TRANSACTION NETWORK
TRANSMISSION REQUIREMENTS

1. GENERAL

1.01 This section contains the transmission requirements for the Transaction Network (TN). The TN is a short-message inquiry/response system for applications such as credit authorization or check verification. An overall description of the system is given in Section 230-100-001.

1.02 Whenever this section is reissued, the reason for reissue will be listed in this paragraph.

1.03 Figure 1 is an overall block diagram of the TN. The message switch controls the flow of data within the TN. The three individual networks of a TN are:

- The synchronous network between the customer service center and the message switch. Interface between the synchronous network and the message switch is through the synchronous line adapter (SLA).
- The dial-in network between stations on the switched telecommunications network (STN), ie, POTS network, and the message switch. Interface between the STN and the message switch is through the dial line adapters (DLAs) and data sets 407-type.
- The polled network between polled stations and the message switch. Interface between the polled network and the message switch is through the asynchronous line adapters (ALAs). The 1A-type data station selectors (DSSs) and data station controllers (DSCs) are considered part of the polled network.

1.04 Inquiry messages may originate from the polled or dial-in stations and are transferred by the message switch to a customer service center. Response messages are routed back to the inquiring station through the message switch. Dial-in inquiry messages are transmitted to the message switch as Touch-Tone* characters which are digitally encoded within the message switch for transmission to a customer service center.

1.05 Reply messages to a dial-in station are transmitted digitally from the customer service center. These are converted to machine-generated voice replies, keyed answer tones (KAT) or frequency-shift key (FSK) modulated serial digital messages within the message switch dependent upon the class of service for the inquiring station.

1.06 The polled stations are sequentially interrogated (polled) under control of the message switch until a station with an inquiry message to be transmitted responds. Poll addresses for a DSS are stored in the ALA and for the DSC in the DSC itself. The DSS or DSC does the actual switching, permitting data transfer between the station and ALA. Inquiry messages are in the form of FSK modulated ASCII characters. These inquiry messages are transmitted via the message switch to a customer service center.

1.07 Reply messages from a customer service center are routed within the message switch to the ALA where the digital words are FSK modulated. The FSK signal is routed through the DSS or DSC to the station.

1.08 The DSS and DSC are dualized devices; each of the two sections of these devices are interfaced with an ALA channel from different ALA units to provide maximum reliability. Each DSS may control up to 61 polled stations. DSSs may be used in tandem with the maximum number of stations served dependent upon traffic considerations. Tandem operation utilizes redundant channels from the primary DSS to the secondary DSS. The DSS may be installed in a telephone company (Telco) central office or on customer premises. Each DSC may control up to 192 stations, such as the Transaction III terminal set, requiring 2-wire loops;

**Reprinted to comply with modified final judgment.

Printed in U.S.A.

or 96 stations requiring 4-wire loops, such as the NCR 279 terminals. Both 2- and 4-wire stations may be served from a DSC. The actual number of stations served is a function of the network configurations and traffic considerations. DSCs are not installed on customer premises.

2. TRANSMISSION REQUIREMENTS

A. Synchronous Network

2.01 For analog transmission the synchronous network consists of 4-wire private lines (3002-type) from the message switch to the customer service centers using data sets 201C (2.4 kb/s), 208A (4.8 kb/s) or 209A (9.6 kb/s). Data sets at the service center may be customer-provided equipment. Each line will make one or more private line STC appearances. The 3002 channel is described in Section 314-410-100. No line conditioning is required for 2.4- or 4.8-kb/s service; however, D1 conditioning is required for 9.6 kb/s service. D1 conditioning is described in 314-410-105.

2.02 The following is a summary of the levels in the synchronous network.

- The MOD IN jack of a broadband carrier is always at -29 dBm data power and the DEMOD OUT is always at -6 dBm data power.
- The standard data set 3-second average rms transmit power is 0 dBm at the interface between the data set and the channel. Any pads, amplifiers, equalizers, etc, which are required are considered part of the channel.
- The standard net loss at 1004 Hz between data sets is 16 dB.
- The 3-second average rms data power on the channel should not exceed -13 dBm0.

2.03 For digital transmission interface between the digital data system (DDS) and a TN is accomplished by direct connection of an SLA channel to a 500A-type data service unit (DSU). This connection is through a standard EIA interface; the SLA supplies the same inputs to the DSU as would a customer business machine. The DSU is described in Section 595-200-100.

B. Dial-in Network

2.04 The dial-in network for TN uses the POTS network and no additional requirements above those for POTS are specified. However, the data set 407 answer-back (transmit) level must be set to compensate for the loop loss between the data set and the associated line-hunting group. Data set attenuator options for various 1004-Hz loop losses are given below:

1004-HZ LOOP LOSS	DATA SET 407 OPTION
<5 dB	G (factory installed)
5-9 dB	F
>9 dB	E

The loop loss may be measured using the central office milliwatt source.

C. Polled Network

Introduction

2.06 All transmissions on the polled network are FSK modulated serial digital signals. Data is transmitted at 1200 bits-per-second (bps) with a mark frequency (logic 1) of 1200 Hz and a space frequency (logic 0) of 2200 Hz. The polled network may consist of both 2- and 3-link circuits. These links are defined as follows:

- ***Primary Link***—The 4-wire facility between an ALA in the message switch and the DSC, or DSS. The DSS may be collocated with the message switch or remotely located in a Telco local central office or on the station customer premises. DSCs are located only in Telco central offices. Primary links are always in redundant pairs.
- ***Secondary Link***—The 2- or 4-wire facility between a primary and secondary DSS. Where a 2-wire facility is used, a RG2 2-wire interface circuit pack is installed in the secondary DSS. When a 4-wire facility is used, a terminal set (hybrid) is used to interface the primary DSS to the 4-wire facility and a 829 L1A-type DAS is used in the secondary DSS. Secondary links are always in redundant pairs. DSCs are not

used in tandem and, therefore, secondary links do not apply to DSC service.

