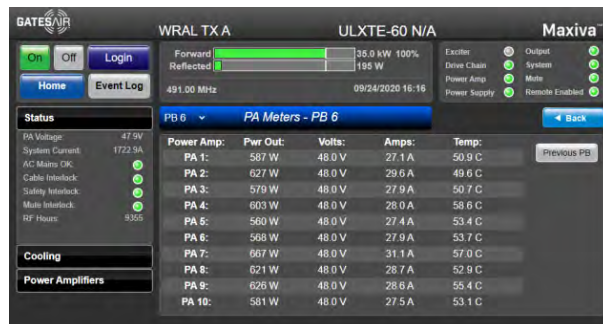
Power Block 3



Power Block 4



Power Block 5



Power Block 6

TX A Power Block P/G Meters A



Power Block 1



Power Block 2



Power Block 3



Power Block 4



Power Block 5



Power Block 6

TX A Power Block P/G Meters B



Power Block 1



Power Block 2



Power Block 3



Power Block 4



Power Block 5



Power Block 6

TRANSMITTER B STM SCREENS

TX B System Home Screen

WRAL TX B **ULXTE-60 N/A** **Maxiva™**

On Off Login
 Menu Event Log

Forward 100%
 Reflected
 491.00 MHz 09/24/2020 16:39

Home

Exciter A → P/G → Power Amps → Output

Power Supplies Cooling

PB 1 PB 2
 PB 3 PB 4
 PB 5 PB 6

Status
 PA Voltage: 47.9V
 System Current: 1717.3A
 AC Mains OK:
 Cable Interlock:
 Safety Interlock:
 Mute Interlock:
 RF Hours: 9366

Cooling
Power Amplifiers

Exciter Output
 Drive Chain System
 Power Amp Mute
 Power Supply Remote Enabled

TX B System Service

WRAL TX B **ULXTE-60 N/A** **Maxiva™**

On Off Login
 Home Event Log

Forward 99%
 Reflected
 491.00 MHz 09/24/2020 16:41

System Service Back

Station Name:
 Model Number:
 Serial Number:

Status
 PA Voltage: 47.9V
 System Current: 1717.2A
 AC Mains OK:
 Cable Interlock:
 Safety Interlock:
 Mute Interlock:
 RF Hours: 9366

Cooling
Power Amplifiers

Exciter Output
 Drive Chain System
 Power Amp Mute
 Power Supply Remote Enabled

TX B System Version

The screenshot shows the 'Version' page of the TX B System. The interface includes a top navigation bar with 'GATESAIR', 'WRAL TX B', 'ULXTE-60 N/A', and 'Maxiva™'. On the left, there are control buttons for 'On', 'Off', 'Login', 'Home', and 'Event Log'. The main area displays system status: Forward power at 34.9 kW (100%) and Reflected power at 259 W. Frequency is 491.00 MHz and the time is 09/24/2020 16:41. A 'Status' sidebar on the left shows PA Voltage (47.9V), System Current (1716.7A), and various interlocks (AC Mains OK, Cable Interlock, Safety Interlock, Mute Interlock) all with green status indicators. RF Hours are 9366. Below the status are sections for 'Cooling' and 'Power Amplifiers'. The central 'Version' section lists the following information:

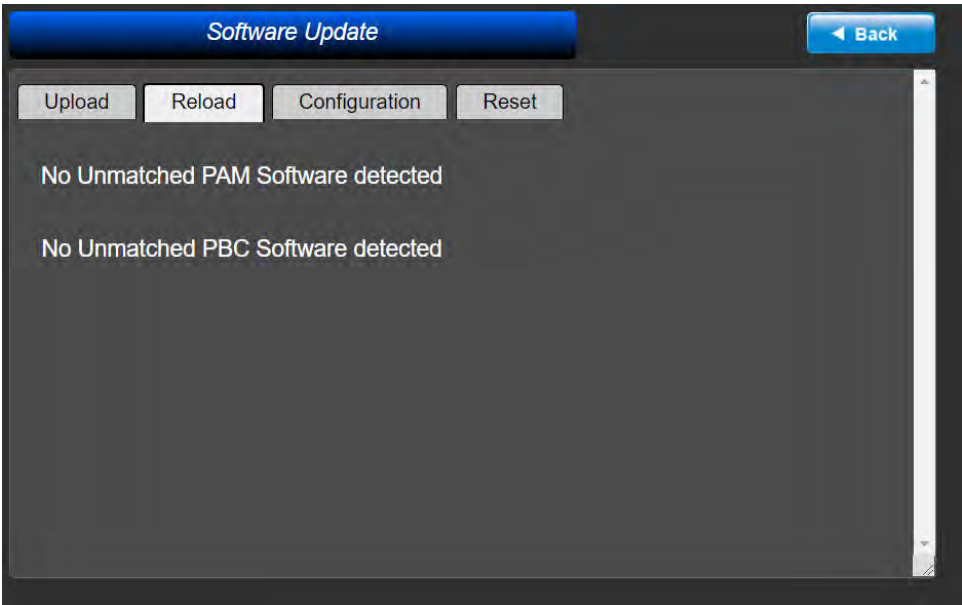
Release Version:	A09
Software Part Number:	8611162042
Bootloader Software:	0035, Mar 29 2010,14:51:06
Application Software:	1029, Feb 13 2020,14:49:27
GUI Software:	V1.0.9
STM CPLD Firmware:	0017
BOM PBC Software:	0280
BOM PAM Software:	0099
Monitor Board:	C.0
Micro Module:	D.0
LS Board Rev:	E.0

Buttons for 'Back' and 'Power Block' are also visible.

