ENGINEERING REPORT OF ATSC

TELEVISION TRANSMITTER PERFORMANCE CHARACTERISTICS

FOR

WRAL-DT
Raleigh North Carolina

ULXTED-120

Capitol Broadcasting
Raleigh
North Carolina

Measured by:

C B A

CHUCK BRITT AND ASSOCIATES, INC.

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:	: FC
Exciter Type:	: XTE (x2)

TRANSMITTER POWER SUMMARY: (Average, Digital Power)

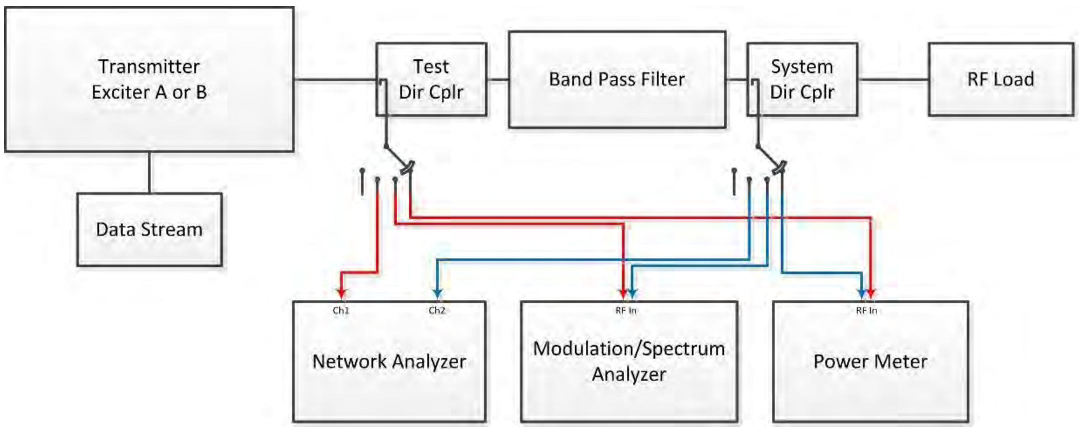
Amplifier (s) rated power	: 0.627 kW (*120= 75.24 kW)
Transmitter system rated power (Pre-filter)	: 75.24 kW
Transmitter power output (TPO-Post filter)	: 69.34 kW
Transmission line loss	: 1.63 dB
Antenna input power	: 47.1 kW
Antenna power gain (Max)	: 12.43 dB.
ERP (Ave.)	: 833.7 kW

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:

Test Equipment	Make	Model	S/N
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.

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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.

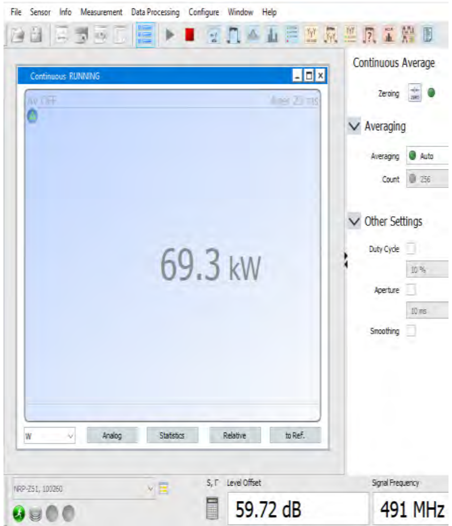
- PRE-Filter coupling value(s) & Power: TX 1 Cab-1 51.31 dB ; 17.72 kW / Cab-2 51.60 dB; 17.25kw TX 2 Cab-1 51.64 dB; 17.73kW / Cab-2 51.88 dB ; 17.98 kw

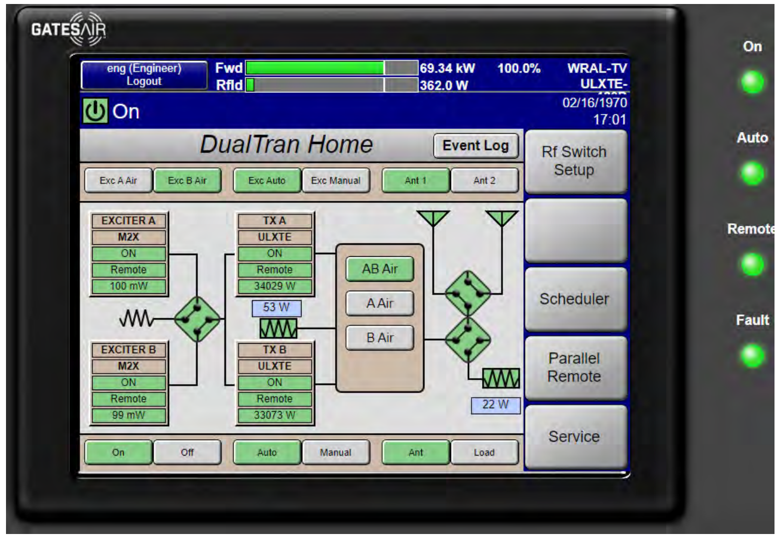
Average pre-filter power displayed from the power meter reading(s): 70.680 kW

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 effeciency	42.94%

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

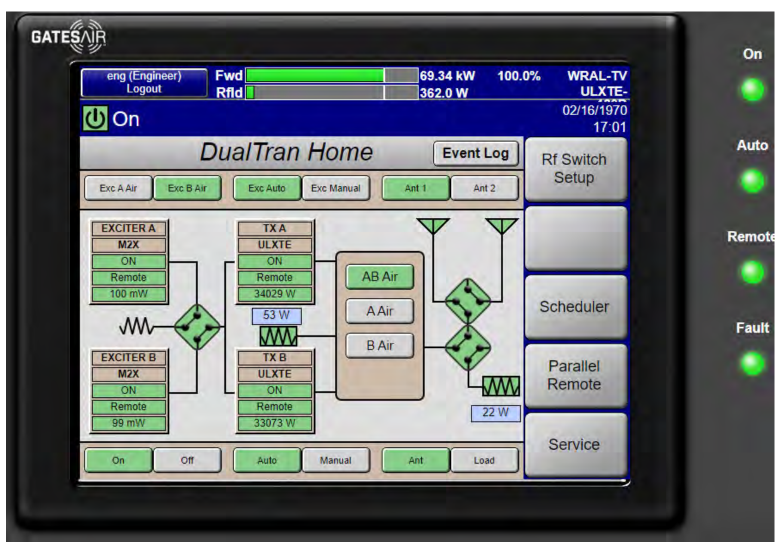




Screen capture showing transmitter power display & POST-filter Reflected power.

- 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.

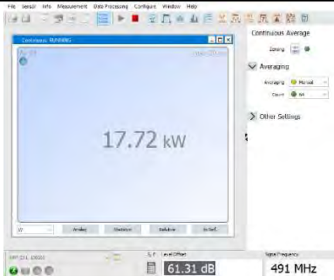
Reflected Power %	
Forward power	69340.00
Reflected power	363.00
Reflected power % < 5%	0.52
VSWR	1.16



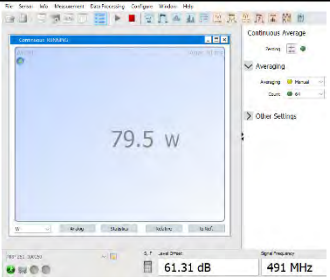
Transmitter A and B Pre-Filter Power Meter Readings.

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

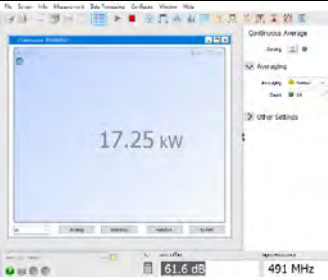


TX A Cab-1 Forward

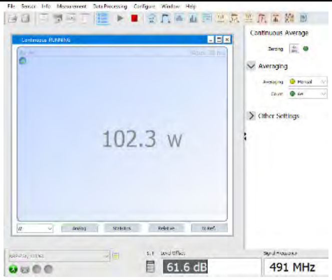


TX A Cab-1 Reflected

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

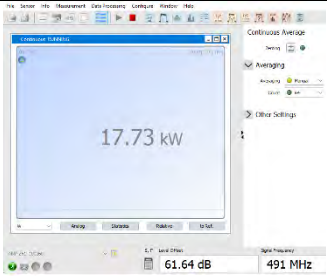


TX A Cab-2 Forward

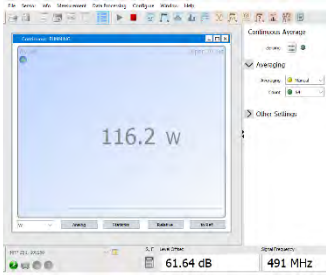


TX A Cab-2 Reflected

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

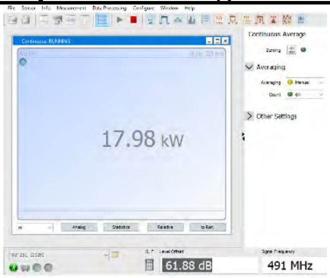


TX B Cab-1 Forward

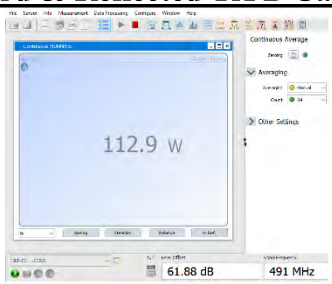


TX B Cab-1 Reflected

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, <u>SN: 100682</u>

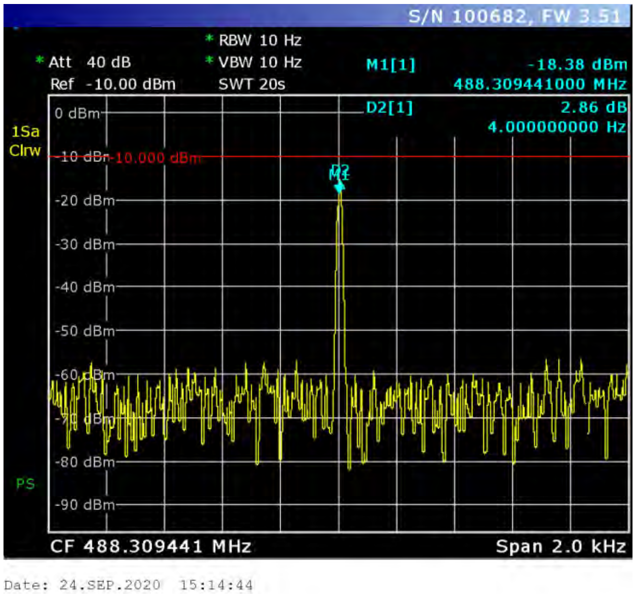
<u>Pilot Frequency= Lower 6 MHZ side band plus 0.309441 MHZ</u>

<u>*Set parameters as listed below;</u>

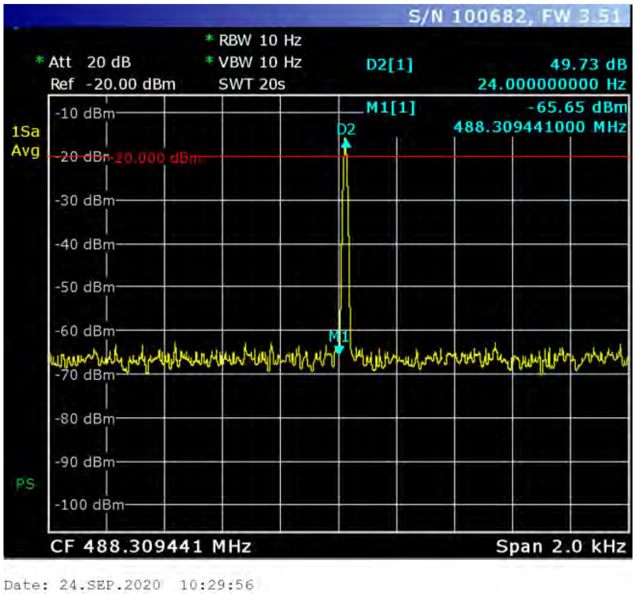
- *<u>Span=2 kHz</u>, RBW=10HZ, VBW=10 HZ for N-1*
- *Span=100HZ, RBW=10 HZ, VBW=10 HZ for DTV-DTV & N+1*
  - *(10mhz EXT reference should be used for 100HZ span)*

*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.*



Exciter A: 488,309,445 Hz



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.

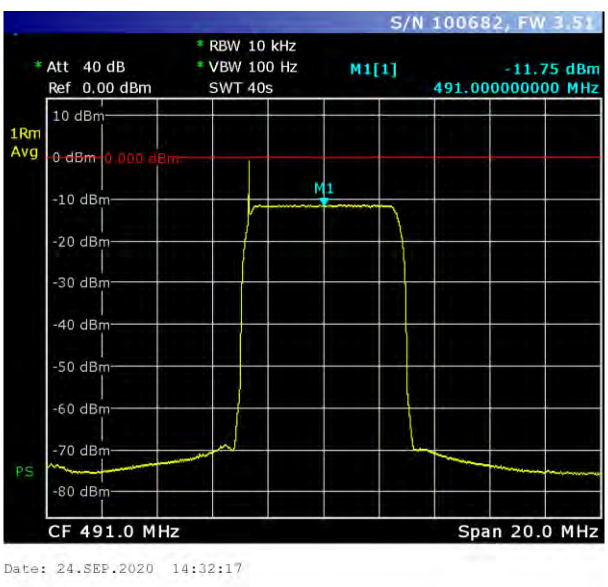
Copper Mountain: S5048 Network Analyzer, SN: 18097093
Spectrum analyzer model: Rohde & Schwarz ETL, SN: 100682
Cable type: Times Microwave Armored Cable Length: 15 ft. Filter used: (2) NHP-1000+ High Pass filters

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.*

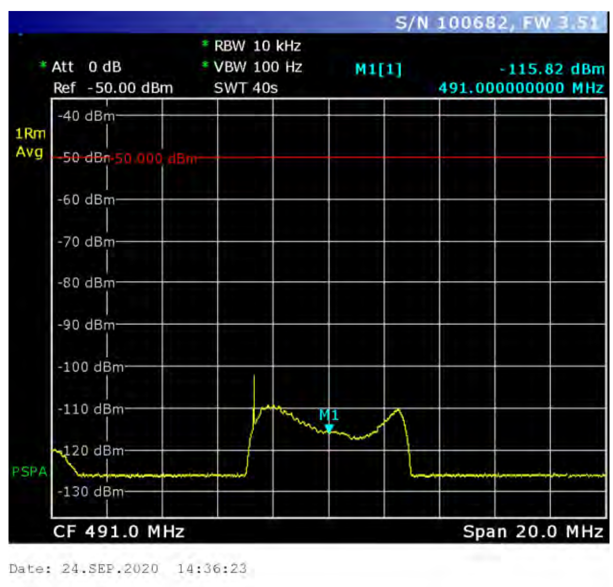
491.00MHz :Measured Center Frequency (MHz)

WRAL Harmonic Measurements Exciter A													
	Frequency	Measured Level	Losses (dB) Coupler	Losses (dB) Cable	Losses (dB) Signal Pad	Losses (dB) Inline Filter	Loss Correction	Measurement RBW (kHz)	RBW Correction	TPO Reference Measurement After Corrections	dBc	FCC Limit	FCC Margin
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	0.000dB	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	0.000dB	0.450dB	41.479dB	10kHz	16.990dB	-50.401dBm	-117.9dBc	-110.000dBc	7.9dB

Exciter A:



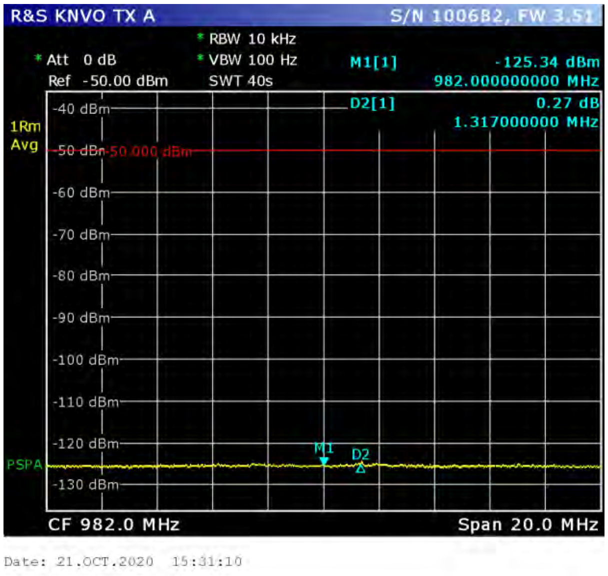
Exciter A:
Input level verified below 30dBm using external power meter, internal attenuation set at 50dB



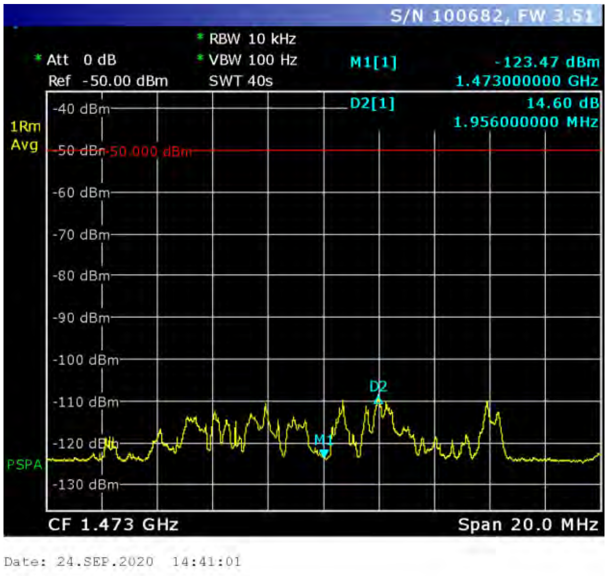
Exciter A:
2 High Pass filters added to system, internal attenuation set at 0dB, pre-amp turned on.

* Standard installation guidelines, Check list and other information located on the GatesAir Web site.

