Gregory L. Masters
202.719.7370
gmasters@wileyrein.com

ORIGINAL

2018 DEC 11 PM 2:23

December 10, 2018

Accepted / Filed

DEC 10 2018

Federal Communications Commission
Office of the Secretary

BY HAND VIA COURIER

Marlene H. Dortch, Secretary
Federal Communications Commission
445 Twelfth Street, S.W.
12th Street Lobby, TW-A325
Washington, DC 20554

Re: **Salem Media of Massachusetts, LLC – FRN 0017216862**
Station WWTC(AM), Minneapolis, MN (Fac. ID 9676)
Application for Station License
Request for Program Test Authority

Dear Ms. Dortch:

On behalf of Salem Media of Massachusetts, LLC, licensee of AM station WWTC, Minneapolis, Minnesota, we are submitting herewith an original and two copies of an application on FCC Form 302-AM for license to cover Construction Permit BP-20180213AAO. Program Test Authority is requested.

The fee due for this application, $1,560.00, has been paid, using the FCC Fee Filer system. A copy of Form 159 confirming the payment is included herewith.

Should there be any questions concerning this application, please contact the undersigned.

Sincerely,

Gregory L. Masters

Enclosures

Agency Tracking ID:PGC3188635
Authorization Number:027896
Successful Authorization -- Date Paid: 12/10/18
FILE COPY ONLY!!

READ INSTRUCTIONS CAREFULLY BEFORE PROCEEDING (1) LOCKBOX #979089	FEDERAL COMMUNICATIONS COMMISSION **REMITTANCE ADVICE** **FORM 159** PAGE NO 1 OF 1	APPROVED BY OMB 3060-059 SPECIAL USE FCC USE ONLY

SECTION A - Payer Information

(2) PAYER NAME (if paying by credit card, enter name exactly as it appears on your card)	(3) TOTAL AMOUNT PAID (dollars and cents)
Salem Media of Massachusetts, LLC	**$1560.00**

(4) STREET ADDRESS LINE NO. 1
4880 Santa Rosa Road

(5) STREET ADDRESS LINE NO. 2

(6) CITY	(7) STATE	(8) ZIP CODE
Camarillo	**CA**	**93012**

(9) DAYTIME TELEPHONE NUMBER (INCLUDING AREA CODE)	(10) COUNTRY CODE (IF NOT IN U.S.A.)
805-3844502	**US**

FCC REGISTRATION NUMBER (FRN) AND TAX IDENTIFICATION NUMBER (TIN) REQUIRED

(11) PAYER (FRN)	(12) FCC USE ONLY
0017216862	

IF PAYER NAME AND THE APPLICANT NAME ARE DIFFERENT, COMPLETE SECTION B
IF MORE THAN ONE APPLICANT, USE CONTINUATION SHEETS (FORM 159-C)

(13) APPLICANT NAME
Salem Media of Massachusetts, LLC

(14) STREET ADDRESS LINE NO. 1
4880 Santa Rosa Road

(15) STREET ADDRESS LINE NO. 2

(16) CITY	(17) STATE	(18) ZIP CODE
Camarillo	**CA**	**93012**

(19) DAYTIME TELEPHONE NUMBER (INCLUDING AREA CODE)	(20) COUNTRY CODE (IF NOT IN U.S.A.)
805-3844502	**US**

FCC REGISTRATION NUMBER (FRN) AND TAX IDENTIFICATION NUMBER (TIN) REQUIRED

(21) APPLICANT (FRN)	(22) FCC USE ONLY
0017216862	

COMPLETE SECTION C FOR EACH SERVICE, IF MORE BOXES ARE NEEDED, USE CONTINUATION SHEET

(23A) FCC Call Sign/Other ID	(24A) Payment Type Code(PTC)	(25A) Quantity
WWTC	**MMR**	**1**
(26A) Fee Due for (PTC)	(27A) Total Fee	FCC Use Only
$725.00	**$725.00**	
(28A) FCC CODE 1	(29A) FCC CODE 2	
9676	**Form302-AM**	

(23B) FCC Call Sign/Other ID	(24B) Payment Type Code(PTC)	(25B) Quantity
WWTC	**MOR**	**1**

(26B) Fee Due for (PTC)	(27B) Total Fee	FCC Use Only
$835.00	**$835.00**	
(28B) FCC CODE 1	(29B) FCC CODE 2	
9676	**Form302-AM**	

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-20181210ABV

SECTION I - APPLICANT FEE INFORMATION

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

SALEM MEDIA OF MASSACHUSETTS, LLC

MAILING ADDRESS (Line 1) (Maximum 35 characters)
4880 SANTA ROSA ROAD

MAILING ADDRESS (Line 2) (Maximum 35 characters)

CITY	STATE OR COUNTRY (if foreign address)	ZIP CODE
CAMARILLO	CA	93012

TELEPHONE NUMBER (include area code)	CALL LETTERS	OTHER FCC IDENTIFIER (If applicable)
(805)987-0400	WWTC	9676

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
MMR	0001	$ 725.00	

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
MOR	0001	$ 835.00	

	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.	$ 1560.00	

SECTION II - APPLICANT INFORMATION		
1. NAME OF APPLICANT SALEM MEDIA OF MASSACHUSETTS, LLC		
MAILING ADDRESS 4880 SANTA ROSA ROAD		
CITY CAMARILLO	STATE CA	ZIP CODE 93012

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
WWTC	MINNEAPOLIS, MN	BP-20180213AAO		6/18/2021

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. Program test authority is hereby requested pursuant to condition #3 of the CP. See Engineering Statement.

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	
CHRISTOPHER J. HENDERSON		
Title	Date	Telephone Number
EXECUTIVE VICE PRESIDENT & SECRETARY	12/6/2018	(805)987-0400

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
SALEM MEDIA OF MASSACHUSETTS, LLC

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
WWTC	BP-20180213AAO	1280	Unlimited	15.0	10.0

2. Station location

State	City or Town
Minnesota	Minneapolis

3. Transmitter location

State	County	City or Town	Street address (or other identification)
MN	Dakota	Eagan	2110 Cliff Road

4. Main studio location

State	County	City or Town	Street address (or other identification)
MN	Dakota	Eagan	2110 Cliff Road

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

State	County	City or Town	Street address (or other identification)
MN	Dakota	Eagan	2110 Cliff Road

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. ENG.

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
17.8	14.5

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	50.0	-6.4	-6.4

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(S)	-81.3	-88.5	.791	.661		
2(SC)	137.9	108.0	1.168	1.054		
3(NC)	0.0	0.0	1.000	1.000		
4(N)	-139.9	-106.6	.260	.231		

Manufacturer and type of antenna monitor: Potomac Instruments 1901-4

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.
Guyed tower	76.2	77.1	78.0	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
44 ° 47 ' 18 "	93 ° 12 ' 54 "

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. ENG.

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

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

Change to ground system description

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

New Construction

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 (check appropriate box below)
Kurt Gorman	
Address (include ZIP Code)	Date
Phasetek Inc. 550 California Rd., Unit 11 Quakertown, PA 18951	December 6, 2018
	Telephone No. (Include Area Code) 215-536-6648

☐ Technical Director

☐ Registered Professional Engineer

☐ Chief Operator

☑ Technical Consultant

☐ Other (specify)

ENGINEERING STATEMENT CONCERNING

APPLICATION FOR LICENSE INFORMATION

EMPLOYING MOMENT METHOD MODELING

WWTC, 1280 KHZ, DA-2

MINNEAPOLIS, MINNESOTA

DECEMBER, 2018

PHASETEK INC.

ENGINEERING STATEMENT CONCERNING APPLICATION FOR LICENSE INFORMATION EMPLOYING MOMENT METHOD MODELING WWTC, 1280 KHZ, DA-2 MINNEAPOLIS, MINNESOTA DECEMBER. 2018

TABLE OF CONTENTS

PHASETEK INC.

ENGINEERING STATEMENT CONCERNING APPLICATION FOR LICENSE INFORMATION EMPLOYING MOMENT METHOD MODELING WWTC, 1280 KHZ, DA-2 MINNEAPOLIS, MINNESOTA DECEMBER. 2018

SUMMARY

Adjustment of the Antenna System and a Proof of Performance employing Moment Method Modeling was performed on Radio Station WWTC, 1280 KHz, Minneapolis, Minnesota, after installation of Antenna Phasing equipment, Transmission and Sampling Lines, and new Tower Feed Assemblies. WWTC holds Construction Permit Number: BP-20180213AAO to change Transmitter site and patterns. This report was prepared on behalf of Salem Media of Massachusetts, LLC, licensee of Radio Station WWTC.

SITE MODIFICATIONS

The WWTC Transmitter site is that as currently licensed for Radio Station KKMS, 980 KHz. New Transmission Lines, Sampling Lines, and Antenna Phasing and Branching equipment have been installed. All Towers remain unchanged. A License Application employing Moment Method Modeling as set forth in Section 73.151(C) has been done to cover the Radio Station WWTC Construction Permit and license under the new rules.

REFERENCE POINTS

Reference Points were measured at pattern minima and maxima for the Directional modes of operation. These Points and their measured field intensity are shown in Figure 15.

SPURIOUS EMISSIONS

Due to the common usage of the Transmitter site by both Radio Stations WWTC, 1280 KHz and KKMS, 980 KHz, filtering has been installed and adjusted at all Towers to prevent interaction and spurious radiation products. Figure 17 shows measurement of any spurious radiation products. All filter circuits are located on the matching network side of the Sampling TCT's for both stations. The "reject" 1280 kHz Filters (located in the KKMS equipment) measure greater than 50,000 ohms, and are not included in the circuit model.

PHASETEK INC.

ENGINEERING STATEMENT CONCERNING
APPLICATION FOR LICENSE INFORMATION
EMPLOYING MOMENT METHOD MODELING
WWTC, 1280 KHZ, DA-2
MINNEAPOLIS, MINNESOTA
DECEMBER. 2018

SPECIAL OPERATING CONDITION #3

As stated above, filtering has been installed and adjusted at all Towers to prevent interaction and spurious radiation products. All filter circuits are located on the matching network side of the Sampling TCT's for both stations. The "reject" Filters for both stations measure greater than 50,000 ohms, and are not included in the circuit model. The currently licensed sampling system for KKMS remains unchanged, except that the TCT's were re-located to the tower output side of the filtering. Short equal length jumpers were used to make the connections. The sampling lines with the jumpers were measured for all KKMS towers, and are within 1.0 electrical degree of each other. A summary of the revised line measurements is included as Figure 18. Due to the high impedance of the reject filtering in parallel, the TCT current equals the base network input current. KKMS tower impedance measurements agree with previously taken, therefore there is no change to the current licensed operating parameters or common point current. A form 302-AM has not been done, as there are no operating changes.

METHOD OF MOMENTS DETAIL

All Moment Method Modeling was done with Expert MININEC Broadcast Professional, Version 23. One wire was used to represent each Tower. Towers were driven individually to verify the Model compared to measured impedance data. Once the Model was verified, both the Day and Night Directional Antenna Systems were computed. For Directional modes, the complex voltage values for sources located at ground level were computed. These sources produce current moment sums for each Tower that, when normalized, equate to the Theoretical Field Parameters for each respective Tower.

PHASETEK INC.

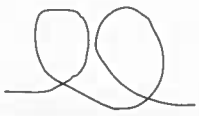
ENGINEERING STATEMENT CONCERNING
APPLICATION FOR LICENSE INFORMATION
EMPLOYING MOMENT METHOD MODELING
WWTC, 1280 KHZ, DA-2
MINNEAPOLIS, MINNESOTA
DECEMBER. 2018

MEASURING EQUIPMENT AND PERSONNEL

All Tower Resistance and Reactance measurements were made with a HP 8753ES Network analyzer with a Tunwall directional coupler and a Delta Electronics OIB-3 Operating Impedance Bridge. Before use, tests of known impedances were made to verify operation. All Field Intensity Measurements were made with a Potomac Instruments Field Intensity Meter; FIM-21, Serial Number 1235, calibrated on May 18, 2017. The meter was calibrated by Potomac Instruments, Frederick, Maryland. All measurements were taken by Phasetek Inc. and WWTC personnel supervised by Kurt Gorman of Phasetek Inc.

