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TECHNICAL REFERENCE

TRANSMISSION SPECIFICATIONS for LOW SPEED SIGNALING SYSTEM CHANNELS

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Transmission Specifications for Low Speed Signaling System Channels

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ENGINEERING DIRECTOR-TRANSMISSION SERVICES

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If further information is required, please contact:

Engineering Director — Transmission Services
American Telephone and Telegraph Company
195 Broadway
New York, New York 10007

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1. INTRODUCTION

1.1 General

This document describes a Low Speed Signaling System which permits unidirectional data transfer for alarm reporting, telemetry, and other purposes. This new system is compatible with customer signaling equipment and network configurations generally characterized as "McCulloh" systems (Reference 1).

This specification describes the interface to the customer at the remote stations and the central station of such systems, typical signal formats employed, the operational characteristics of the system during fault conditions, and the maintenance objectives.

While the signaling system is not restricted to any one type of customer, many of the examples employed in this document are drawn from applications in the alarm industry, which represents a major user of low speed, one-way data communications.

1.2 System Description

The Low Speed Signaling System transmits contact closure signals at speeds up to 15 bits per second. A typical customer network employing the system is shown in Figure 1. Data flows from the remote stations located on diverse customer premises to a single central station also on customer premises. One or more customer-provided transmitters may be connected to a single metallic signaling leg. Several signaling legs may be connected in series to form a single, continuous signaling loop. Battery is applied to the signaling loop from the serving central office. The transmitters normally keep the loop closed and ungrounded. To signal the receiver at the customer central station, the transmitter opens, recloses and grounds the loop, and then returns it to its normal condition. The resulting three-part signal is repeated several times in a coded sequence used to identify the particular transmitter. The sequence itself may be repeated a number of times, depending on the particular service.

The open and ground signals on the loop are detected by the encoding data set which terminates the signaling loop in the serving central office. The data set converts the loop signals into two independent signals "loop open or ground," called G′, and "loop open and not ground," called N′. These two signals are then transmitted over separate interoffice paths, as shown in Figure 1.

The interoffice transmission paths for the N′ and G′ signals are normally provided on voice grade channels. Since separate channels are used for the two signals, a failure on one path should not interfere with transmission of the signal on the other.

The two signals are received at the decoding data set in the serving central office for the central station (CS). The decoding data set reconstitutes these signals to contact closures which open and ground the loop to the central station. Power is supplied to this loop at the CS. This loop will be referred to, hereafter, as the central station trunk.

The CS typically contains sensors to monitor the loop for both open and ground conditions. Additionally, these sensors can be conditioned to compensate for the presence of a continuous single fault and to detect those signals transmitted under fault conditions. This operation is covered in Section 4.

2. INTERFACE

2.1 Physical

The 2-wire interface between the customer-provided equipment (CPE) and the telephone company channel facilities will, in general, be a terminal block arranged for convenient connection of the cable conductors to the CPE. The terminal block will be provided by the telephone company and space must be provided by the customer for the telephone company to install the terminal block in a suitable location to permit maintenance testing of the circuit. The customer is responsible for the connection of his equipment to the terminal block. He is also responsible for disconnecting his equipment at the interface to allow telephone company repair personnel to perform normal work operations.

2.2 Transmitter Interface

2.2.1 Transmitter Configuration

The transmitter is connected to the signaling leg at a remote station as shown in Figure 2. The loop contact is normally closed between the two sides of the leg. The terminology "feed" and "return" arises from signaling systems in which the customer provides battery to the loop on the feed side. Although the battery in this system is provided by the telephone company, the terminology is retained.

The normally open ground contact is connected between the return side of the leg and the local ground, The junction of the two contacts should be connected to the return side of the leg to minimize distortion. The transmitter contacts must each have a closed resistance of less than 10 ohms measured at the transmitter terminals and an open resistance of more than 10M ohms across the contact and to any other transmitter component. The insulation breakdown of the transmitter contacts to any ground-seeking path must be greater than 1000 volts peak. Occasional surges of greater amplitude may be encountered in some cases. The transmitter must not introduce any associated power sources to the signaling leg.

Other transmitter contact configurations can be used. Figure 3 shows two normally closed loop contacts with the normally open ground contact connected to their common point. Figure 4 shows two normally open ground contacts with the normally closed loop contact between them. Since these transmitter configurations are balanced, there is no preferred arrangement for the telephone facility connection.

