STATION LOOPS, REMOTE EXCHANGE LINES, FOREIGN EXCHANGE LINES, AND WIDE AREA TELECOMMUNICATIONS LINES ENGINEERING DESIGN GUIDELINES

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1. GENERAL

1.01 This section provides the engineering design guidelines for station loops, remote exchange lines, foreign exchange lines, and wide area telecommunications lines. These facilities are used to provide data communications service for the switched network access.

1.02 This section is reissued for the following reasons.

(a) To change the title

(b) To eliminate the term DATAPHONE® throughout the section.

Revision arrows are used to emphasize the more significant changes.

1.03 The term data communications service is now used for data services in general. As used in this series of sections, the term implies the use of data sets as station equipment and the use of the switched network for data transmission services. It is occasionally necessary that data service loops, when designed, be carefully designed because of transmission variations which occur in the routing of calls. Transmission objectives are specified in Section 880-440-105. These objectives are expected to be met if the loop design guidelines given in Part 3 are observed. In some cases it will be necessary to apply special treatment to cable facilities in order to meet the given objectives.

1.04 There are various ways to provide switched data communications services. Access to the network can be gained by normal lines (loops), foreign exchange (FX) lines, wide area telecommunications service (WATS) and PBX/Centrex trunks. These access lines can be connected in a number of ways resulting in a myriad of combinations of arrangements. Since it is not possible to control the transmission in all arrangements, it is necessary to define supported versus unsupported services. Definitions of these terms are given below.

1.05 ***Supported*** switched data services are services for which at least 85 percent of the connections will provide acceptable data transmission service. In complaint cases, this level of performance is assured by treatment of the access line as required. The overall performance is described on the basis that at least 85 percent of the calls will meet or exceed the end-to-end transmission requirements called minimum acceptable performance (MAP) criteria. These requirements are specified in Section 314-205-503. The measurements are made as a last resort and require the guidance and assistance of network technical support (NTS) personnel.

1.06 ***Unsupported*** switched data services are those for which voice performance standards for each telephone company-provided element will be assured. It is possible that some customers may use these arrangements for data transmission and satisfactory service may result. Examples of unsupported switched data services are as follows:

(a) An FX line to a station located more than 200 airline miles from dial tone office

(b) Any station to any other station through customer-provided equipment (CPE) or facilities

(c) Data services terminating on a voice jack

(d) Switched data services to any countries other than the 50 states and Canada

(e) Data services from any common control switching arrangement (CCSA), or similar private switched network, using off-net access lines

(f) Switched data services provided by a central office (CO) or PBX with features, such as "call waiting," "executive override," or bridged stations without the "exclusion" feature

(g) Acoustically or inductively coupled stations.

2. REGISTRATION CONSIDERATIONS

2.01 Registration is the Federal Communications Commission (FCC) Program for terminal equipment establishing protection requirements to minimize potential harms to the network from terminal equipment directly accessing the message network. To qualify for registered status, terminal equipment must meet requirements which are concerned with:

(1) Longitudinal imbalance

(2) Hazardous voltage protection

(3) Signal power level

(4) Network control signaling

(5) Call charge protection.

2.02 Certain unregistered equipment lawfully connected to the network prior to May 1, 1976, is considered to be "grandfathered" equipment and will continue to use connecting arrangements. For new installations, only registered data sets or registered

data protective circuitry can be connected to the switched network. In addition, grandfathered apparatus can be disconnected and/or reconnected for life.

2.03 Some manufacturers are modifying their grandfathered data equipment at the factory in either of two ways: (1) Output level fixed at −9 dBm maximum and set equipped with cord and miniature 6-position plug for use with standard telephone company-provided voice jack, such as RJ11C (supported as a telephone service, not data only). (2) Output level fixed at −4 dBm maximum and set equipped with cord and miniature 8-position keyed plug for use with standard telephone company-provided universal data jack, such as RJ41S (supported for data service).

2.04 These methods are recommended in order to maintain as much as possible, the plug and jack concept for terminal devices covered under the registration program. Such connections allow for easy and immediate disconnection by the user without need for the involvement of telephone company personnel. They are in line with our need for a distinct demarcation and test point and promote the use of such devices in a manner less likely to cause network harms.

2.05 The work performed on grandfathered CPE is to be limited to connections on the end of the mounting cord. Telephone company personnel should not remove CPE equipment housing, perform any wiring internal to the equipment or provide mounting cords or other wire in order to connect the device to the network. If the device has no cord, the customer should be referred to the vendor or manufacturer of the device.

