Engineering Tech Tips

United States Department of Agriculture
Forest Service
Technology & Development Program
December 2006
7100/7300 0671–2344–MTDC

Using VHF Telemetry To Transmit Data From Remote Sites

Ted Etter, Project Leader, and Charlie Showers, Program Leader

Land managers and their staffs often monitor remote areas with equipment that records changes in weather, streamflows, or other conditions. Access to these sites is often difficult or time consuming. Employees may have to be sent on long hikes, cross-country skiing trips, or long trail rides, and may have to stay overnight in the backcountry. The Forest Service Technology and Development Program was asked to find a way to make it easier for the Forest Service to access data collected at remote sites. Using information and equipment developed on other projects, MTDC electronics engineer Ted Etter used radio telemetry to provide real-time links from Forest Service offices to data loggers at the Sierra National Forest in California and at the Land Between the Lakes National Recreation Area in Kentucky.

Highlights...

- National forests often need to gather weather or streamflow data at remote sites.
- Sending an employee to the site to collect the data is expensive and can require many hours of travel.
- Data can be transmitted using the VHF radio signals that form the basis for the Forest Service's radio networks.

Project Overview

This project provided radio telemetry links from a variety of data loggers in mountainous regions to central computers that archived and analyzed the field data. The distances involved were too great for typical UHF (ultrahigh frequency, 300 to 3,000 megahertz) spread-spectrum links, but not remote enough to warrant satellite links; many satellite and cellemetry (cellular telephone telemetry) links have limited the size of data packets, making those links unsuitable for this application. The availability of local VHF (very high frequency, 30 to 300 megahertz) repeaters contributed to the decision to use narrow-band FM radios (figure 1). The data were being retrieved from four different types of data loggers with dissimilar file formats and communications protocols, so the methods for selecting individual sites and downloading data needed to be compatible with all data loggers with asynchronous serial data (RS–232) ports.

Figure 1—Data is transmitted from a remote site by a modem (left), interface (center), and Bendix-King radio (right).

For additional information, contact: *Ted Etter, project leader; USDA Forest Service, MTDC; 5785 Hwy. 10 West; Missoula, MT 59808–9361. Phone: 406–329–3980; fax: 406–329–3719; e-mail: tetter@fs.fed.us*

Hardware

Each site and the office with the host computer need a narrow-band FM radio, a modem designed to function with the radio, and an antenna. A remote site also requires a circuit that links the radio to the modem and determines when that site has been selected for communication. The office requires another custom circuit that allows the computer to generate signals that determine which of the remote sites will be enabled for communication.

Software

Software has been created at MTDC for downloading data from two types of traffic counters, a Campbell Scientific data logger, and an Isco water sampler/depth monitor. At the very least, the software needs to control which remote site will be enabled for communication. The software may initiate the data retrieval or it may launch a communications program that controls the download operation. Different data loggers use different communication programs.

Downloads can be scheduled during hours when a repeater tends to be idle. The Scheduled Tasks program in the Microsoft Windows control panel allows downloading to take place automatically at 3 a.m., for instance.

Some data loggers and their associated software have timing constraints that prevent data transfers through radio links—including satellite links. Establishing a serial data link between a host computer and a data logger can take around a second through a VHF repeater. Satellite data links have similar delays. Some data loggers and their communications software were designed with a direct connection in mind and "time out" if the link isn't made in a fraction of a second. Two of the four products we tied to our VHF link required updates for the data logger's firmware or the host computer's communications software to accommodate the longer delays. The other two data loggers worked without modification.

Other Applications

The wireless telemetry system described above can be used in many applications where a data logger (or a similar device with a microcomputer) communicates with a host computer over an asynchronous serial data port (figure 2). The constraints involve timing issues: the time allowed to poll and respond to queries over the asynchronous serial data port must be long enough to accommodate the half-duplex format (transmissions only take place one way at a time) and transmit settling time (the time needed to establish a transmission) of the radios and repeaters that are used.

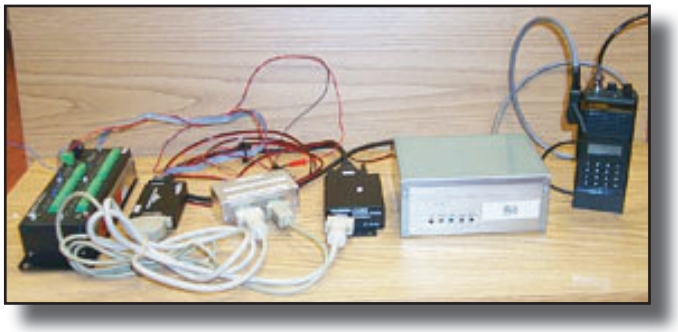

Figure 2—A Campbell Scientific CR10x data logger (left) set up for a wireless telemetry system.

Antenna Requirements

The choice of antennas is driven by the signal path loss between the repeater and the data logger site; line-of-sight communications typically permit operation for more than 50 miles, but a steep ridge between a site and the repeater can cut operating distances down to a few miles. The radios typically transmit 4 to 5 watts of radiofrequency power compared with the 20 to 50 watts broadcast by many repeaters. A radio may receive a repeater signal in a fringe area, but the repeater may not be able to receive the radio. In situations where the repeater signal is relatively strong, an omnidirectional vertical antenna is suitable for the remote site. When the signal is weaker, a Yagi antenna can be used at the remote site to improve reception.

Additional measures can be taken if a Yagi antenna does not provide sufficient gain to make the site radio connect reliably with the repeater. One step is to add a power amplifier at the site to boost the radio's power from 5 to 50 or 100 watts. This may require increasing the solar power and battery backup at sites that weren't designed for large, quick current drains.

