Fiberoptic Scada streamlines downtown network operations

A fiberoptic-based monitoring system installed in the dense distribution network of downtown San Francisco, Calif, significantly reduces the time maintenance crews need to clear a feeder and is helping to identify problems that often go unnoticed in a fully automated network. Also, because true loads are now known, network equipment can be loaded much more efficiently than before. Yet another benefit is that outages can be better planned.

The utility, Pacific Gas & Electric Co (PG&E), chose a fiberoptic system because fiberoptic cables can be pulled through existing ducts along with power cables (Fig 1), yet provide a communications system that is completely independent of the power system's parameters. This enables about 500 remote terminal units (RTUs), located in vaults throughout the city (Fig 2), to communicate at random time intervals with a master station computer. The RTUs monitor vault fan operation; vault flooding; phase currents; network-protector position; transformer temperature; pressure; and where relays are installed, relay status.

PG&E's project manager of strategic technology operations, Dan Partridge, explains that, to increase security, the RTUs are connected in loops. This has the benefit that if a loop is broken, communication to all RTUs is still possible. Loops also allow engineers to daisy-chain many RTUs together, avoiding the need for separate communications cables from the control center to each vault.

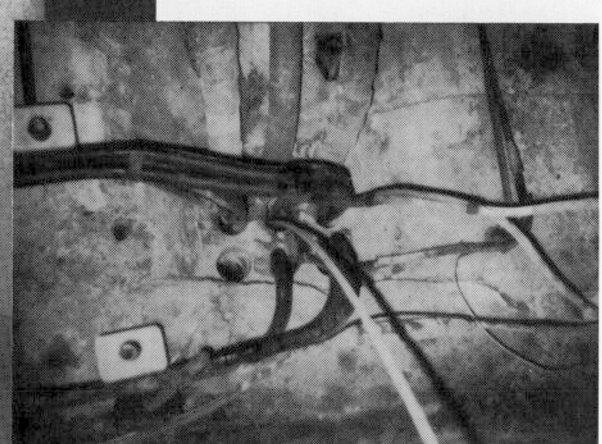
In the San Fransisco system, about 10 loops connect the RTUs with a central point, located at a substation. From this point, the data are transmitted to the master computer, located at the switching center several miles from downtown.

Before the monitoring system was installed, maintenance crews often spent hours going from vault to vault to locate a network protector that had hung up before they could begin work. Now the switching-center operator knows immediately in which vault or vaults the protectors have hung up. If a protector fuse opens, a serviceman can be dispatched immediately to replace it. Previously the fuse might remain open until the vault was entered for regular maintenance. During that time, customers would still have 3-phase power, but one of the transformers would be feeding on only two phases, which is inefficient and reduces the emergency loading of the vault.

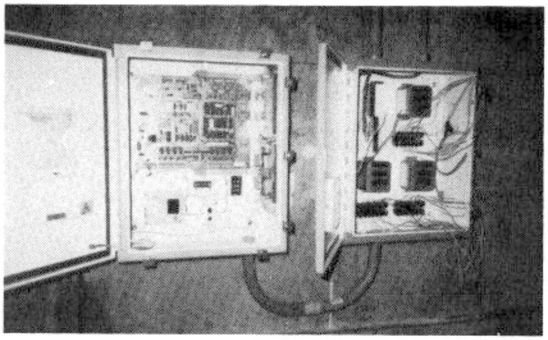
How the fiberoptic loops work

Key to the reliable operation of the looped monitoring system is a special tranceiver or repeater, which was developed for this application by H&L Instruments Inc, Burlingame, Calif. Although there are a several fiberoptic/RS-232 modems on the market, what is needed is a transceiver that can repeat a message and pass it on around the loop without distortion. It is not possible to do this by simply connecting two modems back-to-back because of distortion that occurs in the optical/electrical conversion.

