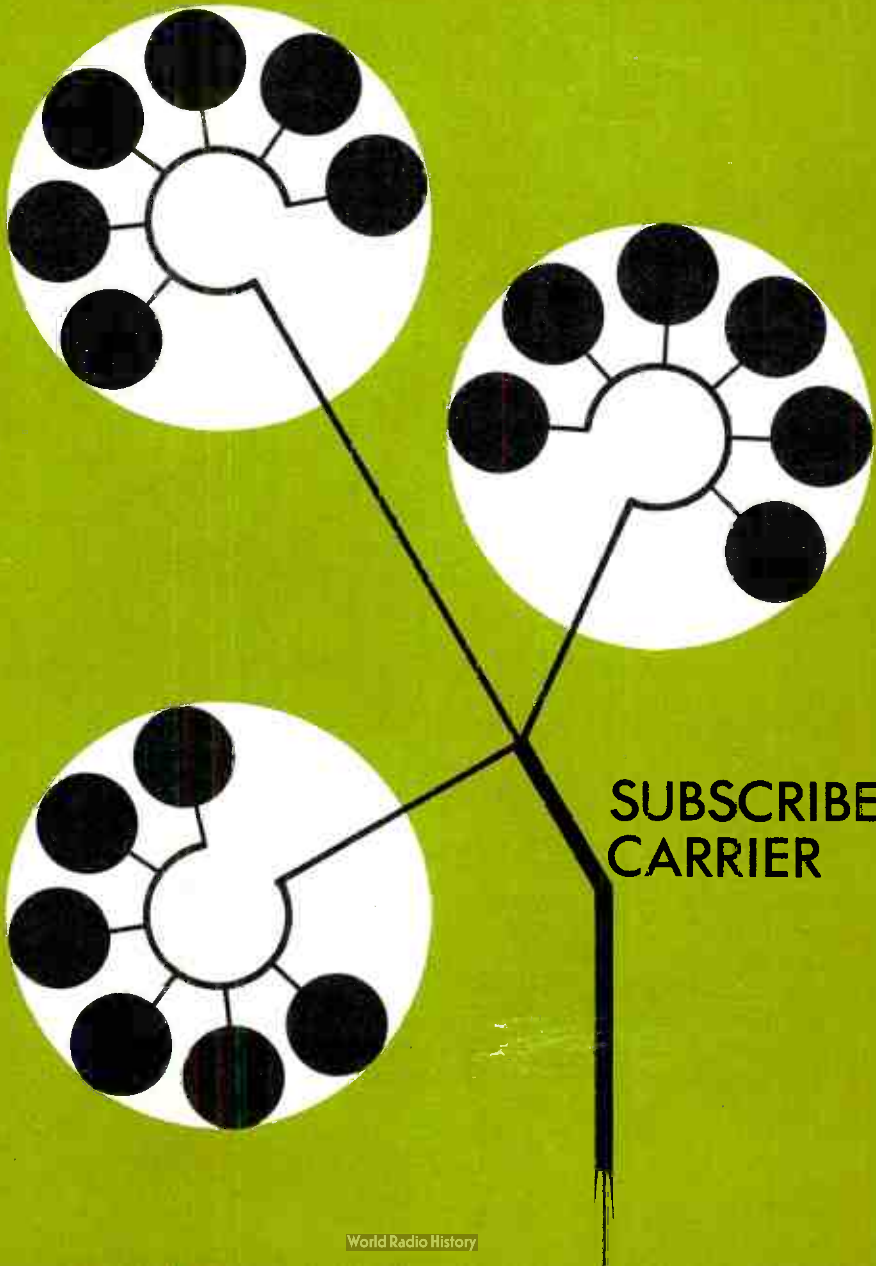
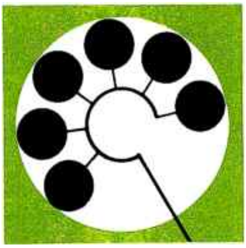
The Lenkurt® DEMODULATOR

MARCH 1970



SUBSCRIBER CARRIER



Subscriber carrier transmission systems economically expand existing cable capacity to meet the demand for additional voice and data circuits.

Man's unbounded desire to communicate has led to an ever increasing demand for new telephone circuits. A method of increasing telephone circuits without adding thousands of miles of wire is obviously desirable (Figure 1). While putting paired wires into cables serves to remove some of the wire from view, the problem of continually enlarging the number of physical circuits to satisfy the increasing demand remains.

Multiplexing permits simultaneous transmission of two or more signals over the same telephone circuit and has been one of the most valuable developments in the telephone industry since the early 1900's. Of course, the first multiplex carrier equipment was expensive and only practical for long distance circuits. As technology improved this condition changed.