HARMONIC MEASUREMENTS-POST FILTER--EXCITER A



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



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

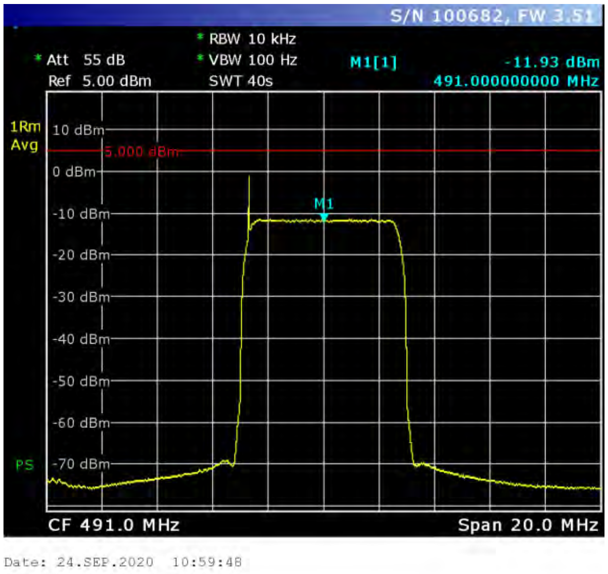
NOTE; review document "Harmonic Measurement Instructions-ATSC-Rev B" prior to measure" Measurements to be taken with Spectrum Analyzer set for 10 kHz resolution bandwidth, and 10 kHz or less video bandwidth. *** Set span to 20-30 MHz*
NOTE, only required to measure to the 3rd harmonic due to moding
**GatesAir, Inc. Moding document attached at the end of this report.*

491.00MHz :Measured Center Frequency (MHz)

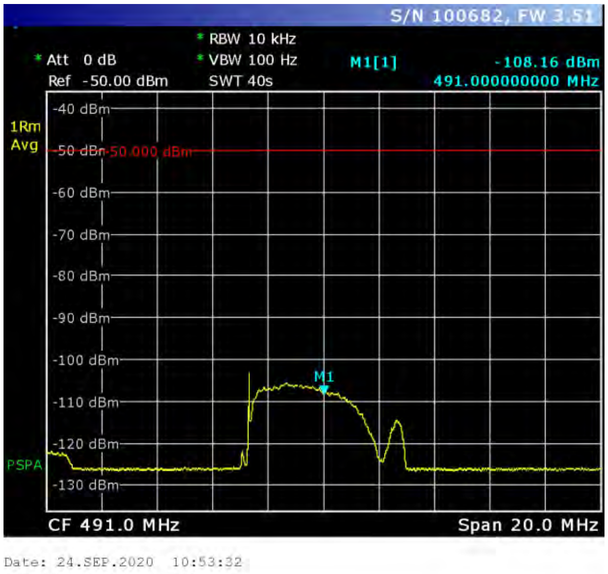
WRAL Harmonic Measurements Exciter B

	Frequency	Measured Level	Losses (dB) Coupler	Cable	Signal Pad	Inline Filter	Loss Correction	Measurement RBW (kHz)	RBW Correction	Measurement After Corrections	dBc	FCC Limit	FCC Margin
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:

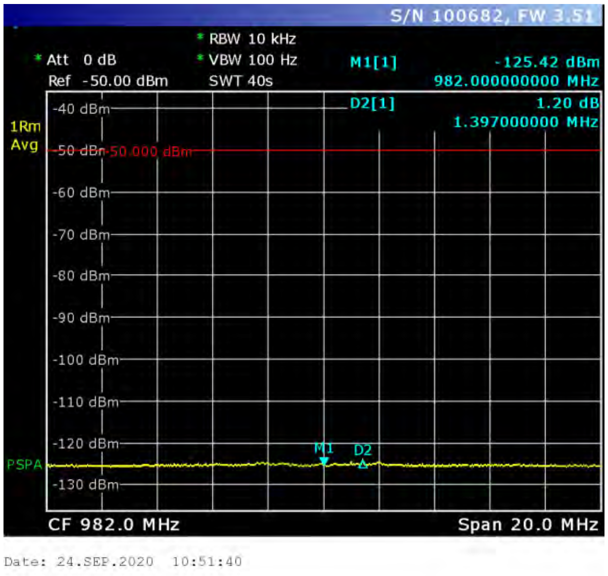


Exciter B:
Input level verified below 30dBm using external power meter, internal attenuation set at 55dB

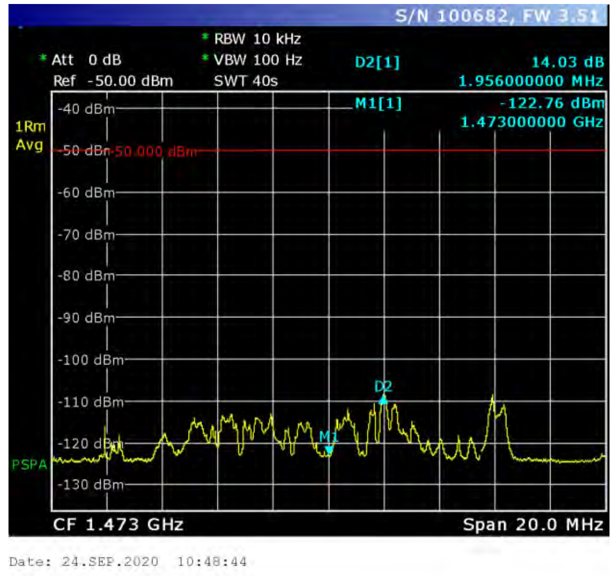


Exciter B:
2 High Pass filters added to system, internal attenuation set at 0dB, pre-amp turned on.

HARMONIC MEASUREMENTS-POST FILTER--EXCITER B



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



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

Notes:

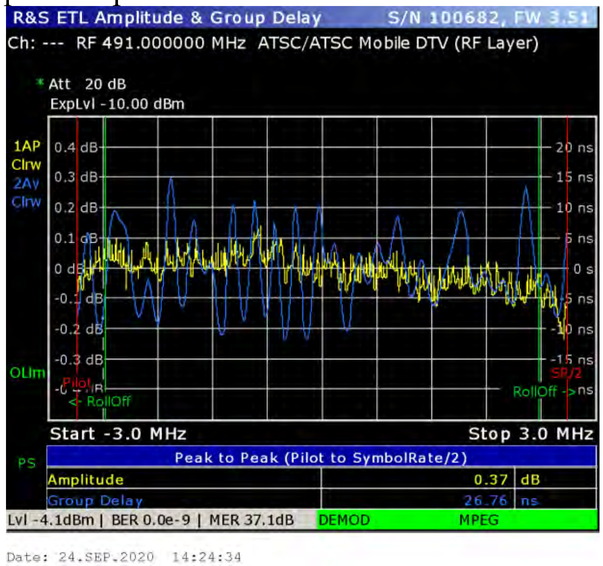
RESPONSE AND GROUP DELAY-POST FILTER-EXCITER A & B

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

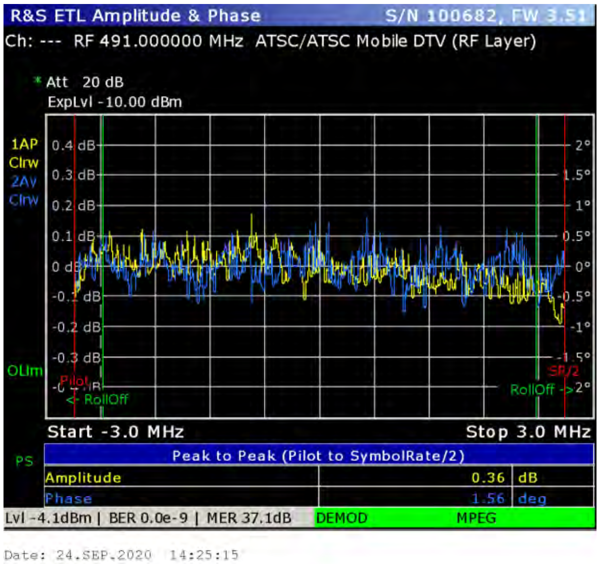
Note if Amplitude is skewed, often can be adjusted via the exciter (typically not required). RTAC>Calibration>Down Converter Tilt Compensation Enabled "yes">

- *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)*

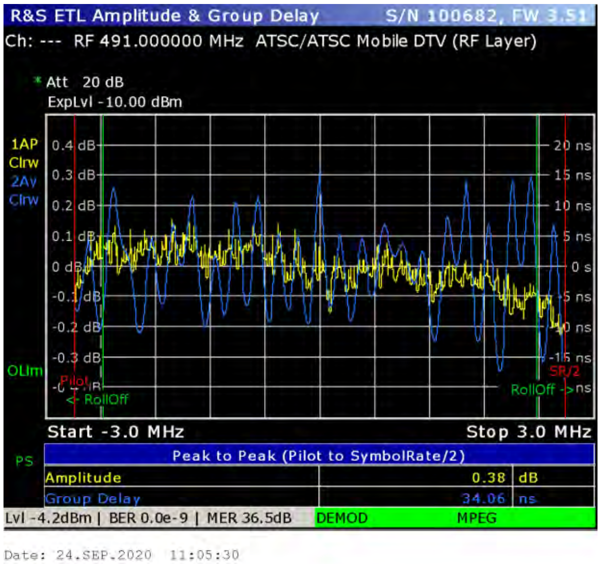
Rohde & Schwarz ETL, SN: 100682
*Spec: Amplitude variation < 1dB



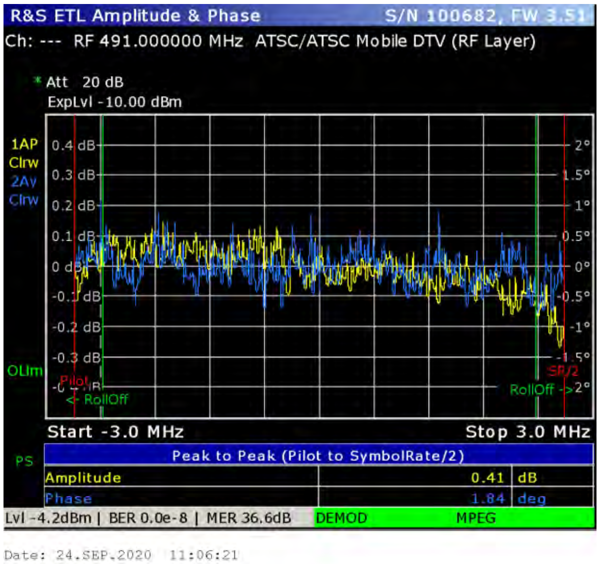
Exciter A – Amplitude & Group Delay



Exciter A – Amplitude & Phase



Exciter B – Amplitude & Group Delay

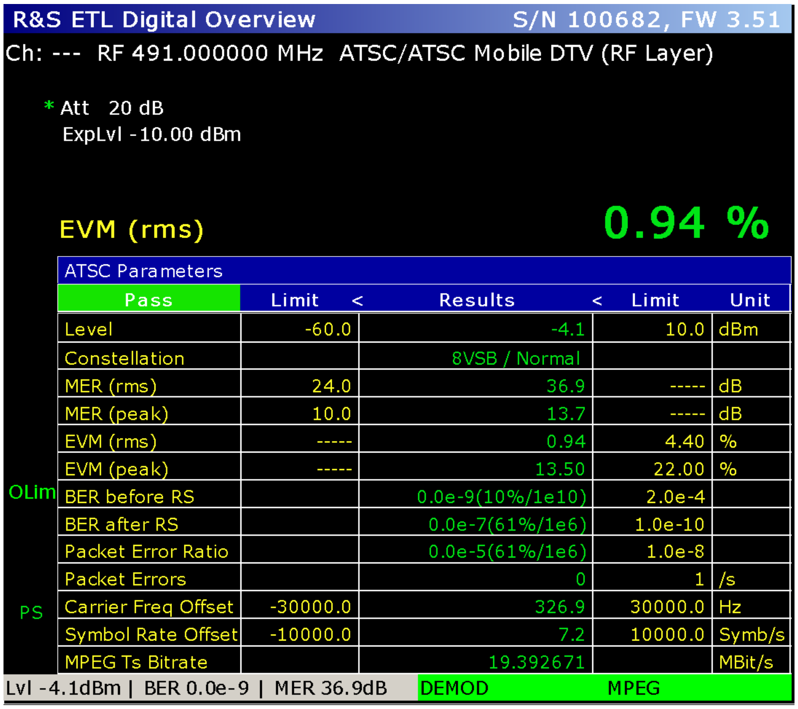


Exciter B – Amplitude & Phase

ERROR VECTOR MAGNITUDE-POST FILTER-EXCITER A

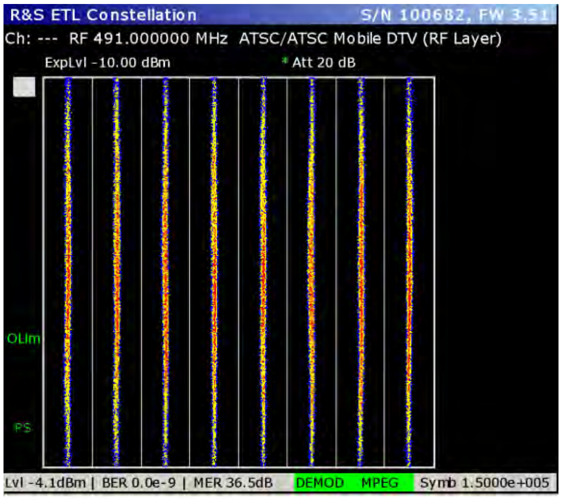
The Error Vector Magnitude was measured using the Rhode and Swartz ETL Television analyzer
Menu-digital TV for ETL* *Zoom-select EVM for overview screen

Rohde & Schwarz ETL, SN: 100682



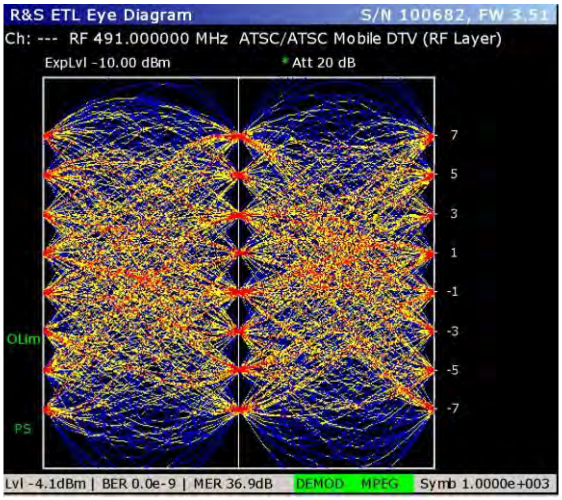
Date: 24.SEP.2020 14:22:08

Overview *EVM Spec <4%*



Date: 24.SEP.2020 14:22:55

Exciter A: Constellation



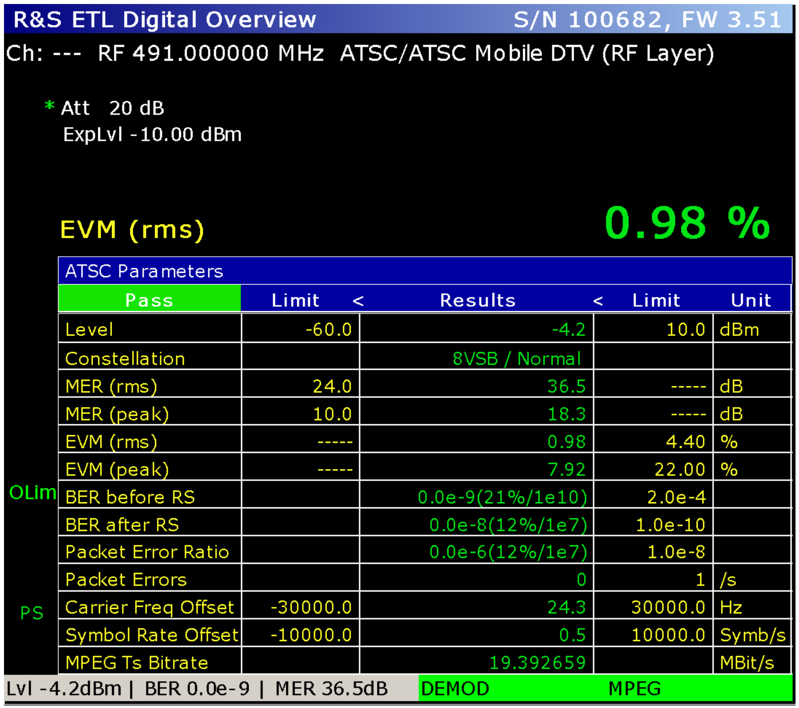
Date: 24.SEP.2020 14:23:30

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

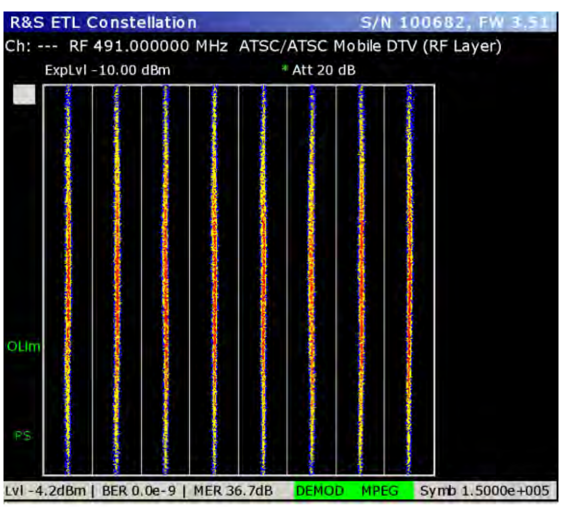
Rohde & Schwarz ETL, SN: 100682



Pass	Limit <	Results	< Limit	Unit
Level	-60.0	-4.2	10.0	dBm
Constellation		8VSB / Normal		
MER (rms)	24.0	36.5	-----	dB
MER (peak)	10.0	18.3	-----	dB
EVM (rms)	-----	0.98	4.40	%
EVM (peak)	-----	7.92	22.00	%
BER before RS		0.0e-9(21%/1e10)	2.0e-4	
BER after RS		0.0e-8(12%/1e7)	1.0e-10	
Packet Error Ratio		0.0e-6(12%/1e7)	1.0e-8	
Packet Errors		0	1	/s
Carrier Freq Offset	-30000.0	24.3	30000.0	Hz
Symbol Rate Offset	-10000.0	0.5	10000.0	Symb/s
MPEG Ts Bitrate		19.392659		MBit/s

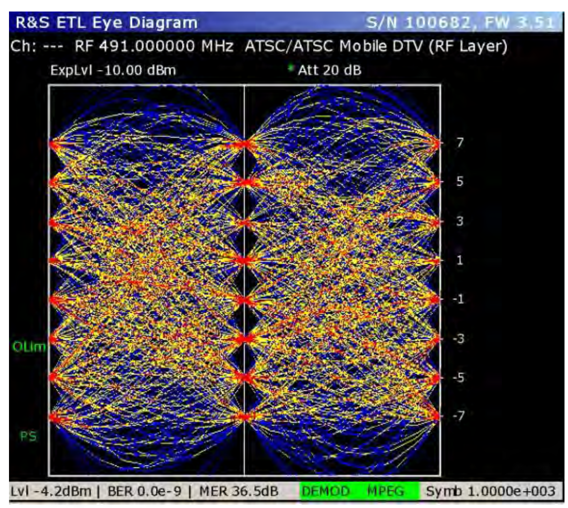
Date: 24.SEP.2020 11:07:32

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

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

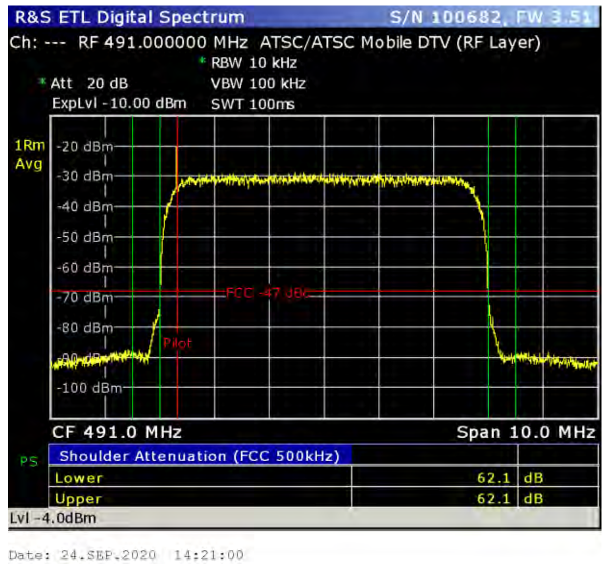
Specification= –37 dB.*

*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 <u>-47 dB.</u> 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).

