Federal Communications Commission
Washington, D. C. 20554

Approved by OMB
3060-0627
Expires 01/31/98

FOR FCC USE ONLY

FCC 302-AM
APPLICATION FOR AM BROADCAST STATION LICENSE

(Please read instructions before filling out form.

FOR COMMISSION USE ONLY
FILE NO. BMML-20110701AEW

SECTION I - APPLICANT FEE INFORMATION

1. PAYOR NAME (Last, First, Middle Initial)

Capstar TX LLC

MAILING ADDRESS (Line 1) (Maximum 35 characters)
2625 S. Memorial

MAILING ADDRESS (Line 2) (Maximum 35 characters)
Suite A

CITY	STATE OR COUNTRY (if foreign address)	ZIP CODE
Tulsa	OK	74129

TELEPHONE NUMBER (include area code)	CALL LETTERS	OTHER FCC IDENTIFIER (If applicable)
918-664-4581	WWVA	Fac ID: 44046

2. A. Is a fee submitted with this application? ☑ Yes ☐ No

B. If No, indicate reason for fee exemption (see 47 C.F.R. Section

☐ Governmental Entity ☐ Noncommercial educational licensee ☐ Other (Please explain):

C. If Yes, provide the following information:

Enter in Column (A) the correct Fee Type Code for the service you are applying for. Fee Type Codes may be found in the "Mass Media Services Fee Filing Guide." Column (B) lists the Fee Multiple applicable for this application. Enter fee amount due in Column (C).

(A) FEE TYPE CODE	(B) FEE MULTIPLE	(C) FEE DUE FOR FEE TYPE CODE IN COLUMN (A)	FOR FCC USE ONLY
M M R	0 0 0 1	$ 635.00	

To be used only when you are requesting concurrent actions which result in a requirement to list more than one Fee Type Code.

(A)	(B)	(C)	FOR FCC USE ONLY
M O R	0 0 0 1	$ 730.00	

	TOTAL AMOUNT REMITTED WITH THIS APPLICATION	FOR FCC USE ONLY
ADD ALL AMOUNTS SHOWN IN COLUMN C, AND ENTER THE TOTAL HERE. THIS AMOUNT SHOULD EQUAL YOUR ENCLOSED REMITTANCE.	$ 1365.00	

SECTION II - APPLICANT INFORMATION		
1. NAME OF APPLICANT Capstar TX LLC		
MAILING ADDRESS 2625 S. Memorial, Ste A		
CITY Tulsa	STATE OK	ZIP CODE 74129

2. This application is for:

☑ Commercial ☐ Noncommercial

☑ AM Directional ☐ AM Non-Directional

Call letters	Community of License	Construction Permit File No.	Modification of Construction Permit File No(s).	Expiration Date of Last Construction Permit
WWVA	Wheeling, WV			

3. Is the station now operating pursuant to automatic program test authority in accordance with 47 C.F.R. Section 73.1620?

☐ Yes ☐ No

If No, explain in an Exhibit.

Exhibit No.

4. Have all the terms, conditions, and obligations set forth in the above described construction permit been fully met?

☐ Yes ☐ No

If No, state exceptions in an Exhibit.

Exhibit No.

5. Apart from the changes already reported, has any cause or circumstance arisen since the grant of the underlying construction permit which would result in any statement or representation contained in the construction permit application to be now incorrect?

☐ Yes ☐ No

If Yes, explain in an Exhibit.

Exhibit No.

6. Has the permittee filed its Ownership Report (FCC Form 323) or ownership certification in accordance with 47 C.F.R. Section 73.3615(b)?

☐ Yes ☐ No

☐ Does not apply

If No, explain in an Exhibit.

Exhibit No.

7. Has an adverse finding been made or an adverse final action been taken by any court or administrative body with respect to the applicant or parties to the application in a civil or criminal proceeding, brought under the provisions of any law relating to the following: any felony; mass media related antitrust or unfair competition; fraudulent statements to another governmental unit; or discrimination?

☐ Yes ☑ No

If the answer is Yes, attach as an Exhibit a full disclosure of the persons and matters involved, including an identification of the court or administrative body and the proceeding (by dates and file numbers), and the disposition of the litigation. Where the requisite information has been earlier disclosed in connection with another application or as required by 47 U.S.C. Section 1.65(c), the applicant need only provide: (i) an identification of that previous submission by reference to the file number in the case of an application, the call letters of the station regarding which the application or Section 1.65 information was filed, and the date of filing; and (ii) the disposition of the previously reported matter.

Exhibit No.

8. Does the applicant, or any party to the application, have a petition on file to migrate to the expanded band (1605-1705 kHz) or a permit or license either in the existing band or expanded band that is held in combination (pursuant to the 5 year holding period allowed) with the AM facility proposed to be modified herein?

☐ Yes ☑ No

If Yes, provide particulars as an Exhibit.

Exhibit No.

The APPLICANT hereby waives any claim to the use of any particular frequency or of the electromagnetic spectrum as against the regulatory power of the United States because use of the same, whether by license or otherwise, and requests and authorization in accordance with this application. (See Section 304 of the Communications Act of 1934, as amended).

The APPLICANT acknowledges that all the statements made in this application and attached exhibits are considered material representations and that all the exhibits are a material part hereof and are incorporated herein as set out in full in

CERTIFICATION

1. By checking Yes, the applicant certifies, that, in the case of an individual applicant, he or she is not subject to a denial of federal benefits that includes FCC benefits pursuant to Section 5301 of the Anti-Drug Abuse Act of 1988, 21 U.S.C. Section 862, or, in the case of a non-individual applicant (e.g., corporation, partnership or other unincorporated association), no party to the application is subject to a denial of federal benefits that includes FCC benefits pursuant to that section. For the definition of a "party" for these purposes, see 47 C.F.R. Section 1.2002(b).

