The Lenkurt Demodulator

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45-CLASS CARRIER NETWORKS

In the past, most carrier systems have been designed with one main objective—that of increasing the message handling capabilities of a particular type of transmission facility. While this is still of paramount importance, the increasing complexity of toll networks has added to the importance of other objectives of equipment designers and toll network planners. One of the most important of these is "direct interconnectability of carrier systems operating over different transmission media." Lenkurt 45-class carrier equipment has been designed to meet this objective.

This article discusses the interconnection of 45-class carrier systems to form carrier frequency networks and introduces a new concept of toll circuit planning.

Many different carrier systems have been developed for each of the three basic transmission media (open wire, cable, and radio). Most of these systems have used the same basic technique of dividing the frequency spectrum into small segments, but have been mechanically and electrically different. With the exception of Western Electric Types J, K, and L carrier systems for long-haul 'backbone' toll routes, the majority of systems have not been interconnectable on a carrier-frequency basis.

The 45-Concept

To replace the practice of installing different systems using different equipment for each different transmission facility, 45-class carrier equipment makes available a single type of short to long-haul, low to medium cost channelizing equipment that can be arranged in a number of ways to provide the proper transmission levels and frequency ranges for transmission of channel groups over wire lines, cable, or radio. Specific systems of 45-class carrier are distinguished by two basic differences. The number of modulation steps varies with the number of channels and the final frequency allocation desired, and, the system transmitting, regulating, and equalizing equipment arrangements vary with the characteristics of the transmission media.

There are two modulation steps common to all 45-class systems. The first step combines four voice channels and positions them in the frequency spectrum from 8 to 24 kc. This arrangement is called a pregroup.

The second step combines three

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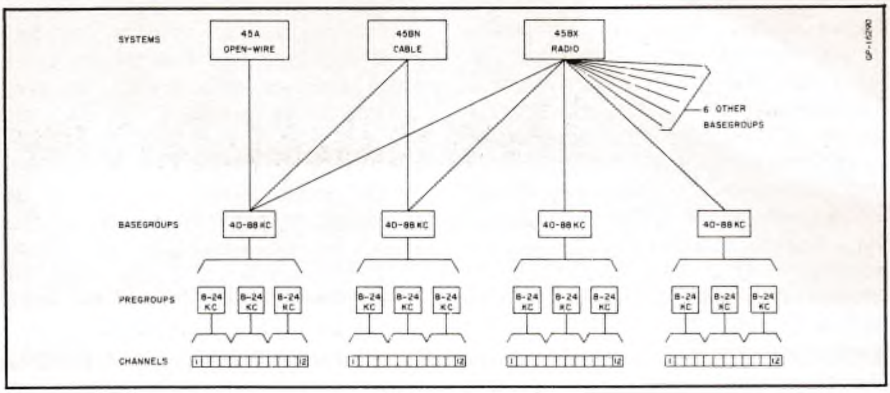


FIGURE 1. Different 45-class carrier systems are developed by combining suitable numbers of pregroups and basegroups and preparing them for transmission over different media.

pregroups and then positions them in the frequency spectrum from 40 to 88 kc. This grouping is called a basegroup. Pregroups and basegroups are always essentially identical regardless of where they originated or which types of transmission facilities they are transmitted over. Figure 1 shows how channels, pregroups, and basegroups are used to develop different 45-class systems.

Carrier Network Planning

The use of standard pregroups and basegroups that are the same for all 45-class carrier systems permits a convenient new way of thinking about toll networks derived from carrier equipment. Instead of thinking in terms of specific systems with the limitations of voice frequency interconnections, circuit planning can be done in terms of channel groups transmitted between any desired locations. Groups of 4, 12, or 60 channels can often be routed to achieve a toll circuit arrangement tailor-made for a specific situation.

Typical of the many possible toll circuit layouts is the simple network shown in Figure 2. The equipment required for this network is only a small fraction of the equipment required to accomplish the same results without carrier frequency interconnection. Actual amounts of equipment required at end terminal and interconnect points are shown by the scaled photograph insets.

Equipment Arrangements

Planning in terms of channel groups rather than separate systems per facility creates a natural division of carrier equipment functions and requires a somewhat different terminology than that used with individual systems. On one side of the division is the channel terminating and grouping equipment and on the other side is the system terminating equipment.

