

Cape Coral Southwest Water Plant

900 MHz MAS

SCADA Radio Study

Performed on Tuesday, May 7th 2013

Study Performed For:



Study Performed By:
ADVANTAGE COMMUNICATIONS, Inc.



Report Written May 24th 2013



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Excellence in SCADA Radio Networks

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Mr. Hollis Woodcox,

May 24, 2013

On Tuesday May 7th ACI performed an in field radio study for Commerce Controls Inc. The study was a 900 MHz Multiple Address System (MAS) SCADA radio network for the City of Cape Coral, Florida. This radio network is for a well field SCADA system associated with the city's Southwest Water Plant production. There are two types of radio studies; computer modeled and in field. An In field radio study is where a temporary SCADA radio network is installed and radio frequency (RF) signals are measured for quality between the paths of interest. For 900 MHz SCADA radio networks, there is significantly more accuracy with the in field vs. computer modeled radio study. The higher level of accuracy allows both the integrator and the end user a high level of confidence in the radio network they are building. When mission critical SCADA radio networks are designed, the industry standard RF fade margins must be met or exceeded on each radio path. Reliability is of high importance for mission critical SCADA radio networks.

ACI commenced this radio study by constructing an antenna system on the Lee County guyed tower that is located 100 meters north of the operations building at the Cape Coral SW Water Plant. The top of the omnidirectional antenna was placed at a height of 100' above ground level (AGL). ACI selected 100' because largely the tower was already constructed and this height was considered liberal to what was actually needed to cover the SCADA system's service area. A side arm was used to support the antenna, offsetting it 5' from the tower. The antenna was attached to a 100' long Times Microwave LMR-400 coaxial transmission line, both the antenna and line were selected for their ease of installation and not for suitability for a permanent installation.

This temporary radio study test antenna system was tested for proper operational characteristics with both a high quality network analyzer and spectrum analyzer. The results of these tests showed a very healthy 900MHz antenna system.

RF spectral analysis showed that there is ample clear radio spectrum in the 900 MHz MAS band 952/928 MHz. See graphic below.

Cape Coral will be assigned an operating frequency pair during the FCC licensing phase of this SCADA radio project. The master radio will receive SCADA traffic from the RTUs on an assigned frequency between 928 - 929MHz and the master station will transmit traffic to the RTUs on an assigned frequency between 952 - 953MHz. FCC radio station licensing is specialized work that must be done with skill to avoid co channel and adjacent channel RF interference. ACI has a 20 year history of procuring quality radio channels for our clients.

From the GEMDS Radio model SD9 Manual

RECEIVER

Maximum Usable Sensitivity: -112 dBm at 1×10^{-6} BER (9600 BPS)

NOTE: Typical sensitivity rating at 9600 BPS. See modem type listing in Section 6.0 for detailed ratings.

The manufacturer GEMDS states that the SD9 radio can transport data at a minimum RF signal level of 1 bit error per million bits of data transported, at an RF signal level of -112 dBm. If we add 20 dB of RF margin to this, we have an RF signal level of -92dBm as our minimum RF signal level acceptable. -92 dBm is the weakest signal we could measure and still be confident that the path will be reliable for the measured RTU antenna height. It is noteworthy to mention that the weakest RF signal level in the Cape Coral SW Water Plant's SCADA radio network is -75 dBm as determined from measurements made at well # 214 (1203 Trafalgar Parkway). This RF level is 17 dB stronger than our weakest acceptable and 17 dB also means 50 times stronger than the weakest acceptable RF signal level that is acceptable.

Results of the radio study: In the following table are the results from the in field radio study. There are "As Measured" RSSI values; these fields represent Receiver Signal Strength Indicated (RSSI) as measured with our radio study test SCADA radio, the SD9. There are also "As Built" RSSI values, these fields represent what RSSI values would be present if the actual SCADA radio network were constructed. The reason these numbers are different is because the test gear, specifically the antenna system at the master radio site, was intentionally undersized due to bulky and cumbersome nature of full sized antenna system. When a permanent SCADA master antenna system is built, it will have an antenna with 10 dBd of gain and less coaxial transmission line loss. These differences total 11 dB as our test master antenna had a gain figure of 0 dBd. This difference can be added to our measurements in the "As Measured" column and provide data of what an "As Built" Cape Coral SW Plant SCADA radio network would look like in terms of RSSI at each well site RTU. All of the signal to noise ratio measurements were extremely strong. This value speaks to the quality of the radio channel as it relates to the noise floor. The noise floor is analogist to listening to a conversation in a quite room vs. a noisy environment. The larger the signal to noise ratio value the quieter the environment the receiver has to do its work of decoding signals. In our system it has the most quiet environment to listen to RF signals.