☑ Yes ☐ No

2. I certify that the statements in this application are true, complete, and correct to the best of my knowledge and belief, and are made in good faith.

Name	Signature	
Stephen G. Davis		
Title	Date	Telephone Number
Senior Vice President Engineering	6/28/11	918-664-4581

WILLFUL FALSE STATEMENTS ON THIS FORM ARE PUNISHABLE BY FINE AND/OR IMPRISONMENT (U.S. CODE, TITLE 18, SECTION 1001), AND/OR REVOCATION OF ANY STATION LICENSE OR CONSTRUCTION

FCC NOTICE TO INDIVIDUALS REQUIRED BY THE PRIVACY ACT AND THE PAPERWORK REDUCTION ACT

The solicitation of personal information requested in this application is authorized by the Communications Act of 1934, as amended. The Commission will use the information provided in this form to determine whether grant of the application is in the public interest. In reaching that determination, or for law enforcement purposes, it may become necessary to refer personal information contained in this form to another government agency. In addition, all information provided in this form will be available for public inspection. If information requested on the form is not provided, the application may be returned without action having been taken upon it or its processing may be delayed while a request is made to provide the missing information. Your response is required to obtain the requested authorization.

Public reporting burden for this collection of information is estimated to average 639 hours and 53 minutes per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, can be sent to the Federal Communications Commission, Records Management Branch, Paperwork Reduction Project (3060-0627), Washington, D. C. 20554. Do NOT send completed forms to this address.

THE FOREGOING NOTICE IS REQUIRED BY THE PRIVACY ACT OF 1974, P.L. 93-579, DECEMBER 31, 1974, 5 U.S.C. 552a(e)(3), AND THE PAPERWORK REDUCTION ACT OF 1980, P.L. 96-511, DECEMBER 11, 1980, 44 U.S.C. 3507.

SECTION III - LICENSE APPLICATION ENGINEERING DATA

Name of Applicant
CAPSTAR TX LLC (for license revision with new towers)

PURPOSE OF AUTHORIZATION APPLIED FOR: (check one)

☐ Station License ☑ Direct Measurement of Power

1. Facilities authorized in construction permit

Call Sign	File No. of Construction Permit (if applicable)	Frequency (kHz)	Hours of Operation	Power in kilowatts	
				Night	Day
WWVA	N/A	1170	UNLIMITED	50	50

2. Station location

State	City or Town
WEST VIRGINIA	WHEELING

3. Transmitter location

State	County	City or Town	Street address (or other identification)
OH	BELMONT	ST. CLAIRSVILLE	70130 BARTON ROAD

4. Main studio location

State	County	City or Town	Street address (or other identification)
WV	OHIO	WHEELING	1015 MAIN STREET

5. Remote control point location (specify only if authorized directional antenna)

State	County	City or Town	Street address (or other identification)
WV	OHIO	WHEELING	1015 MAIN STREET

6. Has type-approved stereo generating equipment been installed? ☐ Yes ☑ No

7. Does the sampling system meet the requirements of 47 C.F.R. Section 73.68? ☑ Yes ☐ No ☐ Not Applicable

Attach as an Exhibit a detailed description of the sampling system as installed. Exhibit No. TECH EXHIBIT

8. Operating constants:

RF common point or antenna current (in amperes) without modulation for night system	RF common point or antenna current (in amperes) without modulation for day system
32.45	28.40

Measured antenna or common point resistance (in ohms) at operating frequency		Measured antenna or common point reactance (in ohms) at operating frequency	
Night	Day	Night	Day
50.0	62.0	-j9.0	-j222.0

Antenna indications for directional operation

Towers	Antenna monitor Phase reading(s) in degrees		Antenna monitor sample current ratio(s)		Antenna base currents	
	Night	Day	Night	Day	Night	Day
1 (W)	+ 95.7	N/A	0.492	N/A	N/A	N/A
2 (C)	0.0	N/A	1.000	N/A	N/A	N/A
3 (E)	- 95.0	N/A	0.500	N/A	N/A	N/A

Manufacturer and type of antenna monitor: POTOMAC INSTRUMENTS AM 19 (204)

SECTION III - Page 2

9. Description of antenna system ((f directional antenna is used, the information requested below should be given for each element of the array. Use separate sheets if necessary.)

Type Radiator	Overall height in meters of radiator above base insulator, or above base, if grounded.	Overall height in meters above ground (without obstruction lighting)	Overall height in meters above ground (include obstruction lighting)	If antenna is either top loaded or sectionalized, describe fully in an Exhibit.
UNIFORM CROSS-SECTION, STEEL GUYED	121.9	123.6	124.4	Exhibit No. N/A

Excitation ☑ Series ☐ Shunt

Geographic coordinates to nearest second. For directional antenna give coordinates of center of array. For single vertical radiator give tower location.

North Latitude	West Longitude
40 ° 06 ' 07 "	80 ° 52 ' 02 "

If not fully described above, attach as an Exhibit further details and dimensions including any other antenna mounted on tower and associated isolation circuits. Exhibit No. N/A

Also, if necessary for a complete description, attach as an Exhibit a sketch of the details and dimensions of ground system. Exhibit No. N/A

10. In what respect, if any, does the apparatus constructed differ from that described in the application for construction permit or in the permit?
N/A

11. Give reasons for the change in antenna or common point resistance.

I certify that I represent the applicant in the capacity indicated below and that I have examined the foregoing statement of technical information and that it is true to the best of my knowledge and belief.