The reduction in cost of multiplex equipment played an important role in the expansion of carrier for short haul transmission. One advance that made carrier practical for short haul transmission was in semiconductor technology, resulting in high performance, low cost transistors. The use of integrated circuits also improved performance and reliability, thereby decreasing cost still further.

Carrier transmission over open wire or cable between the central office and a subscriber is called subscriber carrier or station carrier. These systems provide less expensive transmission by using the medium more effectively. An ordinary cable pair carries one voice or data channel. The same cable pair, using a station carrier system can carry six carrier frequency derived circuits which can be used for voice or data.

Three Types

There are three basic types of subscriber carrier systems in use today. Each is designed to satisfy specific requirements, and each offers individual economic advantages. One class of subscriber carrier effectively extends the reach of the central office to outlying areas (as much as 30 miles away) and may carry 20 or more channels. A second type, providing six channels, serves to expand cable facilities closer to the central office. The third is a single-channel system specifically designed to add one additional subscriber to a cable pair easily and inexpensively at distances under 3.5 miles (5.4 kilometers).

Although the three types have different uses, they have some common advantages. All can be used with a combination of standard gauge cables. Minimum maintenance is possible because of the advantage of simply replacing defective equipment. Cable additions can, also, be deferred and planning flexibility provided using any of these carrier systems.

Multi-channel systems provide even greater service flexibility because each channel can be used for party-line service.

Multi-channel carrier equipment, for relief of existing facilities, is presently most practical at about 4 miles (6.4 kilometers) from the central office (Figure 2). Whereas presently, for

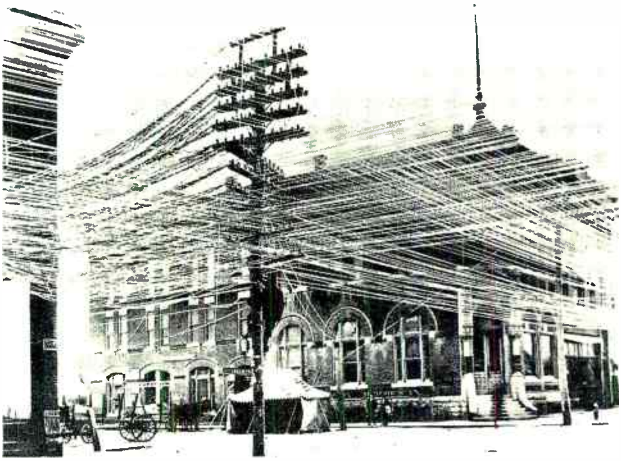


Figure 1. Maze of wires in this 1909 photograph epitomized telephone circuits before multiplex techniques were developed.

Bell Labs RECORD

initial installation, closer than 10 miles (16 kilometers) multi-channel equipment is not always practical. Cable must be installed initially, even when carrier is used; therefore, the economic trade-offs differ for initial and relief installations.

Upgrading and Expanding

Subscriber carrier first proved suitable for expanding cable and wire to rural and sparsely populated areas. Customers in these locations were accustomed to multi-party service and shared a circuit with as many as nine neighbors. As the economy of the established rural population changed, demands for urban quality service increased. The migration of urban workers – accustomed to single or two-party service – to rural areas has also added pressure for improved telephone service.

One-party service is being established under ambitious upgrading programs. Improving service by adding new physical circuits to remote areas, however, is not always economically practical. Factors, such as the need for automatic toll ticketing and increased copper and labor costs, also influence the decisions of planning engineers toward layout of new systems and planning the company's approach to growth areas.

The general need to upgrade service, relieve cable congestion, and provide growth margins in new developments has enhanced the addition of carrier equipment to exchange loop facilities. Carrier systems upgrade existing service and provide new service in areas without spare cable pairs. Additional benefits are realized in planning new cable installations around carrier systems.

Station carrier is also being used to provide temporary service for such functions as charitable and political campaigns, conventions, county fairs, home shows, sports events, etc. The largest application to date has been to provide immediate relief for a fraction of the cost of new cable installation. Carrier has gained recognition controlling new construction while meeting customer requests for additional and upgraded service in areas where facilities are already used to capacity.

Comparison

Carrier systems used to supplement existing physical circuits must provide a high degree of reliability, transmis-

Figure 2. For relief of overloaded facilities, the green areas indicate, at the present level of technology, each system's recommended operating range.

sion performance, flexibility, and economy compared to the alternative use of cable.