TX B System Network

The screenshot shows the 'Network IP Addressing' page of the TX B System. The interface is similar to the version page, with the same top navigation and left sidebar. The main area displays system status: Forward power at 35.0 kW (100%) and Reflected power at 260 W. Frequency is 491.00 MHz and the time is 09/24/2020 16:42. The central 'Network IP Addressing' section is divided into 'Rear' and 'Front' columns. The 'Address Type' is set to 'Static' for both. The 'Address' field shows 192.168.67.12 for Rear and 192.168.117.88 for Front. The 'Subnet Mask' is 255.255.254.0 for both. The 'Gateway' is 192.168.67.1. The 'DNS Server' is 172.23.4.10 and the 'HTTP Port' is 80. There are also buttons for 'ENET Interface', 'Date/Time', and 'SNMP'.

TX B Software Management Reload Page



TX B System Phase A



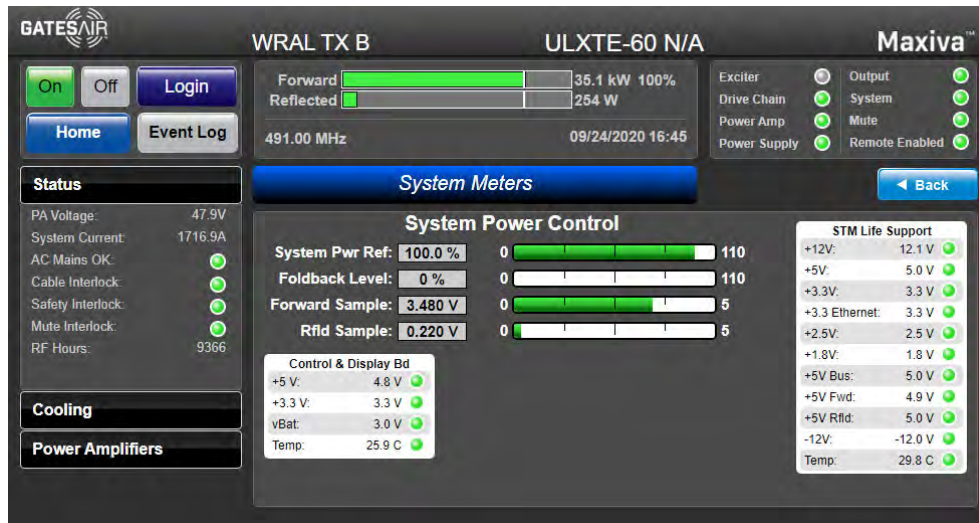
TX B System Phase B



TX B System Gain



TX B System Meters



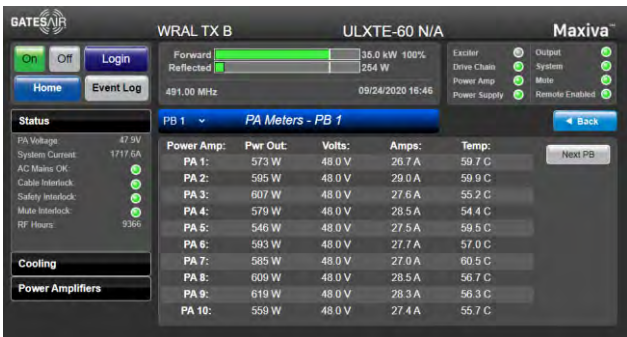
TX B System Output Overview



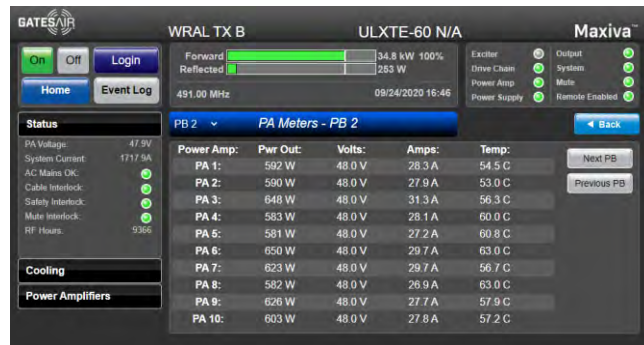
TX B Cooling Meter Summary



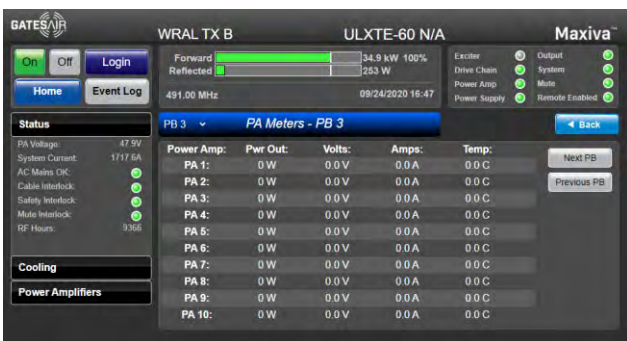
TX B Power Block PA Meters



Power Block 1



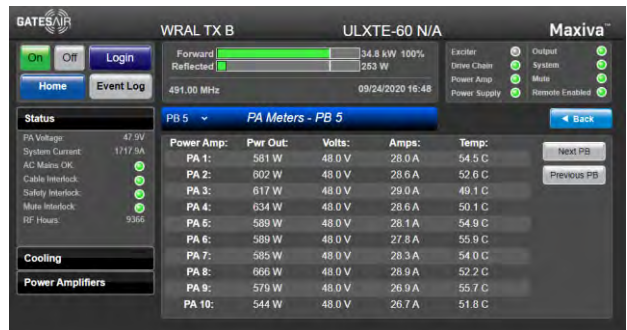
Power Block 2



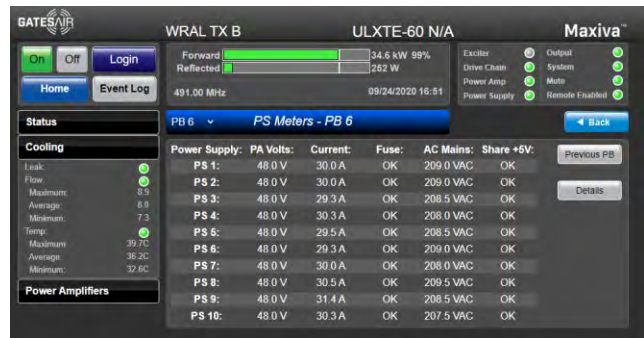
Power Block 3



Power Block 4

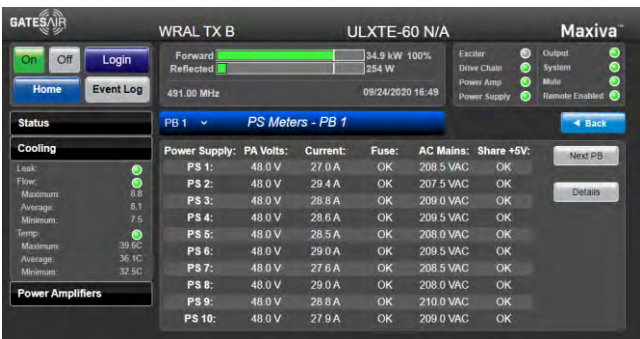


Power Block 5

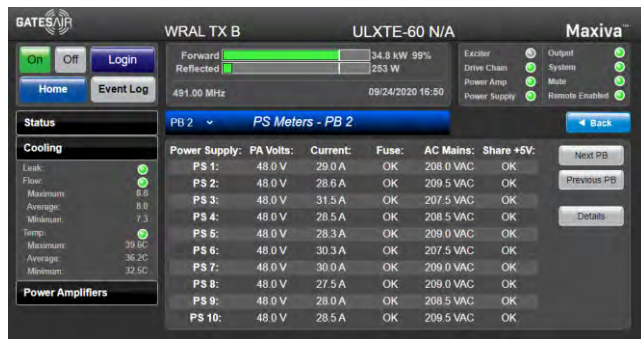


Power Block 6

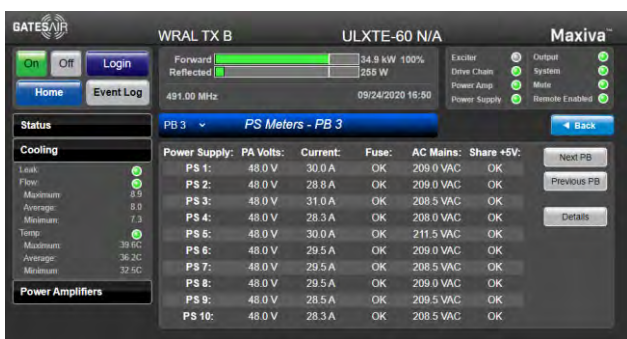
TX B Power Block PS Meters



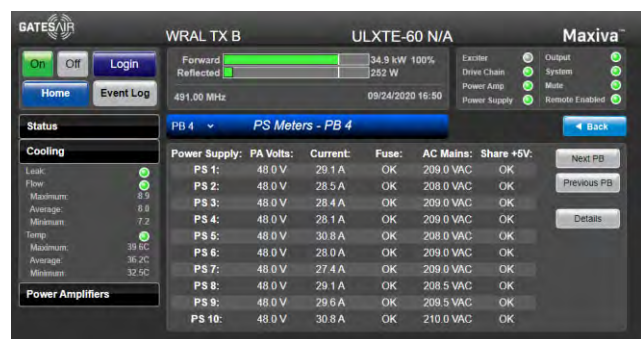
Power Block 1



Power Block 2



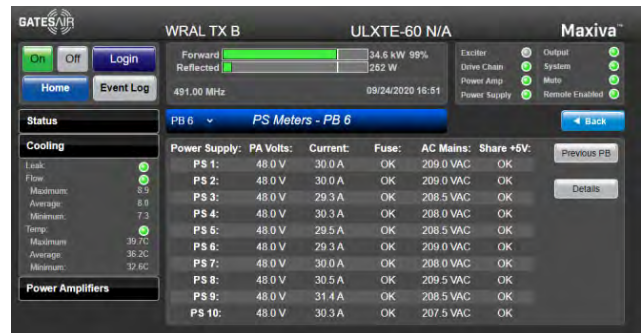
