TRANSMISSION AND SIGNALING DESIGN OF FOREIGN EXCHANGE, LONG DISTANCE, AND REMOTE WIDE AREA TELEPHONE SERVICE TRUNKS SHORT HAUL

CONTENTS PAGE

CONTENTS PAGE

1. GENERAL

1.01 This section presents standard transmission and signaling designs for short-haul (no more than 6-ms round-trip delay at 1 kHz) foreign exchange (FX) and remote wide area telephone service (WATS) trunks terminating at a class 5 office. These designs are also suitable for WATS trunks terminating at a class 4 (toll) office and long distance (LD) trunks terminating at a toll switchboard. These designs provide for terminal balance at the PBX for FX and WATS trunks switched by the PBX to tie trunks on a through (pad-out) basis. These designs are also used when terminal balance at the PBX is not required for

FX and WATS trunks which do not switch to tie trunks.

1.02 This section is reissued to incorporate the following changes:

(a) To add Metallic Facility Terminal (MFT) equipment designs

(b) To add Customer Premises Facility Terminal (CPFT) information

(c) To add DIMENSION® PBX applications

(d) To clarify the use of metallic and carrier facilities for CO-CO links

(e) To clarify the 1-kHz transmission levels applied to cables

(f) To add cable transducer loss values

(g) To add SMAS-4A access point guidelines

(h) To remove WATS line designs. This information will be included with FX line designs (Section 851-311-121, Issue 2).

Since this is a general revision, change arrows have been omitted.

1.03 Section 851-300-101 gives a general discussion of the use of standard designs for special services. Familiarity with its contents is a prerequisite to the use of this section. That section covers several important aspects of design that are not covered at length in this section, such as temperature effects, tables of data, and network prescription setting references used with E6 and V4 repeatered designs.

1.04 This section tells how to code and select standard designs using the metallic [voice frequency (VF)] and carrier facilities available between central offices and from central offices to PBX locations. This section contains standard design layouts using MFT, E6, and V4 transmission and signaling equipment. MFT and E6-V4 designs are included and presented separately.

1.05 The designs for trunks considered in this section are divided into two links: CO-CO and CO-PBX. The FX and class 5 WATS office supplying dial tone is designated CO(A) and the office serving the PBX is designated CO(Z). Intermediate offices are shown as CO(I). Similarly, the class 4 office or toll switchboard (for WATS trunks and LD trunks) is designated CO(A) and the office serving the PBX is designated CO(Z).

1.06 The two basic links may be selected and lined up end-to-end (overall designs) or each link may be selected and lined up separately. E6 and V4 designs use both methods. MFT layouts use overall designs because significant equipment savings result. Some MFT layouts are suitable for separate link designs. These are indicated on the layouts. Where individual link designs are used, the CO-CO links are designed for 1.0-dB loss. This standardization of 1-dB CO-CO links is consistent with standard designs for other special services and allows flexibility in assignment, installation, and trouble restoration. It is also advantageous for forecasting CO-CO link requirements in that it permits prealigning a number of standard design 1-dB links to save time when providing service on new orders. Careful planning is required if prealigned CO-CO links are to prove economical especially with MFT designs.

1.07 The technique of operating a V4 repeatered CO-CO link at net gain in order to save a repeater in an adjacent 2-wire link (gain transfer) is not used in link designs. Overall (end-to-end) designs use this technique. Section 851-300-101 provides the circuit designer with information for using gain transfer for V4 designs when economy of equipment is a prime factor.

1.08 Figure 1 shows the general plan and the types of facilities used for FX, WATS, and LD trunk standard designs. Metallic facilities between COs use H88 loaded cables and loaded or nonloaded cables from the serving CO(Z) to the PBX. These cable types are used for 2-wire and 4-wire designs. Carrier facilities with or without 4-wire metallic extensions are used between central offices. References shown on Fig. 1 indicate where examples of similar standard design layouts are shown.

1.09 Standard designs use prescription link coding to identify and classify the various designs. The use of prescription coding is optional; however, all designs are based on the coded 1-kHz loss and roll-off limitations. Figures 2A, B, and C list the 1-kHz cable loss limits, by coded links, which will produce overall layouts that meet the transmission

objectives given in Section 851-300-100. The cable loss limits shown in Fig. 2A, B, and C are based on the 68°F transducer loss or attenuation loss values. Transducer cable loss values are used for coding MFT designs while attenuation loss is used for E6-V4 link coding to conform to past practices. The link codes shown in Fig. 2 are arranged by equipment applications as follows:

FIGURE	EQUIPMENT ARRANGEMENTS	VALID CODE TABLES
2A	MFT Designs	A
2B	E6-V4 Combined Designs	B
2C	E6-V4 Link Designs	C

1.10 Not all possible combinations of numerical codes provide workable layouts. Tables A, B, and C list the valid 2-digit layout codes derived from the link codes shown in Fig. 2A, 2B, and 2C, respectively. Codes with underlined digits indicate end-to-end lineup (combined design). Layout codes without underlining are made up of links that are selected and lined up independently. Link design CO-CO links are operated at 1-dB net loss with the CO(Z)-PBX link operated at 2.5- or 3.5-dB net loss depending upon the service application. E6-V4 layouts using 1-dB CO-CO links are normally simpler to design, lineup, and maintain, and generally give superior performance. The underlined (combined) codes usually do not require a gain device for each link and generally are more economical. MFT layout codes are shown as combined (all digits underlined); however, those designs suitable for 1-dB CO-CO link applications are indicated on the layouts and may be used in this manner if desired. There is no performance advantage with MFT designs using 1-dB CO-CO links. All valid layout codes are suitable for voiceband and low-speed data transmission (C1 conditioning). Codes selected for applications requiring C2 conditioning must be examined to determine their transmission capability.

1.11 The underlined E6-V4 metallic codes in Table B have the maximum layout facility attenuation loss limits shown separately for layouts terminating in class 5 and class 4 offices. The reduction in overall facility loss required with an intermediate dial long line (DLL) range extender is shown. E6-V4 codes with the letter A suffixed to the numerical code, eg, 43A, indicate that this layout may be used without an impedance compensator network at the PBX when PBX terminal balance is not a requirement. The codes listed in Tables A, B, and C include alphabetical signaling codes (defined in the tables) which are assigned in left-to-right order for each link or as one letter when one type of signaling is used for the overall layout.

1.12 Figure 3 shows several examples of layout coding for 2-wire and 4-wire metallic and carrier links using MFT, E6, and V4 equipments. When layouts use MFT with E6 or V4 repeaters within a section, use the E6-V4 cable loss limits since the 1-kHz loss and equalization requirements are more limiting.

1.13 Most 2-wire layouts and 2-wire extensions from CO(Z) include an impedance compensating network at the PBX which is used when PBX terminal balance is a requirement. The 837-type or the equivalent J99380 networks are shown as dashed boxes on the layouts to indicate optional usage. Tables D, E, and F contain application data for the various types of impedance compensators. Two-wire WATS and LD trunks terminating at a class 4 office or toll switchboard require an 837-type network at that location. Some 1-dB CO-CO links for E6-V4 designs include an 837-type network at CO(Z) for use with preinstalled applications. 837-type networks should not be used adjacent to E6 repeater 830-type networks since they both serve similar functions.

1.14 All of the designs show possible locations for range extenders and battery-boost types of signaling equipment. MFT and DLL types of range extenders may be placed at any CO or PBX but no more than one unit should be placed at any one location. No more than two units will be required for any design. The layouts show dashed boxes to indicate optional equipment locations. The location of range extenders is based on the range tables given in Section 851-300-170. Specific details are given in the design procedures of this section.

1.15 Chart 1 provides a flow-chart guide through the basic steps used in the standard design

method. Prescription coding of links is assumed; however, this is optional. The design process is the same in either case. All standard design layouts are identified by their assigned layout codes. The table and figure references shown in Chart 1 are grouped by MFT designs in the upper path and E6-V4 or combined MFT/E6-V4 designs in the lower path.

1.16 There are no design examples included in this section because of the many types and varieties of designs presented. However, the methods used for the design examples in Section 851-311-111 or 851-321-101 may be used where difficulty is encountered in applying the procedures outlined in Parts 2 and 3.

2. MFT EQUIPMENT DESIGNS

A. Initial Considerations

2.01 MFT terminal and intermediate repeaters (2-wire and 4-wire types) and signaling units are preferred for metallic links or layouts for all types of 2-wire and 4-wire trunks. The MFT designs include all-metallic 2-wire and 4-wire circuits as well as combinations of metallic and carrier layouts using analog and digital carrier channels. This part outlines the basic MFT design procedures and provides 2-wire and 4-wire layouts with signaling and transmission information. Section 851-300-130 lists application information for MFT equipment and related references for descriptive and lineup sections in the 332 division.

2.02 All MFT designs are suitable for voiceband and low-speed data transmission (C1 conditioning). Most designs are suitable for C2 conditioned applications. Layouts selected for C2 applications should be checked to ensure satisfactory transmission for the data sets to be used.

2.03 The maximum transducer loss limits assigned to the coded links shown in Fig. 2A and cable transmission levels are based on the cable crosstalk maximum and minimum level restrictions listed in Table G. MFT repeater equalization techniques and considerations are outlined in Section 851-300-130 with prescription settings given in Sections 332-912-212, -222, and -232 for 2-wire and 4-wire repeater types.

2.04 All designs are based on a nominal 600-ohm impedance at PBX locations (although 900-ohm PBXs can be used). Two-wire types of MFT repeaters have 900-ohm terminations on the A and B sides. The MFT 2-4 terminal repeaters have 600- or 900-ohm 2-wire terminations with the MFT 4-2 intermediate types providing 900-ohm 2-wire terminations. The 4-wire sides of MFT repeaters have switch-selected 600- or 1200-ohm terminations for nonloaded and loaded cables, respectively.

2.05 Cable and design losses are specified in terms of transducer loss between appropriate impedances. For example, with 2-wire layouts, transducer loss is specified for 900-900 ohm or 900-600 ohm (loaded or nonloaded) impedances. With 4-wire layouts, transducer loss is specified for 600-600 ohm (nonloaded) or 1200-1200 ohm (loaded) impedances. Tables of transducer loss values at 68°F and computation procedures are listed in Section 304-305-100 and the 332 division sections. The effect of temperature change on the cable transducer loss should be checked to provide stable circuit operation over the expected temperature range. Section 851-300-101 outlines the considerations and illustrates the procedures.

2.06 MFT transmission and signaling units used at customer locations are mounted in the Customer Premises Facility Terminal (CPFT, SD-7C010, J99380) equipment which also provides impedance compensator networks when terminal balance at the PBX is required. Two-wire MFT repeaters are not recommended for customer locations. Tables D, E, and F list application information for the various types of impedance compensators with and without range-extending units.

B. Metallic Facilities

2.07 MFT standard designs assume H88(HC) or 25H88 MAT (metropolitan area trunk) loaded cable for the CO-CO link and either nonloaded or loaded (2-wire or 4-wire) cable from the serving CO(Z) office to the customer locations. MFT equipment can equalize the roll-off for mixed nonloaded and loaded cables.

2.08 The MFT designs assume that metallic facilities between COs will be H88 loaded with both CO end section lengths near 3 kilofeet (3±0.5 kft). Cable plant between a PBX and the serving CO can be either nonloaded, H88 loaded, or mixed. For H88 loaded CO-PBX cable, the length of the PBX end section should be between

1.5 and 4.5 kft including any bridged tap (BT) so that prescription settings may be used directly. Longer lengths will require touch-up adjustments. The PBX end section plus BT should not exceed 6 kft without terminal balance or 5 kft with terminal balance. To use prescription settings without measurement, BT on loaded cable is permitted only in PBX end sections. End sections over 4.5 kft or BT in the CO(Z) end section will require field touchup as described in Section 332-912-231. BT on nonloaded cables should not exceed 6 kft.

2.09 Tables D, E, and F list application information for 837 and equivalent types of J99380 impedance compensators used at PBXs when terminal balance is a requirement. The maximum CO(Z)-PBX link 1-kHz transducer loss limit is reduced 0.5 dB for loaded cable types and 3.0 dB for nonloaded types to allow for the insertion loss of the network. The link loss limits are shown on the various MFT layouts. When a nonloaded CO(Z)-PBX link loss limit of 4.5 dB is exceeded with an impedance compensator at the PBX, a 2-wire loaded or 4-wire facility should be used. Refer to Section 332-205-100 for details on the various types of impedance compensators.

2.10 Two-wire MFT repeater gains are limited to 6 dB for terminal applications and 12 dB for intermediate applications. The 12-dB gain at intermediate locations assumes that repeater disabling is provided by the signaling unit. If no signaling unit is used, the gain is limited to 8 dB. Figure 4 gives the method for computing 2-wire repeater gains and cable transducer loss limits for the various repeater arrangements. Four-wire intermediate repeater gains are limited to 15 dB while intermediate 4-2 repeater gains are limited to 12 dB. MFT repeater gains are overall; internal losses are included. Part 4 outlines a method of reducing transmission levels by symmetrical averaging of cable losses which will improve the cable crosstalk performance.

2.11 Repeater sections using a mixture of nonloaded and H88 loaded cables are allowed in 4-wire layouts. Sections with 9 kft or less of nonloaded cable between a repeater and the first load coil are treated as loaded at that end. When the nonloaded cable length exceeds 9 kft, the repeater at that end is set to 600 ohms and the H88 loaded end is set to 1200 ohms. Mixed gauge cables will require the frequency measurement procedure outlined in Section 332-912-231 to obtain equalizer and balance network settings.

C. MFT 2-Wire Designs

2.12 Two-wire designs are presented for FX, WATS, and LD trunks to class 4 or class 5 offices or toll switchboards. The inserted connection loss (ICL) objectives for the various applications are shown on the design layouts. All MFT layouts are coded as overall designs (all link codes underlined) and are lined up end-to-end to the ICL assigned to the circuit application. This is the most economical arrangement. Some 4-wire designs may be lined up as individual links. Two-wire designs terminating at a class 4 office require an 837-type impedance compensator at CO(A).

2.13 Two-wire MFT layouts use either one or two repeater designs. Figure 4 shows the basic repeater locations, maximum cable facility transducer loss limits, and gives equations for computing repeater gains. The losses shown include the cable transducer loss (900-900 or 900-600) and any equipment items (837 networks and passive 2-wire transmission units). Figure 5 shows detailed coded layouts with equipment types and repeater locations referred to in Fig. 4. Diagrams are shown for each basic design which indicates the type of repeater (J99343PA, etc) to use, A-B and B-A orientation of the repeater, and the cables the A and B sides will properly terminate. The 2-repeater types shown (eg, PA/PG) indicate the older and newer repeater types (left to right). The right (PG) repeater is similar to PA with the additional feature included for use with 25H88 MAT cables. Similar designations are used with other repeater types. Possible locations for MFT signaling units (SU) are shown as dashed boxes. Double-module MFT arrangements are shown; however, the battery-boost LSE unit may be used without the passive 2-wire transmission unit in the TU slot for single-module arrangements. Equipment types with application notes are shown in Fig. 5. The 2-repeatered layouts suitable for E6 repeater substitutions are shown. An E6 repeater may be substituted for either MFT repeater. Note the 7.5-dB maximum facility loss for E6 repeater substitutions. Figure 5 also shows, by simplified repeater diagrams, the signaling lead circuits for the various types of 2-wire repeaters (and 2-wire transmission unit) with and without signaling units for A-B and B-A circuit orientations.

2.14 Figure 6 shows diagrams of the MFT equalization techniques for the various 2-wire coded layouts. Refer to Section 851-300-130 for more details on MFT equalization and to Section 332-912-212 for settings. Section 332-912-212 contains settings for terminal and intermediate repeater locations. No prescription equalizer settings are given for H88 loaded repeaters equipped with 309C amplifiers as they furnish a small amount of fixed gain shaping for H88 loaded cables. Repeaters using the 309D amplifiers provide adjustable slope equalizers for nonloaded cables. Single-gauge and mixed 2-gauge tables are supplied. A small roll-off at 400 Hz and 2800 Hz, referenced to 1000 Hz, is desirable for 2-wire circuit stability for the range of far-end terminations that may be used. It is necessary to stop short of a completely flat frequency response due to stability considerations.

2.15 Figure 7 shows the recommended locations for one or a maximum of two range extender signaling units for trunk applications. The signaling design procedure is presented in Part 4. The signaling unit is selected to provide ground-start (GS) or loop-start (LS) operation depending on the requirements of the PBX. The range tables referenced in Fig. 7 are located in Section 851-300-170 and their limits will result in satisfactory signaling design for trunks. These range tables list the conductor loop resistance (CLR) values which must also include the loop resistance of any equipment items in the signaling path. The range tables referenced in Section 851-300-170, Issue 1 are based on 48-volt operation; when 24-volt or 72-volt operation is used, refer to the range tables listed in SD-1C359.

D. MFT 4-Wire Designs

2.16 MFT 4-wire designs include overall metallic layouts and metallic 4-wire CO-CO links with 2-wire extensions to the PBX. In addition, designs using analog and digital carrier channels in the CO-CO link with 4-wire and 2-wire metallic extensions are presented. Four-wire designs are coded for end-to-end lineup; however, some 4-wire designs with 2-wire PBX extensions may be operated with 1-dB CO-CO links. Four-wire designs meet terminal balance requirements at CO(A). Designs with 2-wire extensions use 837-type or the equivalent J99380 impedance compensators at the PBX when PBX terminal balance is a requirement.

2.17 Figure 8 shows 4-wire designs with equipment types and design notes for 4-wire metallic and carrier layouts with 2-wire extensions. All repeater types shown are of the MFT J99343 series. Refer to Section 851-300-130 for details on the various repeater types. The 2-repeater types shown (eg, RD/RH) indicate the older and newer repeater types (left to right). The right (RH) repeater is similar to RD with the additional feature allowing use with 25H88 MAT cable. Similar designations are used with other repeater types. All facility losses shown are transducer loss (TL) values between equipment terminations as follows: 4-wire H88 loaded, 1200-1200; 4-wire nonloaded, 600-600; 2-wire H88 loaded or nonloaded extensions, 900-600. Transducer loss tables at 68°F are given in Section 304-305-100 with prescription settings given in Sections 332-912-222 and 332-912-232. Possible locations for signaling units (SU) and intermediate repeaters are indicated by dashed boxes. In general, 4-wire metallic designs are limited to one intermediate repeater between CO(A) and CO(Z). Long metallic designs should be checked to insure that they do not exceed the 6-ms round-trip delay requirement for short-haul designs.

2.18 Figure 8 also shows, by simplified repeater diagrams, the signaling leads for the various repeaters with and without signaling units for A-B and B-A circuit orientation of the repeaters. Sheet notes list application data for the various designs. Simplified diagrams also show the signaling lead arrangements for the FA, FB, FC, and FD E&M converter units.

2.19 Figure 9 shows detailed carrier channel coded layouts equipped with MFT transmission and signaling units. Layouts using digital or analog carrier channels and single-frequency (SF) signaling are shown. Dashed boxes indicate possible locations when required. The ICL limits shown are for the various trunk applications. The layouts are coded for end-to-end lineup; however, some layouts with 2-wire extensions to the PBX may be operated with 1-dB CO-CO links. Equalization techniques for metallic sections are indicated with post equalization used primarily with settings obtained from prescription tables. In those cases where a repeater amplifier provides both pre- and post equalization, the manual measurement procedures outlined in Section 332-912-231 will be required.

2.20 Figure 10 shows more detailed equalization techniques. Equalization for 4-wire sections with 2-wire extensions for 4-wire metallic and carrier channels is shown. When the J99343BD

4-wire extension network is used with carrier channels, pre- and post equalization for the metallic extension must be provided by the repeater located at CO(Z) or the PBX. In this case, pre- and post equalizer prescription settings are the same. The FUD SF converter provides gain and equalization for the 2-wire extension. The 4-2 types of repeaters used at CO(Z) use precision balance networks (PBN).

E. MFT Signaling Units

2.21 MFT signaling units for ground-start or loop-start range extension consist of the J99343AC, AF loop signaling repeater (LSR) or the J99343CB, CC, or CD battery-boost loop signaling extender (LSE). The J99343AD or modified AB units (LSO) may be used for loop-start operation. The LSR and LSO units are used with a companion transmission unit in double-module MFT arrangements. When using the LSR and LSO signaling units with repeaters, the disabling feature should be used. At the customer location, these units are used with the passive 2-wire transmission unit (J99343BC or modified BA) mounted in the CPFT equipment. The LSR AC unit is set to the GS or LS mode depending on circuit operation. The LSR AF unit automatically selects the GS or LS mode of circuit operation. In addition, the J99343AE loop-start to ground-start converter may be used at CO(A) to convert from loop-start to ground-start operation. Signaling unit location and range table references in Fig. 7 are applicable for 2-wire or 4-wire applications. The simplex resistance for 4-wire circuits is converted to the equivalent conductor loop resistance (CLR) values. Refer to SD-1C359 for 72-volt ranges for the battery-boost LSE units.

2.22 Analog carrier channels (OBS) with E&M lead signaling use the J99343FA, FB, or FC, and FD loop-to-E&M converter circuits. The FA and FB units provide loop-start conversion with the FC and FD pair providing ground-start conversion. Typical applications for these converters are indicated in Fig. 9. Ranges for converter units are listed in SD-1C359.

F. MFT Design Procedure

2.23 A step-by-step procedure for standard design of FX, WATS, and LD trunks using MFT transmission and signaling equipment is outlined in the following steps. Chart 1 shows the procedure in flowchart manner.

(a) Determine the layout configuration to be used (2-wire, 4-wire metallic or carrier). Determine terminal balance requirements. Two-wire layouts terminating at a class 4 office will require an impedance compensator at CO(A), and PBX terminal balance requires an impedance compensator at the PBX. Refer to Tables D, E, and F for impedance compensator types.

(b) Calculate the 68°F cable transducer loss for each link. Two-wire links use 900-900 or 900-600 ohm transducer loss values. Four-wire links use 1200-1200 (H88) or 600-600 (NL) values. Separate by aerial, buried, or underground lengths for temperature correction (refer to Section 851-300-101 for temperature correction procedure). Transducer loss tables are given in Sections 304-305-100 and 332-912-222. Refer to Fig. 4 for 2-wire layout loss limits and repeater locations.

MFT Layout Coding

(c) Determine the 2-digit numerical code for the 2-wire and 4-wire links from Fig. 2A to form the layout. Some CO-CO link numerical codes, shown in Fig. 2A, use an alphabetical modifier (A, B, C, or D) to indicate various repeater locations.

(d) Determine the validity of the selected code from Table A. When a nonvalid code is encountered, a new code for one of the links must be selected. Repeat the process until a valid code combination for the layout is found. Numerical layout codes using MFT repeaters may optionally be prefixed with the letter M.

(e) Select the coded layout (Fig. 5, 8, or 9) and locations for intermediate repeaters or carrier interface equipment units.

(f) Determine if signaling units are required. (Refer to Part 4.)

(g) Recompute the cable transducer loss between repeaters and compute the transmitting and receiving TLPs using the symmetrical averaging method. (Refer to Part 4.) The maximum and minimum TLPs listed in Table G should not be exceeded. Compute the transducer loss using the proper working impedances at each end of the cable.

(h) Assign levels at each repeater point.

(i) From the assigned levels, compute the required 1-kHz gain. The total 1-kHz repeater gain is the sum of the the active equalizer gain and the flat gain. The total gain is the net circuit gain. Repeater internal loss need not be included.

(j) Determine the equalizer and network prescription settings from the appropriate section in the 332-912-ZZZ series. Refer to Fig. 6 for 2-wire equalization techniques and to Fig. 10 for 4-wire sections. Specify the measurement procedure in Section 332-912-231 for mixtures of nonloaded and H88 loaded cables within a repeater section.

(k) Specify other transmission and signaling switch settings for repeaters and signaling units. These options are listed in the notes in Fig. 5 and 8. Take special care in specifying the SX reversing switch on each repeater for A-B and B-A orientation of the repeater. Simplified repeater diagrams showing signaling leads are shown in Fig. 5 and 8 with and without signaling units.

(l) Assign SMAS-4A access points, if required.

Note: Access points are indicated as AP-1, AP-2, AP-3, AP-4, or AP-5 on the coded layouts and are shown in detail in Fig. 11.

3. E6 AND V4 EQUIPMENT DESIGNS

A. Initial Considerations

3.01 This part outlines the standard design procedures for FX, WATS, and LD trunks to class 4 and 5 offices and toll switchboards using E6 and V4 repeatered metallic layouts. Carrier channels using metallic extensions with V4 and related equipment are also included. Two-wire and 4-wire overall designs (end-to-end lineup) and individual link designs are included. Carrier links and layouts include analog and D1-D3 digital carrier channels. All designs are based on the general transmission objectives given in Section 851-300-100. Additional references for design work are listed in Section 851-300-101. Specific E6 and V4 repeater information and data for Switched Special Services application are given in the 851-300-1ZZ series of sections.

3.02 Charts 1, 2A, and 2B provide design aids for use with E6 and V4 repeater applications. Chart 1 provides a flowchart of the general design process with table and coded layout figures referenced. Charts 2A and 2B define equipment symbols and design references shown in Fig. 12, 13, and 14.

3.03 The coded attenuation loss limits assigned to metallic links in Fig. 2B and 2C will result in layouts that meet the roll-off and crosstalk objectives for trunk applications. Figure 2B lists the link code assignments for combined (end-to-end) designs. Table B lists the corresponding underlined valid layout codes for combined designs with maximum loss limits for 2-wire codes. Figure 2C lists the link code assignments for individual link designs. Table C lists the corresponding valid layout codes (not underlined). Figures 2B and 2C list attenuation-to-transducer 600-900 ohm conversions. The attenuation loss limits for 4-wire metallic links are the same for all applications. Four-wire metallic sections are limited to one intermediate 44V4 repeater.

3.04 Individual link designs for all services use a CO-CO link with a nominal net loss of 1.0 dB. When 2-wire D1D-D1D or D1D-D3 channel banks are used in the CO-CO link, a net link loss of 0.75 dB is recommended instead of 1.0 dB to maintain the transmission levels used with these channel units. The CO(Z)-PBX link net loss is lined up to 2.5 or 3.5 dB for the service application (see Ref. 6, Chart 2B). Some individual link designs will result in back-to-back V4 and E6 repeaters at CO(Z). The net circuit gain should not exceed 12 dB for E6s or 15 dB for V4/E6 combinations to maintain cable transmission levels within the crosstalk limits. The V4 repeater adjacent to an E6 repeater must use the compromise network.

B. Metallic Facilities

3.05 Metallic facilities for 2-wire and 4-wire trunk layouts use H88 or 25H88 MAT loaded cables for the CO-CO link and either loaded or nonloaded cables for the CO(Z)-PBX link. Short loaded cables with only two load coils should be used as nonloaded with the load coils removed. Bridged taps (BTs) are only permitted in the PBX end sections.

Four-Wire End Section BT Lengths

3.06 For 4-wire loaded links, end sections plus bridged taps are expected to be between 1.5 and 4.5 kft at any CO or PBX location. This permits prescription settings to be used. End sections plus BT should not exceed 5 kft with terminal balance or 6 kft without terminal balance. Bridged taps on nonloaded cables should not exceed 6 kft. When longer lengths are used, field touchup will be required.

Two-Wire End Section BT Lengths

3.07 Loaded cable end section plus BT lengths for trunk applications at CO and PBX locations should be within the following limits:

LOCATION	WITH TERMINAL BALANCE (KFT)	WITHOUT TERMINAL BALANCE (KFT)
CO(A)	1.5 - 5.0	1.5 - 4.5
CO(I)	1.5 - 4.5	1.5 - 4.5
PBX	UP TO 5.0	UP TO 6.0

Code 11A limits the CO(Z) end section length to 3.0 kft. When greater end section lengths are used with code 11A, the excess length beyond 3 kft is considered part of the nonloaded PBX link. The cable plus BT length is limited to 5 kft. This ensures that the 2800-Hz roll-off objective for trunks will be met.

C. Terminal Balance Guidelines

3.08 The following guidelines will enable 2-wire designs to meet all transmission objectives when terminal balance at CO(A) or the PBX is required. All 2-wire layouts to class 4 office require an 837-type network at CO(A).

(a) Layout codes suitable for use with or without PBX terminal balance are suffixed by the letter A when terminal balance is not required. The letter A is dropped from the code when terminal balance is required. These codes may be used for either application. Some layout codes are intended for terminal balance applications.

(b) ***End section lengths***—Observe the end section lengths listed in 3.07.

(c) ***End section BT loss***—Disregard. The small loss is corrected at lineup.

(d) ***Nonloaded cable BT***—Maximum length limited to 6 kft. Subtract 0.25 dB per kft of BT from CO(Z)-PBX link loss limit.

3.09 When terminal balance at the PBX is required, Tables D, E, and F provide impedance matching data for the various types of 837 and J99380 impedance compensating networks with and without range-extending units. Refer to Sections 851-300-112 and 851-300-113 for 837-type network application data.

D. Two-Wire Designs

3.10 Two-wire trunk designs consist of nonrepeatered layouts, one E6 repeater, or two E6 repeatered layouts. Layout codes for nonrepeatered designs or one E6 repeater use overall (end-to-end) lineup and are shown underlined in the valid code tables and layout drawings. Individual link designs use one E6 repeater for each link with layout codes shown without underlining in Table C. The CO-CO link is lined up to a net 1-kHz loss of 1.0 dB. The CO(Z)-PBX link is lined up to 2.5- or 3.5-dB net loss to produce the ICL specified for the intended service application. The various layouts locate E6 repeaters at CO(A), CO(I), and CO(Z). No designs use E6 repeaters at customer locations. Also, E6 repeaters are not preferred at class 4 central offices. The maximum net gain for E6 repeaters at CO(A) is limited to 6 dB and 12 dB at CO(I) and CO(Z). This also applies when two E6 repeaters operate back-to-back at CO(Z) for certain link design codes.

3.11 The 851-300-1ZZ sections provide specific design data for E6 repeater applications for loaded and nonloaded cables. The E6 repeater disabler is indicated on the layouts by a dashed line. Section 851-300-114 outlines the use of the disabler.

E. Four-Wire Designs

3.12 Four-wire designs include metallic sections and carrier channels for overall and link designs. The designs also include 4-wire CO-CO links with 2-wire CO(Z)-PBX links. Four-wire metallic facilities are used on either or both sides of a carrier channel in the CO-CO link. The 4182-extension networks interface 4-wire metallic facilities with carrier channels when gain is not required. The MFT BD transmission unit is similar (no equalizer is provided). When gain is required, the 44V4 repeater is used. The coded layouts show an optional arrangement for both applications. The metallic 4-wire links indicate the optional (dashed box) use of a 44V4 repeater when required. The maximum loaded cable loss between V4 repeaters is 15 dB. All 4-wire designs meet terminal balance objectives at CO(A) and at the PBX. Gain transfer at intermediate 4-wire to 2-wire locations may be used for overall designs. Gain transfer for link designs is not satisfactory since 1-dB CO-CO links are used. See Ref. 10 through 13, Chart 2B for V4 repeater information.

F. Terminating Impedances

3.13 Two-wire layouts are designed using 900-ohm impedance at COs and 600-ohm impedance at the PBX for trunk applications (900-ohm PBXs may also be used). For 2-wire gain computations, transducer loss values (900-900 or 600-900) are used for CO-CO links with 900-600 ohm values used for CO(Z)-PBX links for loaded or nonloaded cables. The 68°F transducer loss values should be adjusted to the temperature at lineup time. When 900-ohm terminations are used at the PBX, use 900-900 transducer loss values for the CO(Z)-PBX link. Four-wire cables use 1200-ohm terminations for loaded cables and either 600 or 150 ohms for nonloaded cables. Table H lists the 359 types of equalizers to use with nonloaded cable by gauge and length. These types of nonloaded cable equalizers provide either 150- or 600-ohm cable terminations. Transducer loss values for the various cable terminal impedances are listed in Section 304-305-100. Transducer losses are used for gain computations since they are more accurate than attenuation values for the various cable terminations.

3.14 Transmission measurements should be made with test sets adjusted to match the equipment impedance. Losses measured with 600-ohm test sets at 900-ohm points indicate 0.2 dB more loss and 0.5 dB at 1200-ohm points. For combined layouts, the standard designs do not specify individual link net losses since only the overall layout loss and repeater gain are considered. On individually designed links, the net loss for each link is the loss that should be obtained when the circuit is measured with specified test equipment impedances. V4 repeater ports provide 1200-ohm impedance for loaded cables and 600 ohms for nonloaded. When 600-ohm test sets are used at V4 repeater 1200-ohm ports (359A equalizer), 0.5 dB is subtracted from the indicated level to obtain the expected measured gains (EMG). The 600-ohm ports require no correction.

G. Repeater Gain Calculations

3.15 The following procedures provide prescription gain setting information required to establish (1) an overall layout ICL for those codes shown fully underlined in the valid code tables and (2) the net loss for single links. The 2-wire and 4-wire metallic codes are considered separately. This is not a new concept. Detailed computations previously made by the engineer, plus the allowance for excess loss readings (made during installation) due to dissimilar test equipment terminations, are now included in the expected measured loss (EML).

2-Wire Overall Designs

3.16 Use the following procedures to determine the repeater design (net) gain required for the overall layout.

(a) Determine the total 68°F cable transducer loss for the CO-CO and CO(Z)-PBX links (refer to Section 304-305-100). Overall layouts are shown in Fig. 12. Use the following cable terminal impedances:

CO-CO: 900-900
CO(Z)-PBX: 900-600*

*Use 900 ohms if this cable termination is used.

(b) Adjust the total cable 68°F loss to the ambient temperature as outlined in Section 851-300-101. Areas with moderate temperature extremes may not require this correction.

(c) Determine the insertion loss (IL) of 830- and any 837-type networks from Section 851-300-101 for the overall layout.

(d) Determine the location of any DLL, LSR, or E6B (battery-boost) signaling unit required as outlined in Part 4A. Allow 0.5-dB loss for a DLL, 0.8-dB for LSR, or 0.2-dB for the E6B. Be sure no back-to-back signaling units are used.

(e) Add together the layout cable (temperature corrected), network, and DLL, LSR, or E6B losses. This is the computed end-to-end layout loss. No correction factor is required when the impedance of the test set matches the point of measurement.

(f) Determine the ICL for layout selected (see Ref. 6, Chart 2B).

(g) Compute the design gain as follows:

Design gain = Computed layout loss - ICL.

(h) Determine the EML temperature correction and adjust the computed design gain when EML temperature correction is used. Section 851-300-101 outlines the EML temperature correction procedure.

The computed gain should be within the required limits; however, minor gain readjustment may be required when overall measurements are made.

2-Wire Link Designs

3.17 Use the following procedures to determine the repeater design (net) gain required for each link.

(a) Determine the 68°F cable transducer loss separately for the CO-CO and CO(Z)-PBX links (refer to Section 304-305-100). Link layouts are shown in Fig. 13 and 14. Use the following cable terminal impedances:

CO-CO Link: 900-900

CO(Z)-PBX: 900-600*

*Use 900 ohms if this cable termination is used.

(b) Adjust each link 68°F cable loss to the ambient temperature as outlined in Section 851-300-101. Areas with moderate temperature extremes may not require this correction.

(c) Determine the insertion loss (IL) of 830- and any 837-type networks from Section 851-300-101 for each link.

(d) Determine the location of any DLL, LSR, or E6B signaling unit required as outlined in Part 4A. Allow 0.5-dB loss for a DLL, 0.8-dB for LSR, or 0.2-dB for the E6B. Be sure no back-to-back signaling units are used when the links are joined together.

(e) For CO-CO links, add together the cable (temperature corrected), network, and DLL, LSR, or E6B losses. This loss is defined as the computed link loss. The CO-CO links use loaded cable and are always computed and measured between 900-ohm cable terminations.

(f) For the CO(Z)-PBX end link, using a 900-ohm termination at CO(Z) and 600- or 900-ohm termination at the PBX, add together the cable (temperature corrected), network, and DLL, LSR, or E6B losses. No correction factor is required when the impedance of the test set matches the impedance of the point of measurement.

(g) Determine the link net loss (TL) required for the service application. Use 1.0 dB for CO-CO links and 2.5 or 3.5 dB for the CO(Z)-PBX link net loss.

(h) Compute the link gain as follows:

Design gain = Computed link loss - TL.

(i) Determine the EML temperature correction and equally divide the correction between the design gains for the two links when EML temperature correction is used. Section 851-300-101 outlines the EML temperature correction procedure.

The computed gains should be within the required limits; however, minor gain readjustments may be required when overall measurements are made.

4-Wire Links or Overall Layouts

3.18 Detailed repeater gain calculation methods for 4-wire metallic facilities are given in the V4 series of sections referenced in Section 851-300-101. Information on equalizer loss values is also included in the V4 series. The latest figures for terminating set losses are included in Section 812-002-290. Nonloaded cable losses should use

transducer loss (not attenuation) values for the 359-type equalizer impedance terminating the cable (150 ohms for type 359B and 600 ohms for type 359F). Cable plus equalizer transducer loss values are given in chart form in Section 852-307-102 for solid-gauge cables. When mixed-gauge cables are used, the curves shown in Section 304-300-102 may be used. Transducer loss values at 68°F for the various cable terminations are listed in Section 304-305-100. All cable losses should be temperature-corrected if necessary, as outlined in Section 851-300-101.

3.19 Losses for loaded cables may be computed using 1200-1200 attenuation or transducer loss values. The difference between 1200-ohm attenuation and transducer losses is quite small.

3.20 The gain of the 227-type transmitting amplifiers is set to produce an output level into cable facilities no higher than that permitted for crosstalk reasons. Gains at COs should be set to provide maximum cable input levels no higher than +6.0 dB relative to the transmitting level point (TLP) used for lineup. Gains at PBXs should be set to provide maximum input levels no higher than +6.0 dB for nonloaded cables or +3.0 dB for loaded cables relative to the lineup TLP. When the cable loss between repeaters is less than maximum values, the symmetrical average technique, given in Part 4, should be used. The milliwatt (MW) supply is considered to be the 0.0-dB TLP as shown on the layouts. All receiving amplifiers must be set to an output level which will produce the link net loss, ICL, or the +7 level for carrier channels. Overall ICL and EML values are listed in Ref. 6 and 7 of Chart 2B.

3.21 Where carrier facilities or SF signaling units are used, amplifiers and pads are set to meet the +7, -16 transmission level points shown on the layouts.

3.22 To compute the gain required for each amplifier, it is necessary to determine the following items (see Section 852-307-201):

(a) Cable levels

(b) Design losses

(c) Design gains

(d) Expected measured gain (EMG).

Design losses in each direction of transmission must include the following:

(a) Loss of office wiring to the switch

(b) Terminating set (hybrid and pad) losses

(c) Cable-pair losses:

For loaded cable, use attenuation or 1200-1200 ohm transducer values.

For nonloaded cable, use V4 section or Section 304-305-100 and include BT loss.

(d) Equalizer losses (EQL receive side for loaded cable)

(e) PBX trunk circuit loss.

3.23 An alternate lineup procedure, for 4-wire metallic facilities, establishes +7, -16 transmission level points at the 24V4 repeater at the PBX. The standard level points are set up in the 24V4 repeater between the 227 amplifier IN and OUT jacks facing the 1M or 1N terminating sets. The amplifier gains and terminating set pad losses are computed to establish these standard levels for ease of lineup, maintenance, and trouble testing. To accomplish this procedure, the following steps should be taken.

(a) Compute the transmit pad loss to give -16.0 dBm amplifier input (allow 4.5-dB hybrid loss).

(b) Compute the transmit amplifier gain to give the 2-wire line input.

(c) Compute the receive amplifier gain to give +7.0 dBm 4-wire input to the terminating set.

(d) Compute the receive pad loss which will give the required ICL. Include 4.5-dB hybrid loss and the loss of the 2-wire loop.

See Part 4D for symmetrical averaging of metallic facility transmission levels.

3.24 Include a table on the circuit layout record card showing the lineup EML adjustments by ranges of cable ambient temperature when temperature compensation is used (see Section

851-300-101). This provides for a more stable layout over the expected range of temperatures.

H. Signaling Equipment Selection

3.25 Range extension is required when the total conductor loop resistance from the dial tone CO to the PBX exceeds the signaling range. Refer to Part 4A for signaling design procedures.

3.26 The LSR unit (J99343AC or AF) of the MFT group provides either loop-start or ground-start operation and is the preferred type of range-extending equipment. The Loop-Start Only (LSO) unit is also suitable for loop-start operation. Both units provide pulse correction when used in either the 2-wire path with the 2-wire transmission unit or in the A and B leads (2-wire to 4-wire operation). This feature permits any number of LSRs to be used in tandem. Normally, no more than two are required. The LSR does not open the transmission path while pulsing, and E6 repeater disablers are not required since disabling is provided by the LSR. The RE designation used in the 4-wire layouts implies the application of either DLL or MFT units; however, the MFT units are preferred. Descriptive information on the LSR is given in Section 332-911-101. The LSR is used with a 2-wire or 4-wire passive transmission unit or with a repeater in double-module mountings. Switch settings must be included on the circuit layout record card. A switch on either side of the 2-wire transmission unit selects the 600- or 900-ohm impedance for that side. The BOR in the LSR may be switched in or out. A reverse switch (REV) interchanges the A and B leads to the switched or station sides of the LSR. (Later models locate the switch within the unit.) The feature is useful when the LSR is associated with a dedicated E6 repeater. Where an LSR is used adjacent to an E6 repeater on a circuit using a DLL at a different location, the LSR disabling control should be used for all applications. The passive 4-wire transmission unit (BB) is used with the LSR for 24V4 2- to 4-wire operation. BORs and reversing switches are provided.