2.06 Due to the variability of grandfathered station equipment and local loop plants, each loop that requires design may require design on an individual case basis to ensure that the maximum signal power criteria (−12 dBm at the serving CO) is not violated, or does not impair the signaling and/or talking capability.

3. TRANSMISSION PARAMETERS

A. Station Loops

3.01 It has been found that access lines (loops) for data installations should not be designed. It is more economical to design loops only when necessary.

3.02 Transmission design parameters enable the circuit to meet the end-to-end criteria for MAP on at least 85 percent of the lines. Almost all data circuits will meet this without any design of the loops. In certain situations it may be necessary to design the loop. Examples of situations which require loop design are:

- Transmission problems on installation
- Customer trouble reports
- Local conditions, such as noisy switching offices and customers located in remote fringe areas, which cause the loop to require initial design. Under any of these examples it will be necessary to route or reroute to the circuit provisioning center (CPC) for design.

3.03 Transmission objectives for loops, or other access lines, terminate in voice jacks are the same as these required for voice services. The data communications service loop transmission objectives for local loops terminating in data jacks are summarized in Section 880-440-105. The objectives listed in that section apply to loops equipped with either telephone company data sets or customer-provided equipment.

B. FX Lines

3.04 Data service over FX lines is only supported for distances up to 200 miles from the office which supplies dial tone. This limit exists since an FX line could conceivably extend from coast to coast. Therefore, starting with the end-to-end transmission requirements, the major portion of the allocations is given to the FX line. A relatively small portion of each impairment is left for the facilities supplying service in the 200 mile radius. The limits for FX lines are given in Section 880-440-105, and the design requirements for FX lines are given in Section 851-300-100.

C. PBX Stations

3.05 Data stations may be located on stations behind PBXs. These stations will be provided using voice jacks only, and therefore be treated as voice services.

4. DESIGN GUIDELINES

4.01 Guidelines for designing loops are given in this part.

A. Loops

4.02 The station loop consists of all facilities and line equipment between the data jack at the customer premises and the side of the main distributing frame that is hard-wired to the line equipment (telephone number) at the dial tone office (Fig. 1). If proper (resistance design) rules are followed, the actual loop loss should not exceed 8.0 dB. Losses stated in this section are 1004-Hz losses unless otherwise stated.

4.03 In order not to overload carrier and radio facilities, the average signal power at a class 5 CO must not exceed −13 dBm0. This level is reduced at the CO switch by the office loss applicable to the particular office.

B. FX, Remote WATS Line, and PBX Design on Facilities Other Than Carrier

4.04 The applicable design sections on FX, WATS, and PBX special service lines that are available are as follows:

SECTION	TITLE
851-300-100	Transmission Design Considerations and Objectives—Switched Special Services and Private Branch (PBX) Automatic Call Distribution (ACD)/Centrex Station Services
851-311-101	Transmission and Signaling Design of PBX-CO and Local WATS