Since carrier systems operate over physical circuits, total system reliability is the sum of the carrier reliability and the reliability of the physical circuit. Designing high reliability carrier equipment is thus a primary requirement. Although such tight quality control increases the product cost, frequent service complaints and high repair costs are not an acceptable compromise. Today's carrier systems have been able to maintain high reliability at reduced costs by using integrated circuits and semiconductor devices.

Transmission Performance

Transmission advantages obtained from carrier derived circuits include signal consistency and stability. The quality of a carrier signal is almost identical at any cable length. In addition, net losses can be carefully controlled, and environmental conditions will have little effect on the stability of the circuits.

Long physical circuits (approximately 8 - 10 miles) contribute to increased noise, delay distortion, and degraded frequency response. These are major considerations especially when data is being transmitted. These parameters are degraded with increasing cable length. Using carrier, long loop transmission performance is significantly improved.

With station carrier systems such as Lenkurt's 82A, all carrier frequency signals leaving the central office are fixed at the same level. In the individual subscriber terminal, the received carrier level is regulated and the voice frequency is then detected. The carrier signal from the subscriber back to the central office is automatically preadjusted to compensate for cable loss. Channel signal levels within a carrier system will be different because each channel is a different frequency and line loss varies with frequency. However, the level of a particular channel frequency in one system will be the same as the level of the same channel frequency in another system operating over cable pairs within a common cable sheath.

This automatic regulation reduces far-end crosstalk between systems by maintaining similar levels for all systems within the cable sheath, regardless of channel terminal location.

The automatic signal regulation eliminates the need for manual level adjustment and also makes it possible to install and maintain the equipment by personnel not familiar with electronic circuits.

Installation

Carrier systems can be added to almost any type physical circuit — open wire, cable (aerial and buried), or a combination of open wire and cable — to increase the number of circuits available for voice and data transmission, or to reach out distances where transmission limitations prevent the use of voice frequency circuits.

Once preliminary engineering is completed and a cable has been specified, carrier installation with systems such as Lenkurt's 82A and 83A is routine and much faster than installa-

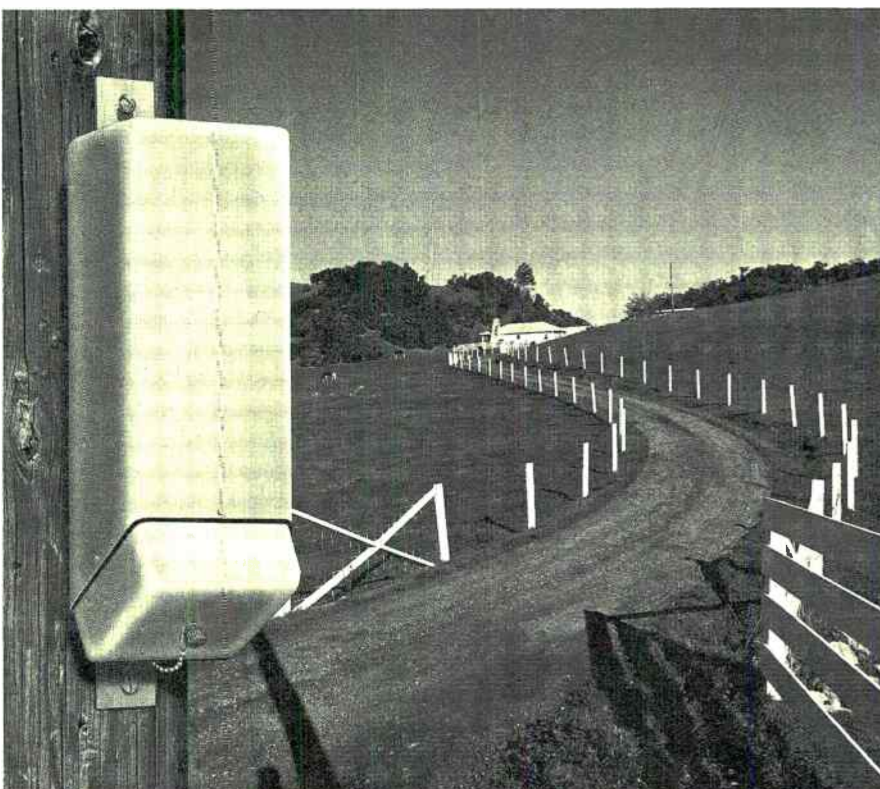


Figure 3. The subscriber terminal, shown here pole mounted, may be placed at any point along the cable.

Figure 4. Operations at the Charlotte Speedway in North Carolina, were able to start on time, with the necessary additional telephone service provided by Lenkurt's 82 A Station Carrier system.

tion of additional cable. Carrier equipment is installed at the same time as the home instrument, and can be placed at any point along the cable. No field adjustments are needed. The subscriber terminals and repeaters – identical in appearance – are designed for pole, crossarm, strand, or pedestal mounting (Figure 3).

