

### ENGINEERING EXHIBIT IN SUPPORT OF AN APPLICATION FOR LICENSE STATION WWTC - MINNEAPOLIS, MINNESOTA 1280 kHz - 5 kW, U, DA-N Facility ID: 9676

Applicant: Salem Media Group, LLC

APRIL, 2010

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# SECTION III OF FCC FORM 302-AM

# ENGINEERING STATEMENT OF JAMES D. SADLER

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### ENGINEERING STATEMENT OF JAMES D. SADLER IN SUPPORT OF AN APPLICATION FOR LICENSE STATION WWTC - MINNEAPOLIS, MINNESOTA 1280 kHz - 5 kW, U, DA-N Facility ID: 9676

Applicant: Salem Media Group, LLC

I am a Technical Consultant, an employee in the firm of Carl T. Jones Corporation with offices located in Springfield, Virginia. My education and experience are a matter of record with the Federal Communications Commission.

### 1.0 GENERAL

Station WWTC is licensed for operation on 1280 kHz at a power of 5 kilowatts during daytime and nighttime hours employing a directional antenna pattern during nighttime hours (DA-N). This office has been authorized by Salem Media Group, LLC ("Salem"), licensee of Station WWTC, Minneapolis, Minnesota, to prepare this engineering statement and the associated figures and appendices in support of an Application for License. This application follows minor adjustments to the nighttime directional array to return the monitor points within licensed tolerances. During this process, it was determined that efforts to combat the seasonal field strength increases at the monitor points could be eliminated by performing a proof of performance in accordance with the computer modeling and sample system verification procedures contained in 47 CFR 73.151(c) of the

FCC Rules. Information is provided herein to support a complete directional antenna performance verification pursuant to the FCC Rules. The measurement and modeling techniques used to perform the proof of performance are described in this engineering statement. The measurement data and the pertinent computer generated input and output files are contained in the associated figures and Appendices A and B.

### 2.0 COMPUTER MODELING AND SAMPLE SYSTEM VERIFICATION

The proof of performance contained herein is based on the computer modeling and sample system verification procedures described in 47 CFR 73.151(c). The WWTC antenna array consists of four identical, triangular, uniform cross-section, steel, guyed, series-fed towers. Each tower is 90 electrical degrees (58.55 meters) in height. All towers have a 15-inch face width. The sampling system utilizes identical toroidal current transformers located at the output of the antenna matching network and prior to the diplexer network at the base of each tower.

#### 2.1 INDIVIDUAL TOWER IMPEDANCE MEASUREMENTS

Impedance measurements were performed at the base of each tower by the undersigned at the output J-Plug of the antenna matching network. This measurement location corresponds to the input to the diplexer network and the location of the sampling system toroidal current transformer. The impedance measurements were performed using a Hewlett-Packard, Model 4396A, network analyzer; an Amplifier Research, Model

5W1000, power amplifier; and a Tunwall Radio directional coupler. The impedance was measured for each tower in the array with the other three towers open circuited at the same ATU output J-Plug location that was used to perform the impedance measurement.

#### 2.2 INDIVIDUAL TOWER COMPUTER MODELS

A Method of Moments ("MoM") computer model was developed to model each element in the array using Expert MININEC Broadcast Professional (Version 12.5). The WWTC towers are all equal height, uniform cross-section, guyed structures with base insulators. A vertical wire model was developed for each tower. The radiator was defined by eighteen segments, and an equivalent radius was calculated based on the tower face width using the following formula:

$$R = \frac{1}{2} \times \frac{3F}{\pi}$$

where:

**R** = Equivalent Radius **F** = Tower face width

The tower physical heights were adjusted and lumped series inductances and shunt capacitances were inserted at the base of each tower to replicate the individual measured tower base impedances within FCC Rule tolerances.

A tabulation of the details employed in the individual tower modeling is included herein as Figure 1. A comparison of the measured individual tower impedances versus the modeled individual tower impedances along with the shunt capacitances and the lumped

series inductances employed in the model is contained in Figure 2. The adjusted tower heights, radii, shunt capacitances, and lumped series inductances employed are all well within the corresponding tolerances set forth in the Rules. As demonstrated in Figure 2, the adjusted modeled individual tower resistances and reactances are within  $\pm 2$  ohms and  $\pm 4$  percent of the respective individual measured tower resistances and reactances. The text files containing all necessary input and output data associated with the individual tower modeling are contained in Appendix A.

#### 2.3 DIRECTIONAL ANTENNA COMPUTER MODEL

The theoretical directional antenna parameters were used in conjunction with the individual tower computer models to produce the nighttime directional antenna computer model. From the computer model, tower current distributions were derived that, when numerically integrated and normalized to the reference tower, are identical to the authorized field parameters of the theoretical directional antenna patterns. The modeled relative antenna monitor parameters, as calculated at the base of the tower and corresponding to the location of the individual tower impedance measurement locations used in the model, are provided in Figure 3. Shunt capacitances employed for each tower were used to derive the final antenna monitor parameters. The text files containing all necessary input and output data associated with the nighttime directional antenna computer model are contained in Appendix B.

#### 2.4 COMMON POINT IMPEDANCE AND CURRENT

The networks associated with the nighttime directional antenna system were adjusted for proper impedance transformation and the common point impedance matching network was set for Z = 50-j13 ohms. The type accepted transmitter output power level was adjusted such that the common point current was 10.39 amperes to achieve an input power of 5,400 Watts. The daytime base impedance remains as currently licensed, Z = 89 + j 140. The daytime base current remains 7.49 amperes for an antenna input power of 5,000 Watts.

#### 2.5 SAMPLE SYSTEM DESCRIPTION AND VERIFICATION MEASUREMENTS

The WWTC antenna sampling system utilizes identical Delta Electronics, Model TCT-1, toroidal current transformers mounted at the output of each tower's impedance matching network. The transformers are connected to a Potomac Instruments, Model 1901-4, antenna monitor with equal lengths of Cablewave, Type FCC38-50J, phase stabilized, foam dielectric, <sup>3</sup>/<sub>8</sub> inch coaxial cable. The sample cables, including excess lengths of cable, are buried such that each cable is subjected to the same environmental conditions.

In accordance with the Rules, the sampling system toroidal current transformer performance was verified by driving a common reference current through all four transformers and comparing their outputs against one another as observed on the Potomac Instruments Model 1901-4 antenna monitor. The devices were found to perform well within

the manufacturer's stated accuracy. A tabulation of the measured values along with the serial number for each of the toroidal current transformers is included in Figure 4. The antenna monitor, Serial Number 473, was calibrated by the manufacturer April 13, 2010, as required by 47 CFR 73.69(e).