Name (Please Print or Type)	Signature
RONALD D. RACKLEY, P.E.	Ronald D. Rackley
Address (include ZIP Code) DUTREIL, LUNDIN & RACKLEY, INC. 201 FLETCHER AVENUE SARASOTA, FL 34237	Date 6/23/2011 Telephone No. (Include Area Code) 941-329-6000

☐ Technical Director ☑ Registered Professional Engineer

☐ Chief Operator ☐ Technical Consultant

☐ Other (specify)

du Treil, Lundin & Rackley, Inc.
Consulting Engineers

APPLICATION FOR LICENSE
INFORMATION
RADIO STATION WWVA
WHEELING, WEST VIRGINIA

JUNE 23, 2011

1170 KHZ 50 KW U DA-N

APPLICATION FOR LICENSE
INFORMATION
RADIO STATION WWVA
WHEELING, WEST VIRGINIA

1170 KHZ 50 KW U DA-N

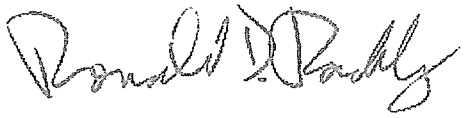
Table of Contents

Executive Summary - WWVA

This engineering exhibit supports an application for Direct Measurement of Power (requesting modification of the station license to specify new antenna monitor operating parameters) for the directional antenna system of radio station WWVA in Wheeling, West Virginia. WWVA operates fulltime on 1170 kilohertz with 50 kilowatts, employing a directional antenna during nighttime hours.

The authorized WWVA directional antenna theoretical parameters and array geometry remain unchanged. The antenna monitor operating parameters specified herein were derived through Method of Moments modeling following replacement of the antenna system's three self-supporting towers with new guyed, uniform cross section towers. The former self-supporting towers were in use until they were destroyed by high winds during a storm in August of 2010. The RF networks in the antenna tuning units ("ATUs") at the tower bases were modified with new components to match the base impedances of the new towers and the remainder of the phasing and coupling equipment remains unchanged. New antenna monitor sampling lines and sampling loops were installed on the new towers and the remainder of the sampling system remains unchanged.

Information is provided herein demonstrating that the directional antenna parameters have been determined in accordance with the requirements of section 73.151(c) of the FCC Rules. The antenna system has been adjusted to produce antenna monitor parameters within +/- 5 percent in ratio and +/- 3 degrees in phase of the modeled values, as required by the Rules. Information regarding direct measurement of power is also included herein.



Ronald D. Rackley, P.E.
June 23, 2011

Analysis of Tower Impedance Measurements to Verify Method of Moments Model - WWVA

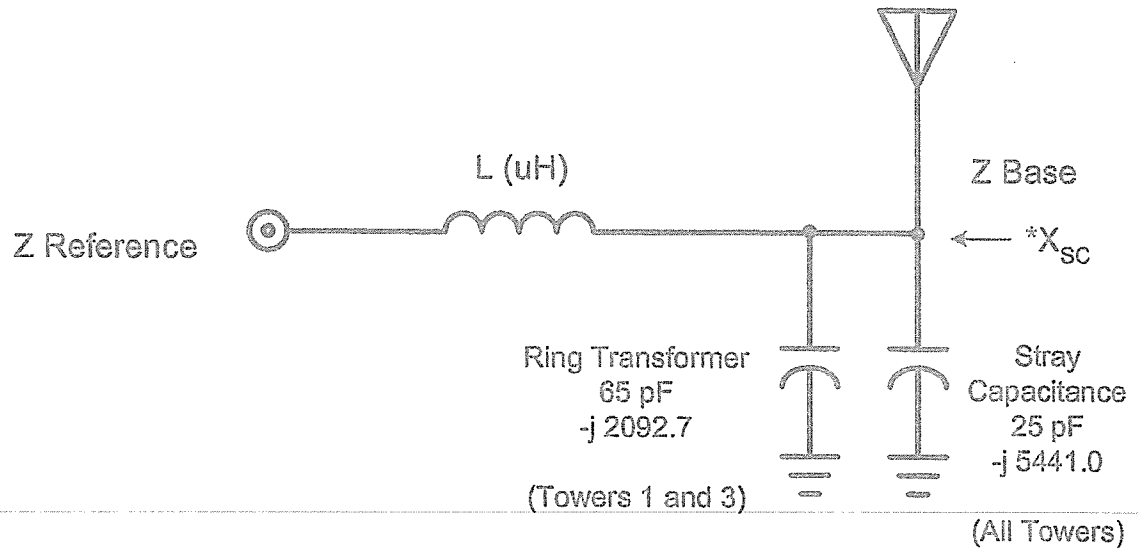
Tower base impedance measurements were made at the final J-plugs within the antenna tuning units ("ATUs") using a Hewlett-Packard 4396A network analyzer and a Tunwall Radio directional coupler in a calibrated measurement system. The other towers were short circuited directly across their base insulators for each of the measurements. The sampling line isolation coils with their parallel adjustable capacitors were disconnected from the towers for the measurements so that the impedances would not be impacted by them.

The reference point at each tower is at the output of the ATU enclosure. The current passes directly from that point over conductors through the enclosure insulator and on to the tower above the base insulator. An assumed value for the sum of the base insulator and base region stray capacitances across the ATU output were employed in the base circuit calculations for each tower. In addition, assumed capacitances representing the ring transformers that couple electric power to the tower lights on towers 1 and 3 were included in the analysis. Circuit calculations were performed to relate the method of moments modeled impedances of the tower feedpoints to the ATU output measurement (reference) points as shown on the following pages. Values for the series hookup inductances between the ATUs and tower bases were derived for the calculations. The appropriateness of the assumed capacitances is demonstrated by the modeling results.

In addition to the page showing the schematic of the assumed circuit and tabulation of calculated values, pages showing the results of calculations using the WCAP network analysis program from Westberg Consulting are provided. WCAP performs such calculations using nodal analysis, as do other modern circuit analysis programs such as the commonly available ones based on SPICE software.