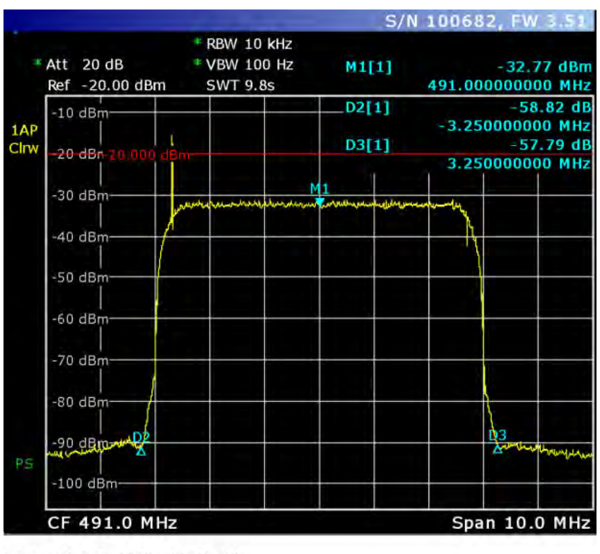
<u>*Measurements to be taken with Spectrum Analyzer set for **10 kHz resolution bandwidth, and 10 kHz or less video bandwidth, 10MHz span.** Post-Filter. *NOTE, if Spectrum Analyzer does not have the preconfigured set up, those screen shots can be omitted.*</u>

Rohde & Schwarz ETL, SN: 100682

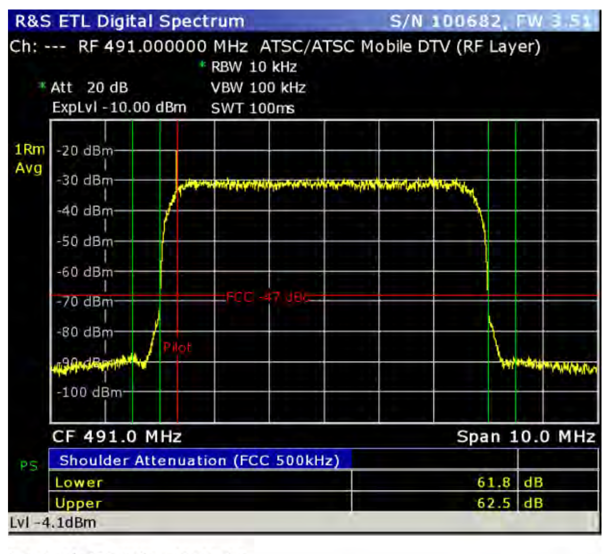
Exciter A: Standard Spectral Screen



Exciter A: ETL Pre-Configured Screen



Exciter B: Standard Spectral Screen



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)

	Summary Filter Response			Transmitter Response before filter					
Frequency	Analyzer Reading	Center Freq. Reference	Filter Response	Analyzer Reading	Center Freq. Reference	Transmitter Response	Net Response	FCC Mask Response	Negative # Is out of FCC Specifications
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

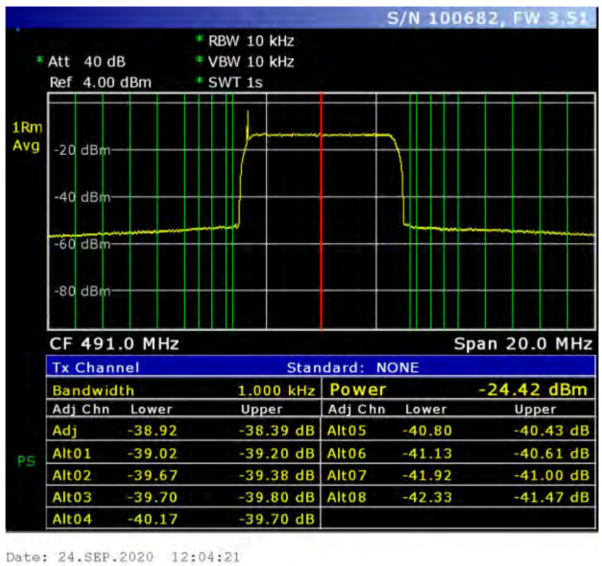
Center Frequency =			**491.00**	**MHz**				
Markers					Lower		Upper	
Adj	=	±	3.25	MHz	487.75	MHz	494.25	MHz
Alt01	=	±	3.50	MHz	487.50	MHz	494.50	MHz
Alt02	=	±	4.00	MHz	487.00	MHz	495.00	MHz
Alt03	=	±	4.50	MHz	486.50	MHz	495.50	MHz
Alt04	=	±	5.00	MHz	486.00	MHz	496.00	MHz
Alt05	=	±	6.00	MHz	485.00	MHz	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

* Standard installation guidelines, Check list and other information located on the GatesAir Web site.

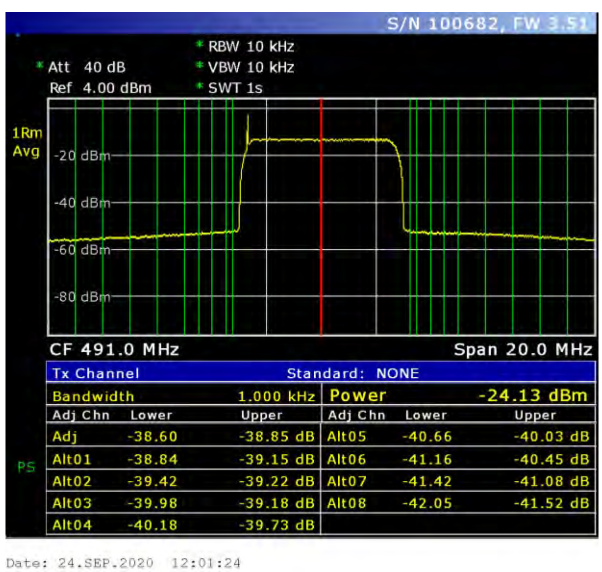
DIGITAL TRANSMITTER AMPLITUDE RESPONSE--EXCITER A

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



TX A Exc A Pre-Filter



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)									
	Summary Filter Response			Transmitter Response before filter				FCC	Negative # Is out of FCC Specifications
Frequency	Analyzer Reading	Center Freq. Reference	Filter Response	Analyzer Reading	Center Freq. Reference	Transmitter Response	Net Response	Mask 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

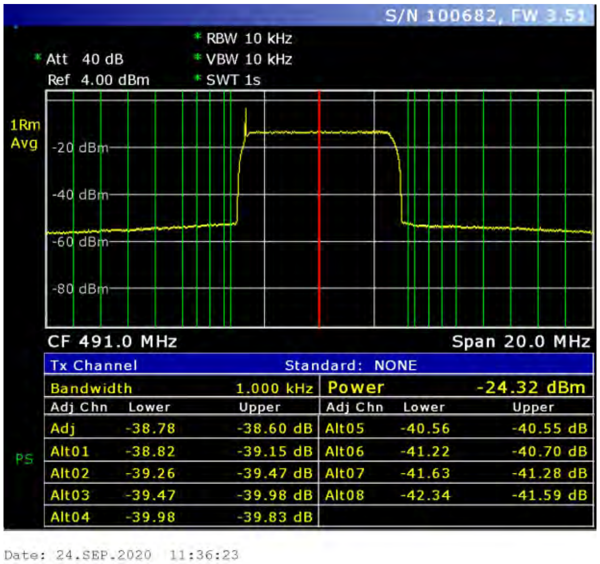
Center Frequency =	**491.00**	**MHz**				
Markers			Lower		Upper	
Adj = ±	3.25	MHz	487.75	MHz	494.25	MHz
Alt01 = ±	3.50	MHz	487.50	MHz	494.50	MHz
Alt02 = ±	4.00	MHz	487.00	MHz	495.00	MHz
Alt03 = ±	4.50	MHz	486.50	MHz	495.50	MHz
Alt04 = ±	5.00	MHz	486.00	MHz	496.00	MHz
Alt05 = ±	6.00	MHz	485.00	MHz	497.00	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

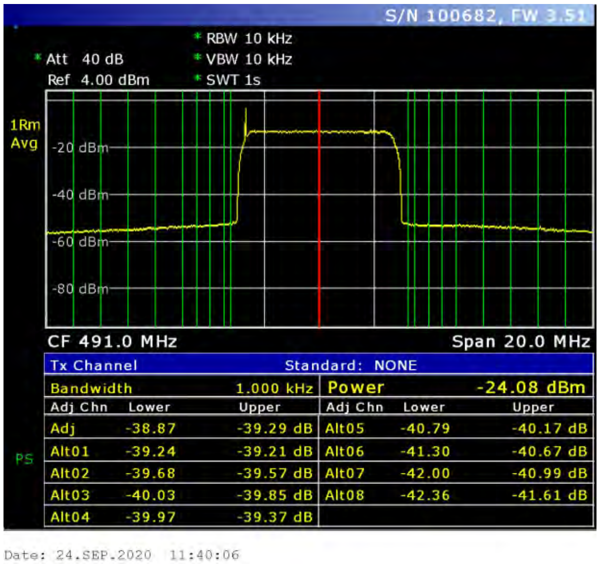
The test equipment was connected as shown in the Block Diagram. The response was measured **at the pre-filter coupler** on the transmitter output. The results are recorded below.
*Example below is multi/chart-screen, other screens or chart type data is acceptable as well.

*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



TX A Exc B Filter



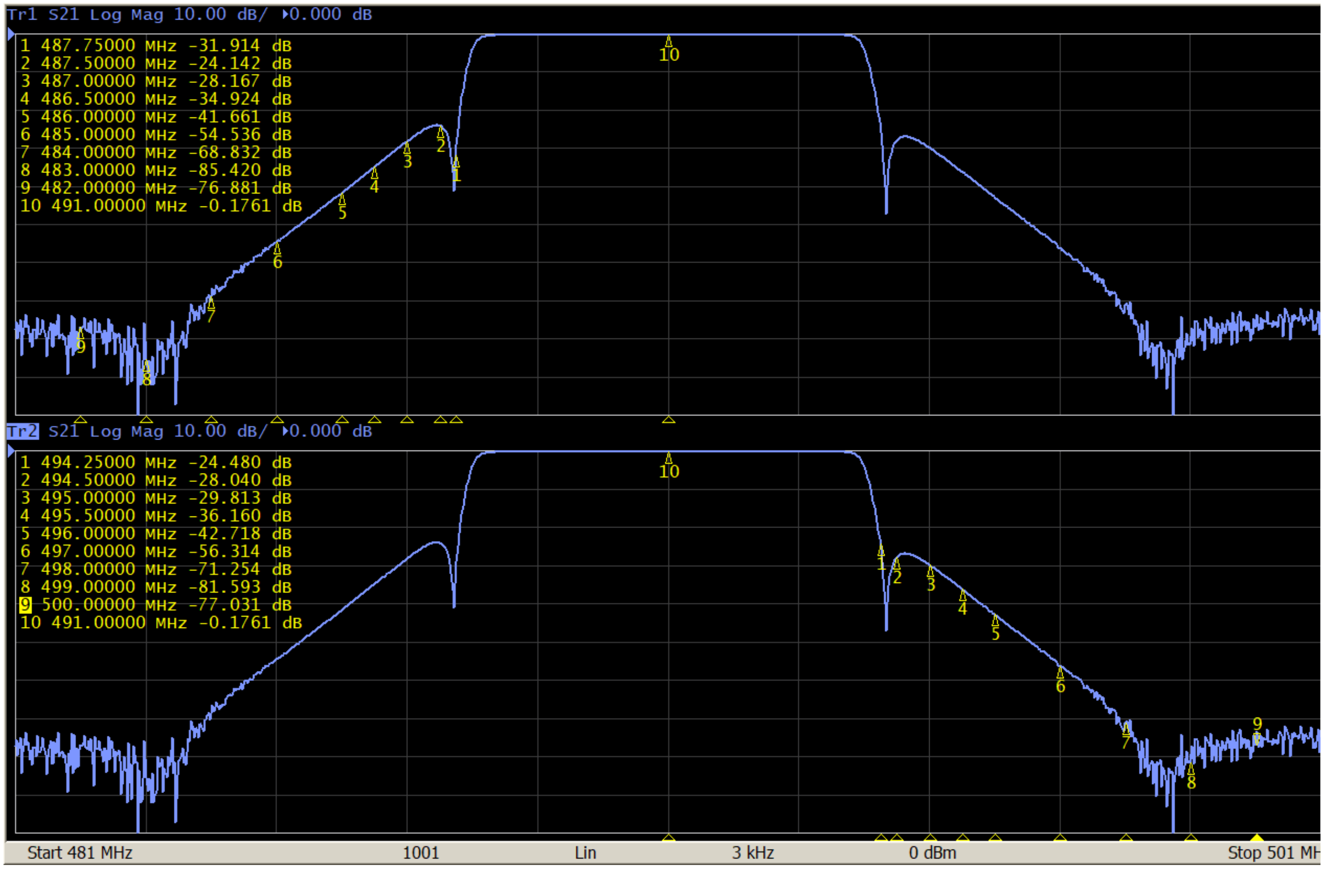
TX B Exc B Filter

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

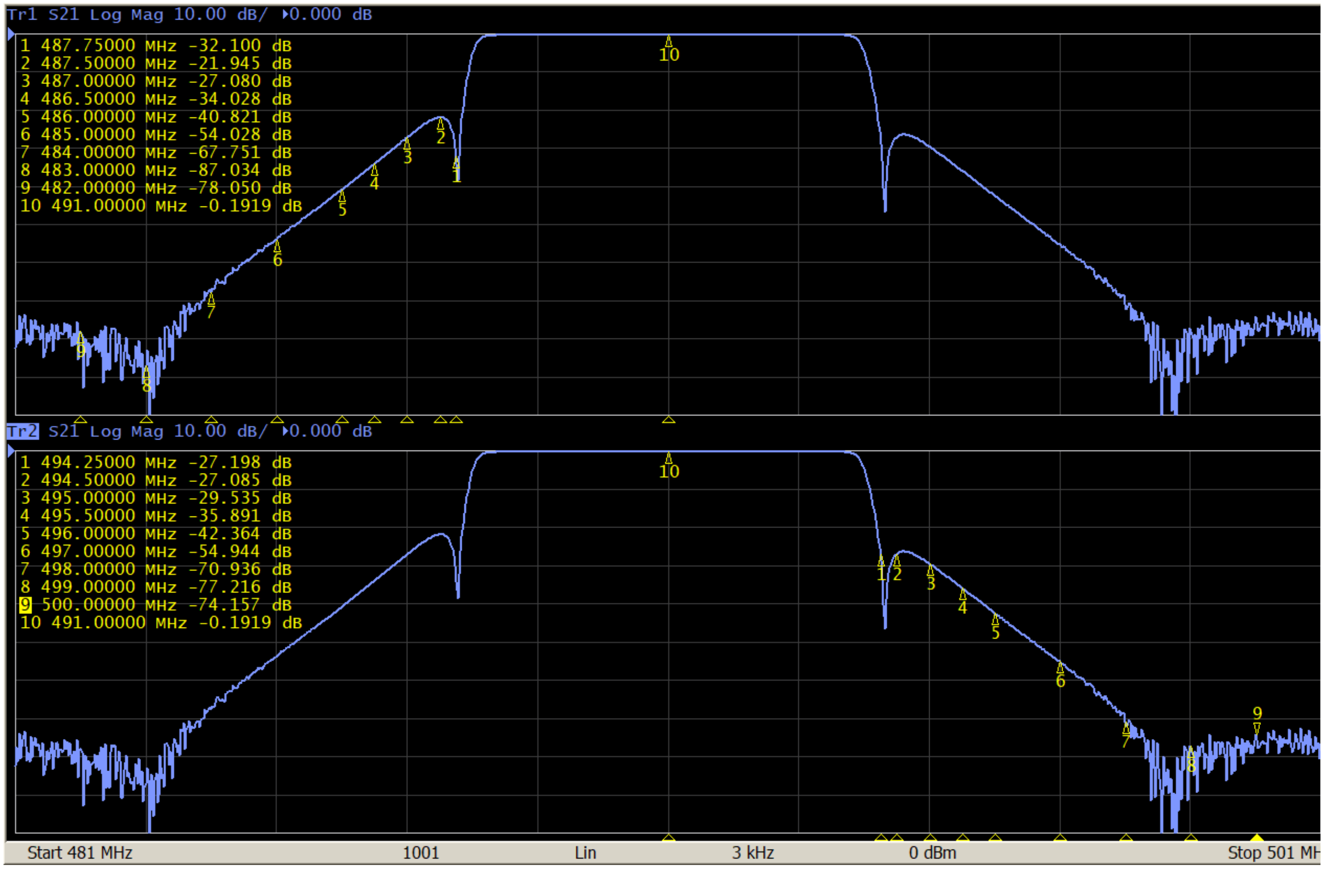


DIGITAL TRANSMITTER AMPLITUDE RESPONSE -TX B BANDPASS FILTER

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.