- ***Polled Link***—The 2-wire facility between a primary or secondary DSS, or a DSC and the 150A channel service unit (CSU) at the station. A 2-wire polled link may incorporate 4-wire facilities by use of 24V4 or 24-type MFTs. A 4-wire polled link consists of two 2-wire loops, each terminated at the station by a 150A CSU.

2.07 All test data should be recorded on a data transmission history card such as form E-5596 described in Section 314-410-300. These test results will serve as bench marks to be used during maintenance and trouble isolation testing.

Transmission Levels

2.08 Data transmission levels (absolute power levels in dBm) for each direction of transmission in the polled network are given in Figures 2 and 3. All levels on 4-wire facilities are specified with 600-Ω termination and on 2-wire facilities with 900-Ω termination except at the station which is terminated with 600 Ω via a 150A CSU.

2.09 In the primary link, the transmit level from the ALA in the message switch is at 0 dBm. This is seen at the TRANS TST jack of the associated DAS 829 as 0 dBm less the loop loss between the ALA and the DAS 829. The transmit attenuator of this DAS 829 is set to give -8 dBm into the cable facility (trunk to the primary DSS). The maximum allowable power into the cable facility under any circumstance is -6 dBm. The receive level at the REC TST jack of the DAS 829 is adjusted by the receive attenuator to -16 dBm. The same levels are set at the DAS 829 associated with the DSS or DSC. Note that jack access to the cable facility at the DSS or DSC is provided by the REC and TRANS jacks on the data mounting which houses the equipment.

2.10 DAS 829A-, B-, or C-L1A types are used depending upon the facility characteristics (see Section 598-082-100). The DAS must be optioned for 600-Ω line impedance. The -48V power supply and 8-dB loopback gain options must be used at the DSS while the 24V ac power supply and 16-dB loopback options must be used at the ALA. DAS 829 L1-types may also be used at the ALA.

2.11 Regardless of the network configuration, the line side (toward the station) of the DSS or DSC transmits at -8 dBm and receives at -12 dBm. No attenuation adjustments are provided at the line side of the DSS or DSC; level adjustments are made at the station (150A CSU) or at the secondary DSS (RG2 circuit pack or DAS 829). The dc resistance of the 2-wire loop from a DSS terminated by the 150A CSU must be less than 2.3 kΩ. Resistances greater than 2.3 kΩ may cause erratic operation of the 1000-Hz lineup tone circuit at the lower limit of the -48V supply. To operate at the lower limit of the central office emergency -48V supply, loop resistance must be less than 1.6 kΩ. In addition, resistance from tip to ring and from tip or ring to ground must be greater than 61 KΩ with no termination on the loop.

2.12 The 1000-Hz lineup tone from the DSS or DSC may be activated from the 150A CSU at the station, provided that the polled link consists of a metallic pair. It is important to note that this tone is transmitted from the DSS or DSC at a fixed level of -18 dBm.

2.13 Figures 4 and 5 give the transmission levels for a 4-wire polled link with carrier. Adjustment of the receive level to -10 dBm at the terminal set (hybrid) in the local central office is made at the 150A CSU.

Transmission Parameter Limits

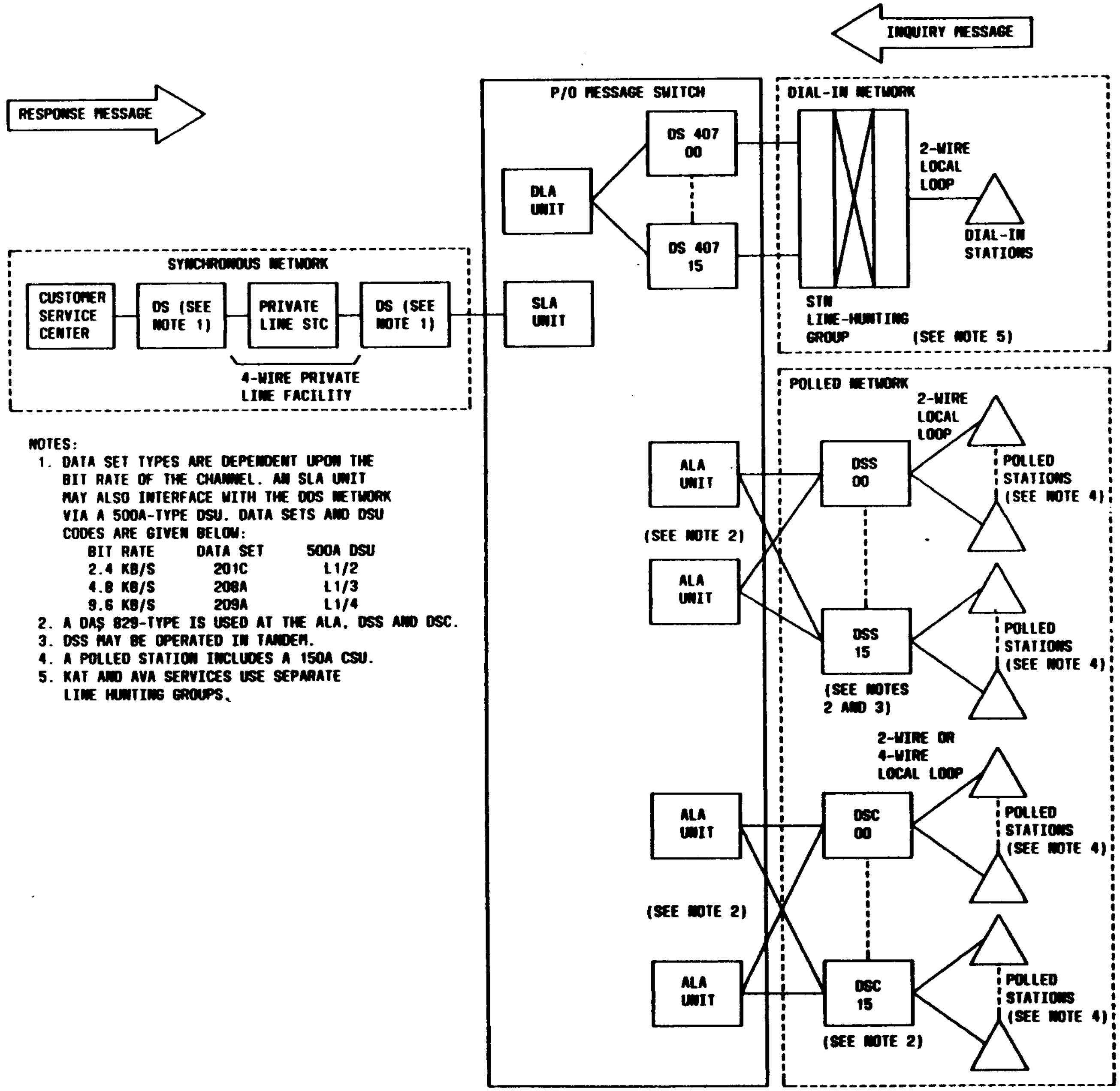
2.14 Transmission parameter limits are specified in Table A. A description of these parameters is contained in Part 3 of this section; testing procedures are only in Section 314-410-500. Suggested test apparatus is given in Table B.