3.27 If the LSR is not available, DLL circuits (per SD-96555 or SD-96234 for loop-start, SD-66474 or SD-66192 for ground-start, and SD-96371 for loop-start or ground-start converter at the switching CO) may be used. It is desirable to specify 120T repeating coils for these types. The 120T-type coils not only provide better transmission than other 120-type coils but also provide a choice of 600- or 900-ohm impedance on one side. Although DLLs with 120T repeating coils are the best of the older DLLs, not more than two in tandem should be used. If more than two are needed, an LSR should be placed at an intermediate location to provide pulse correction.

3.28 Where DLLs (not LSRs) are used at intermediate points in a layout, each E6 repeater is usually supplied with a repeater disabler (Section 851-300-114) to keep the circuit stable in the idle condition. A disabler may be omitted if the loss of a repeatered section between DLLs or a DLL and either end is 2 dB or more. The resistance-capacitance (RC) network across the DLL pulsing contact provides some loss but, if the circuit is low-frequency critical, the RC network is not effective.

3.29 Where a DLL containing an older 14A ballast lamp is required at a PBX, station set currents greater than 65 mA will result in degraded transmission. It is recommended that a 14B ballast lamp be substituted. This can easily be done since both the 14A and 14B lamps are of the plug-in variety and are interchangeable.

3.30 The E6B or the E6RE (MD) battery-boost range extender provides up to 24 volts dc boost and may be used in place of the E6 repeater 832A (dummy) network shown at CO(A). The E6B (E6RE) provides repeater disabling and conductor loop resistance range up to 2400 ohms. Refer to Ref. 26 of Chart 2B.

3.31 Where range-extending equipment is required at the junctions of the 2-wire and 4-wire links, LSRs (J99343BB with AC, AF) or DLLs (SD-96234 or SD-96555; options ZK, ZL, and ZM) may be used. SD-66474 and SD-66192 DLLs may be used in ground-start circuits at these junctions, but options are not available to connect these devices to the A and B leads. Care should be taken in the use of the older type ground-start DLLs since some types do not provide forward-disconnect supervision. Therefore, the suggested use of LSR units is justified since the LSR is suitable for connection between the SX, SX1, and A, B leads. A repeater disabler is not required in the 2-wire extension for this arrangement. The use of either the LSR or a DLL with 24V4 repeaters also prevents noise, picked up by the 4-wire simplex circuit, from entering the 2-wire circuit. Since DLL options ZK,

ZL, and TM short out the repeating coil, the type used is not important.

3.32 An alternative to loop-type DLLs on 4-wire CO-CO links is the use of SF signaling units (coded S on the layouts). The preferred SF units are the F-type units. The FUA or FUD converter with one of the auxiliary units, such as the FLA or FSA, may be used. These combinations provide loop-start or ground-start signaling over 2-wire links with external circuit resistance up to 1200 (with the FLA) and 1800 (with the FSA) ohms. Where longer 2-wire links are required, the 4-wire FPA and FRA units may be used in conjunction with a 24V4 repeater (which uses a type 1M or 1N terminating set) located at the far end of the 4-wire link. The newer FUD converter is preferred for use with 2-wire extensions since gain and equalization are provided. The F-type signaling units may be used in many combinations, depending on the specific 2-wire link requirements (see Section 851-300-150). Where F-type signaling units are not available, E-type units (E1P, E1R, E2L, and E2S) may be substituted, provided these units can fulfill the limitations and circuit criteria (see Ref. 17, Chart 2B).

All Carrier or Mixed Carrier-and-Metallic Facilities

3.33 Where D1 and D3 foreign-exchange channel units are used, external signaling equipment is not required since their loop signaling ranges are sufficient for trunk designs. For inband signaling, the SF signaling units listed in 3.32 are used. Channel units for links employing SF and D1-D3 digital signaling are selected for the type of loop signaling used in the 2-wire extension. Four-wire metallic sections may be used on either or both sides of a carrier channel in the CO-CO link.

3.34 The E&M to loop signaling converter units used with analog carrier channels (Ref. 22 and 32, Chart 2B) may require range extension when located at CO(I). The MFT J99343FA-FD units provide loop-start or ground-start conversion and may be used at any location indicated by DLL-1 and DLL-2 notation in the layouts.

I. E6 and V4 Design Procedure

3.35 The following procedure is used to select a layout code. The procedure is outlined in Chart 1 which lists table and figure references. Attenuation loss values are used for coding the link loss limits shown in Fig. 2B and 2C. Transducer loss values should be used for gain computations. A 900-600 transducer loss conversion table is provided on these figures. Refer to Section 851-300-101 for cable attenuation and 2-wire network loss factors.

(a) Where the facility is 2-wire or 4-wire metallic, determine:

(1) The working length of each gauge

(2) Whether it is loaded or nonloaded

(3) Total length of bridged taps (BTs).

Note: BTs are only permitted in the PBX end section. Refer to Part 3B for metallic facility information.

(b) Compute separately the 1-kHz loss at 68°F for working lengths of underground cable, aerial cable, and bridged taps for temperature correction.

(c) Compute the total cable loss for each link, including bridged taps on nonloaded cable. Bridged tap losses in the end sections of loaded cable are not included in this calculation.

(d) Select the code for each link from:

Fig. 2B—Combined Designs

Fig. 2C—Individual Link Design

(e) If the link loss is greater than that allowed in any one link for 2-wire facilities, it will be necessary to use 4-wire facilities (either metallic or carrier).

(f) Combine the link codes in left-to-right order from CO(A) to PBX to form the 2-digit layout code. Add the letter A to trunk codes when terminal balance at the PBX is not required.

(g) Check the following tables to see whether the layout code is listed:

Table B—Combined Designs

Table C—Individual Link Designs

If it is not, select a different design premise for one of the links (eg, 4-wire *vs* 2-wire or loaded *vs* nonloaded). Again check the appropriate table to see whether the new layout code is listed. If it is not, repeat the above process until an acceptable code is found.

(h) Select the coded layout from the following figures:

Fig. 12—Overall Designs

Fig. 13—1-dB CO-CO Links

Fig. 14—CO(Z)-PBX Links

Note: If the desired coded layout is not shown in Fig. 12, try selecting links from Fig. 13 and 14.

(i) The need for range-extending equipment required can be made only after the conductor loop resistance is calculated as outlined in Part 4. A letter code added to the numerical layout code (L for loop signaling, S for SF signaling, etc) indicates the type of signaling chosen.

(j) The maximum sum of the link losses for nonrepeatered layouts has been set to limit the overall ICL to 4.0 dB (class 5) or 4.0 to 5.0 dB (class 4) (see Ref. 6, Chart 2B). The overall loss requirement for LD and WATS trunks terminating in a class 4 office is limited to 4.5 dB (VNL + 4.0 dB) for repeatered and nonrepeatered layouts. This allows access into the DDD network at a level consistent with the grade-of-service concept.

(k) The use of repeaters allows the ICL for FX trunks to be reduced to 3.5 dB for repeatered 2-wire layouts. This reduction is necessary when the maximum nonrepeatered 4.0-dB limit is exceeded.

4. DESIGN CONSIDERATIONS

4.01 This part provides general design information that applies to any equipment layout or circuit arrangement selected.

A. FX, WATS, and LD Trunks Signaling Design

4.02 The conductor loop resistance (CLR) of metallic 2-wire, 4-wire, and 4-wire links with 2-wire extensions from CO(A) (dial tone CO) through the PBX to the longest PBX station extension must be determined to ensure adequate signaling to class 5 and class 4 offices. The simplex resistance for 4-wire facilites is used. The CLR includes the cable loop resistance and any equipment in the signaling path. The procedures given in this part are based on the information and range tables listed in Section 851-300-170, Issue 1. Signaling unit locations and range table references are shown in Fig. 7. Section 851-300-170 should be consulted before signaling designs are begun. The range tables given in Section 851-300-170 provide satisfactory signaling for all FX, WATS, and LD trunk designs. Figure 7 shows range table references and signaling unit locations as configurations 1 through 5 for trunks. Configuration 5 locates the signaling unit at the PBX and should be necessary only when the PBX type is not listed in the range tables or the CLR to the PBX station exceeds the trunk range requirement.

4.03 Perform the following procedures for each metallic link or overall layout.

(a) Select the coded layout and do the initial transmission design. This locates transmission equipment in the signaling path.

(b) Determine the following data:

(1) Type of switching equipment of CO(A) which is the dial tone office.

(2) Type of PBX and station set (equipment)

Note: When TOUCH-TONE® station sets (LC dials) are used with polarity guards, add 116 ohms to the station CLR.

(3) The CLR of transmission equipment in the signaling path. Refer to Sections 851-300-101 (E6), 852-307-101 (V4), and 851-300-130 (MFT).

(c) Determine if a signaling unit is required:

(1) Compute the cable plus transmission equipment CLR from CO(A) to the PBX. Do each link separately. Call this R_T.

(2) Compute the CLR from the PBX to the longest on- and off-premises station. For off-premises station lines equipped with a

signaling unit, the CLR is computed to the signaling unit. Use Rs to indicate the largest CLR from the PBX to the station or signaling unit. For the DIMENSION® PBX, CLR information on lines is not necessary since the trunk resistance is independent of line resistance unless emergency transfer is a feature of a particular installation (see 4.07).

(3) Determine the maximum trunk CLR range:

Using Rs, determine the maximum allowable trunk range from the CO-to-PBX tables in Section 851-300-170. For cases not covered by Section 851-300-170, use Sections 534-362-151 through 534-362-160.

Note: If the PBX has tie trunks, the maximum allowable trunk range may be further restricted. Check the CO-to-PBX tables in Section 851-300-170 with the table in SD-65718.

(4) If R_T is within the trunk CLR ranges, use configuration 1 of Fig. 7. No signaling unit is required.

(5) If R_T exceeds the trunk ranges, one or possibly two signaling units are required.

(d) Determine the location of signaling unit(s) using the lowest numbered configuration in Fig. 7 that will meet the signaling ranges.

Use the following guidelines.

(1) Use the appropriate table in Section 851-300-170.

(2) Use configuration 5 when sufficient range information is not available or when the CLR to the station requires it.

(3) If a signaling unit is not required at the PBX, try one at the CO nearest the PBX and then moved toward the dial tone CO if necessary. It is desirable to place the signaling unit near the PBX to insure a station set current of 36 to 65 mA, although 23 mA is acceptable.

(4) When two signaling units are used, the range between them may be reduced by the use of an E6 repeater. Guidelines are given in Section 851-300-170 for E6 repeater applications.

(e) Select options for the type of signaling unit to be used (see Section 851-300-170). Check impedance options on signaling units at the PBX. Refer to Tables D, E, and F in this section when impedance compensators are used.

(f) If an E6 repeater disabler (J99253L) is used, add 138 ohms to the CLR (see section 851-300-114).

Note: Disabling by an adjacent 2-wire transmission unit and LSR adds the coil resistance and BOR used.

(g) Recheck the transmission layout and include the signaling unit(s) 1-kHz loss in the 2-wire repeater gain computation.

(h) Check the lead continuity in the signaling path. The coded layouts indicate the switch settings.

B. SMAS-4A Access Points

4.04 Switched Maintenance Access System 4A (SMAS-4A) provides access for testing FX, WATS, and LD trunks at central office locations either locally or by the Switched Access Remote Test System 1A (SARTS-1A). Figure 11 shows examples of central office locations for a minimum number of access points for the various circuit arrangements used in standard design layouts. The access points in Fig. 11 are grouped by the corollary rule numbers outlined in Section 667-302-103. MFT equipment with built-in access points are indicated. The possible access point circuit locations shown in the coded layouts are indicated by codes (AP-1, AP-2, AP-3, AP-4, and AP-5) to correspond with the corollary rules. Additional information is available in Sections 667-302-102 and 667-302-200.

C. DIMENSION PBX Applications

4.05 The DIMENSION PBX (formerly CSS201) (J58879, SD-1E440) provides time division switching with stored program control and is compatible with all types of FX, WATS, and LD trunk standard designs. The LC8 circuit pack provides a 600-ohm termination for 2-wire facilities using ground-start signaling. Ground-start operation is provided on incoming and outgoing calls with

dial pulsing toward the CO (outgoing). The conductor loop resistance range for connecting 2-wire facilities is listed in Section 851-300-170. The battery-boost types of signaling units (LSE and E6B) provide extended ranges for the LC8 circuit pack.

4.06 The time division switching network used by the DIMENSION PBX cannot pass dc signals; therefore, supervisory and dial pulse signals are regenerated on outgoing calls. Dial pulses are regenerated at a constant 10-pulse-per-second rate with 60-percent break. Signaling units are not often required at the DIMENSION PBX. Refer to sections in the 554 division for additional information on the DIMENSION PBX.

4.07 ***Emergency Transfer:*** The emergency transfer feature of a DIMENSION PBX provides service to and/or from the exchange network for a limited number of preselected (station) lines during a power failure at the PBX when reserve power is not provided or is depleted. When a power failure occurs, preselected PBX-CO trunks are connected directly to the preselected lines. Consequently, the CLR of the trunk plus the CLR of the line must not exceed the range limit of the circuit (CO or RE) that supplies talk battery. If the line CLR does not exceed 100 ohms, the trunk plus line resistance will not exceed range limits. However, where the line CLR does exceed 100 ohms, the sum of the trunk and line resistance must be checked to insure proper operation during emergency transfer.

D. Metallic Facilities Transmission Levels

4.08 Transmission levels for metallic facilities are established to minimize crosstalk between cable pairs. The transmission level point (TLP) values shown in Table G are the 1-kHz maximum transmitting and minimum receiving TLPs for the crosstalk limited cable losses. The TLP values in Table G are the gain (+) or loss (-) relative to 0 TLP. The milliwatt (MW) supply shown in the layouts is considered to be at 0 TLP. The 1-kHz test tone power in dBm will be equal to the TLP values when 1 milliwatt (0 dBm) is applied at the 0 TLP (0 dBm0) or when the 1-kHz test tone power level is adjusted equal to other TLP values at other circuit points. For example, if +6 dBm were applied at +6 TLP, the level at the -9 TLP would be -9 dBm. If 0 dBm were applied at the +6 TLP, the level at the -9 TLP would be -15 dBm.

4.09 When the cable loss between repeaters is less than the maximum 15-dB or 12-dB values indicated in Table G, it is recommended that the maximum and minimum TLPs shown in Table G be adjusted symmetrically about the actual cable loss used for lineup. This procedure minimizes crosstalk by lowering transmitting levels. Symmetrical averaging of the maximum transmitting and minimum receiving TLPs based on the actual cable pair transducer loss is provided as follows:

$$TLP_{TA} = [TLP_T\,(Max) + TLP_R\,(Min) + Loss] \div 2$$

$$TLP_{RA} = [TLP_T\,(Max) + TLP_R\,(Min) - Loss] \div 2$$

Where:

TLP_T (Max) = Maximum cable pair transmitting TLP at CO or PBX location from Table G.

TLP_R (Min) = Minimum cable pair receiving TLP at CO or PBX location from Table G.

TLP_{TA} = Adjusted transmitting TLP

TLP_{RA} = Adjusted receiving TLP

Loss = Cable transducer loss with proper terminations.

Table I is a summary of formulas for 4-wire applications using the maximum and minimum TLP values from Table G. Only the actual cable transducer loss to be used need be substituted to obtain adjusted TLP values.

4.10 Repeater net gains for 2-wire layouts are computed to produce the assigned link net loss (TL) or the ICL for end-to-end overall layouts. Figure 4 gives the equations for computing MFT repeater gains for the range of acceptable transducer loss limits for the various repeater locations for 2-wire designs. Allocation of repeater gains for the cable loss limits shown minimizes level differences for the best crosstalk performance. The gain equations are valid for loss limits between repeaters less than 10 dB and approximate from 10 dB to the 15 dB maximum. The TLP values along a 2-wire layout are computed by assigning 0TLP to the switch at CO(A) or the PBX and assigning other TLP values along the layout using the cable

loss and computed repeater gains. Repeater gains for E6 repeatered links or overall designs are computed to produce the required link net loss or the ICL for overall designs using repeater locations indicated in the coded layouts.

E. V4 Equipment Considerations

4.11 ***Terminating Set Switch Options:*** One reversal of the simplex signaling leads is required to preserve the continuity between end units. The proper SX reverse (REV) - Normal (NOR) switch positions are shown on the standard design layouts. The terminating set SX inductors are shorted when either a DLL or MFT signaling unit is used at the PBX or CO(Z) facing the PBX. SX inductors are used when DLL or MFT signaling units are not required. The appropriate NBOC screws should be down when terminal balance is required. The COMP NET screws are turned down at CO(A) and PBX locations.

4.12 ***Equipment and Cable Losses:*** Losses for terminating sets and equalizers are listed in the V4 sections referenced in Section 851-300-101. Nonloaded cable losses should be the cable transducer (not attenuation) loss between the impedances determined by the type of equalizer facing the cable (150 ohms for 359B equalizers, 600 ohms for 359F equalizers). Table H lists the types of 359 equalizers for nonloaded cables by gauge and length. Cable plus equalizer losses are given in chart form in Section 852-307-102 for solid gauges. Cable transducer losses for single and mixed gauges with and without bridged taps may be found in Section 304-305-100. Losses for loaded cable may be the attenuation loss or the 1200-ohm transducer losses. The differences between these loss quantities are very small for loaded cables.

4.13 ***V4 Amplifier Gain and Pad Loss:*** The procedures given in the V4 sections referenced in Section 851-300-101 should generally be followed to determine the 227 amplifier gain or pad loss when amplifiers are not required. The method of computing cable facility transmission levels for minimum crosstalk given in Part 4D should be used. The maximum transmitting and minimum receiving levels for cable facilities should not be exceeded. Transmitting amplifier gains are set to establish the computed cable input level while receiving amplifier gains at CO(A) and the PBX are set to an output level that will produce the layout EML. When PBX +7 and -16 TLP operation for metallic facilities is not desired, the 1N or 1M terminating set should include at least 5.0-dB pads to improve the 2-wire return loss. The 1N or 1M terminating set has fixed NO AMPL impedance correction shunts and the use of less than 5.0-dB pad between the amplifier and the terminating set will result in degraded 2-wire return loss. The receive pad also helps reduce the impedance variation caused by different receive amplifier gain settings. Amplifier gains are increased beyond other circuit losses to compensate for the loss of these pads. Where carrier channels or SF signaling units are used, amplifier gains or pad losses are set to meet the +7 and -16 TLPs shown on the layouts.

F. Combined E6, V4, and MFT Equipment Designs

4.14 V4 and MFT repeaters will operate satisfactorily within the same repeater section for all types of H88 loaded and nonloaded cables when the proper equalization techniques are used. Substitute a terminal or intermediate MFT repeater for the 24V4 or 44V4 repeater shown in the standard design layouts in Fig. 12. Use the E6-V4 facility loss limits shown in Fig. 2B and 2C. Figure 15 shows examples of combined repeaters used in 4-wire layouts and 4-wire links with 2-wire extensions. When V4 and MFT repeaters are used for the same layout, the 2-digit numerical code may be optionally prefixed with MV to indicate the V4-MFT equipment combination. Cable transducer loss values are used for gain computation. Prescription equalizer settings for 4-wire MFT repeaters are given in Section 332-912-232. Refer to the equalization techniques for MFT repeaters outlined in Section 851-300-130.

4.15 The first 4-wire layout in Fig. 15 (code MV65-L) uses the MFT J99343SB intermediate repeater with 24V4 terminal repeaters. The SB repeater provides post and pre-equalization for the layout with the 359-type V4 equalizers providing either 600- or 1200-ohm cable terminations without equalization. A second arrangement of the same 4-wire layout uses an intermediate 44V4 repeater equipped with 359-type network equalizers. Post equalization is provided jointly by the intermediate 44V4 repeater and the terminal J99343RA repeaters. The reduced facility loss limits are controlled by the 359-type equalizers. The third layout (code MV62-L) uses the 4-2 intermediate MFT repeater which provides equalization for both the 4-wire and 2-wire links. MFT facility limits are used for this case. The 24V4 repeater at CO(A) provides

no equalization. The fourth layout (code MV63-L) uses post equalization for the 4-wire link, supplied by the intermediate 24V4 repeater and the terminal RA repeater. The 2-wire link uses an E6 repeater which permits link design for the layout. When an MFT repeater provides both pre- and post equalization, the 4-frequency measurement method outlined in Section 332-912-231 must be used to obtain prescription settings.

4.16 Two-wire MFT coded layouts shown in Fig. 5 may use an E6 repeater at CO(A) or at an intermediate CO for the 2-repeatered layouts. End link facility loss is limited as indicated in Fig. 5 to meet roll-off objectives. Layouts using combined MFT and E6 repeaters may optionally prefix the numerical layout code with ME to indicate combined repeater layouts.

5. EXAMPLES OF PERFORMANCE

5.01 Figures 16 through 21 show the frequency-loss and envelope-delay distortion characteristics of a number of all-metallic 2-wire layouts using E6 and MFT repeaters. Four-wire metallic links were not included since they generally provide superior transmission performance. Carrier channels were not included as they are essentially flat in the 0.3- to 3.0-kHz voiceband and contribute little to overall high-frequency roll-off in a layout.

5.02 The frequency-loss characteristics were plotted using 900- and 600-ohm resistive terminations at CO(A) and the PBX, respectively. Return-loss measurements were plotted using a 900-ohm + 2.16 μF termination at CO(A) and a 600-ohm + 2.16 μF or 4066H termination at the PBX. The 4066H network provides an equivalent station set impedance termination for currents less than 36 mA. If a 900-ohm impedance had been selected for the PBXs, requiring different types of terminating sets, the overall performance would have been about the same as shown for the 600-ohm condition.

5.03 Figures 16 and 17 compare the performance of similar facilities using E6 and MFT terminal repeaters at CO(A). The 2.8-kHz roll-off for the E6 repeatered layout is near the 4.5-dB trunk limit. The MFT repeatered layout roll-off is 2.7 dB. Some low- and high-frequency roll-off is desirable in 2-wire circuits to improve the circuit stability. MFT designs for nonloaded cables can be equalized up to the assigned loss limits.

5.04 Figures 18 and 19 show the loss characteristics of a long loaded CO-CO link with nonloaded and loaded CO-PBX end lengths. Repeating coil DLLs are not used in either layout. The effect of terminal balance at the PBX is shown.

5.05 Figures 20 and 21 show the frequency loss, return loss, and envelope delay distortion for a loaded layout using 22H88 and 26H88 cables with two DLL units using 120C and 120T repeating coils.

6. REFERENCES

6.01 The following are related sections that will often be required to design FX, WATS, and LD trunks using E6, V4, and MFT equipment.

SECTION	TITLE
851-300-100	Transmission Objectives
851-300-101	General Design Considerations (additional references listed)
851-300-106	Administrative and Maintenance Considerations
851-300-110	E6 Repeater Application—Nonloaded Cable
851-300-111	E6 Repeater Application—Loaded Cable
851-300-112	Impedance Compensating Networks—Nonloaded Cable
851-300-113	Impedance Compensating Networks—Loaded Cable
851-300-114	Application of Repeater Disablers
851-300-120	V4 Repeater Design Applications (additional references listed)
851-300-130	MFT Equipment Design Applications (additional references listed)
851-300-141	Common Language Codes—Special Services
851-300-150	F Signaling General—Special Services

SECTION	TITLE
851-300-155	Digital Carrier System—Special Services
852-307-101	V4 Repeaters—Message Circuits
852-307-102	V4 Repeaters—Loss and Gain
667-302-102	SMAS-4A—Access Point Location
667-302-103	SMAS-4A—Access Point Assignment
667-302-200	SMAS-4A—Access Point Cross-Connections
554-101-1ZZ	DIMENSION (CSS201) PBX
332-206-129	E6 Range Extender
332-610-100	CPFT—Description
332-610-200	CPFT—Installation
332-610-500	CPFT—Maintenance and Tests
332-910-102	Test Extender (J99343TB)
332-910-180	MFT—Applications
352-912-211	MFT 2-Wire Repeaters—Installation and Tests
332-912-212	MFT 2-Wire Repeaters—Prescription Equalizer Settings
332-912-221	MFT 4-2 Wire Repeaters—Installation and Tests
332-912-222	MFT 4-2 Wire Repeaters—Prescription Equalizer Settings
332-912-231	MFT 4-Wire Repeaters—Installation and Tests
332-912-232	MFT 4-Wire Repeaters—Prescription Equalizer Settings
311-350-100	PBX Trunks—Balance Tests
311-350-500	PBX Trunks—Balance Tests
304-305-100	Transducer Loss—Tables
179-100-322	Signaling Compatibility

7. INDEX OF TABLES, CHARTS, AND FIGURES

7.01 The following list of tables, charts, and figures provide access to specific information used in design work.

TABLE	TITLE
A	Valid MFT Repeatered Layout Codes
B	Valid Layout Codes for Combined E6-V4 Layouts
C	Valid Codes for Link Design E6-V4 Layouts
D	Network Selection and Range-Extender Impedance for 22-, 24-, and 26-Gauge Nonloaded Cable Links
E	Network Selection and Range-Extender Impedance for 19-, 22-, and 24-Gauge H88 or D88 Loaded Cable Links
F	Network Selection and Range-Extender Impedance for 25H88 and 26H88 Loaded Cable Links
G	Metallic Facilities Maximum Permissable Transmitting Transmission Level Point (TLP) and Minimum Permissable Receiving Transmission Level Point (TLP) (Crosstalk Limiting)
H	Nonloaded Cable 359-Type Equalizers for V4 Repeater Applications
I	Four-Wire Metallic Facilities Transmitting Transmission Level Point (TLP) and Receiving Transmission Level Point (TLP) Adjustment Formulas

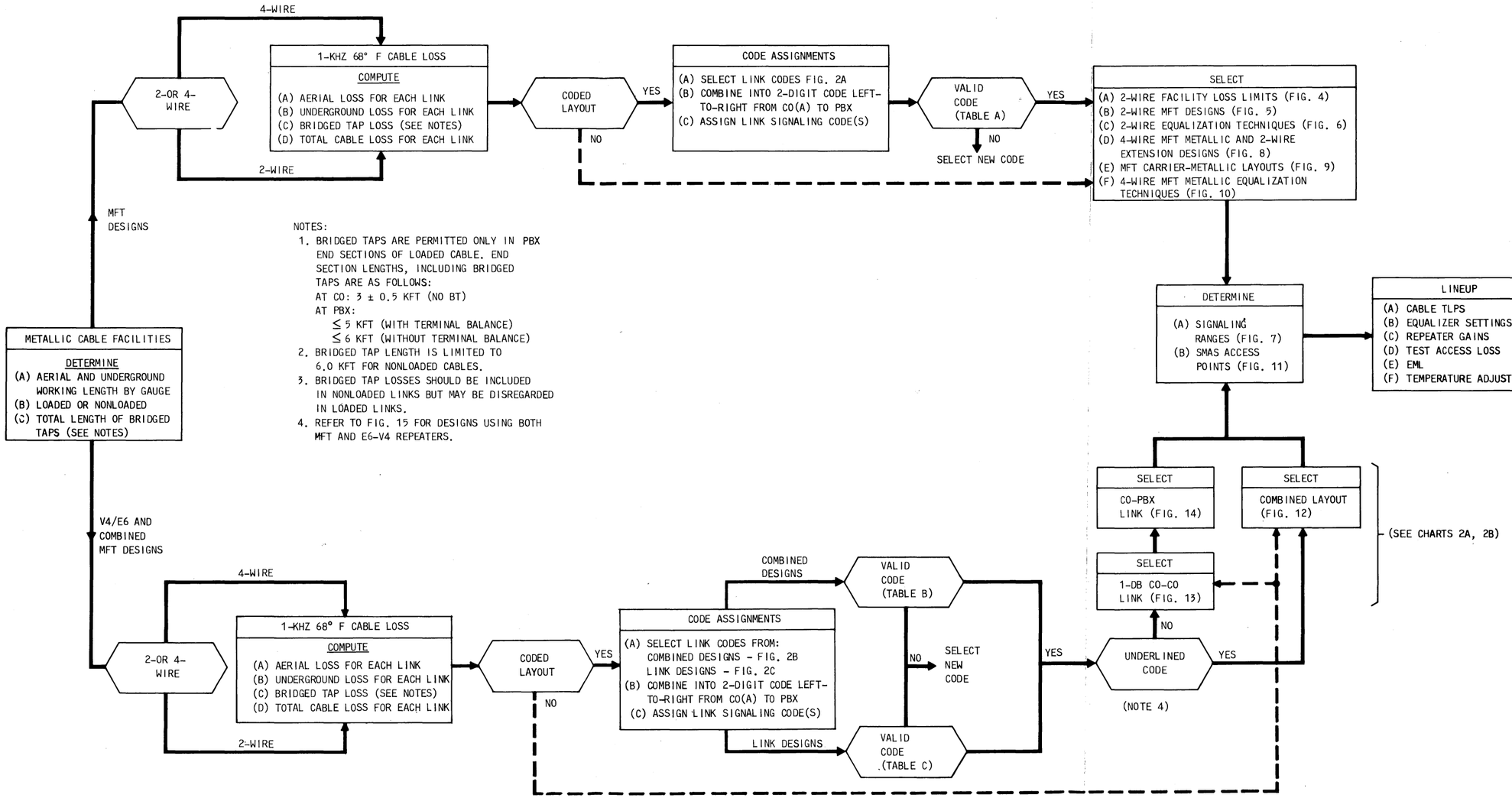


CHART 1—FX, WATS, or LD Trunks

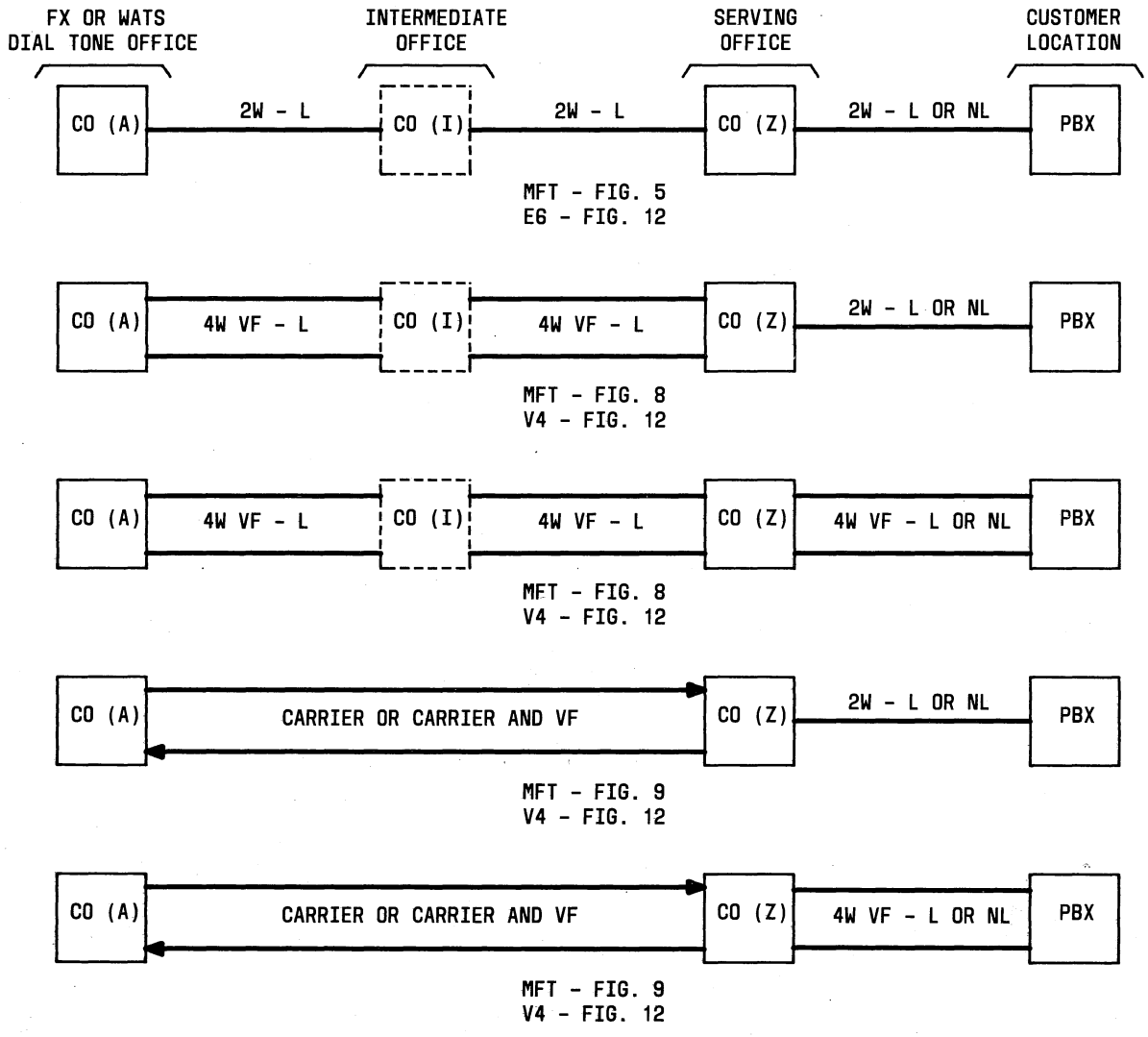


Fig. 1—General Layout Plan for FX, WATS, or LD Trunks

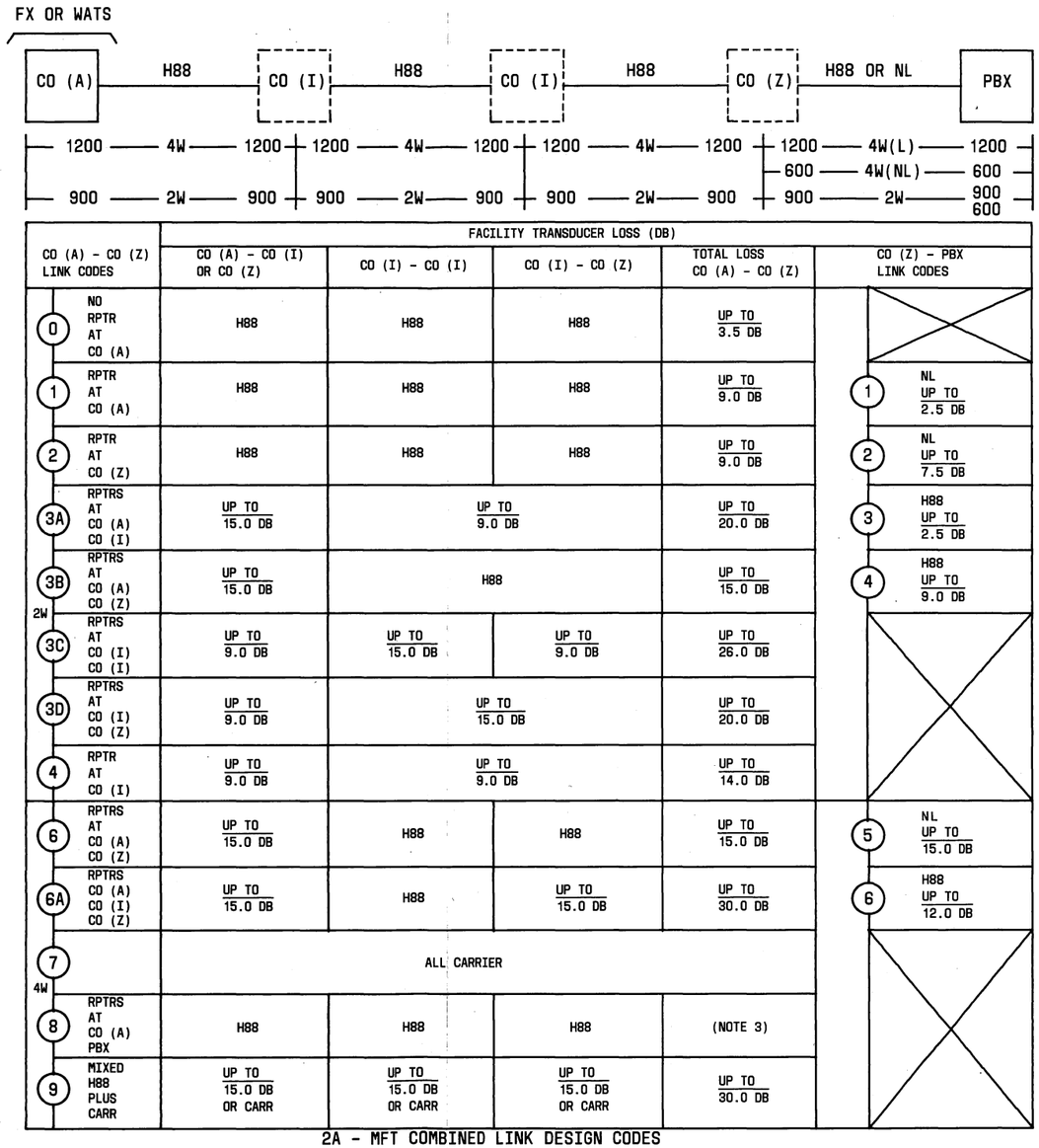
TABLE A

VALID MFT REPEATERED LAYOUT CODES

2-WIRE CODES				
01-L (NOTE 6) 03-L (NOTE 6) 11-L 13-L 14-L	21-L 22-L 23-L 24-L	3A1-L 3A3-L 3A4-L 3B1-L 3B2-L 3B3-L 3B4-L	3C1-L 3D1-L 3D2-L	41-L 43-L 44-L
4-WIRE CODES				
61-L,SL 62-L,SL 63-L,SL 64-L,SL 65-L 66-L	6A1-L,SL 6A2-L,SL 6A3-L,SL 6A4-L,SL 6A5-L 6A6-L	71-ML,CL,SL 72-ML,CL,SL 73-ML,CL,SL 74-ML,CL,SL 75-ML,CL,SL 76-ML,CL,SL	85-L 86-L	91-ML,CL,SL 92-ML,CL,SL 93-ML,CL,SL 94-ML,CL,SL 95-ML,CL,SL,S 96-ML,CL,SL,S

VALID CODE NOTES:

1. LETTER CODES C, L, M, AND S INDICATE LINK SIGNALING AS FOLLOWS:
   C — D1 OR D3 DIGITAL CHANNELS
   L — LOOP SIGNALING (LS OR GS)
   M — E&M LEAD ANALOG CARRIER
   S — SINGLE FREQUENCY (SF).
2. A SINGLE LETTER INDICATES THAT ONE TYPE OF SIGNALING IS USED FOR BOTH LINKS. A COMBINATION OF LETTERS INDICATES THAT A DIFFERENT TYPE IS USED FOR EACH LINK.
3. SUFFIX THE LAYOUT NUMERICAL CODE WITH THE FOLLOWING ALPHABETICAL CODES TO INDICATE USE OF IMPEDANCE COMPENSATOR:
   B — REQUIRED AT CO(A)
   C — REQUIRED AT PBX
   D — REQUIRED AT CO(A) AND PBX.
4. NONLOADED PBX LINKS-MAXIMUM 6 KFT OF BRIDGED TAP (BT).
5. LOADED PBX LINKS-END SECTION PLUS BT EQUAL TO OR LESS THAN 5 KFT WITH TERMINAL BALANCE, UP TO 6 KFT WITHOUT TERMINAL BALANCE.
6. NONREPEATERED CODES 01-L AND 03-L — MAXIMUM LOSS 4 DB (CLASS 5) OR 4 TO 5 DB (CLASS 4).



2A - MFT COMBINED LINK DESIGN CODES

CODING NOTES:
1. CIRCLED NUMBERS DENOTE LINK CODE ASSIGNMENTS.
2. THE DB FACILITY LIMITS ARE TRANSDUCER LOSS (TL) VALUES (SEE SECTION 304-305-100).
3. THE FACILITY LOSS FOR CODES 85-L AND 86-L ARE AS FOLLOWS:
   85-L: 15.00 DB, 86-L: 12.0 DB

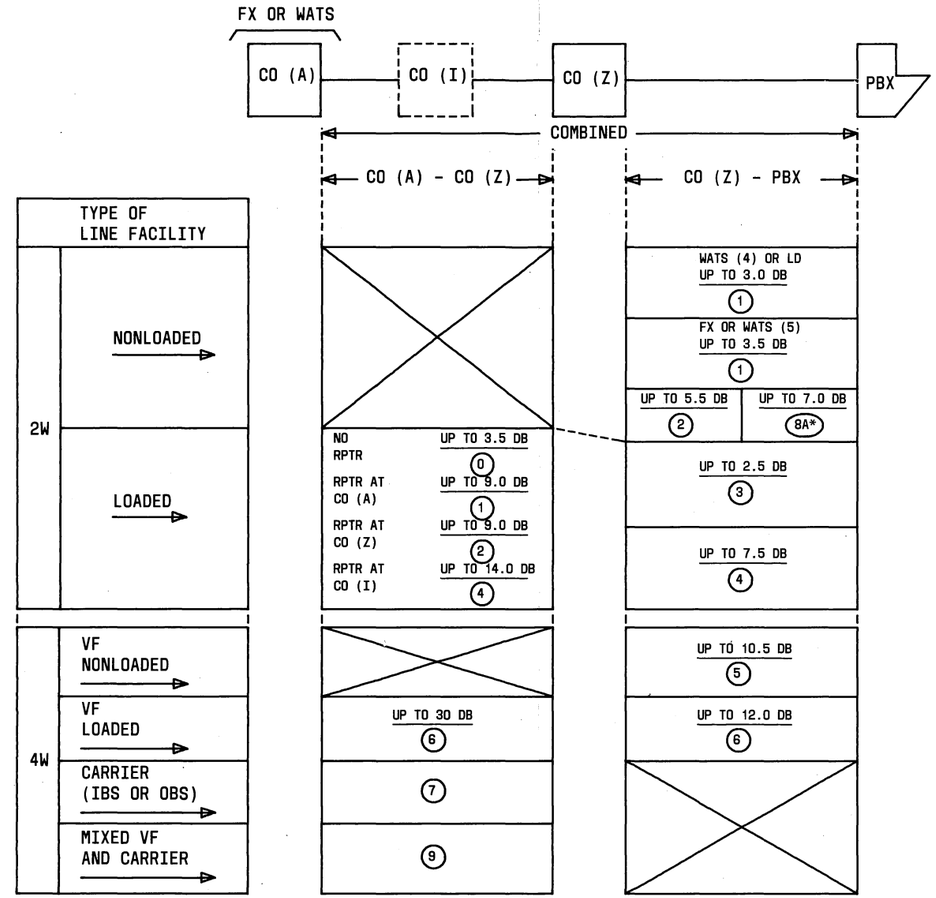
Fig. 2A—Prescription Code Assignments for MFT Repeatered Layouts and TABLE A

TABLE B

VALID LAYOUT CODES
FOR COMBINED E6-V4 LAYOUTS
(Notes Shown on Sheet 2)

COMBINED LINK LAYOUT CODES		MAXIMUM OVERALL FACILITY (TRANSDUCER) OR ATTENUATION LOSS (dB)				
		CODE	CLASS 5		CLASS 4	
			WITH INTER. DLL	NO INTER. DLL	WITH INTER. DLL	NO INTER. DLL
01A-L	43A-L	01A	(4.0)*	(4.0)	(4.0—5.0)	(4.0—5.0)
03A-L	44-L	03A	(4.0)	(4.0)	(4.0—5.0)	(4.0—5.0)
05-L	44A-L	11A	7.0	9.0	—	—
06-L	61A-L	13A	8.0	9.0	—	—
11-L	63-L	14A	8.0	9.0	—	—
11A-L	63A-L	21A	8.0	10.0	8.0	10.0
13-L	65-L	22	6.0	6.0	6.0	6.0
13A-L	66-L,S	23A	10.0	11.5	10.0	11.5
14-L		24A	10.0	13.0	10.0	14.0
14A-L	71A-CL,ML,SL	28A	6.0	7.0	6.0	7.0
21A-L	73-CL,SL	41A	8.0	11.0	8.0	10.0
22-L	73A-CL,ML,SL	43A	10.0	14.0	10.0	14.0
23-L	75-CL,ML,SL	44A	10.0	14.0	10.0	14.0
23A-L	76-CL,ML,SL					
24-L	91A-SL					
24A-L	93-SL					
28A-L	93A-SL					
41-L	95-SL,S					
41A-L	96-SL,S					
43-L						

*PARENTHESES INDICATE TRANSDUCER LOSS. OTHER VALUES ARE ATTENUATION LOSS.