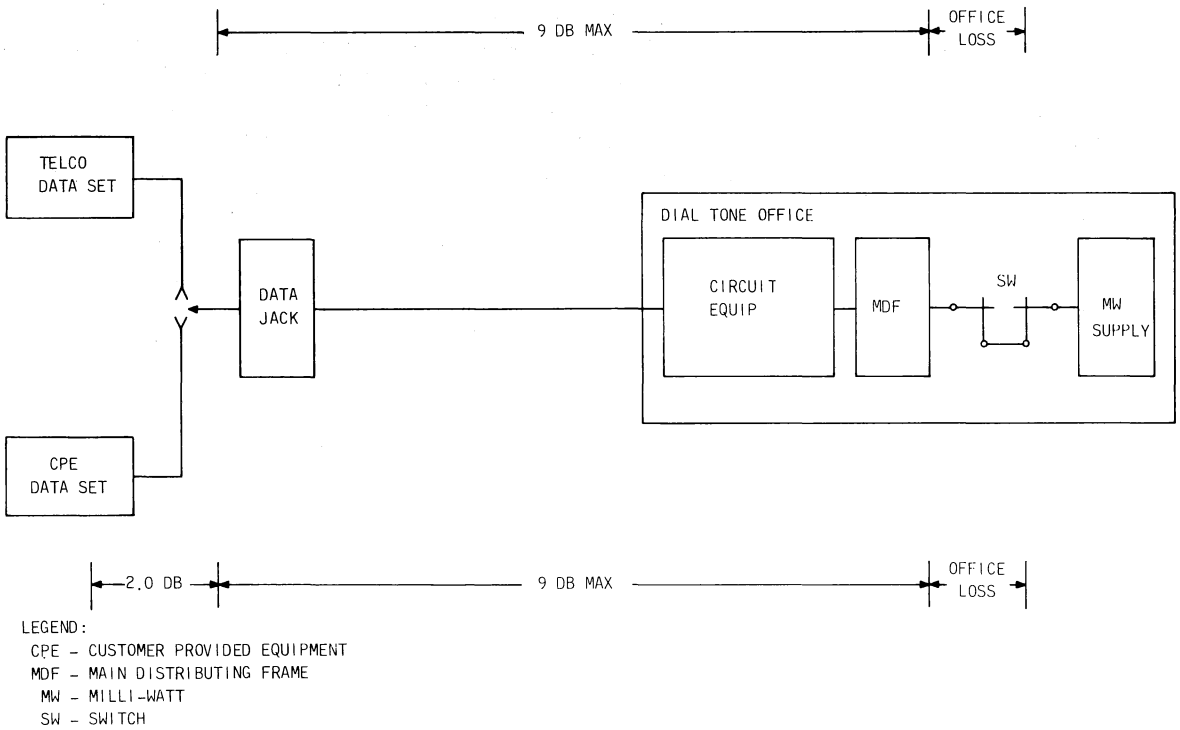


Fig. 1—Designs for Data Communications Service Loops

SECTION	TITLE
	Trunks for PBXs Requiring Terminal Balance
851-311-102	Transmission and Signaling Design of PBX-Central Office and Local Wide Area Telecommunications Service Trunks
851-311-121	Transmission and Signaling Design of Foreign Exchange and Remote Wide Area Telecommunications Service Lines—Short Haul
851-311-122	Transmission and Signaling Design of Foreign Exchange, Long Distance, and Remote Wide Area Telecommunications Service Trunks
851-321-101	Transmission and Signaling Design of 4-Wire PBX Dial Tie Trunks
851-326-101	Transmission and Signaling Design of 4-Wire PBX Dial Tie Trunks—Long Haul

C. FX and Remote WATS Line Design Using Carrier Facilities

4.05 The maximum practical transmitting level of a data set is limited primarily by the maximum level of a steady tone or combination of tones that may be applied to a carrier terminal unit without overloading.

4.06 Whenever the FX/WATS line goes over analog carrier, it should be designed as shown in Fig. 2. The design maintains message levels near normal values while preventing excessive input to the carrier system. The design places the data station at a +4 TLP. This design requires a 20-dB loss in the transmitting direction from the data station to the −16 TLP at the carrier input (MOD IN jacks). The data signal power at the −16 TLP is −29 dBm which means that the data signal power transmitted at the data station is adjusted to −9 dBm (or to the next lower power setting on step-adjustable sets). This represents a fixed-loss design of 4 dB. An assumed office loss of 0.5 dB is used. The example shown in Fig. 2 represents FX or WATS line with a 4-dB local channel terminating in a class 5 office. In cases where the line is to terminate in a class 4 office, the design loss will be a fixed 6 dB. This is to make up for the missing toll-connecting trunk (TCT) loss of 3 dB. See Fig. 1 in Appendix 1.

4.07 In Fig. 2, the 20-dB loss from the data station to the carrier input consists of the T pad (13 dB), the hybrid loss (4 dB), and the loss of a 2-wire nonloaded cable link (3 dB). The losses are assumed for the purpose of illustrating the design. The value of the T pad is determined by the cable loss, but it should be noted that there is a practical limit to the loss that can exist in the 2-wire extension since the singing margin must be protected in the carrier link. In part, the singing margin is dependent on the loss across the hybrid which, in turn, depends on the degree of balance obtained. A loop loss should not exceed 3 dB. If the actual loss is more than 3 dB, 2-wire gain must be added. The loss across the hybrid should be sufficient to provide adequate singing margin for loops having 3-dB loss. In some cases, losses of longer loops can be tolerated if such loops are loaded and use a precision network to provide a better degree of balance and, consequently, a higher loss across the hybrid. The method for determining the maximum loss in the 2-wire section of a loop is not always fully understood. Especially one that yields a proper singing margin when the loop also contains a carrier link in conjunction with adequate balance in the hybrids. Appendix 1 is included in this section to illustrate the correct method in making this determination.