The sample lines were verified to be equal in length by measuring the open-circuit series resonate frequency closest to the carrier frequency. The characteristic impedance was verified by measuring the impedance at frequencies corresponding to odd multiples of 1/8 wavelength immediately above and below the open circuit series resonant frequency closest to the carrier frequency, while the line was open circuited. The characteristic impedance impedance was calculated by the following formula:

$$Z = \sqrt{\sqrt{R_1^2 + X_1^2}} \times \sqrt{R_2^2 + X_2^2}$$

where:

**Z** = Characteristic impedance and  $\mathbf{R}_1 + \mathbf{j} \mathbf{X}_1$  and  $\mathbf{R}_2 + \mathbf{j} \mathbf{X}_2$  are the measured impedances at  $\pm 45$  degrees offset frequencies.

A tabulation of the sample line verification measurements is included herein as Figure 5. All sample line verification measurements were performed by the undersigned using a Hewlett-Packard, Model4396A, network analyzer; an Amplifier Research, Model 5W1000, power amplifier; and a Tunwall Radio directional coupler. As demonstrated by the measured values in Figure 5, the measured sample line lengths are within 1 electrical degree of each other and the measured characteristic impedances are well within 2 ohms of each other as required by 47 CFR 73.151(c)(2)(i) of the FCC Rules and Regulations.

An impedance measurement was performed at the input to each sample line, at the antenna monitor end of the line, with the sample toroid connected. The measurement was performed at the WWTC operating frequency of 1280 kilohertz. The measurements are contained in the table of Figure 5.

### 2.7 POST-CONSTRUCTION CERTIFICATION

In accordance with the Rules, this facility is exempt from the requirement of submitting a surveyor's certification as to the location of the towers as the application merely proposes a re-licensing of this existing facility under the new rules.

### 2.8 REFERENCE FIELD STRENGTH MEASUREMENTS

Reference field strength measurements were performed on a total of five radial bearings. The 26° radial corresponds to the major lobe while the 107°, 158°, 241°, and 307° radials correspond to the pattern minima. A total of three field strength measurements were performed on each of the five radials. The measurements were performed by Mr. Rob Goldberg, contract engineer for the station, using a Potomac Instruments, Model FIM-21, field intensity meter, Serial Number 926, calibrated May 5, 2006. The meter was checked against a meter calibrated in the last two years and was found to be in close agreement. The GPS coordinates (NAD83) and descriptions of the reference point

locations are provided in Figure 6 along with the corresponding measured field strength value for each established location.

### **SUMMARY**

It is submitted that the WWTC nighttime directional antenna system has been adjusted to conform with the technical specifications contained in the Station License. The WWTC nighttime pattern performance has been verified using computer modeling and sample system verification procedures in accordance with Section 47 CFR 73.151(c) and it is believed that the WWTC antenna system is operating within the terms of it's License Authorization and the FCC's Rules and Regulations. It is requested that a superceding license authorization be issued to reflect the new operating parameters and additional supporting data contained herein. The license should reflect the replacement of the existing monitoring points with the newly established reference points.

This engineering statement, FCC Form 302-AM, Section III, and the attached figures and appendices were prepared by the undersigned or under the direct supervision of the undersigned and are believed to be true and correct.

Dated: April 21, 2010

# TOWER MODEL HEIGHT AND RADIUS

STATION WWTC - MINNEAPOLIS, MINNESOTA 1280 kHz - 5 kW, U, DA-N APRIL, 2010

Tower	Physical Height (meters)	Modeled Height (meters)	Percent of Physical Height	Tower Face Width (meters)	Equivalent Radius (meters)	Modeled Radius (meters)	Percent of Equivalent Radius
1	58.55	64.40	110.0	0.3810	0.1819	0.1819	100.0
2	58.55	64.40	110.0	0.3810	0.1819	0.1819	100.0
3	58.55	64.40	110.0	0.3810	0.1819	0.1819	100.0
4	58.55	64.40	110.0	0.3810	0.1819	0.1819	100.0

# **MEASURED AND MODELED IMPEDANCES**

STATION WWTC - MINNEAPOLIS, MINNESOTA 1280 kHz - 5 kW, U, DA-N APRIL, 2010

Tower	Measured Tower Base Impedance <sup>1</sup>	Modeled Tower Base Impedance	Shunt Capacitance (pF)	Lumped Series Inductance (uH)	Adjusted Tower Base Impedance
1	69.4 +j 139.8	57.3 +j 74.7	155.0	7.8	69.2 +j 139.6
2	63.6 +j 127.5	55.3 +j 76.7	110.0	6.0	63.4 +j 127.3
3	55.8 +j 121.6	57.3 +j 74.7	0.0	5.8	57.3 +j 121.3
4	61.3 +j 121.9	55.3 +j 76.7	90.0	5.4	61.8 +j 122.1

<sup>1</sup> Measured at output J-Plug of matching network with other towers opened at J-Plug

STATION WWTC - MINNEAPOLIS, MINNESOTA 1280 kHz - 5 kW, U, DA-N APRIL, 2010

	NIGHTTIME								
	Mininec Model	ed Parameters	Final Circuit Modeled Paramet						
Tower	Ratio	Phase (degrees)	Ratio	Phase (degrees)					
1	1.000	0.0	1.000	0.0					
2	0.644	-143.7	0.654	-141.6					
3	0.352	80.0	0.393	78.2					
4	0.650 -129.7 0.675 -128.5								
	Common Point Impedance = 50 -j 13 ohms								
	Common Point Current = 10.39 amperes								
	Antei	nna Input Power =	5,400 Watts						

# SAMPLE DEVICE CALIBRATION

# STATION WWTC - MINNEAPOLIS, MINNESOTA 1280 kHz - 5 kW, U, DA-N APRIL, 2010

Reference	Measured	Measured		
Sample Toroid	Sample Toroid	Field	Phase	
Number	Number	Ratio	(degrees)	
1	2	0.992	-36.9	
1	3	0.995	-36.9	
1	4	0.998	-36.8	
3	4	0.998	-36.6	

Sample Toroid Number	Туре	Serial Number
1	Delta Electronics, TCT-1	1781
2	Delta Electronics, TCT-1	5399
3	Delta Electronics, TCT-1	15714
4	Delta Electronics, TCT-1	1042

# SAMPLE LINE VERIFICATION MEASUREMENTS

STATION WWTC - MINNEAPOLIS, MINNESOTA 1280 kHz - 5 kW, U, DA-N APRIL, 2010

Tower	Open Circuit Series Resonant Frequency <sup>1</sup> (kHz)	Open Circuit Measured Line Length <sup>2</sup> (degrees)	Resonant Frequency -45 degree Offset Frequency (kHz)	Resonant Frequency -45 degree Offset Impedance (Ohms)	Resonant Frequency +45 degree Offset Frequency (kHz)	Resonant Frequency +45 degree Offset Impedance (Ohms)	Calculated Characteristic Impedance (Ohms)	Reference Impedance Sample Toroid Connected <sup>2</sup> (Ohms)
1	1154.0	499.1	1038.6	10.45 <i>-</i> j 45.35	1269.4	9.71 +j 52.10	49.66	49.14 -j0.60
2	1154.8	498.8	1039.3	10.53 <i>-</i> j 45.58	1270.3	9.48 +j 51.75	49.61	49.05 +j0.79
3	1154.4	499.0	1039.0	10.50 -j 45.55	1269.8	9.12 +j 50.85	49.14	48.79 +j0.28
4	1155.8	498.4	1040.2	10.42 -j 45.45	1271.4	9.78 +j 52.41	49.86	48.76 -j1.01

<sup>1</sup> At this frequency, the sample line electrical length is equal to 450°.