2B - E6-V4 COMBINED LINK DESIGN CODES

CODING NOTES:
1. CIRCLED NUMBERS DENOTE LINK ASSIGNMENTS.
2. THE DB LIMITS REFER TO 1-KHZ ATTENUATION LOSS (BRIDGED TAP LOSS FOR NONLOADED CABLE MUST BE INCLUDED.)
3. NUMBERS IN PARENTHESES DENOTE THE OFFICE CLASS OF CO (A).
4. SUFFIX THE LETTER A TO LAYOUT CODE WHEN TERMINAL BALANCE AT THE PBX IS NOT REQUIRED FOR 2-WIRE CO (Z) - PBX LINKS.
5. NONLOADED PBX LINKS-MAXIMUM 6 KFT OF BRIDGED TAP (BT).
6. LOADED PBX LINKS-END SECTION PLUS BT EQUAL TO OR LESS THAN 5 KFT WITH TERMINAL BALANCE, UP TO 6 KFT, WITHOUT TERMINAL BALANCE.
7. * CODE 8A IS NOT VALID WHEN TERMINAL BALANCE IS REQUIRED AT PBX.
8. THE EQUIVALENT 600-900-OHM TRANSDUCER LOSS FOR NONLOADED CABLE IS AS FOLLOWS:

ATTEN DB	TL (DB)
1.0	1.0
2.0	2.0
3.0	2.7
3.5	3.4
4.5	4.0
5.5	4.7
6.0	5.1
6.5	5.5
7.0	6.0
7.5	6.4
8.0	6.5

Fig. 2B—Prescription Code Assignments for E6-V4 Repeatered Combined Layouts

and

TABLE B (Sheet 1 of 2)

NOTES FOR TABLE B

NOTE NO.	INFORMATION
1.	THE LETTER A SUFFIXED TO A CODE INDICATES THE LAYOUT MAY BE USED WITHOUT 837-TYPE NETWORK AT THE PBX WHEN TERMINAL BALANCE IS NOT A REQUIREMENT.
2.	SIGNALING CODES: C-D1 OR D3 DIGITAL CHANNELS L-LOOP SIGNALING (LS OR GS) M-E&M LEAD ANALOG CARRIER S-SINGLE FREQUENCY (SF)
3.	LAYOUT RESTRICTIONS: CODE 41A — LIMIT PBX LINK LOSS TO 1-DB TO MEET ROLL-OFF OBJECTIVES CODE 11A — WHEN THE CO(Z) END-SECTION LENGTH EXCEEDS 3000 FT., CONSIDER THE EXCESS AS PART OF THE NONLOADED PBX LINK. THIS ENSURES ROLL-OFF OBJECTIVES WILL BE MET.
4.	FOR PBXS REQUIRING TERMINAL BALANCE, SUBTRACT 0.5 DB FROM THE OVERALL LOSS LIMIT TO ALLOW FOR THE 837-TYPE NETWORK LOSS. THE FOLLOWING CODES ARE EXCEPTIONS: CODE 01 — THE 837D NETWORK LOSS OF 4 DB WILL REQUIRE AN E6 REPEATER FOR THE LAYOUT. THE LAYOUT CODE THEN BECOMES 22. CODE 22 — NO REDUCTION IN OVERALL FACILITY LOSS IS NECESSARY SINCE THE LOSS OF 830C AND 837D NETWORKS HAS BEEN INCLUDED IN THE OVERALL LOSS LIMIT. 837G NETWORK — SUBTRACT 1.5 DB FROM THE PBX 837J LINK LOSS.
5.	PBX TERMINAL BALANCE RULES: (a) REDUCE OVERALL FACILITY LOSS FOR 837-TYPE NETWORK USED. (b) LOADED CABLE — PBX END SECTION PLUS BT MUST NOT EXCEED 5 KFT. (c) NONLOADED PBX LINK CODE 1 — SUBTRACT 0.25 DB FROM THE LINK LOSS LIMIT FOR EACH KFT OF BT. IF THE DIFFERENCE IS GREATER THAN THE ACTUAL LOSS OF THE LINK, THE LINK CODE WILL BE 2. (d) CODES 11,41 — THE SUM OF CO(Z) END SECTION, PBX LINK, AND BT LENGTHS MUST NOT EXCEED 5 KFT.
6.	PBX TERMINAL BALANCE NOT REQUIRED: (a) LOADED CABLE — PBX END SECTION PLUS BT MUST NOT EXCEED 6 KFT. (b) NONLOADED PBX LINK CODE 1 — SUBTRACT 0.25 DB FROM THE LINK LOSS LIMIT FOR EACH KFT OF BT. IF THE DIFFERENCE IS GREATER THAN THE ACTUAL LOSS OF THE LINK, THE LINK CODE WILL BE 8A.
7.	SIGNALING RANGE LIMITS FOR 2-WIRE OVERALL LAYOUTS MAY BE EXCEEDED WHEN THE OVERALL FACILITY LOSS EXCEEDS 12 DB. THE FACILITY LOSS LIMIT OF 14 DB ASSUMES NO INTERMEDIATE REPEATING COIL TYPE DLL IS USED. BATTERY-BOOST (72 VOLT) SIGNALING UNITS MAY NOT ACHIEVE A WORKABLE SIGNALING DESIGN. IN THIS CASE, A LINK DESIGN LAYOUT SHOULD BE USED.

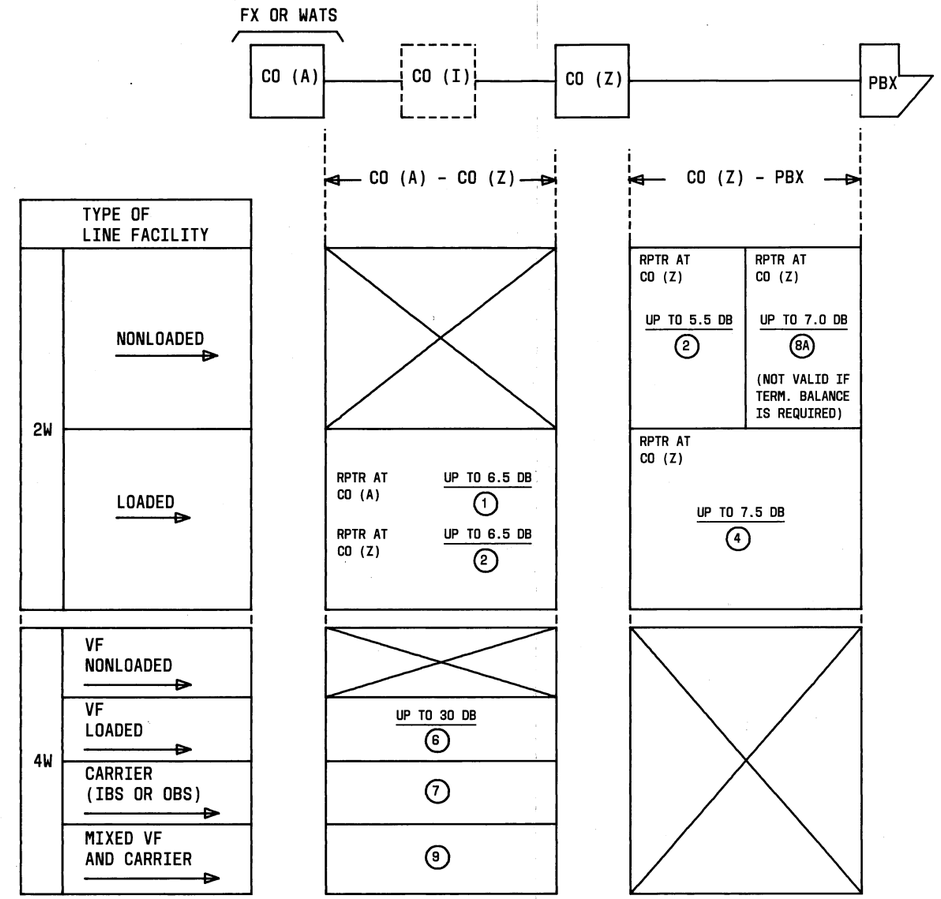
VALID CODE NOTES

1. THE LETTER A SUFFIXED TO A CODE INDICATES THE LAYOUT MAY BE USED WITHOUT 837-TYPE NETWORK AT THE PBX WHEN TERMINAL BALANCE IS NOT A REQUIREMENT.
2. SIGNALING CODES:
   C — D1 OR D3 DIGITAL CHANNELS
   L — LOOP SIGNALING (LS OR GS)
   M — E&M LEAD ANALOG CARRIER
   S — SINGLE FREQUENCY (SF)
3. PBX TERMINAL BALANCE RULES:
   (a) REDUCE PBX LINK LOSS 0.5 DB FOR THE 837 NETWORK USED (ALLOW 4 DB FOR 837D).
   (b) LOADED CABLE — PBX END SECTION PLUS BT MUST NOT EXCEED 5 KFT.
4. SIGNALING RANGE LIMITS FOR 2-WIRE LAYOUTS MAY BE EXCEEDED WHEN THE FACILITY LOSS FOR BOTH LINKS EXCEEDS 12 DB. BATTERY-BOOST (72 VOLT) SIGNALING UNITS MAY NOT ACHIEVE A WORKABLE SIGNALING DESIGN.

TABLE C

VALID CODES FOR LINK DESIGN E6-V4 LAYOUTS

LINK DESIGN LAYOUT CODES	
12-L	64-L,SL
14A-L	68A-L,SL
14-L	72-CL,ML,SL
	74A-SL
	74-SL
18A-L	78A-SL
22-L	92-SL
24A-L	94A-SL
24-L	94-SL
	98A-SL
28A-L	
62-L,SL	
64A-L,SL	



2C - E6-V4 LINK DESIGN CODES

CODING NOTES:
1. CIRCLED NUMBERS DENOTE LINK ASSIGNMENTS.
2. THE DB LIMITS REFER TO 1-KHZ ATTENUATION LOSS (BRIDGED TAP LOSS FOR NONLOADED CABLE MUST BE INCLUDED.)
3. SUFFIX THE LETTER A TO LAYOUT CODE WHEN TERMINAL BALANCE AT THE PBX IS NOT REQUIRED FOR 2-WIRE CO (Z) - PBX LINKS.
4. NONLOADED PBX LINKS-MAXIMUM 6 KFT OF BRIDGED TAP (BT).
5. LOADED PBX LINKS-END SECTION PLUS BT EQUAL TO OR LESS THAN 5 KFT WITH TERMINAL BALANCE UP TO 6 KFT WITHOUT TERMINAL BALANCE.
8. THE EQUIVALENT 600-900-OHM TRANSDUCER LOSS FOR NONLOADED CABLE IS AS FOLLOWS:

ATTEN DB	TL (DB)
1.0	1.0
2.0	2.0
3.0	2.7
3.5	3.4
4.5	4.0
5.5	4.7
6.0	5.1
6.5	5.5
7.0	6.0
7.5	6.4
8.0	6.5

Fig. 2C—Prescription Code Assignments for E6-V4 Repeatered Link Design Layouts and TABLE C

TABLE D

NETWORK SELECTION AND RANGE-EXTENDER IMPEDANCE
FOR NONLOADED CABLE LINKS
22, -24, -26-GAUGE NL

DESIRED PBX IMPEDANCE (OHMS)	WHEN NO DLL OR LSR IS REQUIRED AT PBX OR WHEN RE WITHOUT IMPEDANCE OPTIONS (1:1 COIL RATIO) IS USED	CONDITIONS WHICH USE DLL WITH IMPEDANCE OPTIONS OR LSR AT PBX			
	NETWORK	NETWORK	2-W TU (NOTE 1)		DLL SET COIL RATIO (NOTE 3)
			LINE SIDE (OHMS)	PBX SIDE (OHMS)	
600	837D OR J99380 AA (NOTE 2)	837D OR J99380 AA (NOTE 2)	600	600	1:1
		837C	900	600	1.5:1
900	837C, 837D, OR J99380 AA (NOTE 2)	837D OR J99380 AA (NOTE 2)	900	900	1:1
		837C	900	900	1:1

NOTES (TABLE D):
1. J99343 BC 2-WIRE TRANSMISSION UNIT MUST BE USED WITH LSR.
2. SET 837D OR J99380 AA NETWORK TO 600 FOR 600-OHM PBX OR 900 FOR 900-OHM PBX.
3. SD-96555 OR SD-96234 WITH 120T COIL HAS IMPEDANCE RATIO OPTIONS OF 1:1 AND 1.5:1 (LINE TO DROP). 120C COILS HAVE ONLY A 1:1 IMPEDANCE RATIO.

TABLE E

NETWORK SELECTION AND RANGE-EXTENDER IMPEDANCE
FOR LOADED CABLE LINKS
19-, 22-, 24-GAUGE D88 OR H88

DESIRED PBX IMPEDANCE (OHMS)	CABLE LOADING	WHEN NO DLL OR LSR IS REQUIRED AT PBX OR WHEN RE WITHOUT IMPEDANCE OPTIONS (1:1 COIL RATIO) IS USED	CONDITIONS WHICH USE DLL WITH IMPEDANCE OPTIONS OR LSR AT PBX			
		NETWORK	NETWORK	2-W TU (NOTE 1)		DLL SET COIL RATIO (NOTE 2)
				LINE SIDE (OHMS)	PBX SIDE (OHMS)	
600	D88 HC	837E, 837F, OR J99380 AB	837A OR 837B	900	600	1.5:1
	H88 HC OR LC		837E, 837F, OR J99380 AB	600	600	1:1
900	D88 HC	837A OR 837B	837A OR 837B	900	900	1:1
	H88 HC OR LC		837E, 837F, OR J99380 AB	600	900	1:1.5

NOTES (TABLE E):
1. J99343 BC 2-WIRE TRANSMISSION UNIT MUST BE USED WITH LSR.
2. SD-96555 OR SD-96234 WITH 120T COIL HAS IMPEDANCE RATIO OPTIONS OF 1:1 AND 1.5:1 (LINE TO DROP). DLL WITH 120C COILS HAVE ONLY 1:1 IMPEDANCE RATIO.

TABLE F

NETWORK SELECTION AND RANGE-EXTENDER IMPEDANCE FOR 25H88 AND 26H88 LOADED CABLE LINKS

DESIRED PBX IMPEDANCE (OHMS)	CABLE LOADING	WHEN NO DLL OR LSR IS REQUIRED AT PBX OR WHEN RE WITHOUT IMPEDANCE OPTIONS (1:1 COIL RATIO) IS USED	CONDITIONS WHICH USE DLL WITH IMPEDANCE OPTIONS OR LSR AT PBX			
		NETWORK	NETWORK	2-W TU (NOTE 1)		DLL SET COIL RATIO (NOTE 3)
				LINE SIDE (OHMS)	PBX SIDE (OHMS)	
600	26H88 HC	837G (NOTE 2) OR J99380 AC	837G	900	600	1.5:1
			J99380 AC	600	600	1:1
900		837G	837G	900	900	1:1
			J99380 AC	600	900	1:1.5
600	25H88 LC	837J (NOTE 2)	837J	900	600	1.5:1
900		837J	837J	900	900	1:1

NOTES (TABLE F):

1. J99343 BC 2-WIRE TRANSMISSION UNIT MUST BE USED WITH LSR.
2. A 120T COIL, WIRED AS SHOWN (1.5:1), MUST BE USED BETWEEN THE NETWORK AND THE PBX TO PROVIDE THE PROPER IMPEDANCE MATCH.
3. SD-96555 OR SD-96234 WITH 120T COIL HAS IMPEDANCE RATIO OPTIONS OF 1:1 AND 1.5:1 (LINE TO DROP). DLL WITH 120C COILS HAVE ONLY 1:1 IMPEDANCE RATIO.

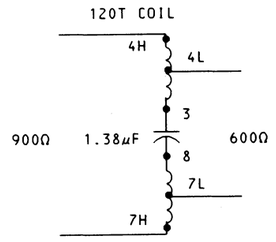


TABLE G

METALLIC FACILITIES MAXIMUM PERMISSIBLE TRANSMITTING TRANSMISSION LEVEL POINT (TLP) AND MINIMUM PERMISSIBLE RECEIVING TRANSMISSION LEVEL POINT (TLP) (CROSSTALK LIMITING)

	H88-LOADED CABLE		NONLOADED CABLE	
	MAXIMUM OUTPUT TO CABLE (dB)	MINIMUM INPUT FROM CABLE (dB)	MAXIMUM OUTPUT TO CABLE (dB)	MINIMUM INPUT FROM CABLE (dB)
At CO	+6	−9	+6	−9 (−15) *
At PBX	+3	−6	+6	−9 (−15) *

*The −15 dB TLP applies only when a nonloaded cable is provided with 150-ohm terminations at both ends.

TABLE H

NONLOADED CABLE 359-TYPE EQUALIZERS FOR V4 REPEATER APPLICATIONS

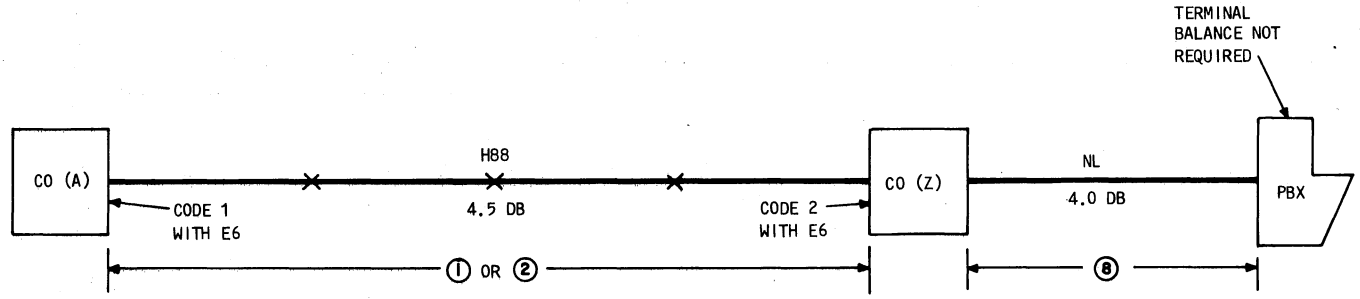
CABLE GAUGE	CABLE LENGTH IN KFT		
	359F – 359F	359F – 359B	359B – 359B
19	0-9	9.1-16	16.1-
22	0-8	8.1-14	14.1-
24	0-7.5	7.6-12	12.1-
25	0-9	9.1-13	13.1-
26	0-7	7.1-10	10.1-
	(SHORT)	(MEDIUM)	(LONG)

EQUALIZER IMPEDANCE: 359F = 600, 359B = 150

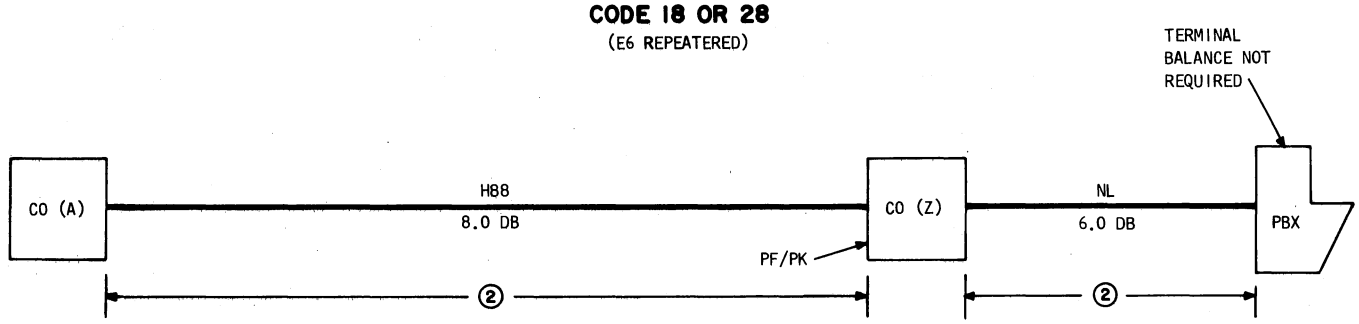
TABLE I

FOUR-WIRE METALLIC FACILITIES TRANSMITTING TRANSMISSION LEVEL POINT (TLP) AND RECEIVING TRANSMISSION LEVEL POINT (TLP) ADJUSTMENT FORMULAS

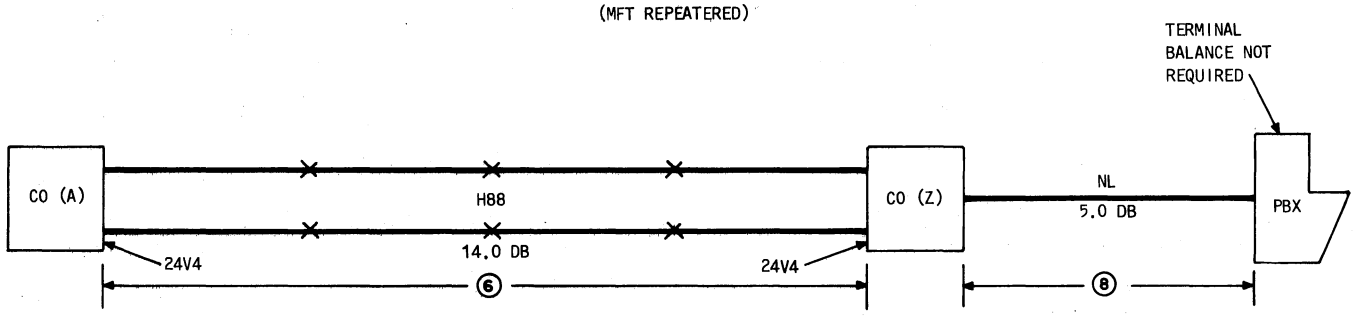
CO-CO (H88) CO-PBX (NL-600-OHM TERMINATIONS)	CO-PBX (H88)	CO-PBX (NL) (150-OHM TERMINATIONS)
At CO or PBX: TLP_T (Max.) = +6 dB TLP_R (Min.) = −9 dB $TLP_{TA} = -1.5 + \frac{Loss}{2}$ $TLP_{RA} = -1.5 - \frac{Loss}{2}$	At PBX: TLP_T (Max.) = +3 dB TLP_R (Min.) = −9 dB $TLP_{TA} = -3 + \frac{Loss}{2}$ $TLP_{RA} = -3 - \frac{Loss}{2}$	At CO or PBX: TLP_T (Max.) = +6 dB TLP_R (Min.) = −15 dB $TLP_{TA} = -4.5 + \frac{Loss}{2}$ $TLP_{RA} = -4.5 - \frac{Loss}{2}$
	At CO: TLP_T (Max.) = +6 dB TLP_R (Min.) = −6 dB $TLP_{TA} = + \frac{Loss}{2}$ $TLP_{RA} = - \frac{Loss}{2}$	



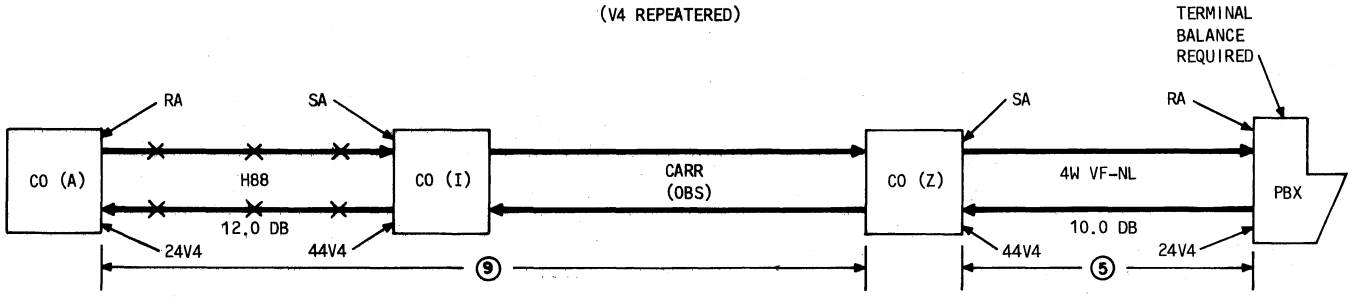
CODE 18 OR 28
(E6 REPEATERED)



CODE 22
(MFT REPEATERED)



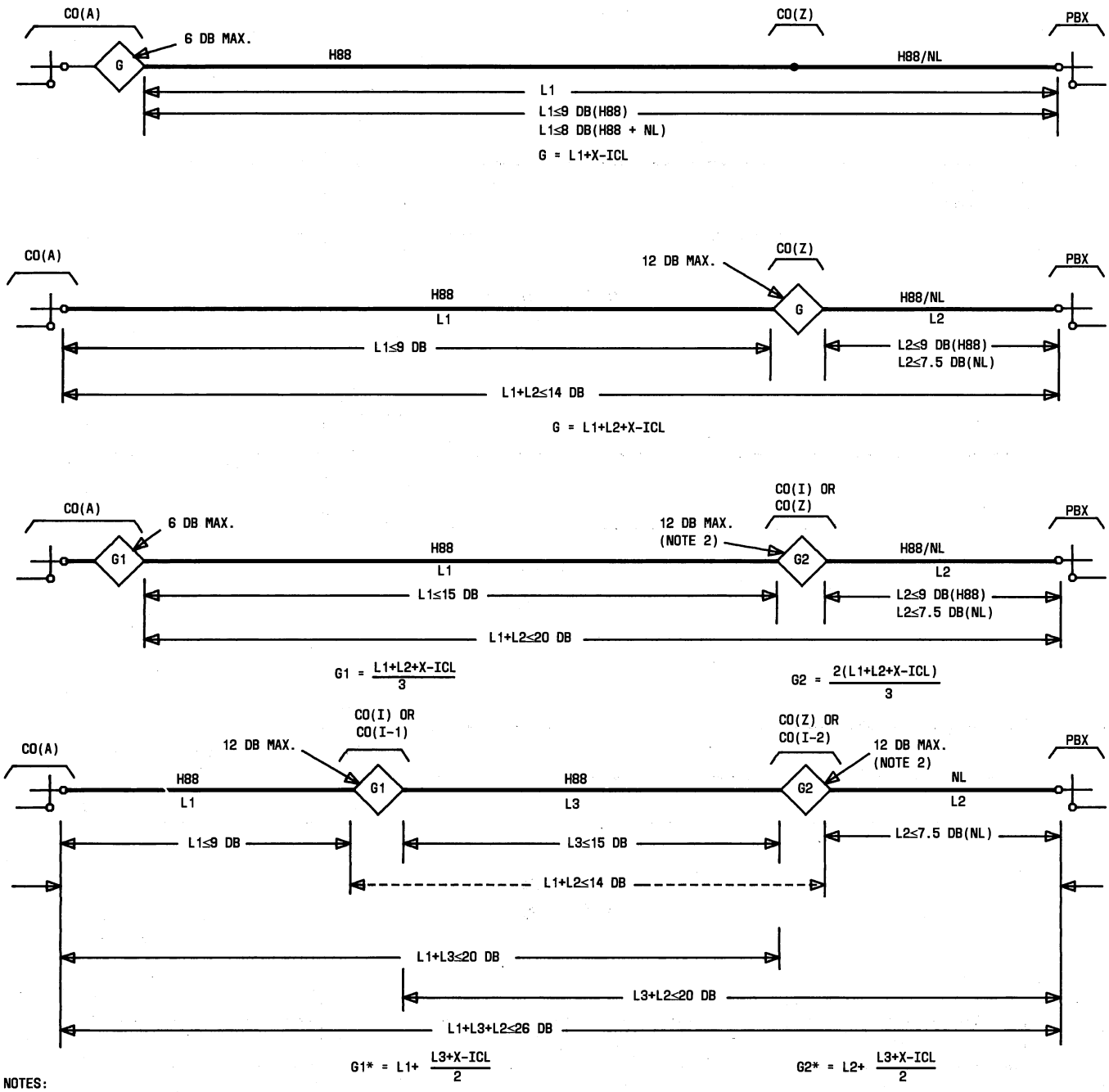
CODE 68
(V4 REPEATERED)



CODE 95
(V4 OR MFT REPEATERED)

NOTE:
LAYOUT CODES MAY OPTIONALLY BE PREFIXED WITH THE LETTERS E, V, M, ME, OR MV TO DENOTE THE TYPE OF REPEATERS USED.

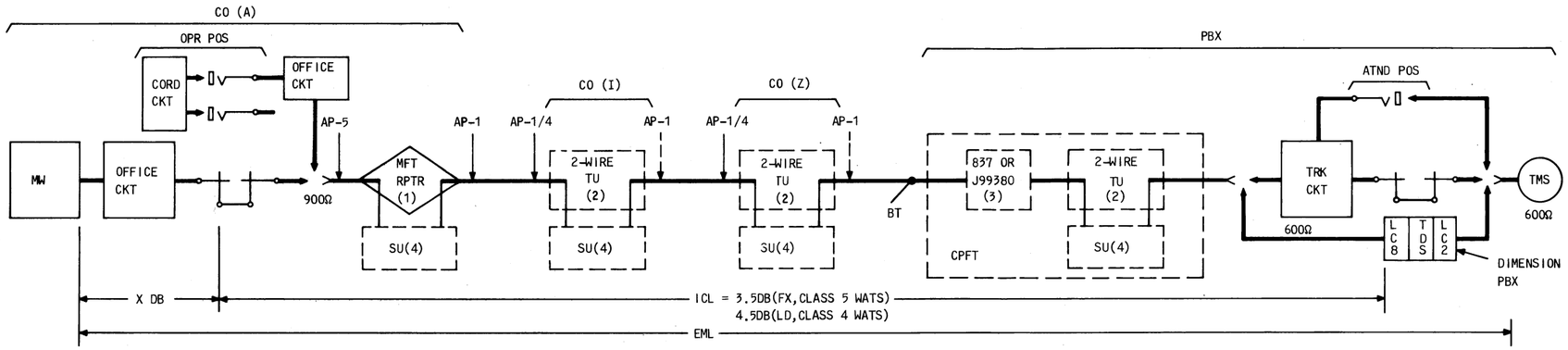
Fig. 3—Examples of Layout Coding



NOTES:
1. X DENOTES LAYOUT EQUIPMENT LOSSES.
2. THE G2 GAIN IS LIMITED TO 6 DB WHEN THE PA(PG) REPEATER IS USED.

* VALID FOR L3≤10 DB

Fig. 4—Two-Wire MFT Repeatered Facility Loss Limits and Gain Computation Methods



CODES 11-L, 13-L, 14-L

NOTES:

1. J99343PA TERMINAL REPEATER SWITCH SETTINGS:

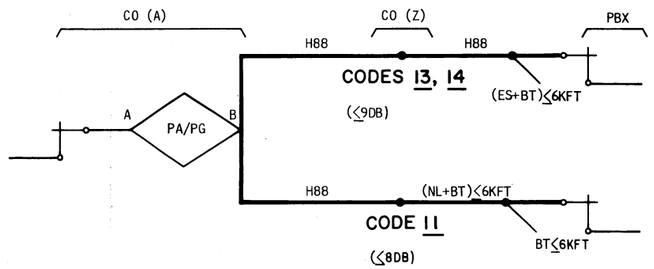
WITHOUT SU	WITH SU
NOR-RV=NOR	NOR-RV=NOR
NOR-RV/T=RV/T	NOR-RV/T=NOR
NOR-SX SH=NOR	NOR-SH SH=NOR
	=SX/SH(WITH LSE)

2. 2-WIRE TU-J99343BC

WITHOUT 837 TYPE NET.	WITH 837 TYPE NET.
A SIDE Z=900	(SEE TABLES D,E,F)
B SIDE Z=900	
NOR-REV=NOR(A-B),	
=REV(B-A)	
NOR-L1 SH=NOR	
NOR-L2 SH=NOR, L2 SH(WITH LSE)	
SB1=IN(BEST RETURN LOSS)	
=OUT(REDUCES 1-KHZ LOSS FROM 0.8 DB TO 0.4 DB)	

3. IMPEDANCE COMPENSATORS:
SEE TABLES D, E, AND F FOR TYPES

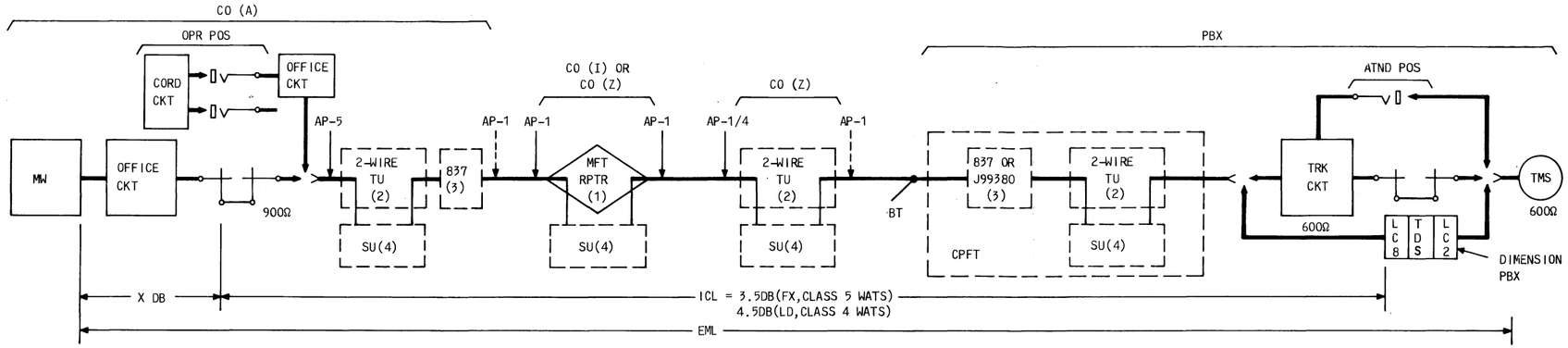
4. SIGNALING UNITS:
LSR-J99343AC, AF, OR MODIFIED AA:
LS-GS=GS(GROUND START)
LS(LOOP START)
BOR: SEE SECTION 851-300-130
LSO-J99343AD OR MODIFIED AB:
BOR:SEE SECTION 851-300-130
LSE-J99343CC, CA, (CB OR CD TOLL DIVERSION)
(S1)NOR-REV=NOR(A-B), REV(B-A)
LS-GS CONVERTER-J99343AE (USE AT CO(A))
S1-S12: SEE SECTION 332-911-101



MFT REPEATER TYPES

NOTE: SEE FIG. 11 FOR SMAS-4A ACCESS POINTS.