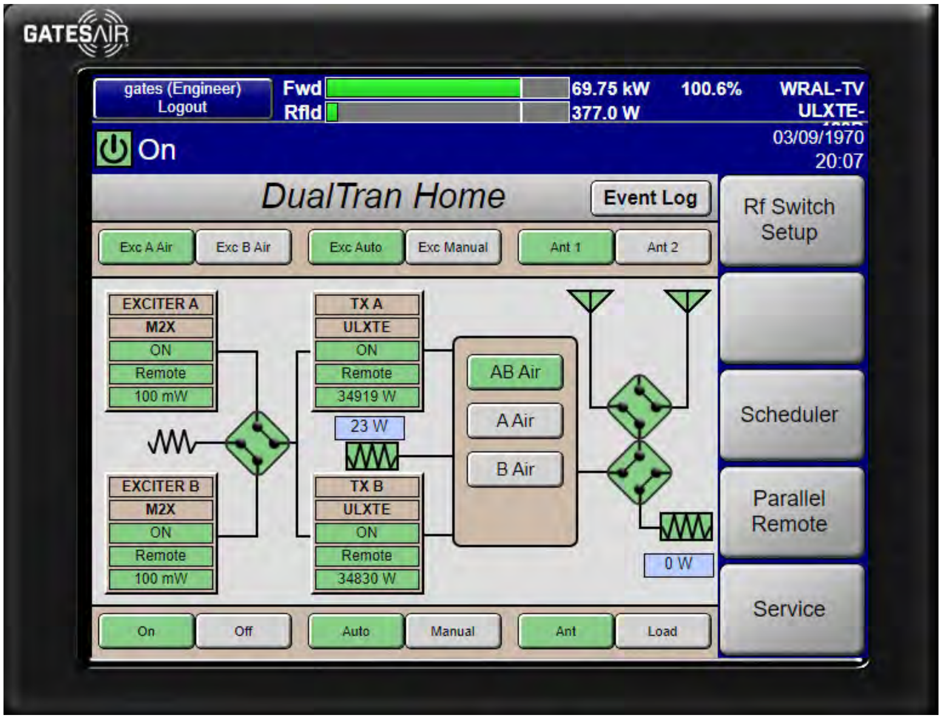
Copper Mountain: S5048 Network Analyzer, SN: 18097093



Page **23** of **64**	* Standard installation guidelines, Check list and other information located on the GatesAir Web site.	Document number: 888-9101-010 Revision: D