<sup>2</sup> At carrier frequency (1280 kHz)

# **REFERENCE FIELD STRENGTH MEASUREMENTS**

## STATION WWTC - MINNEAPOLIS, MINNESOTA 1280 kHz - 5 kW, U, DA-N APRIL, 2010

### Nighttime - 26 Degree Radial

Point	Distance	Measured Field	Geographic Coordinates (NAD83)		
Number	(km)	(mV/m)	Latitude	Longitude	Description
1	1.88	339	44° 58' 34"	93° 20' 48"	Point is located at the west side of Lawn Terrace, south corner of driveway entrance at 115 Lawn Terrace.
2	6.67	98	45° 00' 54"	93° 19' 11"	Point is located at the north peak of the corner of crosswalk of Lakeland Avenue N and York Avenue N.
3	8.92	71	45° 01' 59"	93° 18' 26"	Point is located at the corner of 43rd Avenue N and N Oliver Avenue on the south side of 43rd and the eastside of N Oliver.

## Nighttime - 107 Degree Radial

Point	Distance	Measured Field	Geographic Coordinates (NAD83)		
Number	(km)	(mV/m)	Latitude	Longitude	Description
1	1.58	99	44° 57' 25"	93° 20' 16"	Point is located on the west side of Monterey Avenue S, at the curb in front of the front door to 2524 Monterey Avenue S.
2	4.28	66	44° 57' 00"	93° 18' 17"	Point is located on east bound W 29th Street (Mall Street - one way) at the corner of S Knox Avenue and Mall Street.
3	8.40	8.3	44° 56' 21"	93° 15' 18"	Point is located on the west side of 14th Avenue S directly in front of 3508 14th Avenue S.

# **REFERENCE FIELD STRENGTH MEASUREMENTS**

## STATION WWTC - MINNEAPOLIS, MINNESOTA 1280 kHz - 5 kW, U, DA-N APRIL, 2010

# Nighttime - 158 Degree Radial

Point	Distance	Measured Field	Geographic Coordinates (NAD83)		
Number	(km)	(mV/m)	Latitude	Longitude	Description
1	2.57	40	44° 56' 22"	93° 20' 40"	Point is located on the east side of Raleigh Avenue S, 25 feet south of the stop sign near the corner of W 35th Street and Raleigh Avenue S.
2	4.96	8.2	44° 55' 10"	93° 19' 59"	Point is located 10 feet north of the stop sign on the south east corner of Sunnyside Road and Townes Road.
3	9.59	6.1	44° 52' 44"	93° 18' 35"	Point is located on the east side of Queen Avenue S at curb directly in front of 6825 Queen Avenue S.

### Nighttime - 241 Degree Radial

Point	Distance	Measured Field	Geographic Coordinates (NAD83)		
Number	(km)	(mV/m)	Latitude	Longitude	Description
1	1.42	34.5	44° 57' 17"	93° 22' 23"	Point is located on the south side of W 27th Street at the east tip of curb at the entrance to parking lot for building 7309 W 27th Street.
2	4.32	13.9	44° 56' 32"	93° 24' 19"	Point is located on the north side of Lahti Lane (Gaynor Street), 40 feet east of Oak Ridge Road and 30 feet east of the stop sign at Oak Ridge Road and Lahti Lane.
3	7.55	8.1	44° 55' 41"	93° 26' 27"	Point is located on the west side of Windridge Circle at north tip of curb for driveway at 4136 Windridge Circle.

# REFERENCE FIELD STRENGTH MEASUREMENTS

## STATION WWTC - MINNEAPOLIS, MINNESOTA 1280 kHz - 5 kW, U, DA-N APRIL, 2010

# Nighttime - 307 Degree Radial

Point	Distance	Measured Field	• •	Coordinates D83)	
Number	(km)	(mV/m)	Latitude	Longitude	Description
1	2.49	66	44° 58' 29"	93° 22' 56"	Point is located on the west side of Utah Avenue S at the curb in front of 516 Utah Avenue S.
2	5.19	45	44° 59' 21"	93° 24' 35"	Point is located at the west corner of parking lot entrance for 10250 10th Avenue N.
3	8.42	23.2	45° 00' 24"	93° 26' 31"	Point is located 15 feet east of the north east corner of 25th Avenue N and Quinwood Lane N.