Fig. 5—Two-Wire MFT Repeatered Designs (Sheet 1 of 7)



CODES 21-L, 22-L, 23-L, 24-L, 41-L, 43-L, 44-L

NOTES:

1. J99343 REPEATERS AT CO(I) OR CO(Z)
   SWITCH SETTINGS:

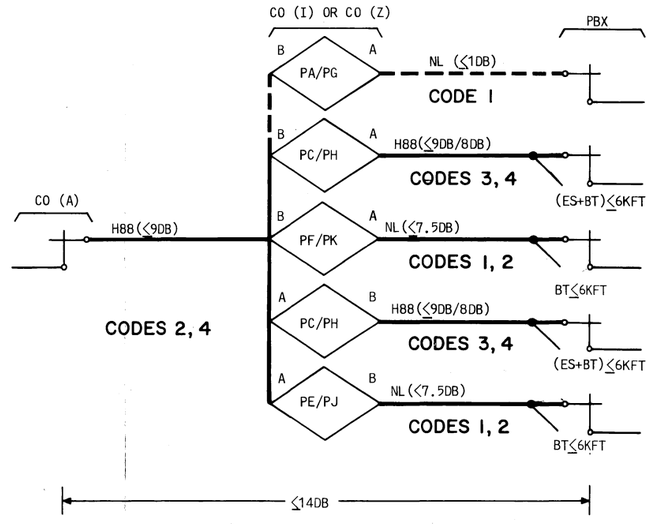
WITHOUT SU:	WITH SU
NOR-RV=NOR	NOR-RV=NOR(A-B),RV(B-A)
NOR-RV/T=RV/T	NOR-RV/T=NOR(A-B),RV/T(B-A)
NOR-SX SH=NOR	NOR-SX SH=NOR =SX SH(WITH LSE)

2. 2-WIRE TU-J99343BC:

WITHOUT 837 TYPE NET.	WITH 837 TYPE NET. (SEE TABLES D, E, F)
A SIDE Z=900	
B SIDE Z=900	
NOR-REV=NOR(A-B) =REV(B-A)	
NOR-L1 SH=NOR	
NOR-L2 SH=NOR, L2 SH(WITH LSE)	
SB1=IN(BEST RETURN LOSS) =OUT(REDUCES 1-KHZ LOSS FROM 0.8 DB TO 0.4 DB)	

3. IMPEDANCE COMPENSATORS:
   NONLOADED CABLE AT PBX ≤4.5 DB: TABLE D
   (USE WITH PE, PF REPEATERS)
   19, 22, 24H88: SEE TABLE E
   25H88: SEE TABLE F
   26H88: SEE TABLE F

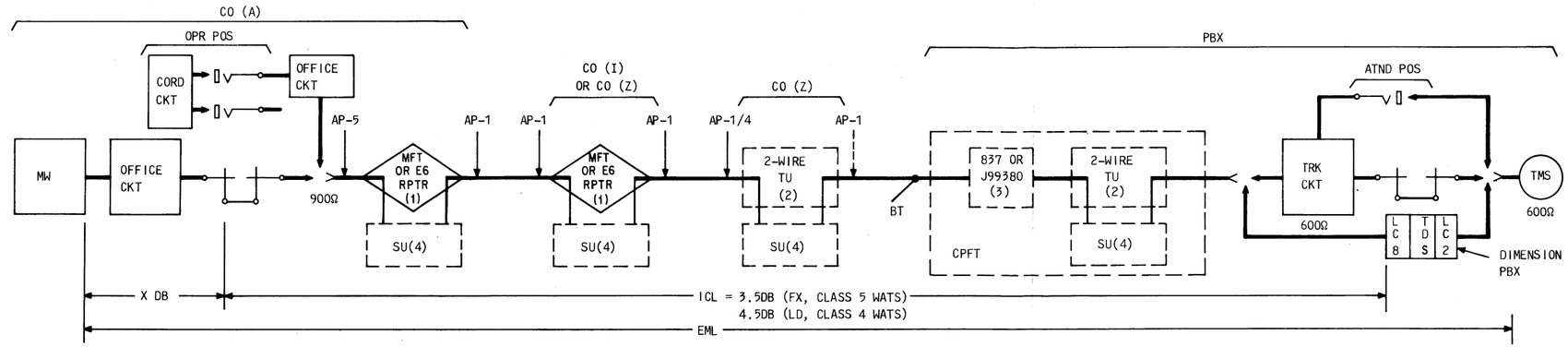
4. SIGNALING UNITS:
   LSR-J99343AC, AF, OR MODIFIED AA:
   LS-GS=GS(GROUND START)
   LS(LOOP START)
   BOR: SEE SECTION 851-300-130
   LSO-J99343AD OR MODIFIED AB:
   BOR: SEE SECTION 851-300-130
   LSE-J99343CC, CA, (CB OR CD TOLL DIVERSION)
   (S1)NOR-REV=NOR(A-B), REV(B-A)
   LS-GS CONVERTER-J99343AE (USE AT CO(A))
   S1-S12: SEE SECTION 332-911-101



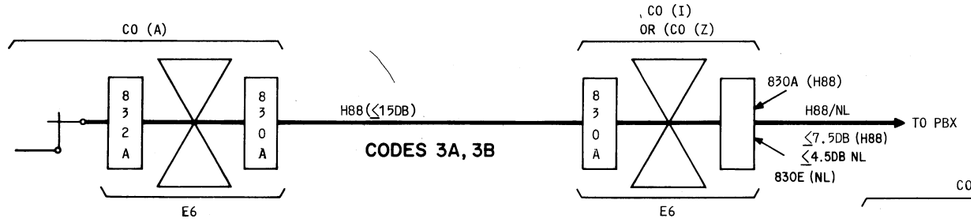
MFT REPEATER TYPES

NOTE: SEE FIG. 11
FOR SMAS-4A ACCESS POINTS

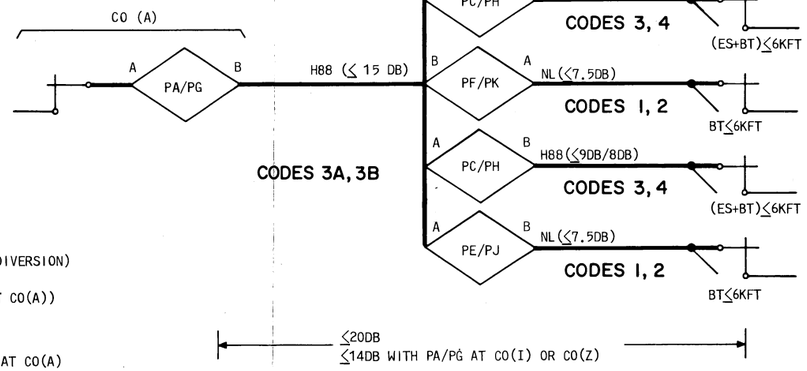
Fig. 5—Two-Wire MFT Repeatered Designs (Sheet 2 of 7)



CODES 3AI-L, 3A3-L, 3A4-L
3BI-L, 3B2-L, 3B3-L, 3B4-L



E6 REPEATER SUBSTITUTIONS
(NOTE 5)



NOTES:

1. J99343 REPEATERS AT CO(A). CO(I), OR CO(Z)
   SWITCH SETTINGS:

WITHOUT SU	WITH SU
NOR-RV=NOR	NOR-RV=NOR(A-B), RV(B-A)
NOR-RV/T=RV/T	NOR-RV/T=NOR(A-B), RV/T(B-A)
NOR-SX SH=NOR	NOR-SX SH=NOR, SX SH(WITH LSE)

2. 2-WIRE TU-J99343BC:

WITHOUT 837 TYPE NET.	WITH 837 TYPE NET.
A SIDE Z=900	(SEE TABLES D,E,F)
B SIDE Z=900	
NOR-REV=NOR(A-B)	
=REV(B-A)	
NOR-L1 SH=NOR	
NOR-L2 SH=NOR, L2 SH(WITH LSE)	
SB1=IN(BEST RETURN LOSS)	
=OUT(REDUCES 1-KHZ LOSS FROM 0.8 DB TO 0.4 DB)	

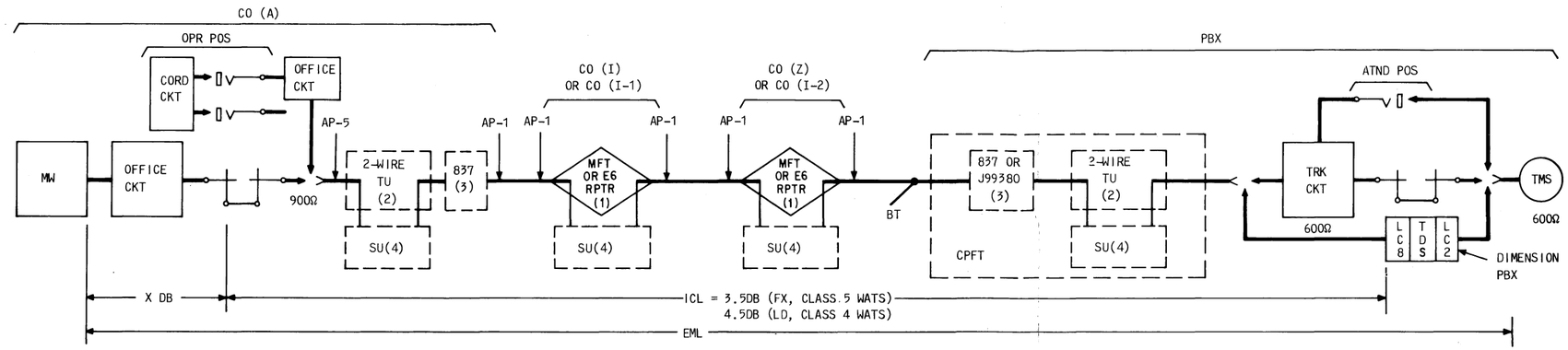
3. IMPEDANCE COMPENSATORS:
   NONLOADED CABLE AT PBX ≤ 4.5 DB: TABLE D
   (USE WITH PE, PF REPEATERS)
   19,22, 24H88: SEE TABLE E
   25H88: SEE TABLE F
   26H88: SEE TABLE F

4. SIGNALING UNITS:
   LSR-J99343AC, AF, OR MODIFIED AA:
   LS-GS=GS(GROUND START)
   LS(LOOP START)
   BOR: SEE SECTION 851-300-130
   LSO-J99343AD OR MODIFIED AB:
   BOR: SEE SECTION 851-300-130
   LSE-J99343CC, CA, (CB OR CD TOLL DIVERSION)
   (SI)NOR-REV=NOR(A-B), REV(B-A)
   LS-GS CONVERTER-J99343AE (USE AT CO(A))
   S1-S12: SEE SECTION 332-911-101

5. E6 REPEATER SUBSTITUTIONS:
   AN E6 REPEATER MAY BE SUBSTITUTED AT CO(A) WITH MAXIMUM GAIN OF 6.5 DB. AN E6 REPEATER MAY BE USED AT CO(Z) WITH UP TO 7.5-DB LOSS (H88) IN THE CO(Z)-PBX LINK. A DLL MUST NOT BE USED BETWEEN AN 830E NETWORK AND THE CABLE. AT CO(Z), THE REPEATER GAIN (INCLUDING LOSS OF LBO NETWORKS SHOULD NOT EXCEED CO(Z)-PBX LINK LOSS BY MORE THAN 1 DB. FOLLOW DISABLER RULES IN SECTION 851-300-114.

NOTE:
SEE FIG. 11 FOR SMAS-4A ACCESS POINTS.

Fig. 5—Two-Wire MFT Repeatered Designs (Sheet 3 of 7)



CODES 3C1-L, 3D1-L, 3D2-L

NOTES:

1. J99343 REPEATERS AT CO(I), CO(I-1), CO(Z), OR CO(I-2) SWITCH SETTINGS:

WITHOUT SU	WITH SU
NOR-RV=NOR	NOR-RV=NOR(A-B), RV(B-A)
NOR-RV/T=RV/T	NOR-RV/T=NOR(A-B), RV/T(B-A)
NOR-SX SH=NOR	NOR-SX SH=NOR, SX SH WITH LSE

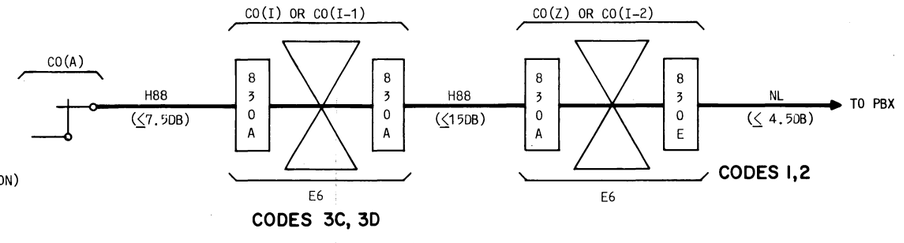
2. 2-WIRE TU-J99343BC:

WITHOUT 837 TYPE NET.	WITH 837 TYPE NET. (SEE TABLES D, E, F)
A SIDE Z=900	
B SIDE Z=900	
NOR-REV=NOR(A-B) =REV(B-A)	
NOR-L1 SH=NOR	
NOR-L2 SH=NOR, L2 SH(WITH LSE)	
SB1=IN(BEST RETURN LOSS) =OUT(REDUCES 1-KHZ LOSS FROM 0.8 DB TO 0.4 DB)	

3. IMPEDANCE COMPENSATORS:
   NONLOADED CABLE ≤4.5 DB: TABLE D (USE WITH PE, PF REPEATERS)
   19,22, 24H88: SEE TABLE E
   25H88: SEE TABLE F
   26H88: SEE TABLE F

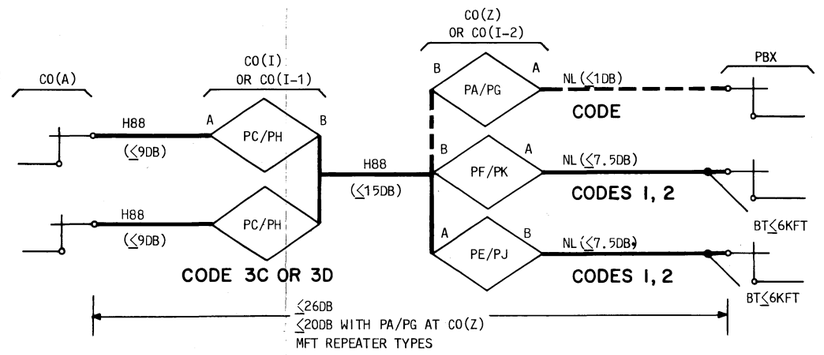
4. SIGNALING UNITS:
   LSR-J99343AC, AF, OR MODIFIED AA:
   LS-GS=GS(GROUND START)
   LS(LOOP START)
   BOR: SEE SECTION 851-300-130
   LSO-J99343AD OR MODIFIED AB:
   BOR: SEE SECTION 851-300-130
   LSE-J99343CC, CA, (CB OR CD TOLL DIVERSION)
   (SI)NOR-REV=NOR(A-B), REV(B-A)
   LS-GS CONVERTER-J99343AE (USE AT CO(A))
   S1-S12: SEE SECTION 322-911-101

5. E6 REPEATER SUBSTITUTIONS:
   AN E6 REPEATER MAY BE USED AT CO (I) OR CO (Z) WITH END LINK LOSSES OF UP TO 4.5 DB. THE E6 REPEATER GAIN (INCLUDING LOSS OF LBO NETWORKS) SHOULD NOT EXCEED THE END LINK LOSS BY MORE THAN 1 DB. A DLL MUST NOT BE USED BETWEEN THE 830E NETWORK AND THE CABLE. FOLLOW THE DISABLER RULES IN SECTION 851-300-114.



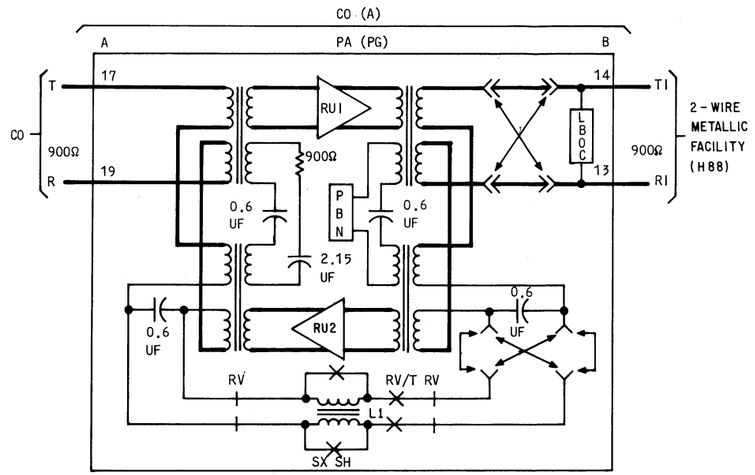
CODES 3C, 3D

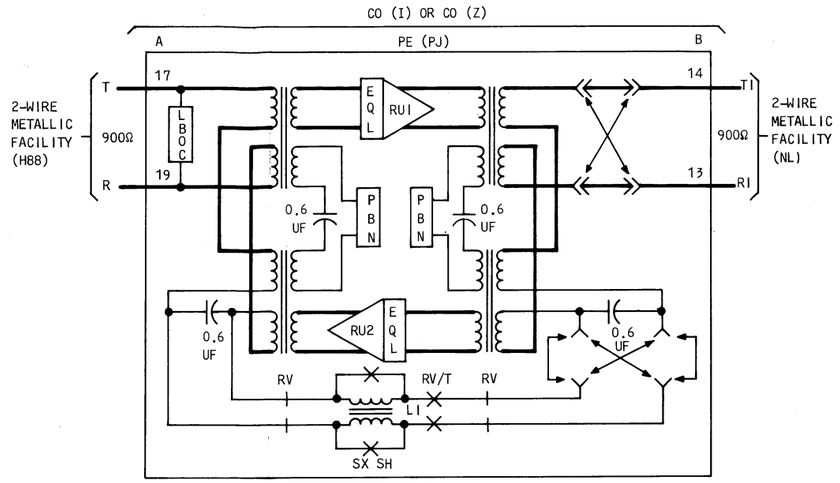
E6 REPEATER SUBSTITUTIONS
(NOTE 5)

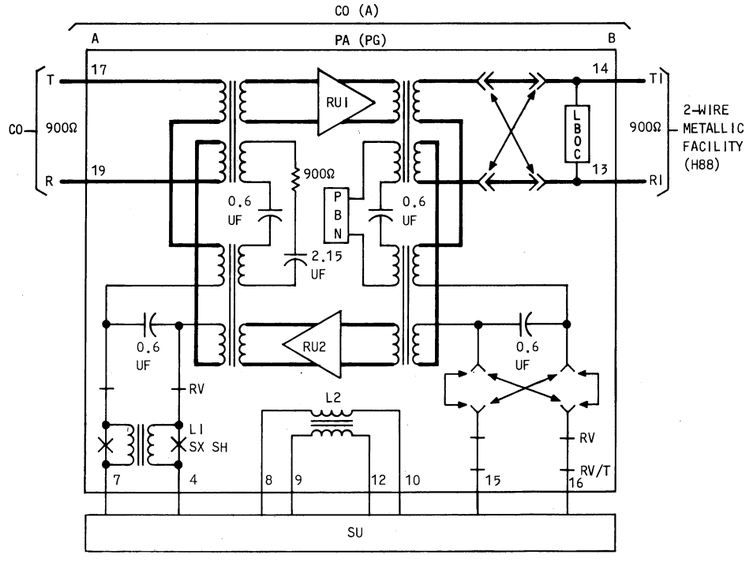


NOTE:
SEE FIG. 11 FOR SMAS-4A ACCESS POINTS.

Fig. 5—Two-Wire MFT Repeatered Designs (Sheet 4 of 7)







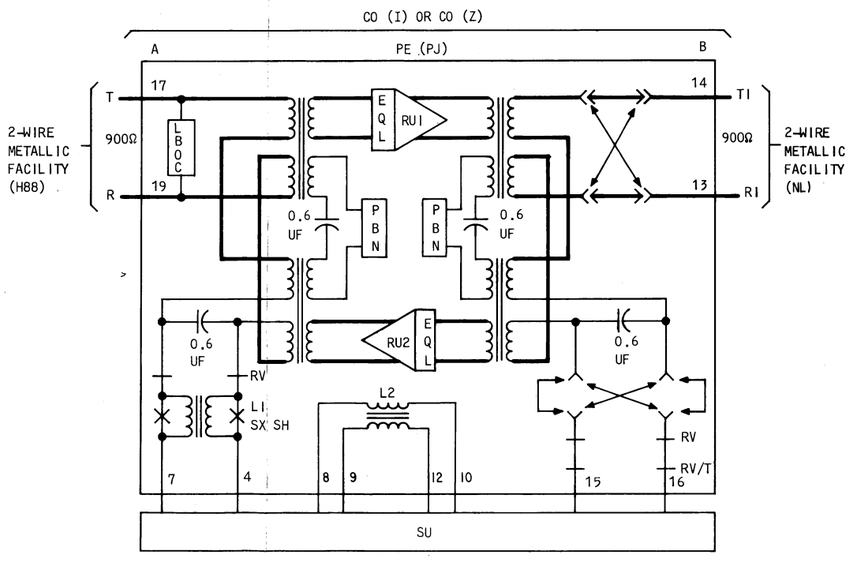
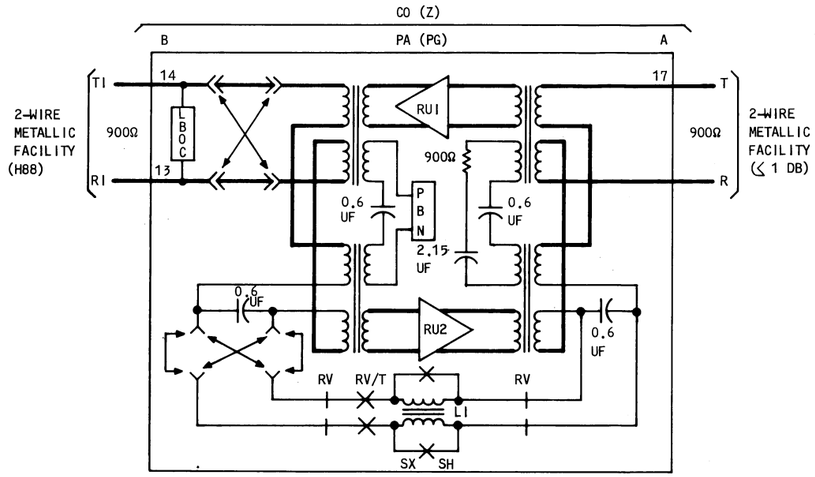
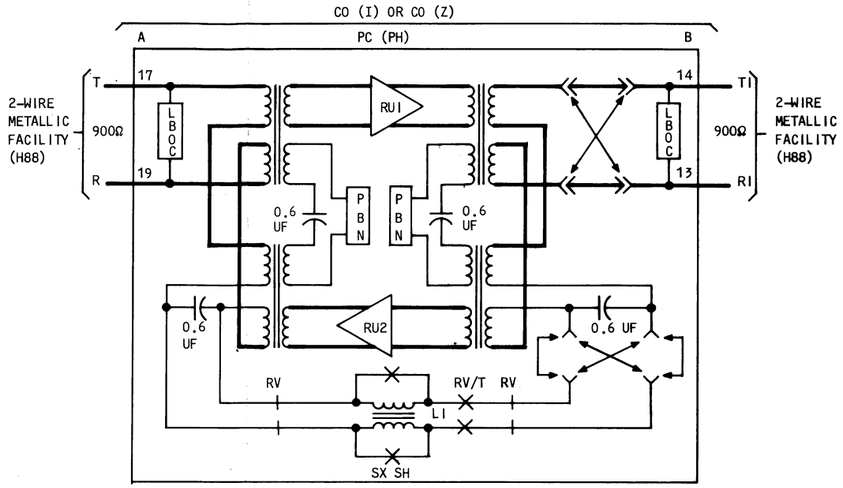
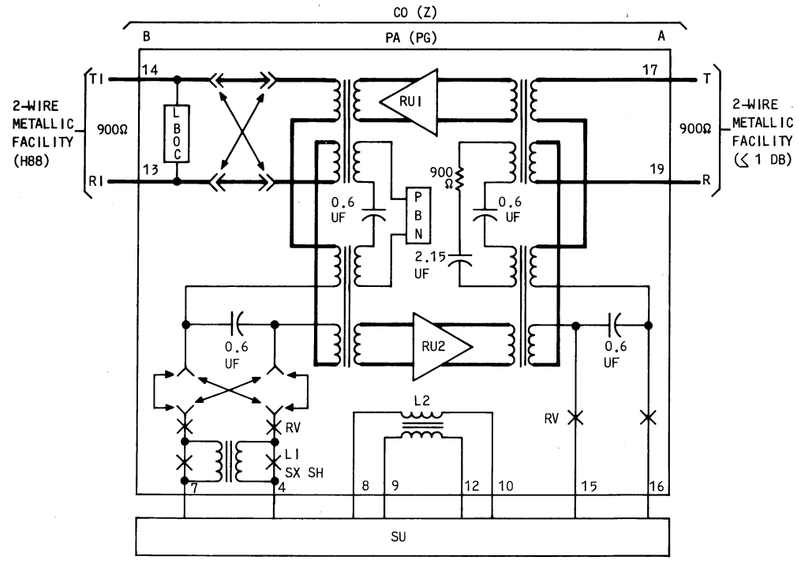


Fig. 5—Two-Wire MFT Repeatered Designs (Sheet 5 of 7)







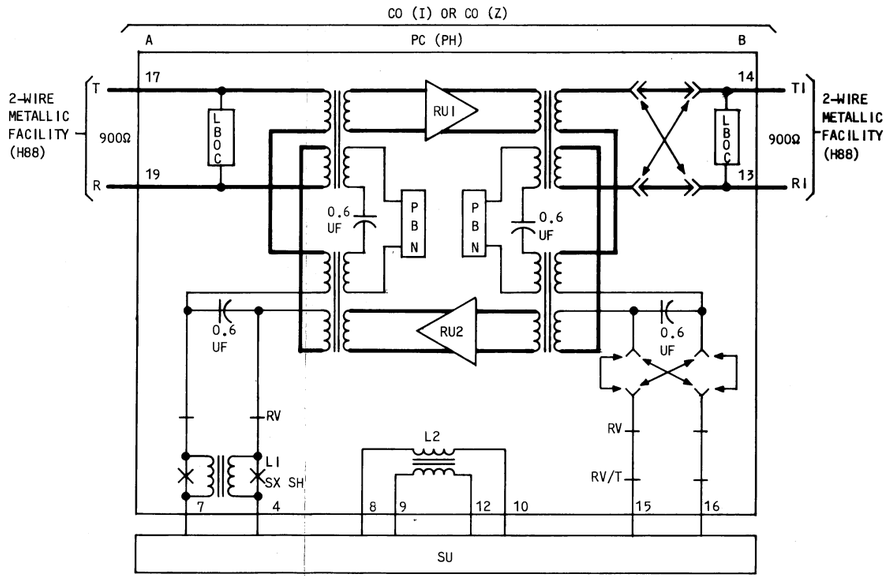
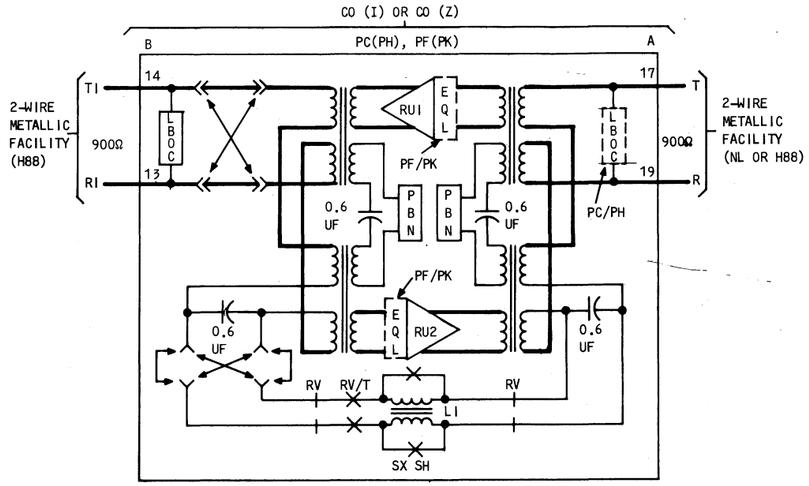
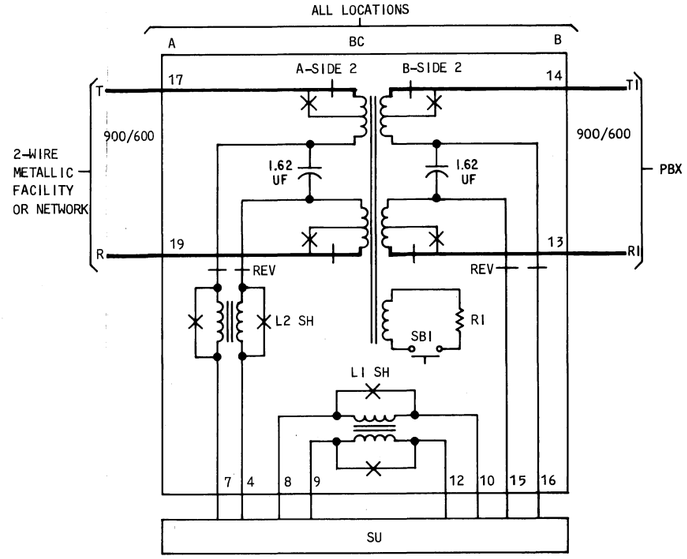
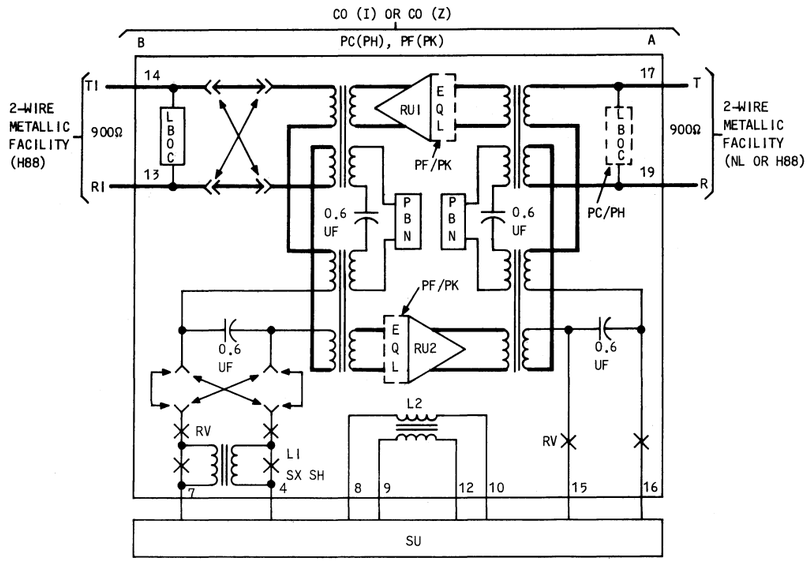


Fig. 5—Two-Wire MFT Repeatered Designs (Sheet 6 of 7)







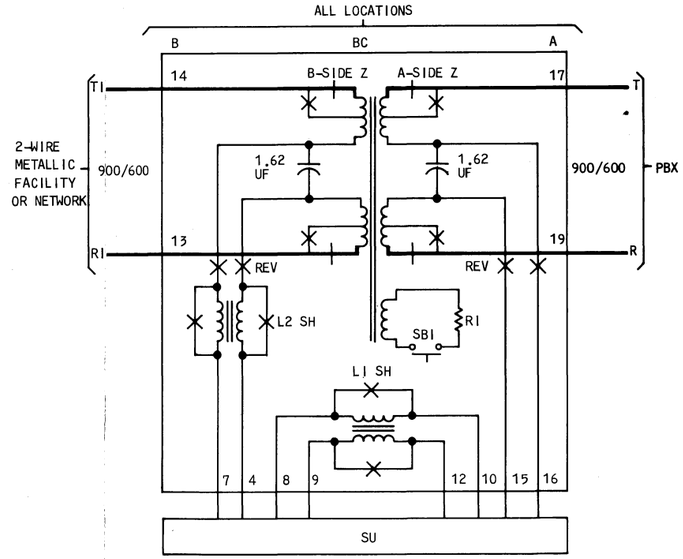
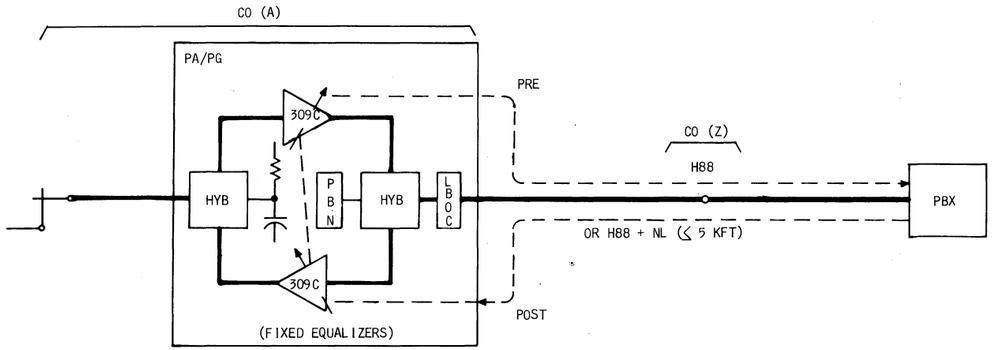
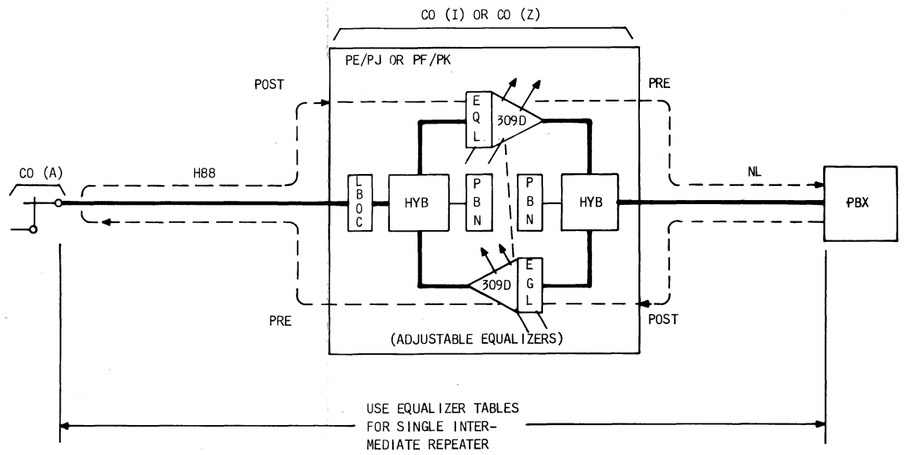
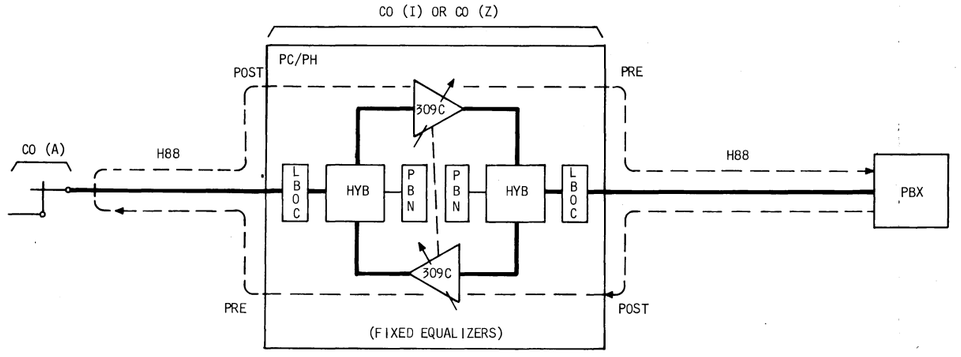


Fig. 5—Two-Wire MFT Repeatered Designs (Sheet 7 of 7)





NOTES:
1. REFER TO SECTION 332-912-212 FOR PRESCRIPTION SETTINGS.
2. PRESCRIPTION BALANCE NETWORK SETTINGS ARE DETERMINED WITHOUT REGARD FOR TOTAL CIRCUIT CONFIGURATION. A DISTANT 2-WIRE REPEATER IS ASSUMED TO TERMINATE THE CABLE IN 900 + 2.15 UF.



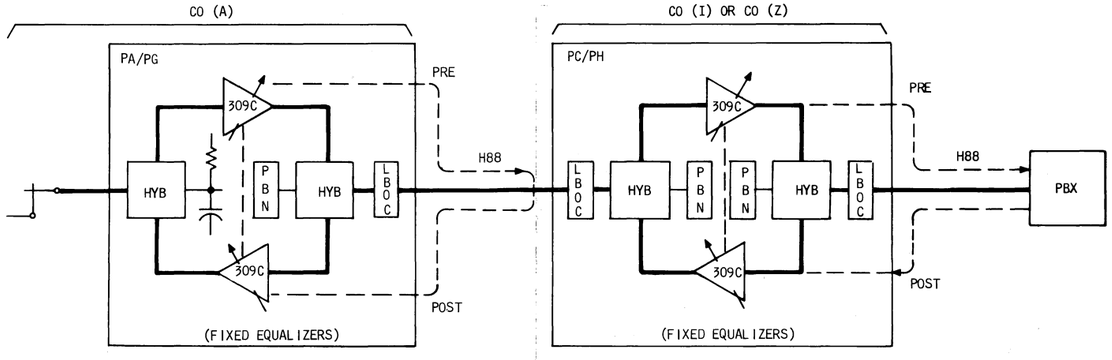
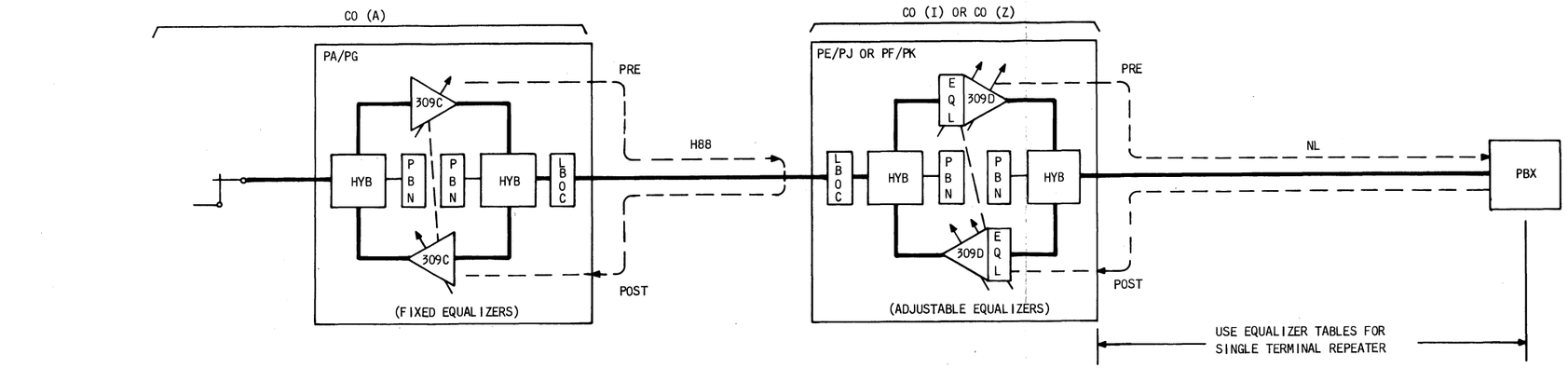


Fig. 6—Equalization Techniques for 2-Wire MFT Repeatered Designs (Sheet 1 of 2)



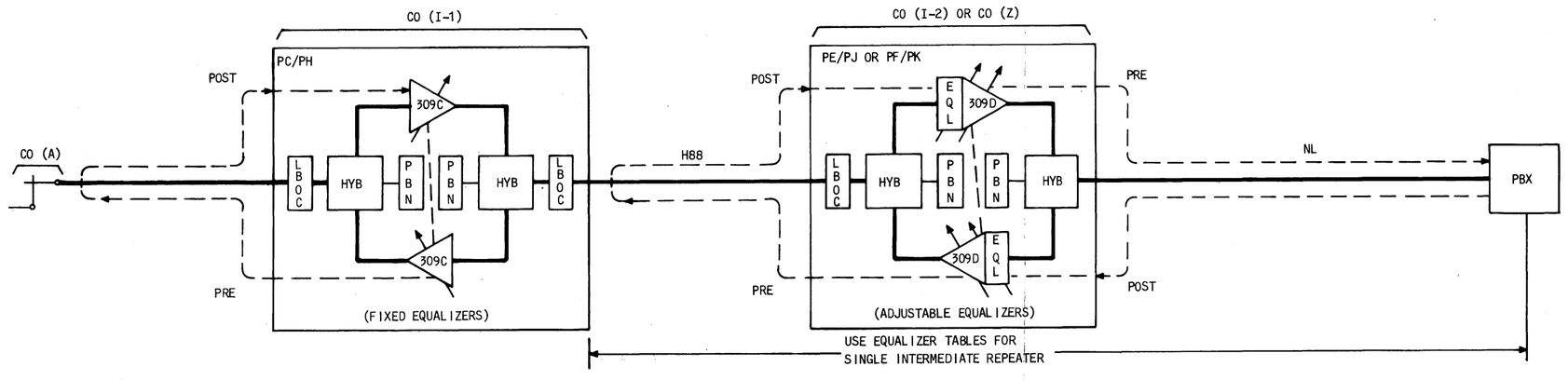
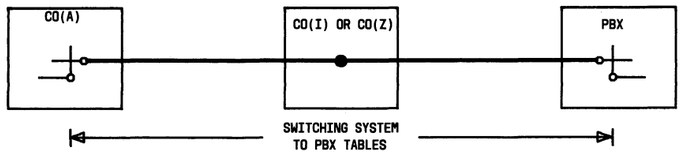
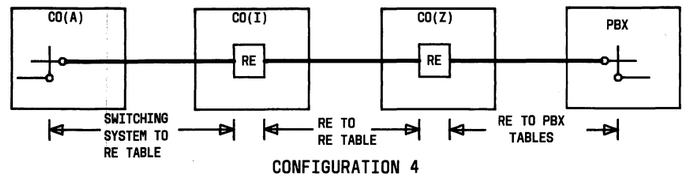


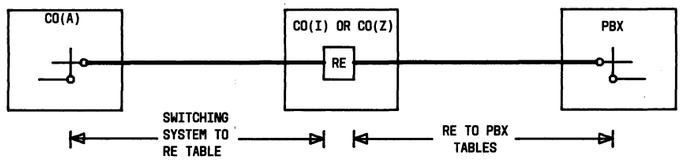
Fig. 6—Equalization Techniques for 2-Wire MFT Repeatered Designs (Sheet 2 of 2)



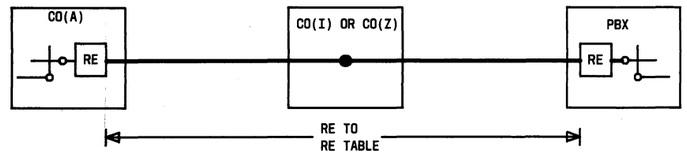
CONFIGURATION 1



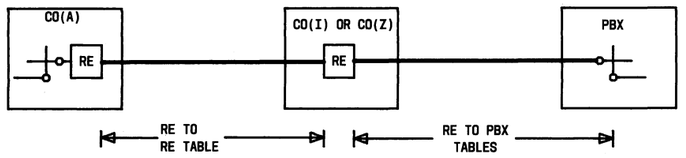
CONFIGURATION 4



CONFIGURATION 2



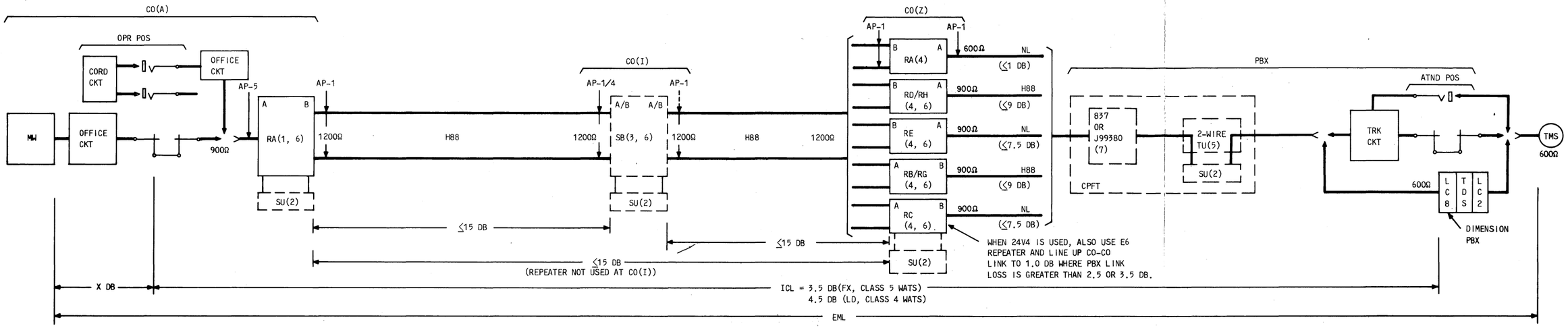
CONFIGURATION 5



CONFIGURATION 3

NOTES
1. SEE SECTION 851-300-170 FOR REFERENCED TABLES.
2. RE DENOTES DLL OR MFT RANGE-EXTENDING EQUIPMENT.

Fig. 7—Range-Extension Equipment Locations and Limits



CODES 61-L, 62-L, 63-L, 64-L
6A1-L, 6A2-L, 6A3-L, 6A4-L

NOTES:

1. **RA REPEATER AT CO(A):**
   HYB 1, 2 = 900
   S1, S4 = IN (1.06UF)
   NOR - SX SH = NOR
   NOR - SX RV = NOR, SX RV (SU AT CO(I)
   NOR - RV = NOR
   OUT = 1200
   NOR - RV/T = NOR (WITH SU)
   RV/T (NO SU)

2. SIGNALING UNIT TYPES:
   LSR - J99343AC, AF, OR MODIFIED AA
   LS - GS = LS (LOOP-START)
   GS (GROUND-START)
   BOR - SEE SECTION 851-300-130
   LSO - J99343AD OR MODIFIED AB
   BOR - SEE SECTION 851-300-130
   LSE - J99343CA, CC, (CB, CD TOLL DIVERSION)
   (S1)NOR-REV=NOR(A-B), REV(B-A)
   LS - GS CONVERTER - J99343AE (AT CO(A))
   S1 THROUGH S12 - SEE SECTION 332-911-101
   NOTE: REFER TO FIG. 7 FOR RANGE LIMITS.

3. SB REPEATER AT CO(I):

SWITCH	A-B	B-A
IN	1200	1200
OUT	1200	1200
NOR-RV (NO SU)	RV	NOR
NOR-RV (WITH SU)	NOR	RV
NOR-RV/T (NO SU)	NOR	RV/T
NOR-RV/T (WITH SU)	NOR	RV/T

   REFER TO FIG. 7 FOR SIGNALING UNIT LOCATIONS.