2.15 Since end-to-end tests of the TN polled network are not normally made, transmission parameters given in Table A are specified for each link of the network separately. Tests are performed at installation or for trouble isolation as given in Table C.

3. CATEGORIES OF POLLED NETWORK TRANSMISSION PARAMETERS

3.01 The circuit transmission parameters are divided into the following categories:

- Interface Parameters



NOTES:

1. DATA SET TYPES ARE DEPENDENT UPON THE BIT RATE OF THE CHANNEL. AN SLA UNIT MAY ALSO INTERFACE WITH THE DDS NETWORK VIA A 500A-TYPE DSU. DATA SETS AND DSU CODES ARE GIVEN BELOW:

BIT RATE	DATA SET	500A DSU
2.4 KB/S	201C	L1/2
4.8 KB/S	208A	L1/3
9.6 KB/S	209A	L1/4

2. A DAS 829-TYPE IS USED AT THE ALA, DSS AND DSC.
3. DSS MAY BE OPERATED IN TANDEM.
4. A POLLED STATION INCLUDES A 150A CSU.
5. KAT AND AVA SERVICES USE SEPARATE LINE HUNTING GROUPS.

Fig. 1—TN Block Diagram

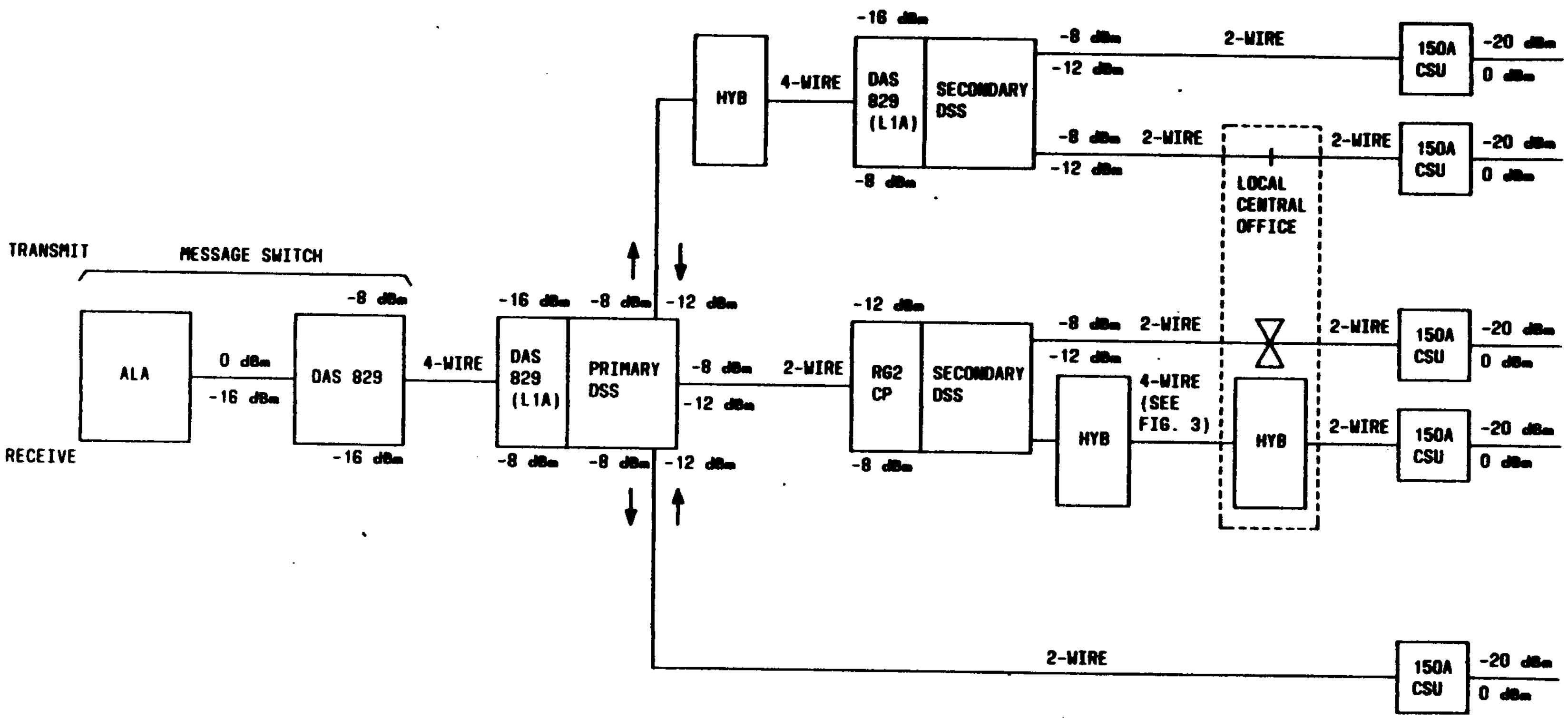
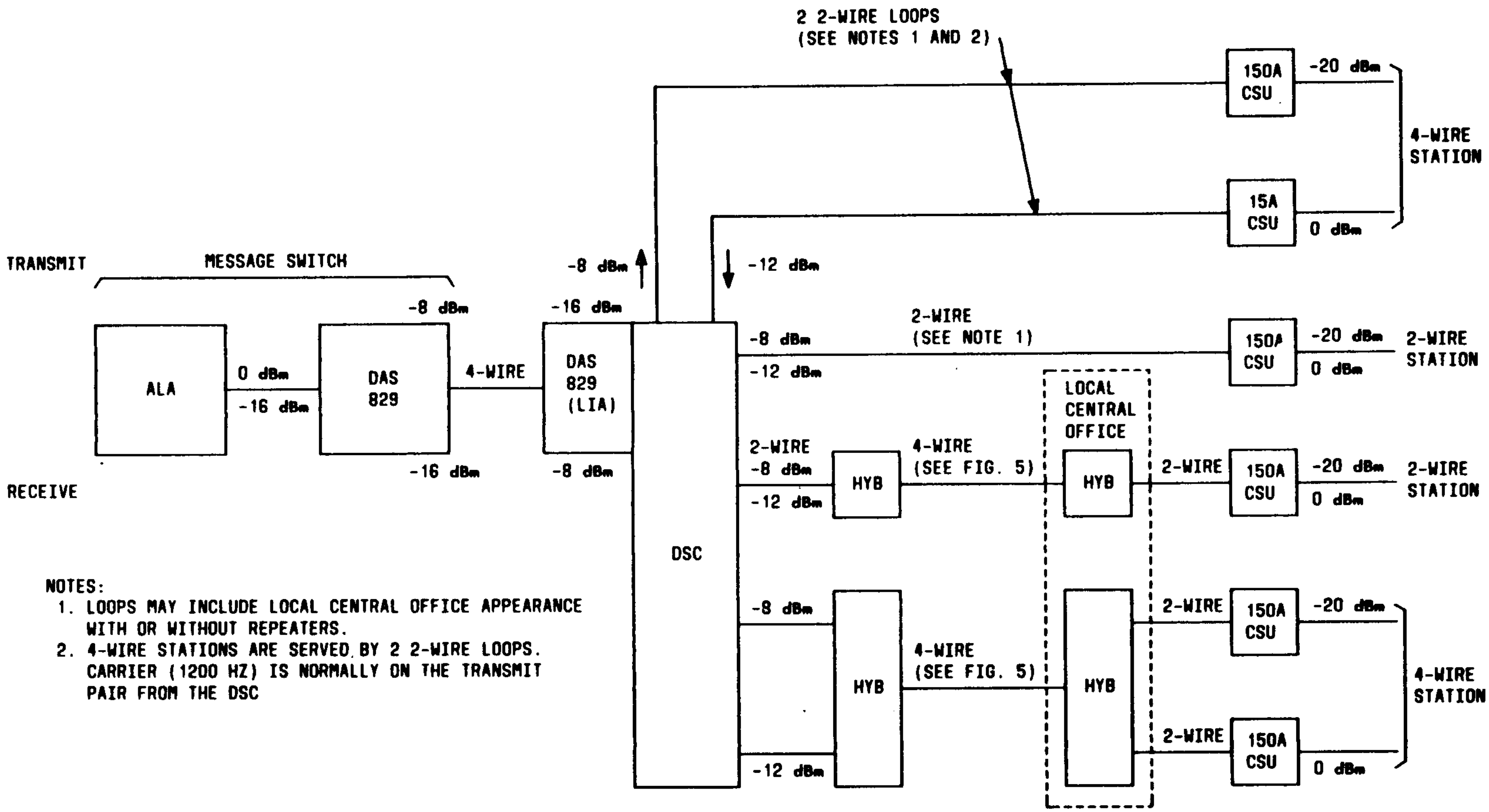


Fig. 2—Polled Network With DSS—Transmission Levels



NOTES:
1. LOOPS MAY INCLUDE LOCAL CENTRAL OFFICE APPEARANCE WITH OR WITHOUT REPEATERS.
2. 4-WIRE STATIONS ARE SERVED BY 2 2-WIRE LOOPS. CARRIER (1200 HZ) IS NORMALLY ON THE TRANSMIT PAIR FROM THE DSC

