The Installation and Use of Spread Spectrum Radio in Dormont and Turtle Creek Boroughs, Pennsylvania

by John J. Rudik, Traffic Systems Control Specialist, District 11, Traffic Engineering Unit, Pennsylvania Department of Transportation

The official state construction project in Dormont Borough, Pennsylvania is known as S. R. 3069, Section A09, and is located on West Liberty Avenue from Bower Hill Road to Pioneer Avenue. The construction project consisted of reconstructing seven existing traffic signal installations which included all new mast arm supports, vehicular and pedestrian signals, Type 170 controllers, underground conduit and wiring, and the overhead fiber optic interconnection of the system to a designated master controller. The master controller would be accessed by a PC computer located in the District 11 offices of PENNDOT through a telephone modem creating a closed loop system.

The choice of fiber optic interconnect was originally proposed to be a pass through cost item with a local utility known as DQE Energy, an electric supplier utility. The reasons for this was that neither PENNDOT or Dormont Borough own the utility support poles within the project limits. The existing pole line along this route consisted of deteriorating iron trolley cable support poles partially abandoned by the utility and now only support street lighting and holiday decoration wiring. Since several had already failed and had been replaced by wooden supports it was our opinion that attaching additional loads was precarious. All electrical service to the customers on West Liberty Avenue are serviced from the rear adjoining streets by DQE Energy.

At that time this left the options available to paying a yearly fee to attach to utility owned poles, paying for make ready work for the space needed on the poles, and for the cable and labor to install the cable, or entering into an agreement with a utility to provide this fiber optic service. TCI of PA, Bell Atlantic of PA, and DQE were each contacted for estimates of providing this work. All would lease the lines to Dormont Borough (PENNDOT owns no traffic signals) for a predetermined yearly period for a set fee to be paid up front. The utility would maintain the line for that period but the Borough would assume liability for failures in the system and would have to pay to locate and determine the cause of failure. Costs for this service were: TCI of PA, $149,000 (10 year, 120 month period), DQE Energy, over $100,000 (Price was lump sum of $252,000 for 3 separate systems on this project for a 15 year period), Bell Atlantic of PA, no exact price given but verbally estimated over $100,000 (no time limits given. It appeared that they were not interested in sharing their existing duct lines.). Only $100,000 was estimated for the entire project based on a cost of the linear foot of fiber optic cable installation already installed on other projects. Clearly the utilities where charging premium costs for this work. Alternative methods of interconnection had to be examined.

The preferred method of interconnection presently used in the traffic signal industry is fiber optic cable. However an alternative form of closed loop system interconnection was investigated and included wireless cell phone modems, hardwire telephone connections and a form of Wireless Traffic Control System (WTCS) known as Spread Spectrum Radio. Wireless modems and telephone connections were initially inexpensive but our expe-
Mr. Tom Miller at the Master Controller location.

The experience is that the municipalities fail to keep phone service even at the master controllers over time. Apparently the $200 annual costs per phone line is prohibitive when no direct benefit can be observed by the public. Multiply this by 8 intersections and the annual cost would be about $1,600 for the system.

The supplier of the traffic signal equipment on this project, Traffic Control Products, Mr. Robert Durgin, recommended that the district investigate the use of Spread Spectrum Radio (SS). At first the district traffic personnel were skeptical since we had never even heard of SS. Our only experience with radio control was with the City of Pittsburgh who used a very limited radio system in the early 60's. It was somewhat successful but was abandoned as infeasible due to the terrain, the limited ability to transfer data and, most importantly, because eventual non support by the original manufacturer due to the City's unwillingness to upgrade the technology at that time. It also required an extensive antennae system and tests with the system engineer at the traffic signal installations so we knew that the system would function. Approval was then requested and received approval from the Borough of Dormont since they would be ultimately responsible for the continued operation and maintenance of the system and had initially approved fiber optic cable interconnect.

Spread Spectrum Radio has also been successfully used by other industries such as the electric, water, and gas utilities, railroad communication systems, electric distribution automation and the military for years. It has long been a favorite technology of the military because it resists jamming and is hard for the enemy to intercept. Some typical applications include digital cellular telephones, police radars and

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This set of photos is also from the Turtle Creek Project. The photos illustrate mounting of the Scala Yagi Directional Antennae on top of the poles.

radios, personal communications system (PCS), various alarm systems, amateur radio and traffic control systems. Although it was new to this District and State, it was not new to others.

A short explanation of this method of interconnection is that Spread Spectrum is a technique in which a transmitted signal is spread over a frequency range that is greater than the minimal bandwidth required for information transmission. The purpose of a spread spectrum system is to improve the bit error rate in the presence of noise or interference. The two commonly used techniques are direct sequence (DS) spreading and frequency hopping (FH). In frequency hopping, the transmitter repeatedly changes (hops) the carrier frequency from one frequency to another. The hopping pattern is usually controlled by a periodic pseudo random noise (PN) code. A narrow band interference, can only jam the FH signal for a short time in every PN code period. For FH systems, fast frequency hopping systems will outperform the slow FH system in a fading channel or in a partial-band jamming environment, though they have the same processing gain. Direct sequence technique spreads the spectrum by modulating the original signal (information) with a PN wideband sequence of digital bits called chips to reduce confusion. The DS spread spectrum receiver converts this wideband signal by the despreading operation. While despreading its own signal, it spreads any narrowband interfering signals, reducing the interference power in the narrowband detection system. The amount of performance improvement achieved against interference is the processing gain of the system.\(^1\)