2.2.2 Electrical Interface

The encoder interface with the signaling leg is shown in Figure 5. The loop detector of the encoder powers the loop with a floating supply of 42 to 55 volts dc that is capable of delivering a maximum of 20 milliamperes of current into a zero-ohm loop. The detection of a loop closure is assured at currents greater than 3 milliamperes. A loop open will be detected at currents less than 2 milliamperes. This requires that the total series resistance of the signaling loop including CPE and customer wiring be less than 10,000 ohms with the loop closed and that the total leakage resistance in the loop open state be greater than 30,000 ohms.

The ground detector of the encoder will supply between 2 and 4 milliamperes through the ground signal path at an open circuit voltage of 55v maximum. To insure proper operation of the ground detector, the total ground return path resistance, exclusive of the wire resistance of the signaling loop, must be less than 8,000 ohms with the loop grounded and greater than 65,000 ohms with the loop ungrounded.

2.2.3 Signal Criteria

The system will accept loop open and loop ground pulses which range from 67 milliseconds to 500 milliseconds. This corresponds to a maximum signaling rate of 15 bits per second and a minimum of 2 bits per second.

As an example, consider a transmitter with a three-part signal element: one period of loop OPEN, one period of loop GROUND, and one period where both contacts are returned to the NORMAL condition. At some point after the GROUND period is started, the loop OPEN period is ended. The time during which these two signals overlap is the TRANSITION interval, built in to avoid multiple ground signals. Each signal element contains three bits of information; namely, OPEN, GROUND, and NORMAL.

The contact sequence may also be reversed to the GROUND, OPEN, and NORMAL, order.

Referring to Figure 6, a timing sequence for the transmitter described above is defined on the basis of its three period (or bit) signal element. During the transition from the loop OPEN to the loop GROUND state the signals overlap for a period, T2, as shown. This overlap, which prevents a short period of loop NORMAL from appearing between the OPEN and GROUND states should be no greater than 10 percent of the average of the OPEN and GROUND bit periods.

The maximum bit rate is determined by the minimum of the bit periods T1, T3, and T4. The signal element rate is determined by the sum of T1, T2, T3, and T4 and is maximized by making all bit periods equal and minimum and minimizing the transition interval. Rates in excess of 15 bits per second may be garbled by the transmission system, however, and a rate less than 2 bits per second may be detected as a trouble fault condition by the encoding data set. Slower signaling speeds should be discussed with the telephone company representative.

2.3 Receiver Interface

2.3.1. Electrical Characteristics

The customer's receiver is connected to the CS trunk of the circuit. At the serving central office, the CS trunk is terminated in a decoding data set, represented in Figure 7, which reconstitutes the interoffice signals back to loop and ground contact closures.

The normally closed loop contact, N', is connected between the feed or tip side of the line and the return or ring side. The normally open ground contact, G', is connected between the return side of the line and central office ground.

With the loop closed and ungrounded, the decoding data set has a 2-volt diode drop in series with a 300-ohm resistor. In addition, optional current limiting resistances of up to 4000 ohms are available. The telephone loop between the CS and the serving central office will add between 0 and 1300 ohms of series resistance. The decoder supplies no electrical power to the CS trunk.

2.3.2 Received Signal Characteristics

The decoding data set presents two data signals to the CS trunk; the G' signal and the N' signal, as shown in Figure 8. The G' signal, a logical OR combination of the open and ground signals, lasts for two bit periods. The N' signal is the logical AND combination of the open and NOT ground signals and lasts for one bit period. The N' signal should not be confused with the NORMAL state, in which the loop is closed and ungrounded. The N' signal may occur during the first or second bit interval of the G' signal, depending upon the signaling sequence of the customer transmitter. Depending upon the location of the transmitter and the existence and location(s) of fault(s), the signals may be distorted from their normal position and length. In addition, jitter from the interoffice transmission system may cause random displacement of any or all of the signal transistions by as much as 20 milliseconds. For the maximum bit rate, the bit period may be shortened to a minimum of 25 milliseconds in the encoding data set, and then quantized to the nearest 20 millisecond step by the transmission system. In no case will the pulse be reduced to less than 20 milliseconds.

2.3.3 Interconnection and Options

The power required to detect signals from the decoder must be supplied by the CS receiver. The decoding data set will operate with currents between 5 and 15 milliamperes. Current supplied from the CS must fall in this range.

The normal connection of the decoder requires negative feed battery in the CS receiver. A wiring option permits operation of the decoder with positive feed battery. However, this option must be specified by the customer at the time of installation. If no polarity is specified, the negative feed battery option will be supplied. The decoder will not operate properly with the wrong polarity option.