Fig. 3—Polled Network With DSC—Transmission Levels

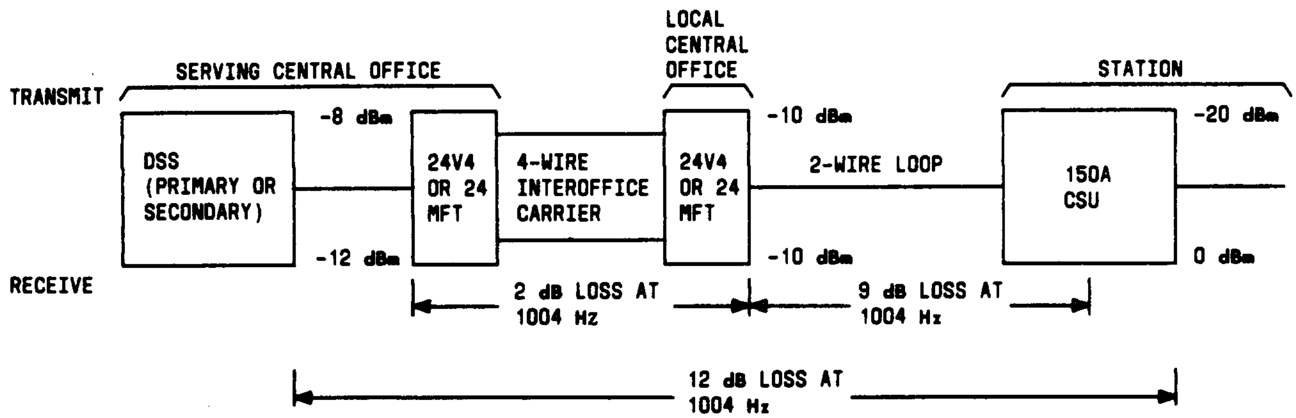


Fig. 4—Polled Link With DSS Using Carrier to Local Central Office

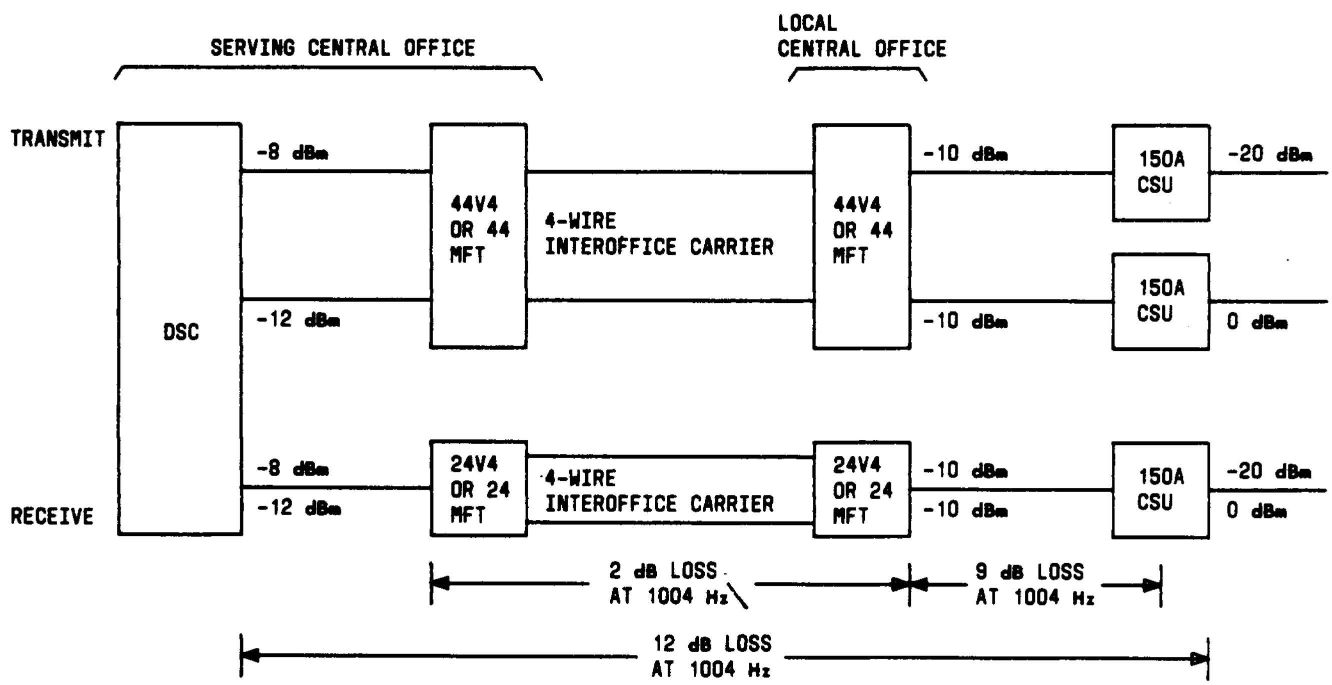


Fig. 5—Polled Link With DSC Using Carrier to Local Central Office

- Facility Parameters.

The facility transmission parameters that must be tested to ensure that limits are met were given in Part 2. Additional transmission parameters along with a brief description of those parameters and their characteristics are given in the following paragraphs.

A. Interface Parameters

3.02 The voiceband interface parameter specifications are influenced by two considerations: electrical protection of the telephone network and its operating personnel, and standardization of private line design arrangements. The voiceband interface for the TN polled network is compatible with the EIA standard RS-232-C. The various parameters of this category are as follows:

- Terminal Impedance and Balance
- In-Band Data Signal Power
- Transmitted Test Signal Power
- Out-of-Band Transmitted Signal Power.

A brief description of each of these parameters is given in 3.03 through 3.08.

Terminal Impedance and Balance

3.03 The recommended impedance of data terminal equipment is 600 Ω ±10 percent resistive over the voiceband. The impedance of test equipment used for installation tests and trouble tests is 600-Ω resistive. Channels lined up using 600-Ω terminations should be used with 600-Ω terminations to assure transmitted and received signal power meets required limits.