# APPENDIX A

INDIVIDUAL TOWER MODELING

	DANCE - '						
norma freq	alization res:		t imped	phase	VSWR	S11	S12
-		ms) (ohm			10111	dB	dB
sourc		node 1, s					
1.28	57.2	288 74.6	94 94.13	3 52.5	3.6957	-4.8206	-1.7364
GEOME	ETRY – TO	OWER 1					
			arees; oth	er dimensio	ns in met	ers	
		perfect g					
wire	caps D	istance	Angle	Z	ra	dius	seqs
1	none 0		0	0		819	18
	0		0	99.			
2	none 12	20.	53.	0	.1	819	18
	12	20.	53.	99.			
3	none 2		23.	0	.1	819	18
		07.85	23.	99.			
4	none 12	-	353.	0	.1	819	18
	1.	20.	353.	99.			
Numbe	er of wi	res	= 4				
ivanio c		rrent node					
			minimum		ma	ximum	
Indiv	vidual w	ires	wire va	lue	ma wire	value	
segme	ent leng		wire va 1 5.	5	wire 1	value 5.5	
	ent leng		wire va 1 5.		wire	value	
segme	ent leng		wire va 1 5.	5	wire 1	value 5.5	
segme radiu	ent leng us	th	wire va 1 5. 1 .1	5	wire 1	value 5.5	
segme radiu ELECT	ent leng is CRICAL DI	th ESCRIPTION	wire va 1 5. 1 .1	5	wire 1	value 5.5	
segme radiu ELECT	ent leng us	th ESCRIPTION (MHz)	wire va 1 5. 1 .1	5 819	wire 1 1	value 5.5 .1819	engths)
segme radiu ELECI Frequ	Ent leng S RICAL D Lencies frequent lowest	th ESCRIPTION (MHz)	wire va 1 5. 1 .1 n	5 819 o. of segm	wire 1	value 5.5 .1819	
segme radiu ELECI Frequ	ent leng is CRICAL Di iencies frequenci	th ESCRIPTION (MHz) Cy	wire va 1 5. 1 .1 n s	5 819 o. of segm teps mini:	wire 1 1 ent lengt	value 5.5 .1819 h (wavele	ı
segme radiu ELECI Frequ no. 1	Ent leng S TRICAL D Lencies frequenc lowest 1.28	th ESCRIPTION (MHz) cy step	wire va 1 5. 1 .1 n s	5 819 o. of segm teps mini:	wire 1 1 ent lengt mum	value 5.5 .1819 h (wavele maximum	ı
segme radiu ELECT Frequ no. 1 Source	Ent leng S CRICAL D Lencies frequend lowest 1.28 ces	th ESCRIPTION (MHz) cy step 0	wire va 1 5. 1 .1 n s	5 819 o. of segm teps minin 1 .015	wire 1 1 ent lengt mum	value 5.5 .1819 h (wavele maximum .015277	ı
segme radiu ELECT Frequ no. 1 Source source	ERICAL Di Dencies frequencies 1.28 ces ce node	th ESCRIPTION (MHz) cy step 0 sector	wire va 1 5. 1 .1 n s magnitude	5 819 o. of segm teps minin 1 .015 phase	wire 1 1 ent lengt mum	value 5.5 .1819 h (wavele maximum .015277 type	ı
segme radiu ELECT Frequ no. 1 Source	Ent leng S CRICAL D Lencies frequend lowest 1.28 ces	th ESCRIPTION (MHz) cy step 0	wire va 1 5. 1 .1 n s	5 819 o. of segm teps minin 1 .015	wire 1 1 ent lengt mum	value 5.5 .1819 h (wavele maximum .015277	ı
segme radiu ELECT Frequ no. 1 Source source 1	ERICAL Di Dencies frequencies 1.28 ces ce node	th ESCRIPTION (MHz) cy 0 step 0 sector 1	wire va 1 5. 1 .1 magnitude 1.	5 819 o. of segm teps minin 1 .015 phase 0	wire 1 1 ent lengt mum 2778	value 5.5 .1819 h (wavele maximum .015277 type voltage	1 78
segme radiu ELECT Frequ no. 1 Sourc 1 Lumpe	ERICAL Di Inencies frequencies lowest 1.28 ces ce node 1 ed loads	th ESCRIPTION (MHz) cy step 0 sector 1 resistanc	wire va 1 5. 1 .1 magnitude 1. e react	5 819 o. of segm teps minin 1 .015 phase 0 ance in	wire 1 1 ent lengt 2778 ductance	value 5.5 .1819 h (wavele maximum .015277 type voltage capacita	n 28 ance passive
segme radiu ELECT Frequ no. 1 Sourc 1 Lumpe load	ERICAL Di Interneties frequencies frequencies lowest 1.28 ces ce node 1 ed loads node	th ESCRIPTION (MHz) cy step 0 sector 1 resistanc (ohms)	wire va 1 5. 1 .1 n s magnitude 1. e react (ohms	5 819 o. of segm teps minin 1 .015 phase 0 ance in ) (mi	wire 1 1 ent lengt 2778 ductance	value 5.5 .1819 h (wavele maximum .015277 type voltage capacita (uF)	n 28 ance passive circuit
segme radiu ELECT Frequ no. 1 Source 1 Lumpe load 1	ERICAL Di Interneties frequence lowest 1.28 ces ce node 1 ed loads node 1	th ESCRIPTION (MHz) cy step 0 sector 1 resistanc (ohms) 0	wire va 1 5. 1 .1 n s magnitude 1. e react (ohms 0	5 819 o. of segm teps minin 1 .015 phase 0 ance in ) (m 0	wire 1 1 ent lengt 2778 ductance	value 5.5 .1819 h (wavele maximum .015277 type voltage capacita (uF) 0	n 78 ance passive circuit 0
segme radiu ELECT Frequ no. 1 Source 1 Lumpe load 1 2	ERICAL Di encies frequencies lowest 1.28 ces ce node 1 ed loads node 1 19	th ESCRIPTION (MHz) Cy step 0 sector 1 resistanc (ohms) 0 0	wire va 1 5. 1 .1 n s magnitude 1. e react (ohms 0 -10,0	5 819 o. of segm teps minin 1 .015 phase 0 ance in ) (m 0 00. 0	wire 1 1 ent lengt 2778 ductance	value 5.5 .1819 h (wavele maximum .015277 type voltage capacita (uF) 0 0	ance passive circuit 0 0
segme radiu ELECT Frequ no. 1 Source 1 Lumpe load 1	ERICAL Di Interneties frequence lowest 1.28 ces ce node 1 ed loads node 1	th ESCRIPTION (MHz) cy step 0 sector 1 resistanc (ohms) 0	wire va 1 5. 1 .1 n s magnitude 1. e react (ohms 0	5 819 o. of segm teps minin 1 .015 phase 0 ance in ) (m 0 00. 0 00. 0	wire 1 1 ent lengt 2778 ductance	value 5.5 .1819 h (wavele maximum .015277 type voltage capacita (uF) 0	n 78 ance passive circuit 0