4. CO(Z) REPEATER SWITCH SETTINGS:

SWITCH	RA	RD/RH	RE	RB/RG	RC
HYB1,2	600	-	-	-	-
NOR-SX SH	NOR	NOR	NOR	NOR	NOR
NOR-SX RV	SX RV(1)	SX RV(1)	SX RV(1)	-	-
NOR-RV(WITH SU)	RV	RV	RV	NOR	NOR
NOR-RV(NO SU)	NOR	NOR	NOR	NOR	NOR
NOR-RV/T (WITH SU)	RV/T	RV/T	RV/T	NOR	NOR
NOR-RV/T (NO SU)	RV/T	RV/T	RV/T	RV/T	RV/T
NOR-A/B RV (WITH SU)	-	-	-	NOR	NOR
NOR-A/B RV (NO SU)	-	-	-	(2)	(2)
OUT	1200	1200	1200	1200	1200
S1	IN	-	-	-	-
S2	-	-	-	IN	IN
S3	-	-	-	-	-
S4	IN	-	-	-	-

   1. NOR WITH SU AT CO(I)
   2. NOR WITH SU AT CO(I), RV OTHERWISE

5. 2-WIRE TU-J99343BC:

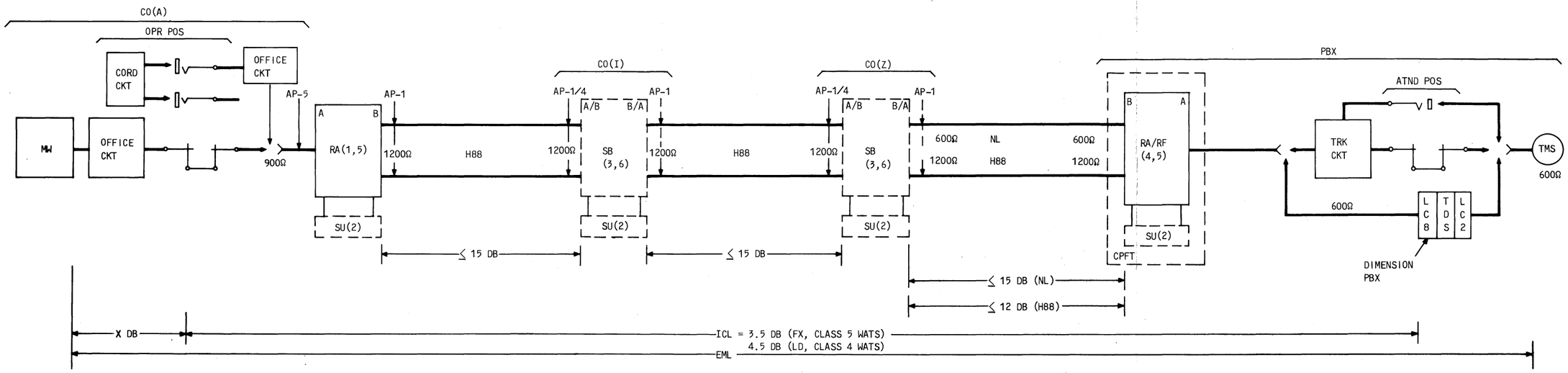
WITHOUT 837 TYPE NET.	WITH 837 TYPE NET. (SEE TABLES D,E,F)
A-SIDE Z = 900	
B-SIDE Z = 900	
NOR-REV = NOR(A-B) = REV(B-A)	
NOR-L1 SH =NOR	
NOR-L2 SH =NOR, L2 SH(WITH LSE)	
SB1 = IN (BEST RETURN LOSS) = OUT(REDUCES 1-KHZ LOSS FROM 0.8 DB TO 0.4 DB)	

6. V4 SUBSTITUTIONS:
   A 44V4 MAY BE SUBSTITUTED DIRECTLY AT CO(I) WITH 359A EQUALIZERS SET ACCORDING TO V4 DESIGN RULES. A 24V4 MAY BE SUBSTITUTED DIRECTLY AT CO(A), ALSO WITH A 359A EQUALIZER. AT CO(Z) A 24V4 (WITH 359A) AND AN E6 MAY BE SUBSTITUTED. THE 2-WIRE LINK SHOULD BE LINED UP TO 2.5 OR 3.5 DB. REFER TO FIG. 15.

7. IMPEDANCE COMPENSATORS:
   NONLOADED CABLE AT PBX ≤4.5 DB: TABLE D
   (USE WITH RC OR RE REPEATERS)
   19, 22, 24H88: SEE TABLE E
   25H88: SEE TABLE F
   26H88: SEE TABLE F

8. SEE FIG. 11 FOR SMAS-4A ACCESS POINTS.

Fig. 8—Four-Wire MFT Repeatered Designs (Sheet 1 of 10)



CODES 65-L, 66-L
6A5-L, 6A6-L
85-L, 86-L

NOTES:

1. RA REPEATER AT CO(A):
   HYB 1, 2 = 900
   S1, S4 = IN (1.06UF)
   NOR - SX SH = NOR
   NOR - SX RV = NOR, SX RV (SU AT CO(I) OR CO(Z)
   NOR - RV = NOR
   OUT = 1200
   NOR - RV/T = NOR (WITH SU)
   RV/T (WITHOUT SU)

2. SIGNALING UNIT TYPES:
   LSR - J99343AC, AF, OR MODIFIED AA
   LS - GS = LS (LOOP-START)
   GS (GROUND-START)
   BOR - SEE SECTION 851-300-130
   LSO - J99343AD OR MODIFIED AB
   BOR - SEE SECTION 851-300-130
   LSE - J99343CA, CC, (CB, CD TOLL DIVERSION)
   (S1)NOR-REV = NOR (A-B) REV (B-A)
   LS - GS CONVERTER - J99343AE (AT CO(A)
   S1 THROUGH S12 - SEE SECTION 332-911-101
   NOTE: REFER TO FIG. 7 FOR RANGE LIMITS.

3. SB REPEATER AT CO(I) OR CO(Z):

SWITCH	A-B	B-A
IN	1200	1200
OUT	1200	1200
NOR-RV (NO SU)	RV	NOR
NOR-RV (WITH SU)	NOR	RV
NOR-RV/T (NO SU)	NOR	RV/T
NOR-RV/T (WITH SU)	NOR	RV/T

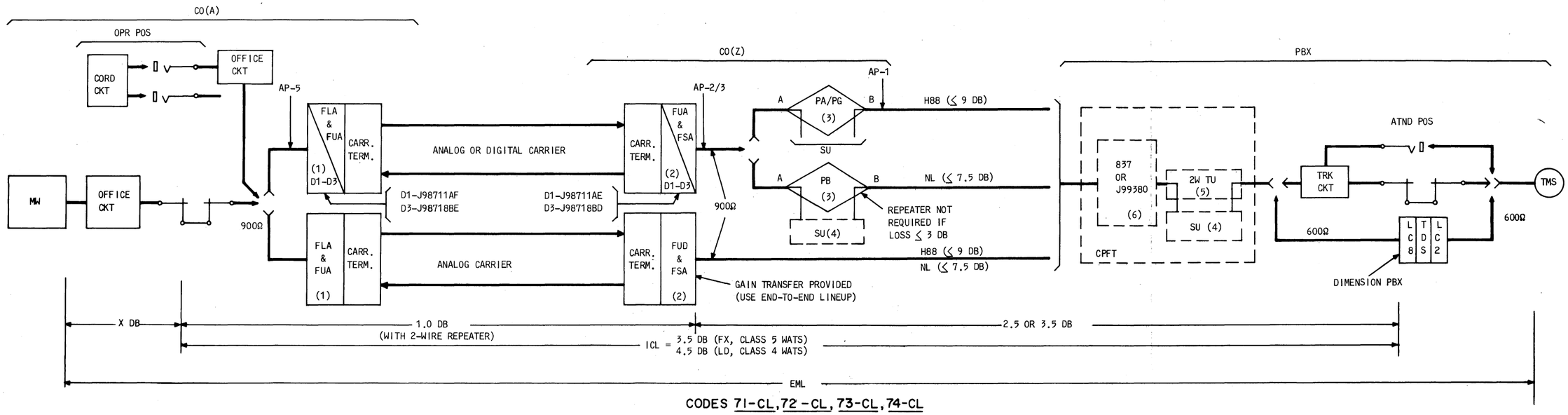
   REFER TO FIG. 7 FOR SIGNALING UNIT LOCATIONS.

4. RA/RF REPEATER AT PBX:
   HYB1,2 = 600
   S1,S4 = IN(1.06UF)
   NOR-SX SH = NOR
   NOR-SX RV = NOR (SU AT CO(I) OR CO(Z)
   SX RV (OTHERWISE)
   NOR-RV = RV (WITH SU)
   NOR (NO SU)
   NOR-RV/T = RV/T
   OUT = 1200(H88), 600(NL)

5. V4 SUBSTITUTIONS:
   A 44V4 MAY BE SUBSTITUTED FOR A 4-4 MFT. AT CO(I) WITH A LOADED CO(Z)-PBX LINK; USE 359A EQUALIZERS PER V4 DESIGN RULES. WITH A NON-LOADED CO(Z)-PBX LINK, USE 359F OR C ON THE NONLOADED SIDE AND AN RF TYPE REPEATER AT THE PBX. A 24V4 MAY BE SUBSTITUTED AT EITHER END IF 359A(LOADED) OR 359F OR C (NONLOADED) EQUALIZERS ARE USED. THE REPEATER AT CO(Z) MUST PRE-EQUALIZE FOR NONLOADED CABLE IN THIS CASE. REFER TO FIG. 15.

6. SEE FIG. 11 FOR SMAS-4A ACCESS POINTS.

Fig. 8—Four-Wire MFT Repeatered Designs (Sheet 2 of 10)



CODES 71-CL,72-CL,73-CL,74-CL
71-SL,72-SL, 73-SL,74-SL

NOTES:

1. 2-WIRE 900-OHM UNITS AT CO(A):
   ANALOG CARRIER: FUA + FLA
   DIGITAL CARRIER: D1-J98711AF
   D3-J98718BE

   COMP NET. = IN
2. 2-WIRE 900-OHM UNITS AT CO(Z):
   ANALOG CARRIER: FUA + FSA(LS OR GS)
   FUD + FSA(LS OR GS)
   DIGITAL CARRIER: D1-J98711AE
   D3-J98718BD

   COMP NET. = IN
3. 2-WIRE MFT REPEATER SWITCH SETTINGS:
   NOR-RV = NOR, RV(WITH LSE)
   NOR-RV/T = NOR(WITH SU)
   RV/T(NO SU)

4. SIGNALING UNIT TYPES:

   LSR - J99343AC, AF, OR MODIFIED AA
   LS- GS = LS (LOOP-START)
   GS (GROUND-START)
   BOR - SEE SECTION 851-300-130
   LSO - J99343AD OR MODIFIED AB
   BOR - SEE SECTION 851-300-130
   LSE - J99343CA, CC, (CB, CD TOLL DIVERSION)
   (SI) NOR-REV = NOR(A-B), REV(B-A)

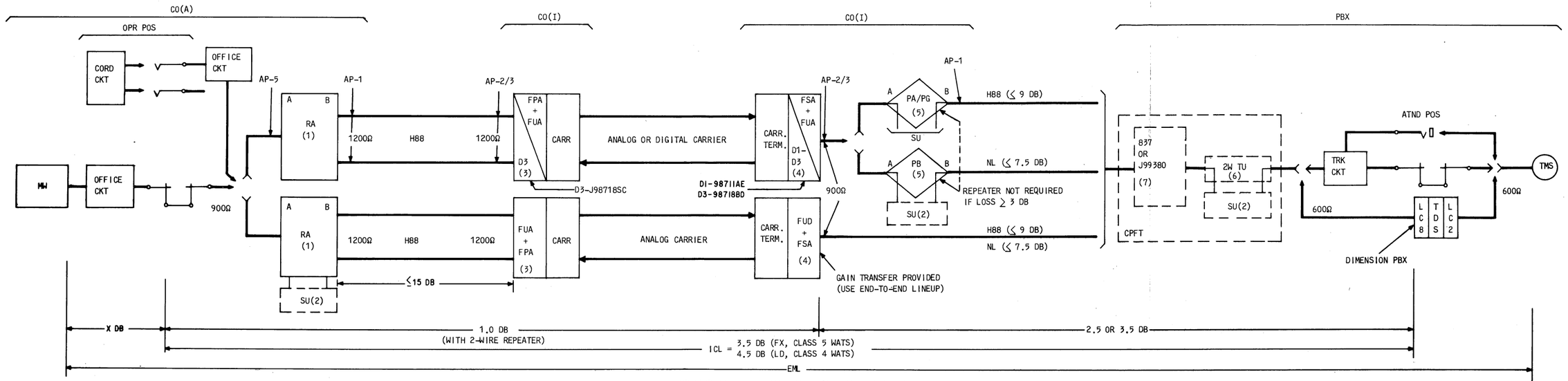
5. 2-WIRE TU-J99343BC:

WITHOUT 837 TYPE NET.	WITH 837 TYPE NET.
A-SIDE Z = 900	(SEE TABLES D,E,F)
B-SIDE Z = 900	
NOR-REV = NOR(A-B)	
= REV(B-A)	
NOR-L1 SH = NOR	
NOR-L2 SH = NOR, L2 SH(WITH LSE)	
SB1 = IN (BEST RETURN LOSS)	
= OUT (REDUCES 1-KHZ LOSS FROM 0.8 DB TO 0.4 DB)	

6. IMPEDANCE COMPENSATORS:
   NONLOADED CABLE AT PBX ≤ 4.5 DB; TABLED
   (USE WITH RC OR RE REPEATERS)
   19, 22, 24H88: SEE TABLE E
   25H88: SEE TABLE F
   26H88: SEE TABLE F

7. SEE FIG. 11 FOR SMAS-4A ACCESS POINTS.

Fig. 8—Four-Wire MFT Repeatered Designs (Sheet 3 of 10)



CODES 91-CL, 92-CL, 93-CL, 94-CL
91-SL, 92-SL, 93-SL, 94-SL

NOTES:

1. RA REPEATER AT CO(A):
   HYB 1, 2 = 900
   S1, S4 = IN (1.06UF)
   NOR - SX SH = NOR
   NOR - SX RV = NOR
   NOR - RV = NOR
   OUT = 1200
   NOR - RV/T = NOR (WITH SU)
   RV/T (WITHOUT SU)

2. SIGNALING UNIT TYPES:
   LSR - J99343AC, AF, OR MODIFIED AA
   LS - GS = LS (LOOP-START)
   GS (GROUND-START)
   BOR - SEE SECTION 851-300-130
   LSO - J99343AD OR MODIFIED AB
   BOR - SEE SECTION 851-300-130
   LSE - J99343CA, CC, (CB, CD TOLL DIVERSION)
   (S1) NOR-REV = NOR(A-B), REV(B-A)
   LS - GS CONVERTER - J99343AE (AT CO(A)
   S1 THROUGH S12 - SEE SECTION 332-911-101
   NOTE: REFER TO FIG. 7 FOR RANGE LIMITS.

3. 4-WIRE UNITS AT CO(I):
   ANALOG CARRIER : FUA + FPA
   (SEE SECTION 332-116-201)
   FOR EQL SETTINGS)
   DIGITAL CARRIER: D3-J98718SC

4. 2-WIRE UNITS AT CO(Z):
   ANALOG CARRIER: FUA + FSA
   DIGITAL CARRIER: D1-J98711AE
   D3-J98718BD

   COMP NET: IN

5. 2-WIRE MFT REPEATER SWITCH SETTINGS:
   NOR-RV = NOR, **RV (WITH LSE)**
   NOR-RV/T = NOR(WITH SU)
   RV/T(NO SU)

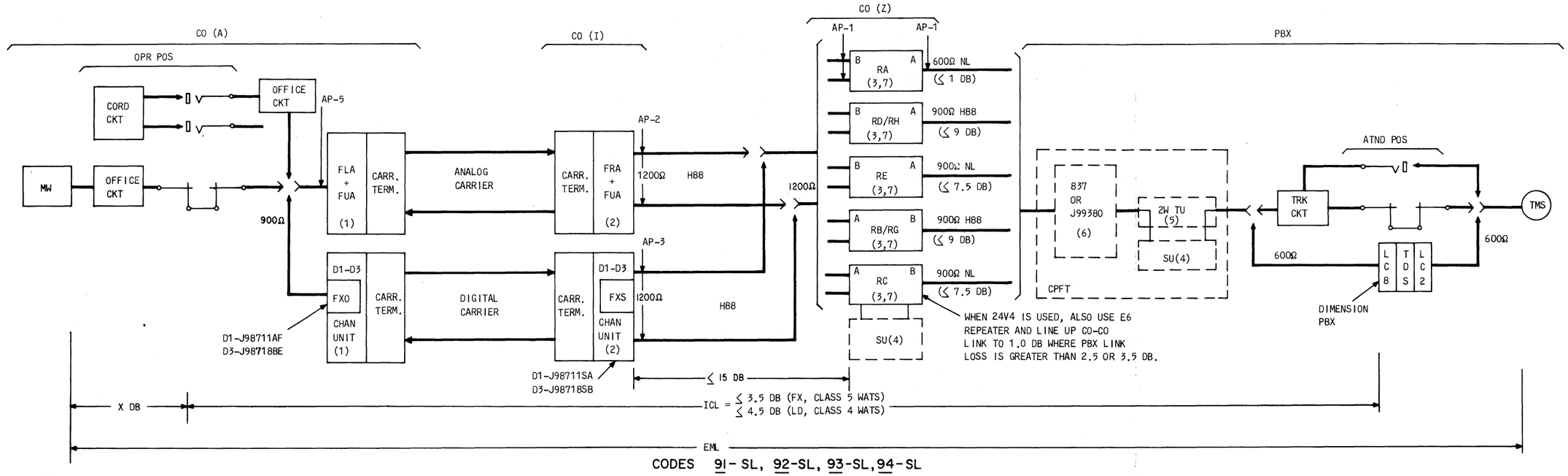
6. 2-WIRE TU-J99343BC:

WITHOUT 837 TYPE NET.	WITH 837 TYPE NET. (SEE TABLES D,E,F)
A-SIDE Z = 900	
B-SIDE Z = 900	
NOR-REV = NOR(A-B)	
= REV(B-A)	
NOR-L1 SH = NOR	
NOR-L2 SH = NOR, L2 SH(WITH LSE)	
SB1 = IN(BEST RETURN LOSS)	
= OUT(REDUCES 1-KHZ LOSS FROM 0.8 DB TO 0.4 DB)	

7. IMPEDANCE COMPENSATORS:
   NONLOADED CABLE AT PBX ≤ 4.5 DB: TABLE D
   (USE WITH PB REPEATER AND FUA + FSA)
   19, 22, 24H88: SEE TABLE E
   25H88: SEE TABLE F
   26H88: SEE TABLE F

8. SEE FIG. 11 FOR SMAS-4A ACCESS POINTS.

Fig. 8—Four-Wire MFT Repeatered Designs (Sheet 4 of 10)



CODES 91-SL, 92-SL, 93-SL, 94-SL
91-SL, 92-SL, 93-SL, 94-SL

NOTES:

1. 2-WIRE 900-OHM UNITS AT CO(A):
   ANALOG CARRIER: FUA + FLA(FLC)
   DIGITAL CARRIER: D1-J98711AF
   D3-J98718BE
   COMP NET = IN
2. 4-WIRE UNITS AT CO(I):
   ANALOG CARRIER: FUA + FRA
   DIGITAL CARRIER: D1-J98711SA
   D3-J98718SB
3. CO(Z) REPEATER SWITCH SETTINGS:

SWITCH	RA	RD/RH	RE	RB/RG	RC
HYB1,2	600	-	-	-	-
NOR-SX SH	NOR	NOR	NOR	NOR	NOR
NOR-SX RV	SX RV	SX RV	SX RV	-	-
NOR-RV (WITH SU)	RV	RV	RV	NOR(1)	NOR(1)
NOR-RV (NO SU)	NOR	NOR	NOR	NOR	NOR
NOR-RV/T (WITH SU)	RV/T	RV/T	RV/T	NOR(1)	NOR(1)
NOR-RV/T (NO SU)	RV/T	RV/T	RV/T	RV/T	RV/T
NOR-A/B RV (WITH SU)	-	-	-	NOR	NOR
NOR-A/B RV (NO SU)	-	-	-	RV	RV
OUT	1200	1200	1200	1200	1200
S1	IN	-	-	-	-
S2	-	-	-	IN	IN
S3	-	-	-	-	-
S4	IN	-	-	-	-

   1. 4-2 REPEATER WILL NOT WORK WITH 4-WIRE SF UNITS AT CO(I) WITH SIGNALING UNIT AT CO(Z).

4. SIGNALING UNIT TYPES:

   LSR = J99343AC, AF, OR MODIFIED AA
   LS - GS = LS (LOOP-START)
   GS (GROUND-START)
   BOR - SEE SECTION 851-300-130
   LSO - J99343AD OR MODIFIED AB
   BOR - SEE SECTION 851-300-130
   LSE - J99343CA, CC, (CB, CD TOLL DIVERSION)
   (S1) NOR-REV = NOR(A-B), REV(B-A)

5. 2-WIRE TU-J99343BC

   WITHOUT 837 TYPE NET. WITH 837 TYPE NET. (SEE TABLES D,E,F)
   A-SIDE Z = 900
   B-SIDE Z = 900
   NOR-REV = NOR (A-B)
   = REV (B-A)
   NOR-L1 SH = NOR
   NOR-L2 SH = NOR, L2 SH(WITH LSE)
   SB1 = IN (BEST RETURN LOSS)
   = OUT(REDUCES 1-KHZ LOSS FROM 0.8 DB TO 0.4 DB)

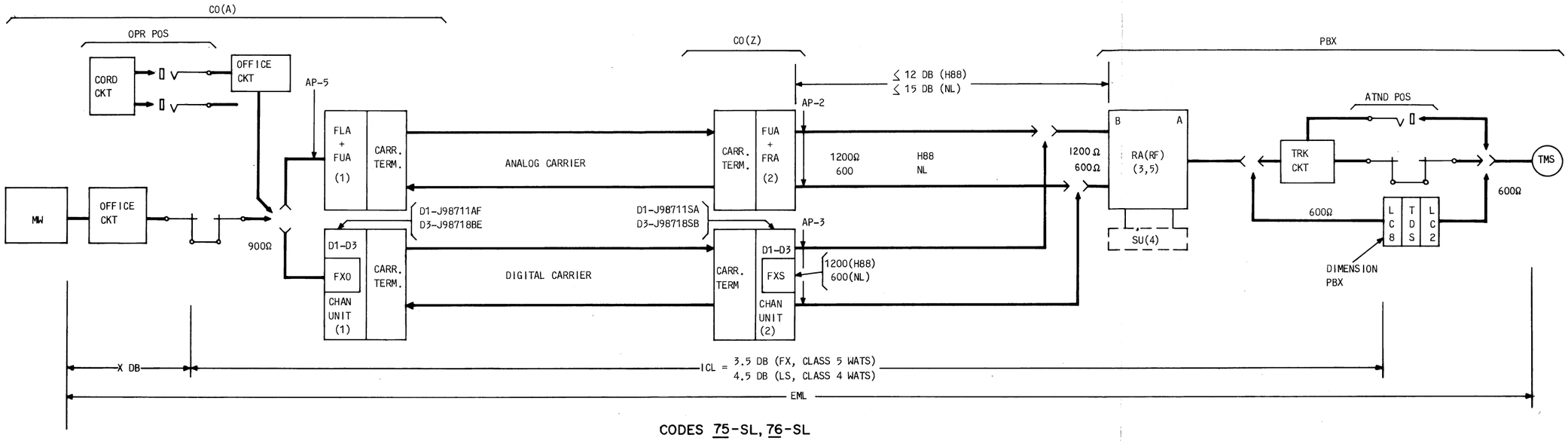
6. IMPEDANCE COMPENSATORS:

   NONLOADED CABLE AT PBX ≤ 4.5 DB: TABLE D
   (USE WITH RC OR RE REPEATERS)
   19, 22, 24H88: SEE TABLE E
   25H88: SEE TABLE F
   26H88: SEE TABLE F

7. A 24V4 MAY BE SUBSTITUED AT CO(Z) FOR THE MFT REPEATERS SHOWN. AN E6 REPEATER IS ALSO REQUIRED TO EQUALIZE THE NONLOADED PBX LINK. THE PBX LINK SHOULD BE LINED UP TO 2.5 OR 3.5 DB. REFER TO FIG. 15.

8. SEE FIG. 11 FOR SMAS-4A ACCESS POINTS.

Fig. 8—Four-Wire MFT Repeatered Designs (Sheet 5 of 10)



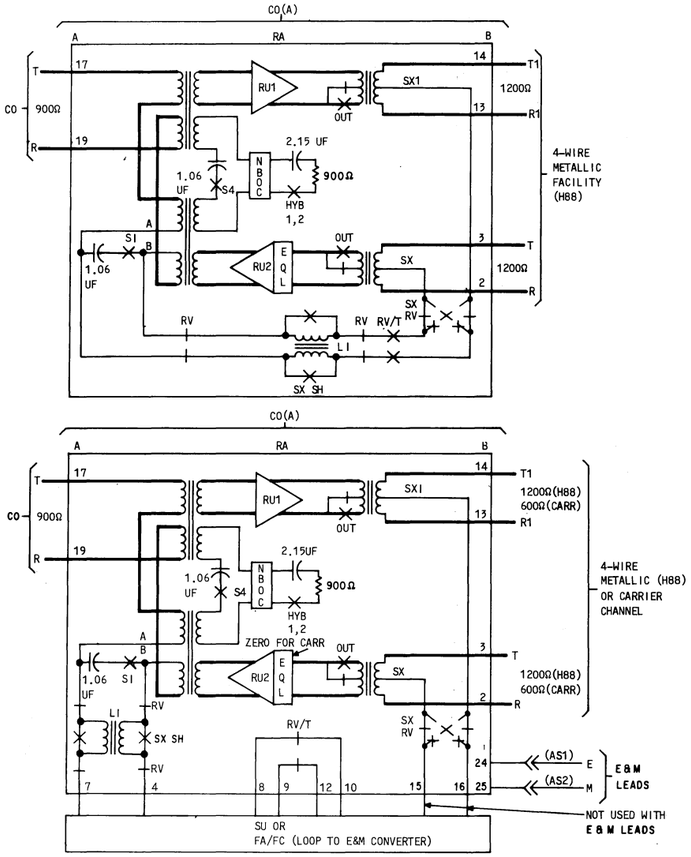
CODES 75-SL, 76-SL
75-CL, 76-SL

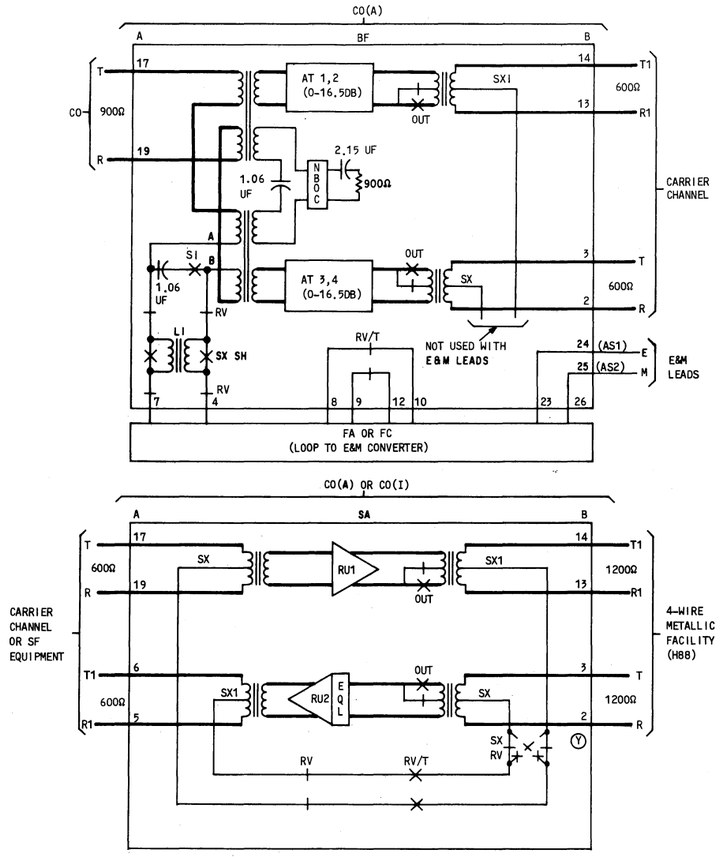
NOTES:

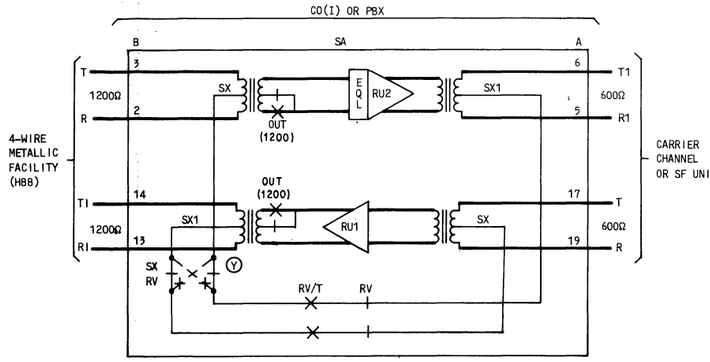
1. 2-WIRE 900-OHM UNITS AT CO(A):
   ANALOG CARRIER: FUA + FLA
   DIGITAL CARRIER: D1-J98711AF
   D3-J98718BE

   COMP NET = IN
2. 4-WIRE UNITS AT CO(Z):
   ANALOG CARRIER: FUA + FPA
   (SEE SECTION 332-116-201 FOR EQL SETTINGS)
   DIGITAL CARRIER: D1-J98711SA
   D3-J98718SB
3. RA(RF) REPEATER AT PBX:
   HYB1,2 = 600
   S1,S4 = IN (1.0(UF)
   NOR-SX SH = NOR
   NOR-SX RV = SX RV
   NOR-RV = NOR (NO SU)
   RV (WITH SU)
   NOR-RV/T = RV/T
   OUT = 1200(H88) OR 600(NL)
4. SIGNALING UNIT TYPES:
   LSR - J99343AC, AF OR MODIFIED AA:
   LS - GS = LS (LOOP-START)
   GS (GROUND-START)
   BOR - SEE SECTION 851-300-130
   LSO - J99343AD OR MODIFIED AB:
   BOR - SEE SECTION 851-300-130
   LSE - J99343CA, CC, (CB, CD TOLL DIVERSION):
   (SI)NOR-REV = NOR (A-B), REV(B-A)
5. A 24V4 REPEATER MAY BE SUBSTITUTED FOR THE RA REPEATER SHOWN. USE 359A EQUALIZER FOR LOADED CABLE. USE A 359C OR 359F EQUALIZER FOR NONLOADED CABLE.
6. SEE FIG. 11 FOR SMAS-4A ACCESS POINTS.

Fig. 8—Four-Wire MFT Repeatered Designs (Sheet 6 of 10)







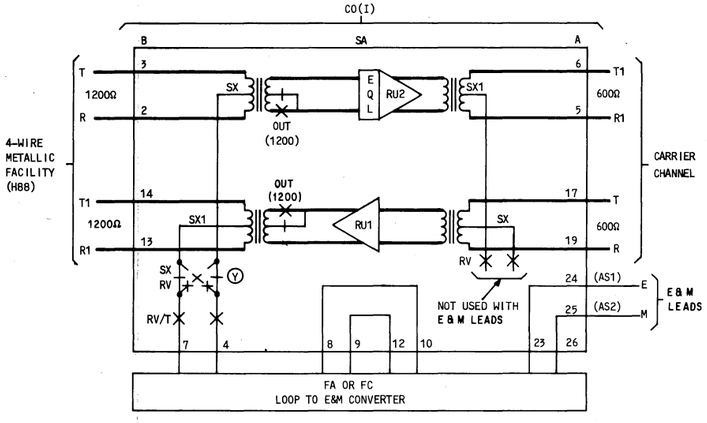
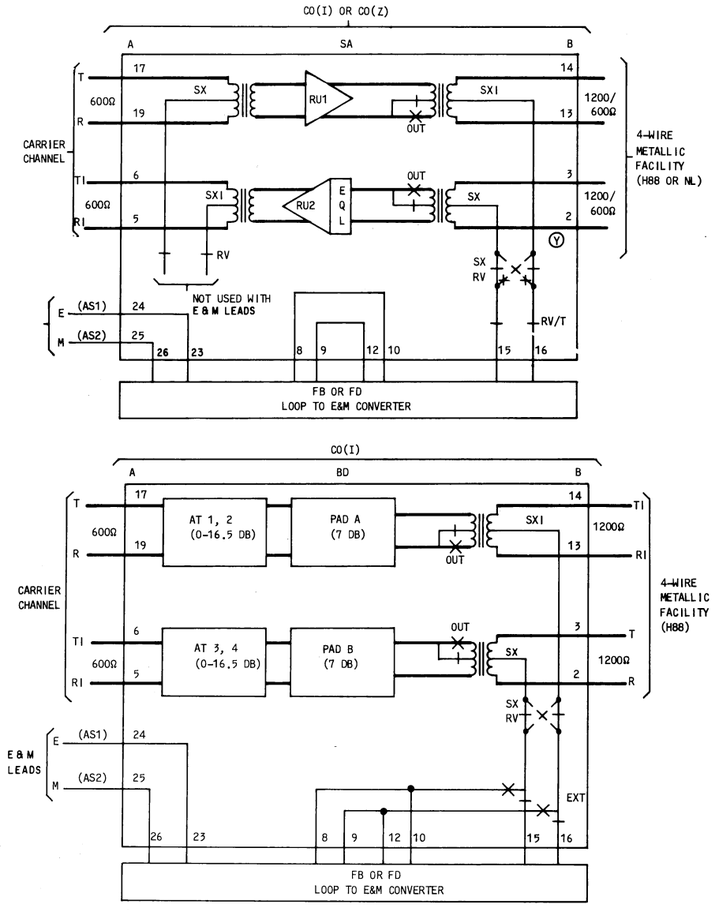
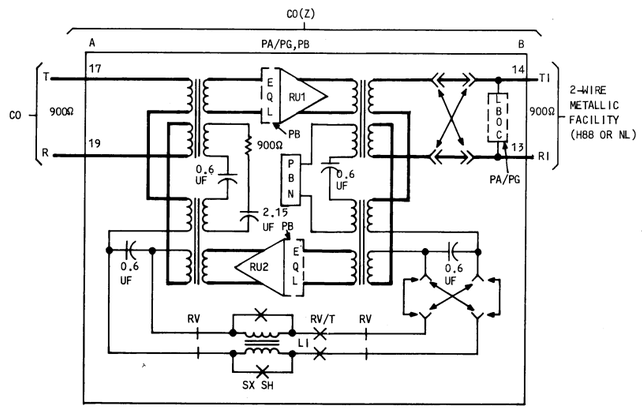
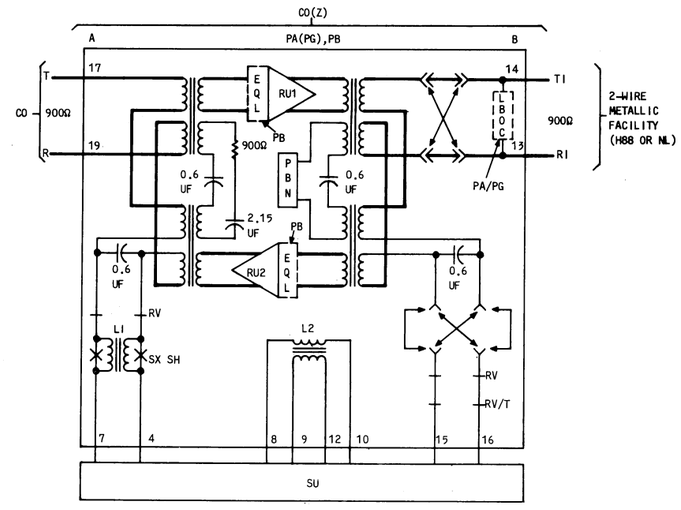
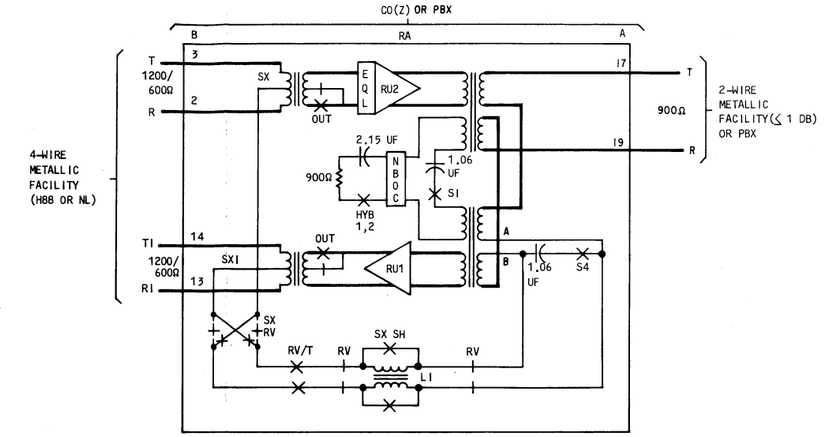


Fig. 8—Four-Wire MFT Repeatered Designs (Sheet 7 of 10)









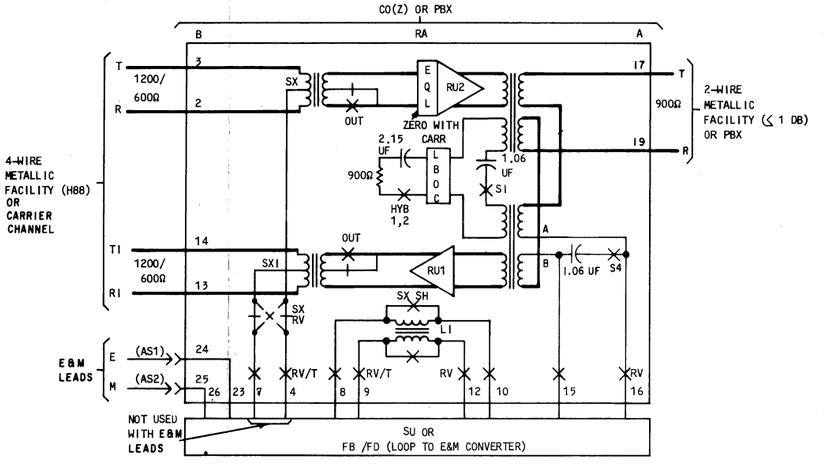
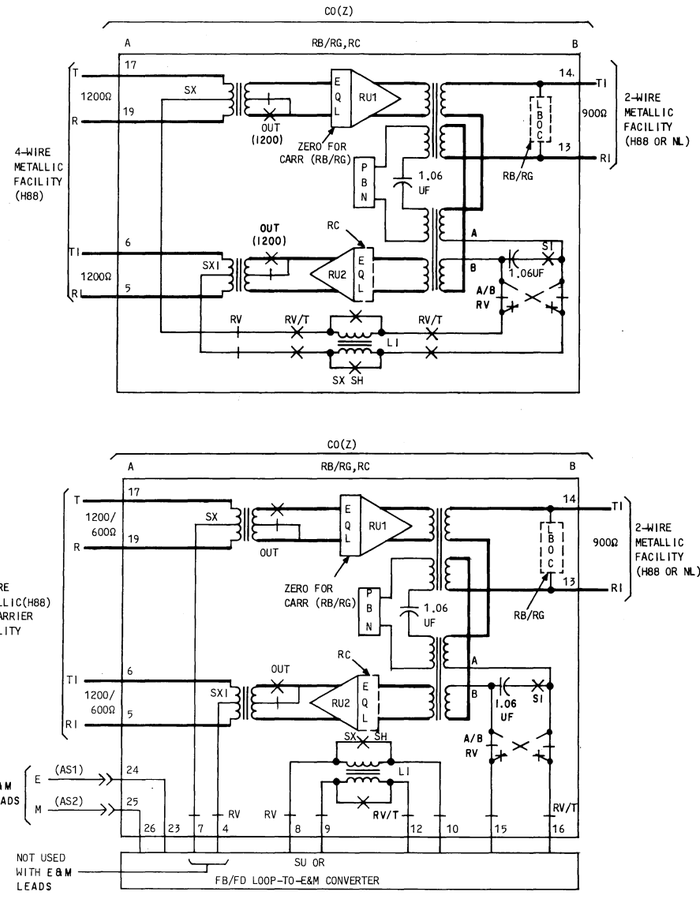
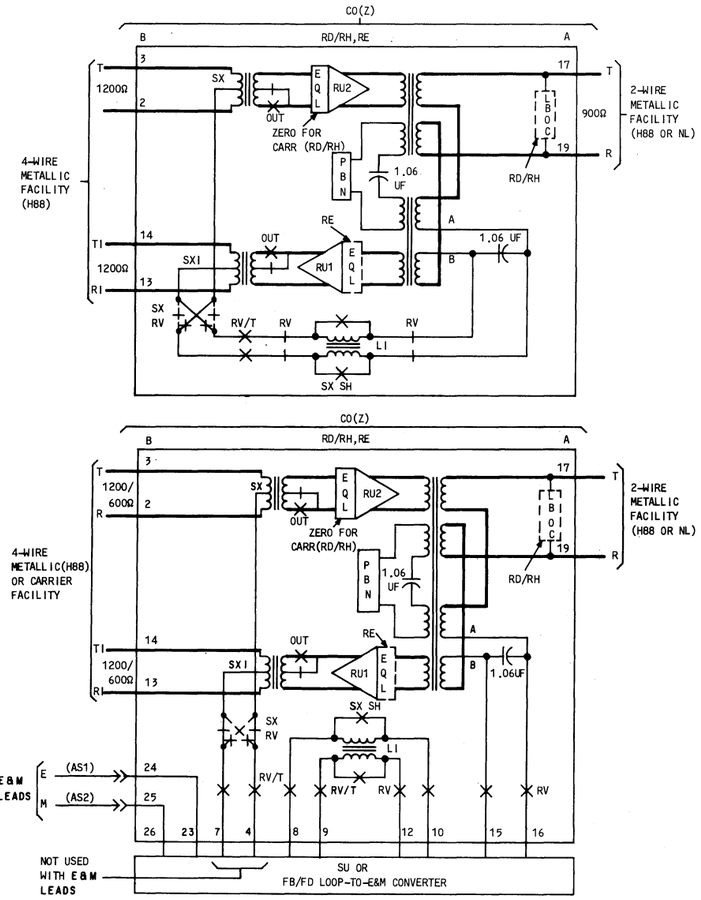


