Fiberoptic Remote Antenna System

Tying remote antenna systems to command centers via fiberoptic links is of increasing military importance.

by Scott D. Wahlstein, SD Laboratories, Inc.

Ground-based transmission and reception systems have historically included the source signal, amplifier, signal conduit and transmission antenna components in the same rigid and vulnerable location. This type of configuration increases attenuation and related expenses, while reducing flexibility in operations and securable range. This problem is even more significant in military field operations, where classified data has to be sent, securely, to and from remote locations.

The FiberOptic Remote Antenna System (FORAS) combines the newest of several technologies – fiberoptics, acousto-optics, digital electronics, and advanced algorithmic processing. A fully functional design includes such features as long-distance operational capabilities; reduced power requirements; immunity from EMI, RFI, and environmental conditions; and security. The following describes such a system.

Hardware

The FORAS can be configured to fit the most demanding tranception situations, and has several advantages over current methods. Figure 1 depicts schematically how a single front-end can drive multiple antenna nodes. In either configuration. The system contains just three basic, modular elements – operator-transceiver, fiberoptic transmission line, and antenna-receiver. These three modular elements, in turn, comprise one or more of eight functional items as listed below and numbered 1 through 8 in Figure 1.

- *Bidirectional signal preamplifier and "preparer" (#1 in Figure 1).* This device prepares the analog signal for conversion to digital form, filters undesirable elements of signal, and boosts signal to a suitable level.
- *A/D conversion/conditioning and digital manipulation (#2).* This device (or in some cases, multiple devices) converts the previously prepared analog signal to a digital equivalent and, together with the algorithm engine, manipulates the data to provide handshaking and coded information. The information is then applied as a drive signal to an acousto-optic driver. Since, in certain cases, the originating signals may be in digital form in the first place, the A/D section may be bypassed, and the signal sent directly for conditioning.
- *Algorithmic, encrypt/decrypt engine (#3).* This device provides the mathematical language to code/decode signals (such as intercoded data streams) or perform other mathematical manipulation. This unit can be programmed in real time by a host and/or received signal source. Additionally, the device provides supervisory control for all system activities.
- *Variable frequency and intensity light source (#4).* This device generates the optical signal and determines the operational bandwidth, as defined as the maximum range of wavelength, pulse (or data packet) duration and repetition rate, as well as intensity. Various sources can be used – from broadband LEDs to semiconductor diode lasers – with the specific choices determined by the overall system requirements.
- *AOTF (Acousto-Optic Tunable Filter) and detection device (#5).* In this unit, digital signals control the emitted light (resultant signal) and the subsequent launch or detection of reception through the fiberoptic link. The AOTF device acts as a precision light filter, allowing the precise light dynamics (frequency – both temporal and spatial – and intensity) of the signal to be launched through the fiberoptic link. The detector, matched to the clear aperture of the AOTF, detects incoming data and converts the light signal to its electrical counterpart.
- *Fiberoptic link (#6).* This cabling attaches all stations and nodes.
- Transceiver/antenna (#7). This device/system comprises a bidirectional transceiver/antenna in one integrated, self-powered package. To save power, the system operates in a "listen mode," without the transmitter or amplifier in operation, until specific coding is received. The system powers up for complete operation for transception, and then returns to its original inactive

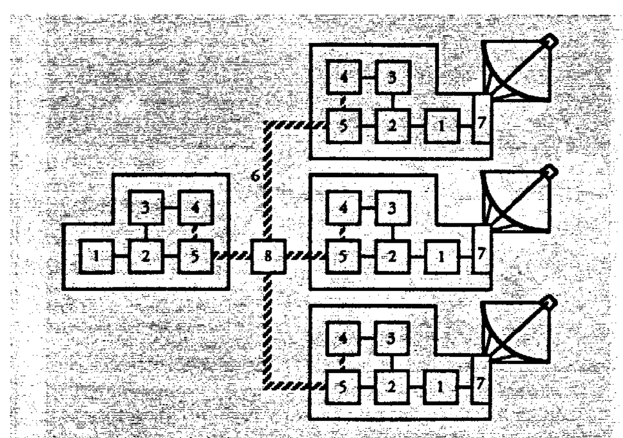

Figure 1. Multinode/network system configuration.

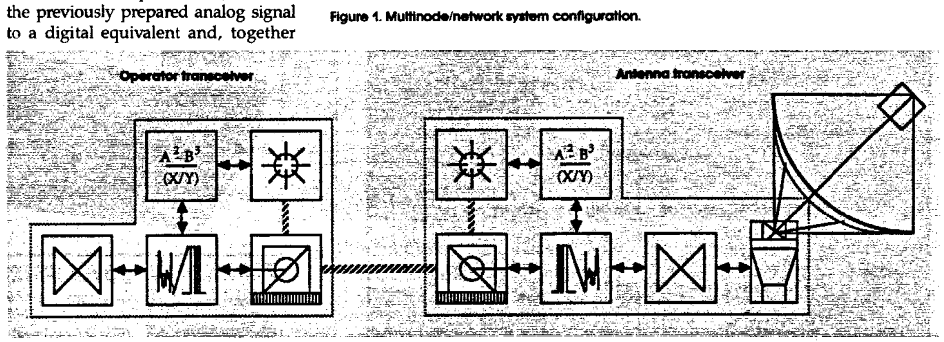

Figure 2. Symbolic operations diagram.

state after transception is complete.