CONCLUSION

It is believed that the WWTC Antenna System has been constructed and adjusted in accordance with all applicable Commission rules and regulations. The foregoing was prepared on behalf of Salem Media of Massachusetts, LLC, under the immediate supervision of Kurt Gorman, Phasetek Inc., Quakertown, Pennsylvania, whose qualifications are a matter of record with the Federal Communications Commission. The statements herein are true and correct of his knowledge, except such statements made on information and belief, and as to these statements he believes them to be true and correct.



Kurt Gorman, President
Phasetek Inc.
Quakertown, Pennsylvania

FIGURE 1

ANTENNA SYSTEM AS ADJUSTED

APPLICATION FOR LICENSE INFORMATION
EMPLOYING MOMENT METHOD MODELING
WWTC, 1280 KHZ, DA-2
MINNEAPOLIS, MINNESOTA
DECEMBER. 2018

ANTENNA SYSTEM DESCRIPTION

1. The Antenna System consists of four (4), uniform, guyed, vertical steel transmitting Towers. All Towers stand 76.2M (117.4°) above their Base Insulators. The Towers are arranged with Tower 1 as a reference; Tower 2 is spaced 117.6° on a bearing of 17.0°T. Tower 3 is spaced 235.2° on a bearing of 17.0°T. Tower 4 is spaced 352.8° on a bearing of 17.0°T. All towers have lighting. The AC feed for the lighting is isolated at the base with a ring transformer.

2. The Ground System for each Tower consists of (120) buried copper Radials, 76.2M in length, except where they intersect with copper transverse straps between Towers or property boundaries. In addition, a 7.3M by 7.3M copper ground screen is installed at the base of each tower. Copper strap connects all Towers to the main Transmitter grounding point.

3. The Sampling System consists of four (4), Phasetek Inc. P600-203, 1.0 V/A Toroidal Current Transformers. All TCT's are at the Output of each diplexing filter. These TCT's are connected to a Potomac Instruments 1901-4 Antenna Monitor via four (4) equal lengths of RFS, LCF-12-50J, 1/2" phase stabilized foam coaxial cable.

4. Tower registration numbers:
   Tower 1: 1039518
   Tower 2: 1039519
   Tower 3: 1039520
   Tower 4: 1039521

FIGURE 1
ANTENNA SYSTEM AS ADJUSTED

APPLICATION FOR LICENSE INFORMATION
EMPLOYING MOMENT METHOD MODELING
CONTINUED
WWTC, 1280 KHZ, DA-2
MINNEAPOLIS, MINNESOTA
DECEMBER. 2018

ANTENNA SYSTEM DESCRIPTION – Continued

DIRECTIONAL OPERATION (DAY)

COMMON POINT

Impedance = 50.0 – j 6.4 Ohms
Current = 14.5 Amperes
Power = 10,530 Watts

DIRECTIONAL OPERATION (NIGHT)

COMMON POINT

Impedance = 50.0 – j 6.4 Ohms
Current = 17.8 Amperes
Power = 15.795 Watts

Directional Antenna Monitor indications are within ±5% and ±3° of the modeled TCT values.

FIGURE 2
WWTC SAMPLING SYSTEM DESCRIPTION/MEASUREMENTS

APPLICATION FOR LICENSE INFORMATION
EMPLOYING MOMENT METHOD MODELING
WWTC, 1280 KHZ, DA-2
MINNEAPOLIS, MINNESOTA
DECEMBER. 2018

SAMPLING SYSTEM DESCRIPTION

The Sampling System consists of Phasetek Inc. P600-203 Toroidal Sampling Transformers (1.0 volt/amp) mounted at the base of each Tower. The sampling devices are connected to the Antenna Monitor with equal lengths of RFS LCF-12-50J. The Antenna Monitor is a Potomac Instruments Model 1901-4, Serial Number 473.

SAMPLE LINE MEASUREMENTS

Impedance measurements were made of the Antenna Sampling Lines using a HP 8753ES Network Analyzer with a Tunwall directional coupler. Measurements were done with the lines open circuited and then connected to the TCT's.

The table below shows the frequencies above and below the carrier frequency where resonance, defined as zero reactance corresponding with low resistance, was found. Frequencies of resonance occur at odd multiples of 90 degrees electrical length, the Sample Line length at the resonant frequency below the carrier frequency, which is the closest one to the carrier frequency, was found to be 450 electrical degrees. The electrical length at carrier frequency appearing in the table below was calculated by ratioing the frequencies.

SAMPLE LINE MEASUREMENTS

	Resonant Frequency (KHz) below 1280 KHz	Resonant Frequency (KHz) above 1280 KHz	Calculated Electrical Length (deg) at 1280 KHz	Measured Impedance (ohms) Connected to TCT @ 1280 KHz
Tower 1	1103.9	1547.9	521.8	48.6 +j 1.67
Tower 2	1103.5	1547.6	522.0	48.7 +j 1.67
Tower 3	1103.6	1547.3	521.9	48.5 +j 1.54
Tower 4	1104.5	1548.5	521.5	48.7 +j 1.21

FIGURE 2
WWTC SAMPLING SYSTEM DESCRIPTION/MEASUREMENTS

APPLICATION FOR LICENSE INFORMATION
EMPLOYING MOMENT METHOD MODELING
WWTC, 1280 KHZ, DA-2
MINNEAPOLIS, MINNESOTA
DECEMBER. 2018
CONTINUED

SAMPLE LINE MEASUREMENTS (CONTINUED)

To determine the characteristic impedance values of the Sample Lines, open-circuited measurements were made with frequencies offset to produce ± 45 degrees of electrical length from resonance. The characteristic impedance was calculated using the following formula, where R1 +j X1 and R2 +j X2 are the measured impedances at the +45 and -45 degree offset frequencies, respectively:

$$Z_0 = ((R_1^2 + X_1^2)^{1/2} \bullet (R_2^2 + X_2^2)^{1/2})^{1/2}$$

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	1214.3	8.7 +j 49.9	993.5	7.0 –j 50.1	50.62
2	1213.9	8.7 +j 50.2	993.2	6.9 –j 50.2	50.81
3	1214.0	8.7 +j 50.2	993.2	7.0 –j 50.3	50.87
4	1215.0	8.7 +j 49.9	994.1	7.0 –j 50.3	50.72

SAMPLING TCT MEASUREMENTS

Measurements of the Phasetek Inc. Model P600-203, 1.0 V/A Toroidal Current Transformers were performed by a Hewlett Packard 8752A, Network Analyzer. Measurements are normalized to Tower #3 (reference) and are within the manufacturer's rating of ± 1.5% and ± 2.0°.

FIGURE 2
WWTC SAMPLING SYSTEM DESCRIPTION/MEASUREMENTS

APPLICATION FOR LICENSE INFORMATION
EMPLOYING MOMENT METHOD MODELING
WWTC, 1280 KHZ, DA-2
MINNEAPOLIS, MINNESOTA
DECEMBER. 2018
CONTINUED

SAMPLING TCT MEASUREMENTS CONT'D

TOWER	TCT SERIAL #	MAGNITUDE	PHASE
1	764	1.000	-0.2°
2	765	1.000	-0.1°
3	766	1.000	0.0°
4	767	1.001	-0.2°

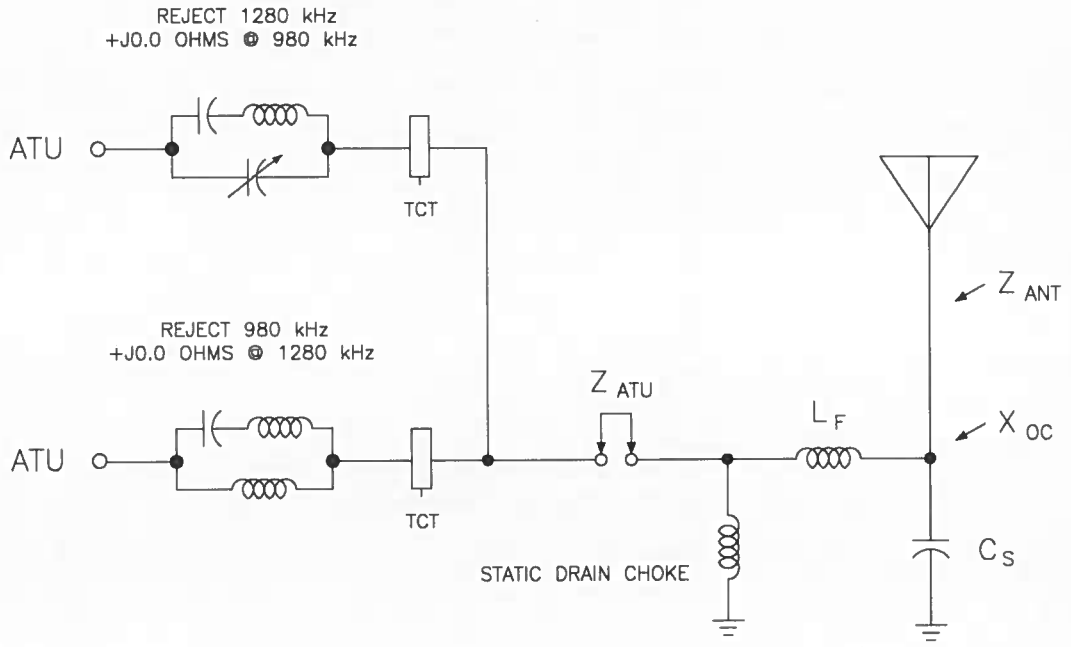
ANTENNA MONITOR MEASUREMENT

Measurement of the Potomac Instruments Model 1901-4 Antenna Monitor was performed to verify calibration. A single RF Voltage was applied to the Reference Input (Tower #3) and each other Input by use of a "T" divider and equal electrical length coaxial cables. This yields the following:

Tower	Ratio	Phase
1	1.001	-0.1°
2	1.001	-0.2°
3	1.000	0.0°
4	1.001	-0.2°

The above is within the manufacturer's rating of $\pm$ 1.0% and $\pm$ 1.0°.

FIGURE 3
WWTC TOWER IMPEDANCE MEASUREMENTS COMPARED TO METHOD OF MOMENTS MODEL



TOWER	Specified Cs (pf)	Measured L_F (µH)	Measured X_F (Ω)	Modeled Z_{ANT} (Ω)	Modeled Z_{ATU} (Ω)	Measured Z_{ATU} (Ω)
1	30	1.87	+j15.0	210.3 +j 275.4	234.9 +j 295.7	235.0 +j 297.0
2	30	0.62	+j5.0	202.0 +j 318.8	230.1 +j 335.5	231.0 +j 331.5
3	50	0.62	+j5.0	190.3 +j 298.3	237.7 +j 320.9	241.0 +j 314.0
4	30	0.87	+j7.0	207.3 +j 263.1	230.6 +j 274.5	230.0 +j 274.0

Tower	Calculated X_{OC} (Ω)
1	-j 4,967.8
2	-j 4,968.2
3	-j 2,761.4
4	-j 4,968.1

FIGURE 4
WWTC MOMENT MODEL PARAMETERS

Tower #	Wire #	# of Segments	Base Node
1	1	24	1
2	2	24	25
3	3	24	49
4	4	24	73

Tower #	Physical Height Degrees	Modeled Height Degrees	Modeled Radius Meters	% of Equivalent Radius
1	117.4	127.6	.26	119.3
2	117.4	128.5	.26	119.3
3	117.4	127.1	.28	128.4
4	117.4	126.8	.30	137.6

All Towers are uniform cross section, guyed with Base Insulator. All Towers are three (3) sided, 18" face width.

All Base Insulators were manufactured by Lapp Insulators. Towers #1, #2, and #3 have an assumed base capacity of 30pf (-j 4,144.7 ohms @ 1280 kHz). Tower 4 has an assumed base capacity of 50pf (-j 2,486.8 ohms @ 1280 kHz).

All Towers have a static Drain Choke. These measure +j 25,000 ohms @ 1280 KHz.