The constructed radio system: The master radio site antenna system should utilize a high quality antenna, designed for operation in the 928 - 953 MHz region of the 900MHz RF Spectrum, with 10 dBd of gain, and 150 MPH wind survival rating. It should be held off the side of the tower with a 4' side arm and heavy duty mounting clamps should be utilized. The main line of coaxial transmission line should be 7/8" hard line such as RFS or Andrew product. It should have a ground kit at the top and bottom of the transmission line. Mounting should be on the east most leg, oriented east. There should be a coaxial surge protector such as Times Microwave or Polyphasor connected to the mainline coaxial cable at the entrance of the radio room or cabinet and bonded to the sites ground.

The RTU radio site should utilize an antenna mounting structure that is capable of withstanding 150 MPH of wind for a period of 3 seconds gusts and it should also meet or exceed the local building code for Cape Coral. A heavy duty pole mount or a small tower both require adequate foundation and/or lateral support. ACI recommends having the antenna's support mast extend beyond the attachment point of the antenna by one to two feet. The antenna should be a YAGI directional antenna designed for operation in the 928 - 953 MHz region of the RF Spectrum. The YAGI antenna should be oriented for optimal RF signal with the bearing listed in the table below being a valued reference point. The main line of coaxial transmission line should be 1/2" hard line such as RFS or Andrew product. There should be a coaxial surge protector such as Times Microwave or Polyphasor connected to the mainline coaxial cable at the entrance of the radio room or cabinet and bonded to the site's ground. Use silver plated RF fittings also.

Installation of RF antenna gear should be performed by skilled persons. High quality connectorization and waterproofing / sealing of RF fittings is imperative for long term reliable SCADA radio networks. Aligning the antenna on the proper bearing and plumb to horizon is also important.