Power Block 3



Power Block 4



Power Block 5



Power Block 6

TX B Power Block P/G Meters A



Power Block 1



Power Block 2



Power Block 3



Power Block 4



Power Block 5



Power Block 6

TX B Power Block P/G Meters B



Power Block 1



Power Block 2



Power Block 3



Power Block 4

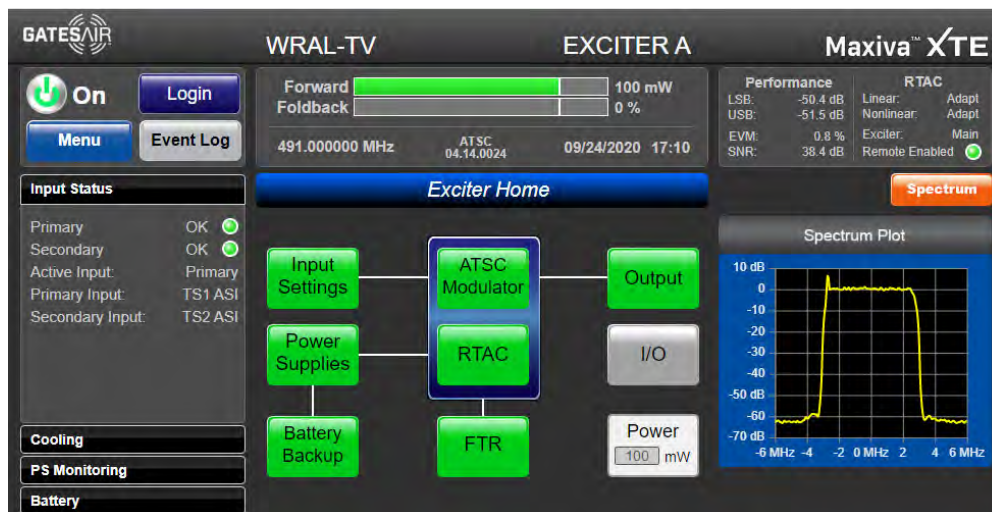


Power Block 5

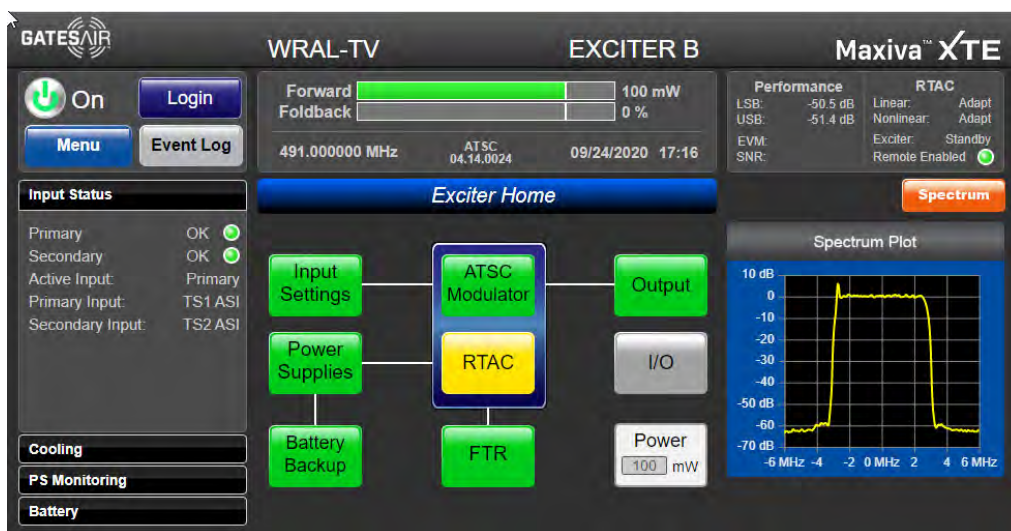


Power Block 6

Exciter Home Screen



Exciter A



Exciter B

Exciter Software Version

The screenshot shows the 'Software Version' screen for Exciter A. The interface includes a top navigation bar with 'GATESAIR', 'WRAL-TV', 'EXCITER A', and 'Maxiva XTE'. On the left, there are buttons for 'On', 'Login', 'Home', and 'Event Log', along with a menu for 'Input Status' (Primary, Secondary, Active Input, Primary Input, Secondary Input) and 'Cooling', 'PS Monitoring', and 'Battery'. The main area displays the following software version information:

Software P/N:	861-1161-032 N1
Software Rev:	04.14.0024
U-Boot Rev:	2014.01.0016
WebBoot Rev:	04.10.0002
Xtmod Setup Rev:	0102
Linux Rev:	4.1.15-01.01.2002
Dev Tree Rev:	02.01.0000 D1
FPGA1 Flash Rev:	0xb2
FPGA1 Rev:	0x0000B2 (ATSC)
CPLD Rev:	0x5
Power Supply SW:	E3 V01_15

Additional information shown includes: Forward power at 100 mW, Foldback at 0%, Frequency at 491.000000 MHz, ATSC version 04.14.0024, and Date/Time 10/21/2020 15:18. Performance metrics (LSB: -50.3 dB, USB: -51.7 dB, EVM: 0.9%, SNR: 38.8 dB) and RTAC status (Linear: Adapt, Nonlinear: Adapt, Exciter: Main, Remote Enabled) are also visible.

Exciter A