	OWER 2					
normalization freq resis		imped	phase	VSWR	S11	S12
-	s) (ohms)		(deg)	VOVIL	dB	dB
source = 1; r						
1.28 55.25	52 76.733	94.555	54.2	3.8838	-4.5758	-1.862
GEOMETRY - TOW	VER 2					
Wire coordinat		ees; other d	limensions	s in met	ers	
Environment: p						
uine ene Die		Are er la	P		a	~ ~ ~ ~ ~
wire caps Dis 1 none 0		Angle 0	Z O	-	dius 819	segs 18
1 11011e 0 0		0	99.	• 1	919	10
2 none 120		53.	0	. 1	819	18
120		53.	99.	• '	019	10
3 none 207		23.	0	.1	819	18
		23.	99.			
4 none 120	).	353.	0	.1	819	18
120	).	353.	99.			
Number of stime		4				
Number of wire	es cent nodes	= 4 = 72				
CULI	lent noues	- 72				
		minimum		ma	ximum	
Individual wir		minimum re value		ma: wire	-	
Individual wir segment length	res wi			-	-	
	res wi	re value 5.5		wire	value	
segment length	res wi n 1	re value 5.5		wire 1	value 5.5	
segment length radius	res wi n 1 1	re value 5.5		wire 1	value 5.5	
segment length radius ELECTRICAL DES	res wi h 1 5CRIPTION	re value 5.5		wire 1	value 5.5	
segment length radius ELECTRICAL DES Frequencies (M	res wi n 1 SCRIPTION MHz)	re value 5.5 .1819	of seamer	wire 1 1	value 5.5 .1819	ngths)
segment length radius ELECTRICAL DES Frequencies (M frequency	ces wi n 1 1 SCRIPTION MHZ)	re value 5.5 .1819 no. c		wire 1 1	value 5.5 .1819 h (wavele	
segment length radius ELECTRICAL DES Frequencies (M	res wi n 1 SCRIPTION MHz)	re value 5.5 .1819		wire 1 1 nt lengt	value 5.5 .1819	1
segment length radius ELECTRICAL DES Frequencies (M frequency no. lowest	ces wi n 1 SCRIPTION MHz) Z step	re value 5.5 .1819 no. c steps	s minimu	wire 1 1 nt lengt	value 5.5 .1819 h (wavele maximum	1
segment length radius ELECTRICAL DES Frequencies (M frequency no. lowest	res wi n 1 SCRIPTION MHz) / step 0	re value 5.5 	s minimu	wire 1 1 nt lengt	value 5.5 .1819 h (wavele maximum	1
segment length radius ELECTRICAL DES Frequencies (M frequency no. lowest 1 1.28 Sources source node	res wi n 1 SCRIPTION MHz) / step 0 sector m	re value 5.5 .1819 no. c steps	minimu .01527 phase	wire 1 1 nt lengt	value 5.5 .1819 h (wavele maximum .015277 type	1
segment length radius ELECTRICAL DES Frequencies (M frequency no. lowest 1 1.28 Sources	res wi n 1 SCRIPTION MHz) / step 0 sector m	re value 5.5 	minimu.01527	wire 1 1 nt lengt	value 5.5 .1819 h (wavele maximum .015277	1
segment length radius ELECTRICAL DES Frequencies (M frequency no. lowest 1 1.28 Sources source node 1 19	res wi n 1 SCRIPTION MHz) / step 0 sector m	re value 5.5 	minimu .01527 phase	wire 1 1 nt lengt	value 5.5 .1819 h (wavele maximum .015277 type	1
segment length radius ELECTRICAL DES Frequencies (M frequency no. lowest 1 1.28 Sources source node 1 19 Lumped loads	res wi n 1 SCRIPTION MHz) 7 step 0 sector m 1 1	re value 5.5 	s minimu .01527 phase 0	wire 1 1 nt lengt 1 m 778	value 5.5 .1819 h (wavele maximum .015277 type voltage	8
segment length radius ELECTRICAL DES Frequencies (M frequency no. lowest 1 1.28 Sources source node 1 19 Lumped loads	res wi 1 1 SCRIPTION MHz) 7 sector m 1 1 resistance	re value 5.5 	s minimu .01527 phase 0 s indu	wire 1 1 nt lengt 1 778	value 5.5 .1819 h (wavele maximum .015277 type voltage capacita	8 nce passive
segment length radius ELECTRICAL DES Frequencies (M frequency no. lowest 1 1.28 Sources source node 1 19 Lumped loads	res wi 1 1 SCRIPTION MHz) 7 sector m 1 1 resistance (ohms)	re value 5.5 	s minimu .01527 phase 0	wire 1 1 nt lengt 1 778	value 5.5 .1819 h (wavele maximum .015277 type voltage	8
segment length radius ELECTRICAL DES Frequencies (M frequency no. lowest 1 1.28 Sources source node 1 19 Lumped loads	res wi 1 1 SCRIPTION MHz) 7 5 5 5 5 5 5 5 5 5 1 1 1 1 1 5 5 5 5 5 5 5 5 5 5 5 5 5	re value 5.5 	s minimu .01527 phase 0 e indu (mH)	wire 1 1 nt lengt 1 778	value 5.5 .1819 h (wavele maximum .015277 type voltage capacita (uF)	8 nce passive circuit
segment length radius ELECTRICAL DES Frequencies (M frequency no. lowest 1 1.28 Sources source node 1 19 Lumped loads	res wi 1 1 SCRIPTION MHz) 7 sector m 1 1 resistance (ohms) )	re value 5.5 .1819 no. c steps 1 agnitude  reactance (ohms) -10,000.	s minimu .01527 phase 0 e indu (mH) 0	wire 1 1 nt lengt 1 778	value 5.5 .1819 h (wavele maximum .015277 type voltage capacita (uF) 0	8 nce passive circuit 0

