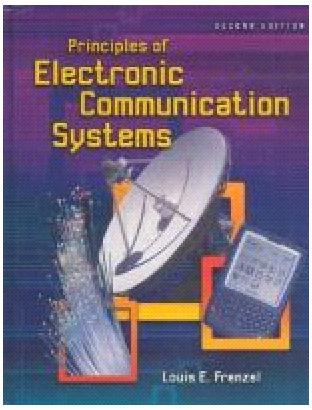
Title: Electric Communication

Fiber optics Communications



Even though optical fibers are much smaller than wire pairs , and silica (the most widely used material in fibers) is vastly more abundant than copper, the cost of preparing the rods from which optical fibers are drawn is several times greater than the cost of producing wires1 Moreover,studies suggest that this may be the case for some time.

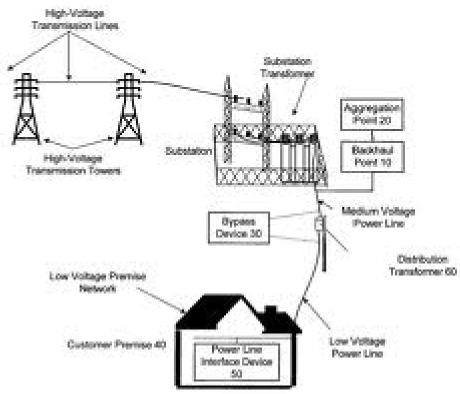
However, fiber systems can carry so many more telephone conversations at the same time than wire pairs, and can carry them so much farther without amplification of regeneration, that when there are many telephone calls to be carried between points such as switching off ices, fiber systems are economically attractive2. Thus the interoffice trunk network will be the first to benefit from this new technology.

Competition is more difficult, though, with existing high-capacity systems that use coaxial transmission lines, waveguide, microwave radio, and satellites. Larger fiber bandwidth, lower loss, and more reliable optical sources would make optical fibers more competitive in this sector.

The heart of an optical communications system is something which transmits electrical signals: a telephone, computer or cable TV. A light emitting diode or laser converts those signals into light pulses, which travel along a glass fiber. At the receiving end, a photo detector converts them back to electrical signals.

The system provides significant advantages over conventional ones which rely heavily on electrical signals and copper wire. Included is the handling of large amounts of information; a high-performance laser can produce up to a half-billion light pulses a second. As a result, it is possible to transmit the entire 30-volume Encyclopedia Britannica in a tenth of a second, since optical communications are free from electromagnetic interference which can cause noise in copper cable, they produce clear signals, despite nearby power lines or electric motors.

Copper wires, although they are insulated, can leak electrical signals and cause crosstalk in nearby wires. Not so with optical communication equipment. A glass fiber cable, moreover, weighs only about 1 % as much as the copper cable carrying the same number of signals. Indeed, one a half-inch thick can carry as many signals as a copper cable as big as a man’s arm. Then, too, since glass fibers carry light rather than electricity, there’s no danger of sparks in dangerous environments like chemical plants or nuclear reactors.



Power Line Carrier Communications

Power Line Carrier (PLC) was first introduced in the 1920’s. Since then. PLC technology has evolved into a mature and reliable communications technique for power transmission systems, Today it is used primarily for protective relaying, SCADA and voice data on transmission systems.

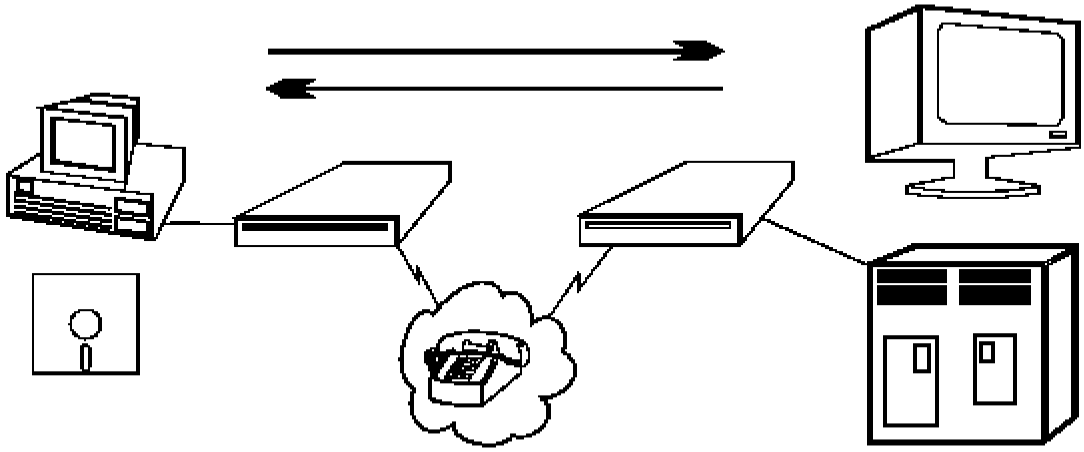
PLC utilizes a carrier frequency to transmit information over existing transmission lines. For transmission line applications the carrier frequency is usually between 20 kHz and 300 kHz.Information is encoded on the carrier through the use of Amplitude Modulation (AM), Single Side Band (SSB), Frequency Shift Keying (FSK). At the sending end, the modulated carrier is injected onto a transmission line by means of a coupling capacitor and tuner. The modulated signal propagates down the transmission line to the receiving end. At the receiving end, a coupling capacitor and tuner separates the PLC signal from the power frequency voltage and a demodulator extracts the information encoded in the signal. Line traps at either end of the line prevent the carrier from traveling down undesired paths.