FIGURE 5
WWTC MOMENT SUMMARY FOR INDIVIDUAL TOWERS

WWTC TOWER 1 (OTHERS OPEN)

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

wire	caps	Distance	Angle	Z	radius	segs
1	none	0	0	0	.26	24
		0	0	127.6		
2	none	117.6	17.	0	.26	24
		117.6	17.	128.5		
3	none	235.2	17.	0	.28	24
		235.2	17.	127.1		
4	none	352.8	17.	0	.3	24
		352.8	17.	126.8		

Number of wires = 4
current nodes = 96

	minimum		maximum	
Individual wires	wire	value	wire	value
segment length	4	5.28333	2	5.35417
radius	1	.26	4	.3

ELECTRICAL DESCRIPTION
Frequencies (MHz)

	frequency		no. of	segment length (wavelengths)	
no.	lowest	step	steps	minimum	maximum
1	1.28	0	1	.0146759	.0148727

Sources

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

Lumped loads

load	node	resistance (ohms)	reactance (ohms)	inductance (mH)	capacitance (uF)	passive circuit
1	25	0	-4,968.2	0	0	0
2	49	0	-2,761.4	0	0	0
3	73	0	-4,968.1	0	0	0

IMPEDANCE
normalization = 50.

freq (MHz)	resist (ohms)	react (ohms)	imped (ohms)	phase (deg)	VSWR	S11 dB	S12 dB
source = 1; node 1, sector 1							
1.28	210.25	275.43	346.51	52.6	11.573	-1.5048	-5.3337

FIGURE 5
WWTC MOMENT SUMMARY FOR INDIVIDUAL TOWERS

WWTC TOWER 2 (OTHERS OPEN)

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

wire	caps	Distance	Angle	Z	radius	segs
1	none	0	0	0	.26	24
		0	0	127.6		
2	none	117.6	17.	0	.26	24
		117.6	17.	128.5		
3	none	235.2	17.	0	.28	24
		235.2	17.	127.1		
4	none	352.8	17.	0	.3	24
		352.8	17.	126.8		

Number of wires = 4
current nodes = 96

	minimum		maximum	
Individual wires	wire	value	wire	value
segment length	4	5.28333	2	5.35417
radius	1	.26	4	.3

ELECTRICAL DESCRIPTION
Frequencies (MHz)

	frequency		no. of	segment length (wavelengths)	
no.	lowest	step	steps	minimum	maximum
1	1.28	0	1	.0146759	.0148727

Sources

source	node	sector	magnitude	phase	type
1	25	1	1.	0	voltage

Lumped loads

load	node	resistance (ohms)	reactance (ohms)	inductance (mH)	capacitance (uF)	passive circuit
1	1	0	-4,967.8	0	0	0
2	49	0	-2,761.4	0	0	0
3	73	0	-4,968.1	0	0	0

IMPEDANCE
normalization = 50.

freq (MHz)	resist (ohms)	react (ohms)	imped (ohms)	phase (deg)	VSWR	S11 dB	S12 dB
source = 1; node 25, sector 1							
1.28	202.	318.75	377.37	57.6	14.277	-1.2188	-6.1138

FIGURE 5
WWTC MOMENT SUMMARY FOR INDIVIDUAL TOWERS

WWTC TOWER 3 (OTHERS OPEN)

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

wire	caps	Distance	Angle	Z	radius	segs
1	none	0	0	0	.26	24
		0	0	127.6		
2	none	117.6	17.	0	.26	24
		117.6	17.	128.5		
3	none	235.2	17.	0	.28	24
		235.2	17.	127.1		
4	none	352.8	17.	0	.3	24
		352.8	17.	126.8		

Number of wires = 4
current nodes = 96

	minimum		maximum	
Individual wires	wire	value	wire	value
segment length	4	5.28333	2	5.35417
radius	1	.26	4	.3

ELECTRICAL DESCRIPTION
Frequencies (MHz)

	frequency		no. of	segment length (wavelengths)	
no.	lowest	step	steps	minimum	maximum
1	1.28	0	1	.0146759	.0148727

Sources

source	node	sector	magnitude	phase	type
1	49	1	1.	0	voltage

Lumped loads

load	node	resistance (ohms)	reactance (ohms)	inductance (mH)	capacitance (uF)	passive circuit
1	1	0	-4,967.8	0	0	0
2	25	0	-4,968.2	0	0	0
3	73	0	-4,968.1	0	0	0

IMPEDANCE
normalization = 50.

freq (MHz)	resist (ohms)	react (ohms)	imped (ohms)	phase (deg)	VSWR	S11 dB	S12 dB
source = 1; node 49, sector 1							
1.28	190.33	298.25	353.81	57.5	13.342	-1.3045	-5.8593

FIGURE 5
WWTC MOMENT SUMMARY FOR INDIVIDUAL TOWERS

WWTC TOWER 4 (OTHERS OPEN)

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

wire	caps	Distance	Angle	Z	radius	segs
1	none	0	0	0	.26	24
		0	0	127.6		
2	none	117.6	17.	0	.26	24
		117.6	17.	128.5		
3	none	235.2	17.	0	.28	24
		235.2	17.	127.1		
4	none	352.8	17.	0	.3	24
		352.8	17.	126.8		

Number of wires = 4
current nodes = 96

	minimum		maximum	
Individual wires	wire	value	wire	value
segment length	4	5.28333	2	5.35417
radius	1	.26	4	.3

ELECTRICAL DESCRIPTION
Frequencies (MHz)

	frequency		no. of	segment length (wavelengths)	
no.	lowest	step	steps	minimum	maximum
1	1.28	0	1	.0146759	.0148727

Sources

source	node	sector	magnitude	phase	type
1	73	1	1.	0	voltage

Lumped loads

load	node	resistance (ohms)	reactance (ohms)	inductance (mH)	capacitance (uF)	passive circuit
1	1	0	-4,967.8	0	0	0
2	25	0	-4,968.2	0	0	0
3	49	0	-2,761.4	0	0	0

IMPEDANCE
normalization = 50.

freq (MHz)	resist (ohms)	react (ohms)	imped (ohms)	phase (deg)	VSWR	S11 dB	S12 dB
source = 1; node 73, sector 1							
1.28	207.33	263.11	334.98	51.8	10.975	-1.5873	-5.1407

FIGURE 6
WWTC MOMENT MODEL ARRAY SYNTHESIS (DIRECTIONAL DAY)

WWTC DAY

MEDIUM WAVE ARRAY SYNTHESIS FROM FIELD RATIOS

Frequency = 1.28 MHz

tower	field ratio magnitude	phase (deg)
1	1.	0
2	1.818	-163.6
3	2.091	67.8
4	.969	-73.

VOLTAGES AND CURRENTS - rms

source node	voltage magnitude	phase (deg)	current magnitude	phase (deg)
1	906.689	82.4	2.72754	7.2
25	1,794.37	280.4	4.41522	203.6
49	2,413.06	144.3	4.53987	89.3
73	1,511.33	7.9	1.02127	333.7

Sum of square of source currents = 97.1741
Total power = 10,000. watts

TOWER ADMITTANCE MATRIX

admittance	real (mhos)	imaginary (mhos)
Y(1, 1)	.00199085	-.00214761
Y(1, 2)	.00102641	-.000346545
Y(1, 3)	-.000269273	-.000440894
Y(1, 4)	-.000194423	.000193316
Y(2, 1)	.00102641	-.000346546
Y(2, 2)	.0021297	-.00193257
Y(2, 3)	.00108062	-.000472037
Y(2, 4)	-.000264675	-.000437422
Y(3, 1)	-.000269273	-.000440895
Y(3, 2)	.00108062	-.000472033
Y(3, 3)	.00225253	-.00204441
Y(3, 4)	.00109591	-.000342049
Y(4, 1)	-.000194424	.000193316
Y(4, 2)	-.000264674	-.000437423
Y(4, 3)	.00109591	-.000342047
Y(4, 4)	.00212381	-.00219323

TOWER IMPEDANCE MATRIX

impedance	real (ohms)	imaginary (ohms)
Z(1, 1)	213.28	275.478
Z(1, 2)	1.18173	-122.101
Z(1, 3)	-89.7613	48.8559
Z(1, 4)	76.835	30.512
Z(2, 1)	1.18178	-122.101
Z(2, 2)	206.344	308.867
Z(2, 3)	21.8699	-137.97
Z(2, 4)	-90.5482	50.9139
Z(3, 1)	-89.7611	48.8561
Z(3, 2)	21.8693	-137.971
Z(3, 3)	193.65	292.373
Z(3, 4)	1.93518	-117.728
Z(4, 1)	76.835	30.5117
Z(4, 2)	-90.5479	50.9144
Z(4, 3)	1.93492	-117.728
Z(4, 4)	208.495	259.866

FIGURE 7
WWTC MOMENT MODEL SUMMARY FOR DIRECTIONAL DAY MODE

WWTC DAY

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

wire	caps	Distance	Angle	Z	radius	segs
1	none	0	0	0	.26	24
		0	0	127.6		
2	none	117.6	17.	0	.26	24
		117.6	17.	128.5		
3	none	235.2	17.	0	.28	24
		235.2	17.	127.1		
4	none	352.8	17.	0	.3	24
		352.8	17.	126.8		

Number of wires = 4
current nodes = 96

	minimum		maximum	
Individual wires	wire	value	wire	value
segment length	4	5.28333	2	5.35417
radius	1	.26	4	.3

ELECTRICAL DESCRIPTION
Frequencies (MHz)

	frequency		no. of	segment length (wavelengths)	
no.	lowest	step	steps	minimum	maximum
1	1.28	0	1	.0146759	.0148727

Sources

source	node	sector	magnitude	phase	type
1	1	1	1,282.25	82.4	voltage
2	25	1	2,537.62	280.4	voltage
3	49	1	3,412.58	144.3	voltage
4	73	1	2,137.34	7.9	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							
1.28	84.926	321.39	332.42	75.2	26.574	-.65401	-8.5449
source = 2; node 25, sector 1							
1.28	92.837	395.66	406.41	76.8	36.093	-.48143	-9.791
source = 3; node 49, sector 1							
1.28	304.82	435.43	531.53	55.	18.647	-.9325	-7.1393
source = 4; node 73, sector 1							
1.28	1,223.3	832.74	1,479.9	34.2	35.817	-.48514	-9.7595

CURRENT rms
Frequency = 1.28 MHz
Input power = 10,000. watts
Efficiency = 100. %
coordinates in degrees

