The Lenkurt Demodulator

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CARRIER CHANNELS FOR TELEGRAPH AND DATA

—A Review of Fundamentals—

Part II

This article concludes the present series on Carrier Telegraph Fundamentals. In the preceding issue, the subject of carrier telegraphy was introduced; transmission problems associated with direct-current telegraph signals were reviewed; and the operation of standard telegraph loops between the teleprinter and the carrier channels was discussed.

In this article, the discussion is continued. However, emphasis is placed on carrier techniques and applications commonly used in present-day carrier telegraph systems.

Two of the factors which led to the use of carrier as a means of transmitting telegraph signals were: (1) the relative ease of transmission; and, (2) the increased number of channels that could be applied to a facility. The development of carrier telephone systems had established the feasibility of using frequency division methods, and this technique has been applied to carrier telegraph systems.

Although other methods might be used, frequency division offers: (1) efficient utilization of the frequency spectrum that might be assigned for telegraph use; and, (2) compatibility with the frequency assignments of carrier telephone systems.

The actual frequency band available to carrier telegraph channels has varied somewhat with the evolution of carrier for telephone applications. Currently, the two bands most commonly employed are in the voice-frequency range. The first occupies the approximate frequency band, 340 to 3400 cycles; or, the approximate band available in a voice-frequency telephone circuit.

The second band occupies the approximate band 3500 to 5150 cycles. This is above the range of a v-f telephone circuit, but is below the lowest frequency used in many carrier-telephone systems. Telegraph channels in this band are often referred to as h-f channels.

The bandwidth required for a carrier telegraph or data channel depends upon such factors as information rate, noise, filter attenuation to adjacent channels

VOICE FREQUENCY GROUP (Frequency Shift each Channel ±35 cps)				HIGH FREQUENCY GROUP		
Mid-band Frequency cps	Channel Spacing Cycles	Mid-band Frequency cps	Channel Spacing Cycles	Mid-band Frequency cps	Frequency Shift cps	Channel Spacing Cycles
425	170	1955	170	3550	±40	200
595	170	2125	170	3750	±40	200
765	170	2295	170	3950	±40	200
935	170	2465	170	4150	±40	210
1105	170	2635	170	4360	±45	220
1275	170	2805	170	4580	±45	230
1445	170	2975	170	4810	±50	240
1615	170	3145	170	5050	±50	-
1785	170	3315	170			

Fig. 1. Channel mid-band frequency assignments for the Type 23A Datatel system. Line frequencies may be obtained by adding and subtracting the frequency shift from the mid-band frequency.

and whether one or both sidebands are transmitted. Because of the relatively narrow bandwidth required, even at telegraph speeds of 100 words per minute (wpm), a total of 18 double-sideband carrier telegraph channels can be derived in the v-f band; and 8 double-sideband channels can be derived in the h-f band. Channel-frequency assignments in the bandwidth available can be made in a number of ways. The method shown in Figure 1 is the one most commonly used for channels with 100 wpm capability.

Conversion Methods

A carrier telegraph channel has two basic functions which are interrelated. At the transmitting end it must convert d-c telegraph loop pulses into carrier frequencies for transmission; and, at the receiving end it must translate the carrier information into d-c pulses to operate the receiving printer. Although a number of methods may be used to accomplish this purpose, only two basic types, amplitude modulation (AM) and frequency shift (FS — also called frequency modulation), enjoy widespread usage.

In both cases, a tone oscillator provides the line frequency. However, for amplitude modulation, the oscillator is keyed on or off; and for frequency shift the oscillator frequency is shifted a specified amount. The mark and space conditions are then indicated by either the presence or absence of tone (AM), or by the specific frequency of the tone (FS).

Keying Methods

A keying device in the telegraph loop controls either the level or frequency of the carrier channel output. The keying function may be accomplished by a variety of circuits. In an AM system, the loop current may be used to open or close relay contacts which are in the oscillator output circuit. A similar arrangement may be used in an FS telegraph system. However, more recent circuits make use of semi-conductors.

An example of the use of semi-conductor diodes is shown in Figure 2. This is a simplified schematic of the keying bridge and tone oscillator used in the 23A FS system. Voltages acting on the bridge are obtained from the loop and from the local office battery. Voltage is obtained from the loop only when the loop is closed (normal marking condition), and the voltage is of greater magnitude than that obtained locally. Therefore, opening and closing the loop for normal transmission reverses the polarity of the voltage applied to the bridge. This shifts the frequency of the tone oscillator by changing the resonance of the tank circuit.

An advantage of the use of a device such as a diode bridge, is that, in addition to standard telegraph-loop voltages and currents, relatively small voltages at low current values may also be used to shift the frequency. This extends the range of usefulness of the carrier channel, and permits operation from data as well as telegraph equipment.