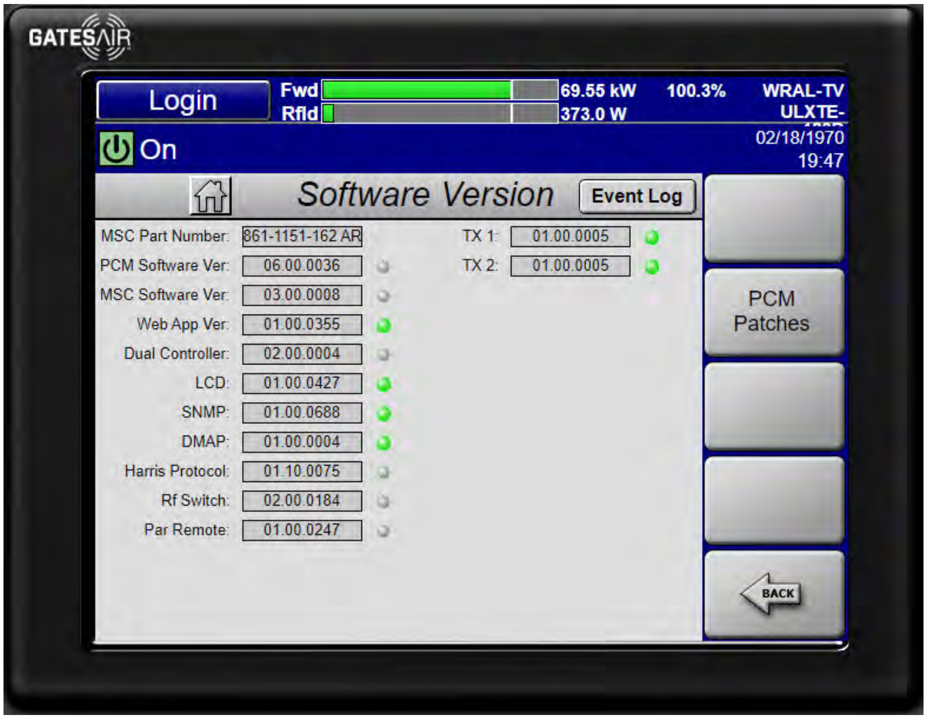
TRANSMITTER MSC SCREENS

System Home Screen



System Service

System Version



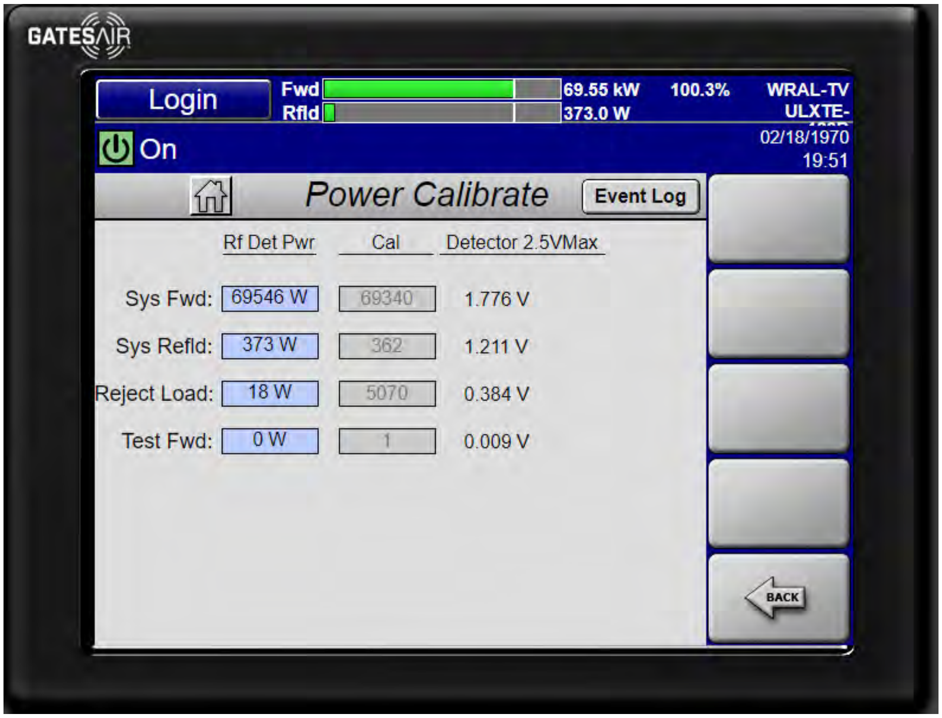
System Network

System Setup

Combiner Config

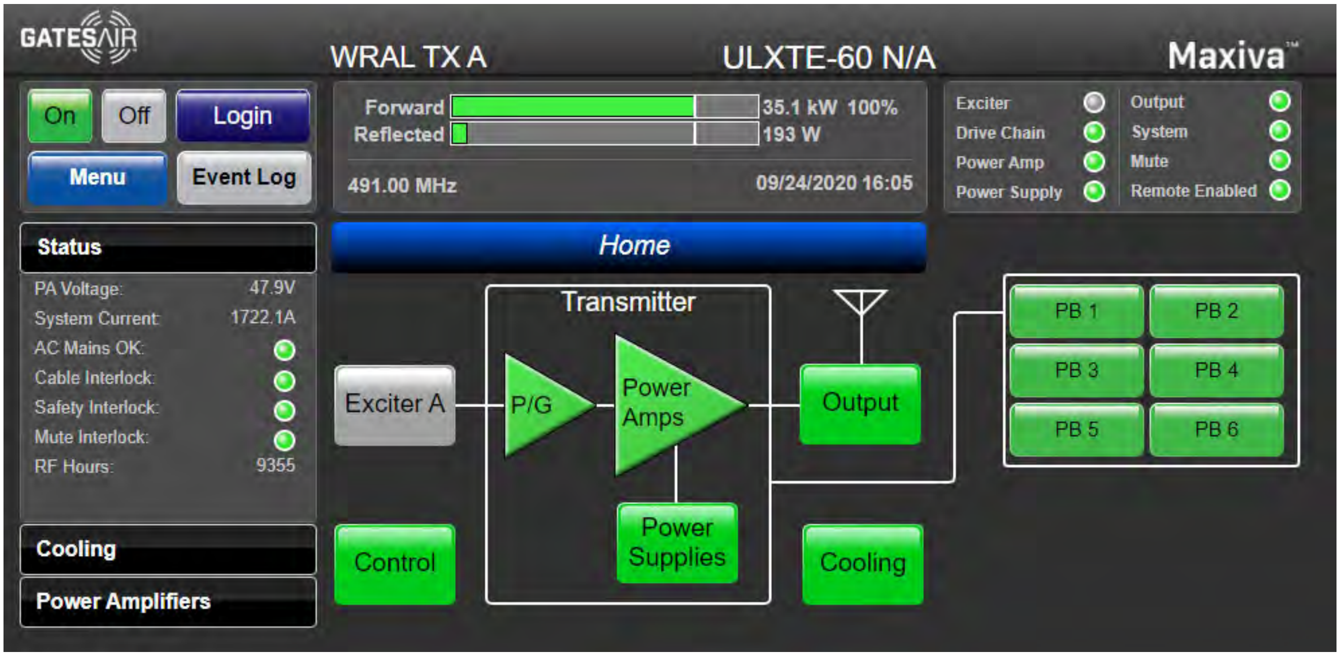
System Thresholds

Power Calibration Screen

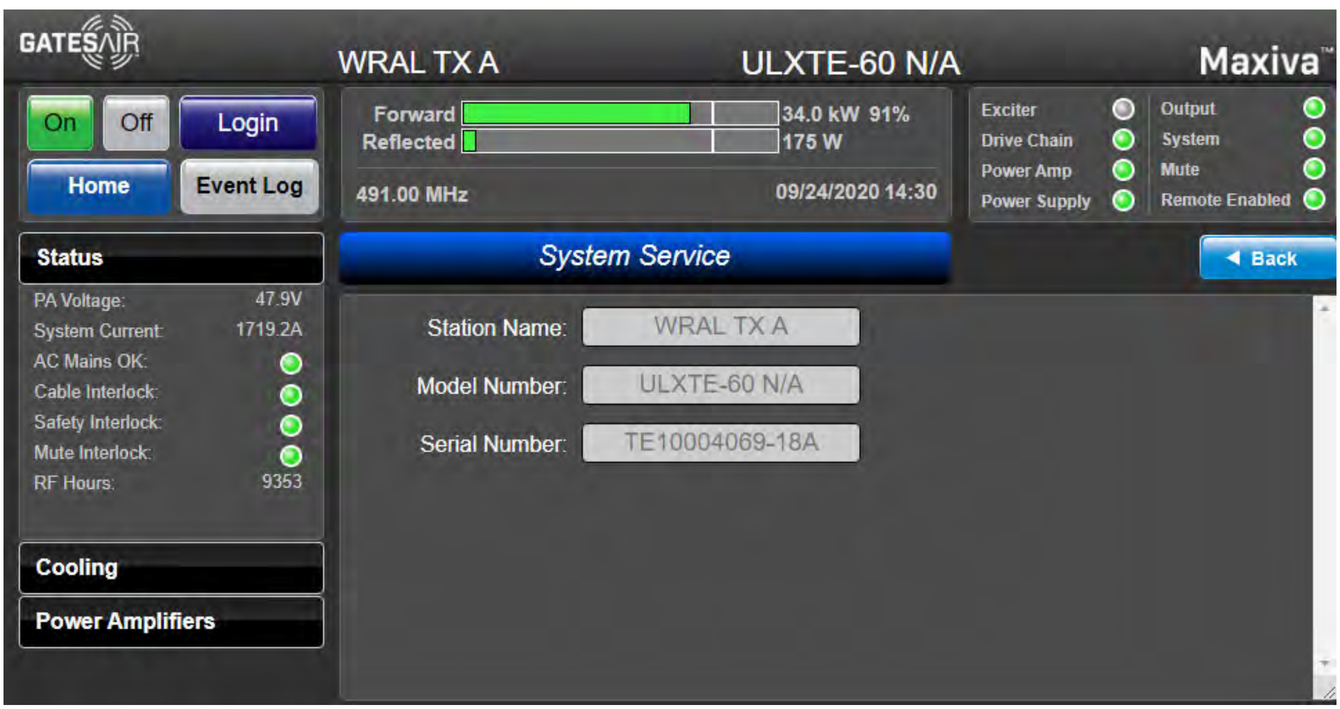


TRANSMITTER A STM SCREENS

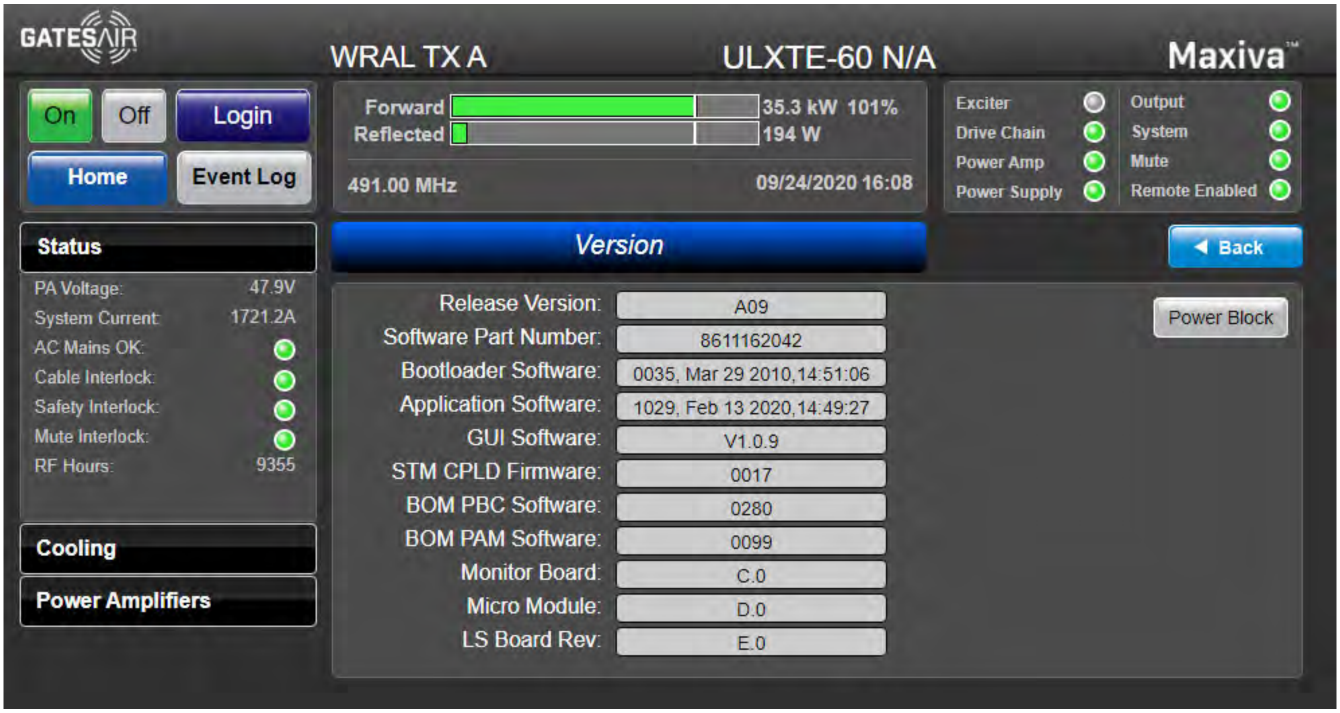
System Home Screen



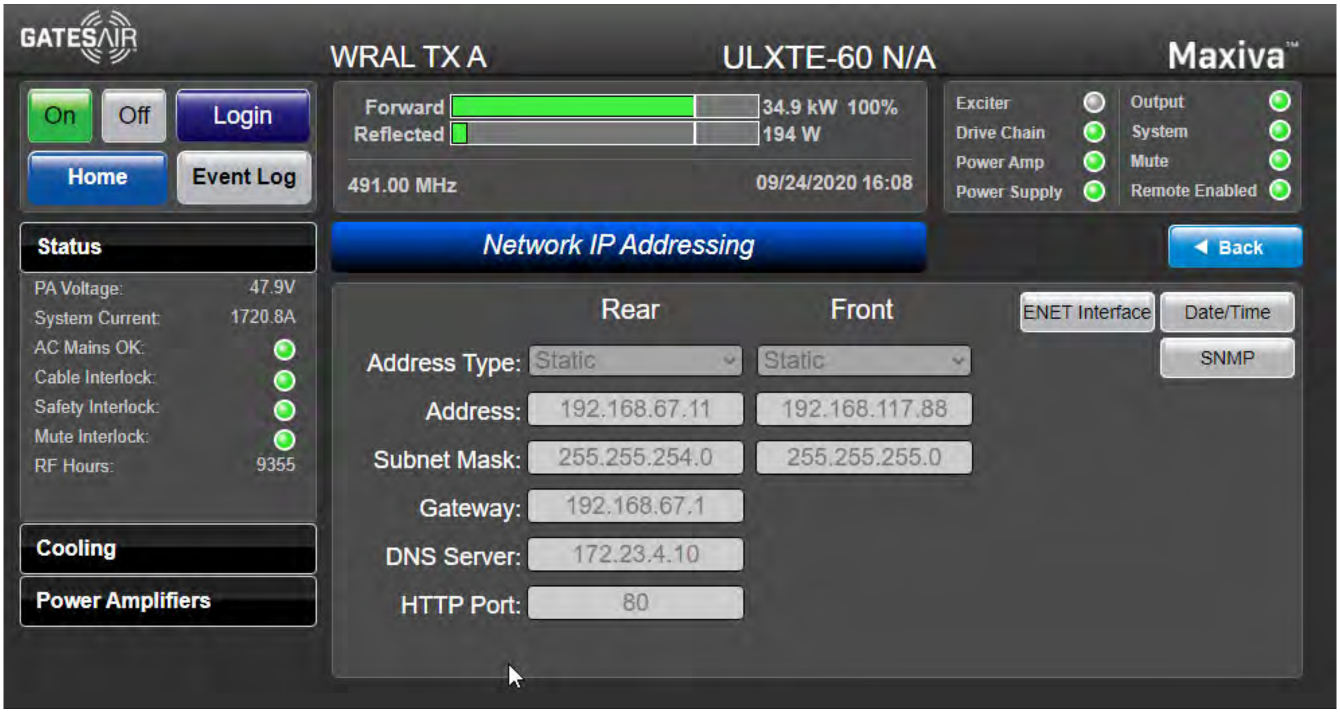
System Service



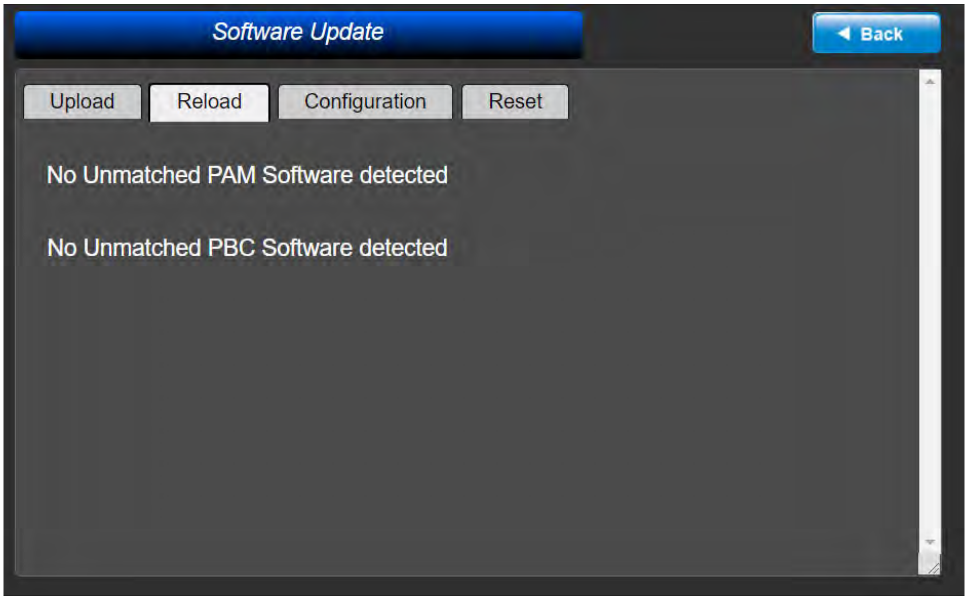
System Version



System Network



Software Management Reload Page



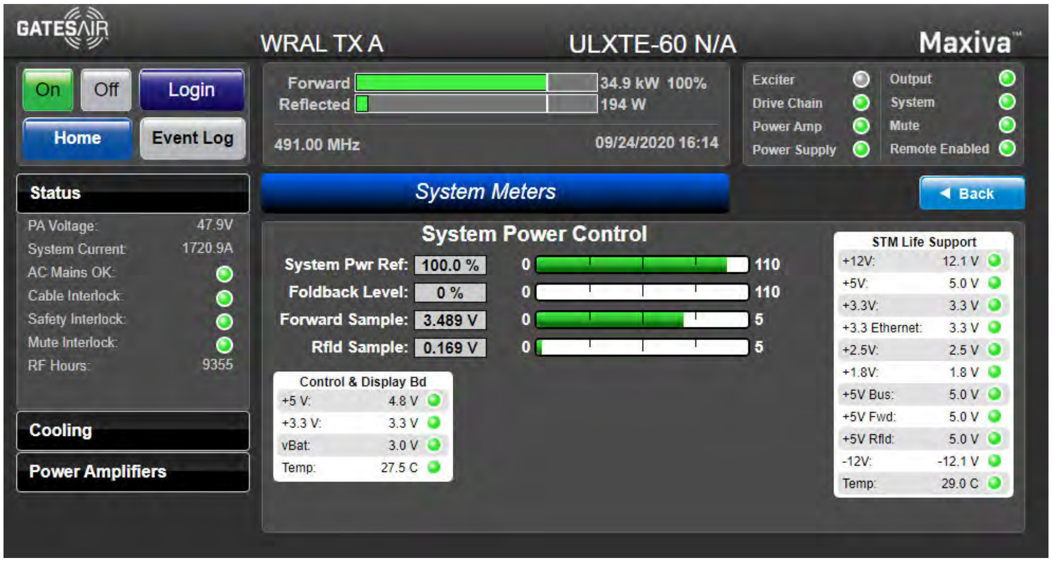
Tx A System Phase A

TX A System Phase B

TX A System Gain A

TX A System Gain B

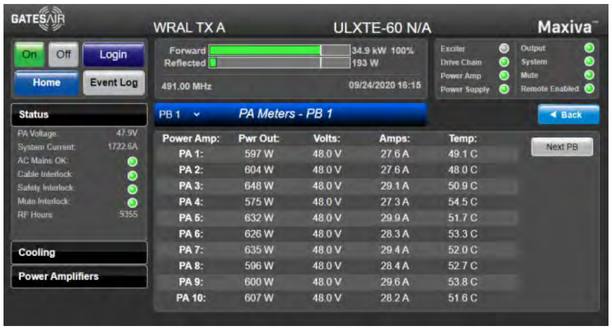
TX A System Meters



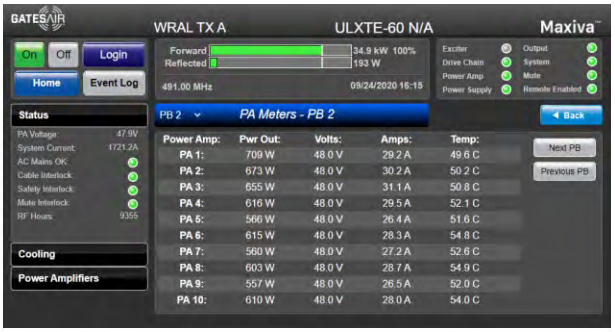
System Output Overview

Cooling Meter Summary

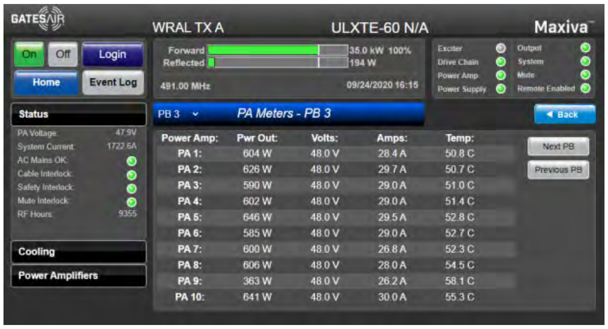
TX A Block PA Meters



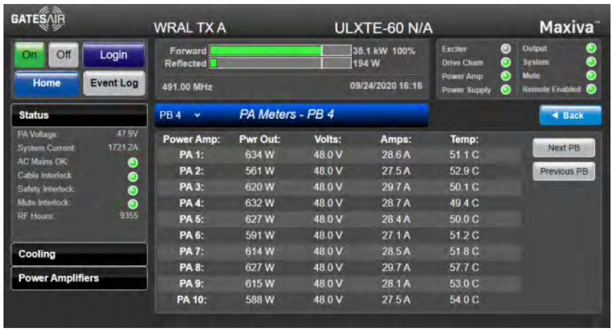
Power Block 1



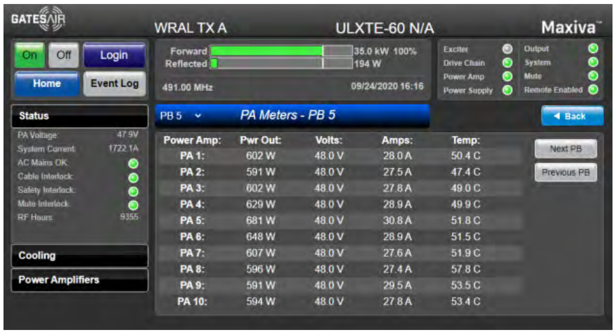
Power Block 2



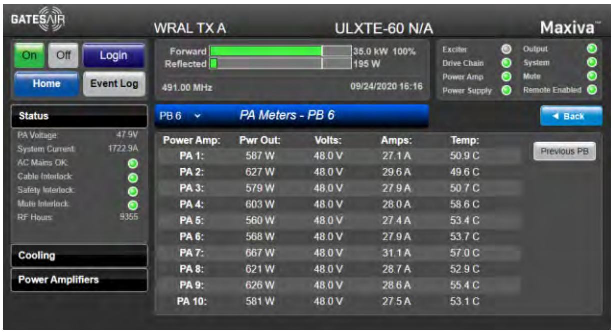
Power Block 3



Power Block 4

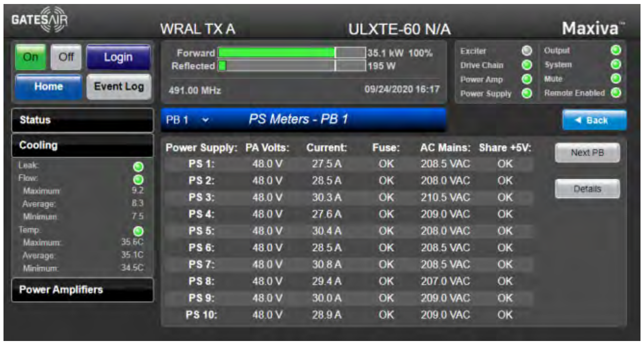


Power Block 5

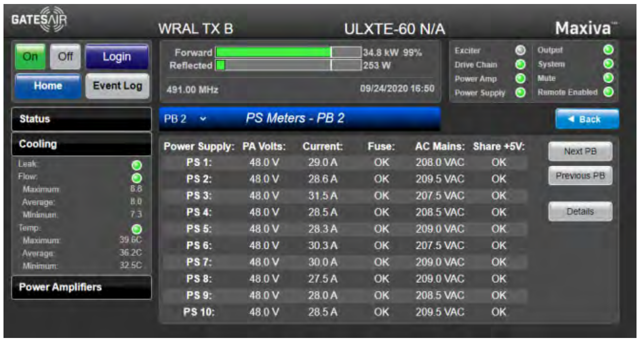


Power Block 6

TX A Power Block PS Meters



Power Block 1



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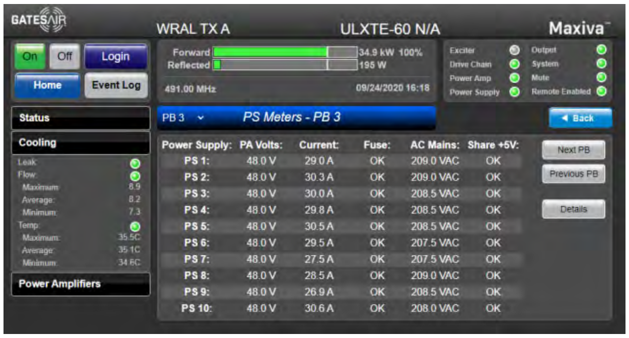
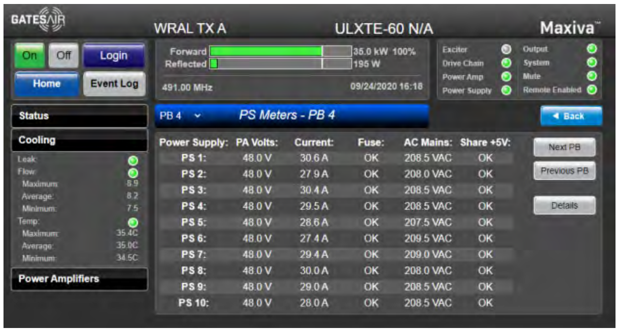
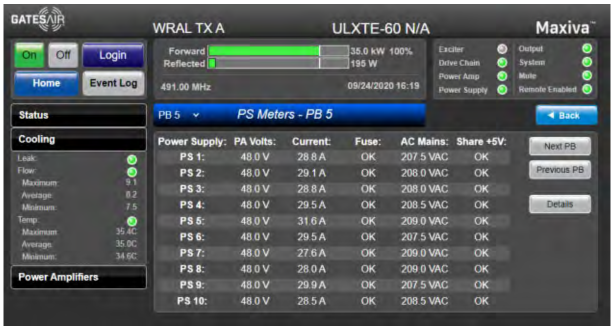


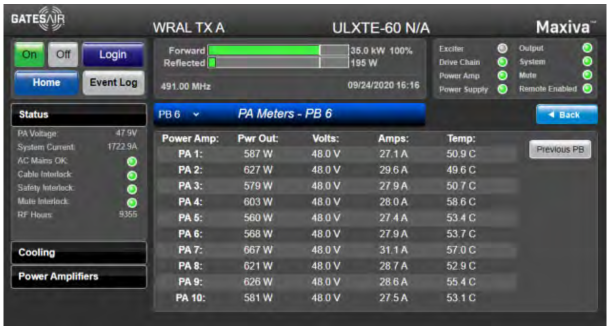
Power Block 3



Power Block 4



Power Block 5



Power Block 6

* Standard installation guidelines, Check list and other information located on the GatesAir Web site.