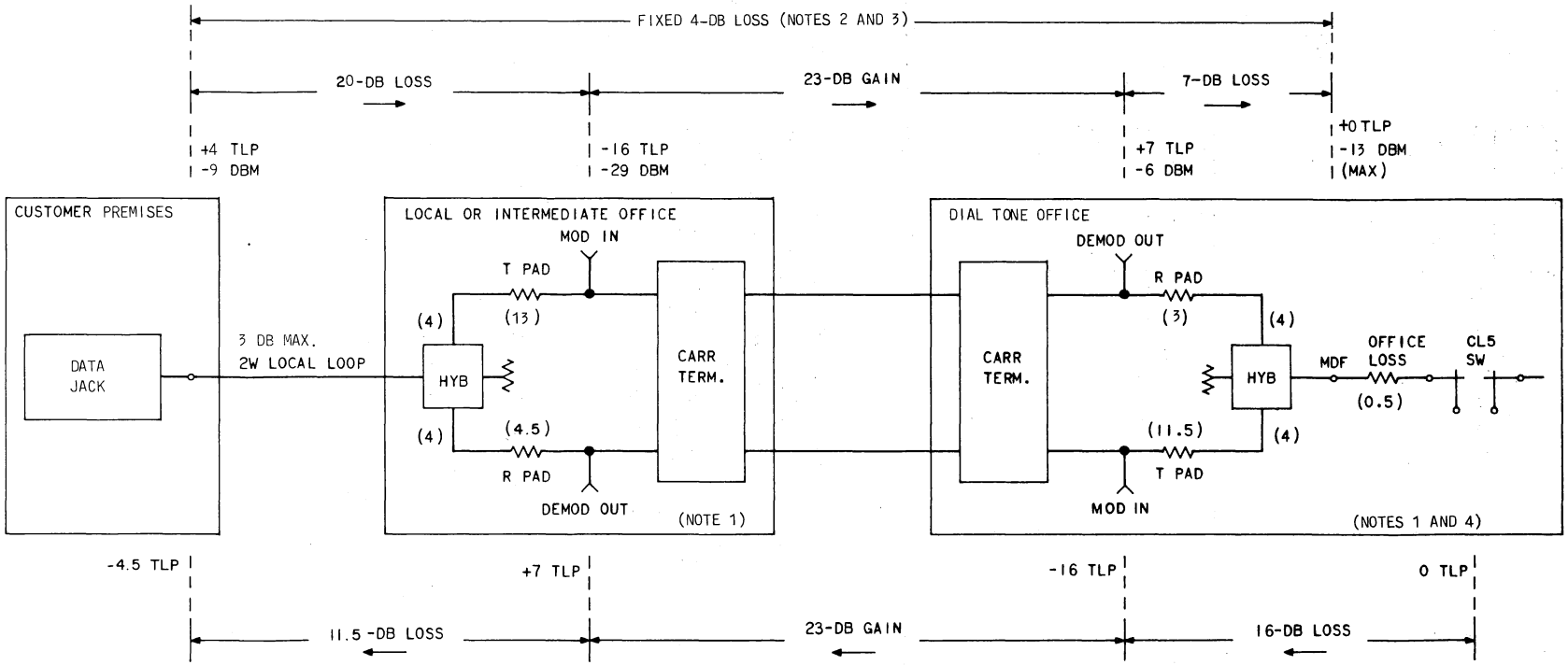
D. PBX

4.08 Design of PBX CO trunks should be per Section 851-300-100.

▶E. Digital Carrier Transmission Designs

4.09 Figure 3 provides a design arrangement on T1 D3-type carrier facilities without gain transfer. Maximum loop loss in this arrangement is 3 dB. Figure 4 shows a design using T1 D4 with an FXO-GT. Minimum and maximum input and output levels and associated TLPs are provided.

4.10 Figure 5 provides possible lineup TLPs on various combinations of D3 and D4 channel units. Where possible, office levels and carrier channel standard test levels are maintained. For design purposes shown in Fig. 5 an office loss of 0.5 dB is shown. Slight adjustments in TLPs may be necessary due to



NOTES:

1. THE PAD VALVES SHOWN IN ( ) ARE CONSISTENT WITH THE DESIGN FOR A 3 DB LOOP. IF THE ACTUAL LOOP IS LESS THAN 3 DB, THE NEAR END T AND R PADS SHOULD BE ADJUSTED TO PROVIDE 20 DB LOSS FROM THE STATION TO THE MOD IN JACK. IF THE ACTUAL LOOP LOSS IS MORE THAN 3 DB, 2 WIRE GAIN SHOULD BE ADDED TO PROVIDE A 3 DB LOOP.
2. RELATIVE TLP POINTS ARE GIVEN FOR LINE-UP ONLY - IN PARTICULAR, THE RECEIVED DIRECTION TLP VALUES DO NOT IMPLY RECEIVED POWER LEVELS.
3. DESIGN INTENT IS TO PROVIDE AN OVERALL 4 DB LOSS FROM THE FAR END (DIAL TONE OFFICE) MDF TO THE STATION WHILE MAINTAINING A 20 DB LOSS FROM THE STATION TO THE NEAR END MOD IN JACK.
4. EXPECTED DATA LEVEL AT THE FAR END MDF IS -13 DBM (MAXIMUM).

Fig. 2—FX or WATS Line Design on Analog Carrier Facilities

office wiring losses. Specific discussion of D3 is given in paragraphs 4.11 and 4.12 to illustrate level problems. The D4 channel units are not expected to be a problem in TLP adjustments. For newer vintage D3 and D4 banks, lineup and maintenance practices and certain test equipment require that standard carrier TLPs will be adhered to.

4.11 The older D2 2-wire FXO and FXS channel units have 0.0 to 3.0-dB receive and transmit pads depending on the list number and options. The pads are adjustable in 1.0-dB steps. In addition, older channel units J98718BD, List 1 and J98718BE, List 1 have gauged receive and transmit potentiometers with 0.1- to 1.5-dB loss. When the gauged pads are adjusted, the same loss is inserted in the receive and transmit path. This makes maintenance of standard levels difficult with certain combinations of carrier terminals.

4.12 New D3 FXO and FXS units J98718BD, List 2 and J98718BE, List 2 have independent receive and transmit pads. When these units are used between D3 and D4, standard office levels can be maintained.◀

F. Guidelines for Loops Terminating in a Data Jack

4.13 Loops which are suitable for high speed data sets terminating in a data jack are as follows:

(a) ***Nonloaded Loops:*** For 19- and 22-gauge cable, the working length plus bridged tap should be less than, or equal to, 9 kft. For 24- and 26-gauge cable, the working length plus bridged tap should be less than, or equal to, 8 kft. Longer nonloaded loops must be designed using Metallic Facility Terminal (MFT) or equivalent type equipment.

(b) ***Loaded (H88) Loops:*** Any gauge cable from ***8 to 10 kft*** with a load point nominally 3 kft from CO and end section length plus bridged tap should be equal to or less than 7 kft. Bridged tap is allowed on end section only.

Any gauge cable from ***10 to 12 kft*** with load points nominally 3 and 9 kft from CO, end section length 1 to 3 kft, and bridged tap should be equal to or less than 6 kft on end section only.

Any gauge cable ***12 to 24 kft*** with load points nominally at 3, 9, and 15 kft with a maximum of 2-percent reference deviation is suitable as follows:

- For 19- and 22-gauge cable, the end section length can be 3 to 9 kft with bridged tap plus the end section equal to, or less than, 9 kft.
- For 24- and 26-gauge cable, the end section length can be 3 to 8 kft with bridged tap plus the end section equal to, or less than, 8 kft.

No bridged tap is allowed except on the end section.