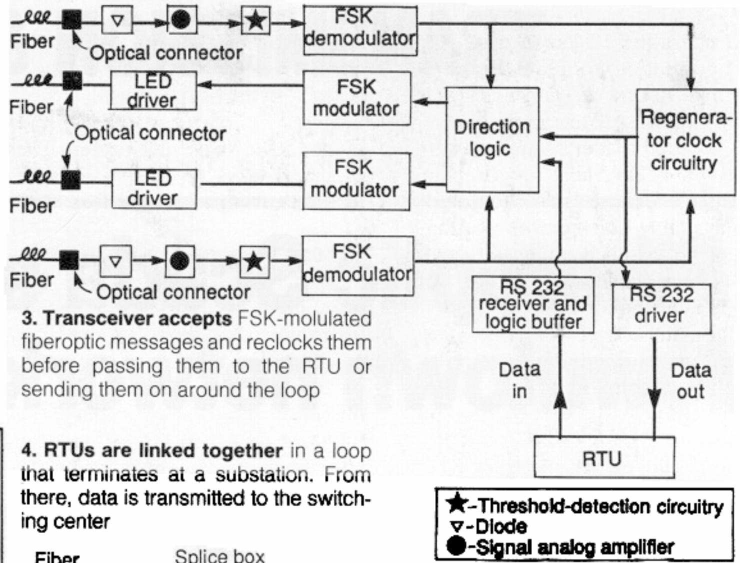
The transceiver also must have some intelligence. When it receives a message from the master station, it must convert



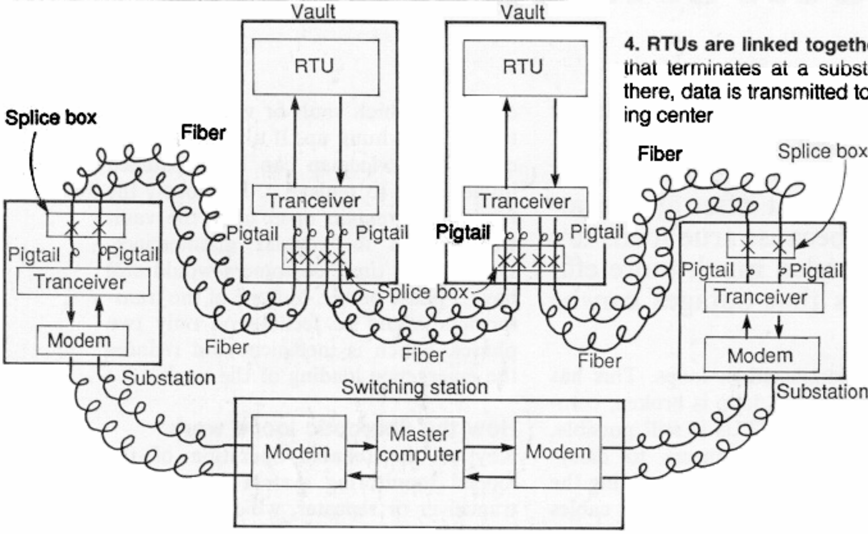
1. Fiberoptic cable is pulled into existing ducts along with power cables, yet provides communications links that are totally independent of the power system



2. Fiberoptic transceiver is mounted alongside RTU. Many RTUs are daisy-chained into communications loop



3. Transceiver accepts FSK-molulated fiberoptic messages and reclocks them before passing them to the RTU or sending them on around the loop



4. RTUs are linked together in a loop that terminates at a substation. From there, data is transmitted to the switching center

the message to serial ASCII and pass it to the RTU. The message is reclocked (to prevent distortion) and passed on in the same direction around the loop (Fig 3). If the RTU responds, the ASCII message coming from the RTU is converted to modulated light waves and sent in both directions around the loop. Transmission on the optical fiber is through frequency-shift keying, similar to the method used on powerline carriers and data transmission over phone lines. However, the frequencies are much higher—150 and 300 kHz.

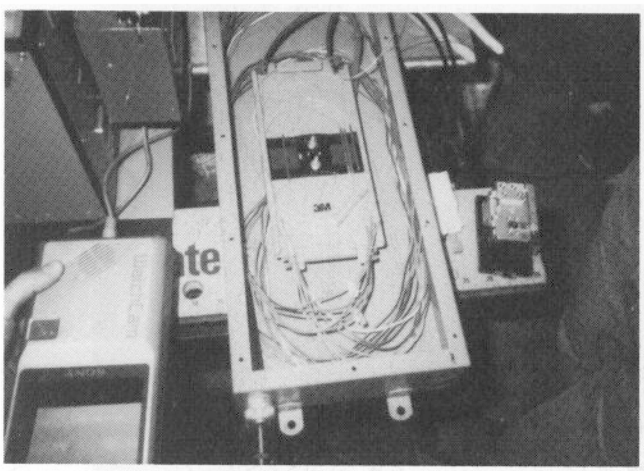
The master station sends messages and listens first in one direction around the loop and then in the other. This ensures that all components of the loop are continually tested (Fig 4). If a break in the loop prevents a message from reaching its address, the message can be sent in the opposite direction. The location of the break can then be found through a diagnostic program that determines which RTUs respond to a message. If no response is received from either direction, this means that the RTU is out of operation.