In each of the WCAP tabulations, node 2 represents the ATU output reference point and node 3 represents the tower feedpoint. Node 0 represents ground potential. The numerals in the file names shown on the tabulations correspond to the tower numbers. It should be noted that the calculated reference point impedances appear under the "TO NODE IMPEDANCE" columns of the WCAP tabulations, following the phantom 1.0 ohm resistors (R 1 - 2) that were included in series with the drive current sources (I 0 -1)) to provide calculation points for the impedances. The tower base impedances from the method of moments model are represented by complex loads from node 3 to ground (R 3 - 0). The shunt capacitive reactances shown for the towers on the schematic were used for the calculations, although they only appear to the nearest 0.0001 microfarad on the WCAP printout due to rounding.

The modeled and measured base impedances at the ATU output jacks with the other towers open circuited at their filter unit output jacks agree within +/- 2 ohms and +/- 4 percent for resistance and reactance, as required by the FCC Rules.



* Impedance measurements were made with the other towers short circuited directly across their base insulators

TOWER	L (uH)	X_L	$*X_{sc}$	Z Base (Modeled)	Z Reference (Modeled)	Z Reference (Measured)
1 (W)	3.319	+j 24.4	0.0	300.9 -j 423.7	179.2 -j 334.4	178.6 -j 334.4
2 (C)	2.122	+j 15.6	0.0	281.8 -j 407.0	243.4 -j 374.8	243.5 -j 374.8
3 (E)	3.809	+j 28.0	0.0	320.7 -j 427.8	189.6 -j 336.8	189.6 -j 336.8

ANALYSIS OF TOWER IMPEDANCE MEASUREMENTS TO VERIFY METHOD OF MOMENTS MODEL

RADIO STATION WWVA
WHEELING, WEST VIRGINIA
1170 KHZ 50 KW U DA-N

du Treil, Lundin & Rackley, Inc. Sarasota, Florida

Tower 1 Individually Driven Base Circuit Analysis

WESTBERG CIRCUIT ANALYSIS PROGRAM

FILE NAME = WWVA1SC.txt

I	1.0000	0	1	.0000	.0000	.0000
R	1.0000	1	2	.0000	.0000	.0000
L	3.3190	2	3	.0000	.0000	.0000
C	.0000	3	0	.0000	.0000	.0000
C	.0001	3	0	.0000	.0000	.0000
R	300.9000	3	0	-423.7000	.0000	.0000
EX	.0000	0	0	.0000	.0000	.0000

FREQ = 1.170

NODE	VOLT MAG	VOLT PHASE
1	379.8757	-61.6772
2	379.4023	-61.8102
3	401.0730	-63.4570

				BRANCH VOLTAGE		BRANCH CURRENT		FROM NODE IMPEDANCE		TO NODE IMPEDANCE	
R	1-	2	1.000	1.00	.000	1.00	.000	180.23	-334.40	179.23	-334.40
L	2-	3	3.319	24.40	90.000	1.00	.000	179.23	-334.40	179.23	-358.80
C	3-	0	.000	401.07	-63.457	.07	26.543	.00	-5441.19	.00	.00
C	3-	0	.000	401.07	-63.457	.19	26.543	.00	-2092.77	.00	.00
R	3-	0	300.900	401.07	-63.457	.77	-8.838	300.90	-423.70	.00	.00

Tower 2 Individually Driven Base Circuit Analysis

WESTBERG CIRCUIT ANALYSIS PROGRAM

FILE NAME = wwva2sc.txt

I	1.0000	0	1	.0000	.0000	.0000
R	1.0000	1	2	.0000	.0000	.0000
L	2.1220	2	3	.0000	.0000	.0000
C	.0000	3	0	.0000	.0000	.0000
R	281.8000	3	0	-407.0000	.0000	.0000
EX	.0000	0	0	.0000	.0000	.0000

FREQ = 1.170

NODE	VOLT MAG	VOLT PHASE
1	447.4339	-56.8951
2	446.8885	-57.0025
3	460.0501	-58.0606

				BRANCH VOLTAGE		BRANCH CURRENT		FROM NODE IMPEDANCE		TO NODE IMPEDANCE	
				MAG	PHASE	MAG	PHASE	RESISTANCE	REACTANCE	RESISTANCE	REACTANCE
R	1-	2	1.000	1.00	.000	1.00	.000	244.38	-374.80	243.38	-374.80
L	2-	3	2.122	15.60	90.000	1.00	.000	243.38	-374.80	243.38	-390.40
C	3-	0	.000	460.05	-58.061	.08	31.939	.00	-5441.19	.00	.00
R	3-	0	281.800	460.05	-58.061	.93	-2.759	281.80	-407.00	.00	.00

Tower 3 Individually Driven Base Circuit Analysis

WESTBERG CIRCUIT ANALYSIS PROGRAM

FILE NAME = WWVA3SC.txt

I	1.0000	0	1	.0000	.0000	.0000
R	1.0000	1	2	.0000	.0000	.0000
L	3.8090	2	3	.0000	.0000	.0000
C	.0000	3	0	.0000	.0000	.0000
C	.0001	3	0	.0000	.0000	.0000
R	320.7000	3	0	-427.8000	.0000	.0000
EX	.0000	0	0	.0000	.0000	.0000

FREQ = 1.170

NODE	VOLT MAG	VOLT PHASE
1	386.9917	-60.4893
2	386.5001	-60.6183
3	411.1291	-62.5332

			BRANCH VOLTAGE MAG	BRANCH VOLTAGE PHASE	BRANCH CURRENT MAG	BRANCH CURRENT PHASE	FROM NODE IMPEDANCE RESISTANCE	FROM NODE IMPEDANCE REACTANCE	TO NODE IMPEDANCE RESISTANCE	TO NODE IMPEDANCE REACTANCE
R	1- 2	1.000	1.00	.000	1.00	.000	190.63	-336.78	189.63	-336.78
L	2- 3	3.809	28.00	90.000	1.00	.000	189.63	-336.78	189.63	-364.79
C	3- 0	.000	411.13	-62.533	.08	27.467	.00	-5441.19	.00	.00
C	3- 0	.000	411.13	-62.533	.20	27.467	.00	-2092.77	.00	.00
R	3- 0	320.700	411.13	-62.533	.77	-9.390	320.70	-427.80	.00	.00