	lizatio	FOWER 3					
freq	res:		t imped	phase	VSWR	S11	S12
-		ms) (ohm	-	(deg)		dB	dB
sourc	e = 1;	node 37,	sector 1				
1.28	57.2	289 74.6	96 94.136	52.5	3.6958	-4.8204	-1.7365
GEOME	יש זירשי						
	TRY - TO		grees; other	dimension	ng in mot	org	
		perfect g				CID	
		2 0					
wire	caps D	istance	Angle	Z		dius	segs
1	none O		0	0	.1	819	18
<u> </u>	0		0	99.			1.0
2	none 12	-	53.	0	.1	819	18
3	none 20	20.	53. 23.	99. 0	1	819	18
3		07.85	23.	99.	• ⊥	019	10
4	none 12		353.	0	. 1	819	18
-		20.	353.	99.	• ±	019	10
Numbe	er of wi		= 4				
	CUI	rrent node	s = 72				
			minimum			ximum	
Indiv	idual w	irog					
	ridual wa		wire valu	ie	wire	value	
	nt leng						
segme	nt leng		wire valu 1 5.5		wire 1	value 5.5	
segme	nt leng		wire valu 1 5.5		wire 1	value 5.5	
segme radiu ELECT	nt lengt s RICAL DI	th ESCRIPTION	wire valu 1 5.5 1 .181		wire 1	value 5.5	
segme radiu ELECT	ent leng s RICAL DI encies	th ESCRIPTION (MHz)	wire valu 1 5.5 1 .181	.9	wire 1 1	value 5.5 .1819	
segme radiu ELECI Frequ	ent lengt s RICAL Di encies frequenc	th ESCRIPTION (MHz) Cy	wire valu 1 5.5 1 .181 no.	.9 of segme	wire 1 1	value 5.5 .1819 h (wavele	
segme radiu ELECT Frequ no.	ent lengt S RICAL D Lencies frequent lowest	th ESCRIPTION (MHz) Cy step	wire valu 1 5.5 1 .181 no. ste	.9 of segme eps minim	wire 1 1 ent lengt	value 5.5 .1819 h (wavele maximum	1
segme radiu ELECT Frequ no.	ent lengt s RICAL Di encies frequenc	th ESCRIPTION (MHz) Cy	wire valu 1 5.5 1 .181 no.	.9 of segme	wire 1 1 ent lengt	value 5.5 .1819 h (wavele	1
segme radiu ELECT Frequ no.	ent lengt STRICAL DI Mencies frequenc lowest 1.28	th ESCRIPTION (MHz) Cy step	wire valu 1 5.5 1 .181 no. ste	.9 of segme eps minim	wire 1 1 ent lengt	value 5.5 .1819 h (wavele maximum	1
segme radiu ELECT Frequ no. 1 Source	ent lengt STRICAL DI Mencies frequenc lowest 1.28	th ESCRIPTION (MHz) Cy step	wire valu 1 5.5 1 .181 no. ste 1	.9 of segme eps minim	wire 1 1 ent lengt	value 5.5 .1819 h (wavele maximum	1
segme radiu ELECT Frequ no. 1 Source	ent lengt STRICAL DI Mencies frequend lowest 1.28	th ESCRIPTION (MHz) Cy step 0	wire valu 1 5.5 1 .181 no. ste 1	.9 of segme eps minim .0152	wire 1 1 ent lengt	value 5.5 .1819 h (wavele maximum .015277	1
segme radiu ELECT Frequ no. 1 Sourc sourc 1	ent lengt STRICAL DI Lencies frequent lowest 1.28 ses se node 37	th ESCRIPTION (MHz) Cy step 0 sector	wire valu 1 5.5 1 .181 no. ste 1 magnitude	.9 of segme eps minim .0152 phase	wire 1 1 ent lengt	value 5.5 .1819 h (wavele maximum .015277 type	1
segme radiu ELECT Frequ no. 1 Sourc sourc 1	ent lengt STRICAL DI Mencies frequend lowest 1.28 Ses se node	th ESCRIPTION (MHz) cy step 0 sector 1	wire valu 1 5.5 1 .181 no. ste 1 magnitude 1.	.9 of segme eps minim .0152 phase 0	wire 1 1 ent lengt 2778	value 5.5 .1819 h (wavele maximum .015277 type voltage	18
segme radiu ELECT Frequ no. 1 Sourc 1 Lumpe	ent lengt RICAL DI Lencies frequend lowest 1.28 es se node 37 ed loads	th ESCRIPTION (MHz) cy step 0 sector 1 resistanc	wire valu 1 5.5 1 .181 no. ste 1 magnitude 1. e reactar	of segme eps minim .0152 phase 0	wire 1 1 ent lengt 2778	value 5.5 .1819 h (wavele maximum .015277 type voltage capacita	n 18 nce passive
segme radiu ELECT Frequ no. 1 Sourc 1 Lumpe load	ent lengt RICAL DI Lencies frequent lowest 1.28 es se node 37 ed loads node	th ESCRIPTION (MHz) Cy step 0 sector 1 resistanc (ohms)	wire valu 1 5.5 1 .181 no. ste 1 magnitude 1. e reactar (ohms)	of segme eps minim .0152 phase 0	wire 1 1 ent lengt 2778	value 5.5 .1819 h (wavele maximum .015277 type voltage capacita (uF)	n 28 ance passive circuit
segme radiu ELECT Frequ no. 1 Sourc 1 Lumpe load 1	ent lengt RICAL DI Lencies frequent lowest 1.28 es se node 37 ed loads node 1	th ESCRIPTION (MHz) cy step 0 sector 1 resistanc	wire valu 1 5.5 1 .181 no. ste 1 magnitude 1. e reactar (ohms) -10,000	of segme ps minim .0152 phase 0 nce ind (mH	wire 1 1 ent lengt 2778	value 5.5 .1819 h (wavele maximum .015277 type voltage capacita	n 18 nce passive
segme radiu ELECT Frequ no. 1 Sourc 1 Lumpe load	ent lengt RICAL DI Lencies frequent lowest 1.28 es se node 37 ed loads node	th ESCRIPTION (MHz) Cy step 0 sector 1 resistanc (ohms) 0	wire valu 1 5.5 1 .181 no. ste 1 magnitude 1. e reactar (ohms)	of segme ps minim .0152 phase 0 nce ind (mH	wire 1 1 ent lengt 2778	value 5.5 .1819 h (wavele maximum .015277 type voltage capacita (uF) 0	n '8 ance passive circuit 0
segme radiu ELECT Frequ no. 1 Source 1 Lumpe load 1 2	ent lengt RICAL Di encies frequencies lowest 1.28 es e node 37 ed loads node 1 19	th ESCRIPTION (MHz) Cy step 0 sector 1 resistanc (ohms) 0 0	wire valu 1 5.5 1 .181 no. ste 1 magnitude 1. e reactar (ohms) -10,000 -10,000	of segme eps minim .0152 phase 0 nce ind (mH). 0 ). 0 0. 0	wire 1 1 ent lengt 2778	value 5.5 .1819 h (wavele maximum .015277 type voltage capacita (uF) 0 0	nce passive circuit 0 0

IMPEDANCE - normalizat:								
freq re (MHz) (d	esist react ohms) (ohms	) (ohms)	phase (deg)	VSWR	S11 dB	S12 dB		
	L; node 55, s 5.251 76.73		54.2	3.8838	-4.5758	-1.862		
GEOMETRY - TOWER 4 Wire coordinates in degrees; other dimensions in meters Environment: perfect ground								
wire caps	Distance	Angle	Z		dius	segs		
1 none	-	0	0	.1	819	18		
2 none	0 120.	0 53.	99. 0	.1	819	18		
	120.	53.	99.					
3 none	207.85	23.	0	.1	819	18		
4 none	207.85	23. 353.	99. 0	1	819	18		
4 110110	120.	353.	99.	• 1 •		10		
Number of t	vires current nodes	= 4 = 72 minimum		ma:	ximum			
Individual		ire value			value			
segment ler radius		1 5.5 1 .1819		1 1	5.5 .1819			
Taurus		.1019		T	.1019			
ELECTRICAL Frequencies freque no. lowest 1 1.28	ency	no. o steps 1		ım	h (wavele maximum .015277			
Sources								
source node 1 55		magnitude 1.	phase 0		type voltage			
Lumped load	ls							
load node	resistance (ohms)	reactance (ohms)	e indu (mH)	lctance	capacita (uF)	nce passive circuit		
1 1	( ormis ) 0	(0000) $-10,000.$	( mH ) 0		(ur) 0	0		
2 19	0	-10,000.	0		0	0		
3 37	0	-10,000.	0		0	0		
4 55	0	0	0		0	0		