To provide isolation and to reduce interference with other telegraph circuits, the oscillator output normally passes through an amplifier and filter. The amplifier not only isolates the oscillator from the line, but permits adjustment of the sending level. In some cases, an amplifier common to a number of channels provides additional amplification and level adjustment range.

The filter reduces the band occupied by the sidebands obtained from the keying operation. Sideband frequencies are dependent upon the keying rate. The assigned bandwidth includes the frequency band necessary to pass the desired keying sidebands, but unnecessary sidebands, which may interfere with other channels, are eliminated by the filter.

At the receiving terminal, the carrier telegraph signals must be translated into d-c pulses in the telegraph loop to operate the receiving printer. A filter is, of course, necessary to select only the desired carrier-channel frequencies from the line. However, the conversion method will depend upon whether AM or FS operation is used.

For example, in an AM system, the marking and spacing conditions are indicated, respectively, by the presence or absence of carrier signal. Rectification of the received signal would appear to be a direct solution to the problem. However, factors such as line noise, low receiving signal levels, line level variations and the magnitude of telegraph-loop currents make the conversion somewhat more complex. Automatic gain control amplifiers are often used to obtain a usable signal level that is relatively independent of line level variations. Then the signal is rectified to operate a relay or vacuum tube that con-

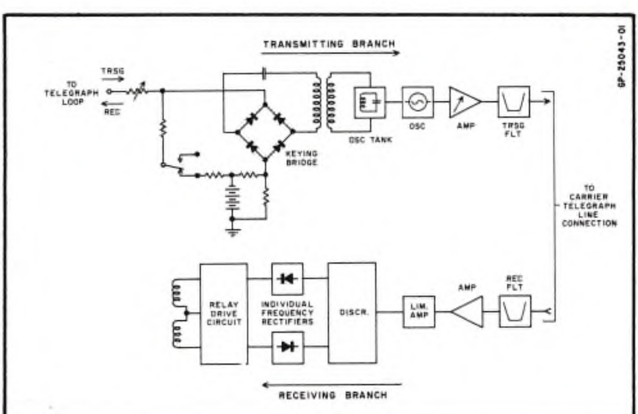


Fig. 2. A simplified block and schematic diagram of a 23A telegraph and data FS carrier channel operating into a half-duplex neutral loop. Frequency shift is controlled by voltage combinations obtained from local battery and the loop.

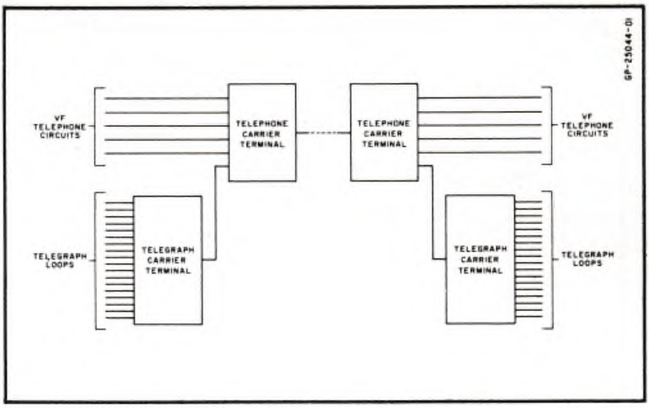


Fig. 3. Eighteen telegraph channels are applied to one carrier telephone channel. Other carrier channels may be used for message circuits or telegraph or data carrier channels.

trols current pulses in the receiving loop.

In an FS system, two different frequencies, which represent the marking and spacing conditions must be converted into telegraph loop signals. One method of doing this is illustrated in Figure 2, and is explained below.

After passing through the receiving filter, the signals are amplified to obtain a usable signal. They are then passed to the limiter amplifier which provides a fairly constant output over a wide range of input signal levels. A discriminator separates the two frequencies, and each frequency is passed to a separate rectifier circuit. The rectified output is applied to the windings of a polar relay, and the position of the relay armature is controlled by the received marking and spacing signals. These signals are translated into telegraph-loop currents under the control of the polar relay.

Transmission Medium

Most facilities which may be used for telephone circuits may also be used for carrier telegraph. These include the voice-frequency channel in open-wire or cable circuits, carrier-derived voice channels and vhf or microwave radio channels.

