The Sky's the Limit...

Spread Spectrum Radio is linking traffic networks from the ground up

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While radio communication has permeated almost all areas of industry, Intelligent Transportation System (ITS) designers have barely scratched the surface of what is capable with today's engineered modems. Over the past 5 decades the technology has evolved into an extremely secure, reliable, and flexible means of communication. It has proven itself as highly effective for rugged data transmission applications and has done so without compromising throughput. It is this inherent ability to remain stable in harsh conditions that has put radio and, more specifically, Spread Spectrum (SS) radio at the forefront of wireless data communications for the modern traffic industry.

What is Spread Spectrum Radio?

In essence, SS is a transmitting technique whereby the originating signal is spread over a wider area than is required for the data being sent. This "spreading" is of benefit in two primary ways. First, it effectively lowers the bit error rate through avoidance of conflicting signals. Second, it allows a higher data throughput while using the standard allocated bandwidth. Given that signal integrity is not diminished during this process, the result is higher throughput with less error. There are two common forms of SS currently in use: Frequency Hopping (FHSS) and Direct Sequence (DSSS). While the crux of these two forms is the same, the methodology of the signal spread is very different. On the one hand FHSS, as the name suggests, uses a hopping pattern to effectively avoid continuous interference within the frequency band. This interference can take the form of competing signals, general radio noise, or any other transmission within "earshot" of the communications system. FHSS uses pre-set patterns to jump around the band as a function of time, thus vastly decreasing the amount of actual interference affecting signal integrity. Direct sequence, on the other hand, works by way of "converting" or modulating the information over a wider area and then demodulating at the receiver site. This spreading technique has a linear trade off in that it can throughput more data, but is more susceptible to interference as it travels across the radio path. It is for this reason that FHSS tends to be the mode of choice for most Spread Spectrum traffic applications.

The use of Spread Spectrum as we know it, traces its history all the way back to World War II. Admired for its rugged and secure versatility, the military researched and tweaked the technology under a veil of secrecy throughout the 50's, 60's and 70's; using the FHSS technology well into the latter part of the century. It was only when satellite communications became feasible that the military decided to deregulate the technology for public use. Subsequently, the first commercial application of SS took place in the early 1980's. The FCC reserved 3 license free bands for industry applications, with varying widths for different applications. The most commonly used bands, and those that are best suited to traffic applications are the 900MHz band and the 2.4GHz band. The key to band (and radio) selection is the simple understanding of two principles.

First, the lower the frequency, the longer the data can travel uncorrupted and **Second**, the fewer competing devices in a given band, the more reliable the communications link will be. It is for this reason that the majority of traffic applications benefit most from utilizing the 900MHz band, despite whatever misconceptions people may have. A recent standardization of network communication has essentially saturated the 2.4GHz band, making the more stable 900MHz band increasingly attractive for ITS projects. A quality manufacturer, however, will still provide the option to operate in either band.

Figure 1

The ENCOM 5100S FHSS radio (Figure 1) is an example of a wireless device that supports multiple data interfaces (RS232 serial / 2 or 4 wire FSK) and is available in the 900MHz and 2.4GHz unlicensed frequency bands.

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Common Applications of FHSS

While FHSS radios lend themselves to a myriad of applications, the two most common uses are interconnect projects and contact closure (remote on / off functions). First, a look at the ways in which FHSS can be effectively deployed to facilitate interconnect communication in common ITS projects. There are several reasons for interconnecting controllers from intersection to intersection, with the most prevalent being a need to integrate a traffic monitoring device into the signal system. This allows for real time data collection and subsequent sequencing changes. Traditionally, the communications medium for achieving such goals was (buried) copper wire. While this solution does serve its purpose, it involves a great deal of intrusive action and cost in terms of both the installation and maintenance of leased lines. Essentially, these leased lines are tantamount to borrowing the communications medium from a third party provider for a set monthly fee, over a fixed period of time. Maintenance can entail digging up concrete / asphalt, re-trenching, and re-paving, all of which are costly and have been shown to contribute to increased overall road degradation, stemming from the patch site. Given this, it is important that a communications system remain flexible in order to alleviate such environmental and infrastructure stressors as well as to facilitate future enhancements.