Derivation of Operating Parameters for Nighttime Directional Antenna – WWVA

The method of moments model of the array, following verification with the measured individual short circuited base impedances, was utilized for directional antenna calculations. Calculations were made to determine the complex voltage values for sources located at ground level under each tower of the array to produce current moment sums for the towers that, when normalized, equated to the theoretical field parameters of the authorized directional antenna pattern. With these voltage sources, the tower currents were calculated. Twenty segments were used for each tower, so that the modeled current pulse between the seventh and eighth segments above ground level would correspond to the sampling loop location on each tower – at 35 percent of the total tower height above the base insulator. These pulses have the minimum currents along the towers when they are modeled to be detuned. As the tower structures, sampling loops and sampling lines are identical, the antenna monitor ratios and phases corresponding to the theoretical parameters were calculated directly from the modeled tower currents.

TOWER	Modeled Current Pulse	Modeled Current Magnitude at Loop (amperes)	Modeled Current Phase at Loop (degrees)	Modeled Antenna Monitor Ratio	Modeled Antenna Monitor Phase (degrees)
1 (W)	8	8.017	+95.7	0.492	+95.7
2 (C)	28	16.304	360.0	1.000	0.0
3 (E)	48	8.160	265.0	0.500	-95.0

Method of Moments Model Details for Towers Driven Individually – WWVA

The array of towers was modeled using Expert MININEC Broadcast Professional Version 14.5. One wire was used to represent each tower. The tower geometry was specified using the geographic coordinate system. Each tower was modeled using 20 wire segments. As the towers are physically 171.3 degrees in electrical height, the segment length is 8.57 electrical degrees.

The individual tower characteristics were adjusted to provide a match of their modeled impedances, when presented to a circuit model which included branches representing the shunt capacitances and feedline hookup inductances, with the base impedances that were measured at the output jacks of the filter units while the other towers of the array were short circuited. The method of moments model did not have loads at the bases of the short circuited towers, as they were shorted to ground directly across their base insulators and, hence, had zero impedance to ground insofar as the electromagnetic model was concerned.

Each tower's modeled height relative to its physical height falls within the required range of 75 to 125 percent and each modeled radius falls within the required range of 80 percent to 150 percent of the radius of a circle having a circumference equal to the sum of the widths of the tower sides. The array consists of identical, triangular uniform cross section towers having a face width of 36 inches.

TOWER	Physical Height (degrees)	Modeled Height (degrees)	Modeled Percent of Height	Modeled Radius (meters)	Percent Equivalent Radius
1	171.3	181.2	105.8	0.437	100
2	171.3	179.4	104.7	0.437	100
3	171.3	179.9	105.0	0.437	100

The following pages show the details of the method of moments models for the individually driven towers. The numerals in the file names shown on the tabulations correspond to the tower numbers.

Tower 1 Driven Individually

C:\MBPRO\WWVA1SC 06-16-2011 20:48:54

IMPEDANCE
normalization = 50.

freq (MHz)	resist (ohms)	react (ohms)	imped (ohms)	phase (deg)	VSWR	S11 dB	S12 dB
source = 1; node 1, sector 1							
1.17	300.92	-423.68	519.67	305.4	18.06	-.9629	-7.0146

GEOMETRY
Wire coordinates in degrees; other dimensions in meters
Environment: perfect ground

wire	caps	Distance	Angle	Z	radius	segs
1	none	0	0	0	.437	20
		0	0	181.2		
2	none	90.	77.	0	.437	20
		90.	77.	179.4		
3	none	180.	77.	0	.437	20
		180.	77.	179.9		

Number of wires = 3
current nodes = 60

	minimum		maximum	
Individual wires	wire	value	wire	value
segment length	2	8.97	1	9.06
radius	1	.437	1	.437

ELECTRICAL DESCRIPTION
Frequencies (MHz)

no.	frequency lowest	step	no. of steps	segment length (wavelengths) minimum	maximum
1	1.17	0	1	.0249167	.0251667

Sources

source	node	sector	magnitude	phase	type
1	1	1	1.	0	voltage

Tower 2 Driven Individually

C:\MBPRO\WWVA2SC 06-16-2011 20:52:29

IMPEDANCE
normalization = 50.

freq (MHz)	resist (ohms)	react (ohms)	imped (ohms)	phase (deg)	VSWR	S11 dB	S12 dB
source = 1; node 21, sector 1							
1.17	281.82	-406.98	495.03	304.7	17.511	-.99314	-6.8949

GEOMETRY
Wire coordinates in degrees; other dimensions in meters
Environment: perfect ground

wire	caps	Distance	Angle	Z	radius	segs
1	none	0	0	0	.437	20
		0	0	181.2		
2	none	90.	77.	0	.437	20
		90.	77.	179.4		
3	none	180.	77.	0	.437	20
		180.	77.	179.9		

Number of wires = 3
current nodes = 60

	minimum		maximum	
Individual wires	wire	value	wire	value
segment length	2	8.97	1	9.06
radius	1	.437	1	.437

ELECTRICAL DESCRIPTION
Frequencies (MHz)

no.	frequency lowest	step	no. of steps	segment length (wavelengths) minimum	maximum
1	1.17	0	1	.0249167	.0251667

Sources

source	node	sector	magnitude	phase	type
1	21	1	1.	0	voltage

Tower 3 Driven Individually

C:\MBPRO\WWVA3SC 06-16-2011 20:54:20

IMPEDANCE
normalization = 50.