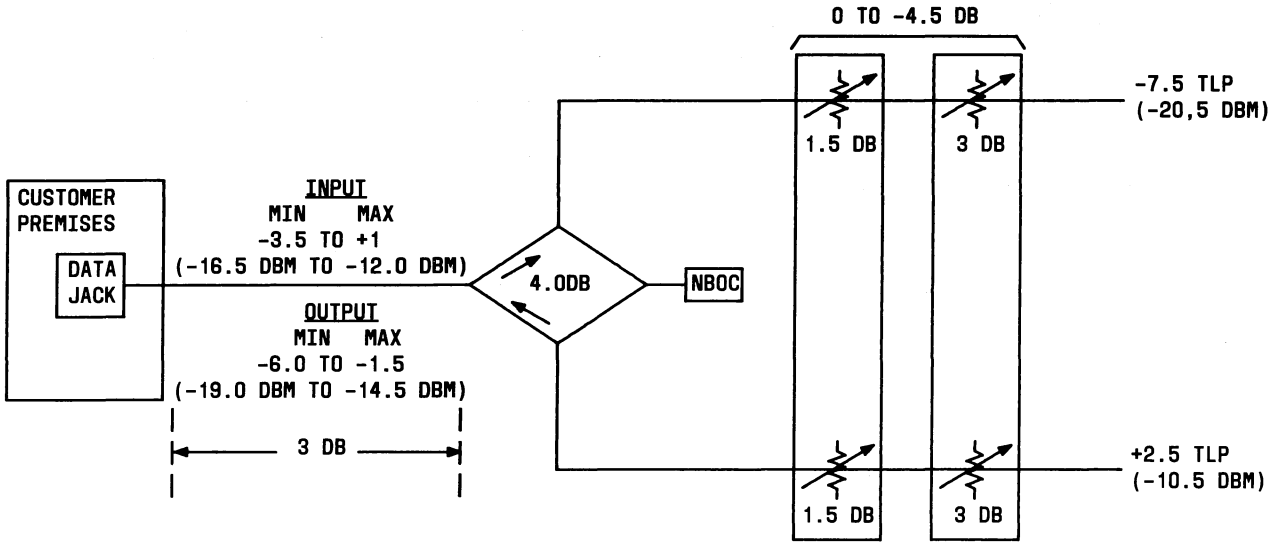


Fig. 3—▶FX or WATS Line Design on D3 Carrier Facilities◀

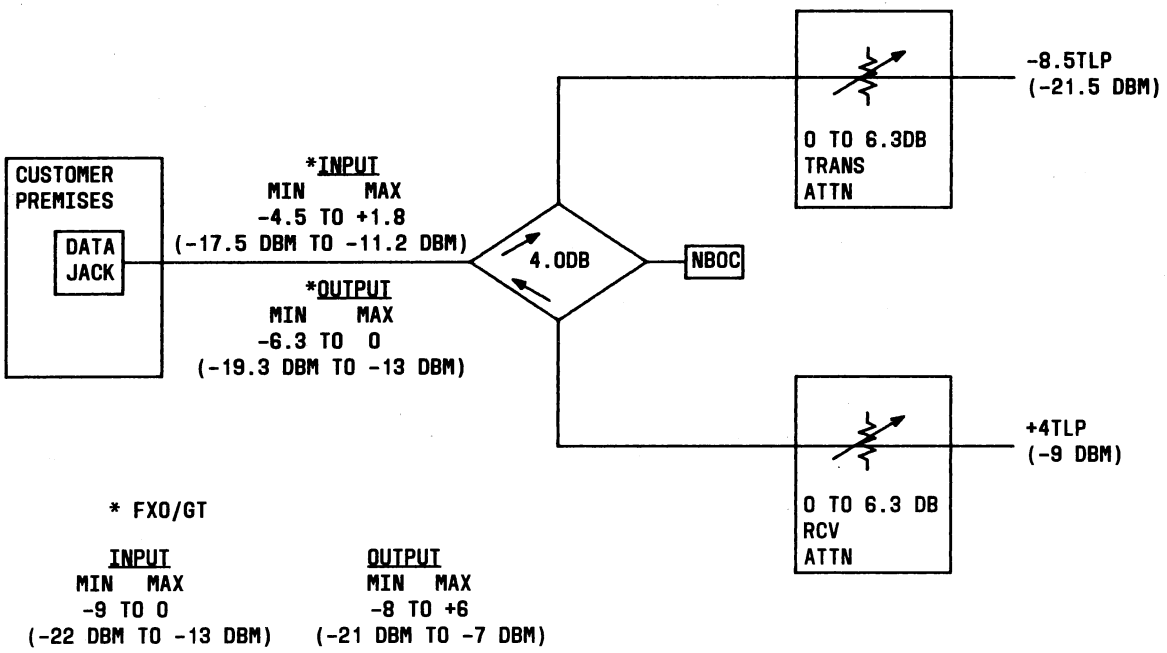


Fig. 4—FX or WATS Line Design on D4 Carrier Facilities

No loaded bridged tap is allowed.

Loaded loops longer than 24 kft must be treated with 4-wire design.

(c) ***Unigauge Loops:*** These are not allowed.