The decoding data set has a provision for adding 2000 or 4000 ohms of resistance to the CS trunk (half of this resistance will be inserted in each side of the CS trunk). This customer specified option will allow overcurrent detectors in CS equipment to operate properly, should an attempt be made to compromise system security by shorting the trunk to the CS. The option is specified by the customer at the time of installation as Low, Medium, or High resistance corresponding to 0, 2000, and 4000 ohms of additional series resistance. If no option is specified, the Low resistance feature will be installed.

3. INTEROFFICE TRANSMISSION

3.1 Transmission Characteristics

The interoffice transmission facility will be designed according to local telephone company practices with the restraint that the two signal channels of a given circuit must be carried over different voiceband paths. Both time division multiplexing and frequency division multiplexing onto a voiceband channel may be used and a given path may encounter both types of multiplexers. When time division multiplexing is employed, up to 20 milliseconds of jitter may be observed on the received signal.

The interoffice transmission is operated in a failsafe mode. When one of the interoffice carrier signals is lost, the interoffice receiver treats this loss as a trouble fault condition. The decoding data set in turn provides this fault information to the CS through the operation of the N′ or G′ contact as appropriate. More detailed information on operation during faults is provided in Section 4.

3.2 Network Planning

3.2.1 Distribution Responsibility

The distribution plan for any given customer circuit is to be specified by the customer, subject to the system constraints of no more than 25 signaling legs and the central station trunk on one circuit and no more than three wire centers on one circuit, including the wire center serving the central station. Telephone company engineering personnel may offer alternatives to a given plan, but the customer has the ultimate responsibility for territorial coverage. The telephone company does not control the class and type of service, nor the number of connections to a given customer circuit, and is not responsible for lost alarms or signal clashes which arise when two or more signals arrive at a decoding data set at the same time.

3.2.2 Addition of Loops

There are several points in the system where signaling loops may be added to the circuit. The output of the encoder is the first point encountered for circuit expansion. As many encoders as needed may be interconnected to add loops to the existing circuit.

The second point for system expansion is the input of the decoding data set. The outputs of interoffice facilities from several remote central offices may feed a single data set decoder. These features are shown in Figure 1.

A third possible means of expansion exists at a tandem tie point. Additional loops may be added via an encoding data set; the signals are then multiplexed onto another interoffice facility.

4. SYSTEM OPERATION UNDER FAULT CONDITIONS

The ability of the low speed signaling system to transmit data in the presence of faults will be defined in relation to the typical CS configuration shown in Figure 9. Under normal conditions, one side of the return relay is grounded. When a fault occurs, this ground is removed and feed battery applied.

A change in system signaling takes place at the encoding data set under some fault conditions. In the event of a fault on the signaling loop, the two signals from the encoding data set revert to the simple forms "open" and "ground."

Table 1 lists all possible single and double fault conditions and the signals which can be received during those conditions at the CS. The column "CS switch position" refers to the switch position on a typical McCulloh receiver. The signal received is the contact configuration presented by the decoding data set on the central station trunk. The signal is detected at the CS on the feed or return side as appropriate for the particular fault. The central office visual indicators are those signals available to telephone company personnel at the encoding and decoding data sets as indicated. They are used as an aid in fault isolation.

As the table indicates, the system will continue to operate under all single fault conditions and some multiple fault conditions. A summary of fault conditions and resultant usable signals is given below.

4.1 Single Fault Conditions

A. Ground fault on any signaling leg or a failure in the interoffice G′ signal transmission path closes the G contact in the decoding data set for the duration of the fault. The central station feed relay detects open signals through the operation of the N contact in the decoding data set.

B. Open fault on any signaling leg or a failure in the interoffice N′ signal transmission path opens the N′ contact in the decoding data set for the duration of the fault. The central station can still detect ground signals through the operation of the G′ contact.

C. Open fault on the return side of the central station trunk disables the return circuit. The central station feed relay can still detect ground signals through the G contact.

D. Open fault on the feed side of the central station trunk disables the feed circuit. The central station return relay can still detect ground signals through the G contact.

E. Ground fault on the return side of the central station trunk shorts out the return circuit and the central station feed relay detects open signals through the N contact.

F. Ground fault on the feed side of the central station trunk shorts out the feed circuit. The decoding data set detects this condition and disables the G contact. The central station return relay can detect open signals through the N contact.