freq (MHz)	resist (ohms)	react (ohms)	imped (ohms)	phase (deg)	VSWR	S11 dB	S12 dB
source = 1; node 41, sector 1							
1.17	320.66	-427.77	534.61	306.9	17.927	-.97006	-6.9859

GEOMETRY
Wire coordinates in degrees; other dimensions in meters
Environment: perfect ground

wire	caps	Distance	Angle	Z	radius	segs
1	none	0	0	0	.437	20
		0	0	181.2		
2	none	90.	77.	0	.437	20
		90.	77.	179.4		
3	none	180.	77.	0	.437	20
		180.	77.	179.9		

Number of wires = 3
current nodes = 60

	minimum		maximum	
Individual wires	wire	value	wire	value
segment length	2	8.97	1	9.06
radius	1	.437	1	.437

ELECTRICAL DESCRIPTION
Frequencies (MHz)

frequency no.	lowest	step	no. of steps	segment length (wavelengths) minimum	maximum
1	1.17	0	1	.0249167	.0251667

Sources

source	node	sector	magnitude	phase	type
1	41	1	1.	0	voltage

Method of Moments Model Details for Nighttime Directional Antenna - WWVA

The array of towers was modeled using Expert MININEC Broadcast Professional Version 14.5 with the individual towers characteristics that were verified by the individual tower impedance measurements. Calculations were made to determine the complex voltage values for sources located at ground level under each tower of the array to produce current moment sums for the towers that, when normalized, equated to the theoretical field parameters of the authorized directional antenna pattern. The following pages contain details of the method of moments model of the directional antenna pattern.

Tower	Wire	Base Node
1	1	1
2	2	21
3	3	41

It should be noted that voltages and currents shown on the tabulations that are not specified as "rms" values are the corresponding peak values.

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MEDIUM WAVE ARRAY SYNTHESIS FROM FIELD RATIOS

Frequency = 1.17 MHz

tower	field ratio magnitude	phase (deg)
1	.5	96.
2	1.	0
3	.5	-96.

VOLTAGES AND CURRENTS - rms

source node	voltage magnitude	phase (deg)	current magnitude	phase (deg)
1	2,085.3	174.8	1.69778	200.5
21	5,520.37	74.	9.57874	128.3
41	4,057.26	336.2	11.3657	45.9

Sum of square of source currents = 447.629
Total power = 50,000. watts

NOTE: The array synthesis calculations (above) were performed to solve for the base voltage drives required to produce the specified field parameters. The remainder of the calculations were done with those base voltages in the final model (below).

GEOMETRY
Wire coordinates in degrees; other dimensions in meters
Environment: perfect ground

wire	caps	Distance	Angle	Z	radius	segs
1	none	0	0	0	.437	20
		0	0	181.2		
2	none	90.	77.	0	.437	20
		90.	77.	179.4		
3	none	180.	77.	0	.437	20
		180.	77.	179.9		

Number of wires = 3
current nodes = 60

	minimum		maximum	
Individual wires	wire	value	wire	value
segment length	2	8.97	1	9.06
radius	1	.437	1	.437

ELECTRICAL DESCRIPTION
Frequencies (MHz)

no.	frequency lowest	step	no. of steps	segment length (wavelengths) minimum	maximum
1	1.17	0	1	.0249167	.0251667

Sources

source	node	sector	magnitude	phase	type
1	1	1	2,949.06	174.8	voltage
2	21	1	7,806.98	74.	voltage
3	41	1	5,737.83	336.2	voltage

IMPEDANCE
normalization = 50.

freq (MHz)	resist (ohms)	react (ohms)	imped (ohms)	phase (deg)	VSWR	S11 dB	S12 dB
source = 1; node 1, sector 1							
1.17	1,106.5	-533.22	1,228.2	334.3	27.277	-.63715	-8.6501
source = 2; node 21, sector 1							
1.17	335.98	-468.25	576.31	305.7	19.87	-.87502	-7.3878
source = 3; node 41, sector 1							
1.17	123.73	-334.84	356.97	290.3	20.954	-.82968	-7.597

CURRENT rms
Frequency = 1.17 MHz
Input power = 50,000. watts
Efficiency = 100. %
coordinates in degrees

current no.	X	Y	Z	mag (amps)	phase (deg)	real (amps)	imaginary (amps)
GND	0	0	0	1.69779	200.5	-1.58986	-.595681
2	0	0	9.06	2.15272	130.1	-1.38792	1.64556
3	0	0	18.12	3.37463	111.9	-1.25726	3.13168
4	0	0	27.18	4.5637	104.5	-1.14576	4.41754
5	0	0	36.24	5.64268	100.7	-1.04705	5.54468
6	0	0	45.3	6.58878	98.4	-.957436	6.51884
7	0	0	54.36	7.38525	96.8	-.874139	7.33333
8	0	0	63.42	8.01743	95.7	-.794851	7.97793
9	0	0	72.48	8.47316	94.9	-.717664	8.44271
10	0	0	81.54	8.74323	94.2	-.641175	8.71969
11	0	0	90.6	8.82177	93.7	-.564542	8.80369
12	0	0	99.66	8.70676	93.2	-.487539	8.6931
13	0	0	108.72	8.40007	92.8	-.410563	8.39003
14	0	0	117.78	7.90744	92.4	-.334615	7.90036
15	0	0	126.84	7.23828	92.1	-.261231	7.23356
16	0	0	135.9	6.40501	91.7	-.192387	6.40212
17	0	0	144.96	5.42218	91.4	-.130367	5.42062
18	0	0	154.02	4.30482	91.	-.0776078	4.30412
19	0	0	163.08	3.06424	90.7	-.0365511	3.06402
20	0	0	172.14	1.69788	90.3	-9.56E-03	1.69785
END	0	0	181.2	0	0	0	0
GND	20.2456	-87.6933	0	9.57877	128.3	-5.9387	7.51562
22	20.2456	-87.6933	8.97	5.85872	92.3	-.237991	5.85389
23	20.2456	-87.6933	17.94	5.88641	52.8	3.55535	4.69141
24	20.2456	-87.6933	26.91	7.75701	27.8	6.8597	3.62157
25	20.2456	-87.6933	35.88	10.1266	15.	9.78317	2.61475
26	20.2456	-87.6933	44.85	12.4553	7.7	12.3431	1.66803
27	20.2456	-87.6933	53.82	14.5461	3.1	14.5248	.788417
28	20.2456	-87.6933	62.79	16.3043	360.	16.3043	-.013725
29	20.2456	-87.6933	71.76	17.6726	357.6	17.6577	-.727167
30	20.2456	-87.6933	80.73	18.6133	355.9	18.5649	-1.34116
31	20.2456	-87.6933	89.7	19.1018	354.5	19.0124	-1.84611
32	20.2456	-87.6933	98.67	19.1257	353.3	18.9947	-2.23418