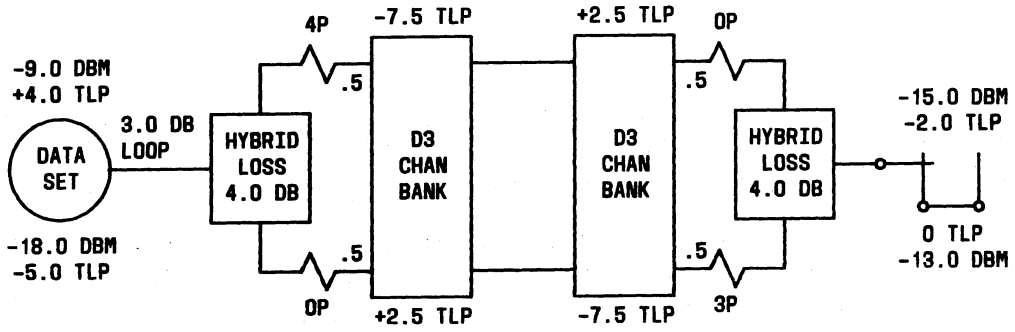
4.14 The Resistance Design Work Sheet (Form E5199) is shown and an example is explained in Section 902-115-101.

G. Universal Cable Circuit Analysis Program

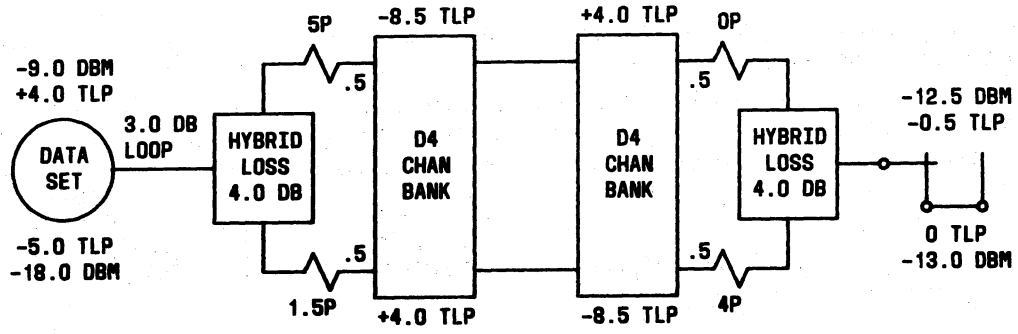
4.15 The Universal Cable Circuit Analysis Program (UNICCAP) is a computer based analysis program which can solve a wide variety of cable circuit problems rapidly. It is described in Section 856-100-100. The UNICCAP is a time-shared computer program which provides an engineer with a convenient and complete analysis of loop problems under varying selected conditions. Familiarity with the operation of a computer is not required nor is any previous knowledge of computer programming. The user provides specific information to the system via a keyboard at a teletypewriter terminal and/or stored data files. The form of the circuit description for UNICCAP is readily available to the design engineer and can be taken directly from existing design records.

4.16 When a user accesses UNICCAP, all the data required to define a particular circuit configuration is entered in terms of length, type, and gauge of the loop cable, presence of bridged tap or loading coils, etc. The problem is processed and the solution returned as output. The user then determines whether requirements are met or whether changes are required. Any number of variations can be made to the input until a satisfactory solution to the problem has been found. In accessing the system, the user transmits a user identification number, a password, and account data. The identification number and password are assigned to the user at the time authorization is given to use the system. The identifiers provide an allocated amount of data storage and assure the user that unauthorized personnel cannot interfere with personal data files. Account information is necessary to maintain accounting records and statistical data for billing purposes.

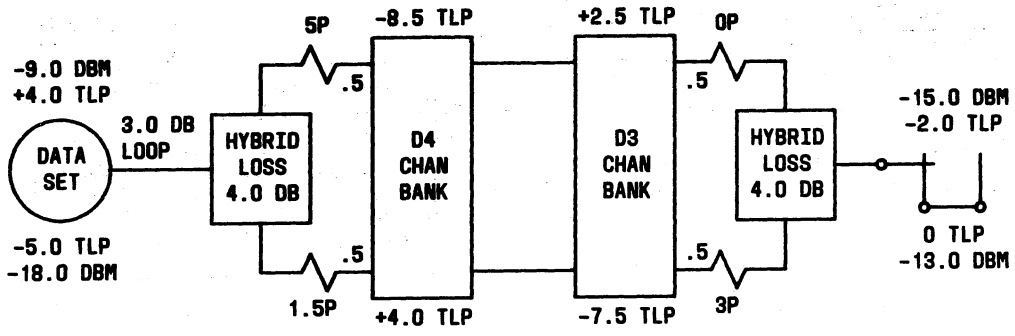
4.17 The UNICCAP cannot replace the engineering design function. Its value is in its ability to rapidly perform the normally time-consuming calculations required to determine the best solution to a design problem.