current no.	X	Y	Z	mag (amps)	phase (deg)	real (amps)	imaginary (amps)
GND	0	0	0	2.72755	7.2	2.70614	.34107
2	0	0	5.31667	3.29608	4.6	3.28565	.261928
3	0	0	10.6333	3.63656	3.3	3.63044	.210934
4	0	0	15.95	3.90529	2.4	3.90173	.166555
5	0	0	21.2667	4.11818	1.8	4.11624	.126607
6	0	0	26.5833	4.28196	1.2	4.28101	.0902199
7	0	0	31.9	4.39968	.7	4.39931	.0570465
8	0	0	37.2167	4.47307	.3	4.47299	.0269551
9	0	0	42.5333	4.50324	360.	4.50324	-8.68E-05
10	0	0	47.85	4.49114	359.7	4.49107	-.0240645
11	0	0	53.1667	4.4377	359.4	4.43747	-.0449433
12	0	0	58.4833	4.34393	359.2	4.34348	-.0626837
13	0	0	63.8	4.211	358.9	4.21029	-.0772501
14	0	0	69.1167	4.04024	358.7	4.03927	-.0886175
15	0	0	74.4333	3.83314	358.6	3.83191	-.0967726
16	0	0	79.75	3.59136	358.4	3.58991	-.101717
17	0	0	85.0667	3.31669	358.2	3.31508	-.103467
18	0	0	90.3833	3.011	358.1	3.00927	-.102053
19	0	0	95.7	2.67617	357.9	2.67439	-.0975165
20	0	0	101.017	2.31394	357.8	2.31219	-.0899009
21	0	0	106.333	1.92567	357.6	1.92404	-.0792427
22	0	0	111.65	1.51185	357.5	1.51042	-.0655414
23	0	0	116.967	1.07069	357.4	1.06958	-.0486888
24	0	0	122.283	.594826	357.3	.594153	-.0282899
END	0	0	127.6	0	0	0	0
GND	112.461	-34.3829	0	4.41523	203.6	-4.04701	-1.7652
26	112.461	-34.3829	5.35417	5.55496	200.8	-5.19304	-1.97227
27	112.461	-34.3829	10.7083	6.2442	199.6	-5.88362	-2.09118
28	112.461	-34.3829	16.0625	6.79473	198.7	-6.43556	-2.17989
29	112.461	-34.3829	21.4167	7.23841	198.1	-6.88163	-2.24449
30	112.461	-34.3829	26.7708	7.58849	197.5	-7.23548	-2.28758
31	112.461	-34.3829	32.125	7.85106	197.1	-7.5034	-2.31045
32	112.461	-34.3829	37.4792	8.02923	196.7	-7.68859	-2.31388
33	112.461	-34.3829	42.8333	8.12505	196.4	-7.79317	-2.29846
34	112.461	-34.3829	48.1875	8.14009	196.2	-7.8187	-2.26472
35	112.461	-34.3829	53.5417	8.07605	195.9	-7.76687	-2.21323
36	112.461	-34.3829	58.8958	7.93455	195.7	-7.63924	-2.14458
37	112.461	-34.3829	64.25	7.71757	195.5	-7.43771	-2.05944
38	112.461	-34.3829	69.6042	7.42751	195.3	-7.16463	-1.95858
39	112.461	-34.3829	74.9583	7.0669	195.1	-6.8224	-1.84279
40	112.461	-34.3829	80.3125	6.63874	195.	-6.41394	-1.71298
41	112.461	-34.3829	85.6667	6.14627	194.8	-5.94234	-1.57009
42	112.461	-34.3829	91.0208	5.59284	194.7	-5.41086	-1.4151
43	112.461	-34.3829	96.375	4.98188	194.5	-4.82278	-1.24897
44	112.461	-34.3829	101.729	4.31658	194.4	-4.18119	-1.07261
45	112.461	-34.3829	107.083	3.59942	194.3	-3.48849	-.886727
46	112.461	-34.3829	112.438	2.83124	194.1	-2.74547	-.691637
47	112.461	-34.3829	117.792	2.00866	194.	-1.94882	-.486643
48	112.461	-34.3829	123.146	1.11771	193.9	-1.08497	-.26855
END	112.461	-34.3829	128.5	0	0	0	0
GND	224.923	-68.7658	0	4.53987	89.3	.0562809	4.53952
50	224.923	-68.7658	5.29583	5.93164	80.3	1.0031	5.8462
51	224.923	-68.7658	10.5917	6.80706	76.6	1.58275	6.6205
52	224.923	-68.7658	15.8875	7.52667	74.1	2.06491	7.23788
53	224.923	-68.7658	21.1833	8.12206	72.3	2.47593	7.73547
54	224.923	-68.7658	26.4792	8.60667	70.8	2.82685	8.12919
55	224.923	-68.7658	31.775	8.98609	69.7	3.12239	8.42618
56	224.923	-68.7658	37.0708	9.26318	68.7	3.36476	8.63046
57	224.923	-68.7658	42.3667	9.43955	67.9	3.55507	8.74452
58	224.923	-68.7658	47.6625	9.51649	67.2	3.69391	8.77033
59	224.923	-68.7658	52.9583	9.49524	66.5	3.78174	8.70966
60	224.923	-68.7658	58.2542	9.37738	66.	3.81901	8.56449
61	224.923	-68.7658	63.55	9.16481	65.5	3.8063	8.33701
62	224.923	-68.7658	68.8458	8.85989	65.	3.74438	8.02977

63	224.923	-68.7658	74.1417	8.46542	64.6	3.63416	7.64567
64	224.923	-68.7658	79.4375	7.98461	64.2	3.47682	7.18789
65	224.923	-68.7658	84.7333	7.42085	63.8	3.27369	6.65973
66	224.923	-68.7658	90.0292	6.77801	63.5	3.02622	6.06493
67	224.923	-68.7658	95.325	6.05984	63.2	2.73594	5.40706
68	224.923	-68.7658	100.621	5.26988	62.9	2.40427	4.68947
69	224.923	-68.7658	105.917	4.41079	62.6	2.03224	3.91472
70	224.923	-68.7658	111.213	3.48313	62.3	1.6199	3.08353
71	224.923	-68.7658	116.508	2.48215	62.	1.16476	2.19189
72	224.923	-68.7658	121.804	1.39007	61.7	.658043	1.22445
END	224.923	-68.7658	127.1	0	0	0	0
GND	337.384	-103.149	0	1.02126	333.7	.915329	-.452929
74	337.384	-103.149	5.28333	1.82653	305.4	1.05716	-1.4895
75	337.384	-103.149	10.5667	2.3993	298.3	1.13693	-2.11282
76	337.384	-103.149	15.85	2.8882	294.5	1.19718	-2.62839
77	337.384	-103.149	21.1333	3.30684	292.1	1.24201	-3.06473
78	337.384	-103.149	26.4167	3.66258	290.3	1.27327	-3.43413
79	337.384	-103.149	31.7	3.95864	289.	1.29189	-3.7419
80	337.384	-103.149	36.9833	4.19653	288.	1.29848	-3.9906
81	337.384	-103.149	42.2667	4.37703	287.2	1.29347	-4.18154
82	337.384	-103.149	47.55	4.50061	286.5	1.27729	-4.31556
83	337.384	-103.149	52.8333	4.56769	285.9	1.25034	-4.39323
84	337.384	-103.149	58.1167	4.57883	285.4	1.21307	-4.41522
85	337.384	-103.149	63.4	4.53474	284.9	1.16595	-4.38229
86	337.384	-103.149	68.6833	4.43635	284.5	1.10948	-4.29537
87	337.384	-103.149	73.9667	4.28485	284.1	1.04423	-4.15566
88	337.384	-103.149	79.25	4.08164	283.8	.970774	-3.96452
89	337.384	-103.149	84.5333	3.82834	283.4	.889732	-3.72352
90	337.384	-103.149	89.8167	3.52669	283.1	.801726	-3.43435
91	337.384	-103.149	95.1	3.1785	282.9	.707383	-3.09879
92	337.384	-103.149	100.383	2.78544	282.6	.607275	-2.71843
93	337.384	-103.149	105.667	2.34871	282.3	.501878	-2.29447
94	337.384	-103.149	110.95	1.86839	282.1	.391433	-1.82693
95	337.384	-103.149	116.233	1.34155	281.9	.2756	-1.31294
96	337.384	-103.149	121.517	.758258	281.6	.152695	-.742725
END	337.384	-103.149	126.8	0	0	0	0

FIGURE 8
WWTC MOMENT MODEL ARRAY SYNTHESIS
(DIRECTIONAL – NIGHT)

WWTC NIGHT

MEDIUM WAVE ARRAY SYNTHESIS FROM FIELD RATIOS

Frequency = 1.28 MHz

tower	field ratio magnitude	phase (deg)
1	1.	0
2	1.943	-150.8
3	2.067	59.6
4	1.056	-86.2

VOLTAGES AND CURRENTS - rms

source node	voltage magnitude	phase (deg)	current magnitude	phase (deg)
1	1,137.99	87.9	3.90345	1.6
25	2,780.27	291.8	5.96378	219.2
49	3,273.98	139.8	5.6776	76.5
73	2,066.33	358.9	1.56793	294.6

Sum of square of source currents = 170.994
Total power = 15,000. watts

TOWER ADMITTANCE MATRIX

admittance	real (mhos)	imaginary (mhos)
Y(1, 1)	.00199085	-.00214761
Y(1, 2)	.00102641	-.000346545
Y(1, 3)	-.000269273	-.000440894
Y(1, 4)	-.000194423	.000193316
Y(2, 1)	.00102641	-.000346546
Y(2, 2)	.0021297	-.00193257
Y(2, 3)	.00108062	-.000472037
Y(2, 4)	-.000264675	-.000437422
Y(3, 1)	-.000269273	-.000440895
Y(3, 2)	.00108062	-.000472033
Y(3, 3)	.00225253	-.00204441
Y(3, 4)	.00109591	-.000342049
Y(4, 1)	-.000194424	.000193316
Y(4, 2)	-.000264674	-.000437423
Y(4, 3)	.00109591	-.000342047
Y(4, 4)	.00212381	-.00219323

TOWER IMPEDANCE MATRIX

impedance	real (ohms)	imaginary (ohms)
Z(1, 1)	213.28	275.478
Z(1, 2)	1.18173	-122.101
Z(1, 3)	-89.7613	48.8559
Z(1, 4)	76.835	30.512
Z(2, 1)	1.18178	-122.101
Z(2, 2)	206.344	308.867
Z(2, 3)	21.8699	-137.97
Z(2, 4)	-90.5482	50.9139
Z(3, 1)	-89.7611	48.8561
Z(3, 2)	21.8693	-137.971
Z(3, 3)	193.65	292.373
Z(3, 4)	1.93518	-117.728
Z(4, 1)	76.835	30.5117
Z(4, 2)	-90.5479	50.9144
Z(4, 3)	1.93492	-117.728
Z(4, 4)	208.495	259.866

FIGURE 9
WWTC MOMENT MODEL SUMMARY FOR DIRECTIONAL NIGHT MODE

WWTC NIGHT

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

wire	caps	Distance	Angle	Z	radius	segs
1	none	0	0	0	.26	24
		0	0	127.6		
2	none	117.6	17.	0	.26	24
		117.6	17.	128.5		
3	none	235.2	17.	0	.28	24
		235.2	17.	127.1		
4	none	352.8	17.	0	.3	24
		352.8	17.	126.8		

Number of wires = 4
current nodes = 96

	minimum		maximum	
Individual wires	wire	value	wire	value
segment length	4	5.28333	2	5.35417
radius	1	.26	4	.3

ELECTRICAL DESCRIPTION
Frequencies (MHz)

	frequency		no. of	segment length (wavelengths)	
no.	lowest	step	steps	minimum	maximum
1	1.28	0	1	.0146759	.0148727

Sources

source	node	sector	magnitude	phase	type
1	1	1	1,609.35	87.9	voltage
2	25	1	3,931.9	291.8	voltage
3	49	1	4,630.11	139.8	voltage
4	73	1	2,922.23	358.9	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							
1.28	18.721	290.93	291.53	86.3	93.458	-.18589	-13.778
source = 2; node 25, sector 1							
1.28	139.42	444.86	466.19	72.6	31.504	-.5516	-9.2345
source = 3; node 49, sector 1							
1.28	259.08	515.17	576.65	63.3	25.824	-.67304	-8.4296
source = 4; node 73, sector 1							
1.28	571.33	1,187.6	1,317.9	64.3	60.869	-.28542	-11.965