Channel terminating and grouping equipment includes the channel units (modulators, demodulators, channel bandpass filters, and signaling equipment) and the grouping units for forming basegroups (pregroup units). This equipment is not associated with any particular type of 45-class equipment or with any particular transmission medium. It is, rather, the basic multiplexing equipment common to all systems of this class. In specifications and literature describing 45-class equipment, channel terminating and grouping equipment arrangements are often referred to as either pregroup or basegroup channel banks depending on whether a 4-channel pregroup or a 12-channel basegroup is terminated. Channel banks are required only where channels terminate in voice frequency circuits or drops.

System terminating equipment includes the final modulation stages necessary for positioning basegroups or linegroups (combinations of basegroups) in the proper frequency spectrum. It also includes transmitting amplifiers, equalizing and regulating equipment and carrier frequency generation and distribution equipment. Specific system terminating assemblies are normally designated as 'Basegroup Terminal Assemblies' which indicates that frequencies on the drop side of the terminal are in the 40-88 kc basegroup band. For example, a 45A Basegroup Terminal Assembly accepts the 40-88 kc band from a basegroup channel bank and conditions it for transmission over an open-wire line. It also accepts a 12-channel linegroup from the open-wire line and conditions it for application to the input of the basegroup channel bank. System terminal equipment is required at both channel terminating points and at interconnect points between transmission media.

Since both system terminal assemblies and channel banks are required at channel terminating points, and since this is the most common arrangement of equipment, assemblies are sometimes combined. The combined assemblies are called channel terminal assemblies. Typical of these combined assemblies are the 45A and 45BX channel terminal assemblies shown in Figure 2.

In addition to system and channel terminating equipment, different amounts of separate grouping and carrier frequency supply equipment may be required at very complex interconnection points. For most interconnections, however, the carrier supplies and basegroup units that are part of a normal system terminal are adequate.

Basegroups

The most common grouping of 45-class carrier channels is the 40-88 kc 12-channel basegroup. This arrangement of channels is readily transferred from one system to another by simple basegroup transfer assemblies. In Figure 2, a 12-channel basegroup is originated at A and transmitted between stations A and F through stations D and E. Between stations A and D the group is carried by a 45A open-wire system. At D the 45A system is terminated and the basegroup is transferred to a 45BN system terminal through a basegroup transfer assembly. The transfer assembly coordinates the output-input levels of the two systems and filters out unwanted frequencies. At E, the 45BN system is terminated and the 12-channel group transferred to a 45BX system terminal through another identical basegroup transfer assembly. At F the channels are again terminated in voice-frequency circuits or drops.

The basegroup transfer assembly is a simple rack-mounted shelf with plug-in components that provide the necessary gain, attenuation, and filtering to permit the output of a basegroup unit in one system terminal to be applied to the input of another. Figure 3 shows the details of a transfer of basegroups between two 45A systems and a 45BN system.

Pregroups

Channel groups smaller than 12 channels often are more economically transferred from one system to another by the interconnection of 4-channel pregroups. A typical application of pregroup interconnection is shown in Figure 2. At station C of this figure, two pre-