Interconnect, Bridging Broken Copper and Infrastructure Integration

The ability for a device to be effectively integrated into an existing system is crucial to the communications selection process. This is true in order to meet both initial, and future, system needs. Fortunately, most quality radios come complete with a 2 or 4 wire FSK port option, allowing for the seamless bridging of copper and radio required for smooth and continuous communication. These ports enable the end user to tie the radio into the existing infrastructure in such a way that it can be upgraded throughout a system as copper problems arise, and without any added service interruption. In fact, many departments have found that replacing the copper system in its entirety is an effective, long term, cost saving measure. This is due, in part, to the elimination of all ongoing leased line costs. While this type of overhaul may not be feasible as a one time project, the technology lends itself very well to a laddered integration approach. The interim hybrid system can include fibre-optic cable, copper, and FHSS, while remaining stable and effective throughout the upgrade. **An industrial-grade interconnect radio such as the ENCOM 5100R rack mount radio (Figure 2) is designed to plug into and draw power from a 170 Input file or NEMA TS1/ TS2 detector rack.**

Figure 2

Loops, Radar and Video Detection

In this application, FHSS radios serve as a high speed method of transmitting information in small pulses from multiple transmitters to one receiver. A typical deployment would be a multi lane highway project with a need to monitor several traffic streams simul-

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taneously and send data wirelessly to the collection point. These **contact closure** radios, in essence, use a very simple process. Imagine a small current being sent after each data point (car, person, animal etc.) is detected. Once the current is identified, the transmitting radio sends a wireless signal to the receiver site where the process is reversed, and the radio turns the wireless signal back into a current. This process happens immediately and simultaneously from multiple send points to the selected receiver point. Each data piece or "current" is then collected and counted to initiate a pre-programmed sequence of events.

Remote Signs and On/Off Control

Another recent trend in ITS design is the use of Variable Message and On/Off Signage. These are normally located along the side of a highway and are strategically placed to inform and advise drivers of current road conditions. Given the nature of their need to be timely, remote, and accurate, the medium selected to communicate the information is essential. FHSS is an ideal medium in that it allows flexibility along the highway, as well as reliable throughput over the long distances specified by most designs. Another feature of a quality FHSS radio designed for this application is immediate signal verification. This allows the sending device and/or person to determine whether the data message was actually received, understood and displayed at the receiver site(s). While the process seems simple, the need for a robust, rugged, and flexible device make alternatives costly and difficult to deploy despite their availability.

Looking to the future. . . While the use of FHSS continues to grow throughout the traffic industry, the ITS world itself continues to evolve and seek out new ways to make roads safer and more efficient. One of the most recent endeavours and one that is highly suited to FHSS is the proliferation of Animal Mitigation Programs in high risk areas. These programs are designed to decrease the amount of damage and deaths that are attributable to vehicle - wildlife collisions. Many of the technologies employed in these programs are already in use throughout ITS projects and typically employ detection devices in conjunction with either Dynamic Messaging or real time on/off signage. To date, Animal sensor demonstration installations are now in progress and being supported by the FHWA and 15 State DOT's.The known reliability and flexibility of FHSS radio communications, combined with its inherent ability to transmit secure data over great distances, make it ideal for such mitigation applications. The fact is that any project requiring environmental sensitivity (and most ITS projects do) will benefit a great deal from considering the switch from buried cable to wireless. Over and above the obvious ethical implications and sustained development issues, the ability to deploy without upsetting a stable environment simply makes sense given the quality and history of the medium. This is true for both urban and rural settings, and has been proven in thousands of successful deployments.

Features of Advanced Connectivity – Flexibility

In order for a communications device to be feasible, it must first and foremost be flexible. Radio provides this flexibility in numerous ways.