CURRENT rms
Frequency = 1.28 MHz
Input power = 15,000. watts
Efficiency = 100. %
coordinates in degrees

current no.	X	Y	Z	mag (amps)	phase (deg)	real (amps)	imaginary (amps)
GND	0	0	0	3.90347	1.6	3.90193	.109521
2	0	0	5.31667	4.63495	1.	4.63422	.0824962
3	0	0	10.6333	5.06778	.7	5.06736	.065294
4	0	0	15.95	5.40565	.5	5.40542	.0505288
5	0	0	21.2667	5.66967	.4	5.66955	.0374396
6	0	0	26.5833	5.86878	.3	5.86872	.02571
7	0	0	31.9	6.00715	.1	6.00713	.0151999
8	0	0	37.2167	6.08716	.1	6.08715	5.84E-03
9	0	0	42.5333	6.1104	360.	6.1104	-2.41E-03
10	0	0	47.85	6.07822	359.9	6.07821	-9.57E-03
11	0	0	53.1667	5.99194	359.9	5.99192	-.0156658
12	0	0	58.4833	5.85302	359.8	5.85298	-.0207046
13	0	0	63.8	5.66305	359.8	5.663	-.0247064
14	0	0	69.1167	5.42388	359.7	5.42381	-.02769
15	0	0	74.4333	5.13754	359.7	5.13745	-.0296775
16	0	0	79.75	4.80628	359.6	4.80618	-.0306942
17	0	0	85.0667	4.4325	359.6	4.4324	-.0307694
18	0	0	90.3833	4.01873	359.6	4.01862	-.0299356
19	0	0	95.7	3.56748	359.5	3.56737	-.0282283
20	0	0	101.017	3.08105	359.5	3.08094	-.025685
21	0	0	106.333	2.56128	359.5	2.56118	-.0223422
22	0	0	111.65	2.00878	359.5	2.0087	-.018229
23	0	0	116.967	1.42121	359.5	1.42115	-.0133495
24	0	0	122.283	.788795	359.4	.788758	-7.64E-03
END	0	0	127.6	0	0	0	0
GND	112.461	-34.3829	0	5.9638	219.2	-4.61927	-3.77217
26	112.461	-34.3829	5.35417	7.7058	215.2	-6.29797	-4.44015
27	112.461	-34.3829	10.7083	8.76974	213.5	-7.3168	-4.83453
28	112.461	-34.3829	16.0625	9.62671	212.3	-8.13903	-5.14099
29	112.461	-34.3829	21.4167	10.3242	211.4	-8.81234	-5.37883
30	112.461	-34.3829	26.7708	10.882	210.7	-9.3566	-5.55624
31	112.461	-34.3829	32.125	11.3089	210.1	-9.78072	-5.67709
32	112.461	-34.3829	37.4792	11.6096	209.7	-10.0894	-5.74354
33	112.461	-34.3829	42.8333	11.7868	209.2	-10.2852	-5.75714
34	112.461	-34.3829	48.1875	11.8429	208.9	-10.3704	-5.71918
35	112.461	-34.3829	53.5417	11.7798	208.6	-10.3468	-5.63094
36	112.461	-34.3829	58.8958	11.6	208.3	-10.2166	-5.49383
37	112.461	-34.3829	64.25	11.3064	208.	-9.98218	-5.30943
38	112.461	-34.3829	69.6042	10.902	207.8	-9.64637	-5.07953
39	112.461	-34.3829	74.9583	10.3909	207.6	-9.21256	-4.80612
40	112.461	-34.3829	80.3125	9.77704	207.3	-8.68435	-4.49138
41	112.461	-34.3829	85.6667	9.06533	207.2	-8.06598	-4.13765
42	112.461	-34.3829	91.0208	8.26066	207.	-7.36177	-3.74736
43	112.461	-34.3829	96.375	7.36798	206.8	-6.5761	-3.32295
44	112.461	-34.3829	101.729	6.39198	206.6	-5.7131	-2.86669
45	112.461	-34.3829	107.083	5.33633	206.5	-4.77601	-2.38037
46	112.461	-34.3829	112.438	4.20221	206.3	-3.76584	-1.86469
47	112.461	-34.3829	117.792	2.98457	206.2	-2.67797	-1.3176
48	112.461	-34.3829	123.146	1.66252	206.1	-1.49358	-.730216
END	112.461	-34.3829	128.5	0	0	0	0
GND	224.923	-68.7658	0	5.6776	76.5	1.32272	5.52137
50	224.923	-68.7658	5.29583	7.69459	69.1	2.73976	7.1903
51	224.923	-68.7658	10.5917	8.93807	66.2	3.60046	8.18082
52	224.923	-68.7658	15.8875	9.95356	64.3	4.30931	8.97235
53	224.923	-68.7658	21.1833	10.7917	63.	4.90591	9.61215
54	224.923	-68.7658	26.4792	11.4743	61.9	5.40694	10.1205
55	224.923	-68.7658	31.775	12.0107	61.	5.81966	10.5066
56	224.923	-68.7658	37.0708	12.4059	60.3	6.14757	10.7756
57	224.923	-68.7658	42.3667	12.6624	59.7	6.39256	10.9303
58	224.923	-68.7658	47.6625	12.7825	59.1	6.5558	10.9733
59	224.923	-68.7658	52.9583	12.7682	58.7	6.63825	10.9069
60	224.923	-68.7658	58.2542	12.6217	58.3	6.64091	10.7334
61	224.923	-68.7658	63.55	12.3459	57.9	6.56498	10.4557
62	224.923	-68.7658	68.8458	11.9438	57.5	6.41197	10.0768
63	224.923	-68.7658	74.1417	11.4195	57.2	6.18365	9.60034

64	224.923	-68.7658	79.4375	10.7771	56.9	5.88213	9.03027
65	224.923	-68.7658	84.7333	10.0215	56.6	5.50981	8.37089
66	224.923	-68.7658	90.0292	9.15774	56.4	5.06924	7.62673
67	224.923	-68.7658	95.325	8.19108	56.1	4.56309	6.80235
68	224.923	-68.7658	100.621	7.12624	55.9	3.99379	5.90194
69	224.923	-68.7658	105.917	5.96684	55.7	3.36314	4.92874
70	224.923	-68.7658	111.213	4.71366	55.5	2.67133	3.88363
71	224.923	-68.7658	116.508	3.36022	55.3	1.91436	2.76158
72	224.923	-68.7658	121.804	1.88247	55.1	1.07805	1.54321
END	224.923	-68.7658	127.1	0	0	0	0
GND	337.384	-103.149	0	1.56793	294.6	.653214	-1.42538
74	337.384	-103.149	5.28333	2.92168	282.3	.624586	-2.85414
75	337.384	-103.149	10.5667	3.7575	279.2	.602873	-3.70883
76	337.384	-103.149	15.85	4.4491	277.5	.580257	-4.4111
77	337.384	-103.149	21.1333	5.03126	276.3	.556101	-5.00044
78	337.384	-103.149	26.4167	5.51938	275.5	.530229	-5.49385
79	337.384	-103.149	31.7	5.92016	274.9	.502679	-5.89878
80	337.384	-103.149	36.9833	6.23692	274.4	.473593	-6.21891
81	337.384	-103.149	42.2667	6.47141	273.9	.443174	-6.45622
82	337.384	-103.149	47.55	6.62478	273.6	.411666	-6.61198
83	337.384	-103.149	52.8333	6.69799	273.2	.379337	-6.68724
84	337.384	-103.149	58.1167	6.69207	273.	.346473	-6.6831
85	337.384	-103.149	63.4	6.60828	272.7	.313373	-6.60084
86	337.384	-103.149	68.6833	6.4481	272.5	.280341	-6.442
87	337.384	-103.149	73.9667	6.21338	272.3	.247677	-6.20845
88	337.384	-103.149	79.25	5.90624	272.1	.215685	-5.9023
89	337.384	-103.149	84.5333	5.52909	271.9	.184657	-5.526
90	337.384	-103.149	89.8167	5.0845	271.7	.154879	-5.08214
91	337.384	-103.149	95.1	4.57511	271.6	.126624	-4.57336
92	337.384	-103.149	100.383	4.00335	271.4	.100151	-4.0021
93	337.384	-103.149	105.667	3.37098	271.3	.0756988	-3.37013
94	337.384	-103.149	110.95	2.67811	271.1	.0534842	-2.67757
95	337.384	-103.149	116.233	1.92059	271.	.0336769	-1.92029
96	337.384	-103.149	121.517	1.08426	270.9	.0163582	-1.08414
END	337.384	-103.149	126.8	0	0	0	0

FIGURE 10
DERIVED DIRECTIONAL PARAMETERS

APPLICATION FOR LICENSE INFORMATION
EMPLOYING MOMENT METHOD MODELING
WWTC, 1280 KHZ, DA-2
MINNEAPOLIS, MINNESOTA
DECEMBER. 2018

DAY:

	Theoretical		Base Network Input Current		Normalized TCT	
Tower	Field	Phase	Amplitude	Phase	Amplitude	Phase
1 (S)	1.000	0.0°	2.55	+8.25°	.661	-88.5°
2 (SC)	1.818	-163.6°	4.07	-155.23°	1.054	+108.0°
3 (NC)	2.091	+67.8°	3.86	+96.76°	1.000	0.0°
4 (N)	.969	-73.0°	0.89	-9.87°	.231	-106.6°

NIGHT:

	Theoretical		Base Network Input Current		Normalized TCT	
Tower	Field	Phase	Amplitude	Phase	Amplitude	Phase
1 (S)	1.000	0.0°	3.68	+1.81°	.791	-81.3°
2 (SC)	1.943	-150.8°	5.43	-139.03°	1.168	+137.9°
3 (NC)	2.067	+59.6°	4.65	+83.08°	1.000	0.0°
4 (N)	1.056	-86.2°	1.21	-56.81°	.260	-139.9°

FIGURE 11
WWTC TOWER BASE CIRCUIT ANALYSIS DESCRIPTION

APPLICATION FOR LICENSE INFORMATION
EMPLOYING MOMENT METHOD MODELING
WWTC, 1280 KHZ, DA-2
MINNEAPOLIS, MINNESOTA
DECEMBER. 2018

CIRCUIT ANALYSIS

Circuit Analysis was performed on each Tower of the WWTC model. "Phasetek" nodal Circuit Analysis program was used to compute base model Input/Output voltages and currents. For the Directional modes, the calculated Mininec Tower Base Drive Voltage was used to determine the Base Network Input Current. This point is the location of the Sampling TCT. "Z_1" represents the ATU Shunt impedance, "Z_2" represents the Tower Feed impedance, and "Z_3" represents the Tower Base Shunt impedance.

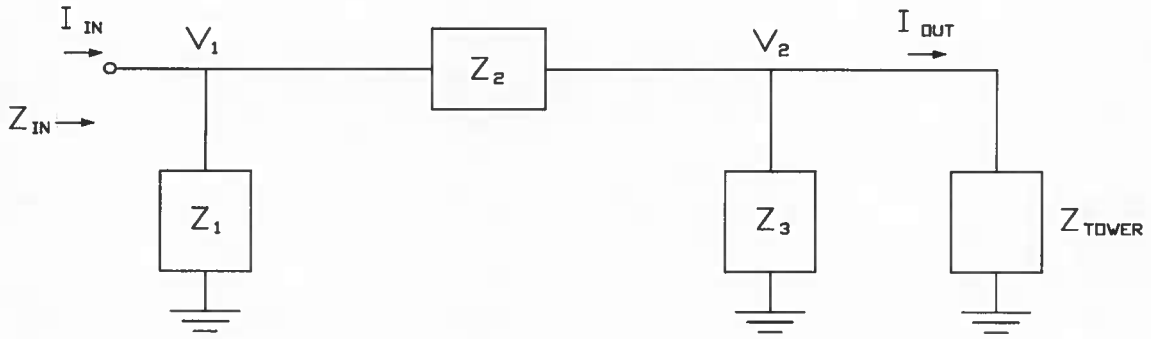


FIGURE 12
WWTC CIRCUIT ANALYSIS FOR INDIVIDUAL TOWERS

CUSTOMER : WWTC
NETWORK ID : TOWER 1 (OTHERS OPEN)

FREQUENCY : 1280.00 kHz
ATU SHUNT IMPEDANCE (R,X) : 0.00, 25000.00 OHMS
TOWER FEED IMPEDANCE (R,X) : 0.00, 15.00 OHMS
TOWER SHUNT IMPEDANCE (R,X) : 0.00, -4144.70 OHMS
TOWER IMPEDANCE (R,X) : 210.25, 275.43 OHMS

NODE	TO	NODE	IMPEDANCE (OHMS) R	X
1		GROUND	0.00	25000.00
2		GROUND	240.54	281.97
1		2	0.00	15.00

NODE	VOLTAGE MAGNITUDE	PHASE
1	100.00	0.00
2	96.98	-1.46

	REAL	IMAGINARY	MAGNITUDE	PHASE
INPUT IMPEDANCE (OHMS) :	234.90	295.71	377.66	51.54
INPUT CURRENT (AMPS) :	0.16	-0.21	0.26	-51.54
OUTPUT CURRENT (AMPS) :	0.16	-0.23	0.28	-54.10

INPUT/OUTPUT CURRENT RATIO = 0.9461
INPUT/OUTPUT PHASE = 2.57 DEGREES

CUSTOMER : WWTC
NETWORK ID : TOWER 2 (OTHERS OPEN)

FREQUENCY : 1280.00 kHz
ATU SHUNT IMPEDANCE (R,X) : 0.00, 25000.00 OHMS
TOWER FEED IMPEDANCE (R,X) : 0.00, 5.00 OHMS
TOWER SHUNT IMPEDANCE (R,X) : 0.00, -4144.70 OHMS
TOWER IMPEDANCE (R,X) : 202.00, 318.75 OHMS