Our SS was supplied by California Microwave, Microwave Data Systems, Model MDS 9810 and installed in March, 1998. The MDS 9810 is a spread spectrum frequency hopping radio designed specifically for telemetry and Supervisory Control and Data Acquisition (SCADA) applications. The MDS 9810 is a high performance license-free radio that provides a viable alternative to licensed radio systems for many applications. Microwave Data Systems has combined their field-proven manufacturing capability with modern digital signal processing (DSP). The result is a radio that utilizes advanced digital techniques such as forward error correction (FEC) to make intelligent radio performance improvements. Data speed is 19.2 KBPS throughout. The time latency of the radio is about 10ms but the typical time is around 7ms, according to the data sheet from Microwave Data Systems. This figure represents the amount of time it takes to key-up the modem inside the radio, before it begins to send the information at the data port. To determine the End-to-End delay one must figure out the length of the message going out, add to that the 10ms delay, add the length of the response from the other end, then add another 10ms. When there is a repeater in between the two radios, as exists in Dormont Borough, one would add another 20ms to the overall time. Our experience of the delay during data transfer from one end of the system to the master was imperceptible. The frequency band is 902-928 MHz Part 15 Spread Spectrum Band. The Frequency

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Hopping Range is 8 selectable zones each containing 128 frequencies for a total of 1019 frequencies.\(^2\)

\[\text{Length of the Poll} + (10\text{ms}) \rightarrow \text{Out}\]
\[\text{Back} \leftarrow (10\text{ms}) + \text{(Length of the data message)}\]

The system was installed by utilizing an MDS 9810 Master Station at S. R. 3069 (West Liberty Avenue) and Wisconsin Avenue which included built in Radio System Diagnostics and a SCADA host CPU along with a local MDS 9810 radio. The local intersections also were equipped with an MDS 9810 radio. Due to the hilly terrain and to insure excellent radio reception one repeater station was included at one of the intersections.

The system continues to operate successfully since installation. The system is continuously being monitored by the District 11 signal designers. As a practical demonstration of an alternative to fiber optic or copper cable interconnection the first

Spread Spectrum Traffic Signal Interconnection in Pennsylvania is clearly an outstanding success.

On March 15, 2001 the Microwave Data Systems, Model MDS 9810, Spread Spectrum Radio System was installed on a project known as S. R. 0130, Continued on page 56

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This photo is from the Turtle Creek Project. The worker in the photo is John McDonough, Electrician, Bronder Technical Services, Inc. Mr. McDonough is shown adjusting the Scala Yagi Directional antenna.

Section A07. The project is in Turtle Creek Borough located in southeastern Allegheny County and consists of 5 signalized intersections with Type 170 controllers. Based on the success of the Dormont Borough project the radio system was chosen in lieu of underground conduit, trench and backfill, and fiber optic interconnect. Preliminary testing indicates that this radio system will also be as successful as the Dormont Borough project and installation.

This report is not an endorsement or recommendation by the Pennsylvania Department of Transportation or its employees of the Microwave Data Systems Inc. radios over those manufactured by other companies. This is a report of the experiences of the user in these two projects. Thanks to Mr. Wade Sober of Microwave Data Systems, Inc., for his technical review of this report and for the in depth explanations of the operation of spread spectrum technology.

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John is an IMSA certified Work Zone Technician, and Traffic Signal Technician, Level I and II. He has sponsored IMSA Certification Courses in Pittsburg at the Pennsylvania DOT offices in Pittsburg, which have been attended by over 35 engineers and technicians. More such courses are planned.
Aerial Lift Fall Protection FOLLOWUP

by Steve Claypool

In 1997, I wrote an article for IMSA on fall protection in aerial lift equipment. At that time, as a result of misinterpretation of recent changes in OSHA standards, there was a common misconception that body harnesses would be required in aerial lifts, and waist belts would no longer be allowed. Today there is still much confusion and disagreement, and in most cases where body harnesses are used in lifts, they do not meet OSHA standards. They are illegal and unsafe. An accident could leave a worker seriously injured or dead, and the employing agency exposed to severe civil and criminal penalties.

The problem is not with the harness itself; properly used, it is an effective safety device. The problem is a failure to properly evaluate the hazards and failure to read, understand, and comply with manufacturers instructions and applicable OSHA regulations. Before 1997, typical fall protection in an aerial lift was a body belt with a six foot or shorter lanyard attached to an anchor point on the boom or bucket. The widespread change in practice since 1997 was to switch to a full body harness with a four foot or six foot lanyard, usually with some type of shock absorber or decelerator, attached to the same anchor point. This configuration is a personal fall arrest system and is regulated by OSHA standard 1926.502(d).

This states, among other things, that the anchor point must be capable of supporting 5,000 lbs. per each worker attached (1926.502(d)(15)); that it must be rigged to prevent the worker from striking the level below, or any object below (1926.502(d)(16)(iii)); and that the employer must provide for prompt rescue in the event of a fall (1926.502 (d)(20)). In most traffic signal or street lighting work, some or all of these standards are violated when using the typical body harness with decelerating lanyard.

5,000 lbs.

Some safety engineers say the objection to use of a harness in a lift or personnel hoist because of the 5,000 lb requirement is a “non-

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