White Paper – Use of 220-222 MHz Radios for Utility Applications

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In recent years there has been a convergence of using the spectrum in the 220-222 MHz band for data applications. While many manufacturers and end users are using this spectrum for automatic vehicle location and mobile data, applications of the 220 MHz spectrum that are useful to utilities are Automatic Meter Reading (AMR) and Supervisory Control and Data Acquisition (SCADA). These systems have traditionally used cellular networks, plain-old telephone service (POTS) networks, and dedicated leased lines in conjunction with private microwave and fiber networks. By using 220 MHz radios, utilities can limit the reoccurring charges that have been associated with cellular phones, POTS, and leased lines. The 220 MHz spectrum provides for a larger coverage area than higher frequency spectrum such as 900 MHz, which reduces the cost of building sites. The spectrum in the 220 – 222 MHz band is especially well suited for rural areas where the devices are spread out over a large area and where rough and wooded terrain exists.

System Architecture

To be able to gather AMR or SCADA data over radio, the host systems should poll the end devices. While AMR systems usually use cellular phones and POTS lines to read meters, most of the AMR systems can be configured to poll addressable meters for responses. SCADA on the other hand has traditionally used a polled architecture to communicate to RTUs. Most utilities also have separate systems for AMR and SCADA operating from different host computers. Therefore, each system needs its own communications channel to poll devices. The host computer polls each addressable device in a certain order at a specific interval. As each device is polled, the device will transmit a response back to the host computer. Devices have traditionally been polled using multi-drop modems over leased lines, private microwave circuits, or a combination of both, since the host computer sends one request at a time and gets only one response at a time. Since this is very similar to a point-to-multipoint radio system architecture, radios can also be used, which limits the need of expensive leased lines. If there are multiple base sites or the base sites are located away from the host computer site then the base sites could be connected to the host computer via private microwave radio links, fiber optic network, leased lines, or frame relay. A point-to-multipoint radio system architecture extended over a private microwave network is illustrated in Figure 1.

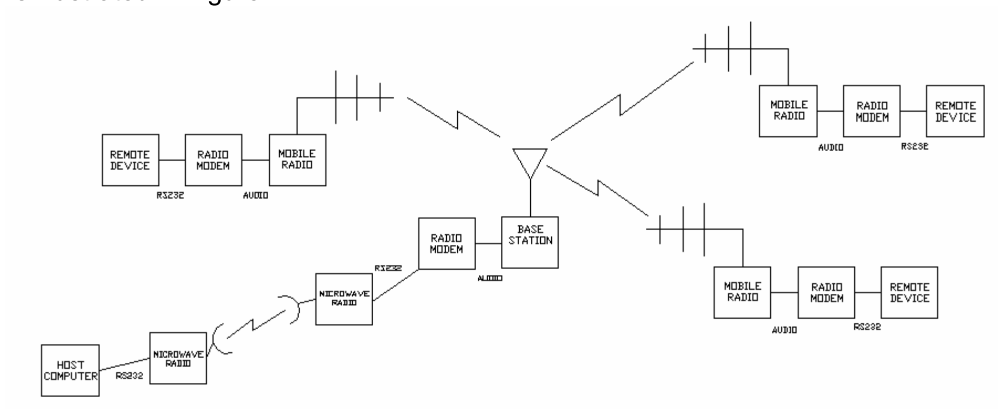

Figure 1 – Point-to-Multipoint Radio System Architecture

Transmission System

The base radio site can have base stations connected to their own antenna system or can have several base stations connected to one antenna system using an antenna combining system. While using an antenna combining system has some added transmission system losses, this can be overcome by using higher power base station radios. By using an antenna combining system, future additions to the site do not require additional tower work, the tower loading is minimized, and if tower space has to be leased, it reduces reoccurring operating costs. It also allows the simultaneous use of the antenna system for both voice and data. Figure 2 shows a tower with multiple systems using a single antenna.