A. D3 DIGITAL CARRIER ARRANGEMENT



B. D4 DIGITAL CARRIER ARRANGEMENT



C. D4 TO D3 DIGITAL CARRIER ARRANGEMENTS FOR WATS LINES

Fig. 5—Digital Carrier Arrangements for WATS Lines

5. MISCELLANEOUS CONSIDERATIONS

A. Line Concentrators

5.01 Where data communications service loops must be routed through remote line concentrators (not data line concentrators), there is the choice of treating all trunks between the remote concentrator and serving office to meet data communications service objectives or of providing a separate loop. A separate loop is recommended where possible. The choice is dependent on available cable pairs and the needs of the customers who would be served through the concentrator. Some noise, particularly impulse noise, may be experienced on loops routed through remote line concentrators. The amount of impulse noise experienced might justify a dedicated loop.

B. Rotary Out Trunk Switches (ROTS)

5.02 Trunk circuits associated with ROTS circuits (in step-by-step COs and PBXs) are subject to excessive impulse noise. If the switch multiples associated with the various trunk circuits are not disconnected after an idle trunk is selected, then impairment to a data signal can occur as a result of impulse noise induced or coupled onto multiples. Some ROTS circuits are equipped with a multiple contact (MC) relay (per SD-30868-02) to disconnect multiples on selection of a trunk. Even when this relay is provided, a very damaging distribution of impulse noise can remain due to false contacting of rotary switches. A determination should be made whether the MC relay is provided. If not, investigation should be made as to whether any reduction in impulse noise results when trunk multiples are disconnected. The investigation may indicate that the addition of the MC relay may be justified, if not provided, but ROTS circuits should be avoided in general. Refer to EL 1379.

C. Automatic Calling Features

5.03 Some offices use operator number identification (ONI) instead of automatic number identification (ANI) for toll message accounting purposes. If a data communications service customer requires automatic calling features (unattended dialing through an 801-type automatic calling unit), the station loop must be extended to a remote exchange which provides ANI and automatic message accounting (AMA). Outward WATS stations and 100-speed teletypewriter exchange stations which originate calls must also be served from this type of office. If the normal serving office does not have these capabilities, a suitable office (No. 5 crossbar) must be selected and an RX line provided. Inward WATS stations and teletypewriter stations, which do not originate calls (receive only), may be served by the office providing regular telephone service.

D. Divided Access Line Circuits

5.04 Low speed service may sometimes be arranged so that the customer originates calls from a designated serving office but receives calls, via a divided access line circuit (DALC), from the office providing regular telephone service. The 1000-Hz loss must be the same from the station to each office. The DALC arrangements will not be required when 100-speed operation is fully implemented.

6. DESIGN RECORDS

6.01 Proper records of loop design must be kept. Circuit layout record cards (CLRCs) on all installations should be kept and adequate files maintained in both the engineering and the plant offices. Information, as applicable, should include length and gauge of the cable, removal of bridged taps, the kind of loading used, corrective devices used, and any other information which would be pertinent. Any changes made in the installation subsequent to the original design and preparation of the CLRC should also be recorded.

7. REFERENCES

7.01 The following references contain additional information useful in designing data communications service facilities. In a few instances, this section provides later information which should be used.

SECTION	TITLE
304-300-102	Length, Resistance Insertion Loss, Nonloaded High-Capacitance Cable Pairs
304-300-103	Insertion Loss of Office Cable, 0.5 to 3.5 kHz
314-205-501	Data Communications Service, Test Requirements for Subscriber,

SECTION	TITLE
	Remote Exchange, Foreign Exchange, PBX and Wide Area Telecommunications Service Lines, Data Systems on the Public Switched Network
331-850-501	Noise Measurements on 2-Wire Subscriber Lines, Methods and Requirements, At station
590-101-103	Jacks for Registered Data Equipment, Single and Multiple Installations
851-300-100	Transmission Design Considerations and Objectives, Switched Special Services Circuits and Private Branch (PBX) Automatic Call Distribution (ACD)/Centrex Station Services
880-100-100	Envelope Delay Characteristics of Telephone Facilities, General Information
880-100-240	Envelope Delay of H-88, Loaded Cable Facilities
880-420-100	Private Line Data Circuits, Voice Bandwidth—General Design Information
880-440-100	Data Service on the Public Switched Network, General Engineering Considerations
880-440-102	Data Service on the Public Switched Network, Signaling and Supervision Arrangements and Analog Interface Characteristics
880-440-105	Data Communications Service, Access Line Design Requirements, Data System on the Public Switched Network
902-115-100	Customer Loop Plant Design
902-115-101	Application of Resistance Design