Document number: 888-9101-010

Revision: D

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

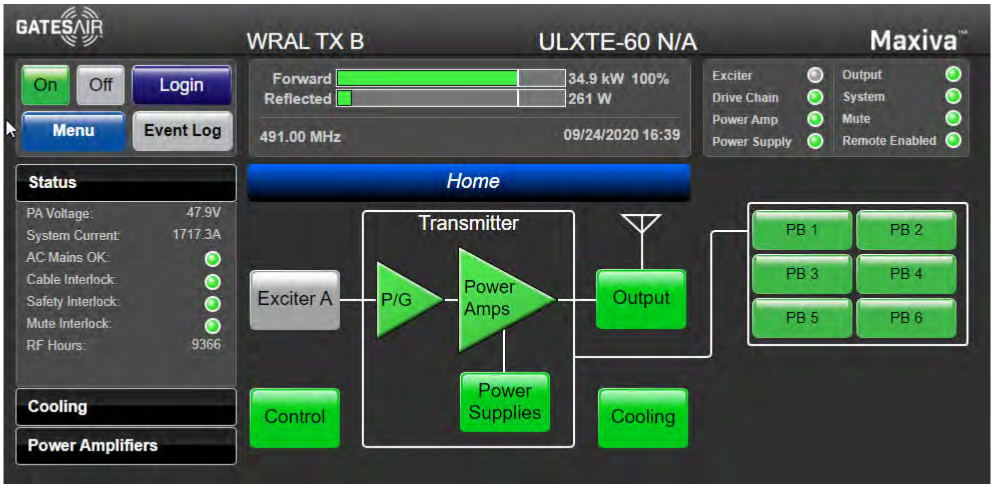
Power Block 4

Power Block 5

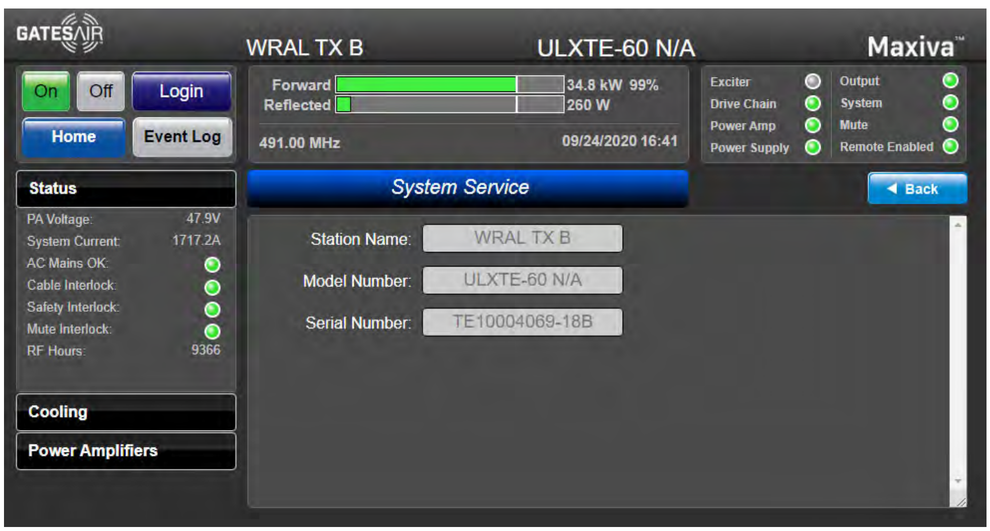
Power Block 6

TRANSMITTER B STM SCREENS

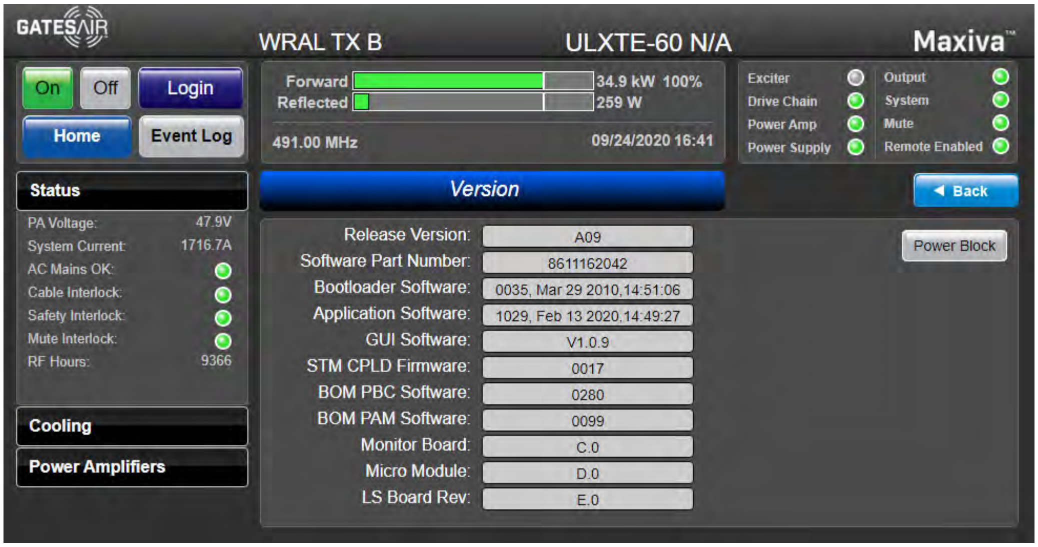
TX B System Home Screen



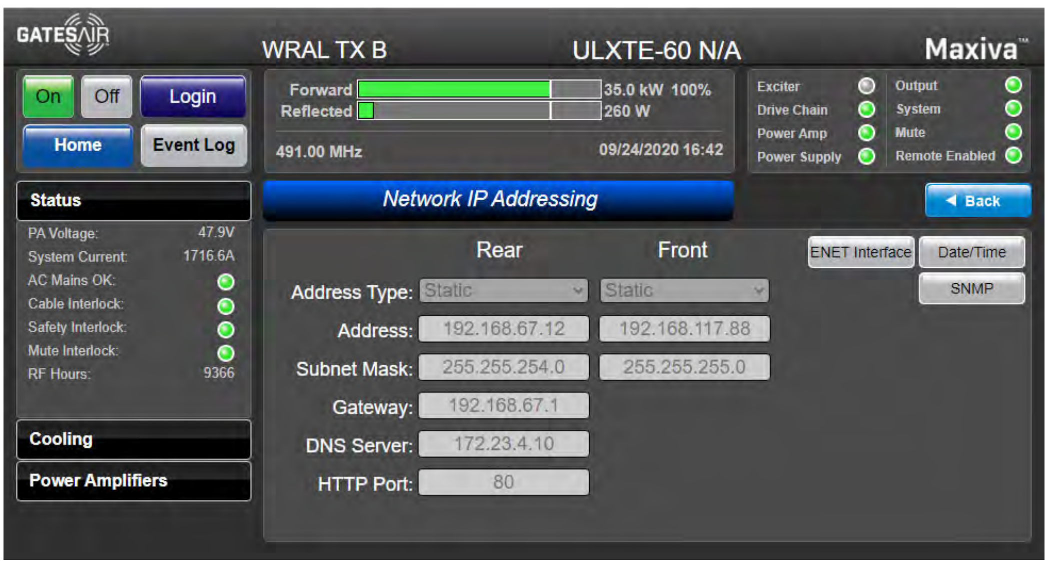
TX B System Service



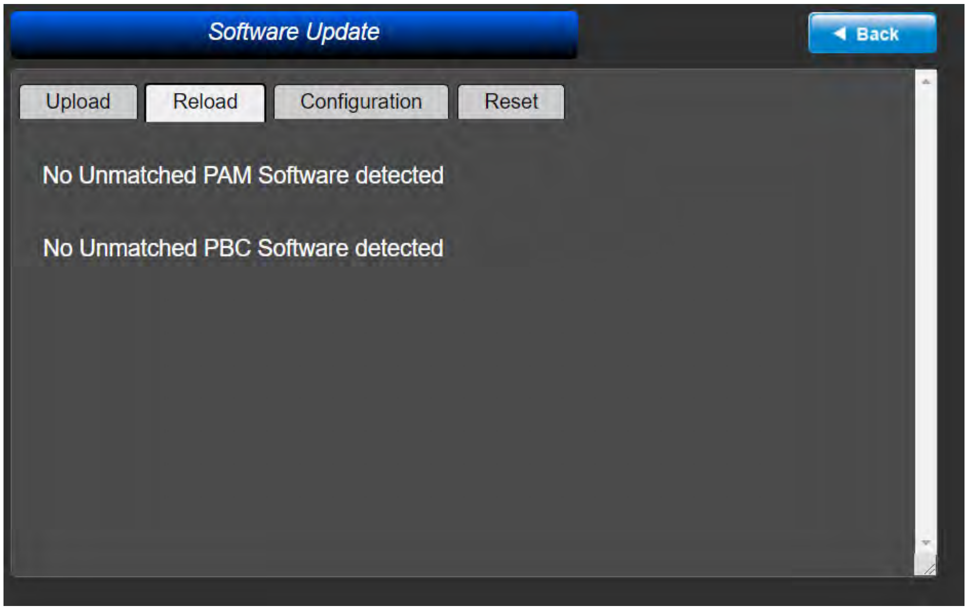
TX B System Version



TX B System Network



<u>TX B Software Management Reload Page</u>

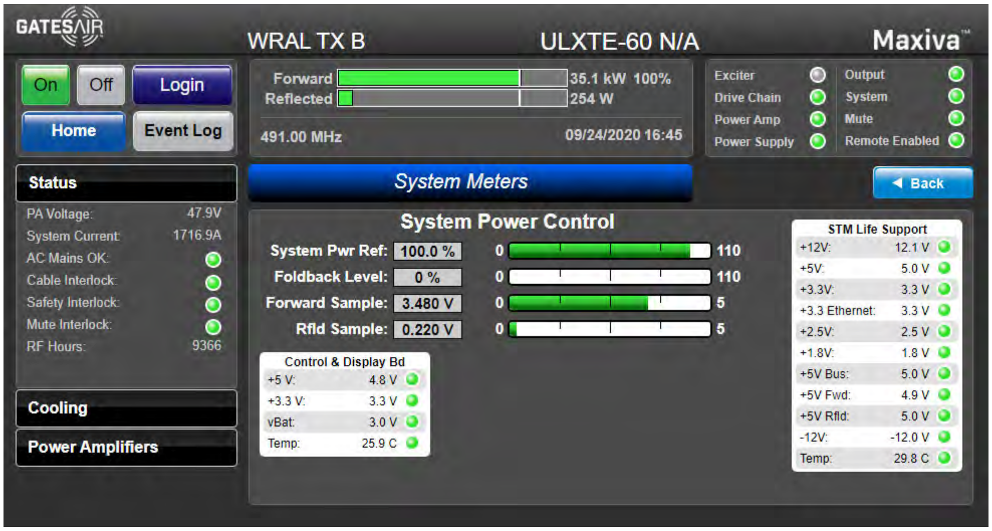


TX B System Phase A

TX B System Phase B

TX B System Gain

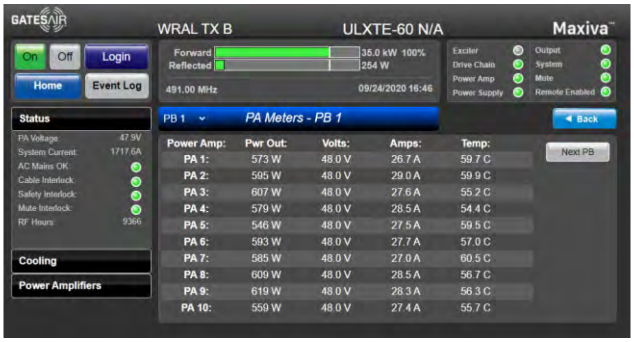
TX B System Meters



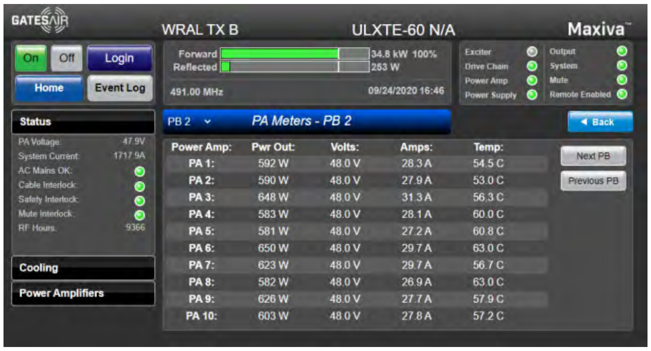
TX B System Output Overview

TX B Cooling Meter Summary

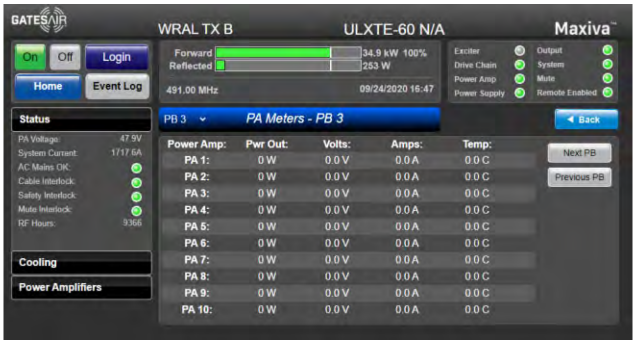
TX B Power Block PA Meters



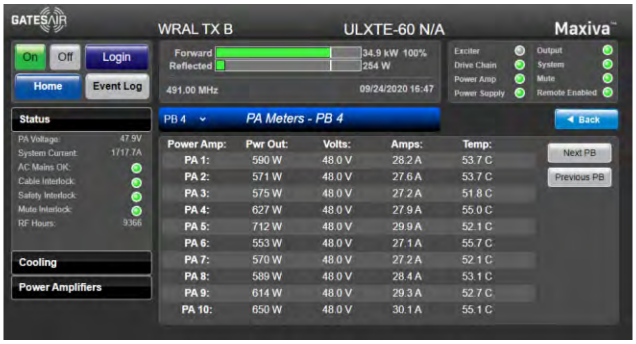
Power Block 1



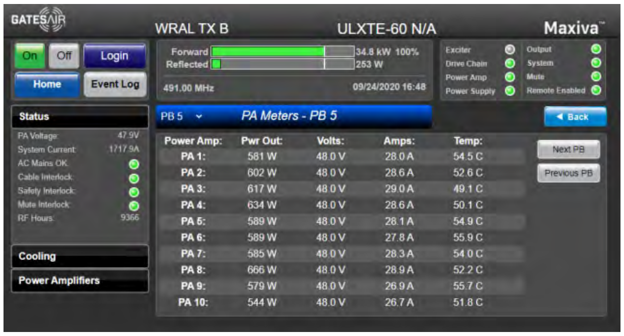
Power Block 2



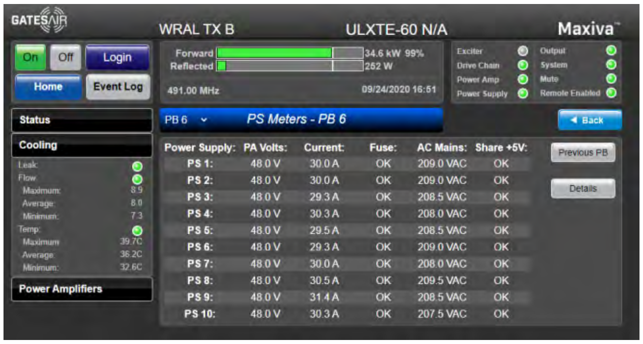
Power Block 3



Power Block 4

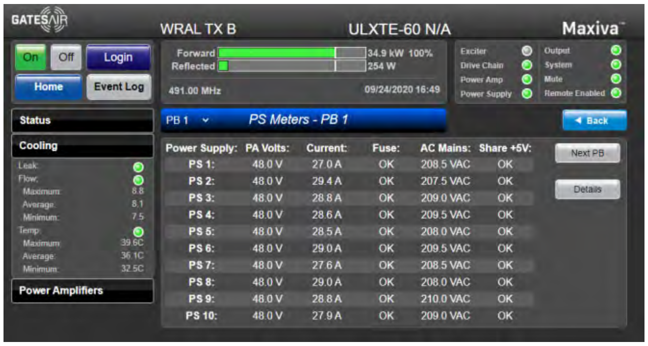


Power Block 5

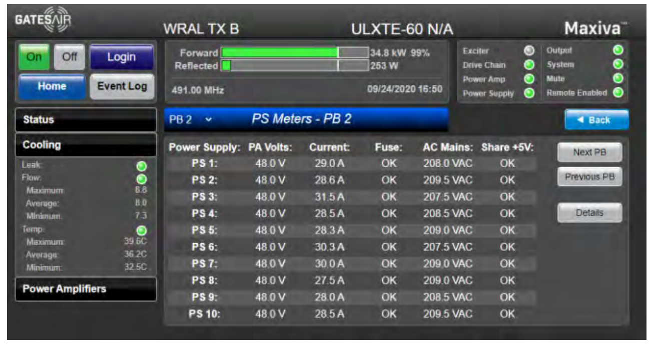


Power Block 6

TX B Power Block PS Meters



Power Block 1



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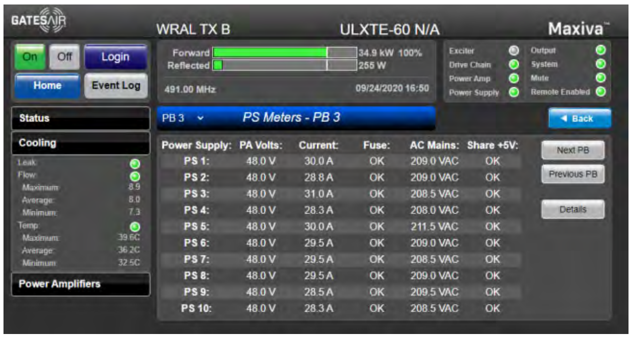

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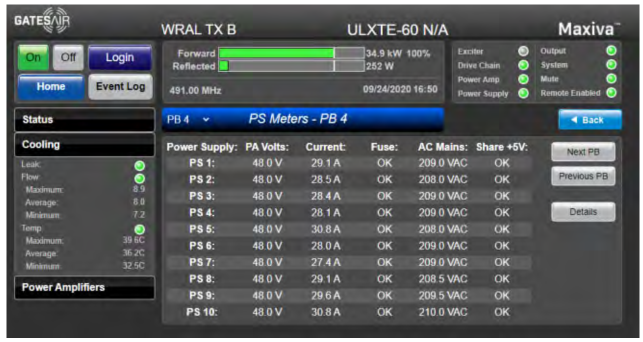

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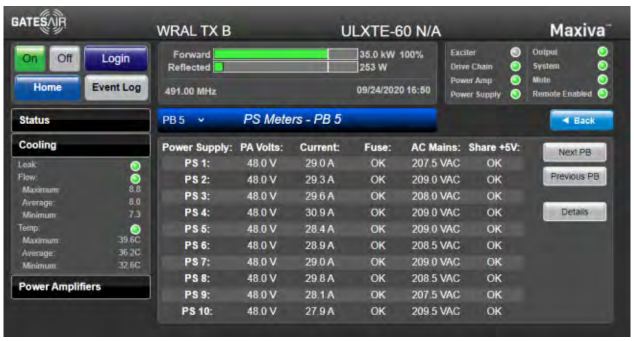
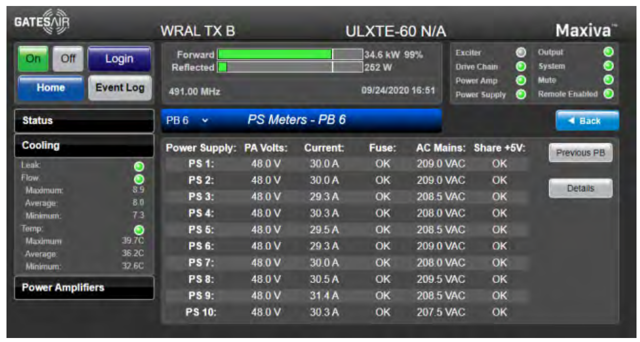


Power Block 5



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

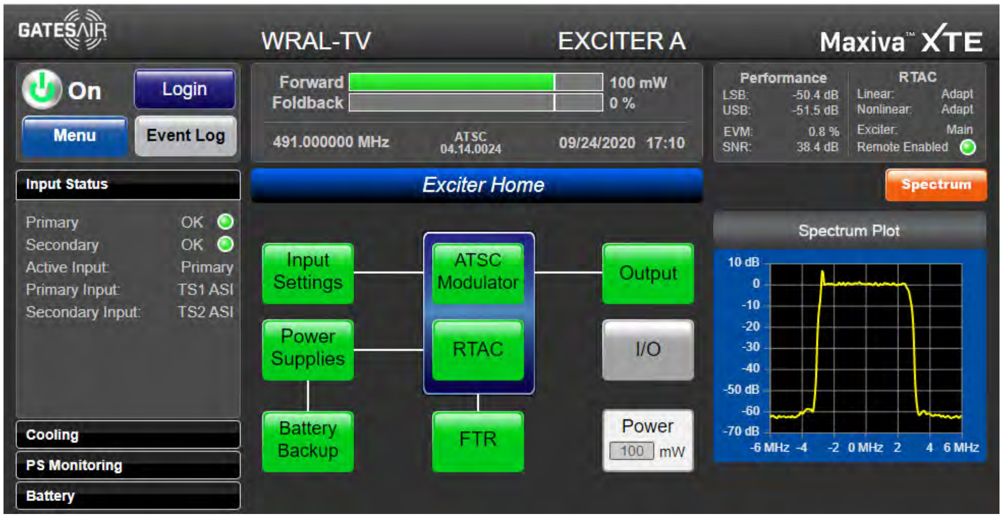
Power Block 3

Power Block 4

Power Block 5

Power Block 6

Exciter Home Screen



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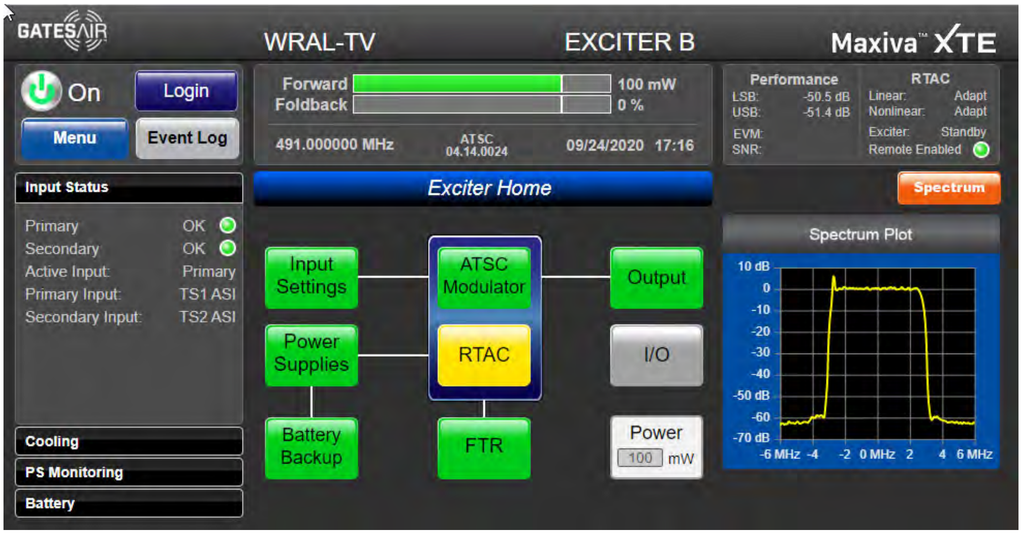