• Bidirectional multiplexer (#8). This device allows multinode/network operations for FORAS. The number of nodes potentially supported in this 1 × N configuration can vary widely, depending on system requirements, as long as loss budgets are kept in line.

Each transceiver station – excluding the antenna itself – is roughly the size of a laptop computer, affording further portability.

Performance

The inherent performance characteristics of FORAS can be described by a closer reference to Figure 2. In transmission, the originating signal is fed into the bidirectional signal preamp and preparation section. The signal undergoes boosting to an appropriate level, and filtering of excess noise.

Next, the signal is sent to A/D conversion/conditioning and digital manipulation section. If the signal is analog, it is converted to digital; otherwise, the signal bypasses the A/D conversion section. The output digital signal is then conditioned to fit specific performance parameters controlled by the algorithmic, encrypt/decrypt engine. The resulting signal is configured into an electro-acousto drive signal to directly control the AOTF.

At this point, the signal is split. One path leads to the algorithmic, encrypt/decrypt engine. The signal undergoes mathematical "mutation" and provides a unique signature, while simultaneously controlling the entire system – the A/D conversion/conditioning and digital manipulation section, and the variable frequency and intensity light source. The other path leads to directly drive the AOTF device.

The control signal from the algorithmic, encrypt/decrypt engine drives the variable frequency and intensity light source. This device converts those codes into related variable wavelengths, intensities, and pulse durations/repetitions. Constant feedback ensures minimal inaccuracies in conversions. The resulting light signal is sent to the AOTF.

The variable frequency and intensity light source signal (light), and the A/D conversion/conditioning and digital manipulation signal (A-O drive signal) are applied to the AOTF and detection section. The resulting signal is one of frequency- and amplitude-agile light. The light signal is sent to the antenna transceiver section over the fiberoptic link.

When the signal arrives at the antenna transceiver section, the detector of the AOTF and detection section senses the incoming signal, and routes the data (after conversion from an optical form to an electrical form) to the A/D conversion/conditioning and digital manipulation section.

The signal is then analyzed for "handshaking" by the A/D conversion/conditioning and digital manipulation section through supervision and control by the algorithmic, encrypt/decrypt engine. Once the handshaking is confirmed, the operator/transceiver unit sends a test signal that includes (among other data) alphanumeric characters and a matrix of both amplitude modulated and frequency modulated data packets, along with their respective data equivalents. As the signal is converted, it is filtered for best quality and integrity of the contained information.

The signal is then boosted or reduced to match the performance characteristics through the bidirectional signal preamp and preparation section. At this point, the prepped signal is used to modulate an amplifier/transmitter and subsequently transmit the signal via the antenna-antenna array.

In reception, the process is basically reversed. The incoming signal is captured by an antenna (or maybe more than one) and is boosted by the amplifier section to preset thresholds. The signal is then fed into the bidirectional signal preamp and preparation section. The signal is further increased or reduced to a certain level, and cleaned of noise.

Next, the signal is sent to the A/D conversion/conditioning and digital manipulation section. The signal bypasses A/D conversion, but is conditioned to fit specific performance parameters controlled by the algorithmic, encrypt/decrypt engine. The resulting signal is configured into an electro-acoustic drive signal to directly control the AOTF.

As with transmission, the signal is split at this point. One path leads to the algorithmic, encrypt/decrypt engine. The signal undergoes mathematical mutation and provides a unique signature, while simultaneously controlling the entire system, A/D conversion/conditioning and digital manipulation section, and variable frequency and intensity light source. The other path directly drives the AOTF device.

The control signal from the algorithmic encrypt/decrypt engine drives the variable frequency and intensity light source. This device converts those codes into related variable wavelengths, intensities, and pulse durations/repetitions. Constant feedback ensures minimal inaccuracy in the conversion process. The resulting light signal is sent to the AOTF.

When the signal arrives at the operator transceiver section, the detector of the AOTF and detection section senses the incoming signal, and sends the data (converted from an optical signal to an electrical one) to the A/D conversion/conditioning and digital manipulation section.

The signal is then analyzed for "handshaking" by the A/D conversion/conditioning and digital manipulation section through supervision and control by the algorithmic, encrypt/decrypt engine. Once the handshaking is confirmed, the operator/transceiver unit sends a test signal that includes multiple data sets plus the incoming signal. As the signal is converted, it is filtered for best quality and integrity of the contained information.

The signal is then boosted or reduced appropriately. Finally, the prepped signal is fed to an operator-based listening device (*i.e.*, speaker, line printer, computer storage, or equivalent).

The system has a wide operational bandwidth, from between 2.7 and 3.2 GHz for civilian use, or between 7 and 40 GHz for military applications. In principle, the operational bandwidth could be even higher. FORAS, by virtue of its portability, can provide secure commercial and military communications in any part of the world.

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EDITORIAL EVALUATION

Circle Number on Reader Service Card

I found this article:

Very Useful	Useful	Not Useful
312	313	314