The screenshot shows the 'Software Version' screen for Exciter B. The interface is identical to Exciter A, but the title is 'EXCITER B'. The software version information is as follows:

Software P/N:	861-1161-032 N1
Software Rev:	04.14.0024
U-Boot Rev:	2014.01.0016
WebBoot Rev:	04.10.0002
Xtmod Setup Rev:	0102
Linux Rev:	4.1.15-01.01.2002
Dev Tree Rev:	02.01.0000 D1
FPGA1 Flash Rev:	0xb2
FPGA1 Rev:	0x0000B2 (ATSC)
CPLD Rev:	0x5
Power Supply SW:	E3 V01_15

Additional information shown includes: Forward power at 100 mW, Foldback at 0%, Frequency at 491.000000 MHz, ATSC version 04.14.0024, and Date/Time 10/21/2020 15:20. Performance metrics (LSB: -50.9 dB, USB: -51.0 dB, EVM: Standby, SNR: Remote Enabled) and RTAC status (Linear: Adapt, Nonlinear: Adapt, Exciter: Standby, Remote Enabled) are also visible.

Exciter B

Exciter Home RTAC Screen

The screenshot shows the RTAC interface for Exciter A. The top header includes 'WRAL-TV', 'EXCITER A', and 'Maxiva XTE'. On the left, there are navigation buttons for 'On', 'Login', 'Home', and 'Event Log', along with a status panel for 'Input Status', 'Cooling', 'PS Monitoring', and 'Battery'. The main area displays 'Forward' and 'Foldback' levels at 100 mW and 0% respectively. Frequency is 491.000000 MHz. Performance metrics include LSB: -51.2 dB, USB: -51.3 dB, EVM: 0.8%, and SNR: 38.4 dB. RTAC settings show Linear mode with 'Adapt' selected, and Nonlinear mode with 'Adapt' selected. Success/Attempt counts are 1774 / 1775 for Linear and 1701 / 1702 for Nonlinear. A 'Pre-filter' bar is visible. The 'RTAC Enabled' indicator is green.