33	20.2456	-87.6933	107.64	18.6826	352.3	18.5146	-2.49949
34	20.2456	-87.6933	116.61	17.7805	351.5	17.5836	-2.63836
35	20.2456	-87.6933	125.58	16.4364	350.7	16.2215	-2.64936
36	20.2456	-87.6933	134.55	14.6751	350.1	14.4548	-2.53314
37	20.2456	-87.6933	143.52	12.527	349.5	12.3155	-2.29216
38	20.2456	-87.6933	152.49	10.0239	348.9	9.83642	-1.92981
39	20.2456	-87.6933	161.46	7.18938	348.4	7.04199	-1.44829
40	20.2456	-87.6933	170.43	4.01408	347.9	3.92455	-.843062
END	20.2456	-87.6933	179.4	0	0	0	0
GND	40.4912	-175.387	0	11.3657	45.9	7.91281	8.15888
42	40.4912	-175.387	8.995	7.38415	34.2	6.10728	4.15053
43	40.4912	-175.387	17.99	5.02516	16.7	4.81205	1.44789
44	40.4912	-175.387	26.985	3.71384	345.3	3.59265	-.940989
45	40.4912	-175.387	35.98	3.92725	308.1	2.42205	-3.09144
46	40.4912	-175.387	44.975	5.18146	284.6	1.30335	-5.01486
47	40.4912	-175.387	53.97	6.70473	272.1	.251056	-6.70003
48	40.4912	-175.387	62.965	8.16041	265.	-.716433	-8.1289
49	40.4912	-175.387	71.96	9.41612	260.3	-1.58002	-9.28261
50	40.4912	-175.387	80.955	10.4072	257.1	-2.32166	-10.1449
51	40.4912	-175.387	89.95	11.0961	254.7	-2.92553	-10.7035
52	40.4912	-175.387	98.945	11.4602	252.9	-3.37874	-10.9508
53	40.4912	-175.387	107.94	11.4878	251.4	-3.6718	-10.8852
54	40.4912	-175.387	116.935	11.176	250.1	-3.79892	-10.5105
55	40.4912	-175.387	125.93	10.5295	249.1	-3.75801	-9.83607
56	40.4912	-175.387	134.925	9.55981	248.2	-3.5505	-8.87603
57	40.4912	-175.387	143.92	8.28329	247.4	-3.18069	-7.64828
58	40.4912	-175.387	152.915	6.7185	246.7	-2.65454	-6.17185
59	40.4912	-175.387	161.91	4.87894	246.1	-1.97653	-4.46065
60	40.4912	-175.387	170.905	2.7561	245.5	-1.14211	-2.50832
END	40.4912	-175.387	179.9	0	0	0	0

Sampling System Measurements – WWVA

Impedance measurements were made of the antenna monitor sampling system using a Hewlett-Packard 4395A network analyzer and a Tunwall Radio directional coupler in a calibrated measurement system. The measurements were made looking into the antenna monitor ends of the sampling lines for two conditions – with them open circuited at their sampling loop ends and with them connected to the sampling loops on the towers.

The following table shows the frequencies above and below the carrier frequency where resonance – zero reactance corresponding with low resistance – was found. As the length of a distortionless transmission line is 180 electrical degrees at the difference frequency between adjacent frequencies of resonance, and frequencies of resonance occur at odd multiples of 90 degrees electrical length, the sampling line length at the resonant frequency below carrier frequency – which is the closest one to the carrier frequency in terms of the ratio of frequencies – was found to be 630 electrical degrees. The electrical lengths at carrier frequency appearing in the table below were calculated by ratioing the frequencies.

Tower	Sampling Line Open-Circuited Resonance Below 1170 kHz (kHz)	Sampling Line Open-Circuited Resonance Above 1170 kHz (kHz)	Sampling Line Calculated Electrical Length at 1170 kHz (degrees)	1170 kHz Measured Impedance with Loop Connected (Ohms)
1 (W)	1148.87	1480.37	641.6	50.5 – j 118.1
2 (C)	1148.49	1479.24	641.8	47.7 – j 114.8
3 (E)	1148.12	1479.24	642.0	46.7 – j 114.5

The sampling line lengths meet the requirement that they be equal in length within 1 electrical degree.