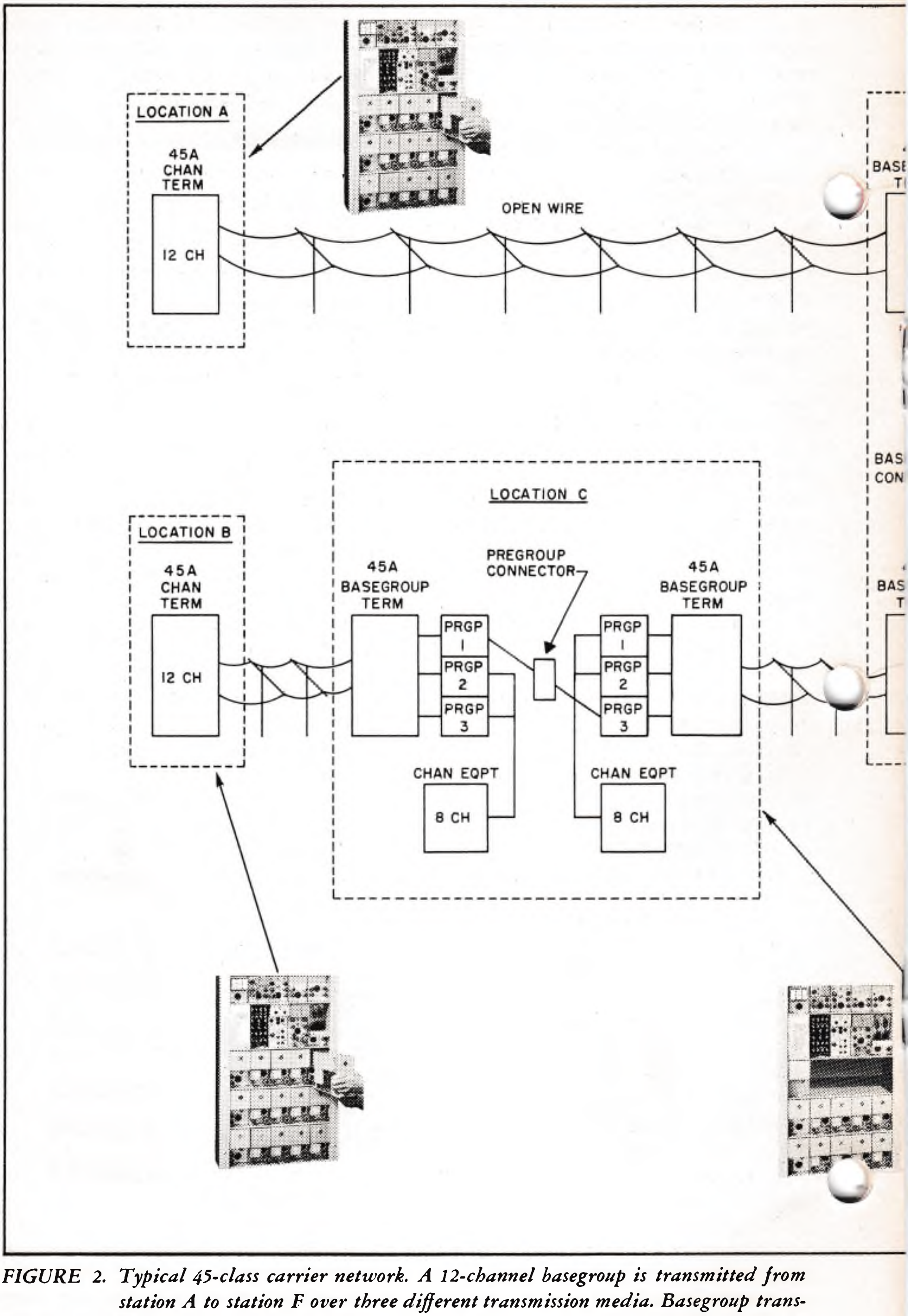
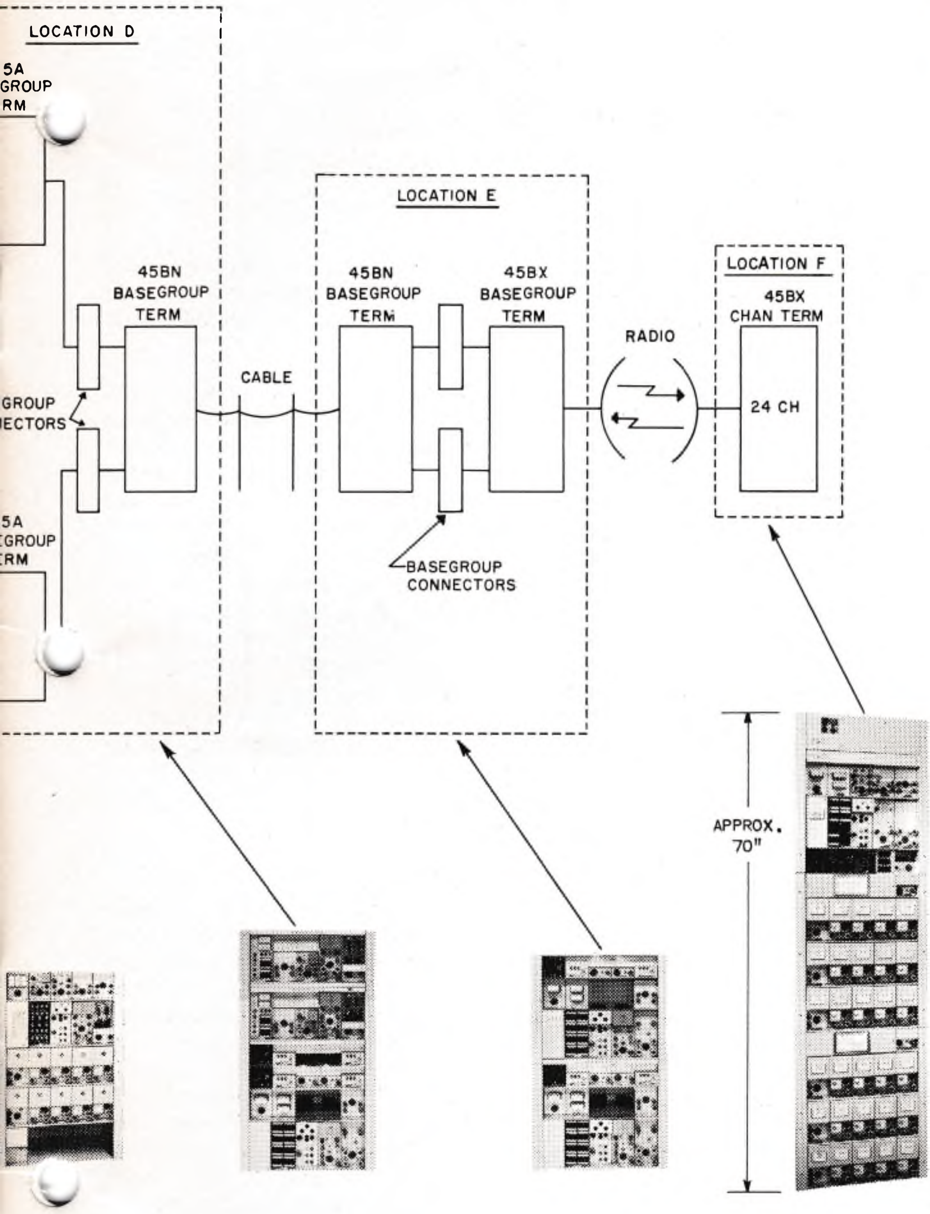