A restricted bandwidth will reduce the number of telegraph channels that may be applied to the facility; and can be determined from the frequency-response characteristic. If the frequency response is not available it should be measured with all intermediate equipment connected in the circuit. The marking and spacing frequencies of each telegraph channel to be used should be plotted on the frequency-response curve. For each channel, the level difference between the marking and spacing frequencies should be noted. If this level difference exceeds 1 db the channels should normally not be used. A 1 db-level difference does not in itself create excessive distortion, but it is usually indicative of filter cut-off (applicable also to loaded cable) which introduces phase-delay distortion.

The actual number of separate channels that may be derived from a facility depends on whether two- or four-wire operation is used. In four-wire circuits each channel requires only one frequency for operation in both directions of transmission; in two-wire circuits a

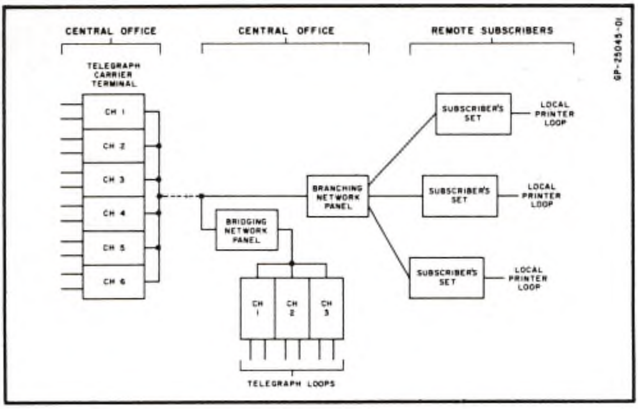


Fig. 4. An example of how the use of bridging and branching network panels and a subscriber's set increases the flexibility of system layout.

channel frequency can only be used in one direction.

Applications

In many applications, direct terminal-to-terminal operation is all that is required. An example of how this may be accomplished is shown in Figure 3. This application shows carrier telegraph channels being applied to one carrier telephone channel, with the remaining carrier telephone channels used for voice circuits.

Additional telegraph circuits may be obtained in two ways: (1) v-f and h-f carrier telegraph channels could be applied directly to the transmission medium; and, (2) v-f carrier telegraph channels could be applied to other carrier telephone channels.

While direct terminal-to-terminal telegraph operation is adequate for many applications, it is sometimes desirable to drop telegraph channels at an intermediate point. Other applications may require termination of some channels at an office with the remaining channels carried through to different subscriber locations as carrier signals.

In each case, accessory equipment items will be necessary. Normally, these consist of bridging and branching network panels, and a subscriber's set which contains the necessary channel and loop equipment. Where the attenuation of the line and network is sufficiently high, a repeater or equipment that can supply the necessary amplification will be required. One circuit arrangement in which bridging and branching panels and a subscriber's set may be used is shown in Figure 4.

Bridging and Branching Panels

Two types of auxiliary panels are provided for connecting 23A system telegraph channels in multiple when the channels of one system are terminated at different locations. These panels are generally used in two-wire applications but may be used in some instances for four-wire operation.

The bridging panel is used where channels are connected at an intermediate point in a system. It contains an impedance matching transformer and bridging resistors.

The branching panel is used to join a maximum of three connecting lines to a main line at one intermediate point. Two or more panels may be used to feed a greater number of lines. The panel has impedance matching transformers and level-coordinating resistors.

Subscriber's Set

The subscriber's set is used to install a single telegraph channel at a subscriber's premises. A subscriber's set is often housed in a cabinet. Contained in the cabinet as a part of the set are line-terminating equipment for the channel unit, loop-terminating equipment, and a terminal strip for connections to the line, teleprinter, and the local d-c power supply. In addition, provision is normally made for such options as: (1) an external 20-cycle ringer when required for TWX service; and, (2) a "carrier on-off" control.

Conclusion

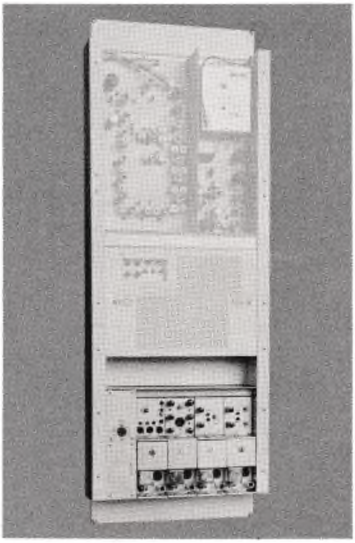
Carrier methods may be used to simplify d-c telegraph and data transmission problems. Carrier also provides an economical and easy means of increasing the circuit capacity of existing facilities. In addition, circuit layout is simplified because of the flexibility possible with carrier applications.

Efficient utilization of the available bandwidth is obtained through the use of frequency division to derive narrow-band carrier channels. Also, frequency division permits channel-frequency assignments to be made which are compatible with those commonly used in carrier telephone systems.