1- It allows for portability. The most common example of this need would be for long term projects that require temporary communications in different stages and locations throughout the project lifecycle. This ability to remain mobile in setup, as well as secure and robust, is a true niche of the FHSS radio world.

2- A quality radio system will provide the ability to allow wireless network configurations that include RS232, RS485 and the aforementioned 2 or 4 wire FSK in a non-intrusive and simple manner. This means seamless interconnect capability throughout the entire system of wires and wireless, whether it is a permanent or temporary installation.

3-The device must be able to interface with any type of controller. This is necessary not just for initial deployment flexibility but for long term planning comfort and security. A quality radio will be compatible with all types of controllers, both new and retroactive.

4-The device should be as unobtrusive as the situation requires. That is, the radio should be able to deploy in numerous ways in order to ensure flexibility in project design. The highest quality and most flexible radios now offer the capability of rack installation. Essentially, it is a plug and play radio that slides directly into any controller rack and requires no outside power source in order to function. In effect, this streamlines the communications and controller functions in one stand alone unit. To facilitate flexibility, the radios can also be deployed as a pole mount, attaching securely and easily to existing infrastructure, much the same as the antennas used in transmission.

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Features of Advance Connectivity - Reliability

While most network systems provide the ability to operate in adverse conditions, it is imperative that a system function in irregular conditions such as rain, snow, wind and humidity both effectively and reliably. This is true not just to ensure seamless operation, but also to avoid the cost of damaged equipment or lines. A quality FHSS radio will provide you with a level of protection likely never required. Appropriate temperature protection, however, is imperative in order for a radio to successfully handle the rugged atmosphere in which it will be deployed. A second reliability feature of a quality FHSS radio is built in error checking and correction software. This is important to maintain data integrity and ensures FHSS as a highly secure mode of transmission.

Features of Advanced Connectivity – Spectrum Scan and Link Analysis

In order to ensure that a link is as strong as it can be, it is important that a wireless system come with reliable and easy to use analytical tools. These tools should allow the user to plug directly into the radio to run a number of diagnostic tests and to assess system performance. This software should provide real time environmental information, spectrum analysis of the active link and the ability to adjust hopping patterns at the site in order to achieve the highest quality link possible. **Figure 3 provides a screenshot of the Spectrum Scan Analyzer, a portion of the diagnostic software that accompanies all ENCOM radios. For a more in-depth and interactive experience, demo software can be downloaded at:** www.encomwireless.com.

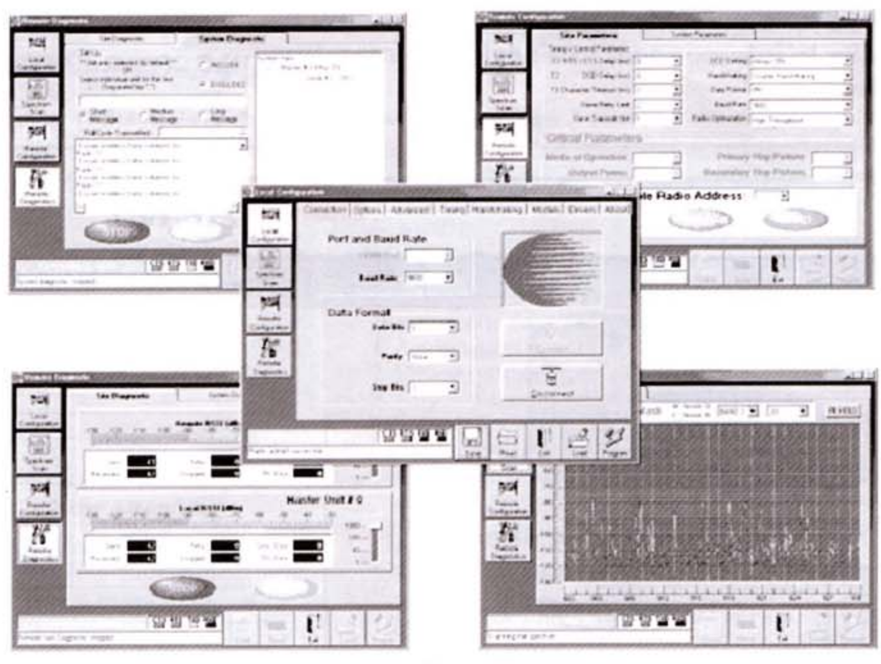

Figure 3

Is Bigger Always Better?