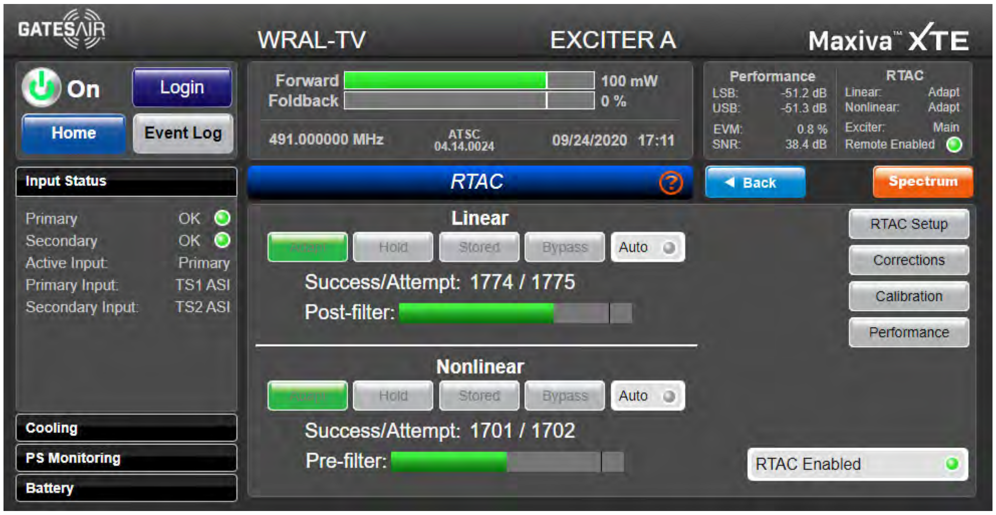
Exciter B

Exciter Software Version

Exciter A

Exciter B

Exciter Home RTAC Screen



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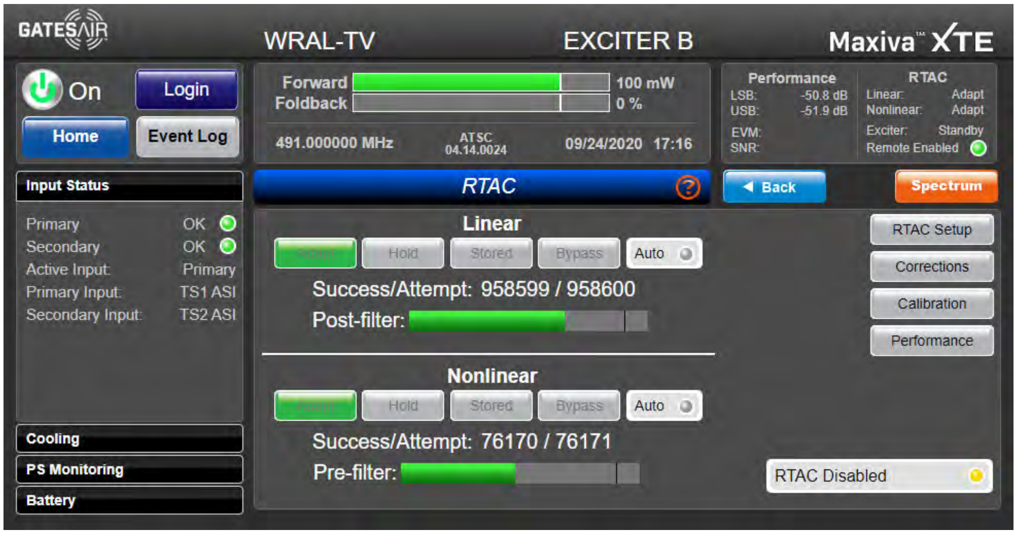
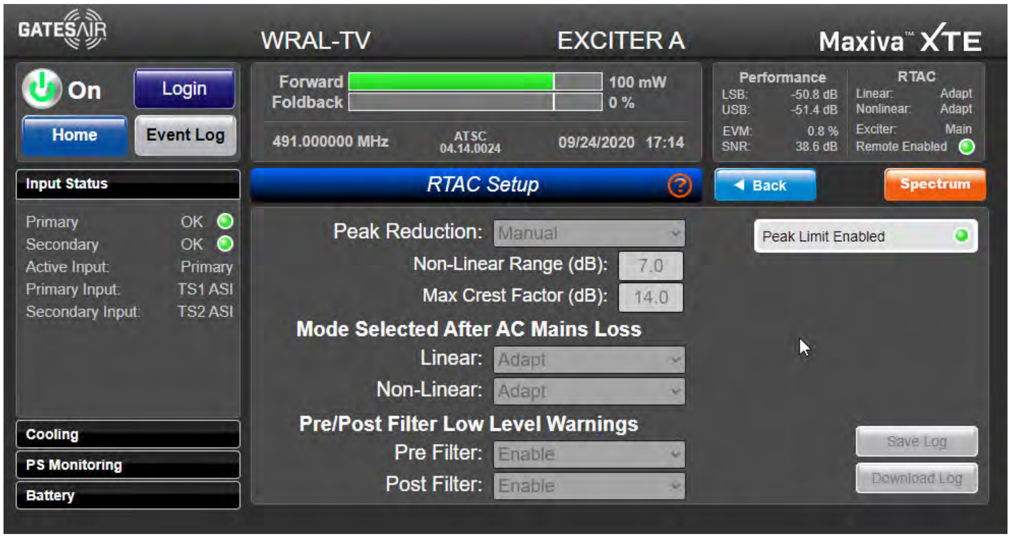


Exciter B

Exciter RTAC Setup



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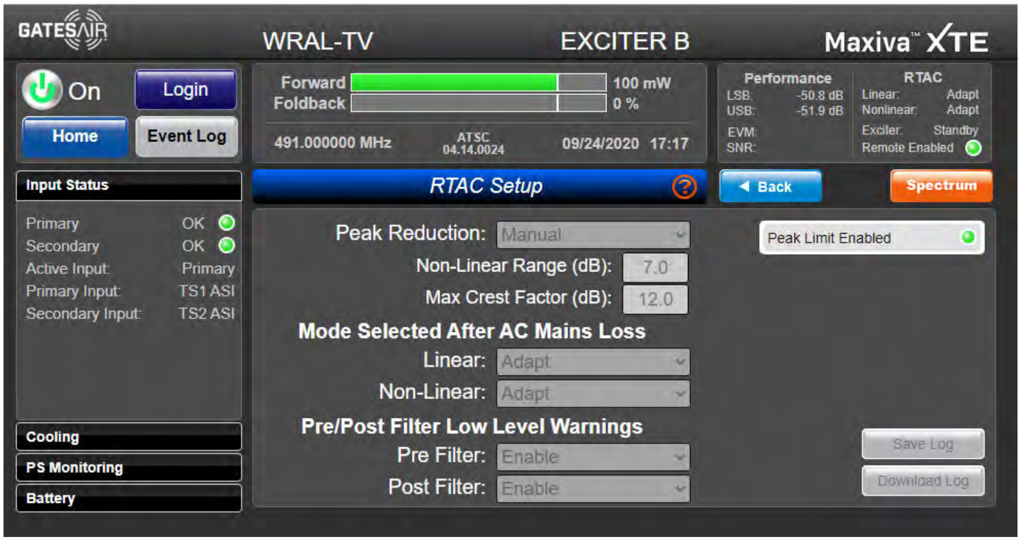


Exciter B

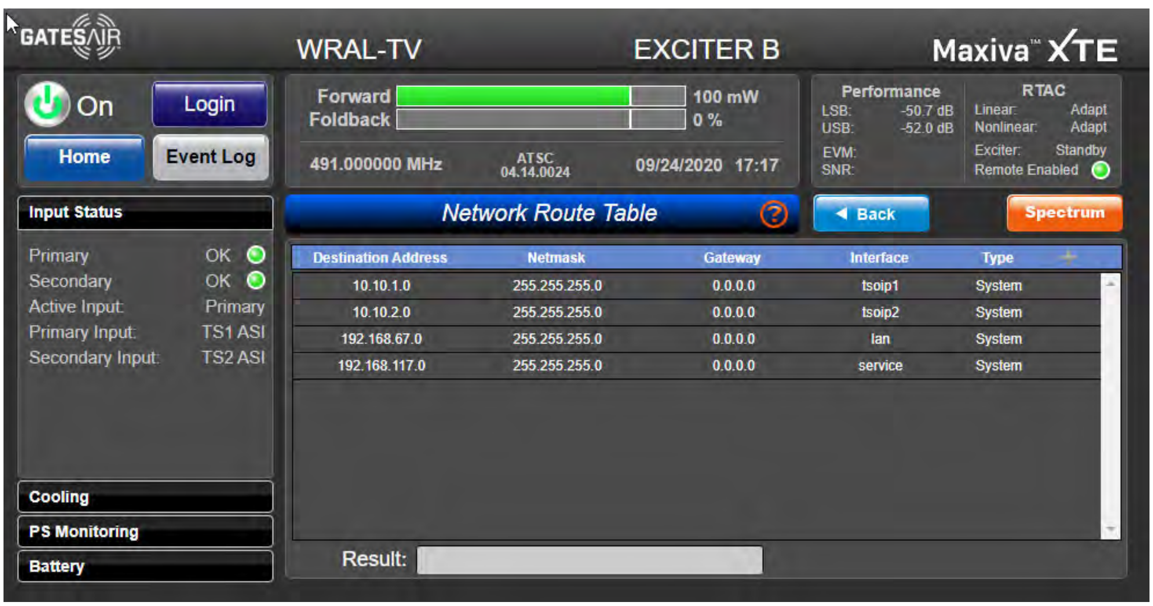
Exciter RTAC Calibration

Exciter A

Exciter B

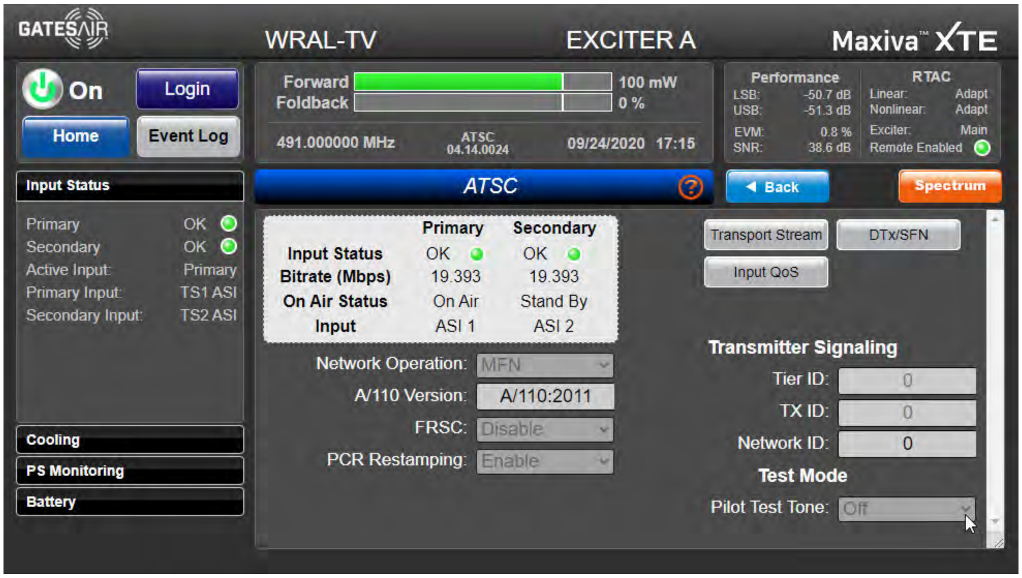
Exciter Network Routes

Exciter A



Exciter B

Exciter Modulator ATSC Setup



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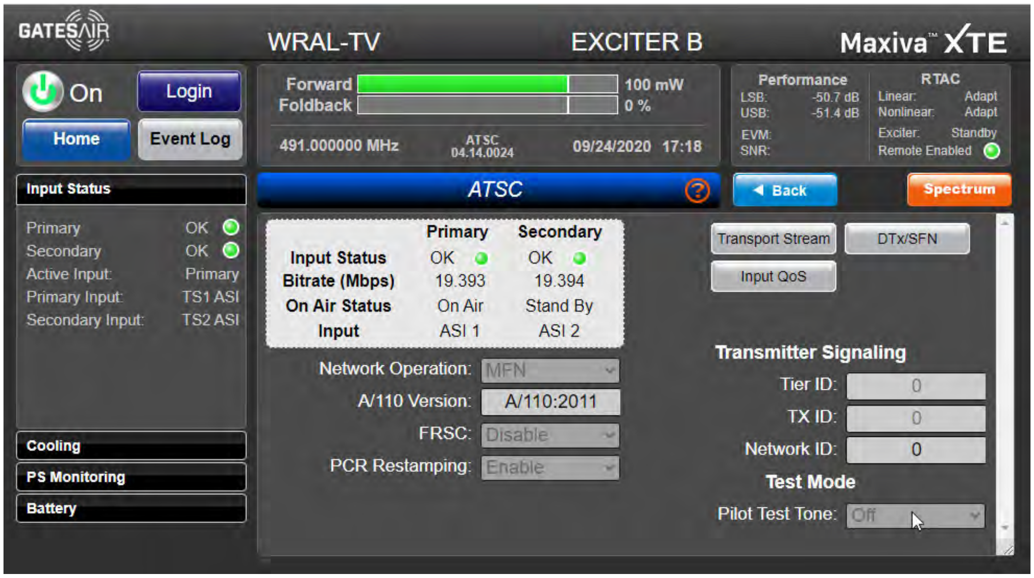
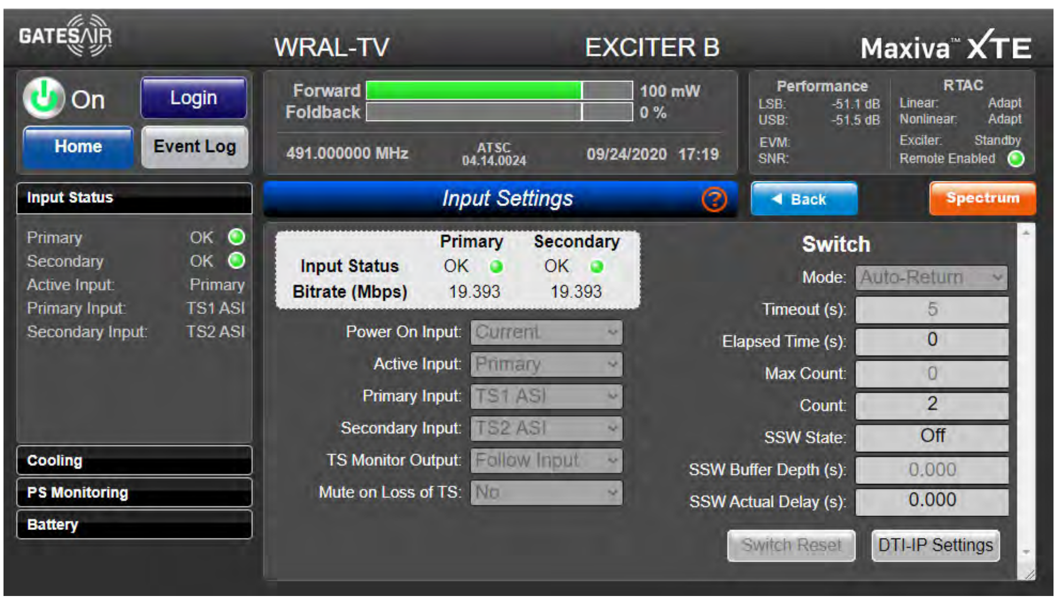


Exciter B

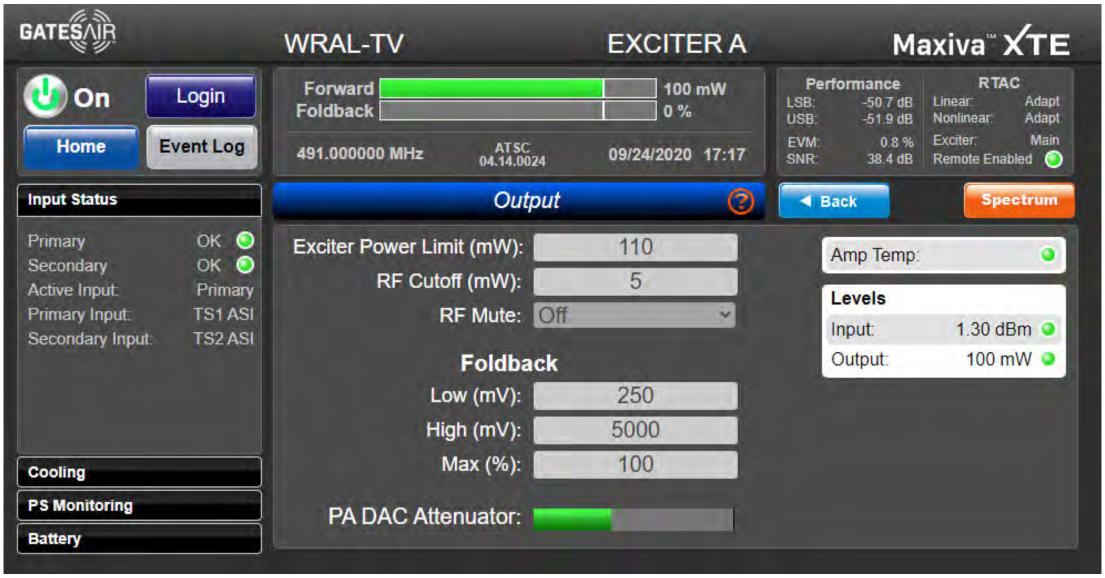
Exciter Input Settings

Exciter A



Exciter B

Exciter Output Config



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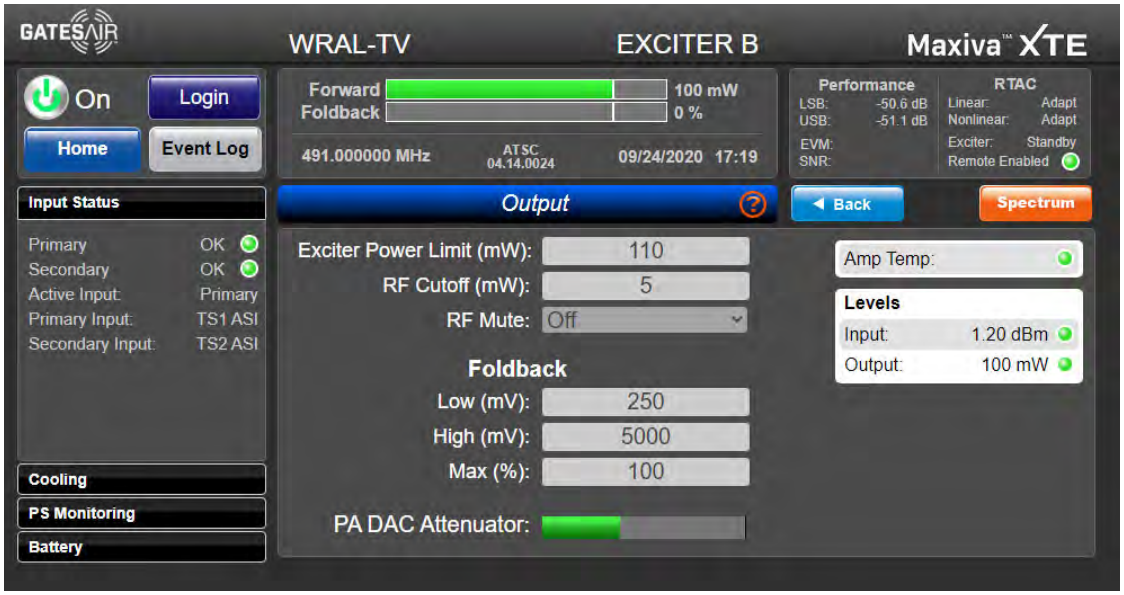
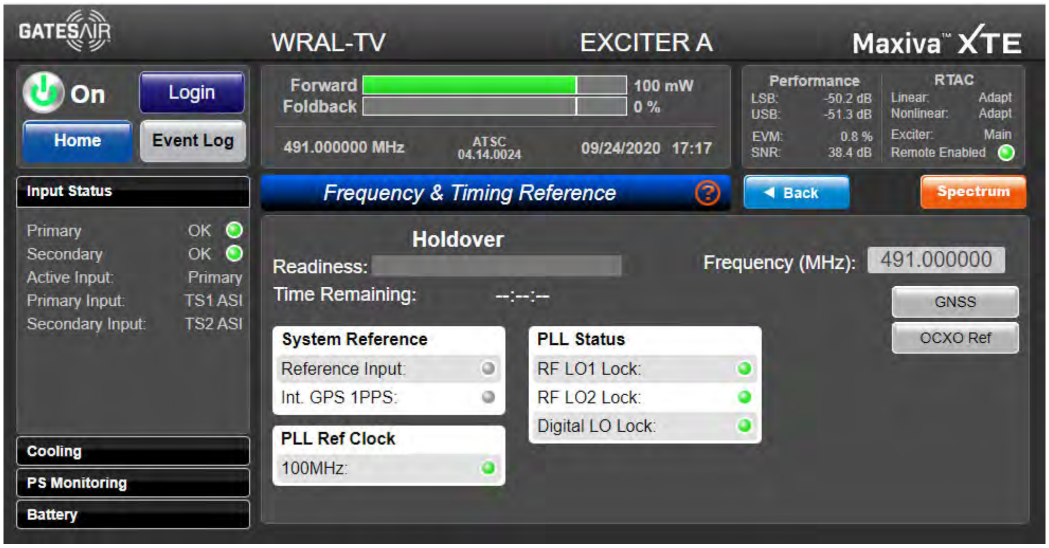