Fig. 8—Four-Wire MFT Repeatered Designs (Sheet 8 of 10)





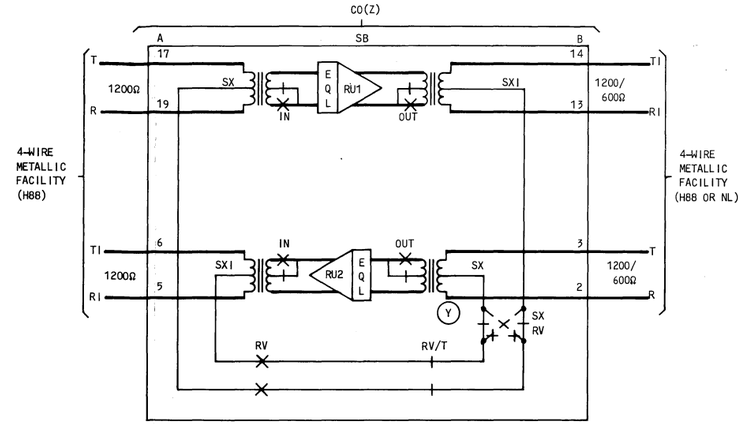
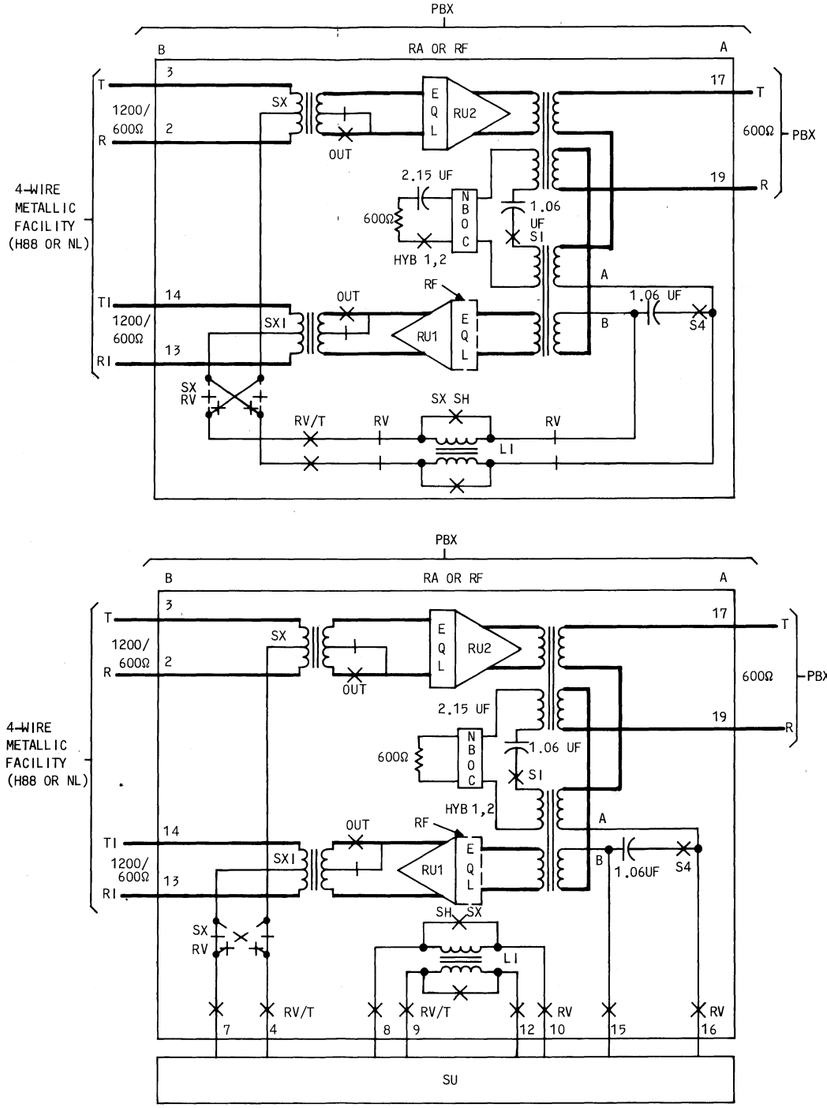


Fig. 8—Four-Wire MFT Repeatered Designs (Sheet 9 of 10)



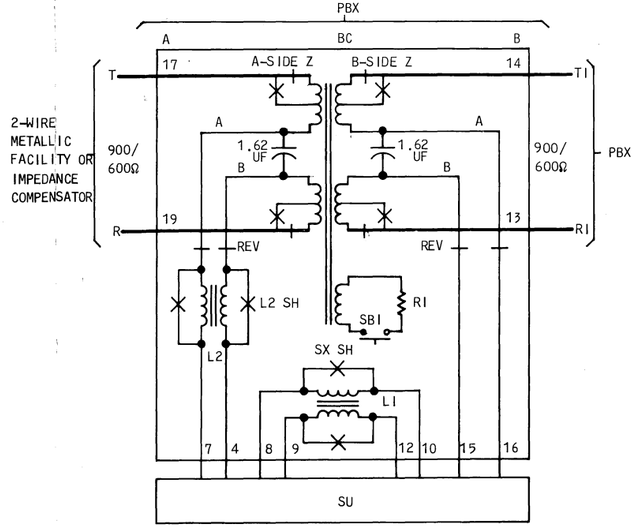
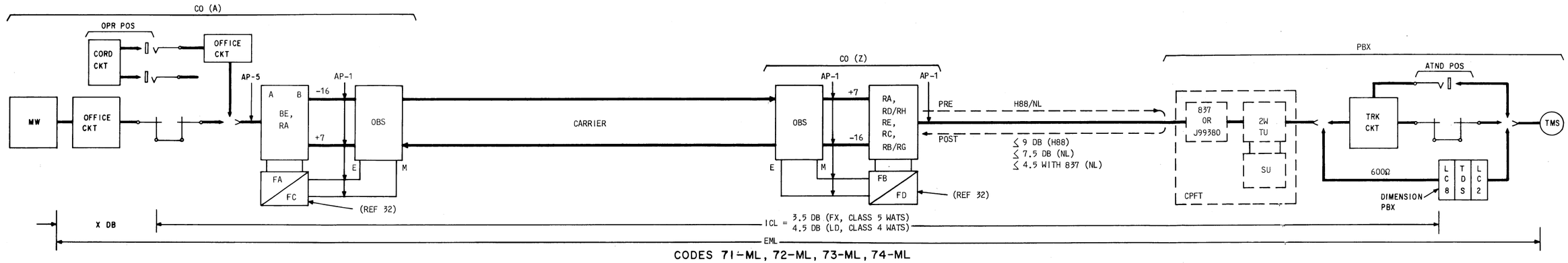
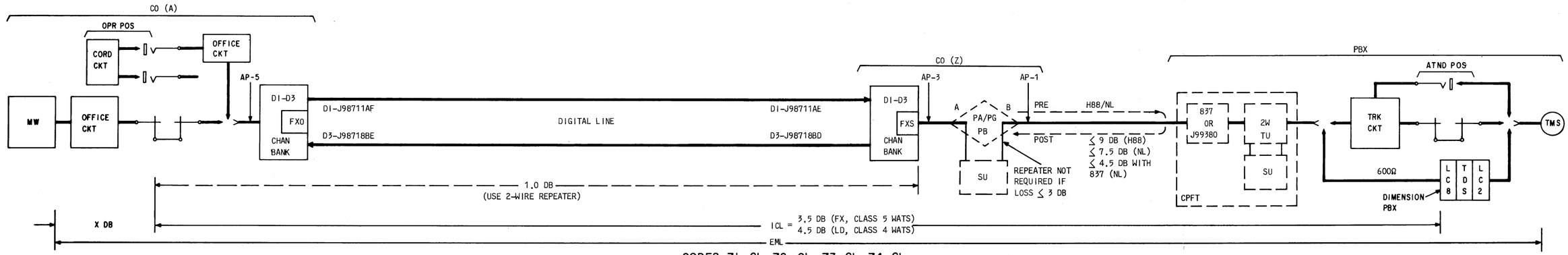


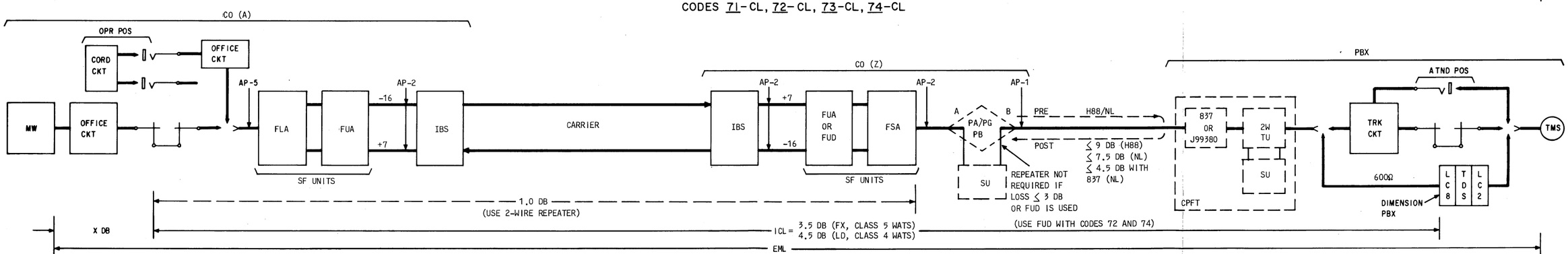
Fig. 8—Four-Wire MFT Repeatered Designs (Sheet 10 of 10)



CODES 71-ML, 72-ML, 73-ML, 74-ML



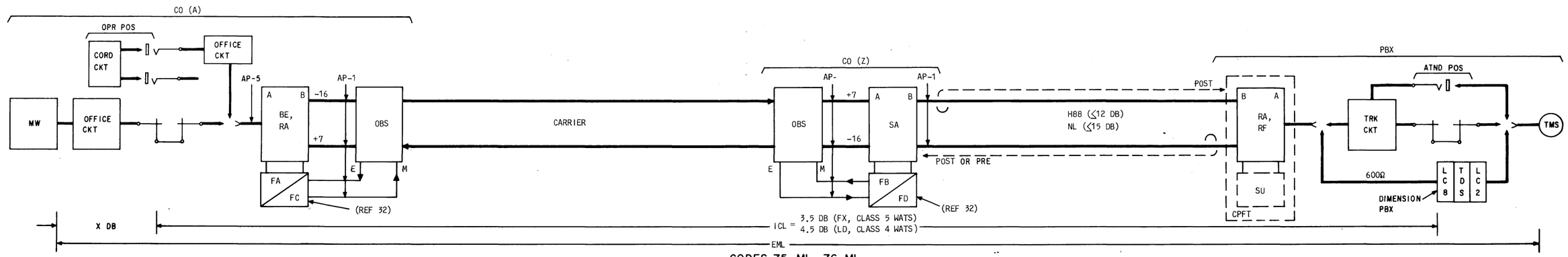
CODES 71-CL, 72-CL, 73-CL, 74-CL



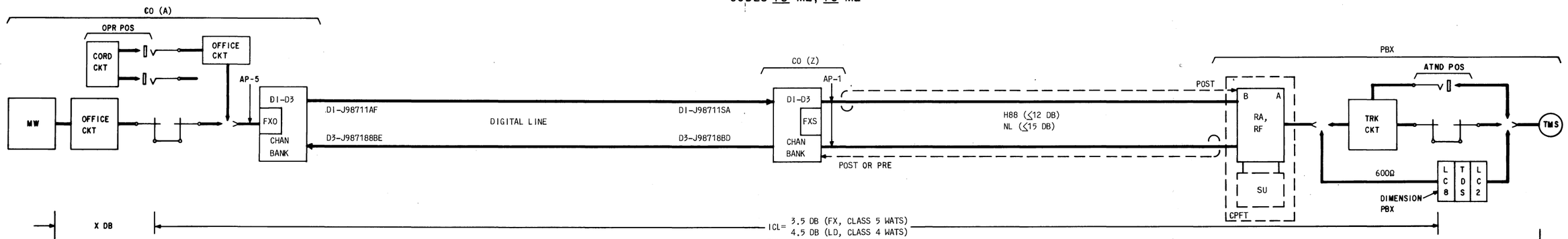
CODES 71-SL, 72-SL, 73-SL, 74-SL

1. SEE CHART 2B FOR REFERENCE INFORMATION.
2. SEE FIG. 11 FOR SMAS-4A ACCESS POINTS.
3. SEE FIG. 5 AND 8 FOR DETAILS OF MFT REPEATERS.

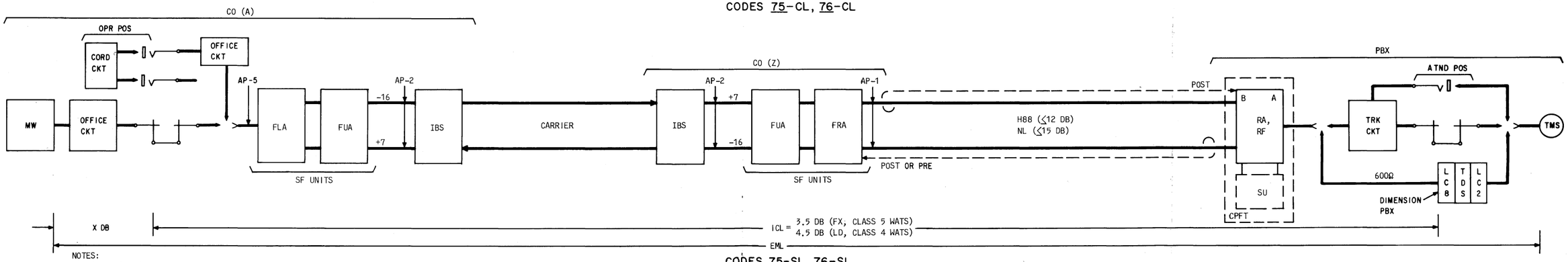
Fig. 9—MFT Carrier-Metallic Layouts (Sheet 1 of 8)



CODES 75-ML, 76-ML



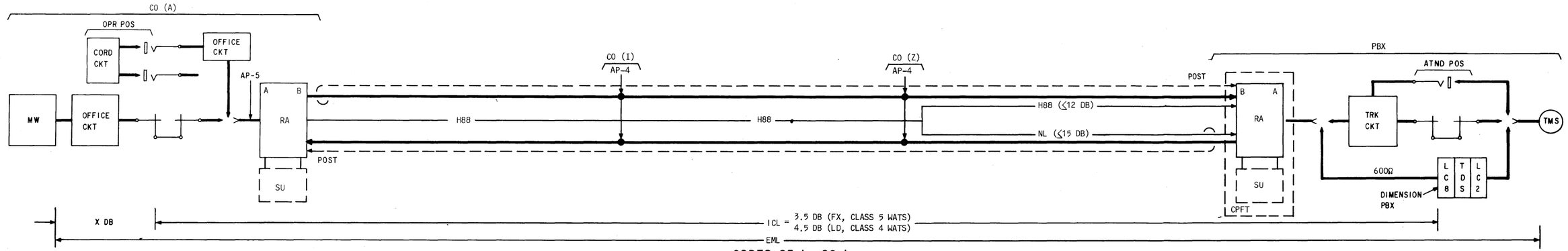
CODES 75-CL, 76-CL



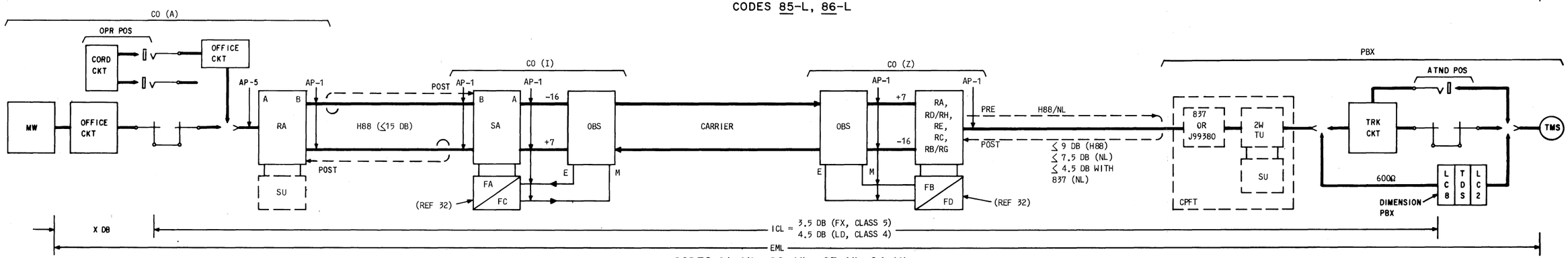
CODES 75-SL, 76-SL

NOTES:
1. SEE CHART 2B FOR REFERENCE INFORMATION.
2. SEE FIG. 11 FOR SMAS-4A ACCESS POINTS.
3. SEE FIG. 5 AND 8 FOR DETAILS OF MFT REPEATERS.

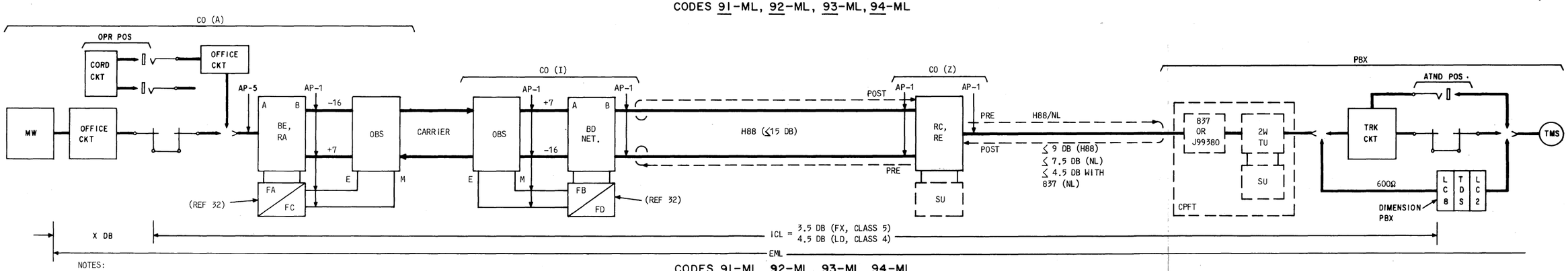
Fig. 9—MFT Carrier-Metallic Layouts (Sheet 2 of 8)



CODES 85-L, 86-L



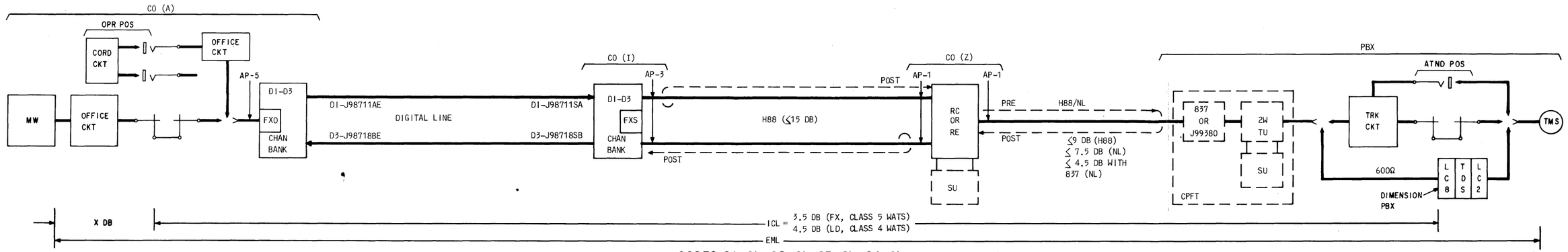
CODES 91-ML, 92-ML, 93-ML, 94-ML



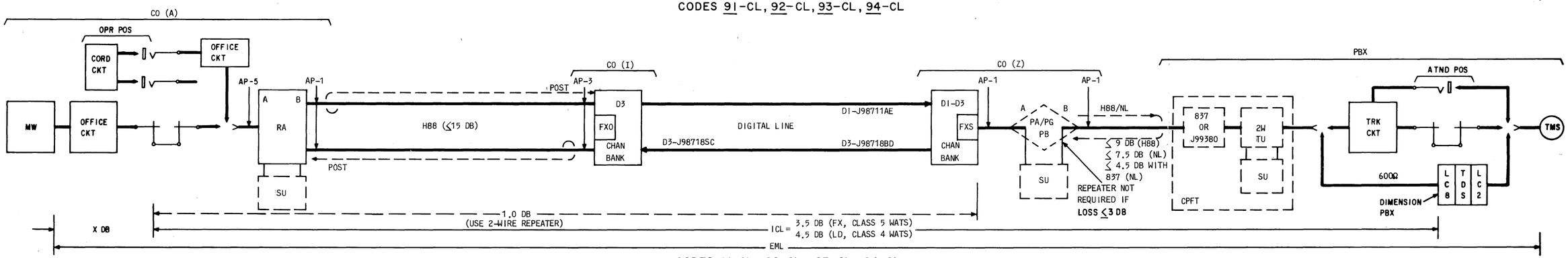
CODES 91-ML, 92-ML, 93-ML, 94-ML

NOTES:
1. SEE CHART 2B FOR REFERENCE INFORMATION.
2. SEE FIG. 11 FOR SMAS-4A ACCESS POINTS.
3. SEE FIG. 5 AND 8 FOR DETAILS OF MFT REPEATERS.

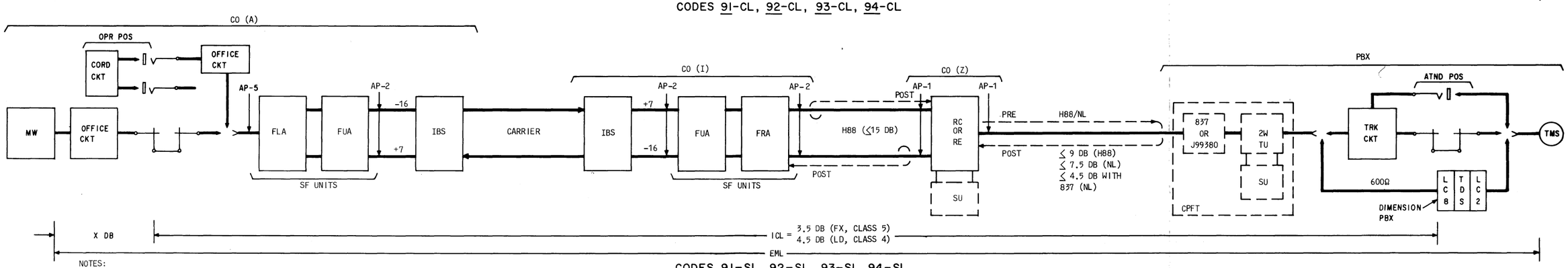
Fig. 9—MFT Carrier-Metallic Layouts (Sheet 3 of 8)



CODES 91-CL, 92-CL, 93-CL, 94-CL



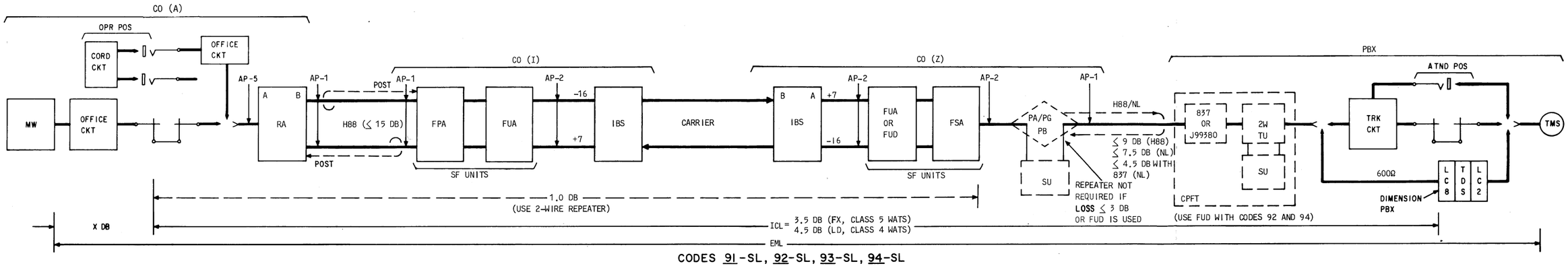
CODES 91-CL, 92-CL, 93-CL, 94-CL



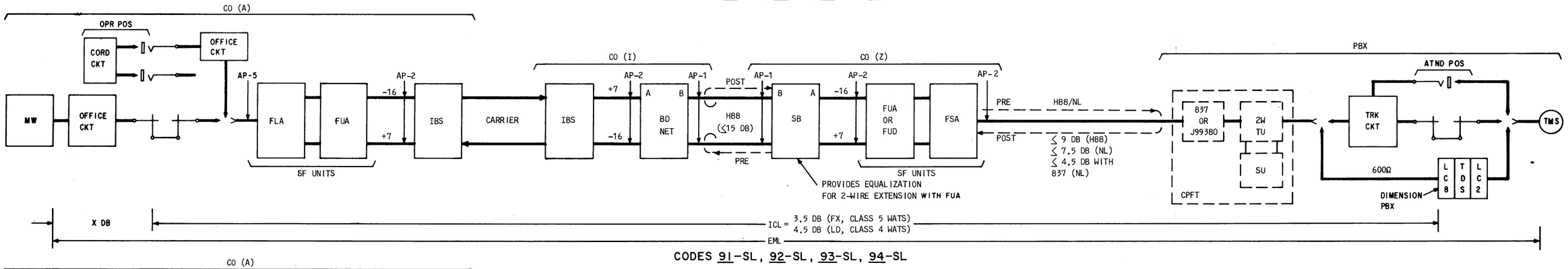
CODES 91-SL, 92-SL, 93-SL, 94-SL

NOTES:
1. SEE CHART 2B FOR REFERENCE INFORMATION.
2. SEE FIG. 11 SMAS-4A ACCESS POINTS.
3. SEE FIG. 5 AND 8 FOR DETAILS OF MFT REPEATERS.

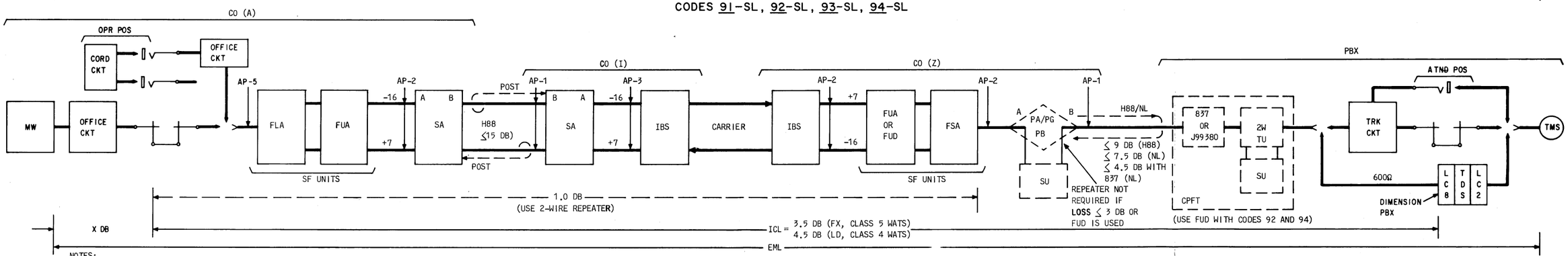
Fig. 9—MFT Carrier-Metallic Layouts (Sheet 4 of 8)



CODES 91-SL, 92-SL, 93-SL, 94-SL



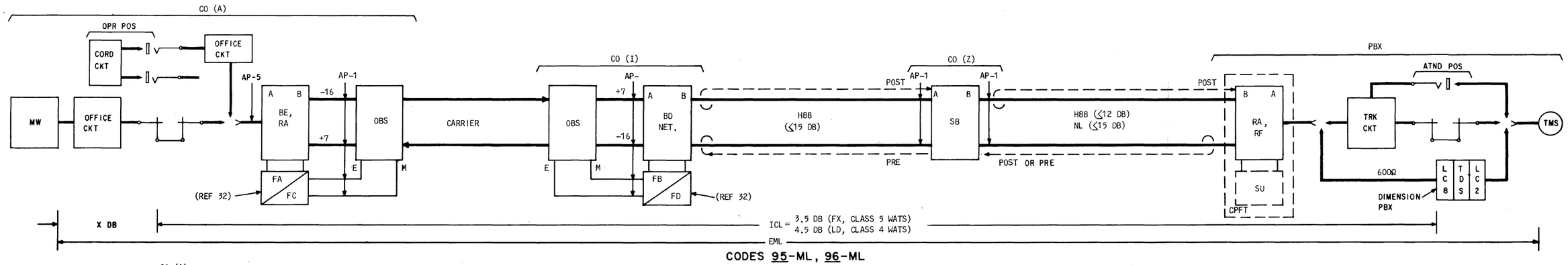
CODES 91-SL, 92-SL, 93-SL, 94-SL



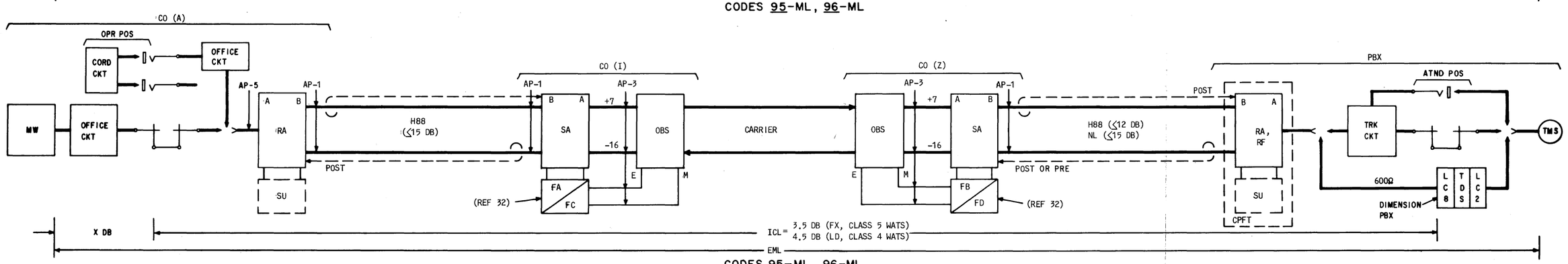
CODES 91-SL, 92-SL, 93-SL, 94-SL

NOTES:
1. SEE CHART 2B FOR REFERENCE INFORMATION.
2. SEE FIG. 11 FOR SMAS-4A ACCESS POINTS.
3. SEE FIG. 5 AND 8 FOR DETAILS OF MFT REPEATERS.

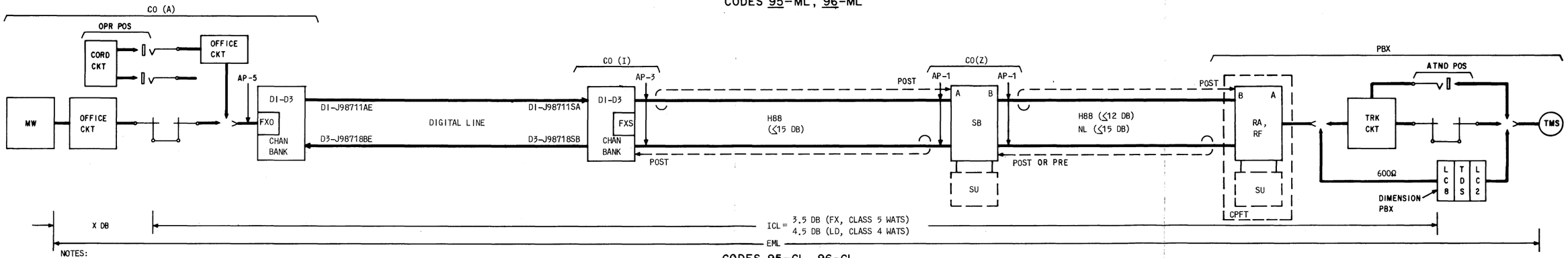
Fig. 9—MFT Carrier-Metallic Layouts (Sheet 5 of 8)



CODES 95-ML, 96-ML



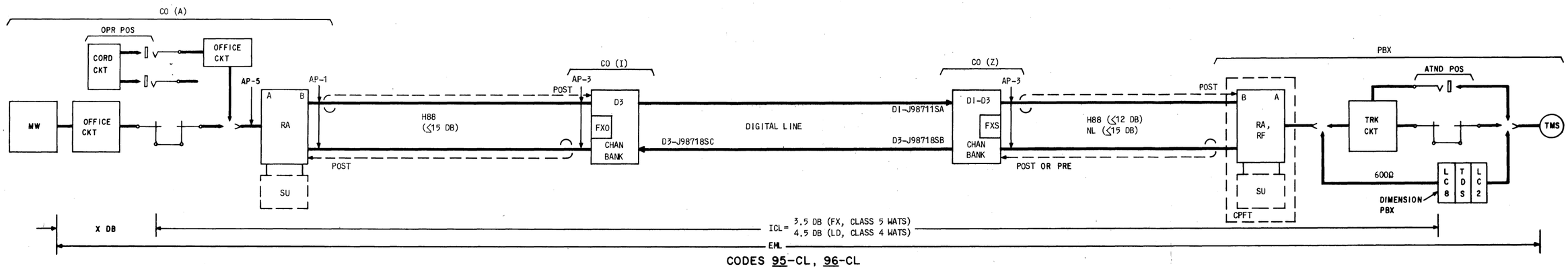
CODES 95-ML, 96-ML



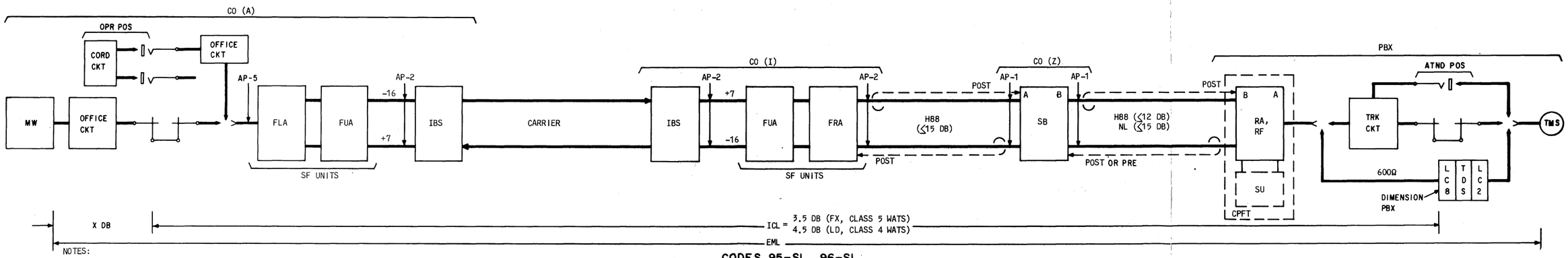
CODES 95-CL, 96-CL

NOTES:
1. SEE CHART 2B FOR REFERENCE INFORMATION.
2. SEE FIG. 11 FOR SMAS-4A ACCESS POINTS.
3. SEE FIG. 5 AND 8 FOR DETAILS OF MFT REPEATERS.

Fig. 9—MFT Carrier-Metallic Layouts (Sheet 6 of 8)



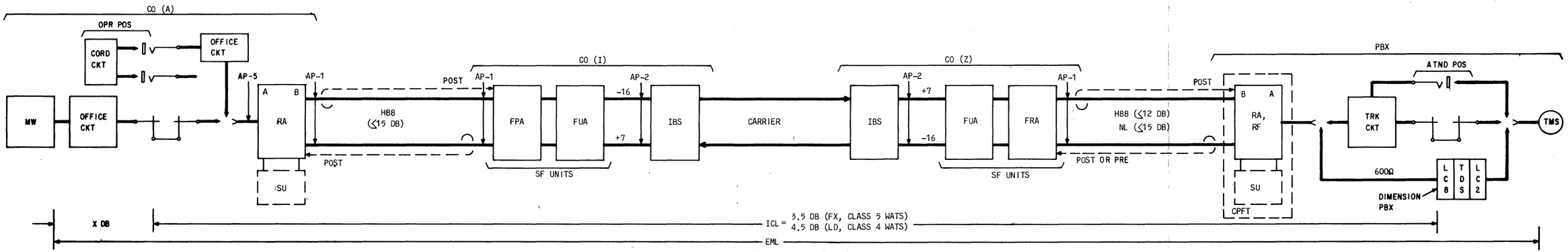
CODES 95-CL, 96-CL



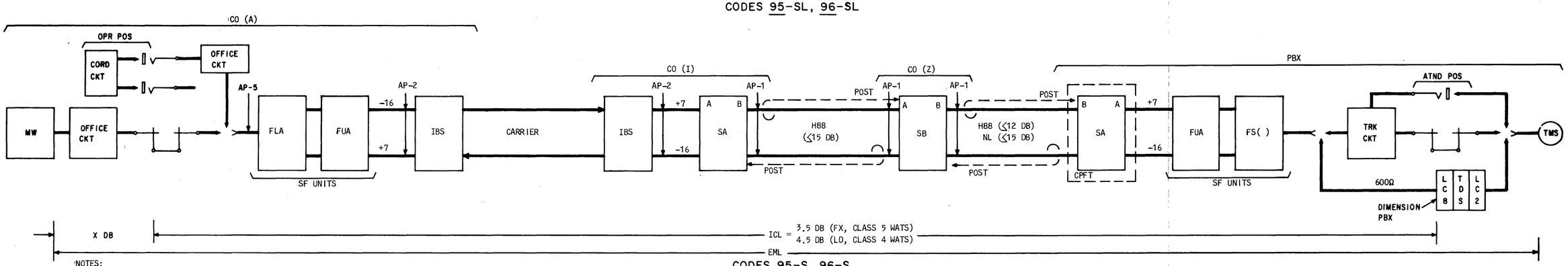
CODES 95-SL, 96-SL

NOTES:
1. SEE CHART 2B FOR REFERENCE INFORMATION.
2. SEE FIG. 11 SMAS-4A ACCESS POINTS.
3. SEE FIG. 5 AND 8 FOR DETAILS OF MFT REPEATERS.

Fig. 9—MFT Carrier-Metallic Layouts (Sheet 7 of 8)



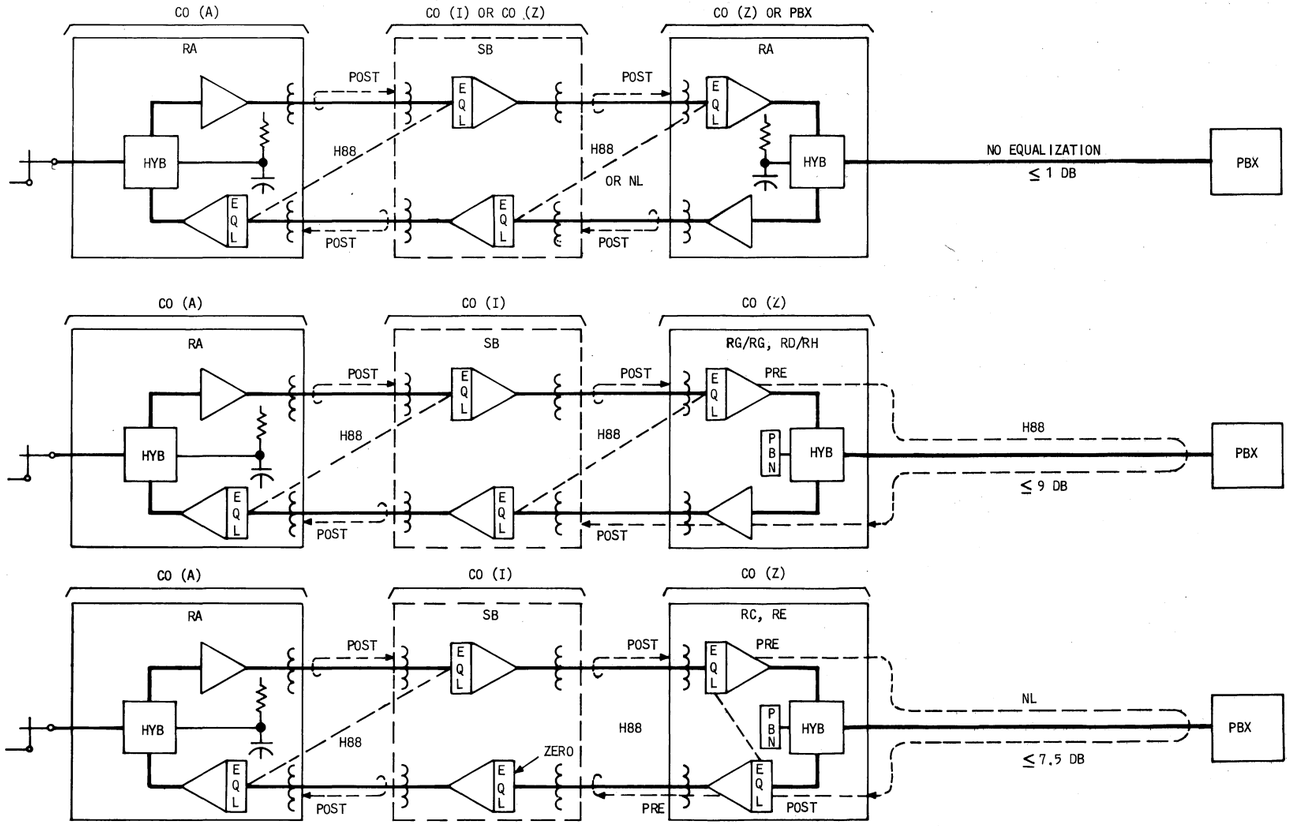
CODES 95-SL, 96-SL



CODES 95-S, 96-S

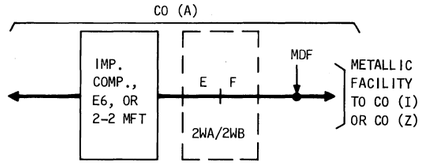
NOTES:
1. SEE CHART 2B FOR REFERENCE INFORMATION.
2. SEE FIG. 11 FOR SMAS-4A ACCESS POINTS.
3. SEE FIG. 5 AND 8 FOR DETAILS OF MFT REPEATERS.