3.04 If the impedance of the customer terminal equipment is substantially different from 600 Ω, echoes interfering with the data signal may result. The CSU at the station provides a balanced termination to the facilities. The customer equipment may be balanced or unbalanced; however, balanced is usually preferred due to local (on premises) noise considerations.

In-Band Data Signal Power

3.05 The maximum allowable transmitted signal power for an end-to-end data signal, averaged over any 3-second interval, is 0 dBm (as measured across a 600-Ω resistor). In meeting the 3-second average power, it is permissible for the instantaneous signal power to exceed the average power by as much as 13 dB. Therefore, at the 0-dBm transmit point, the instantaneous signal power must not exceed +13 dBm (3.46 volts rms across 600-Ω resistive). The total power requirement applies in the frequency band below 3995 Hz (other than dc). All signal energy, spurious or otherwise, must be included when determining whether the transmitted power specification is met. The dc requirement is that the user terminal should cause no more than one milliampere dc to flow through the voiceband channel termination.

Transmitted Test Signal Power

3.06 Test signals applied to the circuit must not exceed 0 dBm. A test signal greater than 0 dBm may give erroneous results because of nonlinear channel response with changes in signal power.

Out-of-Band Transmitted Signal Power

3.07 Out-of-band signals are defined to be in the frequency band of 3995 Hz and above. The limits on out-of-band signal power apply to the transmitted signal power at the interface with the end-to-end channel. The out-of-band signal power limits are required to prevent interference with other services carried on telephone company facilities.

The objectives for short duration (a few seconds or less) rms powers are:

- The power in the band from 3995 to 4005 Hz should not exceed -18 dBm.
- The power in the band from 4 to 10 kHz should not exceed -16 dBm.
- The power in the band from 10 to 25 kHz should not exceed -24 dBm.
- The power in the band from 25 to 40 kHz should not exceed -36 dBm.
- The power in the band above 40 kHz should not exceed -50 dBm.

B. Facility Parameters

3.08 The facility parameters covered in this part represent potential impairments to a data signal. These parameters are objectives only and are not to be measured in normal preservice and maintenance testing. In all cases, the facility parameters exhibit some variation over a period of time. The parameter objectives, unless otherwise stated, apply to measurements of steady-state phenomena and the measurements generally last less than one minute. The various parameters of this category are as follows:

- Envelope Delay Distortion
- C-Message Noise
- C-Notched Noise
- Impulse Noise
- Single Frequency Interference
- Nonlinear Distortion
- Phase Jitter
- Frequency Shift
- Echo
- Singing Margin/Return Loss
- Gain Hits and Phase Hits
- Dropouts.

A brief description of each of these parameters is given in 3.10 through 3.22.

3.09 Transient phenomena (impulse noise, phase hits, gain hits and dropouts) are measured over long periods and events meeting certain criteria are counted. The results of either steady-state or transient measurements may vary by time of day, day of week, season of year, or according to some other time dependency.

Envelope Delay Distortion

3.10 A requirement for distortionless transmission is a linear phase versus frequency characteristic. The channel will, typically, only approximate such linearity over the voiceband. Measuring the phase versus frequency channel characteristic directly is difficult because of problems in establishing a phase reference. However, a usable approximation of phase with respect to frequency, called envelope delay, can be measured. The maximum variation in envelope delay over a band of frequencies is called envelope delay distortion. The quality of the channel with respect to its phase characteristic is controlled by limiting the amount of envelope delay distortion allowed. An 83-1/3 Hz modulating frequency is used for the measurement.

C-Message Noise

3.11 C-message noise is a weighted measurement of the background noise on a channel in the absence of a signal. It is measured with a noise measuring set such as the 3C-noise measuring set. The weighting used is provided by a C-message filter.

C-Notched Noise

3.12 The C-message noise, described above, is often not the principal noise experienced with a signal present. Quantizing noise in digital carrier systems and the effect of compandors in both digital and some analog carrier systems, result in a signal dependent upon noise. C-notched noise is a measure of the amount of noise on a channel with a signal present. The ratio of the received 1-kHz test tone power to C-notched noise power is indicative of the signal-to-noise ratio on the channel.

Impulse Noise

3.13 Impulse noise is characterized by large peaks or impulses in the total noise waveform. It is measured with a counter having a maximum counting rate of approximately seven counts per second. Measurements are made through a C-message filter. A -13 dBrnCO holding tone to activate any compandored facilities in the channel is transmitted and notched out of the receiver.

Single Frequency Interference

3.14 Spurious single frequency tones may interfere with narrowband data signals which are frequency-division multiplexed onto the channel. Message circuit noise will be distributed across the voiceband, so the noise power in each narrowband channel will be less than the total noise power, and the signal-to-noise ratio per channel may be quite adequate. If, however, a single-frequency tone of substantial power is present, it may interfere with one of the narrowband channels.

Nonlinear Distortion

3.15 Nonlinear distortion is that portion of the channel output which is a nonlinear function of the channel input. It is measured by transferring four equal level tones, consisting of two pairs of tones, with a composite signal power at nominal data signal level. Two of these tones are closely spaced around a center frequency "A" (860 Hz) and the other two tones are centered around a center frequency "B" (1380 Hz). The second order distortion is determined from the B-A and B+A products, while the third order distortion is determined from the 2B-A product.

Phase Jitter

3.16 Various sources cause the instantaneous phase, or zero crossings, of a signal to "jitter" at rates normally less than 300 Hz. This phase jitter is typically caused by ripple in the dc power supply appearing in the master oscillator of long-haul carriers and then passing through many stages of frequency multipliers. Some phase jitter occurs in short-haul systems from incomplete filtering of image sidebands. Digital carrier systems also will exhibit phase jitter at certain input frequencies. The most common jitter frequencies are 20 Hz (ringing current) and 60 Hz (commercial power) and the second through fifth harmonics of each of these.