# <u>APPENDIX B</u>

NIGHTTIME DIRECTIONAL ARRAY MODEL

IMPEDANCE

normalization = 50.				
freq resist react imped	phase	VSWR	S11	S12
(MHz) (ohms) (ohms) (ohms)		VOVIC	dB	dB
source = 1; node 1, sector 1	(acg)		ab	ab
1.28         22.731         84.47         87.475	74.9	8.8189	-1.9783	-4.3665
source = 2; node 19, sector 1	/ 1 • 9	0.0109	1.9703	1.3003
1.28 69.591 104.55 125.6	56.4	5.0541	-3.4831	-2.584
source = 3; node 37, sector 1	50.1	3.0311	5.1051	2.301
1.28         54.594         245.16         251.16	77.4	23.984	72472	-8.1334
source = $4$ ; node 55, sector 1		200901		0,1001
1.28 68.358 99.167 120.44	55.4	4.766	-3.6998	-2.4154
1.20 00.000 99.107 120.11	33.1	1.,00	3.0990	2.1101
GEOMETRY				
Wire coordinates in degrees; other	dimensions	s in met	ers	
Environment: perfect ground	a±incii0±0iii	5 111 mee	CT D	
Environmente, perfect ground				
wire caps Distance Angle	Z	ra	dius	segs
1 none 0 0	0		819	18
	99.	• ±	019	10
2 none 120. 53.	0	. 1	819	18
120. 53.	99.	• -	019	20
3 none 207.85 23.	0	. 1	819	18
207.85 23.	99.	• -	019	20
4 none 120. 353.	0	.1	819	18
120. 353.	99.	• -	019	10
120. 333.				
Number of wires = 4				
current nodes = 72				
minimum		ma	ximum	
Individual wires wire value				
		wire	value	
			value 5.5	
segment length 1 5.5		wire 1 1	5.5	
segment length 1 5.5		1		
segment length 1 5.5		1	5.5	
segment length 1 5.5 radius 1 .1819		1	5.5	
segment length 1 5.5 radius 1 .1819 ELECTRICAL DESCRIPTION		1	5.5	
segment length 1 5.5 radius 1 .1819 ELECTRICAL DESCRIPTION Frequencies (MHz)		1 1	5.5 .1819	naths)
segment length 1 5.5 radius 1 .1819 ELECTRICAL DESCRIPTION Frequencies (MHz) frequency no.	of segmer	1 1 nt lengt	5.5 .1819 h (wavele	
segment length 1 5.5 radius 1 .1819 ELECTRICAL DESCRIPTION Frequencies (MHz) frequency no. no. lowest step step	of segmer s minimu	1 1 nt lengt um	5.5 .1819 h (wavele maximum	
segment length 1 5.5 radius 1 .1819 ELECTRICAL DESCRIPTION Frequencies (MHz) frequency no.	of segmer	1 1 nt lengt um	5.5 .1819 h (wavele	
segment length 1 5.5 radius 1 .1819 ELECTRICAL DESCRIPTION Frequencies (MHz) frequency no. no. lowest step step 1 1.28 0 1	of segmer s minimu	1 1 nt lengt um	5.5 .1819 h (wavele maximum	
segment length 1 5.5 radius 1 .1819 ELECTRICAL DESCRIPTION Frequencies (MHz) frequency no. no. lowest step step 1 1.28 0 1 Sources	of segmer s minimu .01527	1 1 nt lengt um	5.5 .1819 h (wavele maximum .015277	
segment length 1 5.5 radius 1 .1819 ELECTRICAL DESCRIPTION Frequencies (MHz) frequency no. no. lowest step step 1 1.28 0 1 Sources source node sector magnitude	of segmer s minimu .0152 <sup>-</sup> phase	1 1 nt lengt um	5.5 .1819 h (wavele maximum .015277 type	
segment length 1 5.5 radius 1 .1819 ELECTRICAL DESCRIPTION Frequencies (MHz) frequency no. no. lowest step step 1 1.28 0 1 Sources source node sector magnitude 1 1 1 936.479	of segmer s minimu .01527 phase 77.2	1 1 nt lengt um	5.5 .1819 h (wavele maximum .015277 type voltage	
segment length 1 5.5 radius 1 .1819 ELECTRICAL DESCRIPTION Frequencies (MHz) frequency no. no. lowest step step 1 1.28 0 1 Sources source node sector magnitude 1 1 1 936.479 2 19 1 866.041	of segmer s minimu .0152 <sup>-</sup> phase 77.2 274.9	1 1 nt lengt um	5.5 .1819 h (wavele maximum .015277 type voltage voltage	
<pre>segment length 1 5.5 radius 1 .1819 ELECTRICAL DESCRIPTION Frequencies (MHz)     frequency no. no. lowest step step 1 1.28 0 1 Sources source node sector magnitude 1 1 1 936.479 2 19 1 866.041</pre>	of segmer s minimu .01527 phase 77.2	1 1 nt lengt um	5.5 .1819 h (wavele maximum .015277 type voltage	

Page 2 of 4

MEDIUM WAVE ARRAY SYNTHESIS FROM FIELD RATIOS Frequency = 1.28 MHz field ratio tower magnitude phase (deg) 0 -148. 1. 1 .67 2 .45 78. 3 .67 4 -134. VOLTAGES AND CURRENTS - rms source voltage current sourcevorcagecurrentnodemagnitudephase (deg)magnitudephase (deg)1662.1977.27.563282.319612.384274.94.87029218.637669.572159.72.6585882.355592.553288.4.91447232.6 Sum of square of source currents = 224.286 Total power = 5,000. watts TOWER ADMITTANCE MATRIXadmittancereal (mhos)imaginary (mhos)Y(1, 1).00655061-.00597279Y(1, 2).00300558.00208126Y(1, 3).000567322.000232731Y(1, 4).00300563.00208135Y(2, 1).00300558.00208126Y(2, 2).0059049-.00487818Y(2, 3).00300564.00208118Y(2, 4).00242337.00300198Y(3, 1).000567322.00208118Y(3, 2).00300564.00208118Y(3, 3).00655092-.00597282Y(3, 4).00300563.00208127Y(4, 1).00300563.00208135Y(4, 3).00300569.00208127Y(4, 4).00590513-.00487814 TOWER ADMITTANCE MATRIX TOWER IMPEDANCE MATRIX TOWER IMPEDANCE FINITUMimpedancereal (ohms)7(1 1)57.469974.604 impedancereal (ohms)imaginaryZ(1, 1)57.469974.604Z(1, 2)10.7314-29.8943Z(1, 3)-23.0497-8.90501Z(1, 4)10.7315-29.8943Z(2, 1)10.7314-29.8943Z(2, 2)55.524776.5275Z(2, 4)8.61392-29.6491Z(3, 1)-23.0497-8.90501Z(3, 1)-23.0497-8.90501Z(3, 4)10.7296-29.8942Z(3, 3)57.470174.6029Z(3, 4)10.7296-29.8941Z(4, 1)10.7315-29.8943Z(4, 2)8.61392-29.6491Z(4, 3)10.7296-29.8943Z(4, 4)55.524776.5242