Exciter A

The screenshot shows the RTAC interface for Exciter B. The top header includes 'WRAL-TV', 'EXCITER B', and 'Maxiva XTE'. The layout is similar to Exciter A. Performance metrics include LSB: -50.8 dB, USB: -51.9 dB, EVM: 0.8%, and SNR: 38.4 dB. RTAC settings show Linear mode with 'Adapt' selected, and Nonlinear mode with 'Standby' selected. Success/Attempt counts are 958599 / 958600 for Linear and 76170 / 76171 for Nonlinear. A 'Pre-filter' bar is visible. The 'RTAC Disabled' indicator is yellow.

Exciter B

Exciter RTAC Setup

The screenshot shows the RTAC Setup interface for Exciter A. The interface includes a top navigation bar with 'GATESAIR', 'WRAL-TV', 'EXCITER A', and 'Maxiva XTE'. On the left, there are status indicators for 'On', 'Home', 'Event Log', 'Input Status', 'Cooling', 'PS Monitoring', and 'Battery'. The main area displays 'Forward' and 'Foldback' levels, frequency (491.000000 MHz), and ATSC version (04.14.0024). Performance metrics (LSB, USB, EVM, SNR) and RTAC settings (Linear, Nonlinear, Exciter, Remote Enabled) are shown. The 'RTAC Setup' section includes 'Peak Reduction' (Manual), 'Non-Linear Range (dB)' (7.0), 'Max Crest Factor (dB)' (14.0), 'Mode Selected After AC Mains Loss' (Linear: Adapt, Non-Linear: Adapt), and 'Pre/Post Filter Low Level Warnings' (Pre Filter: Enable, Post Filter: Enable). A 'Peak Limit Enabled' toggle is also present. 'Save Log' and 'Download Log' buttons are at the bottom right.

Exciter A

The screenshot shows the RTAC Setup interface for Exciter B. The interface is similar to Exciter A but with 'EXCITER B' in the title. The 'RTAC' settings show 'Exciter: Standby' and 'Remote Enabled'. The 'Max Crest Factor (dB)' is set to 12.0. The 'Pre/Post Filter Low Level Warnings' section shows 'Pre Filter: Enable' and 'Post Filter: Enable'. The 'Save Log' and 'Download Log' buttons are at the bottom right.

Exciter B

Exciter RTAC Calibration

The screenshot shows the Maxiva XTE control interface for Exciter A. At the top, it displays 'WRAL-TV' and 'EXCITER A'. The interface includes a 'Calibration' menu, 'Down Converter Tilt Compensation' settings (Enabled: No, Tilt Factor: 0, Profile: Normal), and various performance metrics like Forward, Foldback, and RTAC status.

Exciter A

The screenshot shows the Maxiva XTE control interface for Exciter B. At the top, it displays 'WRAL-TV' and 'EXCITER B'. The interface includes a 'Calibration' menu, 'Down Converter Tilt Compensation' settings (Enabled: No, Tilt Factor: 0, Profile: Normal), and various performance metrics like Forward, Foldback, and RTAC status.

Exciter B

Exciter Network Routes

The screenshot shows the 'Exciter A' interface for WRAL-TV. The main title is 'Exciter A' and the Maxiva XTE logo is present. The interface includes a status bar with 'On' and 'Login' buttons, and a 'Home' button. The 'Input Status' section shows Primary and Secondary inputs as OK. The 'Network Route Table' is the central focus, displaying a table with columns: Destination Address, Netmask, Gateway, Interface, and Type. The table contains four rows of route information. Performance metrics and RTAC status are shown in the top right. A 'Result:' field is at the bottom.

Destination Address	Netmask	Gateway	Interface	Type
10.10.1.0	255.255.255.0	0.0.0.0	tsaip1	System
10.10.2.0	255.255.255.0	0.0.0.0	tsaip2	System
192.168.67.0	255.255.255.0	0.0.0.0	lan	System
192.168.117.0	255.255.255.0	0.0.0.0	service	System

Exciter A

The screenshot shows the 'Exciter B' interface for WRAL-TV. The main title is 'Exciter B' and the Maxiva XTE logo is present. The interface is identical in layout to Exciter A, showing the 'Network Route Table' with the same four rows of route information. Performance metrics and RTAC status are also shown.

Destination Address	Netmask	Gateway	Interface	Type
10.10.1.0	255.255.255.0	0.0.0.0	tsaip1	System
10.10.2.0	255.255.255.0	0.0.0.0	tsaip2	System
192.168.67.0	255.255.255.0	0.0.0.0	lan	System
192.168.117.0	255.255.255.0	0.0.0.0	service	System

Exciter B

Exciter Modulator ATSC Setup

The screenshot shows the ATSC setup interface for Exciter A. The top bar includes 'WRAL-TV', 'EXCITER A', and 'Maxiva™ XTE'. On the left, there are control buttons: 'On' (power icon), 'Login', 'Home', and 'Event Log'. Below these are 'Input Status', 'Cooling', 'PS Monitoring', and 'Battery' sections. The main area displays 'ATSC' settings: Forward/Foldback (100 mW / 0%), Frequency (491.000000 MHz), ATSC version (04.14.0024), and Date/Time (09/24/2020 17:15). A table shows Primary and Secondary input status (both OK), Bitrate (19.393 Mbps), and On Air Status (On Air / Stand By). Below this are dropdown menus for Network Operation (MFN), A/110 Version (A/110:2011), FRSC (Disable), and PCR Restamping (Enable). On the right, 'Performance' metrics (LSB, USB, EVM, SNR) and 'RTAC' settings (Linear, Nonlinear, Exciter) are shown. 'Transmitter Signaling' fields (Tier ID, TX ID, Network ID) are all set to 0. 'Test Mode' is set to 'Off'.