Fig. 9—MFT Carrier-Metallic Layouts (Sheet 8 of 8)

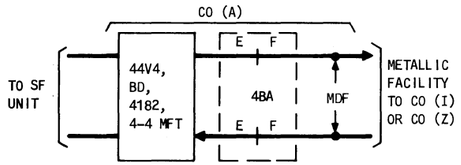


NOTE:
EQUALIZER AMPLIFIERS CONNECTED WITH DASHED LINES USE THE SAME EQUALIZER PRESCRIPTION SETTINGS.

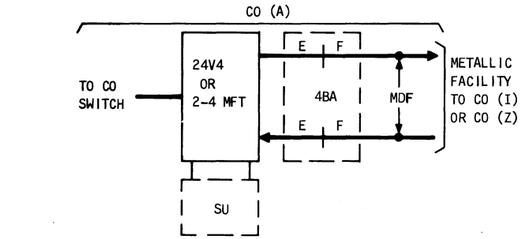
Fig. 10—Equalization Techniques for 4-Wire MFT Designs



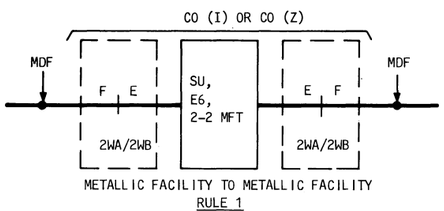
CO (A) TO METALLIC FACILITY
(LOOP SIGNALING)
RULE 1



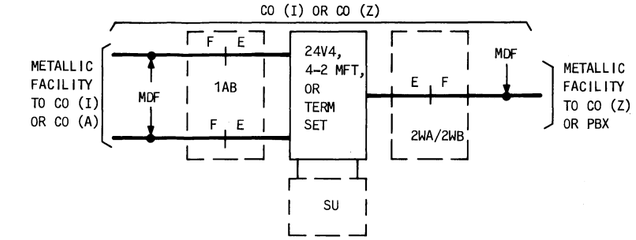
CO (A) TO METALLIC FACILITY
(SF SIGNALING)
RULE 1



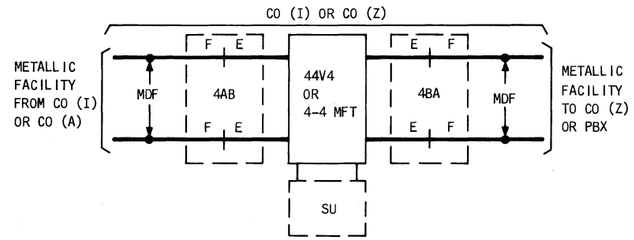
CO (A) TO METALLIC FACILITY
(LOOP SIGNALING)
RULE 1



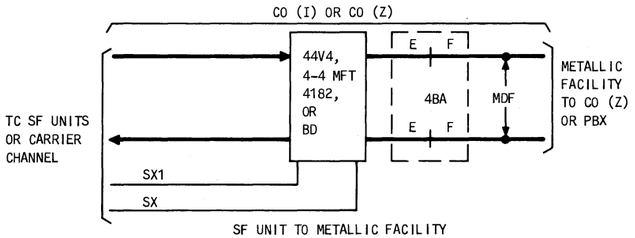
METALLIC FACILITY TO METALLIC FACILITY
RULE 1



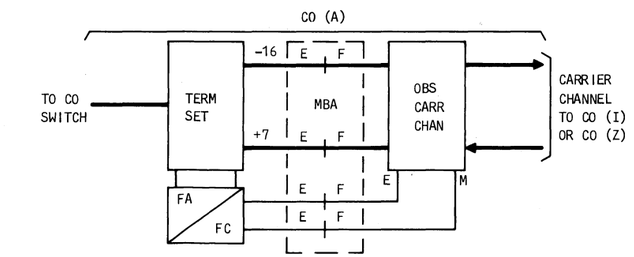
METALLIC FACILITY TO METALLIC FACILITY
(LOOP SIGNALING)
RULE 1



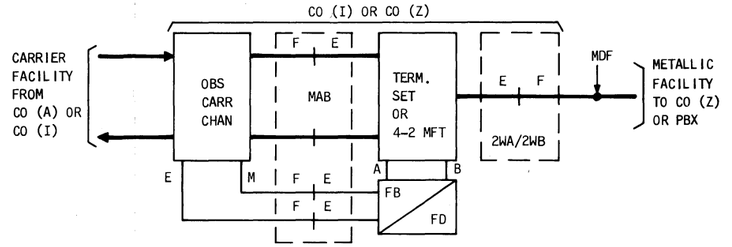
METALLIC FACILITY TO METALLIC FACILITY
RULE 1



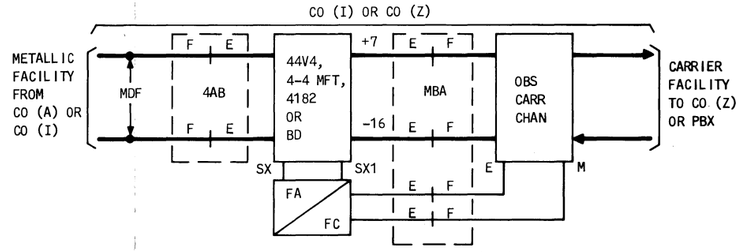
SF UNIT TO METALLIC FACILITY
(SF SIGNALING)
RULE 1



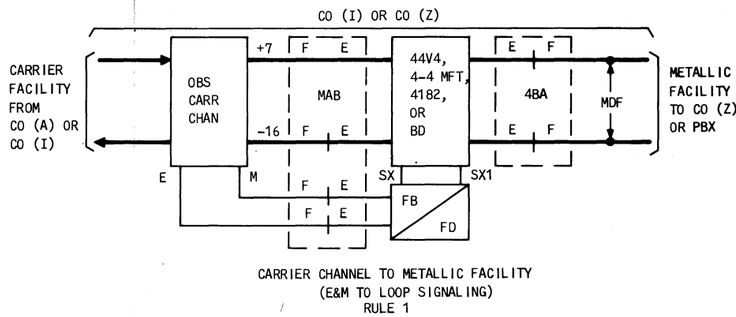
CO (A) TO CARRIER CHANNEL
(LOOP TO E&M SIGNALING)
RULE 1



CARRIER CHANNEL TO METALLIC FACILITY
(E&M TO LOOP SIGNALING)
RULE 1



METALLIC FACILITY TO CARRIER CHANNEL
(LOOP TO E&M SIGNALING)
RULE 1

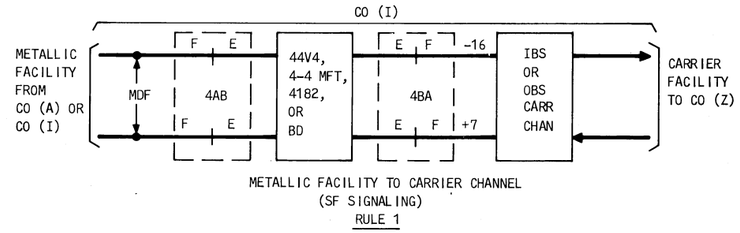


CARRIER CHANNEL TO METALLIC FACILITY
(E&M TO LOOP SIGNALING)
RULE 1

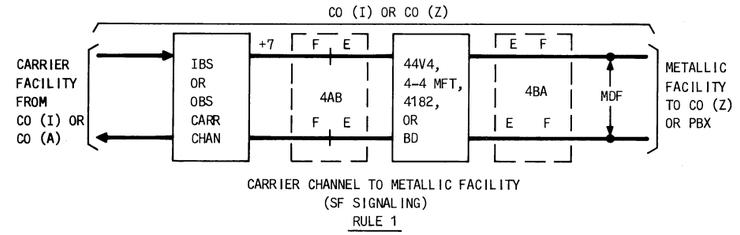
NOTES:
F DENOTES FACILITY
E DENOTES EQUIPMENT
SU DENOTES MFT LSR LSO, OR LSE SIGNALING UNITS.

LEGEND:
F E SMAS ACCESS POINT WITH ORIENTATION CODE AND CONFIGURATION (SEE 2WA REF 33 OF CHART 2B).

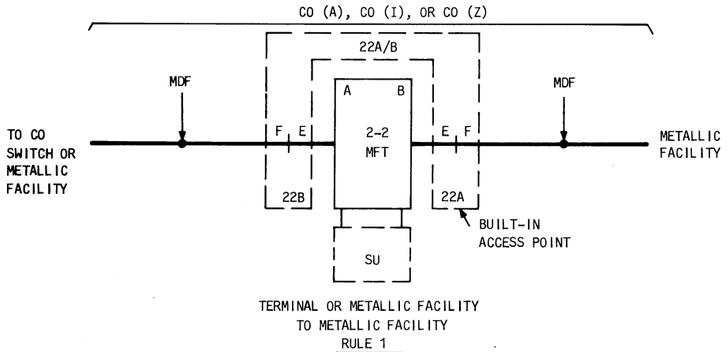
Fig. 11—Examples of SMAS Access Points (Sheet 1 of 3)



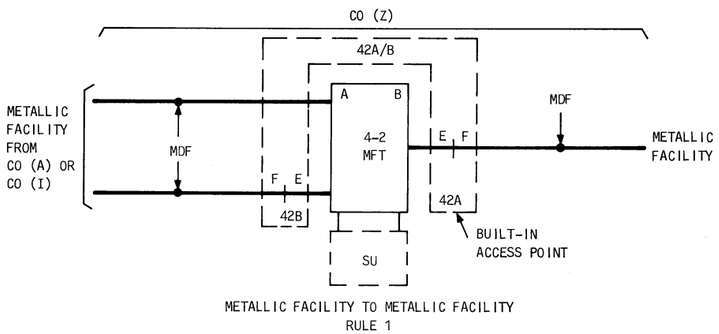
METALLIC FACILITY TO CARRIER CHANNEL
(SF SIGNALING)
RULE 1



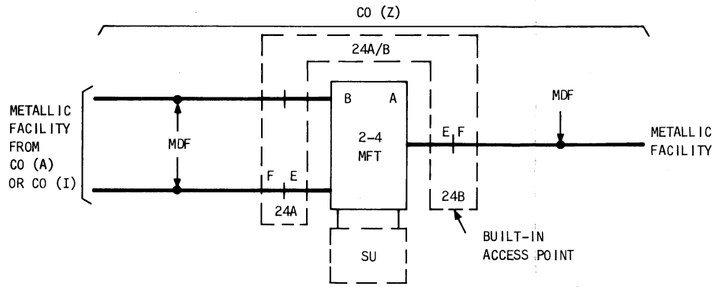
CARRIER CHANNEL TO METALLIC FACILITY
(SF SIGNALING)
RULE 1



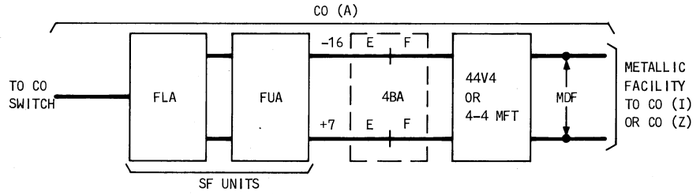
TERMINAL OR METALLIC FACILITY
TO METALLIC FACILITY
RULE 1



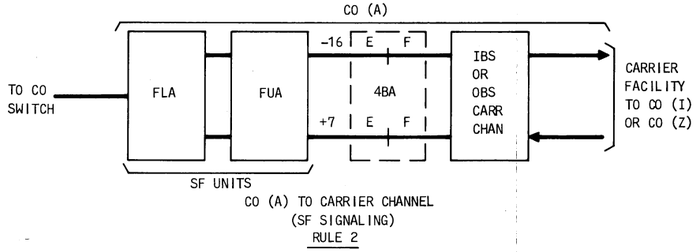
METALLIC FACILITY TO METALLIC FACILITY
RULE 1



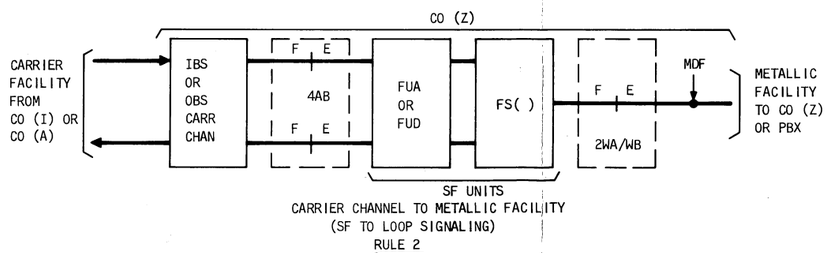
METALLIC FACILITY TO METALLIC FACILITY
RULE 1



CO (A) TO METALLIC FACILITY
(SF SIGNALING)
RULE 2



CO (A) TO CARRIER CHANNEL
(SF SIGNALING)
RULE 2

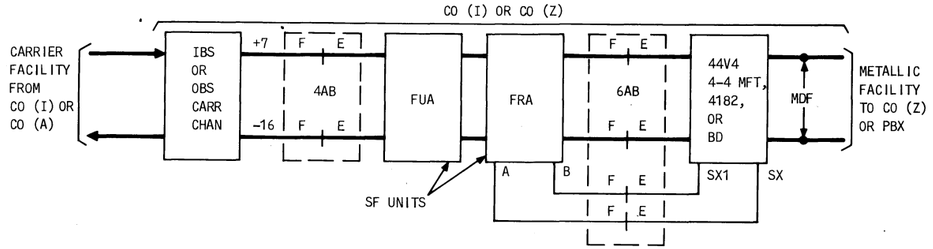


CARRIER CHANNEL TO METALLIC FACILITY
(SF TO LOOP SIGNALING)
RULE 2

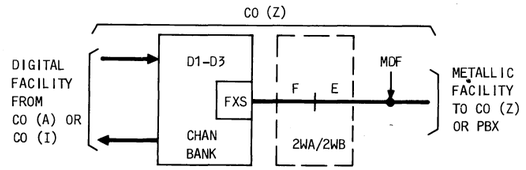
NOTES:
- F DENOTES FACILITY
- E DENOTES EQUIPMENT
- SU DENOTES MFT LSR, LSO, OR LSE SIGNALING UNITS.

LEGEND:
F | E — SMAS ACCESS POINT WITH ORIENTATION CODE AND CONFIGURATION (SEE REF 33 OF CHART 2B).
2WA

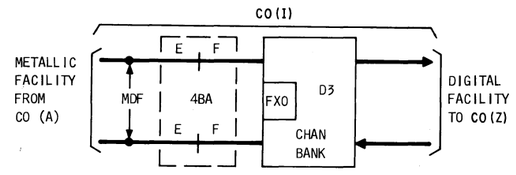
Fig. 11—Examples of SMAS Access Points (Sheet 2 of 3)



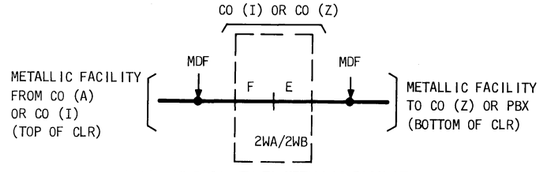
CARRIER CHANNEL TO METALLIC FACILITY
(SF TO LOOP SIGNALING)
RULE 2



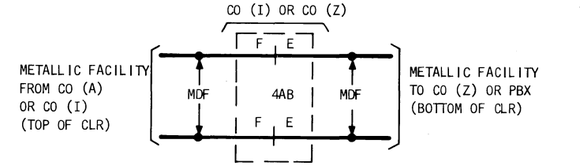
DIGITAL CARRIER CHANNEL TO METALLIC FACILITY
(DIGITAL TO LOOP SIGNALING)
RULE 3



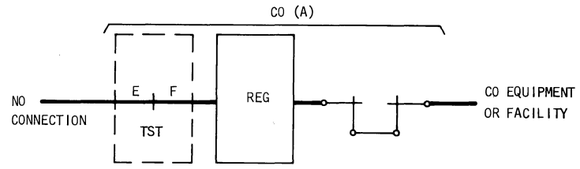
LOOP TO DIGITAL SIGNALING
RULE 3



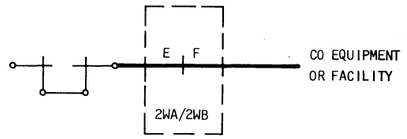
METALLIC FACILITY TO METALLIC FACILITY
RULE 4



METALLIC FACILITY TO METALLIC FACILITY
RULE 4



NO-TEST ACCESS LINE PROVIDED
RULE 5



ACCESS POINT PROVIDED IN LIEU
OF NO-TEST ACCESS CAPABILITY
RULE 5

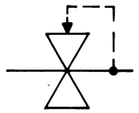
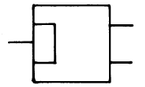
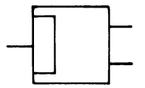
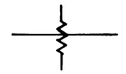
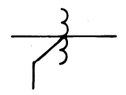
NOTES:
F DENOTES FACILITY
E DENOTES EQUIPMENT
SU DENOTES MFT LSR, LSO, OR LSE SIGNALING UNITS.

LEGEND:

F | E
2WA

SMAS ACCESS POINT WITH ORIENTATION CODE AND ACCESS CONFIGURATION CODE (SEE REF 33 OF CHART 2B).

Fig. 11—Examples of SMAS Access Points (Sheet 3 of 3)

SYMBOL	DESCRIPTION	REFERENCE	SYMBOL	DESCRIPTION	REFERENCE	SYMBOL	DESCRIPTION	REFERENCE	SYMBOL	DESCRIPTION	REFERENCE
	E6 GAIN UNIT (831 NETWORK WITH POSSIBLE GAIN DISABLER)	J99253	EQL	359 EQUALIZER	REFERENCE 12		D1-D3 CHANNEL BANKS (2-4 WIRE)	REFERENCE 18	TMS	TRANSMISSION MEASURING SET	
830( )	E6 LBO NETWORK FOR LOADED CABLE	J99253; REFERENCE 1	4182, BD NETS.	4-WIRE EXTENSION NETWORKS	REFERENCES 15,16		D1-D3 CHANNEL BANK (4-4 WIRE)			LOADED FACILITY	REFERENCE 4
PA SU	2-WIRE MFT REPEATER WITH POSSIBLE MFT SIGNALING UNIT (SU)	SD-1C359-01 REFERENCE 19	E&M DLL-1	E&M CONVERTER: LS-SD-96251-01 GS-SD-1C353-01 (FACES CO)	REFERENCE 22,23	IBS	CARRIER TERMINAL WITH INBAND OR DIGITAL SIGNALING	REFERENCE 24		89-TYPE RESISTOR PAD	REFERENCE 13
B37( ) †	2-WIRE IMPEDANCE COMPENSATOR	SD-97054-01 SD-7C010-01 REFERENCE 4	E&M DLL-2	E& M CONVERTER: LS-SD-96252-01 GS-SD-1C354-01 (FACES PBX)		OBS	CARRIER TERMINAL WITH OUT-OF-BAND SIGNALING (N1, O, ON)	REFERENCE 29		TRANSFORMER SIMPLEX TAP	
RE (DLL) †	2-WIRE RANGE-EXTENDING EQUIPMENT (MFT OR DLL)	SD-96234 (ISS. 21D) SD-96555 (ISS. 10D) Z OPTION REFERENCE 20	FA / FC	MFT E&M CONVERTER: LS-J99343FA GS-J99343FC (FACES CO)	SD-1C359 REFERENCE 32	MW	1004-HZ TEST MILLIWATT OR EQUIVALENT		E F	SMAS-4A ACCESS POINT	REFERENCE 33
SU	METALLIC FACILITY TERMINAL SIGNALING UNIT	SD-1C359 REFERENCES 20,21	FB / FD	MFT E&M CONVERTER LS-J99343FB GS-J99343FD (FACES PBX)		CORD CKT	ATND POS PBX CORD CIRCUIT (CORDBOARD OR CONSOLE)	REFERENCE 30			
24V4 RA/RF	2-4 WIRE REPEATERS WITH TERM. SET, AMPLIFIERS, AND EQUALIZERS	SD-97407-01 SD-1C359-01 REFERENCES 10,11,12, 13,19	FUA OR FUD	E-TYPE 2600-HZ SF SIGNALING CONVERTER		TRK CKT	PBX TRUNK CIRCUIT	SD-65657-01 SD-66719-01 SD-5E001 OR EQUIVALENT			
HYB	1M OR 1N TERMINATING SET	SD-97318-01 REFERENCE 13	FS( )	2-WIRE SF AUXILIARY UNIT (FACES PBX)	SD-1C226 SD-2C230 SD-1C231 REFERENCE 17	LC8 TDS LC2	DIMENSION PBX	SD-1E440 REFERENCE 31			
44V4, SA,SB †	4-WIRE REPEATERS WITH AMPLIFIERS AND EQUALIZERS	REFERENCES 10,11,12	FL( )	2-WIRE SF AUXILIARY UNIT (FACES CO)			CENTRAL OFFICE OR PBX SWITCH	REFERENCE 8, 28			

* SEE CHART 2B FOR REFERENCE INFORMATION.
† DASHES INDICATE POSSIBLE LOCATION WHEN REQUIRED.

ABBREVIATIONS:
VF - METALLIC
CARR - CARRIER
L - LOADED
NL - NONLOADED
BT - BRIDGED TAP
4W - FOUR-WIRE
GS - GROUND-START
LS - LOOP-START

CHART 2A—Layout Legends

CHART 2B
E6-V4 LAYOUT REFERENCES

REF. NO.	INFORMATION
1	830A, B, G, or J networks for loaded cables: 830A for 19-, 22-, or 24H88 high-capacitance (HC) cable. 830B for 19- or 24H88 low-capacitance (LC) cable. 830G for 26H88 cable. 830J for 25H88 cable. 830C or E networks for nonloaded cables: 830C for links with 837-type network at far end. 830E for links without 837-type networks.
2	Where delay equalization is required, specify an 830F network in place of the 832A network.
3	832A network may be replaced with an 830-type network when the adjacent link is 2-wire loaded cable.
4	With 837-type networks, end sections plus bridged tap should not exceed 5 kft for H loading. Where no 837 ( ) network is used, the end section plus bridged tap may be increased to 6 kft. The 837A network must be deleted if adjacent to an E6 repeater link with an 830A network facing the CO-CO link. Impedance compensators at PBXs are listed in Tables D, E, and F. At CO(A), use 837A for 19-, 22-, and 24- gauge H88 or D88 cable. Use 837J for 25H88 and 837G for 26H88. The 837-type network shown in dashed lines at CO(A) is specified when terminal balance is required at the CO. The letter A added to the numerical codes listed in Tables B and C and on the layouts shown in Fig. 12 indicates that the 837( ) network is not used at the PBX when balance is not a requirement.
5	Maximum nonloaded length of 5 kft (without terminal balance) includes nonloaded cable facilities from the PBX to the first load coil of the next loaded section. This length includes all bridged tap and intermediate CO wiring.
6	ICL objectives for standard design layouts are as follows: TYPE — REPEATERED (dB) — NONREPEATERED (dB) FX trunks — 3.5 — up to 4.0* WATS trunks (class 5) — 3.5 — up to 4.0 WATS trunks (class 4) — 4.5 — 4.0 to 5.0 LD trunks — 4.5 — 4.0 to 5.0 * Losses less than 2.0 dB require that the PBX tie-trunk 2.0-dB pad not be switched out.
7	The EML is the ICL plus X dB, where X is the known loss to the milliwatt supply, including office circuitry. Where X is assumed to be 0.5 dB, the EML becomes the ICL + 0.5 dB. It is assumed that there is no loss from the milliwatt supply to the appearance on the switch, since this is the point to which the milliwatt supply must be adjusted for the proper output level. However, since the dialed-up connection may require a second pass-through switch, additional loss may be encountered and is included in the EML.
8	The intraswitch loss of the PBX is assumed to be 0.0 dB. If this loss is known to be other than 0.0 dB, it must be taken into account when calculating the EML. The DIMENSION PBX switch loss is assumed to be 0.3 dB.
9	Net loss objectives for CO-PBX links are as follows: TYPE — OBJECTIVE (DB) FX trunks — 2.5 WATS trunks (class 5) — 2.5 WATS trunks (class 4) — 3.5 LD trunks — 3.5
10	Specify a 24V4A, B, or D shelf. Specify 227-type amplifiers, or 849-type networks, and equalizers for a 44V4A shelf. Listings of shelves are given in J98615 and are described in Sections 332-105-10Z and 332-106-10Z. Care should be taken to ensure that 44V4B shelves *are not used.* The equivalent of a 44V4 repeater can be provided by a 24V4 shelf equipped with a 4182-type network in place of a 1-type terminating set. For such use of a 24V4 shelf, it is essential that the NT and NR network pair between the shelf and the distributing frame be in place to serve as one of the 4-wire legs. The V4 engineering sections are 352-307-ZZZ.
11	Specify 227-type amplifiers as follows: LINE PROTECTION* — LOW DELAY DISTORTION† — AMPLIFIER Not required — Not required — 227A, E Required — Not required — 227B, F Required — Required — 227C, D Unknown — Not required — 227 F * For lightning or induced power voltage. † For certain data circuits.

CHART 2B
E6-V4 LAYOUT REFERENCES (Cont)

<table>
<tr><th>REF. NO.</th><th>INFORMATION</th></tr>
<tr><td>11
(Cont)</td><td>Compared with the 227E and F amplifiers, the 227A and B amplifiers have much greater susceptibility to impulse-type noise and somewhat greater susceptibility to battery noise. The 227C or D amplifiers have much flatter low-frequency characteristics. The prescription settings for the C- and D-type amplifiers are listed in Section 332-116-201 and are not the same as the settings used for the 227A, B, E, or F amplifiers. The 227 amplifiers can be grouped by characteristics into two types: (1) C and D, or (2) A, B, E, and F. Always use the same type amplifier throughout a given transmission design.</td></tr>
<tr><td>12</td><td>Specify 359-type equalizers as follows:

4-WIRE CABLE AND EQUIPMENT — TYPE
H88 (with 227A, B, E, or F) — 359A
H88 (with 227C or D)* — 359A
H88 (with 849 network) — 359D
Short H88 (with 227A, B, E, or F) — 359E (dummy)
H44 (with 227C or D)* — 359K
H44 (with 849 network) — 359L
Short NL (with 227A, B, E, or F) — 359F
Long NL (with 227A, B, E, or F) — 359B†
Long NL (with 227C or D)* — 359M
Short NL (with 227C or D)* — 359N
Loaded cable (special) — 359G/359H
H44 (or 600-ohm equipment) — 359C (dummy)
H88 (with 849 network) — 359J (dummy)
Unigauge — 359P

* Low delay distortion.

† When the 359B equalizer is used at or near a subscriber location, it is necessary to use amplifiers in the T and R sockets of the 44V4 or 24V4 repeaters at that end to avoid poor sidetone balance.

Information on equalizer settings for loaded cables and choice of equalizers for nonloaded cables is given in Sections 852-307-101 and 332-116-201.</td></tr>
<tr><td>13</td><td>Terminating sets are given in Sections 852-307-101 and 332-800-1ZZ. To reduce inventory, the 1M (900-ohm, 4T90700) or 1N (600-ohm, 4T60600) terminating sets are selected. The 1N (600-ohm) terminating set is selected for PBX locations and used where the 1-μF capacitor is required. When the 1M or 1N terminating sets are used in 24V4 repeaters, a pad must be placed in each pad socket for circuit continuity. Compute the terminating pad losses in accordance with Section 852-307-102.</td></tr>
</table>

<table>
<tr><th>REF. NO.</th><th>INFORMATION</th></tr>
<tr><td>13
(Cont)</td><td>Zero pad values should never be used with the 1M or 1N terminating sets since they do not provide satisfactory impedance matching properties. Pads of 5.0-dB loss or greater provide optimum 2-wire return loss.</td></tr>
<tr><td>14</td><td>At the CO(A) end, the SX inductors must be in the circuit (SX INDR SHORT screws up) regardless of whether or not an MFT or DLL is used. When range-extending equipment is not used, connect the A lead to SX1 and the B lead to SX.</td></tr>
<tr><td>15</td><td>Specify 4182-type networks or the MFT 4-wire transmission unit (J99343BD) when gain is not required at a 4-wire repeater point. These networks may be used in place of MFT or V4 repeaters as follows:

4182A — Provides level adjustment pads between 600-ohm impedances. Does not provide simplex leads.

4182B — Provides level adjustment pads between 600-ohm equipment and 150-, 600-, or 1200-ohm line impedances for nonloaded or short lengths of H88 loaded lines. Simplex leads are provided.

4182C — Provides level adjustment pads between 600-ohm equipment and 1200-ohm line impedances for long lengths of H88 loaded cable. Equalizers and simplex leads are provided.

MFT-BD — Provides level adjustment pads between 600-ohm equipment and switch-selected 600- and 1200-ohm line impedances for nonloaded and H88 loaded cables. No equalizers are provided. Simplex leads are provided.

4182 — Network prescription settings may be found in Section 332-104-500.</td></tr>
<tr><td>16</td><td>In place of the 4182-type network shown, F-type signaling bypass units (FMA for pad attenuation and FMC for equalization) may be used when combined F signaling bays are available at intermediate COs. The equalizer components of the FMC are identical to the components in the 4182C network; however, the physical arrangement of the screw switches has been altered. Strapping charts for loaded cable and information for nonloaded cable are given in Section 852-307-101. Care should be taken for loaded cable application since screw designations (actual values of components used) instead of screw codes (column letter and row number) will have to be followed because of rearrangements of the screws on the FMC.</td></tr>
</table>

CHART 2B
E6-V4 LAYOUT REFERENCES (Cont)

<table>
<tr><th>REF. NO.</th><th>INFORMATION</th><th>REF. NO.</th><th>INFORMATION</th></tr>
<tr><td>16
(Cont)</td><td>The line matching components (repeating coil taps) appear for the line or cable side only. The drop or equipment side is always 600 ohms toward the FMA attenuation circuit and carrier channel. Comparison between impedance adjustments for the 359-type equalizers, 4182 network screw codes, and the FMC screw codes are as follows:

<table>
<tr><th>359 EQL</th><th>4182 SCREW CODE</th><th>FMC SCREW CODE</th></tr>
<tr><td>359D</td><td>4182C*</td><td>R-1200</td></tr>
<tr><td>359B</td><td>4182B AB3 or CD3</td><td>R-150</td></tr>
<tr><td>359J</td><td>4182B AB1 or CD1</td><td>R-1200</td></tr>
<tr><td>359F</td><td>4182B AB2 or CD2</td><td>R-600</td></tr>
</table>
* Faceplate has 15 screw-type switches which are the same as 359D

Descriptive information on the FMA and FMC units is given in Section 179-300-101 and SD-1C296-01.</td><td></td><td>For D1 channel banks, see Sections 365-100-100 and 179-100-302 and SDs-97060-01, 97070-01 and 02. For D3 channel banks, see Sections 365-150-100 and 179-100-310 and SD-36104-01. Refer to Section 851-300-155 for application information for D-type channel banks. Preferred types are shown on the layouts.</td></tr>
<tr><td>17</td><td>The FUA or FUD signaling converter (SD-1C226-01) is used with one of the following auxiliary units:

<table>
<tr><th rowspan="2">MODE</th><th colspan="2">4W TO 2W</th><th colspan="2">4W TO 4W</th></tr>
<tr><th>CO</th><th>PBX</th><th>CO</th><th>PBX</th></tr>
<tr><td>600-Ohm LS</td><td>FLD</td><td>FSD</td><td>—</td><td>—</td></tr>
<tr><td>600-Ohm LS/GS</td><td>FLB</td><td>FSB</td><td>FPA</td><td>FRA</td></tr>
<tr><td>900-Ohm LS</td><td>FLC</td><td>FSC</td><td>—</td><td>—</td></tr>
<tr><td>900-Ohm LS/GS</td><td>FLA</td><td>FSA</td><td>—</td><td>—</td></tr>
</table>
Where the F-type signaling units are not available, E-type units (E1P, E1R, E2L, E2S) may be substituted, provided they fulfill the limitations and circuit criteria. Limitations of the E-type units are given in Section C of SD-99421-04 and approved combinations of E and M units are given in SD-1C240-02.</td><td>19</td><td>MFT Repeaters for FX and WATS Trunks:
A. MFT 2-wire Repeaters

<table>
<tr><th>Code</th><th>A Side</th><th>B Side</th></tr>
<tr><td>J99343PA/PG*</td><td>CO</td><td>H88</td></tr>
<tr><td>J99343PB</td><td>CO</td><td>NL</td></tr>
<tr><td>J99343PC/PH*</td><td>H88</td><td>H88</td></tr>
<tr><td>J99343PE/PJ*</td><td>H88</td><td>NL</td></tr>
<tr><td>J99343PF/PK*</td><td>NL</td><td>H88</td></tr>
</table>
B. MFT 4-wire Repeaters

<table>
<tr><th>Code</th><th>A Side</th><th>B Side</th></tr>
<tr><td>J99343RA/RF</td><td>CO/STA (2W)</td><td>H88/NL (4W)</td></tr>
<tr><td>J99343RB/RG*</td><td>H88 (4W)</td><td>H88 (2W)</td></tr>
<tr><td>J99343RC</td><td>H88 (4W)</td><td>NL (2W)</td></tr>
<tr><td>J99343RD/RH*</td><td>H88 (2W)</td><td>H88 (4W)</td></tr>
<tr><td>J99343RE</td><td>NL (2W)</td><td>H88 (4W)</td></tr>
<tr><td>J99343SA</td><td>EQUIP (4W)</td><td>H88/NL (4W)</td></tr>
<tr><td>J99343SB</td><td>H88/NL (4W)</td><td>H88/NL (4W)</td></tr>
</table>
*These codes provide precision balance networks for 19, 22, 24, 25, and 26H88 cables.</td></tr>
<tr><td>18</td><td>D-Type FX Channel Units:
2-4 Wire Types
FXO — D1-J98711AF, D3-J98718BE
FXS — D1-J98711AF, D3-J98718BD

4-Wire Types
FXO — D3-J98718SC
FXS — D1-J98711SA, D3-J98718SD</td><td>20</td><td>Possible locations for 2-wire range-extending equipment for metallic loop signaling. The MFT (SD-1C359) equipped with the J99343BC 2-wire transmission unit and either the J99343Ad loop-signaling repeater unit (loop-start) or the J99343 AC loop-signaling repeater unit (loop-start or ground-start) is preferred. The following types of DLL units may be used: for loop-start, SD-96555 or SD-96234; for ground-start,SD-66192 or SD-66474; for ground-start to loop-start conversion at CO(A), SD-96371. The 120T repeating coil used with DLLs is preferred. DLLs equipped with 94-type repeating coils must be used. Specify loop-start or ground-start units to match the trunk circuit at the PBX. Dial access trunk circuits at the PBX operate in the ground-start mode. A given layout may use either loop-start or ground-start operation but not both. When an MFT or DLL is used in the 2-wire transmission path, an additional unit is not required in the A and B leads of an adjacent terminating set. The SX inductors in the A and B leads must remain in the circuit in this case.</td></tr>
</table>

CHART 2B
E6-V4 LAYOUT REFERENCES (Cont)

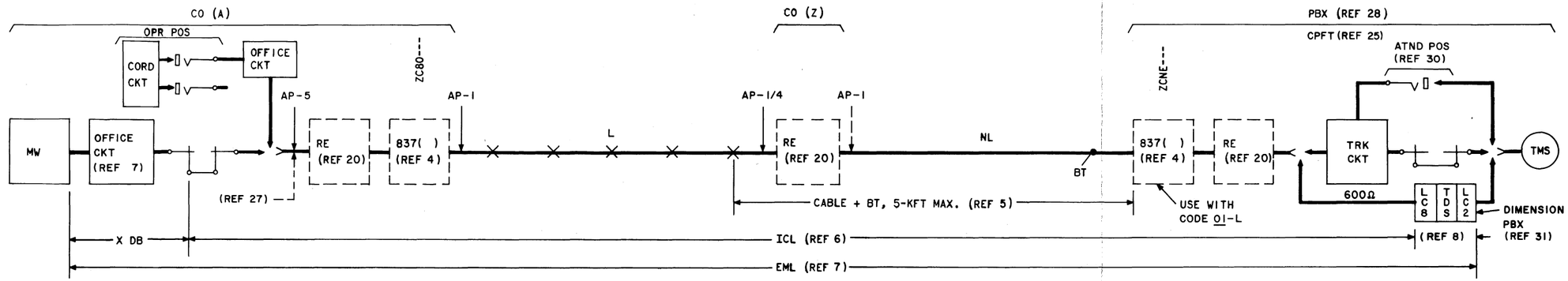
REF. NO.	INFORMATION
21	Possible locations of 4- to 2-wire applications of range-extending equipment for metallic loop signaling. These units are placed between the SX, SX1 and the A, B leads to remove the units from the 2-wire transmission path. When range-extending equipment is used in the A and B leads, it is not used in the 2-wire transmission path. The MFT (SD-1C359) equipped with the J99343BB by-pass transmission unit and either the J99343AD loop-signaling repeater unit (loop-start) or the J99343AC loop-signaling repeater unit (loop-start or ground-start) is preferred. DLLs SD-96555 or SD-96234 may be modified, according to Note 302 on the SDs, for loop-start operation. The SX inductors in the terminating sets must be shorted when either the DLL or MFT is used in the A and B leads at the PBX or the CO(Z) facing the PBX.
22	If the capacitor across A and B leads in the E&M DLL cannot be removed as an option, the S1 screw in the terminating set must be opened to remove the capacitor. SD-96252-01 shows only a 4-μF capacitor for the A and B leads. This would require a 1G (900-ohm) terminating set which does not match a 600-ohm PBX and would not meet terminal balance requirements. Therefore, for the use required of this DLL (E&M-to-loop conversion), the 1-μF capacitor shown on the layouts at 24V4 repeaters is satisfactory and both the 600-ohm and terminal balance requirements can be met. Long trunk circuit drawing SD-1C354-01 shows wiring options B and G for placing the long trunk circuit in the by-pass leads of a 24V4 repeater. DLL SD-96252-01 does not show wiring options for this arrangement, but connections may be made in the same manner as that shown in SD-1C354-01 which will accomplish the same result. The 4-μF capacitor should be disconnected when this arrangement is used.
23	For loop-start to E&M DLL units, the A and B leads are connected as shown. For ground-start to E&M DLL units, the A and B leads of the terminating set are connected to the A and D leads of the DLL.
24	Where end-to-end SF signaling is chosen, any out-of-band signaling (OBS) capabilities of carrier-type CO-CO links must be disabled as follows: *T1 Carrier* — Specify the E and M channel unit with the M lead connected to —48 volts (by Y option screw on units manufactured after 1962; by strap at the distributing frame on older units). *N1 Carrier* — If message-channel unit (J98703FA) is specified, connect the M lead to —38.5 volts. If the channel unit without signaling is specified (J98703AF), it may be used as is.
	O and ON Carrier — Specify the E and M channel unit with the M lead connected to —48 volts by strap at the distributing frame. If channel units without signaling circuits are specified, they may be used as is.
25	CPFT (SD-7C010, J99380) provides plug-in mountings, at the PBX, for MFT transmission and signaling units, 837-type impedance compensator networks, 120T repeat coils used with the 837G network, and the new J99380AA, AB, AC impedance compensator networks which are equivalent to the 837D, E, and G networks. Detailed descriptions of CPFT can be found in Section 332-610-100. General application information of CPFT to switched special services is contained in Section 851-300-130.
26	The E6RE (MD) or the newer E6B battery-boost range extenders may be used where the 832A (dummy) network is shown. Ranges up to 2400 ohms (23 mA) are provided with a maximum loop current of 40 mA. Repeater disabling is provided. Do not operate in tandem with other signaling units operating at —72 volts. Tandem operation with —48 volt signaling units is satisfactory. Introduces 0.2-dB loss at 1 kHz. Refer to Sections 332-206-129 (E6RE) and 332-206-130 (E6B).
27	Auxiliary line circuit SD-99439-01 is used in measured rate Incoming Wide Area Telephone Service (INWATS). Auxiliary line circuits provide additional features such as the generation of a sleeve lead for No. 1 ESS offices (SD-1A160-01) or to prevent the chance of glare in No. 1 step-by-step offices (SD-31652-01). When used, adds 40-ohm series resistance and a short in the ringing path. Range tables in Section 851-300-170 reflect the additional resistance this circuit introduces in the signal path.
28	Interconnection unit input-output impedance is 600:600 ohms with approximately 1.0-dB loss in the voiceband. The ICL and EML should then include the loss of the interconnecting units. Do not include the switching or trunk circuit losses of the CPE PBX. References to interconnecting units may be found in Section 463-300-100.
29	For N1 message channel unit signaling compatibility, see SD-95118-01 (Fig. 2 and 7). Application schematic drawings: for N1, SD-95121-01; for O and ON, SD-95150-01.
30	The PBX cord circuit may be an SD-67034, SD-67035, SD-66198, or equivalent. If measurements are made through the cord circuit, the EML must include the cord circuit loss.