Page	3	of	4

CURRE	NT rms						
Frequ	ency = 1	.28 MHz					
Input	power = 5	,000. watts					
Effic	iency = 1	00. %					
coord	inates in	degrees					
curre		5		mag	phase	real	imaginary
no.	Х	Y	Z	(amps)	(deg)	(amps)	(amps)
GND	0	0	0	7.57037	2.3	7.5644	.300629
2	0	0	5.5	7.89926	1.6	7.89626	.21784
3	0	0	11.	8.05011	1.1	8.0485	.160916
4	0	0	16.5	8.09907	.8	8.09829	.112542
5	0	0	22.	8.05829	.5	8.05798	.0702046
6	0	0	27.5	7.93331	.2	7.93324	.0330376
7	0	0	33.	7.72796	0.0	7.72796	7.16E-04
8	0	0	38.5	7.44544	359.8	7.44539	0268657
9	0	0	44.	7.08888	359.6	7.08871	0497132
10	0	0	49.5	6.66167	359.4	6.66133	0677898
11	0	0	55.	6.16745	359.2	6.16692	0810437
12	0	0	60.5	5.60995	359.1	5.60923	0894212
13	0	0	66.	4.993	358.9	4.99214	0928748
14	0	0	71.5	4.32028	358.8	4.31931	0913615
15	0	0	77.	3.59485	358.6	3.59385	0848304
16	0	0	82.5	2.81827	358.5	2.81732	073193
17	0	0	88.	1.98832	358.4	1.98752	0562422
18	0	0	93.5	1.09212	358.2	1.09161	0333994
END	0	0	99.	0	0	0	0
GND	72.2178	-95.8363	0	4.876	218.6	-3.81125	-3.04134
20	72.2178	-95.8363	5.5	5.14541	216.5	-4.13694	-3.05957
21	72.2178	-95.8363	11.	5.28328	215.2	-4.3172	-3.04546
22	72.2178	-95.8363	16.5	5.34883	214.2	-4.42458	-3.0055
23	72.2178	-95.8363	22.	5.35108	213.3	-4.47038	-2.94104
24	72.2178	-95.8363	27.5	5.2939	212.6	-4.45931	-2.85305
25	72.2178	-95.8363	33.	5.17971	212.	-4.39416	-2.74241
26	72.2178	-95.8363	38.5	5.01055	211.4	-4.27703	-2.61011
27	72.2178	-95.8363	44.	4.78844	210.9	-4.10988	-2.45724
28	72.2178	-95.8363	49.5	4.51552	210.4	-3.89471	-2.28499
29	72.2178	-95.8363	55.	4.19412	210.	-3.63361	-2.09464
30	72.2178	-95.8363	60.5	3.82666	209.6	-3.32875	-1.88752
31	72.2178	-95.8363	66.	3.41567	209.2	-2.98238	-1.665
32	72.2178	-95.8363	71.5	2.96359	208.8	-2.59665	-1.42838
33	72.2178	-95.8363	77.	2.47242	208.5	-2.17335	-1.17874
34	72.2178	-95.8363	82.5	1.9432	208.1	-1.71338	916699
35	72.2178	-95.8363	88.	1.37428	207.8	-1.21528	64166
36	72.2178	-95.8363	93.5	.756643	207.5	670992	349683
END	72.2178	-95.8363	99.	0	0	0	0

CURREI	NT rms - Co	ontinued					
Freque		.28 MHz					
Input	power = $5$ ,	,000. watts					
Effic	-	)0.8					
	inates in d						
curren				mag	phase	real	imaginary
no.	X	Y	Z	(amps)	(deg)	(amps)	(amps)
GND	191.327	-81.2134	0	2.666	82.3	.359029	2.64171
38	191.327	-81.2134	5.5	3.02115	80.7	.487055	2.98163
39	191.327	-81.2134	11.	3.23143	79.9	.567794	3.18115
40	191.327	-81.2134	16.5	3.37397	79.3	.628772	3.31486
41	191.327	-81.2134	22.	3.46048	78.8	.674112	3.39419
42	191.327	-81.2134	27.5	3.49567	78.4	.705387	3.42376
43	191.327	-81.2134	33.	3.48209	78.	.723367	3.40612
44	191.327	-81.2134	38.5	3.42154	77.7	.728508	3.34309
45	191.327	-81.2134	44.	3.31563	77.4	.721161	3.23625
46	191.327	-81.2134	49.5	3.16592	77.2	.701642	3.08719
47	191.327	-81.2134	55.	2.97406	77.	.670274	2.89754
48	191.327	-81.2134	60.5	2.74177	76.8	.627391	2.66902
49	191.327	-81.2134	66.	2.47085	76.6	.573333	2.40341
50	191.327	-81.2134	71.5	2.163	76.4	.508428	2.1024
51	191.327	-81.2134	77.	1.81967	76.2	.432934	1.76741
52	191.327	-81.2134	82.5	1.4415	76.1	.346915	1.39914
53	191.327	-81.2134	88.	1.02717	75.9	.24993	.996301
54	191.327	-81.2134	93.5	.569687	75.8	.140112	.552189
END	191.327	-81.2134	99.	0	0	0	0
GND	119.106	14.6243	0	4.91992	232.5	-2.99296	-3.90485
56	119.106	14.6243	5.5	5.17691	230.5	-3.29582	-3.99224
57	119.106	14.6243	11.	5.30624	229.2	-3.46818	-4.01595
58	119.106	14.6243	16.5	5.36459	228.2	-3.57704	-3.99795
59	119.106	14.6243	22.	5.36061	227.3	-3.63273	-3.942
60	119.106	14.6243	27.5	5.29802	226.6	-3.63953	-3.85004
61	119.106	14.6243	33.	5.17921	226.	-3.59986	-3.7236
62	119.106	14.6243	38.5	5.00617	225.4	-3.51552	-3.5641
63	119.106	14.6243	44.	4.78091	224.9	-3.38813	-3.37308
64	119.106	14.6243	49.5	4.50557	224.4	-3.21933	-3.15215
65	119.106	14.6243	55.	4.18245	224.	-3.01083	-2.90306
66	119.106	14.6243	60.5	3.81398	223.5	-2.76442	-2.62762
67	119.106	14.6243	66.	3.40267	223.2	-2.48194	-2.32769
68	119.106	14.6243	71.5	2.95094	222.8	-2.16514	-2.00505
69	119.106	14.6243	77.	2.46081	222.5	-1.81552	-1.66117
70	119.106	14.6243	82.5	1.93328	222.1	-1.43378	-1.29686
71	119.106	14.6243	88.	1.36672	221.8	-1.01865	911197
72	119.106	14.6243	93.5	.752202	221.5	563346	498447
END	119.106	14.6243	99.	0	0	0	0