3.17 Measurement of phase jitter is made with an instrument sensitive to frequencies within 300 Hz of a 1004-Hz carrier. Noise may strongly influence this measurement; therefore, phase jitter should be measured with a test tone at data level.

Frequency Shift

3.18 Long-haul carrier systems operate in a single sideband suppressed carrier mode. Since the carrier is not transmitted and must be reinserted, there may be a slight difference in frequency between the modulating and demodulating carriers. The resulting frequency shift contributes a constant change at all frequencies in the voiceband. Substantial frequency shift can degrade some data demodulation processes and can cause high distortion in narrowband frequency division multiplex systems.

Echo, Singing Margin/Return Loss

3.19 Impedance mismatches in a channel cause echoes to be returned to the transmitter (talker echo) or the receiver (listener echo). The impedance mismatches may occur at numerous locations in the channel, but the major contributions to echo problems occur at the interface between 2- and 4-wire circuits (hybrid), at the junction between different gauge cables and at station equipment. In the TN, echoes cannot be generated between the message switch and a DSC or a primary DSS since the transmission facility is 4-wire. In addition, the directional control circuit in the DSS blocks echoes that occur at the hybrid in the DSS. Since no direct analog connection exists through the DSC, echoes do not occur at the DSC. The DSS directional control circuit cannot prevent echoes occurring between a DSS and station or between a primary and secondary DSS from reaching both the station and message switch. If the 2-way transmission time between the DSS or DSC and the station and between the primary and secondary DSS is less than 14 msec in each case, echoes should not cause erroneous carrier detection at the message switch or station.

3.20 In addition to the above, it is important that the listener echo be down sufficiently so as not to affect data transmission. The listener echo is most likely to originate in the link between the DSC or DSS in a central office and a station when a 2-wire link contains a 4-wire section (Fig. 4 and 5). The listener echo requirement for this circuit is 20 dB. When this requirement is combined with the expected long-term 1004-Hz loss variation on carrier facilities, the required singing margin of the 4-wire section to meet the listener echo requirement is 28 dB. When the station is connected to the message switch, the singing margin is equal to 4 dB plus the sum of the return losses of the hybrids. To insure a singing margin of 28 dB, the requirement on the return losses at the hybrids at the DSS or DSC and the local central office are 14 dB and 10 dB, respectively.

Gain Hits and Phase Hits

3.21 Gain hits and phase hits are defined to be changes in the amplitude or phase of a signal lasting for at least 4 ms and returning to the original value within 220 ms. Changes in amplitude or phase which last for more than 220 ms are referred to as gain or phase changes. Changes that last for less than 4 ms are classified as impulse noise. Objectives for these parameters are:

Gain hits: no more than eight in 15 minutes $\geq$ 3 dB
Phase hits: no more than eight in 15 minutes $\geq$ 20 degrees.

Dropouts

3.22 A dropout is a decrease in level ≥ 12 dB which lasts for at least 10 ms. Deep fading of radio facilities and defective components can cause dropouts. Since dropouts tend to be long with more than 40 percent in excess of 200 ms, they frequently are responsible for serious performance degradations. The objective for this parameter is no more than two dropouts in 15 minutes.

4. REFERENCES

4.01 The following sections provide additional information on facilities and equipment associated with the TN service.

SECTION	TITLE
230-100-001	Transaction Network—System Description
230-100-455	Transaction Network—Dial Line Adapter Frame J70179E—Description and Theory
230-100-460	TransactionNetwork—Asynchronous Line Adapter J70179A—Description and Theory
314-410-100	Voice Bandwidth Private Line Data Circuits—Description
314-410-105	Voice Bandwidth Private Line Data Circuits—High Performance Data Conditioning (HPDC)—Description and Test Requirements
314-410-300	Voice Bandwidth Private Line Data Circuits—Maintenance
314-410-500	Voice Bandwidth Private Line Data Circuits—Tests and Requirements
590-101-000	150A Channel Service Unit—Description, Installation, Maintenance, and Test
590-102-112	Transaction Network—Data Station Controller (DSC)—Description, Operation, and Theory
590-105-110	Transaction Network—1A-Type Data Station Selector (DSS)—Description, Operation, and Theory
592-027-100	Data Set 208A Transmitter-Receiver—Description
592-029-100	Data Set 201C Transmitter and Receiver—Description
592-032-100	Data Set 209A-L1 Transmitter-Receiver—Description
594-800-100	407-Type Multiple Data Station—Description
595-200-100	Digital Data System 500A-Type Data Service Unit—Description and Operation
598-082-100	Data Auxiliary Set 829-Type—Channel Interface Units—Voiceband Private Line Channels—Description
880-480-000	Transaction Network Service—Engineering Considerations—Description