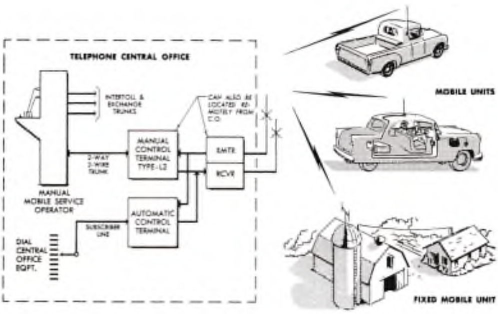
A problem basic to the design of a carrier telegraph and data system is the conversion between standard d-c telegraph-loop currents and carrier line frequencies. In designing for the relatively high currents used in standard telegraph loops, operation of the equipment may be restricted to carrier telegraph applications. However, new design techniques permit a wider range of operating conditions, and carrier systems such as the 23A may be used in data as well as in telegraphy.

A New Communications System

The Lenkurt Type 911 system is an assembly that combines VHF radio with FDM multiplex equipment for low channel capacity applications. The radio equipment operates in the 150 mc region (148 to 174 mc), and in the United States the system may be licensed to operate in Rural Radio Service. Some of the operating features and characteristics of the Type 911 system are described in Product Information Letter No. 26.



mobiltel

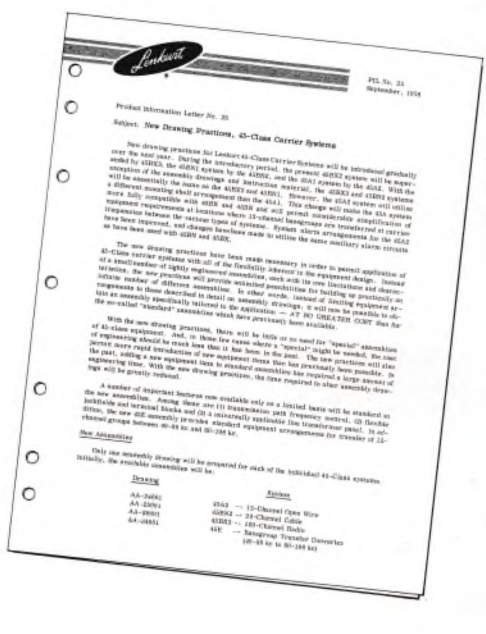


MOBILE TELEPHONE SYSTEM TYPE 901
MANUAL—AUTOMATIC

With the introduction of the Lenkurt Type 901 *mobiltel* system, engineering of mobile telephone equipment into the telephone plant has been greatly facilitated. The problem of connecting r.f. facilities into the telephone plant, both at the attended office and at the dial center, have been fully considered as well as complete system engineering. Equipment features, system operation and ordering procedures for the 901 system are contained in the recently issued publication, Product Information Letter No. 27.

New Drawing Practices For 45-Class Systems

Equipment design changes now in process will increase the flexibility of our 45-class sytems. With their introduction, the system type designation will be changed. The present 45BX2 system will be superseded by the 45BX3; 45A1 system by the 45A2; and the 45BN1 system by the 45BN2. In order to take advantage of the increased flexibility inherent in system design, a new drawing practice will be introduced. Some of the features of this new practice are described in Product Information Letter No. 25.


PIL No. 25
September, 1958

Product Information Letter No. 25

Subject: New Drawing Practices, 45-Class Carrier Systems

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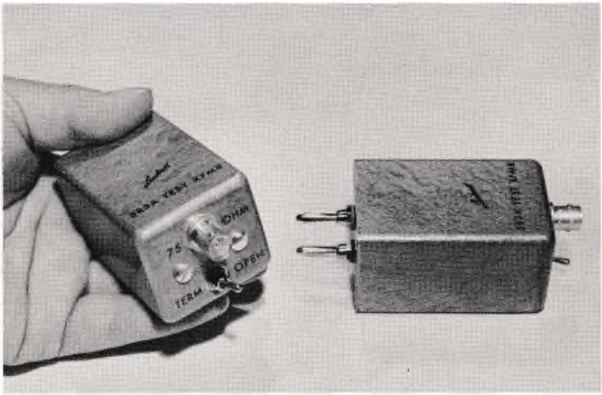

Illustrated above is the **Type 583A Test Transformer.** The transformer in the 583A is designed for impedance matching between 600- and 75-ohm circuits, and facilitates measurements made in radio circuits with 600-ohm test equipment. Banana plugs are provided at one end for connection to test oscillators or vacuum-tube voltmeters. A coaxial connector at the other end permits patching to coaxial circuits with a test cord such as the Lenkurt Type 693A.

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