4.2 Multiple Fault Conditions

A. Multiple open faults or multiple ground faults on a signaling loop with several transmitters on it prevent only those transmitters between faults on that loop from signaling through the system.

B. Faults of a single type (O or G) occuring one to a loop on signaling loops which are combined at the outputs of the encoding data sets (Ref. Figure 1) permit reception at the central station of the nonfaulted signal from all transmitters on those loops.

C. For both cases above, the central station can determine that the circuit is either open faulted or ground faulted, but cannot determine the number of faults that exist.

D. When a multiple fault of a single type involves both the feed and return side of the central station trunk, the circuit is disabled and no signals can be received.

E. A double fault occurs when both an open and a ground fault occur on the same circuit. In general a double fault disables the circuit. For certain cases where a fault on the central station trunk is part of the double fault, some signals may be received.

5. MAINTENANCE

For most security systems such as those used for alarm signals, agreements with the telephone company call for maintenance actions by telephone company personnel only in response to alarm company requests. Such procedures can be applied to those parts of the Low Speed Signaling System peculiar to the alarm application. The system does permit, for example, rapid isolation of individual signaling legs experiencing trouble. Precedents established on dc alarm circuits would permit isolation and restoral of such a leg only after agreement between the telephone company and the alarm company. Those transmission links in common with the voice telephone plant will be serviced in keeping with standard practices.