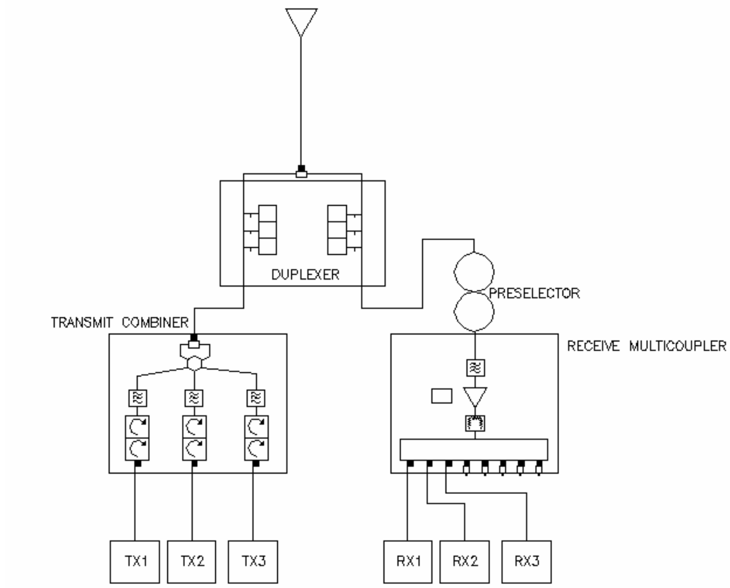

Figure 2 – Transmission Systems

Conventional Base Stations/Mobiles and Radio Modems

While there are many manufactures of dedicated data only radios, the use of conventional base stations and mobiles for data use enables the owner to maintain spares and parts for one type of radio for both data and voice applications. It also allows higher base station power capable of overcoming antenna combining system losses which permits simultaneous use of a single antenna system for both voice and data. High powered conventional base stations operating on 5 kHz channel spacing allows one antenna system to meet the voice coverage required by the FCC for license build-out while also providing for data applications. Conventional base stations and mobiles can be made data ready through the use of radio modems. Radio modems are specialized modems that allow the setting of certain parameters required to transmit data over conventional radios. One of these parameters is transmit attack time, which delays the transmission of data to overcome the radio's push-to-talk (PTT) delay. Most conventional radios have around 100 ms of PTT delay that has to be overcome. These specialized modems allow data to be transmitted over conventional radio systems with highly reliable bit error rates (BER)[1] that are less than 10^{-6} at a level slightly above the listed threshold of the radios receiver. Figure 1 shows a base station and mobile using radio modems to provide paths for RS232 data. Some radios can be fitted with internal modems offered as options by the radio manufacturer.

FCC Rules Regarding Fixed Sites

The FCC has many rules that have been made to govern the use of the 220-222 MHz spectrum. The rules that govern use of the 220-222 MHz spectrum are located in Part 90, Subpart T of Title 47 of the Code of Federal Regulations (47CFR90T). There is one particular rule that directly applies to fixed sites. In order to comply with these FCC rules, the height above average terrain (HAAT) has to be calculated for each base station and fixed station to determine any limitation on antenna height or effective radiated power (ERP). For base station frequencies the maximum ERP permissible for a given HAAT is listed in a chart within Part 90 of the FCC's rules. The maximum permissible ERP for mobiles is

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[1] Bit error rate is value that equals the amount of errors transmitted per bit. A value less than 10^{-6} means that in 1 million bits, there is less than one error.

50 watts, however, when the mobile is used as a fixed station the ERP must be reduced below 50 watts by $20\log_{10}(h/7)$ dB, where h is the HAAT in meters. To comply with this rule the transmit power of the mobile must be reduced so that the ERP is less than 50 watts if the HAAT is greater than seven meters. If the transmit power cannot be reduced to the level needed to meet the 7 meter HAAT rule, attenuators must be added in-line with the coax to reduce the ERP. The transmit power should always be reduced to the lowest level possible before using inline attenuators. By attenuating the output of a mobile radio with attenuators, the receiver is also desensitized which reduces the overall system gain. Reducing the power of the base station to keep it below the maximum ERP is possible through adjustment of the transmitter or through the addition of transmit-only attenuators. These transmit only attenuators only reduce the transmit power and do not desensitize the receiver in the base station.

Multiple Base Sites Connected to One Host Computer Communications Port

Some AMR and SCADA systems have a limited number of communications ports on their host computer systems. If the number of base station sites exceeds the number of communications ports on the host computer system, then modem sharing devices will have to be used to combine data from several base stations onto one communications port. When this is done the order in which the remote devices are scanned will have to be defined over multiple sites. Also, the addition of more meters or RTUs to the host computer's communications port will lengthen the poll time between meters or RTUs. This means that if there are fifteen devices off of one base and ten devices off of another device and they are connected through a sharing device, the host computer has to poll twenty-five devices off of one communications port. By adding up the delays in the system, the maximum polling rate can be determined. The time the host computer takes to scan each device is composed of transmit attack time, path delay, delay of the communications circuit to the base station site, and time of data transfer. If the total time it takes to read all of the register data in a meter takes 5 minutes and there are twenty-five meters on the communications port, that meter can be read every two hours. When planning the system, this must be considered to determine the number of communications ports required in the host computer, the number of base stations required on each communications port, and the number of meters that can be supported on each base station.

Conclusion

The use of the 220 – 222 MHz spectrum to provide AMR and SCADA access via radio can be both an effective as well as a cost effective means of data communications. While there are many ways to implement the 220 – 222 MHz spectrum for data applications, using conventional mobiles, repeaters and antenna combining systems can yield a highly versatile system that allows future growth and applications. It also allows for a reduced maintenance inventory if both 220 MHz voice and data systems are implemented. While this is a data application for utilities, it can be used for other applications as well. Any application where transparent data communications is needed can use this application. The overall system architecture can also be used in other systems. If modems that communicate with a packet data protocol are used, the same architecture can be utilized to provide automatic vehicle location and mobile data. This application is an efficient and effective use of the 220 – 222 MHz spectrum.