NODE	TO NODE	IMPEDANCE (OHMS) R	X
1	GROUND	0.00	25000.00
2	GROUND	236.40	332.82
1	2	0.00	5.00

NODE	VOLTAGE MAGNITUDE	PHASE
1	100.00	0.00
2	99.01	-0.40

	REAL	IMAGINARY	MAGNITUDE	PHASE
INPUT IMPEDANCE (OHMS) :	230.12	335.47	406.81	55.55
INPUT CURRENT (AMPS) :	0.14	-0.20	0.25	-55.55
OUTPUT CURRENT (AMPS) :	0.14	-0.22	0.26	-58.04

INPUT/OUTPUT CURRENT RATIO = 0.9369
INPUT/OUTPUT PHASE = 2.49 DEGREES

CUSTOMER : WWTC
NETWORK ID : TOWER 3 (OTHERS OPEN)

FREQUENCY : 1280.00 kHz
ATU SHUNT IMPEDANCE (R,X) : 0.00, 25000.00 OHMS
TOWER FEED IMPEDANCE (R,X) : 0.00, 5.00 OHMS
TOWER SHUNT IMPEDANCE (R,X) : 0.00, -2486.80 OHMS
TOWER IMPEDANCE (R,X) : 190.33, 298.25 OHMS

NODE	TO	NODE	IMPEDANCE (OHMS) R	X
1		GROUND	0.00	25000.00
2		GROUND	243.90	317.68
1		2	0.00	5.00

NODE	VOLTAGE MAGNITUDE	PHASE
1	100.00	0.00
2	99.02	-0.43

	REAL	IMAGINARY	MAGNITUDE	PHASE
INPUT IMPEDANCE (OHMS) :	237.70	320.86	399.31	53.47
INPUT CURRENT (AMPS) :	0.15	-0.20	0.25	-53.47
OUTPUT CURRENT (AMPS) :	0.15	-0.24	0.28	-57.89

INPUT/OUTPUT CURRENT RATIO = 0.8948
INPUT/OUTPUT PHASE = 4.42 DEGREES

CUSTOMER : WWTC
NETWORK ID : TOWER 4 (OTHERS OPEN)

FREQUENCY : 1280.00 kHz
ATU SHUNT IMPEDANCE (R,X) : 0.00, 25000.00 OHMS
TOWER FEED IMPEDANCE (R,X) : 0.00, 7.00 OHMS
TOWER SHUNT IMPEDANCE (R,X) : 0.00, -4144.70 OHMS
TOWER IMPEDANCE (R,X) : 207.33, 263.11 OHMS

NODE	TO NODE	IMPEDANCE (OHMS) R	X
1	GROUND	0.00	25000.00
2	GROUND	235.72	268.35
1	2	0.00	7.00

NODE	VOLTAGE MAGNITUDE	PHASE
1	100.00	0.00
2	98.54	-0.73

	REAL	IMAGINARY	MAGNITUDE	PHASE
INPUT IMPEDANCE (OHMS) :	230.59	274.50	358.50	49.97
INPUT CURRENT (AMPS) :	0.18	-0.21	0.28	-49.97
OUTPUT CURRENT (AMPS) :	0.18	-0.23	0.29	-52.49

INPUT/OUTPUT CURRENT RATIO = 0.9482
INPUT/OUTPUT PHASE = 2.52 DEGREES

FIGURE 13
WWTC CIRCUIT ANALYSIS FOR DIRECTIONAL DAY MODE

CUSTOMER : WWTC
NETWORK ID : TOWER 1 DAY

FREQUENCY : 1280.00 kHz
ATU SHUNT IMPEDANCE (R,X) : 0.00, 25000.00 OHMS
TOWER FEED IMPEDANCE (R,X) : 0.00, 15.00 OHMS
TOWER SHUNT IMPEDANCE (R,X) : 0.00, -4144.70 OHMS
TOWER IMPEDANCE (R,X) : 84.93, 321.39 OHMS

NODE	TO NODE	IMPEDANCE (OHMS) R	X
1	GROUND	0.00	25000.00
2	GROUND	99.75	346.19
1	2	0.00	15.00

NODE	VOLTAGE MAGNITUDE	PHASE
1	943.02	83.04
2	906.69	82.40

	REAL	IMAGINARY	MAGNITUDE	PHASE
INPUT IMPEDANCE (OHMS) :	96.93	356.43	369.37	74.79
INPUT CURRENT (AMPS) :	2.53	0.37	2.55	8.25
OUTPUT CURRENT (AMPS) :	2.71	0.34	2.73	7.20

INPUT/OUTPUT CURRENT RATIO = 0.9360
INPUT/OUTPUT PHASE = 1.05 DEGREES

CUSTOMER : WWTC
NETWORK ID : TOWER 2 DAY

FREQUENCY : 1280.00 kHz
ATU SHUNT IMPEDANCE (R,X) : 0.00, 25000.00 OHMS
TOWER FEED IMPEDANCE (R,X) : 0.00, 5.00 OHMS
TOWER SHUNT IMPEDANCE (R,X) : 0.00, -4144.70 OHMS
TOWER IMPEDANCE (R,X) : 92.84, 395.66 OHMS

NODE	TO NODE	IMPEDANCE (OHMS) R	X
1	GROUND	0.00	25000.00
2	GROUND	113.40	434.61
1	2	0.00	5.00

NODE	VOLTAGE MAGNITUDE	PHASE
1	1813.70	-79.44
2	1794.37	280.40

	REAL	IMAGINARY	MAGNITUDE	PHASE
INPUT IMPEDANCE (OHMS) :	109.51	432.50	446.15	75.79
INPUT CURRENT (AMPS) :	-3.69	-1.70	4.07	-155.23
OUTPUT CURRENT (AMPS) :	-4.05	-1.77	4.42	-156.40

INPUT/OUTPUT CURRENT RATIO = 0.9207
INPUT/OUTPUT PHASE = 1.16 DEGREES

CUSTOMER : WWTC
NETWORK ID : TOWER 3 DAY

FREQUENCY : 1280.00 kHz
ATU SHUNT IMPEDANCE (R,X) : 0.00, 25000.00 OHMS
TOWER FEED IMPEDANCE (R,X) : 0.00, 5.00 OHMS
TOWER SHUNT IMPEDANCE (R,X) : 0.00, -2486.80 OHMS
TOWER IMPEDANCE (R,X) : 304.82, 435.43 OHMS

NODE	TO NODE	IMPEDANCE (OHMS) R	X
1	GROUND	0.00	25000.00
2	GROUND	438.28	462.73
1	2	0.00	5.00

NODE	VOLTAGE MAGNITUDE	PHASE
1	2426.84	144.61
2	2413.06	144.30

	REAL	IMAGINARY	MAGNITUDE	PHASE
INPUT IMPEDANCE (OHMS) :	422.20	466.41	629.12	47.85
INPUT CURRENT (AMPS) :	-0.45	3.83	3.86	96.76
OUTPUT CURRENT (AMPS) :	0.06	4.54	4.54	89.29

INPUT/OUTPUT CURRENT RATIO = 0.8497
INPUT/OUTPUT PHASE = 7.47 DEGREES

CUSTOMER : WWTC
NETWORK ID : TOWER 4 DAY

FREQUENCY : 1280.00 kHz
ATU SHUNT IMPEDANCE (R,X) : 0.00, 25000.00 OHMS
TOWER FEED IMPEDANCE (R,X) : 0.00, 7.00 OHMS
TOWER SHUNT IMPEDANCE (R,X) : 0.00, -4144.70 OHMS
TOWER IMPEDANCE (R,X) :1223.30, 832.74 OHMS

NODE	TO	NODE	IMPEDANCE (OHMS) R	X
1		GROUND	0.00	25000.00
2		GROUND	1685.81	419.45
1		2	0.00	7.00

NODE	VOLTAGE MAGNITUDE	PHASE
1	1512.81	8.12
2	1511.33	7.90

	REAL	IMAGINARY	MAGNITUDE	PHASE
INPUT IMPEDANCE (OHMS) :	1622.60	526.88	1706.00	17.99
INPUT CURRENT (AMPS) :	0.87	-0.15	0.89	-9.87
OUTPUT CURRENT (AMPS) :	0.92	-0.45	1.02	-26.34

INPUT/OUTPUT CURRENT RATIO = 0.8683
INPUT/OUTPUT PHASE = 16.48 DEGREES

FIGURE 14
WWTC CIRCUIT ANALYSIS FOR DIRECTIONAL NIGHT MODE

CUSTOMER : WWTC
NETWORK ID : TOWER 1 NIGHT

FREQUENCY : 1280.00 kHz
ATU SHUNT IMPEDANCE (R,X) : 0.00, 25000.00 OHMS
TOWER FEED IMPEDANCE (R,X) : 0.00, 15.00 OHMS
TOWER SHUNT IMPEDANCE (R,X) : 0.00, -4144.70 OHMS
TOWER IMPEDANCE (R,X) : 18.72, 290.93 OHMS

NODE	TO NODE	IMPEDANCE (OHMS) R	X
1	GROUND	0.00	25000.00
2	GROUND	21.65	312.79
1	2	0.00	15.00

NODE	VOLTAGE MAGNITUDE	PHASE
1	1192.31	88.08
2	1137.99	87.90

	REAL	IMAGINARY	MAGNITUDE	PHASE
INPUT IMPEDANCE (OHMS) :	21.10	323.56	324.25	86.27
INPUT CURRENT (AMPS) :	3.68	0.12	3.68	1.81
OUTPUT CURRENT (AMPS) :	3.90	0.11	3.90	1.58

INPUT/OUTPUT CURRENT RATIO = 0.9420
INPUT/OUTPUT PHASE = 0.23 DEGREES

CUSTOMER : WWTC
NETWORK ID : TOWER 2 NIGHT

FREQUENCY : 1280.00 kHz
ATU SHUNT IMPEDANCE (R,X) : 0.00, 25000.00 OHMS
TOWER FEED IMPEDANCE (R,X) : 0.00, 5.00 OHMS
TOWER SHUNT IMPEDANCE (R,X) : 0.00, -4144.70 OHMS
TOWER IMPEDANCE (R,X) : 139.42, 444.86 OHMS

NODE	TO	NODE	IMPEDANCE (OHMS) R	X
1		GROUND	0.00	25000.00
2		GROUND	174.71	491.77
1		2	0.00	5.00

NODE	VOLTAGE MAGNITUDE	PHASE
1	2805.38	-68.02
2	2780.27	291.80

	REAL	IMAGINARY	MAGNITUDE	PHASE
INPUT IMPEDANCE (OHMS) :	167.96	488.24	516.32	71.02
INPUT CURRENT (AMPS) :	-4.10	-3.56	5.43	-139.03
OUTPUT CURRENT (AMPS) :	-4.62	-3.77	5.96	-140.80

INPUT/OUTPUT CURRENT RATIO = 0.9111
INPUT/OUTPUT PHASE = 1.77 DEGREES

CUSTOMER : WWTC
NETWORK ID : TOWER 3 NIGHT

FREQUENCY : 1280.00 kHz
ATU SHUNT IMPEDANCE (R,X) : 0.00, 25000.00 OHMS
TOWER FEED IMPEDANCE (R,X) : 0.00, 5.00 OHMS
TOWER SHUNT IMPEDANCE (R,X) : 0.00, -2486.80 OHMS
TOWER IMPEDANCE (R,X) : 259.08, 515.17 OHMS

NODE	TO	NODE	IMPEDANCE (OHMS) R	X
1		GROUND	0.00	25000.00
2		GROUND	405.16	596.54
1		2	0.00	5.00

NODE	VOLTAGE MAGNITUDE	PHASE
1	3292.78	140.02
2	3273.98	139.80

	REAL	IMAGINARY	MAGNITUDE	PHASE
INPUT IMPEDANCE (OHMS) :	386.25	593.52	708.13	56.94
INPUT CURRENT (AMPS) :	0.56	4.62	4.65	83.08
OUTPUT CURRENT (AMPS) :	1.33	5.52	5.68	76.50