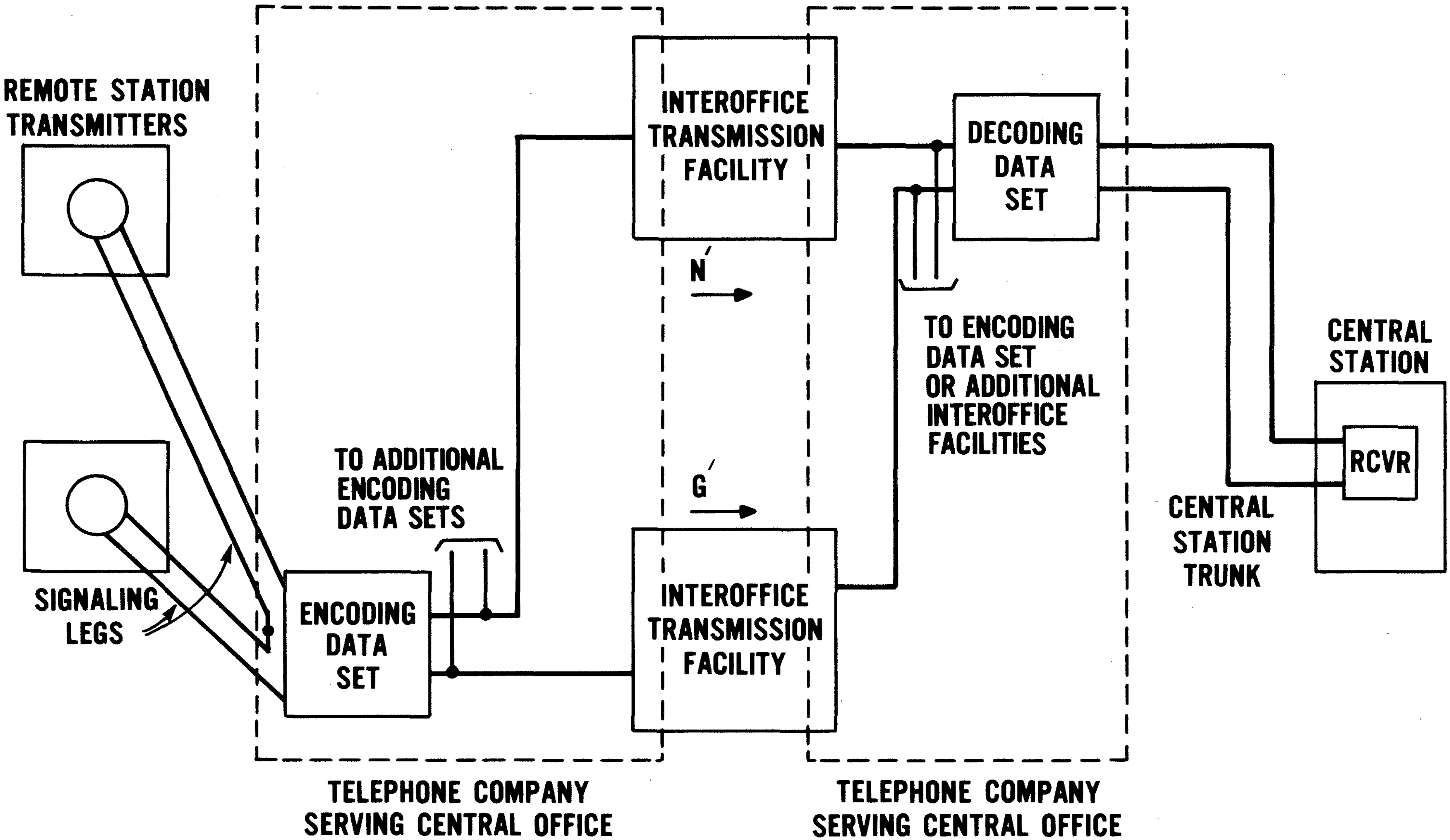
REFERENCES

1. "The Alarm Industry — Their Services and Channels," AT&T publication 1974.

TABLE 1
FAULT INDICATION TABLE

CS Switch Pos.	Signal Rec'd.	Fault Condition: Encoder Loop	Fault Condition: CS Trunk Feed	Fault Condition: CS Trunk Ret.	C.O. Visual* Indicators: Encoder	C.O. Visual* Indicators: Decoder	Note
Norm	O + G	——	——	——	——	——	No Faults
Open	G	O	——	——	O	O	Open on Signaling Loop
Open	O	——	——	O	——	——	Open Return
Open	G	——	O	——	——	——	Open Feed
Open	X	O	——	O	O	O	Double Open
Open	X	——	O	O	——	——	Double Open
Open	G	O	O	——	O	O	Multiple Single Open
Grd	O	G	——	——	G	G	Grd on Signaling Loop
Grd	O	——	——	G	——	——	Grd on Return
Grd	G	——	G	——	——	F	Grd on Feed
Grd	X	——	G	G	——	——	Double Ground
Grd	X	G	G	——	G	G	Double Ground
Grd	G	G	G	——	G	G+F	Feed Ground First
Grd	O	G	——	G	G	G	Multiple Single Ground
O/G	X	O+G	——	——	O+G	O+G	Double Fault
O/G	X	O	——	G	O	O	Double Fault
O/G	X	G	O	——	G	G	Double Fault
O/G	X	——	O	G	——	——	Double Fault
O/G	O	——	——	O+G	——	——	Ground to CS
O/G	G	——	O+G	——	——	F	Ground to Loop
G/O	X	——	G	O	——	——	Double Fault
G/O	O	G	——	O	G	G	Open Return
G/O	O	——	——	O+G	——	——	Ground to Loop
G/O	G	O	G	——	O	O	Ground on Feed

* O = Red Open Indicator; G = Green Ground Indicator;
F = Red Feed Fault Indicator.
—— means Normal Idle Condition
X = No Signal