PLC performs well on transmission systems because they are electrically simple and has few discontinuities; typically, distribution PLC utilizes frequencies from 5 kHz to 20 kHz. Generally frequencies fewer than 20 kHz are referred to as Distribution Line Carrier [DLC] and use is permitted on a non-licensed, non-interference basis. For this reason, when we speak of PLC systems used on the utility distribution system, we refer to it as DLC. Unfortunately, distribution lines are electrically complex due to the existence of numerous junctions, transformers and shunt capacitors. These can severely attenuate the carrier frequencies, making it difficult to reliably propagate a signal through the distribution system. In an attempt to correct this problem, carrier systems for distribution utilize much lower frequencies than are used on transmission systems. These are much closer to the power frequency and therefore are less likely to be attenuated by the large amounts of shunt capacitance found on the distribution system. Despite a significant improvement, the use of lower frequencies has not eliminated the attenuation problems associated with DLC. in addition, signal "holes" are a serious problem. Holes occur at a point where a reflected DLC signal cancels the incident DLC signal. Signal reflections are due to discontinuities such as transformers and line ends. When DLC systems are designed, studies are performed to select a carrier frequency which minimizes difficulties associated with holes. Future modifications of the distribution system can alter the locations of holes or create new ones which could interfere with the DLC system. Special techniques must be employed by the DLC system to correct this problem, just as special techniques must be employed by radio and telephone to correct this problem.

There is considerable argument over the ability of DLC to get past faults and into areas with power outages. On transmission systems PLC can get through single-phase faults because the remaining phases provide an additional path for the carrier. Under the circumstance of a midpoint fault, the carrier can recouple from the adjacent phases into the faulted phase farther down the line away from the fault. On a Power distribution system, there are many sections that are single-phase and cannot do this. In addition, some fault conditions, such as broken conductors, will block DLC passage on the distribution system. Bypass line tuning equipment allows DLC signals to be sent around reclosers and switches, making it possible to communicate into areas with power outage.

Distribution Line Carrier has sufficient data rate capability for most Distribution Automation schemes. In today's technology, the data rate for typical DLC systems operating in the 5 to 20 kHz range is 300 baud or less. Distribution Line Carrier has two-way capability, and is economical to implement for a number of functions such as remote meter reading (RMR), and retrieval of load data from points on the distribution feeder.

DLC has the advantages successfully used that it is under utility control, reaches all points on the utility distribution system, and requires no FCC license. Despite these advantages, DLC has limited data rates. DLC can play a significant role in Distribution Automation, but it is unlikely that it alone will be able to perform all of the communication necessary for Distribution Automation.



Other Wire Communications

Telephone and TV Cable are two kinds of wire communications;,

Telephone is a proven, highly matured communications technique which is extensively used by utilities for SCADA and protective relaying. From a technical standpoint, telephone is suited for Distribution Automation. The telephone system provides a high data rate capacity and is already constructed. Furthermore, it is easily implemented in a two-way configuration. Unfortunately, the cost of leasing telephone circuits is high and utilities have no control over the phone lines, or their communications quality. These drawbacks make telephone communication much less attractive for Distribution Automation than it would be.1 In addition, some locations do not have access and it is more expensive to place lines in service at those points. The use of dial-up telephone lines reduces the cost compared to lease lines, but these are much slower due to the "dialing time." and would be very slow at implementing functions such as fault isolation and service restoration. Telephone lines have been used successfully in distribution communications systems, but utilities continue to seek an alternative system that is under utility control and has no leasing costs.

Areas that are served by cable TV systems operate primarily with coaxial cable as the signal transmission path. Signal amplifiers are placed on the system where necessary. CATV systems have broad bandwidths, significant portions of which are unused. Distribution Automation could utilize a very small fraction of this available bandwidth. Most CATV systems are designed for one-way and not two-way communication. Many utility customers do not subscribe to CATV. CATV suffers from the same disadvantages as telephone, these being that it is under external control and there could be leasing charges associated with its use.

Wireless Communications

Radio has proven itself to be a viable communications technique for certain Distribution Automation functions. Radio is a broad coverage communications technology requiring little or no hardwired signal and can be implemented in two-way configurations. All radio systems have the ability to communicate into areas with power outage.