TABLE A

POLLED NETWORK LINK TRANSMISSION PARAMETER LIMITS

PARAMETER	THREE LINK CIRCUIT			TWO LINK CIRCUIT	
	PRIMARY LINK	SECONDARY LINK	POLLED LINK	PRIMARY LINK	POLLED LINK
1004-Hz Loss Variation					
Circuit Order	±0.5 dB	±0.5 dB	±1 dB	±0.5 dB	±1.0 dB
Long Term Variation	±2 dB	±1 dB	±2 dB	±2.7 dB	±2.7 dB
Attenuation Distortion 504-2804 Hz (ref 1004 kHz)	−1 to +3 dB	−1 to +3 dB[1] −2 to +9 dB[2]	−2 to +8 dB[1] −1 to +2 dB[2]	−2 to +6 dB[3] −3 to +11 dB[4]	−2 to +8 dB[3] −1 to +2 dB[2]
Envelope Delay Distortion 804-2604 Hz	550 μs	550 μs	650 μs	950 μs	800 μs
C-Message Noise					
0—50 Circuit miles	31 dBrnC0	31 dBrnC0	41 dBrnC0	31 dBrnC0	41 dBrnC0
51—100 Circuit miles	34 dBrnC0	34 dBrnC0	41 dBrnC0	34 dBrnC0	41 dBrnC0
101—400 Circuit miles	37 dBrnC0	37 dBrnC0		37 dBrnC0	
C-Notched Noise 1 kHz Signal to C-Notched Noise Ratio	26 dB	26 dB	26 dB	24 dB	24 dB
Impulse Noise Number of counts in 15 minutes at the following threshold levels					
71 dBrn C0	10	10	10	14	15
75 dBrn C0	6	6	6	9	9
79 dBrn C0	3	3	3	5	5
Single Frequency Interference	At least 3 dB below C-Message Noise Limits				
Nonlinear Distortion (Four-Tone Measurement Method)					
Signal to 2nd Order	30 dB	30 dB	30 dB	28 dB	28 dB
Signal to 3rd Order	38 dB	38 dB[2] 31 dB[3]	38 dB[1] 31 dB[2]	34 dB	34 dB
Phase Jitter (peak-to-peak)	8°	8°	4°	9°	9°
Frequency Shift	±2 Hz	±2 Hz	±1 Hz	±3 Hz	±2 Hz
Singing Margin/Return Loss (See Text)					

Notes:
1. Secondary DSS in Telco CO.
2. Secondary DSS on customer (station) premises.
3. Primary DSS in Telco CO.
4. Primary DSS on customer (station) premises.

TABLE B

TEST APPARATUS SUGGESTED FOR MEASUREMENT TESTS

FUNCTION	TEST SETS
1000 Hz Loss and Attenuation Distortion	Hewlett-Packard 4940A Transmission Impairment Measuring Set Hewlett-Packard 3551 Portable Test Set Halcyon 515A Data Line Test Set TTI 1110A Transmission/Noise Test Set
Envelope Delay	Hewlett-Packard 4940A Transmission Impairment Measuring Set Halcyon 515A Data Line Test Set WECo 25B Voiceband Gain and Delay Set
C-Message Noise**	Hewlett-Packard 4940A Transmission Impairment Measuring Set WECo 3C Noise Measuring & Noise Test Set Wilcom T194 Transmission & Noise Test Set
C-Notched Noise **	Hewlett-Packard 4940A Transmission Impairment Measuring Set Hekimian 65LN Level, Noise and Nonlinear Distortion Meter Wilcom T194 Transmission & Noise Test Set WECo 3C Noise Measuring Set [If a 1010 Hz notch filter available i.e., KS-21567L1 (Model 497H) "C" notch filter]
*Single Frequency Interference**	Wilcom T132B Spectrum Analyzer and Noise Measuring Set Wandel-Goltermann SPM-9 Voltage and level meter
Impulse Noise**	Hewlett-Packard 4940A Transmission Impairment Measuring Set Wilcom T194 Transmission & Noise Test Set WECo 6F Noise Measuring Set with a KS-21567L2 (Model 497J) "C" notch filter
Frequency Shift**	Hewlett-Packard 4940A Transmission Impairment Measuring Set Halcyon 515A or 520A Data Line Test Set
Phase Jitter, Phase Hits, and Gain Hits**	Hewlett-Packard 4940A Transmission Impairment Measuring Set Hekimian Laboratories Inc Model 48 Phase Jitter Set TTI Model 1202B Phase Jitter Test Set with a 1201A Hit Monitor

TABLE B (Cont)

TEST APPARATUS SUGGESTED FOR MEASUREMENT TESTS

FUNCTION	TEST SETS
Nonlinear Distortion**	Hewlett-Packard 4940A Transmission Impairment Measuring Set Hekimian Laboratories Inc Model 65 Type Nonlinear Distortion Meter
Singing Margin/Return Loss	KS-20501 Return Loss Measuring Set WECo 2D Singing Point Test Set Wiltron Model 9031 Return Loss Measuring Set Wiltron Model 9041 Transmission Level and Return Loss Measuring Set
Total Power Output	See C-Message Noise
DC Loop Resistance	KS-16979L1 Volt-Ohm-Milliammeter (Triplett Model 310D) KS-14510 Volt-Ohm-Milliammeter Hewlett-Packard 970A Digital Meter

* A listening test is normally sufficient for the detection of single tone interference. The test sets listed here may be used where specialized test equipment is required.

** These tests may also be measured by the Bradley PB1. This is the only measuring set that readily identifies whether a hit is impulse noise, a phase hit, or a gain hit.

TABLE C

REQUIRED TRANSMISSION TESTS

TRANSMISSION TEST	INSTALLATION			TROUBLE ISOLATION
	PRIMARY LINK	SECONDARY LINK	POLLED LINK	
Loss Variation	√	√	√	√
Attenuation Distortion	√	√		√
Envelope Delay Distortion				√
C-Message Noise	√	√		√
C-Notched Noise	√	√		√
Impulse Noise				√
Single Frequency Interference	√	√		√
Nonlinear Distortion*	√	√	√	√
Phase Jitter				√
Frequency Shift				√
Echo				√
Singing Margin/Return Loss**		√	√	√
Phase/Gain Hits				√
Dropouts				√

* Required only for links using T1/D1, N1 or ON2 Carrier Systems

** Required only for links using both 2- and 4-wire facilities.