Exciter A

The screenshot shows the ATSC setup interface for Exciter B. The top bar includes 'WRAL-TV', 'EXCITER B', and 'Maxiva™ XTE'. The layout is identical to Exciter A. The main area displays 'ATSC' settings: Forward/Foldback (100 mW / 0%), Frequency (491.000000 MHz), ATSC version (04.14.0024), and Date/Time (09/24/2020 17:18). The table shows Primary and Secondary input status (both OK), Bitrate (19.393 Mbps), and On Air Status (On Air / Stand By). Below this are dropdown menus for Network Operation (MFN), A/110 Version (A/110:2011), FRSC (Disable), and PCR Restamping (Enable). On the right, 'Performance' metrics (LSB, USB, EVM, SNR) and 'RTAC' settings (Linear, Nonlinear, Exciter) are shown. 'Transmitter Signaling' fields (Tier ID, TX ID, Network ID) are all set to 0. 'Test Mode' is set to 'Off'.

Exciter B

Exciter Input Settings

Exciter A interface showing the following details:

- System Info:** WRAL-TV, EXCITER A, Maxiva™ XTE
- Power:** Forward 100 mW, Foldback 0%
- Performance:** LSB: -50.3 dB, USB: -51.6 dB, EVM: 0.8%, SNR: 38.4 dB
- RTAC:** Linear: Adapt, Nonlinear: Adapt, Exciter: Main, Remote Enabled:
- Frequency:** 491.000000 MHz, ATSC 04.14.0024, 09/24/2020 17:16
- Input Settings:**
 - Primary Input Status: OK
 - Secondary Input Status: OK
 - Bitrate (Mbps): Primary 19.393, Secondary 19.393
 - Power On Input: Current
 - Active Input: Primary
 - Primary Input: TS1 ASI
 - Secondary Input: TS2 ASI
 - TS Monitor Output: Follow Input
 - Mute on Loss of TS: No
- Switch Settings:**
 - Mode: Auto-Return
 - Timeout (s): 5
 - Elapsed Time (s): 0
 - Max Count: 0
 - Count: 2
 - SSW State: Off
 - SSW Buffer Depth (s): 0.000
 - SSW Actual Delay (s): 0.000
- Input Status Summary:**
 - Primary: OK
 - Secondary: OK
 - Active Input: Primary
 - Primary Input: TS1 ASI
 - Secondary Input: TS2 ASI
- Monitoring:** Cooling, PS Monitoring, Battery

Exciter A

Exciter B interface showing the following details:

- System Info:** WRAL-TV, EXCITER B, Maxiva™ XTE
- Power:** Forward 100 mW, Foldback 0%
- Performance:** LSB: -51.1 dB, USB: -51.5 dB, EVM: -51.5 dB
- RTAC:** Linear: Adapt, Nonlinear: Adapt, Exciter: Standby, Remote Enabled:
- Frequency:** 491.000000 MHz, ATSC 04.14.0024, 09/24/2020 17:19
- Input Settings:**
 - Primary Input Status: OK
 - Secondary Input Status: OK
 - Bitrate (Mbps): Primary 19.393, Secondary 19.393
 - Power On Input: Current
 - Active Input: Primary
 - Primary Input: TS1 ASI
 - Secondary Input: TS2 ASI
 - TS Monitor Output: Follow Input
 - Mute on Loss of TS: No
- Switch Settings:**
 - Mode: Auto-Return
 - Timeout (s): 5
 - Elapsed Time (s): 0
 - Max Count: 0
 - Count: 2
 - SSW State: Off
 - SSW Buffer Depth (s): 0.000
 - SSW Actual Delay (s): 0.000
- Input Status Summary:**
 - Primary: OK
 - Secondary: OK
 - Active Input: Primary
 - Primary Input: TS1 ASI
 - Secondary Input: TS2 ASI
- Monitoring:** Cooling, PS Monitoring, Battery

Exciter B

Exciter Output Config

The screenshot shows the configuration interface for Exciter A. At the top, it displays 'WRAL-TV', 'EXCITER A', and 'Maxiva™ XTE'. The interface includes a navigation menu on the left with 'On', 'Login', 'Home', and 'Event Log' buttons. The main area is divided into several sections: 'Forward' and 'Foldback' power levels (100 mW and 0% respectively), 'Performance' metrics (LSB: -50.7 dB, USB: -51.9 dB, EVM: 0.8%, SNR: 38.4 dB), and 'RTAC' settings (Linear: Adapt, Nonlinear: Adapt, Exciter: Main, Remote Enabled). The 'Output' section is highlighted, showing 'Exciter Power Limit (mW): 110', 'RF Cutoff (mW): 5', 'RF Mute: Off', and 'Foldback' settings (Low: 250 mV, High: 5000 mV, Max: 100%). The 'PA DAC Attenuator' is also visible. On the right, 'Levels' are set to 'Input: 1.30 dBm' and 'Output: 100 mW'. The bottom left shows 'Cooling', 'PS Monitoring', and 'Battery' status.

Exciter A

The screenshot shows the configuration interface for Exciter B. It follows the same layout as Exciter A, displaying 'WRAL-TV', 'EXCITER B', and 'Maxiva™ XTE'. The 'Performance' metrics are slightly different (LSB: -50.6 dB, USB: -51.1 dB). The 'RTAC' settings are 'Linear: Adapt, Nonlinear: Adapt, Exciter: Standby, Remote Enabled'. The 'Output' section shows 'Exciter Power Limit (mW): 110', 'RF Cutoff (mW): 5', 'RF Mute: Off', and 'Foldback' settings (Low: 250 mV, High: 5000 mV, Max: 100%). The 'PA DAC Attenuator' is also visible. On the right, 'Levels' are set to 'Input: 1.20 dBm' and 'Output: 100 mW'. The bottom left shows 'Cooling', 'PS Monitoring', and 'Battery' status.