Radio communications techniques are available in the following formats:

AM broadcast

FM broadcast

VHF

UHF

Microwave

Satellite

AM Broadcast-

A radio system, no longer commercially available, used for distribution load control, makes use of AM broadcast stations to transmit information to a large number of load control units located on the distribution system1. The system works by encoding load control information onto the AM broadcast carrier wave. The information is encoded using phase modulation and is not detectable to ordinary radio receivers, therefore, the listener will not notice any degradation in the quality of the radio waves, which are sufficiently long, compared to VHF waves that they bend around the norizon better than VHF signals and are not degraded by shadowing or multipath distortion to the same extent VHF signals are. This makes the AM broadcast carrier suited for communicating with a large number of remotely located receivers in areas of geographic diversity.

FMSCA-

Another system utilizing broadcast radio is FM SCA. SCA stands for Subsidiary Communications Authorization. Essentially, SCA signals are multiplexed onto an FM broadcast by means of frequency modulation of a sub carrier. Ordinary radios will not detect this system, but specially equipped receivers can decode the SCA information. FM SCA is a one-way out bound communication system suited to the same uses as the AM broadcast system. One disadvantage of FM SCA is that the FM broadcast signals, due to their shorter wavelength, are more susceptible to multipath distortion, shadowing and are limited to line of sight. In congested or rugged terrain, FM SCA will probably have spotter coverage than an AM system.

VHF Radio-

Radio waves with a frequency between 30 and 300 MHz are classified as VHF (Very High Frequency). Utilities considering VHF radio systems for use in Distribution Automation will find only three available frequencies. Utilities share one 300 W, 3000 Hz bandwidth channel around 154 MHz Two 50 W 3000 Hz channels are also allocated. Many utilities use these three channels for load control communication and there may be limited access and extensive coordination problems from competing utilities. A license from the FCC will be required for the utility to operate the system. VHF signals have limited coverage and are susceptible to multipath distortion and shadowing. Due caution must be exercised when considering this system; Costs may be prohibitive to achieve 100% coverage. Despite these drawbacks, VHF radio has been used in a number of one-way operational load control systems, and has the ability to communicate into outage areas, is essentially under utility control and has a low initial cost.

UHF Radio-

Radio systems operating in the frequency range from 300 to 1, 000 MHz are classified as UHF (Ultra High Frequency). Recently, the federal Communications Commission authorized the range of frequencies from 940 to 952 MHz for utility applications. This opens up new possibilities to utilities that have not considered radio in the past due to the excessive crowding and interference on existing VHF frequencies. Radio systems operating in the UHF range are more susceptible to atmospheric absorption, multipath distortion and shadowing effects than radio systems at lower frequencies. Nonetheless, radio systems in this range have proven themselves to be quite reliable and are less prone to interference from competing services. Data rates as high as 9600 band have been demonstrated on these new UHF channel. Furthermore, UHF antennas are smaller than VHF antennas; this is due to the shorter wavelengths. At frequencies this high, wave propagation is essentially limited to line of sight. In mountainous areas, UHF radio may not be a viable alternative.

Microwave-

Microwave communication utilizes frequencies higher than 1 GHz. Microwave is currently used by utilities for SCADA and protective relaying applications. The use of microwave communications systems for Distribution Automation is unlikely, except as a final link from the substation RTU to the DistributionDispatchCenter. This is due to the high cost and complexity of setting up a microwave system. Microwave is not well suited to applications requiring multipoint communications. It is a point-to-point communications technology which maintains its economic viability based on two factors. It can replace a hardwired signal path and it has a high bandwidth. For Distribution Automation, the data rate requirements and path lengths are so small, compared to typical microwave applications, that the effective cost per channel becomes very high, making microwave unattractive for Distribution Automation unless it is used in a point-to-point high data rate configuration.

Satellite-

Today, most satellite communications are performed by means of a satellite in geosynchronous orbit. Satellites have transponders which receive an uplink signal and retransmit it at a different frequency. Thanks to their very high altitude, satellites provide broad uniform signal coverage. To communicate through a satellite, it is necessary to lease or own a transponder on the satellite and have the necessary uplink and downlink equipment. Microwave frequencies are commonly used for both uplinks and downlinks. Some utilities are successfully using satellites for SCADA, but because of the 1/4 second delay predate path associated with geosynchronous satellites, they can not be used for SCADA functions requiring very quick response time (such as protective relaying). The use of satellites for Distribution Automation is also being considered.

Spread Spectrum Communication

Spread Spectrum Communication transmits many short messages via low RF power transmitters that do not require licensing. The assigned frequency band is 902 MHz to 928 MHz.

This solution requires relatively a large number of radios, repeaters and RTU installations in order to transfer data over wide area. Further, combination of data and voice is not possible; so the infrastructure can not be utilized cost effectively.