Exciter B

Exciter FTR Reference Config



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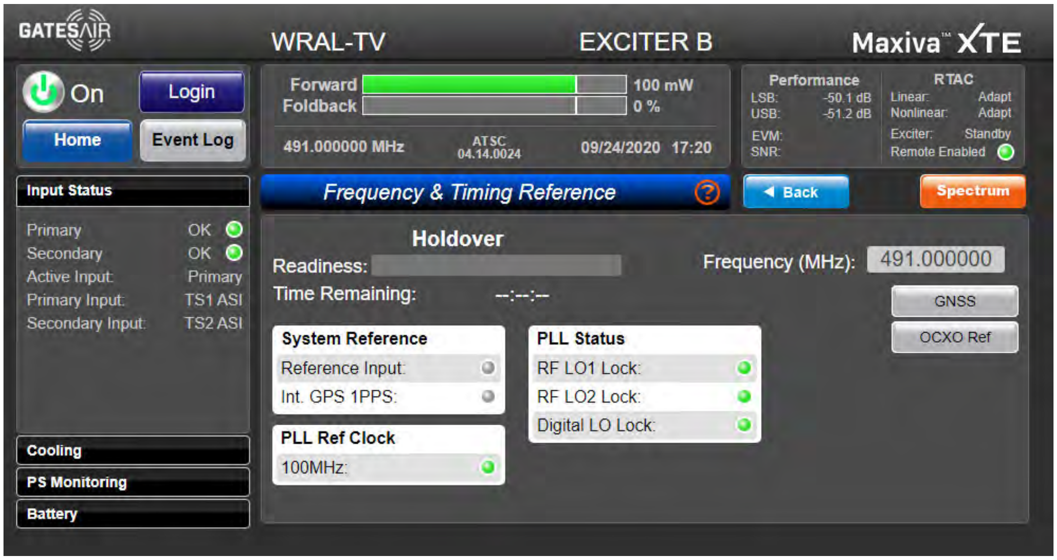
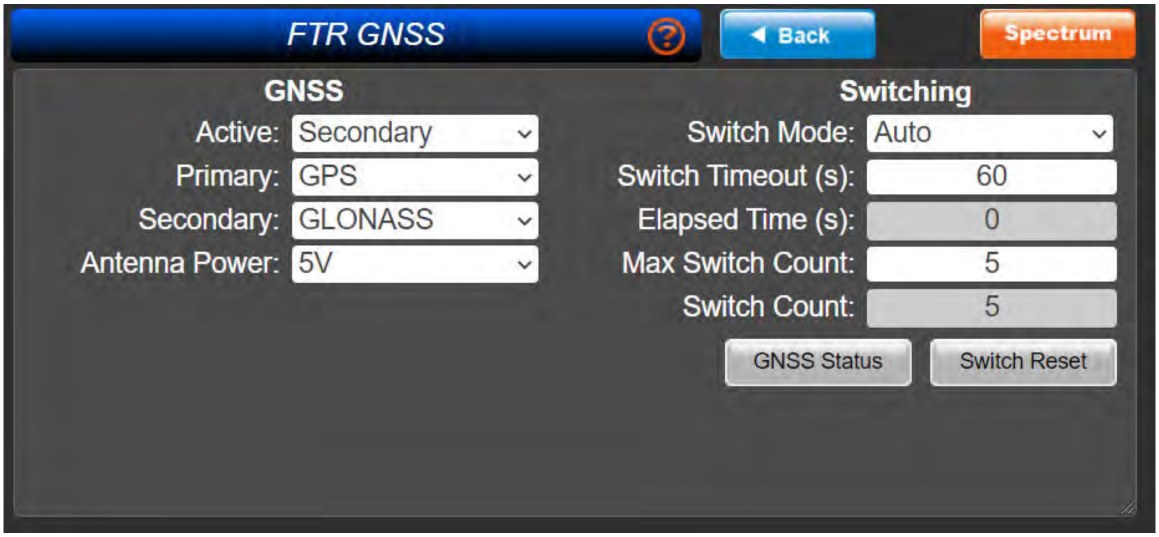


Exciter B

Exciter FTR GNSS



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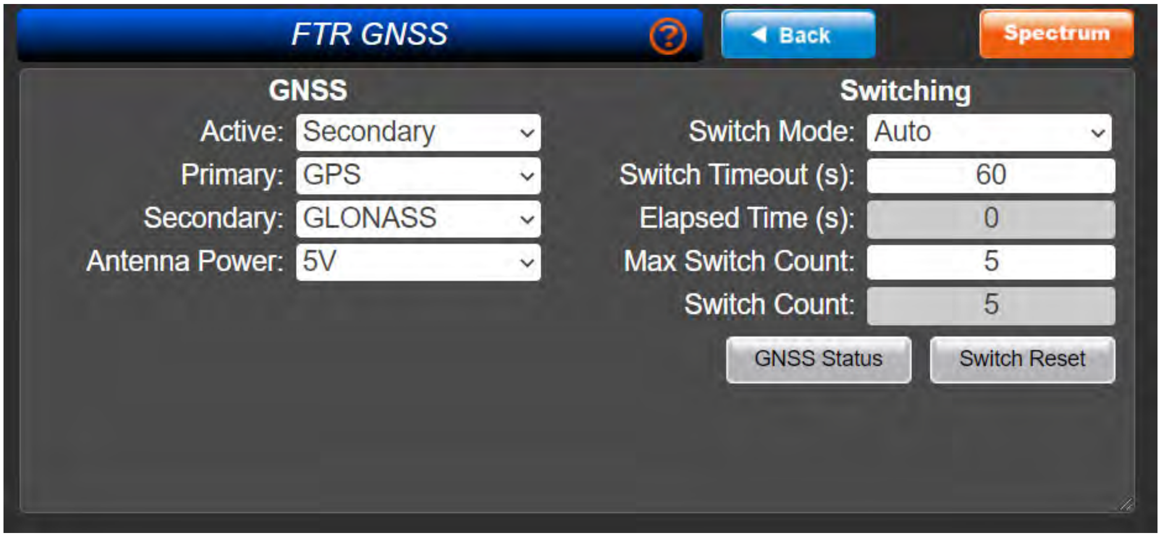
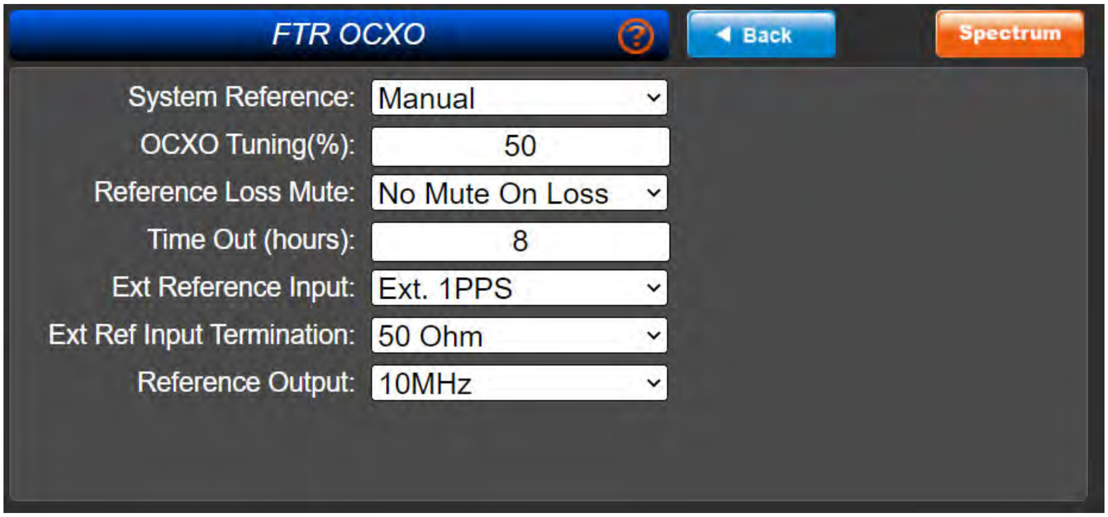
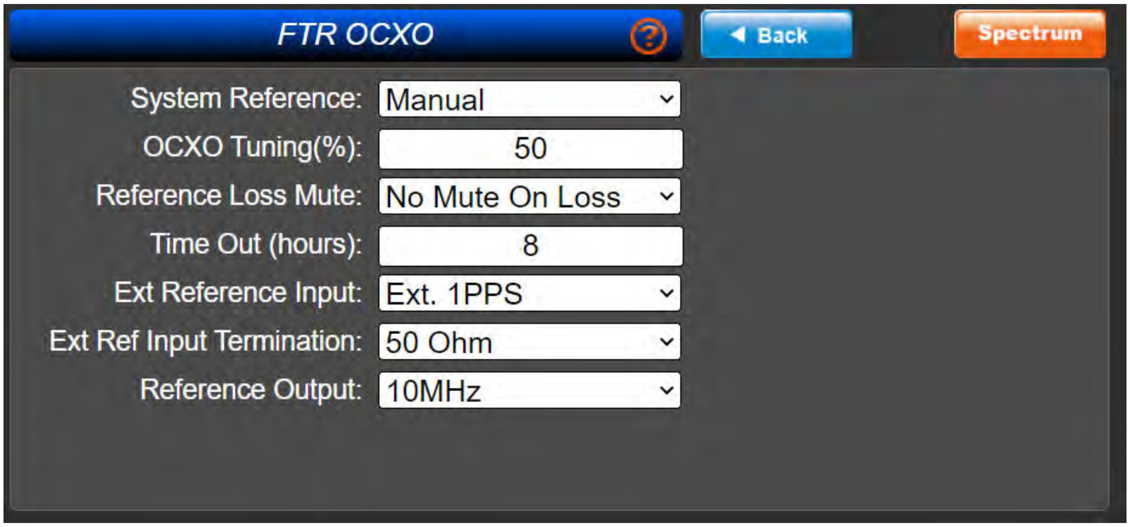


Exciter B

<u>Exciter FTR OCXO</u>



Exciter A



Exciter B

GatesAir Moding Propagation Annex

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:

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

Then

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

Simplifying the equation, it can be approximated to:

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

Where

- fc 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 TE_{11} mode, and this cut-off frequency in air dielectric line is the upper-frequency limit of a practical transmission line. How closely the TE_{11} mode cut-off frequency can be approached depends on the application."

Above the cutoff frequency, the TE_{11} 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 TE_{11} 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 TE_{11} mode is most prevalent in the system. Due to added transmission line lengths and different positions of added transitions, the exact TE_{11} 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 TE_{11} interaction is evident in Figure 1.
Figures 2a-c are plots made from raw network analyzer data from the same ¼ wave directional coupler sweep.

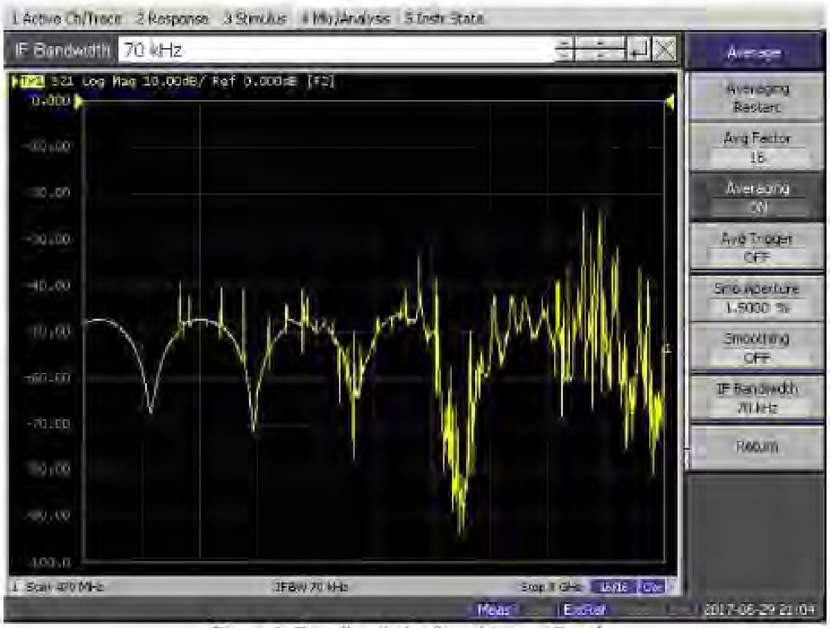


Figure 1. Broadband plot from ¼ wave Coupler

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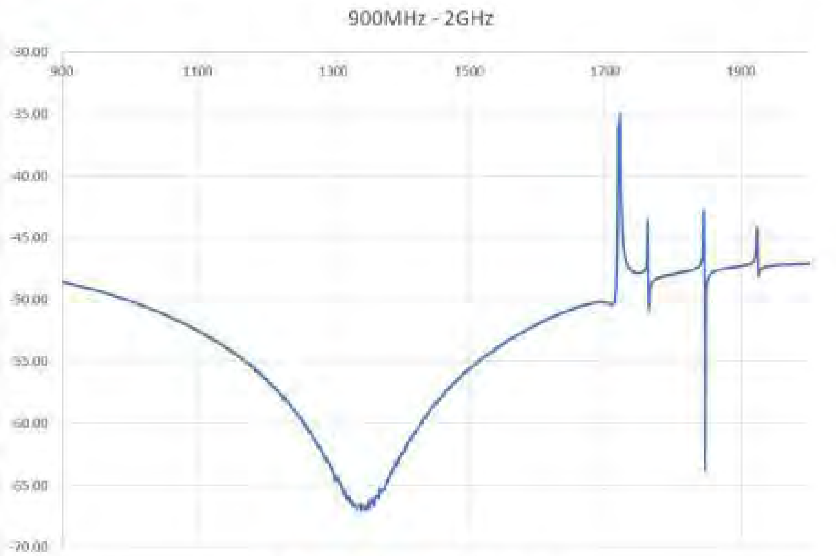

Figure 2a. 900Mhz – 2GHz sweep

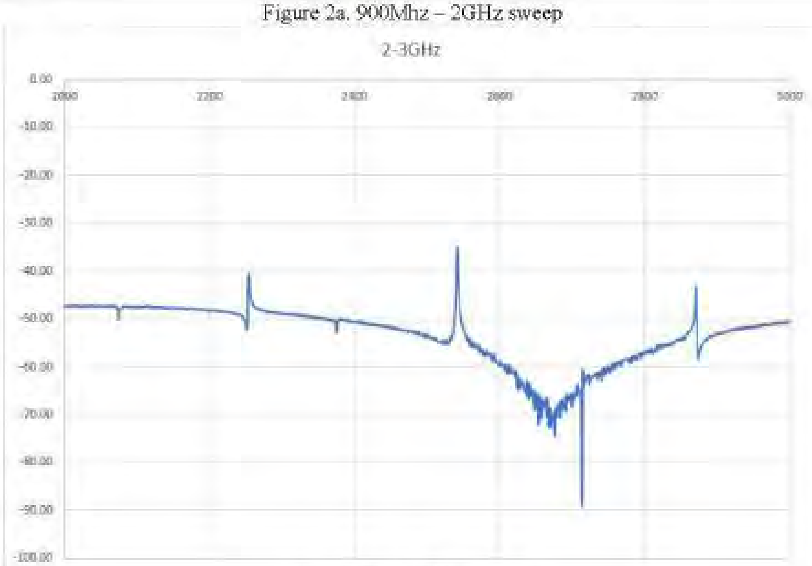

Figure 2b. 2 – 3GHz sweep

3

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		Revision: D

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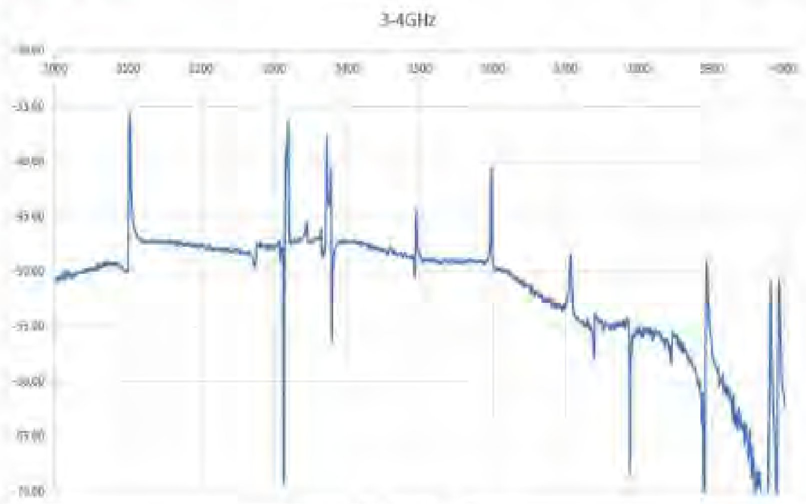

Figure 2c. 3 – 4GHz sweep

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.