Despite its rich history, many misconceptions abound when it comes to radio communications and their relative feasibility when compared to alternatives. This is due, in part, to the general societal trend towards "more throughput, less time". While this relationship is of concern, the most important concept to remember when designing a system is the actual processing power of the information recipient. That is, it does not matter how fast or how dense your transmission is if your receiver can only decipher the information at a limited speed. This is by no means meant to suggest, however, that FHSS is a slow medium. The speed at which a quality FHSS radio link will communicate is over 6.5 times faster than any controller can currently understand and 12 times faster than the average unit. This allows for constant system upgrades and flexible, long term planning without the added cost of data transmission and infrastructure overkill.

Cost/Benefit Analysis of FHSS

Any good decision maker knows that weighing costs against benefits is of paramount importance. Of course, not all costs and benefits can be quantified numerically or immediately. When weighing alternatives, all aspects must be examined in order to appropriately extract a valid decision. Specifically, factors such as environmental impact, current and future integration flexibility , reliability rates, and ease of deployment should all play a vital role in the decision making process. While the scope of this article does not allow for such in-depth departures, it would be wise to thoroughly research each of these factors in conjunction with valid, quantitative pricing data before commiting to any one means of communication. That being said FHSS is a highly balanced alternative in meeting

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all of these objectives and, over and above its unique value, carries numerous additional benefits.

Spotlight on Interconnect

The city of Lincoln, Nebraska has recently completed a successful interconnect system that employs the use of FHSS radio to connect its existing fibre optic cable lines and FSK hardwire **(See Figure 4).** The project, involved the deployment of 16 FHSS ENCOM radios and covered an area of over 30 city blocks. The project scope involved the integration of ENCOM radios to facilitate communication throughout the various locations and the home traffic centre. From the fibre mainline, ENCOM radios were deployed to interconnect the existing infrastructure throughout the downtown core. The project involved the use of repeater technology, 2 and 4 wire FSK ports, fibre optic compatibility and numerous mounting configurations. **The ENCOM 5100P Pole Mount radio package (Figure 5) allowed for a quick and easy installation with the ability to interconnect to all existing infrastructure.**