Flexibility

Carrier equipment is readily available making it practical to work existing cables to a 100 percent voice frequency fill, instead of the 80 to 90 percent usually specified. Carrier equipment can be drawn from stock, or inventory, and installed as quickly as any non-carrier circuit – even when cable pairs are available. This is an important feature which is sometimes overlooked.

If carrier equipment is installed and the anticipated growth is not realized, the unnecessary carrier equipment can be removed and returned to stock with relative ease.

Short haul carrier equipment is practical for long term use in instances where the alternative is a long cable with a small circuit capacity.

If, however, carrier equipment is used as an interim measure to defer new cable provisions, carrier advantages are improved and shorter routes or larger growth rates are warranted. The degree of use which can be justified depends on the installed cost of a new cable in particular localities and on the expected return on investment.

After the addition of a new cable, station carrier systems used as a temporary means of providing additional circuits can be moved to a new location. There is a definite advantage in not having to rely on precise cable section forecasting. Instead, it is quite sufficient to use general circuit requirement forecasting for an area. Carrier equipment can be moved to meet changing demands; but, cable once laid, is fixed.

Economy

In a typical exercise to determine cable size for a new facility, the area's expected five year circuit requirements are reviewed, and possibly revised to reflect the personal experience of local engineers. Based on the results, a cable size is selected. Since cable is supplied in standard numbers of pairs, the usual practice is to choose the next larger size cable to ensure adequate facilities. This method will sometimes result in specifying cable with as many as 50 percent more pairs than are actually necessary. This overspecification can be costly when great distances are involved.

Using carrier systems in planning for maximum future requirements, the plant engineer realistically sizes his new cable to the nearest number of pairs instead of the next larger size. Extra circuits can be added with carrier equipment as required – reducing both initial and annual costs.

Practical Solution

When the Charlotte Motor Speedway in North Carolina, moved its administrative headquarters from downtown Charlotte to the race track near Harrisburg, N.C., it needed five additional circuits at the track immediately.

To install more cable facilities between the Speedway and the Concord Telephone's central office eight miles away would have been a time consuming project. Besides, a cable installation to provide five more circuits would be economically unsound.

In response to the problem, Concord Telephone turned to Lenkurt's 82A Station Carrier system. The 82A, designed to expand the capacity of a single subscriber cable pair to six private lines, proved to be an ideal solution.

The 82A, an extremely adaptable system, required no modification to the existing central office equipment or telephone subsets (Figure 4). All power for the repeaters and subscriber equipment was received from the central office supply, and no batteries were required for subscriber terminal or repeater operation.

A few days before the World 600 race, the Charlotte Motor Speedway officials requested an additional teletype circuit. Using 82A, another circuit was quickly and easily provided.

Even Greater Capacity

Subscriber carrier transmission can be an economical alternative to cable when the annual circuit requirements are small or where the circuit length is quite long. If future requirements are uncertain, carrier provides interim relief, allowing time to gather reliable data before making a major cable addition. Carrier systems are also being used where new cable additions would provide a great many extra pairs that would lie idle for several years.

Until such time as an even greater density, lower cost transmission system becomes practical, carrier will continue to replace cable transmission on shorter and shorter loops.

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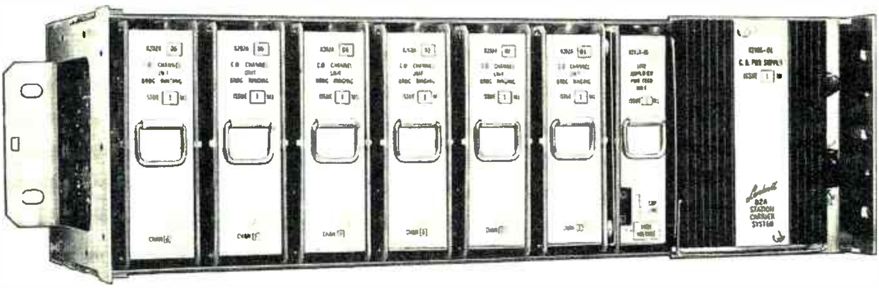

Lenkurt's 82A Station Carrier System expands the capacity of a single subscriber cable or open wire pair to 6 private-line circuits. The 82A is the perfect solution for service expansions where cable construction is being postponed, and where volatile growth of subscriber circuits and demand for service upgrading cannot be economically met by other means. For additional information, write Lenkurt, Department C134.

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