The characteristic impedance was calculated using the following formula, where $R_1 + j X_1$ and $R_2 + j X_2$ are the measured impedances at the +45 and –45 degree offset frequencies, respectively:

$$Zo = ((R_1^2 + X_1^2)^{1/2} \bullet (R_2^2 + X_2^2)^{1/2})^{1/2}$$

Tower	-45 Degree Offset Frequency (kHz)	-45 Degree Measured Impedance (Ohms)	+45 Degree Offset Frequency (kHz)	+45 Degree Measured Impedance (Ohms)	Calculated Characteristic Impedance (Ohms)
1	1066.80	12.41 –j 48.49	1230.93	14.80 +j 48.04	50.2
2	1066.46	12.25 –j 48.11	1230.53	14.73 +j 47.85	49.9
3	1066.11	12.34 –j 48.44	1230.12	14.67 +j 48.16	50.2

The sampling line measured characteristic impedances meet the requirement that they be equal within 2 ohms.

Reference Field Strength Measurements – WWVA

Reference field strength measurements were made at three locations along each of the radials at azimuths with monitor points specified on the present (old) station license, at 225, 257 and 290 degrees true and, additionally, on a major lobe radial at 77 degrees true. The measured field strengths, descriptions and GPS coordinates for the reference measurement points are shown on the following page.

Reference Field Strength Measurements

WWVA DA-N

Radial (Deg.)	Point	Dist. (Km)	Field (mV/m)	Coordinates (NAD 27)		Description
				N	W	
77	1	3.63	540	40-06-31.8	80-49-30.4	Mailbox 70725 Farmington Rd
	2	4.37	300	40-06-39.3	80-49-00.2	South side of Farmington Rd across from underground cable marker
	3	5.52	225	40-06-47.5	80-48-12.9	South side of US 250 0.2 miles south of end of Farmington Rd at north end of short guard rail section
225	1	2.88	46	40-05-1.9	80-53-27.6	East side of Parshall Ave across from # 106 Parshall Ave
	2	3.86	18	40-04-38.7	80-53-55.5	East side of Park Ave in front of # 111 Park Ave
	3	4.71	11	40-04-19.1	80-54-20.9	West side of Allen Ave in front of # 101 Allen Ave
257	1	2.59	39	40-05-48.3	80-54-48.3	West side of access road to Crest View Heights development at CCTV pedestal
	2	3.57	33	40-05-40.1	80-54-26.2	North Market St extended, access road to ball fields between backstops # 6 and # 7
	3	3.80	16	40-05-38.8	80-54-36.0	West side of Providence Rd across from pole # 471-21
290	1	3.17	13	40-06-43.3	80-54-05.6	North side of Maynard Rd in turn from west to south by beige metal shed
	2	5.89	2.9	40-07-13.0	80-55-53.5	In front of 47564 Fairpoint Maynard Rd, north side of road across from driveway
	3	6.83	1.1	40-07-24.3	80-56-30.5	Center of intersection of Columbia Hill Rd and Phillips Rd

All measurements were taken on June 18, 2011 with Potomac Instruments FIM-41 serial number 2112. Prior to making the measurements, its readings were compared with those made with Potomac Instruments FIM-4100 serial number 133, which was most recently calibrated by its manufacturer on March 2, 2011. The readings with both meters were found to be in agreement.

Direct Measurement of Power - WWVA

Impedance measurements were made at the jack adjacent to the current meter that is used to determine operating power for each of the operating modes – at the base of Tower 2 for the daytime nondirectional mode and at the common point within the phasor cabinet for the nighttime mode. The daytime base impedance was measured with a Delta Electronics OIB-3 impedance bridge and the nighttime common point impedance measurements were made using a Hewlett-Packard 4396A network analyzer and a Tunwall Radio directional coupler in a calibrated measurement system.

The daytime tower 2 base impedance, with the other two towers detuned by adjusting detuning inductors at their bases to minimize their antenna monitor loop currents, was 62 –j 222 ohms. For 50,000 watts input power with the base resistance of 62 ohms, the base current is 28.40 amperes.

The nighttime common point impedance was adjusted to 50.0 –j 9 ohms. . This value was found to provide a 50 ohm non-reactive load for the main transmitter at the input terminals of the phasor cabinet. The common point current value for 52,650 watts nighttime[1] antenna input power with the 50 ohm common point resistance is 32.45 amperes.

[1] The FCC Rules specify a 5.3 percent input power adjustment for directional antenna system losses at the 50,000 watt nominal input power level.

Antenna Monitor and Sampling System – WWVA

The antenna monitor is a Potomac Instruments model AM-19 (204), serial number 1046. It was removed from service prior to the proof of performance to be returned to the factory for repairs and recalibration. A Potomac Instruments model AM 1901 antenna monitor was temporarily installed for adjusting the nighttime directional antenna parameters in the mean time.

The sampling devices are identical 12 X 36 inch sampling loops and they are mounted identically on each of the towers. The towers are identical structures. Each tower's sampling loop is mounted at the 140 foot level above its base insulator, which is 35 percent of the total 400 foot tower height, and is at tower potential. The sampling lines have their outer conductors bonded to tower potential below the loops and where they leave to go to the isolation coils at the tower bases. The sampling loops are connected through equal length ½ inch foam heliax sampling lines to the antenna monitor.

RFR Protection – WWVA

No changes have been made to the WWVA antenna system other than replacement of the towers with new ones having heights identical to those of the former towers. The antenna tuning enclosures and ground system are as they were before the towers were replaced. Fences to restrict access to areas near the towers remain in place. The measures to restrict human exposure to radio frequency fields previously provided to the FCC remain in force at the WWVA transmitter site.

Tower Numbering - WWVA

There is confusion with regard to the numbering scheme for the towers of the WWVA directional antenna system. The standard pattern in the FCC's engineering database shows theoretical parameters specified with the towers numbered from west to east. The towers are shown to be on a line bearing 77 degrees true with the west tower being number 1, the center tower being number 2 and the east tower being number 3. The station license, however, shows the parameters with the towers numbered in reverse – from east to west.

To eliminate the confusion, it is requested that the new license have the same numbering scheme as the FCC's engineering database. All tower numbering herein adheres to that scheme, with tower 1 being the west tower and tower 3 being the east tower.