Power Management

The original design of the telemetry interface circuits assumed that the data loggers would be powered by a solar panel with battery storage. The original solar panel and battery selection criteria for sites in the Sierra National Forest did not include power for wireless communications hardware, so the impact of additional hardware had to be minimal. The radio and interface circuit together draw less than 50 milliamps from the 12-volt battery. The demand on the battery is about 250 milliamps when receiving and about 1 amp when the radio is transmitting. Data downloads typically require less than 10 minutes, so the net drain on the battery is small.

Environmental Considerations

Because some of the electronic circuits were sensitive to moisture from condensation, all of the field equipment in the Sierra National Forest installations was mounted in watertight enclosures (figure 3) meeting National Electrical Manufacturers Association standards. Moisture desiccant packages were included in each enclosure to minimize condensation and frost formation during cold weather.

Figure 3—Watertight enclosures meeting National Electrical Manufacturers Association standards can be used to house the telemetry hardware.

Radio and Modem Calibration

Because the radios at the telemetry sites and the office are sharing frequencies with other users in licensed bands, the radios and modems must be calibrated together to comply with the emission specifications for radios in that service. The calibration should be checked every 2 to 3 years because of the temperature extremes the equipment experiences.

Future Options

The VHF telemetry systems employed in the Sierra National Forest and at the Land Between the Lakes National Recreation Area work because the Forest Service repeater accesses the remote sites with the data loggers. The Forest Service recently migrated to narrow-band FM radios from the previous wide-band standard; this allows radio channels to be spaced more closely, effectively doubling the number of channels that could be assigned within the VHF land-mobile radio spectrum. There are discussions underway regarding when to move to a new modulation format, sometimes referred to as digital FM, part of the Project 25 (P–25) standard developed by the Association of Public-Safety Communications Officials International (APCO). The P–25 standard includes a specification for transmitting and receiving data packets. Some manufacturers of P–25 radios are now selling radios with digital data transmission capabilities.

Another feature of P–25 radios is that each radio can be assigned a unique name, and communications with a radio can be directed by sending the radio's name with each transmission. At least one brand of P–25 radio can have the channels selected by commands through its serial data port, so the required hardware for each data logger site would be reduced to that brand of P–25 radio and the data logger; the external modem and the radio-modem interface circuit would no longer be needed. Such radios are more expensive than the older FM models.

For installations where other communication opportunities exist, cellular phone modems are a possibility. Cellular modems do require more power when receiving transmissions than the VHF FM system described previously. Systems relying on solar power with battery storage may require additional solar power for reliable operation.

If the office has a good signal path to the remote sites, a repeater may not be required. A simplex communications channel (signals are broadcast and received on the same frequency, unlike repeaters, which receive on one frequency and transmit on another) may be used for the data transfer. The equipment discussed in the “Hardware” section will work whether you have a repeater or not .

When neither repeater nor cellular links exist, duplex satellite modems are the remaining option. A number of service providers can arrange for satellite data communications using low-earth orbit (LEO) and geostationary satellites. Again, the power consumed by the receiving circuits may require increasing the power harvesting and storage capacity at the site.

Discussions with some service providers and technologists occasionally include the topic of mesh networks and packet radio. The reason this option has not been pursued is because it essentially involves adding a computer—or a programmable device that contains a microcontroller—to the remote site. The data downloading formats of the data loggers typically are not compatible with a packet device, so a computer would be needed to bridge the protocols of the data logger and the packet radio.

Standard Hardware List

Bendix-King radio

GPH5102 or EPH5102 with option LAA0821 (BNC antenna mount)

FSK (Frequency Shift Keying Modulator) modem

Teledesign TS–2000

Lightning arrester

Polyphasor Model IS–50NX–C0

Power amplifier

TPL Model PA3–IAE–6 (Tessco part No. 486134)

Omnidirectional antenna

Maxrad Model MFB–1623

Yagi antenna

Sinclair Model SRL206–EB

About the Authors

Ted Etter joined MTDC in 2002 to work on electronics projects. He has spent more than 25 years working in the area of electronic instrumentation and display technology. He received a bachelor's degree in mathematics from the University of Oregon in 1992 and a master's degree in teacher's education from Eastern Oregon State University in 1993. Before coming to MTDC, he taught courses in programming, digital circuits, data communications, radio frequency communications, robotics, microprocessors, and operating systems at the University of Montana College of Technology.

Charles Showers, professional engineer, became engineering program leader at MTDC in the spring of 2002 after serving 2 years as operations program leader. Charles came to MTDC after 9 years as assistant forest engineer on the Payette National Forest. He began his Forest Service career on the Boise National Forest after completing 8 years as a construction project engineer with the Idaho Transportation Department.

Library Card

Etter, Ted; Showers, Charles. 2006. Using VHF telemetry to transmit data from remote sites. Tech Tip 0671–2344–MTDC. Missoula, MT: U.S. Department of Agriculture Forest Service, Missoula Technology and Development Center. 5 p.

This tech tip describes the use of VHF radio signals to transmit data to headquarters offices from remote sites at the Sierra National Forest in California and at the Land Between the Lakes National Recreation Area in Kentucky. The sites were too far for the data to have been transmitted using UHF spread-spectrum links and many satellite and cellular telephone links would not have transmitted the large data packets that were needed for these applications.

Keywords: cell phones, modems, radios, streamflow, stream flow, weather

For additional information about VHF telemetry, contact Ted Etter at MTDC:

Phone: 406–329–3980
Fax: 406–329–3719
E-mail: tetter@fs.fed.us

Electronic copies of MTDC's documents are available on the Internet at:

http://www.fs.fed.us/eng/t-d.php

Forest Service and Bureau of Land Management employees can search a more complete collection of MTDC's documents, videos, and CDs on their internal computer networks at:

http://fsweb.mtdc.wo.fs.fed.us/search/