FIGURE 2. Typical 45-class carrier network. A 12-channel basegroup is transmitted from station A to station F over three different transmission media. Basegroup transfers are made at the junctions of the media at stations D and E. Similarly, an 8-channel group (2 pregroups) is transmitted from station C to station F, being



combined with the 12-channel group at station D. From station B, a 4-channel pregroup is transmitted to station F with a pregroup transfer being made at station C. The 45A system between stations B and C is also used to provide 8-channels directly between these two points. The photographs show the actual equipment (less compandors) required at each station.

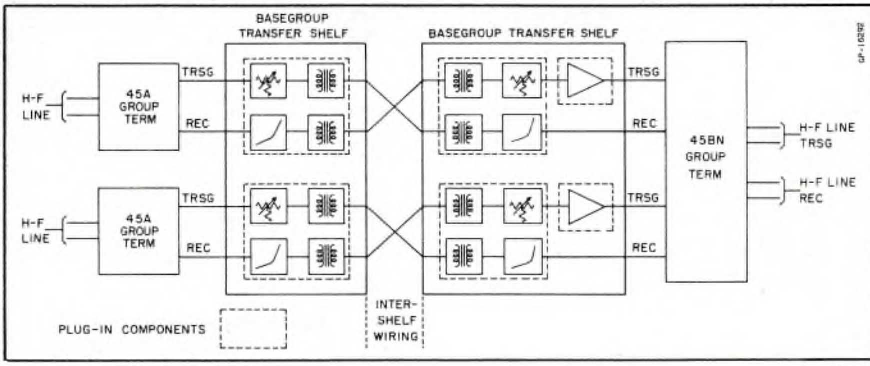


FIGURE 3. Block Diagram of a 45A to 45BN interconnection. Equipment required in addition to the group terminals consists of the amplifiers, pads, filters and transformers making up the transfer shelves.

groups from each direction are terminated to provide 8 circuits from B to C and 8 circuits from C to F. The remaining 4 channels are transferred as a pregroup from one 45A system to another to provide 4 circuits from station B to station F.

The transfer of a pregroup from one system to another is accomplished by a simple plug-in transfer unit which filters and adjusts the output level of a pregroup in one system so it can be applied to the input of a pregroup unit in another system.

Future Developments

Currently, there are three types of 45-class system terminal equipment in actual use. These include the 45A Open-Wire Carrier Equipment, the 45BX Radio Multiplexing Equipment, and prototypes of the 45BN Cable Carrier Equipment. In the past 18 months more than 100 Type 45A systems and more than 15 Type 45BX systems have been installed in the United States and several other countries. Several of these systems have already been interconnected on a carrier frequency basis and more interconnections are contemplated.