Why not use powerline carrier?

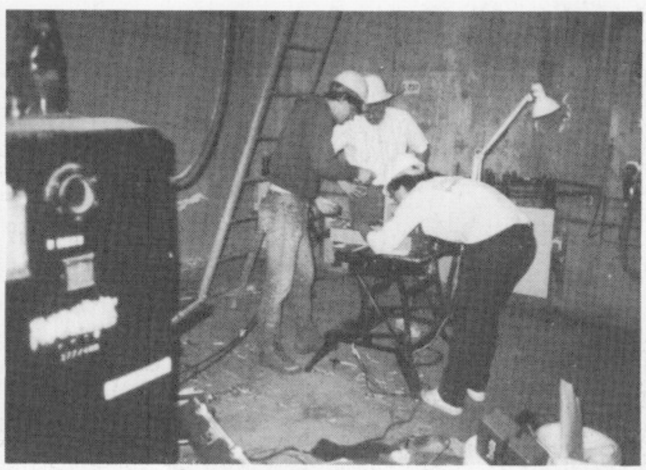
As one of the first steps in the project, PG&E engineers evaluated the distribution monitoring system used by Consolidated Edison Co of New York Inc (EW, May 1989, p 53). This system uses 23,000 waterproof transmitters to send data from vaults to a central location over existing powerlines.

While acknowledging the merits of this system, PG&E decided not to use powerline carrier because it must be engineered and tuned to the cable type, size, and the length of feeders. Also they wanted to avoid a system in which the remote units generate the messages at random intervals, with the inevitable data collisions, retransmission, and resulting uneven data rates.

Instead, they chose standard digital transmission (8-bit NRZ ASCII code) controlled by a master station computer. This provides two-way communications, with data arriving at predictable intervals. The software used was designed by PG&E's Computer Support Services Dept using PG&E's standard Scada protocol. A standard personal computer was selected for the master station for ease of



5. Utility designed it own enclosure for the splice cases. Here, a semiautomatic fusion splicer is being used



6. Utility cable splicers, with no previous experience, are successfully trained in fiberoptic installation setup and operation. It presents all the network information to planning engineers. Critical operation information is ported to switching-center operators.

PG&E also considered using wire pairs and 950-MHz radio. Wire pairs were rejected because spare conduits were not available and communications wire cannot be installed alongside existing high-voltage cable. PG&E did not use radio because of concerns about coverage and the amount of work needed to install and test a system.

The only possible drawback of the looped fiberoptic system is the time taken to send and receive messages. At a baud rate of 1,200, each transceiver takes 8 milliseconds to reclock and retransmit the message block. This time could be reduced to 1 ms if the baud rate were raised to 9,600, but PG&E engineers chose the lower rate because they anticipated a hybrid system using older phone facilities to transmit the data several miles to the switching center. The result is that it takes up to one minute to collect data from all 530 RTUs.

Lessons learned in fiberoptics

Steve Calvert, San Fransisco Div engineer, notes several lessons in the use of fiberoptics that were learned as a result of the project. The original splice cases purchased were specifically designed for fiberoptic telecommunications, but were found to be expensive and not very suitable. As a result, PG&E designed its own splice case using a standard NEMA type metal enclosure (Fig 5). The company also found that the original mechanical splices were expensive and difficult to use. Fibers broke and splices became contaminated with dust. As a result, they now use a small, semi-automatic fusion splicer.

One problem was obtaining trained people to use the splicing equipment. Because of the lack of available technicians for the large amount of work needed, much of the work was done under contract. PG&E also trained cable splicers to work with the fiber. The trainees have no previous experience in either electronics or fiberoptics (Fig 6). The utility is now considering establishing job positions for maintaining the equipment. Because the work is in high-voltage vaults, regular telecommunications technicians cannot do the work. ■

—John Reason, Senior Editor