LOW SPEED SIGNALING SYSTEM

FIGURE 1

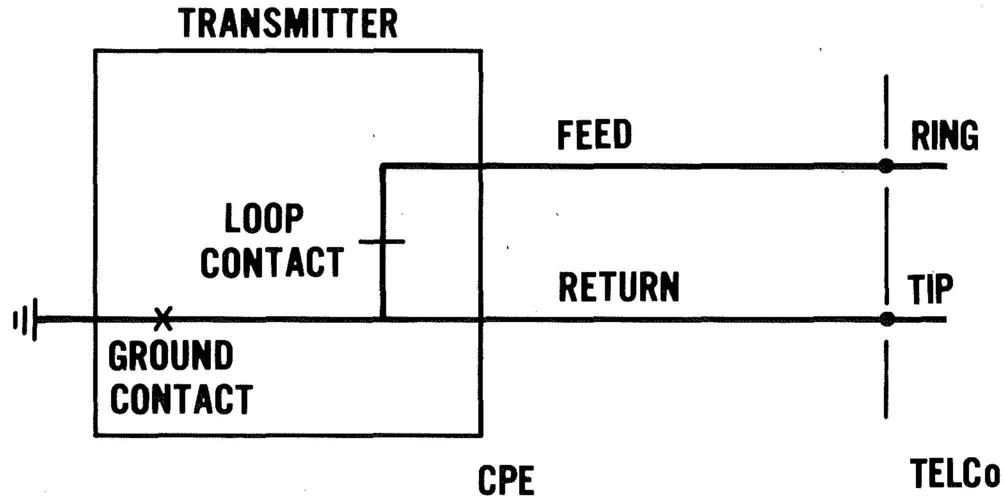


FIGURE 2

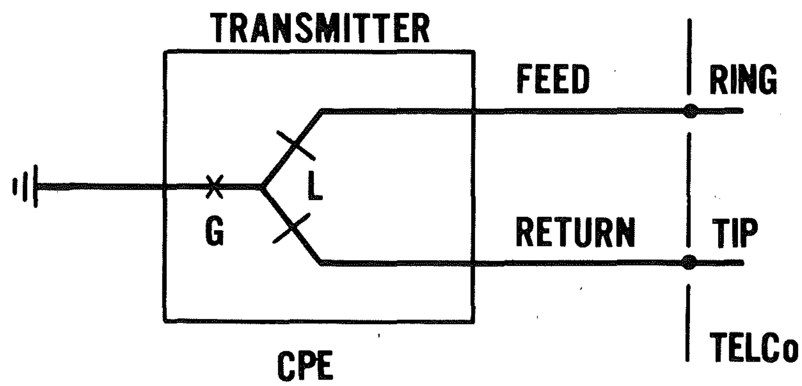


FIGURE 3

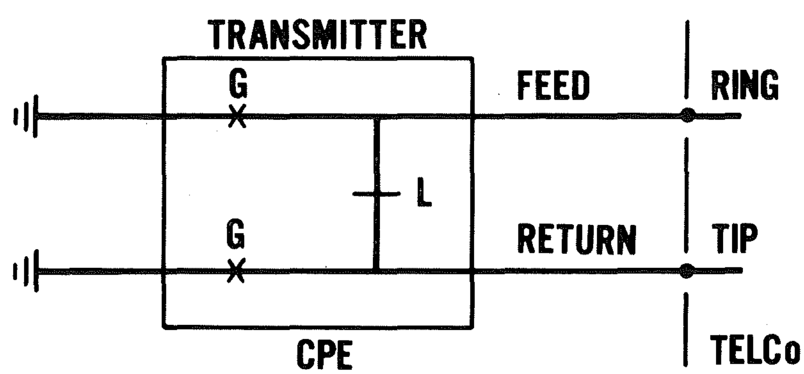
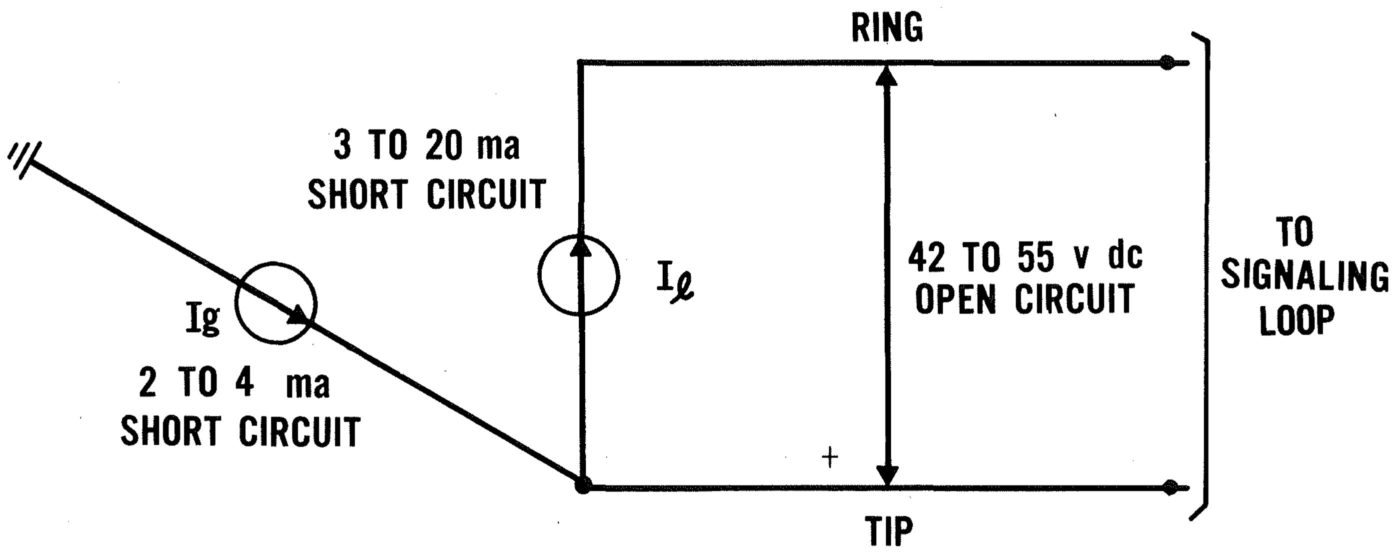