INPUT/OUTPUT CURRENT RATIO = 0.8190
INPUT/OUTPUT PHASE = 6.58 DEGREES

CUSTOMER : WWTC
NETWORK ID : TOWER 4 NIGHT

FREQUENCY : 1280.00 kHz
ATU SHUNT IMPEDANCE (R,X) : 0.00, 25000.00 OHMS
TOWER FEED IMPEDANCE (R,X) : 0.00, 7.00 OHMS
TOWER SHUNT IMPEDANCE (R,X) : 0.00, -4144.70 OHMS
TOWER IMPEDANCE (R,X) : 571.33, 1187.60 OHMS

NODE	TO NODE	IMPEDANCE (OHMS) R	X
1	GROUND	0.00	25000.00
2	GROUND	1081.99	1455.50
1	2	0.00	7.00

NODE	VOLTAGE MAGNITUDE	PHASE
1	2072.74	-0.97
2	2066.33	358.90

	REAL	IMAGINARY	MAGNITUDE	PHASE
INPUT IMPEDANCE (OHMS) :	964.09	1421.10	1717.26	55.85
INPUT CURRENT (AMPS) :	0.66	-1.01	1.21	-56.81
OUTPUT CURRENT (AMPS) :	0.65	-1.43	1.57	-65.41

INPUT/OUTPUT CURRENT RATIO = 0.7698
INPUT/OUTPUT PHASE = 8.59 DEGREES

FIGURE 15
WWTC REFERENCE FIELD INTENSITY MEASUREMENTS
DECEMBER, 2018

REFERENCE FIELD STRENGTH MEASUREMENTS
STATION WWTC – MINNEAPOLIS, MINNESOTA
1280 kHz - 10 kW, U, DA-DAY

Potomac FIM-21 Serial # 1235
Calibration date: MAY. 18, 2017

17 Degree Radial

Point Number	Distance (km)	Field (mV/m)	Geographic Coordinates (WGS84) Latitude	Longitude	Description	Date	Time
1	1.45	1.25 V/m	44 48' 03" N	93 12' 36" W	On Northside of Jasper DR. at end of the driveway for house # 4304	11/28/18	11:09
2	2.71	760 mV/m	44 48' 42" N	93 12' 20" W	On Turquoise Trail at end of driveway for house # 1936	11/28/18	11:19
3	4.29	360 mV/m	44 49' 31" N	93 11' 57" W	On Northside of Burgundy DR. across from Southeast corner of intersection with Vermillion CT. N	11/28/18	11:37

116.5 Degree Radial

Point Number	Distance (km)	Field (mV/m)	Geographic Coordinates (WGS84) Latitude	Longitude	Description	Date	Time
1	1.13	42 mV/m	44 47' 02" N	93 12' 09" W	Southeast corner of the intersection of Covington LN and Galaxie AVE. by telephone pole	11/28/18	12:04
2	2.41	64 mV/m	44 46' 44" N	93 11' 17" W	On Westside of Johnny Cake Ridge RD. 50 feet south of no parking sign and two tenths of a mile North of the MN zoo gate 2.	11/28/18	12:13
3	4.30	21.5 mV/m	44 46' 17" N	93 09' 59" W	On Eastside of Pilot Knob RD. infront of wall across from yellow traffic sign. Two tenths of a mile South of 120th ST. W	11/28/18	12:25

REFERENCE FIELD STRENGTH MEASUREMENTS

STATION WWTC – MINNEAPOLIS, MINNESOTA

1280 kHz - 10 kW, U, DA-DAY

Potomac FIM-21 Serial # 1235

Calibration date: MAY. 18, 2017

173 Degree Radial

Point Number	Distance (km)	Field (mV/m)	Geographic Coordinates (WGS84) Latitude	Longitude	Description	Date	Time
1	1.70	195 mV/m	44 46' 24" N	93 12' 46"	On the Northside of 121st ST. W across from the front door of House # 7280	11/28/18	13:13
2	2.82	94 mV/m	44 45' 48" N	93 12' 39" W	On the Northside of Garret CT. across from House # 12844 by mailboxs	11/28/18	13:01
3	4.51	41.5 mV/m	44 44' 54" N	93 12' 30" W	Northside of Upper 139th W across from Southeast corner of Upper 139th W. and Galway CT.	11/28/18	12:51

221 Degree Radial

Point Number	Distance (km)	Field (mV/m)	Geographic Coordinates (WGS84) Latitude	Longitude	Description	Date	Time
1	1.86	96 mV/m	44 46' 33" N	93 13' 51" W	Northwest corner of 33RD AVE. and E Burnsville Parkway by fire hydrant	11/28/18	13:50
2	2.36	63 mV/m	44 45' 46" N	93 14' 48" W	North corner of the intersection of Acaidia CT and Parc DR.	11/28/18	13:42
3	3.79	57 mV/m	44 45' 46" N	93 14' 48" W	Southside of Great Oaks DR. by mailbox for house # 2001	11/28/18	13:34

REFERENCE FIELD STRENGTH MEASUREMENTS

STATION WWTC – MINNEAPOLIS, MINNESOTA

1280 kHz - 10 kW, U, DA-DAY

Potomac FIM-21 Serial # 1235

Calibration date: MAY. 18, 2017

277.5 Degree Radial

Point Number	Distance (km)	Field (mV/m)	Geographic Coordinates (WGS84) Latitude	Longitude	Description	Date	Time
1	1.46	78	44 47' 24" N	93 14' 01" W	In the parking lot of River Hills Center strip mall on the East side of the Cliff RD entrance by the sidewalk	11/29/18	10:03
2	2.33	65	44 47' 27" N	93 14' 01" W	On Millpond AVE. Just off Cliff RD on the Northside of the drive opening for the resturant by speed sign	11/29/18	10:12
3	3.41	26	44 47' 33" N	93 15' 29" W	On Eastside of 12th AVE S across from pole # 0042 by delivery instruction sign	11/29/18	10:27

FIGURE 15

WWTC REFERENCE FIELD INTENSITY MEASUREMENTS

CONTINUED

REFERENCE FIELD STRENGTH MEASUREMENTS
STATION WWTC – MINNEAPOLIS, MINNESOTA
1280 kHz - 15 kW, U, DA-NIGHT

Potomac FIM-21 Serial # 1235
Calibration date: MAY 18, 2017

17 Degree Radial

Point Number	Distance (km)	Field (mV/m)	Geographic Coordinates (NAD83) Latitude	Longitude	Description	Date	Time
1	1.45	1.5V/m	44 48' 03" N	93 12' 36" W	On Northside of Jasper DR. at end of driveway for house # 4304	11/30/2018	11:03
2	2.71	900 mV/m	44 48' 42" N	93 12' 20" W	On Turquoise Trail at end of driveway for house # 1936	11/30/2018	11:09
3	4.29	450 mV/m	44 49' 31" N	93 11' 57" W	On Northside of Burgundy DR. across from the southeast corner of intersection of Vermillion CT. N	11/30/2018	11:19

91.5 Degree Radial

Point Number	Distance (km)	Field (mV/m)	Geographic Coordinates (NAD83) Latitude	Longitude	Description	Date	Time
1	1.67	50	44 47' 17" N	93 11' 39" W	On the Westside of Lenore LN. across from the door for house # 4644	11/30/2018	11:35
2	2.71	70	44 47' 17" N	93 10' 52" W	On Eastside of Beacon Hill RD. at end of driveway for house 4630	11/30/2018	11:44
3	3.95	25	44 47' 17" N	93 09' 56" W	On Westside of St. Andrew BLVD. in front of door for house # 1351	11/30/2018	11:53

REFERENCE FIELD STRENGTH MEASUREMENTS

STATION WWTC – MINNEAPOLIS, MINNESOTA

1280 kHz - 15 kW, U, DA-NIGHT

Potomac FIM-21 Serial # 1235

Calibration date: MAY 18, 2017

123.5 Degree Radial

Point Number	Distance (km)	Field (mV/m)	Geographic Coordinates (NAD83) Latitude	Longitude	Description	Date	Time
1	1.19	105	44 46' 57" N	93 12' 10" W	South corner of Sky View CT. and Galaxie AVE. by stop sign	11/30/2018	12:20
2	2.68	23.5	44 46' 32" N	93 11' 13" W	Eastside of Johnny Cake Ridge RD. 50' South of City of Eagan sign	11/30/2018	12:13
3	4.48	11.5	44 45' 59" N	93 10' 05" W	South side of Genesee AVE. in front of driveway house # 12602	11/30/2018	12:05

158.5 Degree Radial

Point Number	Distance (km)	Field (mV/m)	Geographic Coordinates (NAD83) Latitude	Longitude	Description	Date	Time
1	1.70	90	44 46' 27" N	93 12' 26" W	Eastside of Safari Pass in front of driveway of 12088	11/30/2018	12:25
2	3.44	68.5	44 45' 35" N	93 11' 56" W	West corner of Florida CT. and 131st ST. W. in front of street sign	11/30/2018	12:32
3	4.50	34.0	44 45' 01" N	93 11' 38" W	Southside of 137th ST. W. in front of driveway of house 6332	11/30/2018	12:37

REFERENCE FIELD STRENGTH MEASUREMENTS

STATION WWTC – MINNEAPOLIS, MINNESOTA

1280 kHz - 15 kW, U, DA-NIGHT

Potomac FIM-21 Serial # 1235

Calibration date: MAY 18, 2017

235.5 Degree Radial

Point Number	Distance (km)	Field (mV/m)	Geographic Coordinates (NAD83) Latitude	Longitude	Description	Date	Time
1	1.73	101	44 46' 46" N	93 14' 00" W	In front of telephone box #L82 next to house # 12400 on Westside on 31st AVE. S	11/30/2018	13:07
2	2.68	75	44 46' 29" N	93 14' 36" W	Northside of E. Burnsville Parkway 100' West of telephone building across from no parking sign.	11/30/2018	13:03
3	3.70	34.5	44 46' 10" N	93 15' 13" W	Directly in front of house # 12917 on Eastside of 16th ave.	11/30/2018	12:57

270.5 Degree Radial

Point Number	Distance (km)	Field (mV/m)	Geographic Coordinates (NAD83) Latitude	Longitude	Description	Date	Time
1	1.93	56	44 47' 19" N	93 14' 23" W	Northeast corner of Highland View LN. and Highland View AVE. S	11/30/2018	13:12
2	3.08	22	44 47' 19" N	93 15' 16" W	On Westside of Larc Industrial BLVD by fire hydrant almost across driveway for business at address number 11965	11/30/2018	13:18
3	4.00	26.5	44 47' 18" N	93 15' 58" W	Northside of entrance t Burnsville Heights Business center @ 11975 Porland AVE. across from business park sign	11/30/2018	13:23

REFERENCE FIELD STRENGTH MEASUREMENTS

STATION WWTC – MINNEAPOLIS, MINNESOTA

1280 kHz - 15 kW, U, DA-NIGHT

Potomac FIM-21 Serial # 1235

Calibration date: MAY 18, 2017

302.5 Degree Radial

Point Number	Distance (km)	Field (mV/m)	Geographic Coordinates (NAD83) Latitude	Longitude	Description	Date	Time
1	1.24	55	44 47' 40" N	93 13' 43" W	On Southside of Gaiter DR. across from drive of 11518 by mailboxs	11/30/2018	13:46
2	2.21	53	44 47' 56" N	93 14' 21" W	At Southern corner of E 114th ST. and Christiansen CT. near light pole	11/30/2018	13:37
3	3.11	48	44 48' 12" N	93 14' 55" W	On Northside of E. Black Dog RD. between house # 11002 and 11000	11/30/2018	13:31