In Lenkurt's engineering laboratories, development programs are proceeding on other types of 45-class carrier equipment and on improvements of existing systems. Many of these development programs are intended to make interconnection of systems and the routing of channel groups even simpler. The new systems and improvements, however, are not designed to make obsolete, replace, or compete with existing Lenkurt equipment. Their purpose is, rather, to enlarge the field of use of Lenkurt carrier so that it will include all applications from one-channel, short-haul systems to large capacity, long-haul systems for major toll routes.

Conclusions

45-class carrier equipment provides a new approach to the planning and engineering of short and medium length toll routes. Through carrier frequency interconnection of systems operating over different transmission facilities, various size channel groups can be routed economically to achieve better toll circuits than previously possible. The use of the same basic multiplexing equipment for all types of systems results in large savings in equipment and maintenance costs and provides a simple means of varying circuit facilities to meet changing traffic demands.

WHAT IS 'Q'?

The design of carrier equipment requires components and circuits that have a high degree of frequency selectivity. A quality term often used to express frequency selectivity is 'Q'. The performance of coils, capacitors, and simple resonant circuits is often measured by this index.

Mathematically, Q is the ratio of the reactance of a coil or capacitor to its resistance at the frequency of interest. It can also be expressed as the ratio of the center frequency of resonance to the bandwidth (measured at half-power points) of a resonant circuit.

Q is most commonly used in connection with coils, oscillators, and filter meshes in communications circuits. The Q of a coil, for example, is a 'figure of merit' which helps indicate its applicability to frequency selective circuits. Coils with high Q permit the design of sharply selective filters and stable, efficient oscillators.

Although a high Q is desirable in most resonant circuits, it is not always easily obtained. Several different factors tend to limit the Q obtainable in practical circuits. At low voice and power frequencies, the Q of a coil or resonant circuit tends to be small because inductive reactance is small at these frequencies. As the frequency is increased, however, the reactance increases rapidly resulting in a higher Q. Resistance also increases with frequency, but not as fast initially as reactance. As the frequency is further increased, skin effect, insulation losses, and core losses cause the effective resistance to increase more rapidly than the reactance; hence a maximum value of Q is obtained at a certain frequency and further increases in frequency result in a declining value of Q. The maximum value the Q attains and the frequency at which the maximum occurs depends on the construction of the coil.

Several methods are used to increase the values of Q obtainable in resonant circuits or coils. These methods also tend to increase the range of frequencies over which the Q remains high. Among them are the use of special core materials, the use of special types of wire, and in some cases, the use of special devices such as crystals or resonant transmission lines and cavities.

The use of magnetic core materials such as carbonyl powdered iron or permalloy permits coils to be wound with fewer turns of wire and consequently less resistance. Such coils have a higher Q over a wider range of frequencies, yet are smaller in size than equivalent air core coils.

Some radio frequency coils are wound with special types of wire designed to reduce skin effect (the tendency of high-frequency currents to flow on the surface of a wire). Hollow tubing, ribbon wire, multistranded wire, special braided wire (Litz wire) are some of the types used. Each type provides increased surface area to lower the effective resistance. At the higher radio frequencies, components are frequently silver plated to reduce the resistance and provide a higher Q.

A few applications of communications circuits require resonant elements with higher values of Q than are obtainable with ordinary coil-capacitor circuits. In these cases, piezoelectric crystals or resonant transmission lines or cavities are often used. Crystals are generally used at frequencies below 100 megacycles while resonant transmission lines and cavities are used in the UHF and microwave regions. Values of Q of several thousand have been obtained from these types of devices.

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Recently Issued Publications

A complete description of the Lenkurt **Type 24C3** AM Telegraph system is included in a new 14-page bulletin **24C3-DES.** Major subject headings include: Performance characteristics, description of operation, testing and maintenance features, and equipment arrangements.

The **Type 24C3** Carrier Telegraph system is used to transmit up to 19 on-off type telegraph channels over a suitable carrier derived or physical voice circuit.

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LENKURT COMPONENTS including powdered iron cores, toroidal coils, and electric wave filters for use in other electronic equipment are distributed by the Lenkurt Electric Sales Co., San Carlos, California.

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