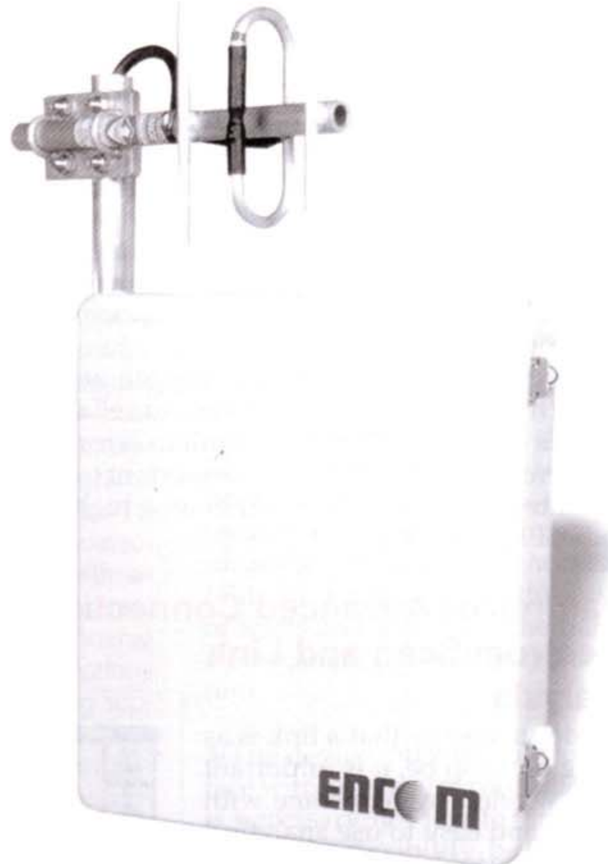

Figure 5

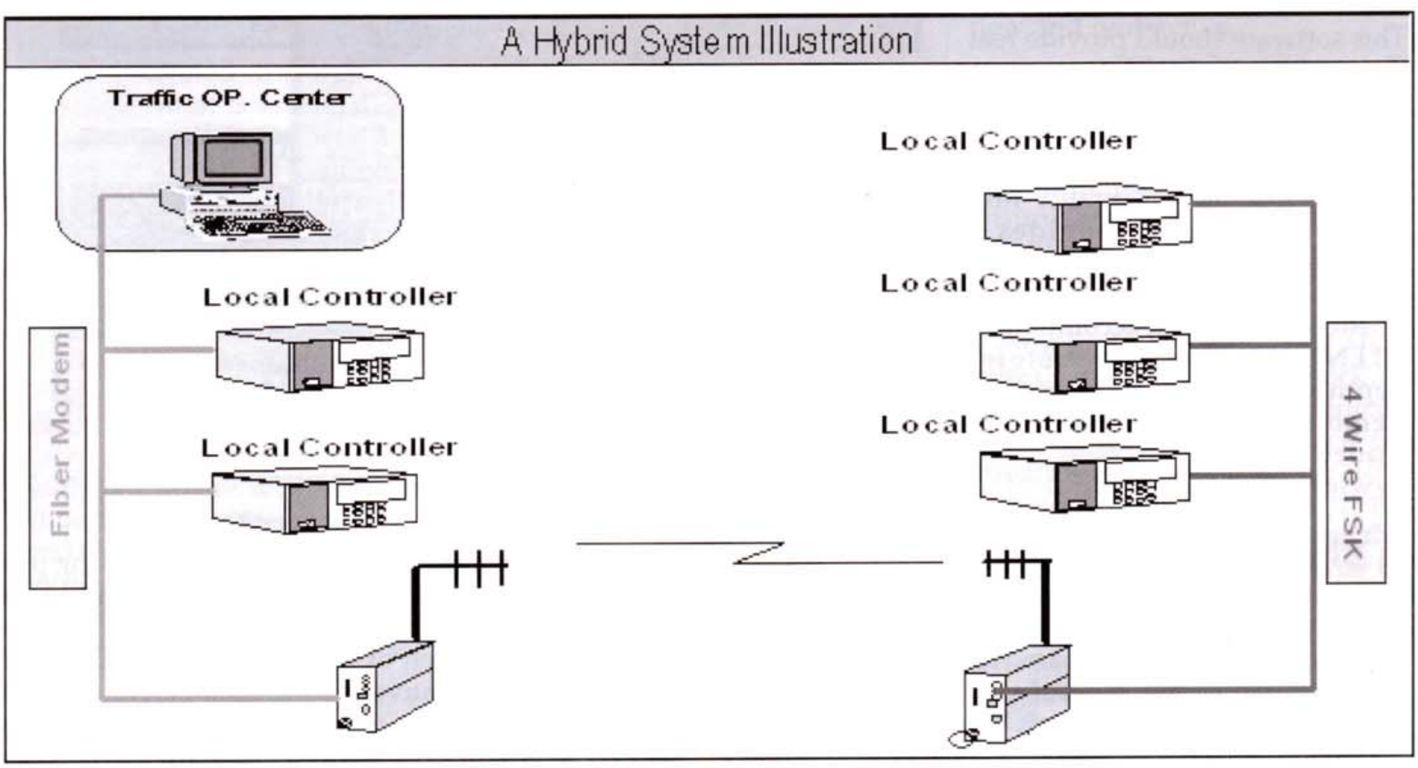

Figure 4