FIGURE 4

TYPICAL TRANSMITTER CONFIGURATIONS

GROUND CONTACTS NORMALLY OPEN; LOOP CONTACTS NORMALLY CLOSED



ENCODER INTERFACE

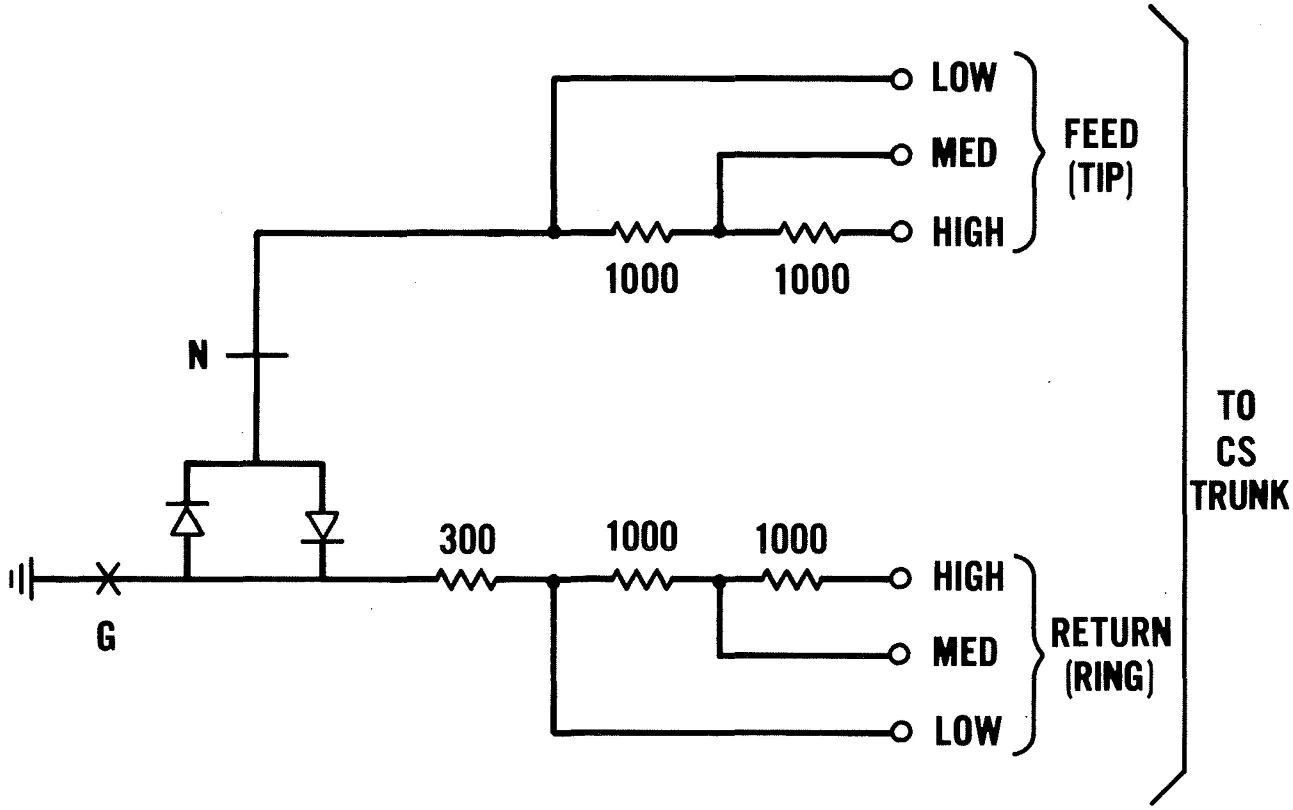
FIGURE 5

	NORMAL	OPEN	TRANSITION	GROUND	NORMAL
		← T_1 →	← T_2 →	← T_3 →	← T_4 →
CONTACT L	CLOSED	OPEN	OPEN	CLOSED	CLOSED
CONTACT G	OPEN	OPEN	CLOSED	CLOSED	OPEN

$$67 \text{ msec} < T_1 < 500 \text{ msec}$$
$$0 < T_2 < .05\,(T_1 + T_3)$$
$$67 \text{ msec} < T_3 < 500 \text{ msec}$$
$$67 \text{ msec} < T_4$$