Exciter B

Exciter FTR Reference Config

The screenshot displays the control interface for Exciter A. At the top, it identifies the station as WRAL-TV and the device as EXCITER A. The main display area is titled "Frequency & Timing Reference" and shows a "Holdover" section with a "Readiness" bar and "Time Remaining" indicator. Below this, there are three status boxes: "System Reference" (with "Reference Input" and "Int. GPS 1PPS" set to off), "PLL Status" (with "RF LO1 Lock", "RF LO2 Lock", and "Digital LO Lock" all set to on), and "PLL Ref Clock" (with "100MHz" set to on). The "Performance" section on the right shows metrics for LSB, USB, EVM, and SNR. The "RTAC" section shows "Linear" and "Nonlinear" modes set to "Adapt" and "Exciter" set to "Main".

Exciter A

The screenshot displays the control interface for Exciter B. It follows the same layout as Exciter A, showing the "Frequency & Timing Reference" settings. The "Holdover" section shows "Readiness" and "Time Remaining". The "System Reference" section has "Reference Input" and "Int. GPS 1PPS" set to off. The "PLL Status" section has "RF LO1 Lock", "RF LO2 Lock", and "Digital LO Lock" all set to on. The "PLL Ref Clock" section has "100MHz" set to on. The "Performance" and "RTAC" sections show similar metrics and settings as Exciter A.

Exciter B

Exciter FTR GNSS

Exciter A

Exciter B

Exciter FTR OCXO

FTR OCXO		Back	Spectrum
System Reference:	Manual		
OCXO Tuning(%):	50		
Reference Loss Mute:	No Mute On Loss		
Time Out (hours):	8		
Ext Reference Input:	Ext. 1PPS		
Ext Ref Input Termination:	50 Ohm		
Reference Output:	10MHz		

Exciter A

FTR OCXO		Back	Spectrum
System Reference:	Manual		
OCXO Tuning(%):	50		
Reference Loss Mute:	No Mute On Loss		
Time Out (hours):	8		
Ext Reference Input:	Ext. 1PPS		
Ext Ref Input Termination:	50 Ohm		
Reference Output:	10MHz		

Exciter B

GatesAir Moding Propagation Annex



GatesAir Moding Propagation Annex
GA-REG-17-012

ANNEX:
Harmonics and Spurious Emissions Measurement Anomalies

Higher order spurious emissions and harmonics measurements are distorted by the propagation of higher order waveguide modes within the couplers and diameter size of low pass filters used within the system. These modes result in anomalous responses and impedance mismatches which cannot be accurately accounted for by a calculated offset from the coupler and the low pass filter characterizations. Because of the moding anomalies, the amplitude accuracy versus frequency response has specific upper bound frequency measurement relative to transmission line sizes. Typical behavior for common transmission line sizes are as such:

Line Size	Calculated Cut-off, MHz	Useful Cut-Off, MHz	Outer I.D. (in)	Inner O.D. (in)
7/8" 50Ω	6658.749	6000	0.785	0.341
1 5/8" 50Ω	3422.068	3000	1.527	0.664
3 1/8" 50Ω	1726.797	1600	3.027	1.315
4 1/16" 50Ω	1327.976	1262	3.935	1.711
6 1/8" 50Ω	873.762	806	5.981	2.600
6 1/8" 75Ω	974.747	830	5.981	1.711
7 3/16" 75Ω	833.083	752	7.000	2.000
8 3/16 75Ω	728.644	704	8.000	2.290
9 3/16" 50Ω	580.771	552	9.000	3.910
9 3/16 75Ω	647.474	615	9.000	2.5

The TEM cutoff frequency happens at the frequency in which the circumference at midpoint inside the dielectric equals a wavelength.

The above statement in equation form:

$$\lambda_c = \pi \left(\frac{D + d}{2} \right)$$

Then:

$$f_c = \frac{c}{\lambda_c} = \frac{c}{\pi \left(\frac{D + d}{2} \right)}$$

Simplifying the equation, it can be approximated to:

$$f_c = \frac{7500}{(D + d)}$$

Where:

- f_c is the cutoff frequency in MHz
- D is the diameter of the outer conductor, in inches
- d is the diameter of the inner conductor, in inches

Referencing EIA RS225, the standard defines Upper-Frequency limit as: "The UPPER-FREQUENCY LIMIT is determined by the cut-off frequency of higher order "waveguide" modes of propagation, and the effect, which they have on the impedance and transmission characteristics of the normal TEM coaxial transmission line mode. The lowest cut-off frequency occurs with the TE₁₁ mode, and this cut-off frequency in air dielectric line is the upper-



frequency limit of a practical transmission line. How closely the TE₁₁ mode cut-off frequency can be approached depends on the application.”

Above the cutoff frequency, the TE₁₁ higher order mode is allowed to propagate and has a different propagation velocity than the base TEM mode, which, in turn, interferes with it. When below the cutoff frequency, the TE₁₁ rapidly disappears along the transmission line. When propagating beyond the cutoff frequency, the effect is unpredictable, based on a complex set of factors, most notably, line length, variable impedance and positioning of the directional coupler feeds relative to the phase of the line.

GatesAir has analyzed this ongoing phenomenon and has characterized/verified our power amplifier/transmitter output independent of these factors. Under controlled lab conditions, we have characterized the raw harmonic energy out of the transmitter and have quantified that the RF energy produced does not exceed -110dBc from 1.907GHz and beyond throughout the rest of the band. We then can use the indirect method to calculate the harmonic response of the transmitter after the low pass filter.