FIGURE 16
WWTC CERTIFIED ARRAY GEOMETRY SURVEY
DECEMBER, 2018

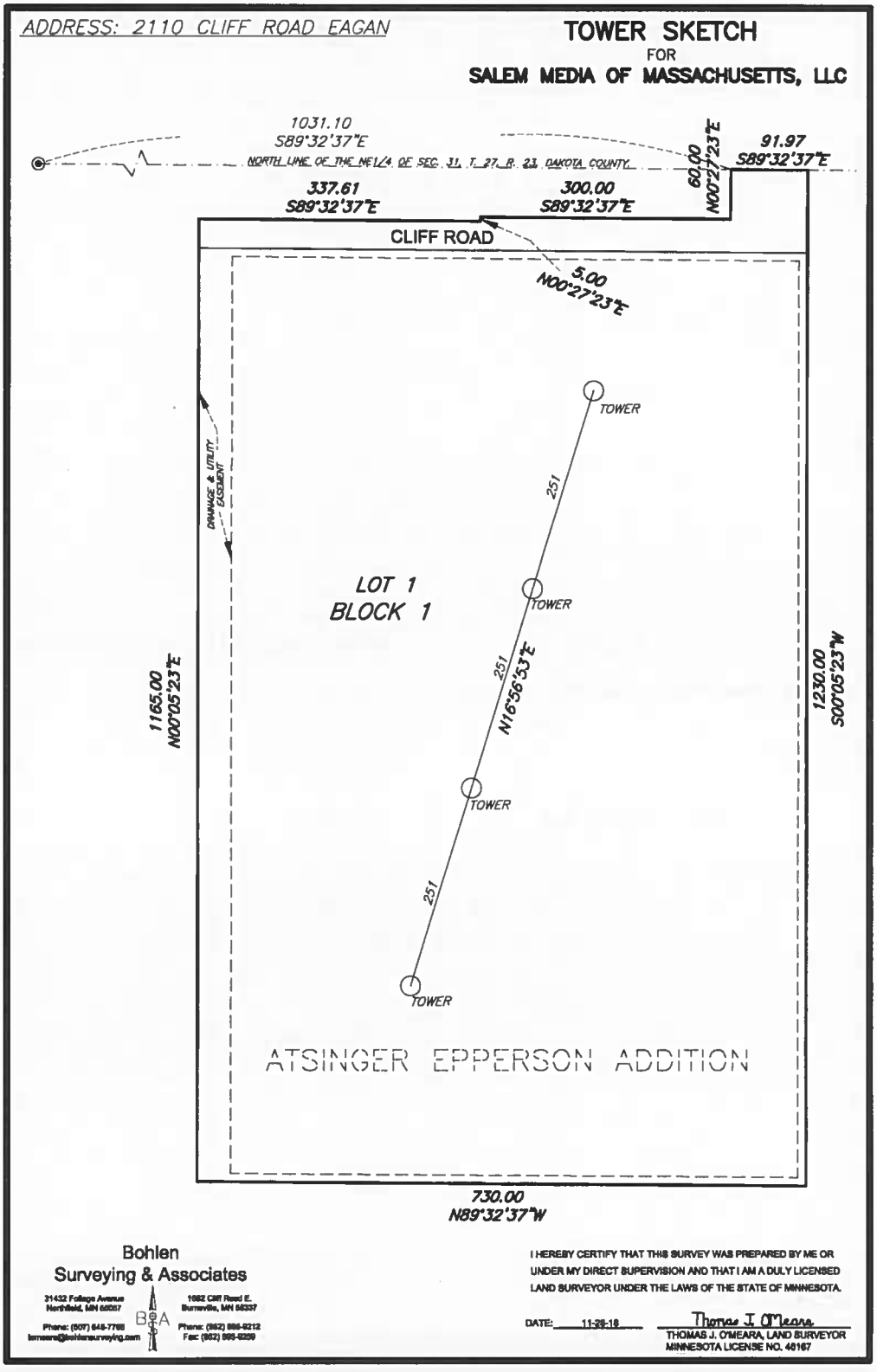


FIGURE 16 CONTINUED
WWTC CERTIFIED ARRAY GEOMETRY SURVEY
DECEMBER, 2018

Station Tower Geometry Analysis

Enter Requested Data in Yellow Blocks			
Callsign:	WWTC	*Reference Tower:*	1
Freq. (kHz):	1280 kHz	*Feet per wavelength:*	768.4148878

Tower Pair Studied	*Licensed Spacing (Electrical degrees)*	*Licensed Azimuth (Degrees True)*	*Measured Distance (feet)*	*Measured Azimuth (Degrees True)*	*Tower Location Error from Licensed (Result in Feet)*	*Tower Location Error from Licensed (Electrical Degrees)*	*Tower No. & (Loc)*
1 (ref)	0.0	0.0	0.0	0.0	0.00	0.00 °	#1(S)
1 to 2	117.6	17.0	251.000	16.9350	0.29	0.13 °	#2(SC)
	235.2	17.0	502.000	16.9350	0.57	0.27 °	#3(NC)
	352.8	17.0	753.000	16.9350	0.86	0.40 °	#4(N)
					--	--	
					--	--	
					--	--	
					--	--	
					--	--	

Law of Cosines Analysis

Tower Pair Studied	Licensed Specification (Side "a") of Triangle (Feet)	Licensed Azimuth Versus Measured Azimuth Difference	Included Angle A Converted to Radians	Tower Location Error from licensed position (Result in Feet)	Error in Feet Converted to Electrical Degrees	*Error Greater Greater Than 1.5° ? (3.20 ft)*
1 (ref)	--	--	--	0.00	0.00 °	N/A
1 to 2	251.02	0.0650 °	0.001134464	0.29	0.13 °	No - Therefore Okay
0	502.03	0.0650 °	0.001134464	0.57	0.27 °	No - Therefore Okay
0	753.05	0.0650 °	0.001134464	0.86	0.40 °	No - Therefore Okay
0	--	--	--	--	--	--
0	--	--	--	--	--	--
0	--	--	--	--	--	--
0	--	--	--	--	--	--
0	--	--	--	--	--	--

FIGURE 17
WWTC SPURIOUS RADIATION MEASUREMENTS
DECEMBER, 2018

KKMS (980 kHz) DA MODE
WWTC (1280 kHz) DAY MODE

Frequency (kHz)	Field Intensity (mV/M)	Attenuation (dB) relative to KKMS	Attenuation (dB) relative to WWTC
980	1250	---	---
1280	1720	---	---
600	<.01	>101.9	>104.7
680	.10	81.9	84.7
900	<.01	>101.9	>104.7
1580	.11	81.1	83.9
1880	.08	83.9	86.6
1960	<.01	>101.9	>104.7
2260	<.01	>101.9	>104.7
2560	.10	81.9	84.7
2860	.02	95.9	98.7
2940	.035	91.1	93.8
3240	.05	88.0	90.7
3840	.09	82.9	85.6
4220	.013	99.7	102.4
4520	<.01	>101.9	>104.7
4820	.023	94.7	97.5

Above taken with Potomac Instruments, FIM-41, 0.93 km from the array on a bearing of 17° T.
Point Coordinates (NAD27): N 44° 47' 47.2", W 93° 12' 41.5".

Above readings meet required attenuation of: 80 dB

FIGURE 17 CONTINUED
WWTC SPURIOUS RADIATION MEASUREMENTS
DECEMBER, 2018

KKMS (980 kHz) DA MODE
WWTC (1280 kHz) NIGHT MODE

Frequency (kHz)	Field Intensity (mV/M)	Attenuation (dB) relative to KKMS	Attenuation (dB) relative to WWTC
980	1250	---	---
1280	2220	---	---
600	<.01	>101.9	>106.9
680	.11	81.1	86.1
900	<.01	>101.9	>106.9
1580	.10	81.9	86.9
1880	.09	82.9	87.8
1960	<.01	>101.9	>106.9
2260	<.01	>101.9	>106.9
2560	.10	81.9	86.9
2860	.02	95.9	100.9
2940	.035	91.1	96.0
3240	.06	86.4	91.4
3840	.09	82.9	87.8
4220	.022	95.1	100.1
4520	<.01	>101.9	>106.9
4820	.028	93.0	98.0

Above taken with Potomac Instruments, FIM-41, 0.93 km from the array on a bearing of 17° T.
Point Coordinates (NAD27): N 44° 47′ 47.2", W 93° 12′ 41.5".

Above readings meet required attenuation of: 80 dB

FIGURE 18
KKMS SAMPLING SYSTEM DESCRIPTION/MEASUREMENTS

APPLICATION FOR LICENSE INFORMATION
EMPLOYING MOMENT METHOD MODELING
WWTC, 1280 KHZ, DA-2
MINNEAPOLIS, MINNESOTA
DECEMBER. 2018

SAMPLING SYSTEM DESCRIPTION

The KKMS Sampling System remains as currently licensed with the addition of short Andrew LDF4-50A jumpers added to each sampling line to allow new mounting of the TCT's. No other changes were made to the sampling system.

SAMPLE LINE MEASUREMENTS

Impedance measurements were made of the Antenna Sampling Lines using a HP 8753ES Network Analyzer with a Tunwall directional coupler. Measurements were done with the lines open circuited and then connected to the TCT's.

The table below shows the frequencies above and below the carrier frequency where resonance, defined as zero reactance corresponding with low resistance, was found. Frequencies of resonance occur at odd multiples of 90 degrees electrical length, the Sample Line length at the resonant frequency below the carrier frequency, which is the closest one to the carrier frequency, was found to be 450 electrical degrees. The electrical length at carrier frequency appearing in the table below was calculated by ratioing the frequencies.

SAMPLE LINE MEASUREMENTS

	Resonant Frequency (KHz) below 980 KHz	Resonant Frequency (KHz) above 980 KHz	Calculated Electrical Length (deg) at 980 KHz	Measured Impedance (ohms) Connected to TCT @ 980 KHz
Tower 1	856.4	1203.4	514.9	48.3 –j 0.1
Tower 2	856.3	1204.5	515.0	48.5 +j 0.1
Tower 3	856.8	1204.6	514.7	48.1 +j 0.3
Tower 4	856.1	1203.8	515.1	48.5 +j 1.0

FIGURE 18
KKMS SAMPLING SYSTEM DESCRIPTION/MEASUREMENTS

APPLICATION FOR LICENSE INFORMATION
EMPLOYING MOMENT METHOD MODELING
WWTC, 1280 KHZ, DA-2
MINNEAPOLIS, MINNESOTA
DECEMBER. 2018
CONTINUED

SAMPLE LINE MEASUREMENTS (CONTINUED)

To determine the characteristic impedance values of the Sample Lines, open-circuited measurements were made with frequencies offset to produce ± 45 degrees of electrical length from resonance. The characteristic impedance was calculated using the following formula, where R1 +j X1 and R2 +j X2 are the measured impedances at the +45 and -45 degree offset frequencies, respectively:

$$Z_0 = ((R_1^2 + X_1^2)^{1/2} \bullet (R_2^2 + X_2^2)^{1/2})^{1/2}$$

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	942.0	19.2 +j 46.5	770.8	14.1 –j 46.8	49.59
2	941.9	19.1 +j 46.4	770.7	14.1 –j 46.8	49.52
3	942.5	19.0 +j 46.5	771.1	14.4 –j 47.0	49.69
4	941.7	18.9 +j 45.7	770.5	14.3 –j 46.9	49.24

AGREEMENT FOR ONGOING OPERATIONS

Salem Communications Holding Corporation, the licensee of radio station KKMS(AM), FCC Facility ID No. 18518 ("KKMS") and Salem Media of Massachusetts, LLC, the licensee of WWTC(AM), FCC Facility ID 9676 ("WWTC"), recognize that use of the diplex site they share requires joint cooperation and coordination including occasional disruption of normal operation. Accordingly, both stations agree:

1 - Provide adequate notice to the other when work is required which will require a reduction in power or mode of operation.

2 - In the unlikely event that a failure should occur in the diplex system, the parties recognize that non-directional operation may be required until the system is repaired. WWTC, as owner of the system, agrees to make the repair and return of the system to normal operation its highest priority.

3 - Upon final implementation of the KKMS and WWTC facilities, all measurements, adjustments and FCC filings having been satisfactorily performed, KKMS and WWTC will continue to maintain their respective transmitters, monitoring, audio and remote control and day-to-day operation of the diplex and directional antenna equipment. Each station will be required to maintain the equipment in the direct path between its transmitter and towers in good repair and in accordance with all applicable FCC rules and regulations.

4. To adhere to a worker safety plan for the diplex site.

5. This agreement may be filed with the FCC by either party hereto.

6. If either party obtains FCC approval to assign the license of its radio station that is involved in the diplex operation, that party may assign this Agreement to the assignee of that license.

SALEM MEDIA OF MASSACHUSETTS, LLC

By: Christopher J. Henderson
Title: Executive Vice President of SCA License Corporation,
Its Managing Member

SALEM COMMUNICATIONS HOLDING CORPORATION

By: Christopher J. Henderson
Title: Executive Vice President