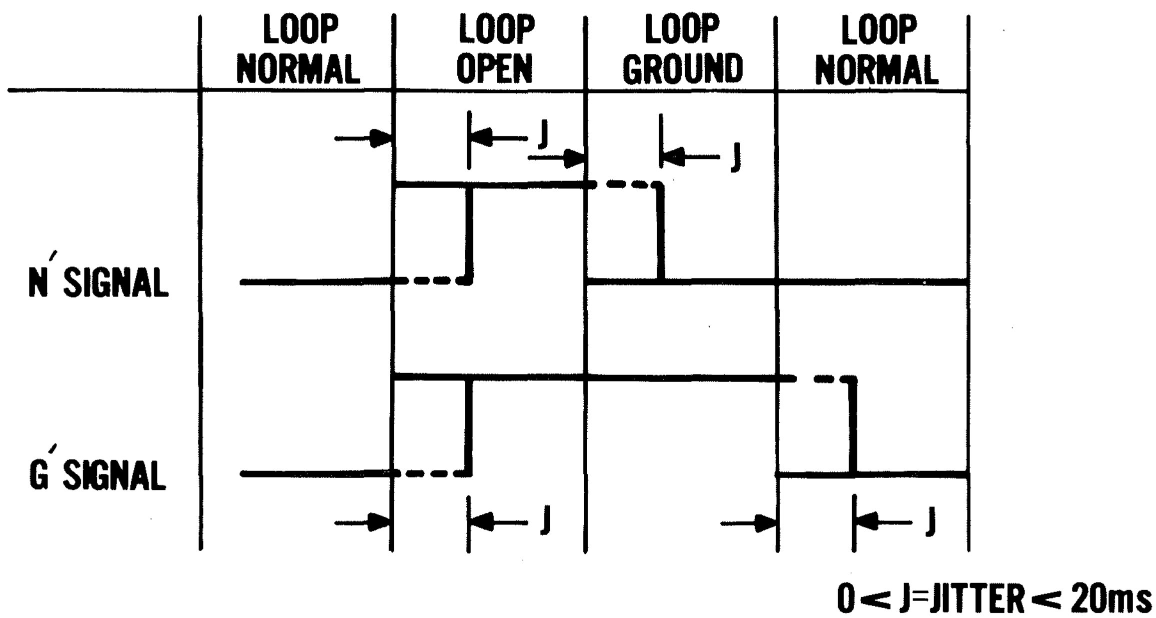
TRANSMITTER SIGNAL SEQUENCE

FIGURE 6



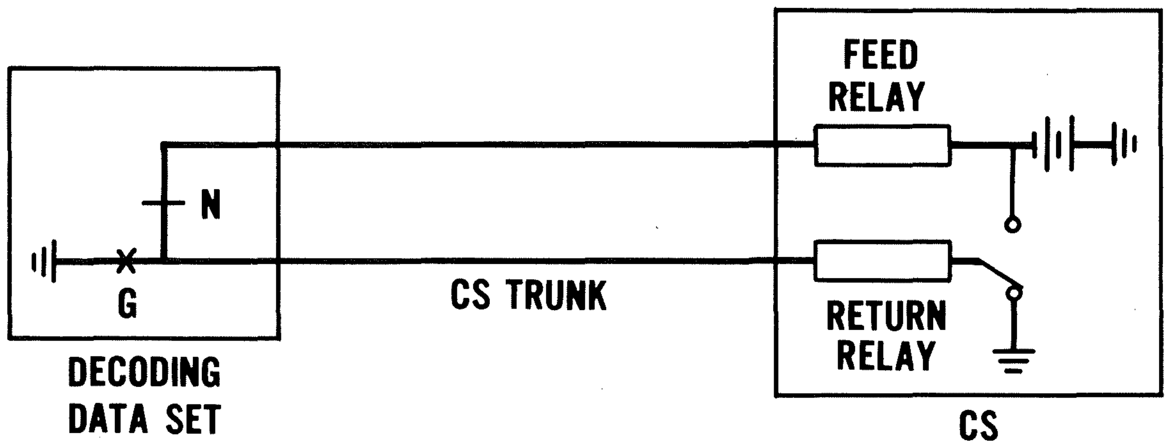
DECODING DATA SET INTERFACE

FIGURE 7



JITTER IN RECEIVED SIGNAL

FIGURE 8



CENTRAL STATION
TYPICAL CONFIGURATION

FIGURE 9