When performing proofs at the broadcasting installation site for FCC compliance, the above technique is not practical, due to mostly installation/infrastructure restraints. So, the spurious measurement must be taken with a directional coupler after all of the appropriate filters. Great care must be taken to have the directional coupler and the low pass filters characterized to show where the TE₁₁ mode is most prevalent in the system. Due to added transmission line lengths and different positions of added transitions, the exact TE₁₁ modes are an unknown variable. These points, therefore, distorts the real output measurement of the spectrum to make the actual harmonic or spurious emission look greater than what is emanating from the transmitter. Therefore, the measured result at the broadcast facility yields erroneous values past the useable cutoff frequency.

Looking at the response of a typical 1/4-wave directional coupler – (in this case a $3\frac{1}{8}$ " diameter), the TE₁₁ interaction is evident in Figure 1.

Figures 2a-c are plots made from raw network analyzer data from the same 1/4 wave directional coupler sweep.



Figure 1. Broadband plot from 1/4 wave Coupler



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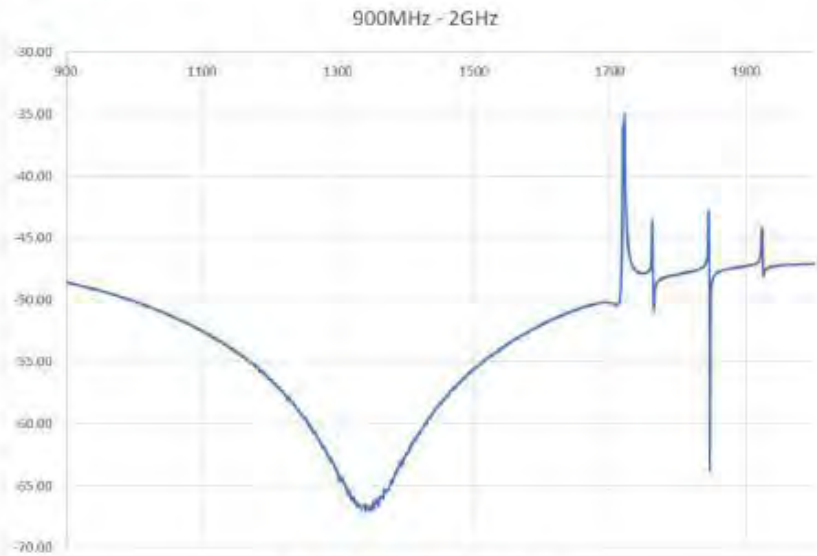


Figure 2a. 900Mhz - 2GHz sweep

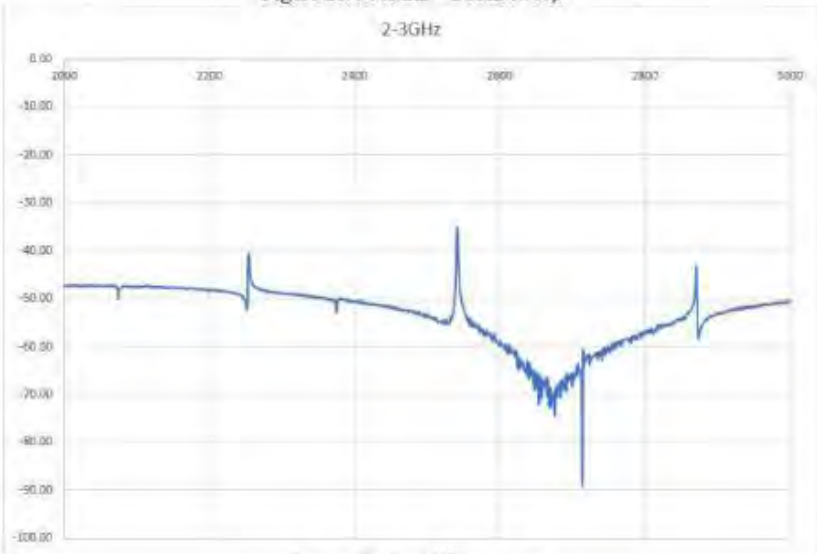


Figure 2b. 2 - 3GHz sweep



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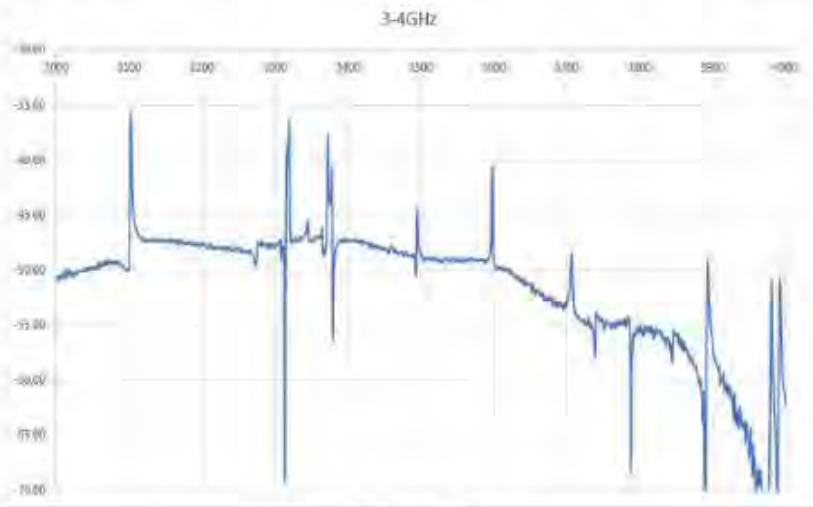


Figure 2c. 3 - 4GHz sweep

The data shows a worst-case measurement uncertainty of +20/-30dB. Therefore, there is no accurate directional coupler correction above the transmission line cut-off frequency that can be applied for an accurate measurement that fully characterizes the transmitter's spectral output for compliance when using directional couplers. This phenomenon is also addressed in the European standard, ETSI EN 302 296 V2.1.1, and the EIA RS225 transmission line standard for frequency cutoff. If further clarification is needed, data from this investigation can be obtained from GatesAir directly.