Cape Coral SW Water Plant Production Well Field SCADA Radio Study

Well #	Location	North Latitude	West Longitude	Bearing to Master (Degrees)	Distance to Master (Miles)	Field Measurements		Comments	As Built RSSI (dBm)
						RSSI (dBm)	SNR (dB)		
Master	SW Water Plt. 2090 SW 32 st.	26 35 31.09	82 0 59.87	0	0	N/A	N/A	MASTER SITE	N/A
101	3300 SW 20th Ave					>-60	24	14' AGL, On property, Line of Sight.	>-60
102	3400 SW 20th Ave	26 35 25.78	82 0 54.96	320.51	0.13	>-60	24	14' AGL, On property, Line of Sight.	>-60
103	3300 SW 20th Ave	26 35 19.97	82 00 54.94	338.21	0.23	>-60	24	14' AGL, Line of Sight	>-60
104	SW Water Plt. 2090 SW 32 st.	26 35 31.91	82 01 4.32	101.61	0.08	>-60	24	14' AGL, On property, Line of Sight.	>-60
105	SW Waste Water	26 35 31.9	82 01 13.64	93.74	0.24	>-60	24	14' AGL, On property, Line of Sight.	>-60
106	2520 Gleason Pkwy	26 35 28.66	82 1 27.90	84.44	0.48	>-60	24	14' AGL, Line of Sight	>-60
107	3514 Chiquata Blvd S	26 35 14.14	82 0 25.02	298.56	0.68	>-60	24	14' AGL	>-60
108	3816 S Chiquata Blvd	26 34 50.55	82 0 24.87	322.34	0.98	>-60	24	14' AGL	>-60
109	4200 S Chiquata Blvd	26 34 26.22	82 0 24.62	334.13	1.38	-65	24	14' AGL	>-60
110	3712 Aqualinda Blvd	26 34 56.60	82 13.04	4.68	0.66	>-60	24	14' AGL	>-60
111	3925 Aqualinda Blvd	26 34 41.76	82 12.84	3.02	0.95	>-60	24	14' AGL	>-60
112	2021 SW 36th Ter	26 35 5.92	82 10.26	0.75	0.48	>-60	24	14' AGL	>-60
211	1900 Trafalgar Pkwy	26 37 21.82	82 0 49.78	184.55	2.12	-71	24	14' AGL	>-60
212	1700 Trafalgar Pkwy	26 37 21.81	82 0 32.74	192.38	2.17	-71	24	14' AGL	>-60
213	1400 Trafalgar Pkwy	26 37 21.74	82 0 16.07	199.49	2.25	-76	24	14' AGL	-65
214	1203 Trafalgar Pkwy	26 37 21.64	82 0 1.87	205.19	2.34	-86	24	14' AGL, Pine tree directly in path.	-75
215	1000 Trafalgar Pkwy	26 37 21.95	81 59 47.50	210.25	2.46	-75	23	14' AGL	-64
216	1500 Gleason Pkwy	26 35 32.8	82 0 21.17	267.18	0.67	>-60	24	14' AGL	>-60
217	1226 Gleason Pkwy	26 35 32.92	82 0 5.78	267.86	0.93	>-60	24	14' AGL	>-60
218	1013 Gleason Pkwy	26 35 33.00	81 59 51.08	268.25	1.18	>-60	24	14' AGL	>-60
219	622 Gleason Pkwy	26 35 33.16	81 59 17.95	268.7	1.75	>-60	24	14' AGL	>-60
220	424 Gleason Pkwy	26 35 33.20	81 59 2.79	268.86	2.02	>-60	24	14' AGL	>-60
221	224 Gleason Pkwy	26 35 33.26	81 58 47.42	269	2.28	-67	24	14' AGL	>-60
222	121 Gleason Pkwy	26 35 33.32	81 58 32.22	269.08	2.54	>-60	24	14' AGL	>-60
223	800 Trafalgar Pkwy	26 37 22.50	81 59 34.25	214.5	2.59	-77	24	14' AGL	-66
224	700 Trafalgar Pkwy	26 37 22.75	81 59 21.61	218.5	2.73	-66	24	14' AGL	>-60
225	1305 Chiquata Blvd S	26 37 39.86	82 0 25.88	193.29	2.53	-66	24	14' AGL	>-60
226	1622 SW 30th Ter	26 35 44.50	82 0 30.81	242.71	0.56	>-60	24	14' AGL	>-60
227	1606 SW 28th Ter	26 35 56.09	82 0 26.90	229.6	0.74	>-60	24	14' AGL	>-60
228	1601 Sw 26th St	26 36 15.84	82 0 26.71	213.58	1.03	>-60	23	14' AGL	>-60
229	1605 SW 23rd Ter	26 36 31.30	82 0 27.16	205.91	1.28	-63	24	14' AGL	>-60
230	911 SW 32nd Terr	26 35 30.98	81 59 40.13	270.1	1.37	>-60	24	14' AGL	>-60
231	1613 SW 19th Ln	26 36 59.53	82 0 29.43	197.06	1.77	-61	23	14' AGL	>-60
232	1602 SW 17th Ter	26 37 13.58	82 0 27.07	195.9	2.04	-73	23	14' AGL	-62

May 5th 2013 Advantage Communications, Inc. 954 961 2642 www.advantage-com.com

Photos of From the In Field Radio Study

Temporary Master Radio Station Antenna for Radio Study, mounted at 100' AGL (antenna top)



The 100' AGL height level is below the microwave dishes so it is clear of other antennas in operation on this Lee County Antenna Tower. ACI's radio test antenna is visible below the lowest dish on the right side of the tower.



The photo below is a well RTU with existing antenna mast and support structure, It was typical to the existing 450 MHz SCADA radio network. This material is television consumer grade hardware. It does not meet building code and has a likely wind survival rating of around 50-75MPH. This is not acceptable for a water production mission critical application of SCADA radio.



ACI's Test antenna is visible in the background here at well # 219



ACI would like to thank Commerce Controls Inc. and the City of Cape Coral for the opportunity to participate on this project.

Mark Lavalley
Radio Surveyor and President of Advantage Communications, Inc.