CHART 2B
E6-V4 LAYOUT REFERENCES (Cont)

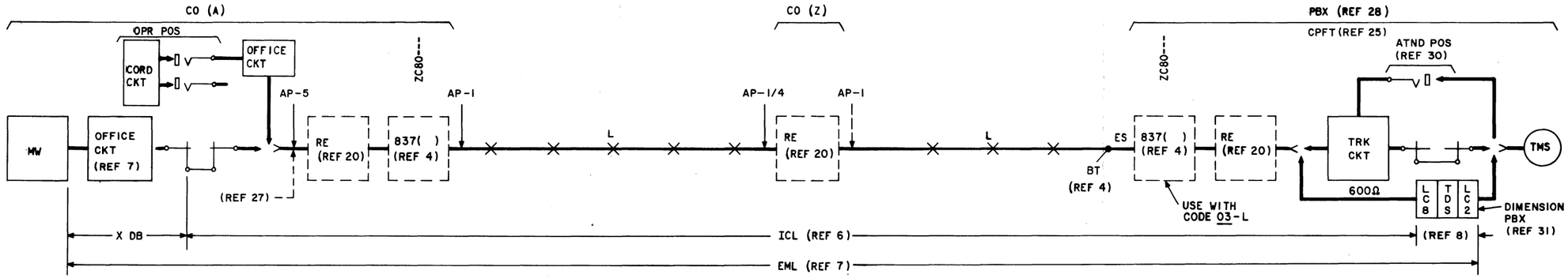
REF. NO.	INFORMATION
31	The DIMENSION® PBX (J58879, SD-1E440) provides the following features: (a) LC8 circuit pack is used with one- and 2 -way FX, WATS, or LD trunks operating ground-start to the CO. The LC8 may be used for one-way incoming, one-way outgoing, or 2-way trunk operation depending on the translation assignment. (b) No adjustable gain, loss, or switchable pads are provided with the LC8 circuit pack. (c) The DIMENSION® PBX nominal overall 1-kHz switch loss is 0.3 dB which may range from 0 to 0.5 dB. No hybrid or additional losses need be included in transmission designs. (d) The LC8 provides a 600-ohm, 2-wire facility termination. (e) The LC8 detects a CO battery reversal for toll restriction.
32	MFT E&M to loop converters provide the following features: (a) J99343FA — Loop-start to E&M (faces CO) J99343FB — E&M to loop-start (faces station) J99343FC — Ground-start to E&M (faces CO) J99343FD — E&M to ground-start (faces PBX) (b) Used in MFT double-module arrangements with MFT repeaters or passive transmission units. (c) Dial pulse correction provided. (d) Refer to Section 332-911-105 for equivalent DLL circuits and ranges for supervision, dial pulsing, and ringing.

REF. NO.	INFORMATION
33	SMAS-4A Access Point Information: Access point codes are indicated on the standard design layouts and are detailed in Fig. 11. These are the minimum set of access points required to take full advantage of the trouble sectionalization capability of the SARTS-1A system. Those circuit elements which should require access points on FX and WATS lines are as follows: (a) Carrier facility interfaces (b) Metallic customer loop interfaces (c) Metallic trunk facility to metallic trunk facility interfaces (d) Metallic trunk facility to CO equipment interfaces (e) Switch interfaces (equivalent of no-test access) (f) Interfaces with non-SARTS environments. To use the information shown in Fig. 11, locate the sketch by the type of code shown on the standard design layouts. Apply the access point to the layout oriented as shown in the sketch. The orientation codes and configuration codes are shown in each sketch. Additional information on the use of SMAS access points, CLR card information, and reference information are given in Sections 667-302-102, 667-302-103, and 667-302-200.

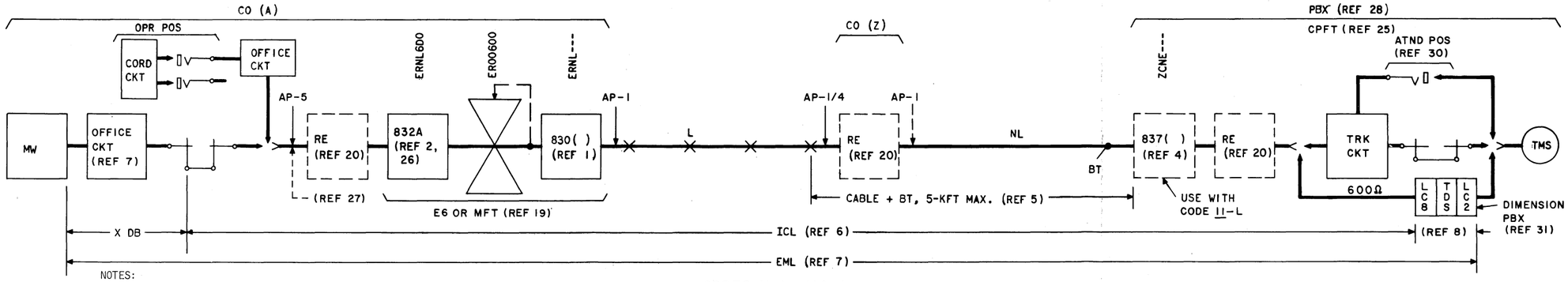
CHART 2B—E6-V4 Layout References (Sheet 5 of 5)



CODES 01-L, 01A-L



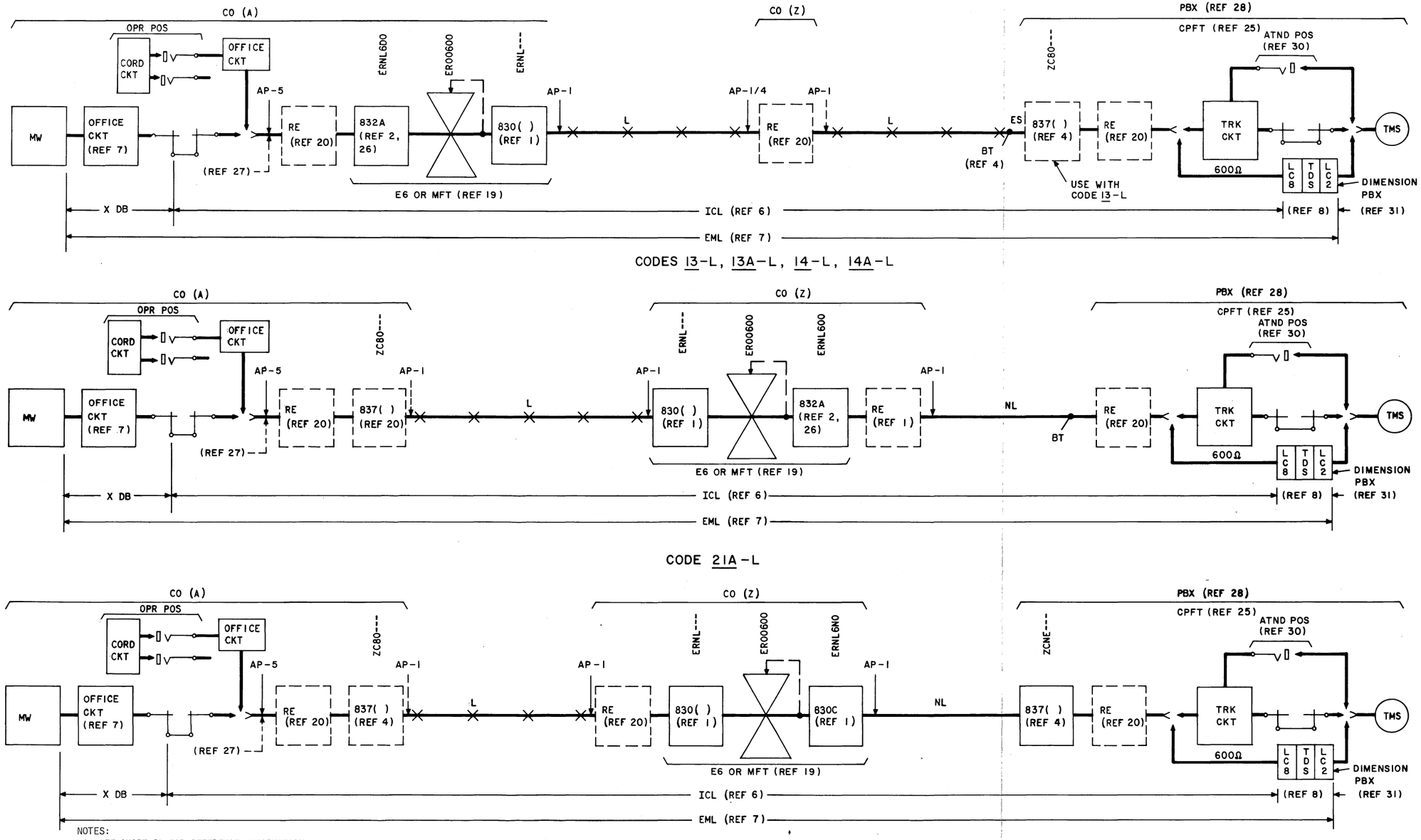
CODES 03-L, 03A-L



NOTES:
1. SEE CHART 2B FOR REFERENCE INFORMATION.
2. SEE FIG. 11 AND REF. 33 FOR SMAS-4A ACCESS POINTS.

CODES 11-L, 11A-L

Fig. 12—E6-V4 Overall Layouts (Sheet 1 of 9)



CODES 13-L, 13A-L, 14-L, 14A-L

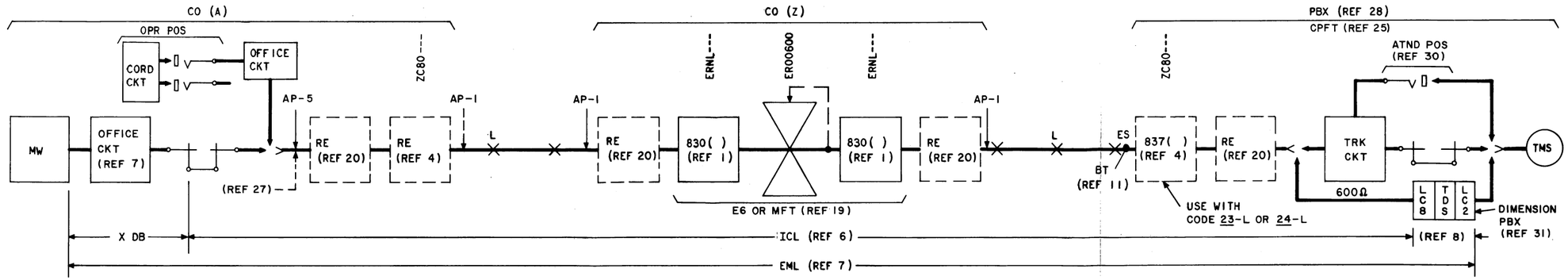
CODE 21A-L

NOTES:
1. SEE CHART 2B FOR REFERENCE INFORMATION.
2. SEE FIG. 11 AND REF. 33 FOR SMAS-4A ACCESS POINTS.

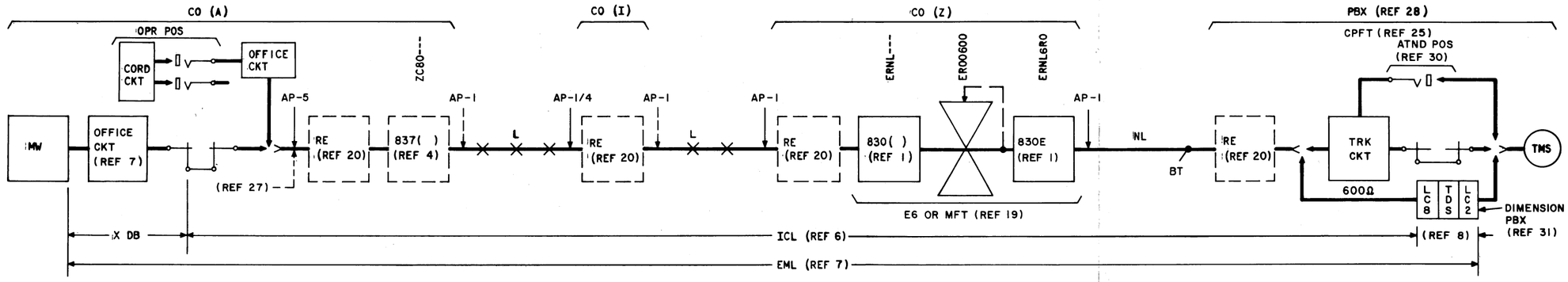
CODE 22-L

(VALID FOR TERMINAL BALANCE AT PBX, OTHERWISE USE CODE 28A-L)

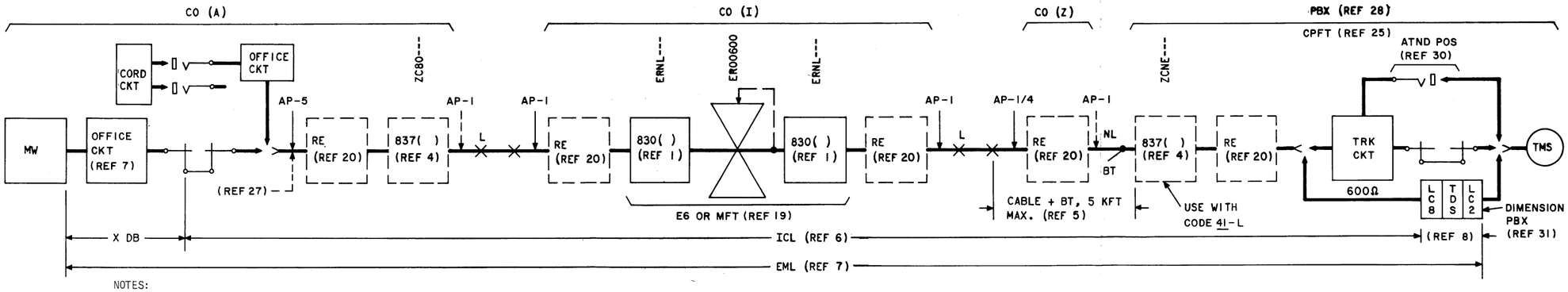
Fig. 12—E6-V4 Overall Layouts (Sheet 2 of 9)



CODES 23-L, 23A-L
24-L, 24A-L



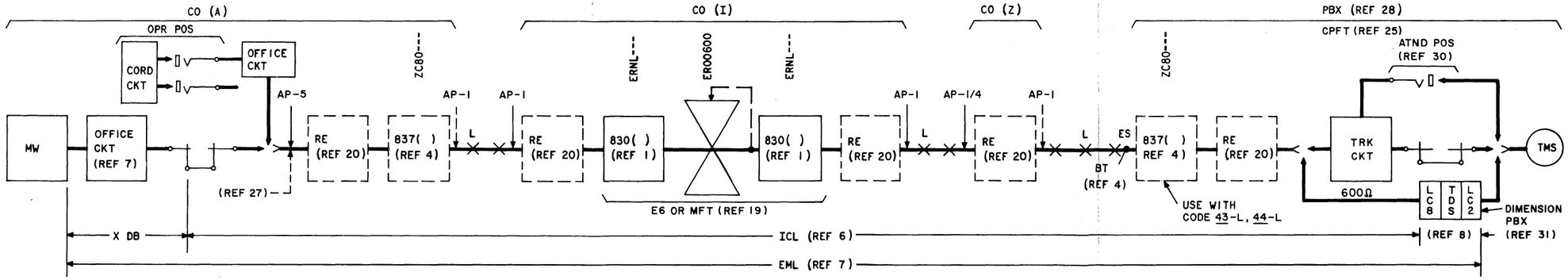
CODE 28A-L



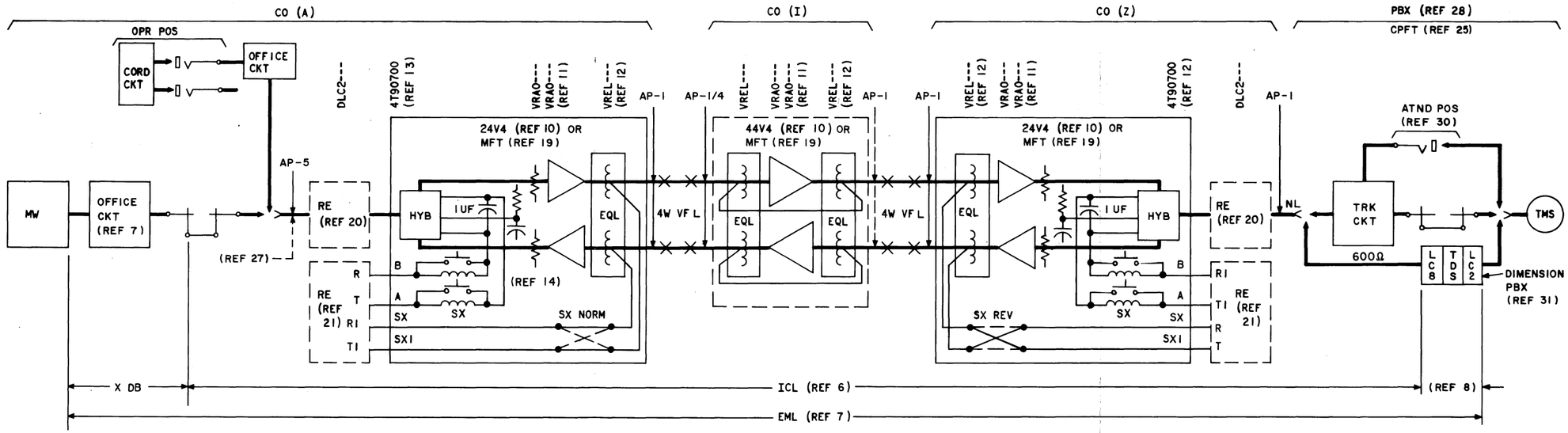
NOTES:
1. SEE CHART 2B FOR REFERENCE INFORMATION.
2. SEE FIG. AND REF. 33 FOR SMAS-4A ACCESS POINTS.

CODES 41-L, 41A-L

Fig. 12—E6-V4 Overall Layouts (Sheet 3 of 9)



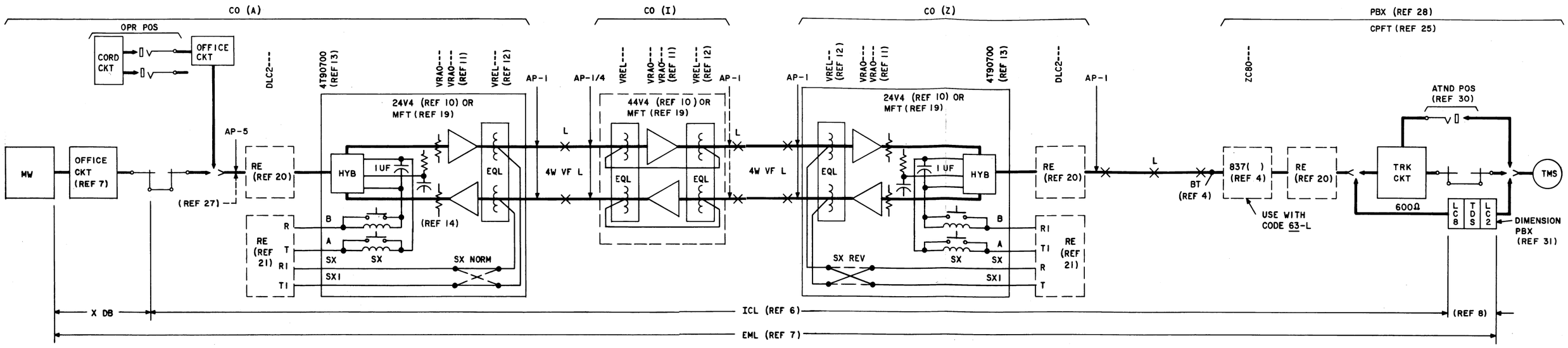
CODES 43-L, 43A-L
44-L, 44A-L



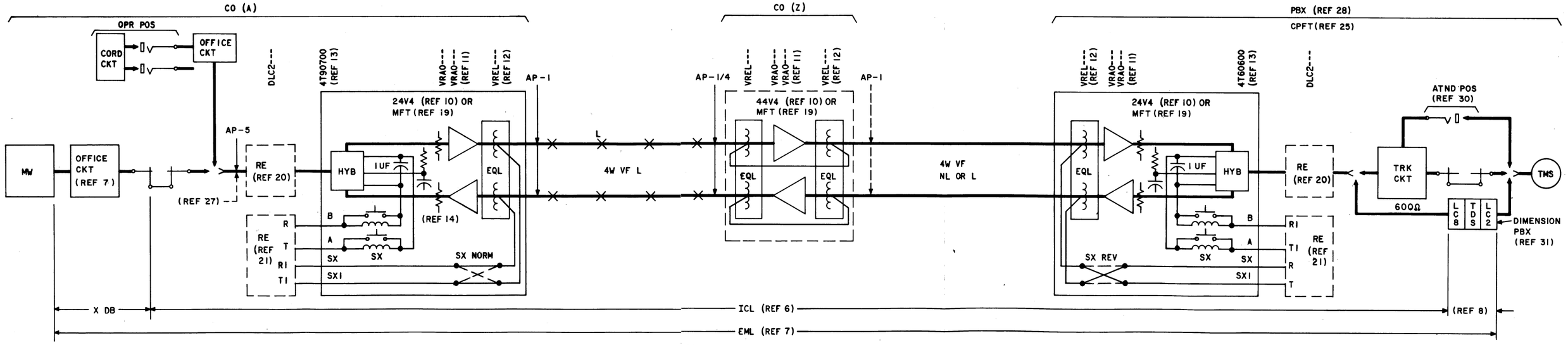
CODE 61A-L

NOTES:
1. SEE CHART 2B FOR REFERENCE INFORMATION.
2. SEE FIG. 11 AND REF 33 FOR SMAS-4A ACCESS POINTS.

Fig. 12—E6-V4 Overall Layouts (Sheet 4 of 9)



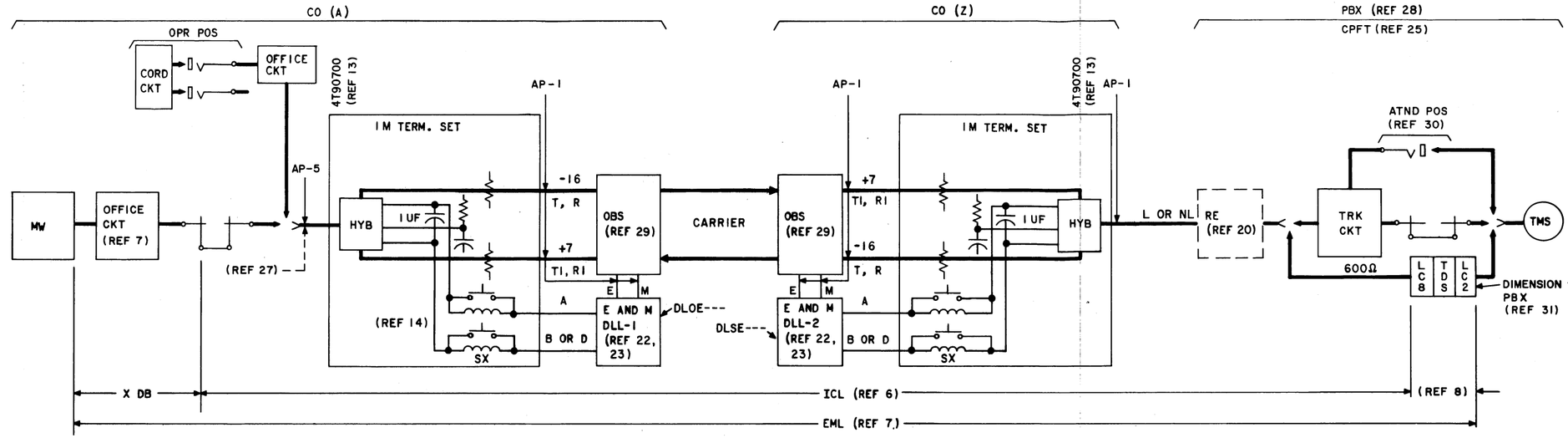
CODES 63-L, 63A-L



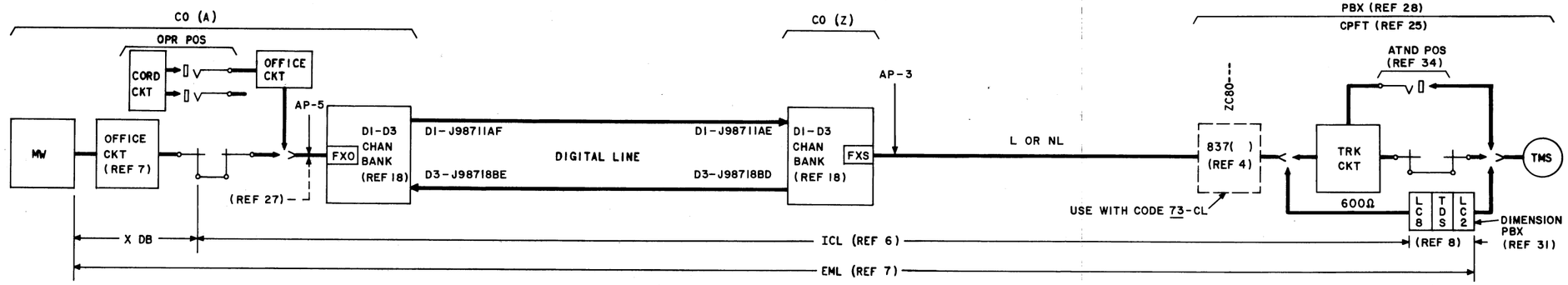
CODES 65-L, 66-L

NOTES:
1. SEE CHART 2B FOR REFERENCE INFORMATION.
2. SEE FIG. 11 AND REF 33 FOR SMAS-4A ACCESS POINTS.

Fig. 12—E6-V4 Overall Layouts (Sheet 5 of 9)



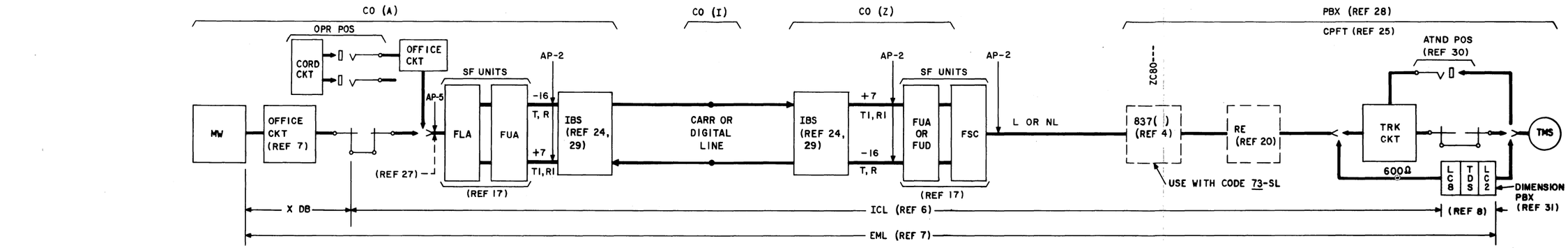
CODES 71A-ML, 73A-ML



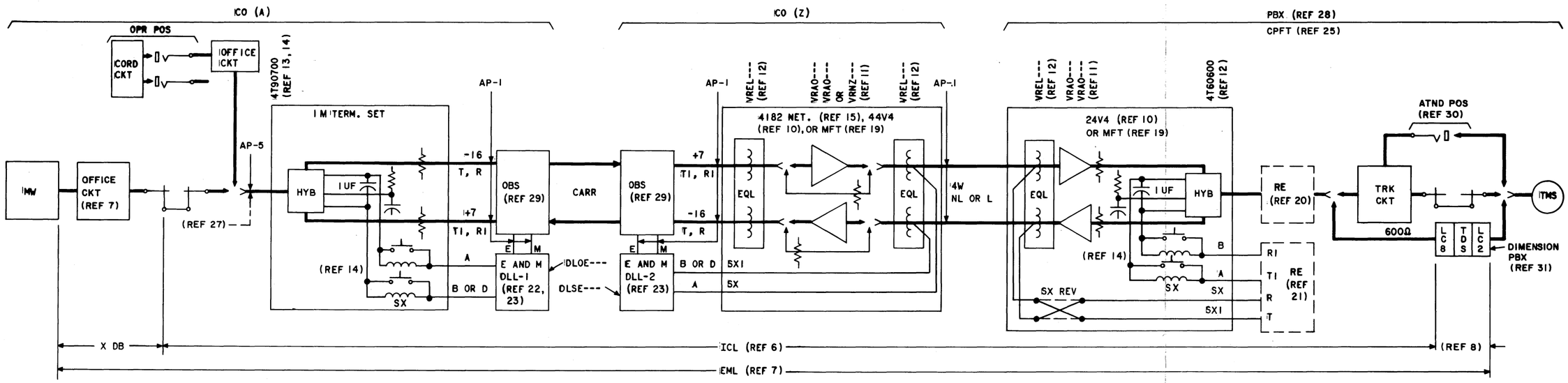
CODES 71A CL, 73-CL, 73A-CL

NOTES:
1. SEE CHART 2B FOR REFERENCE INFORMATION.
2. SEE FIG. 11 AND REF. 33 FOR SMAS-4A ACCESS POINTS.

Fig. 12—E6-V4 Overall Layouts (Sheet 6 of 9)



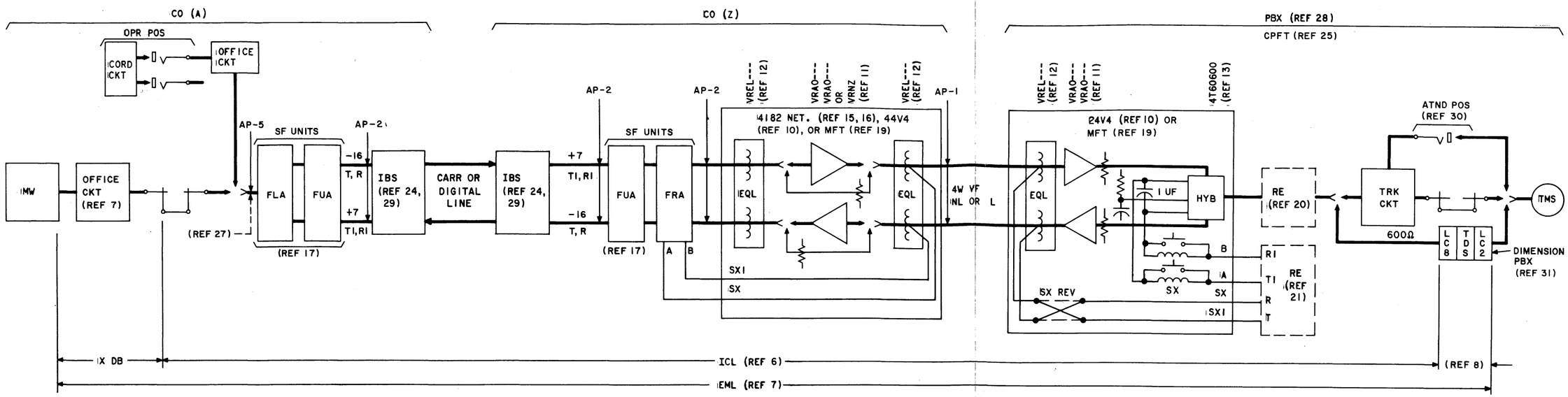
CODES 71A-SL, 73-SL, 73A-SL



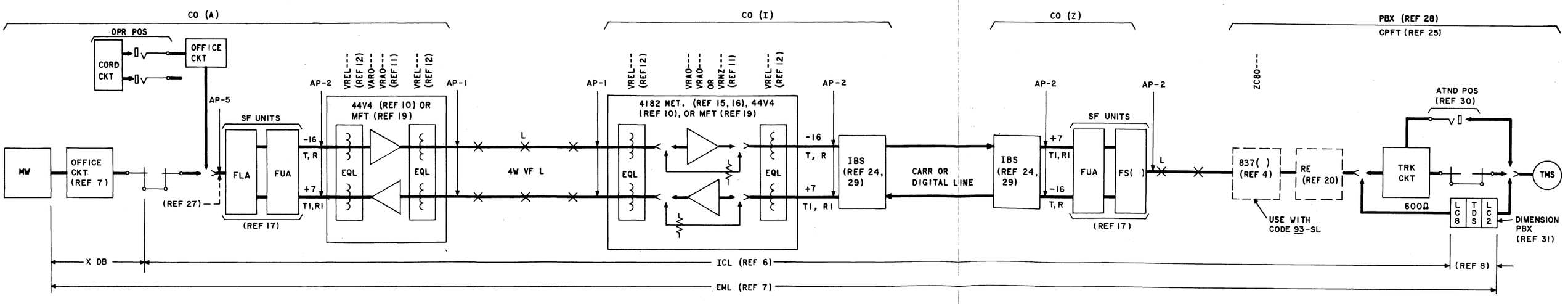
NOTES:
1. SEE CHART 2B FOR REFERENCE INFORMATION.
2. SEE FIG. 11 AND REF. 33 FOR SMAS-4A ACCESS POINTS.

CODES 75-ML, 76-ML

Fig. 12—E6-V4 Overall Layouts (Sheet 7 of 9)



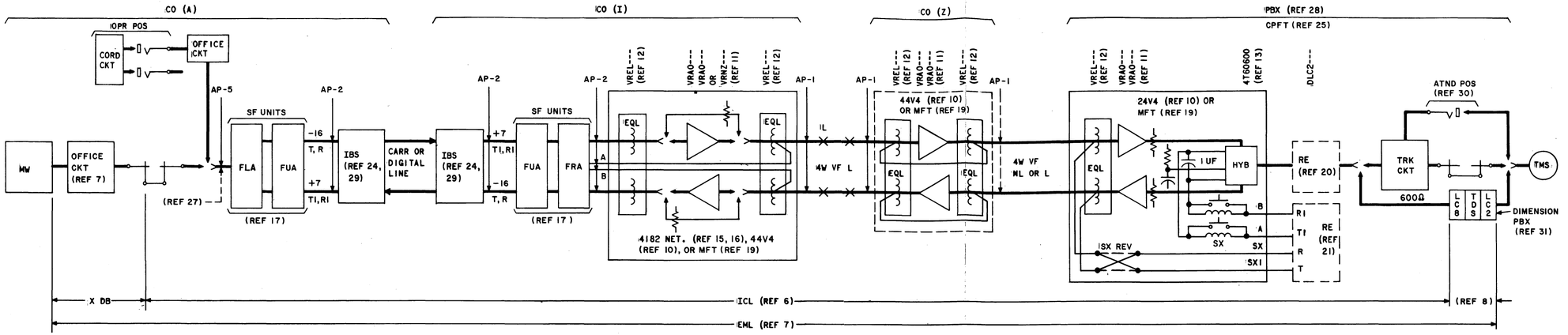
CODES 75-SL, 76-SL



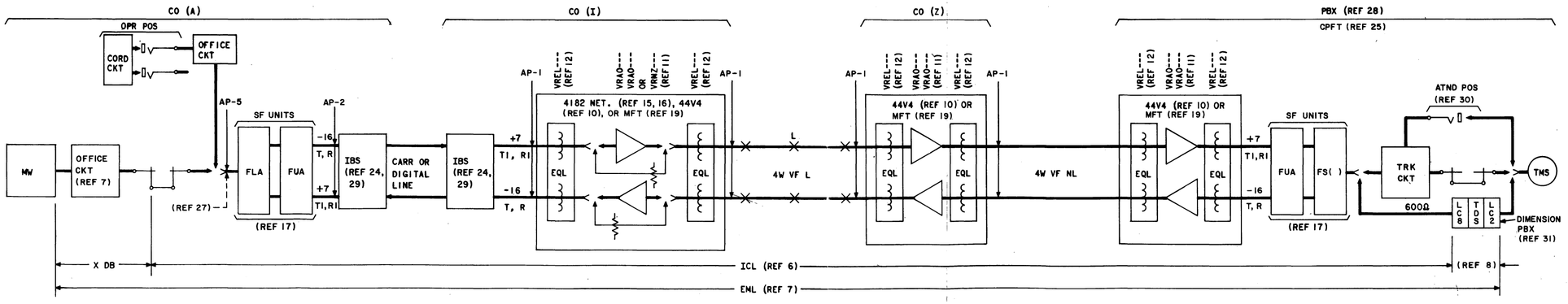
CODES 93-SL, 93A-SL

NOTES:
1. SEE CHART 2B FOR REFERENCE INFORMATION.
2. SEE FIG. 11 AND REF. 33 FOR SMAS-4A ACCESS POINTS.

Fig. 12—E6-V4 Overall Layouts (Sheet 8 of 9)



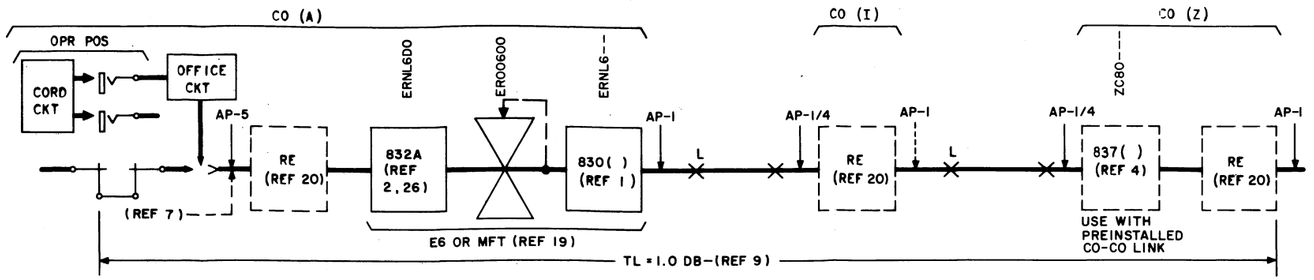
CODES 95-SL, 96-SL



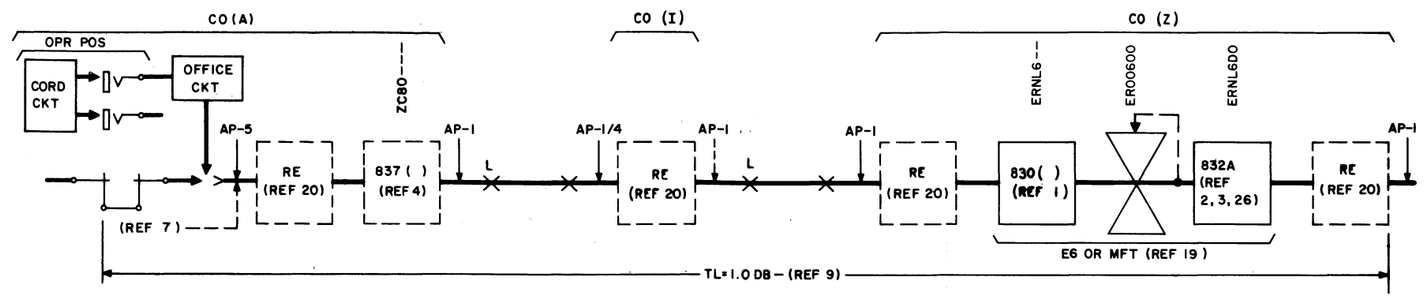
CODES 95-S, 96-S

NOTES:
1. SEE CHART 2B FOR REFERENCE INFORMATION.
2. SEE FIG. 11 AND REF 33 FOR SMAS-4A ACCESS POINTS.

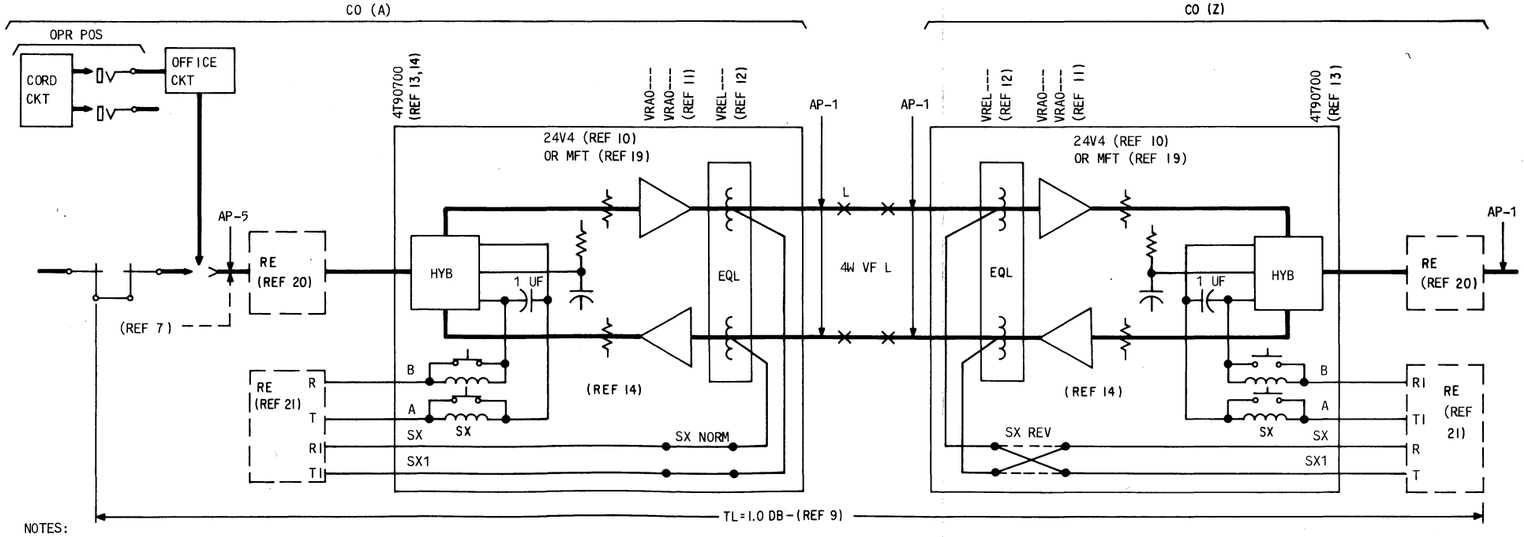
Fig. 12—E6-V4 Overall Layouts (Sheet 9 of 9)



CODE 1-L



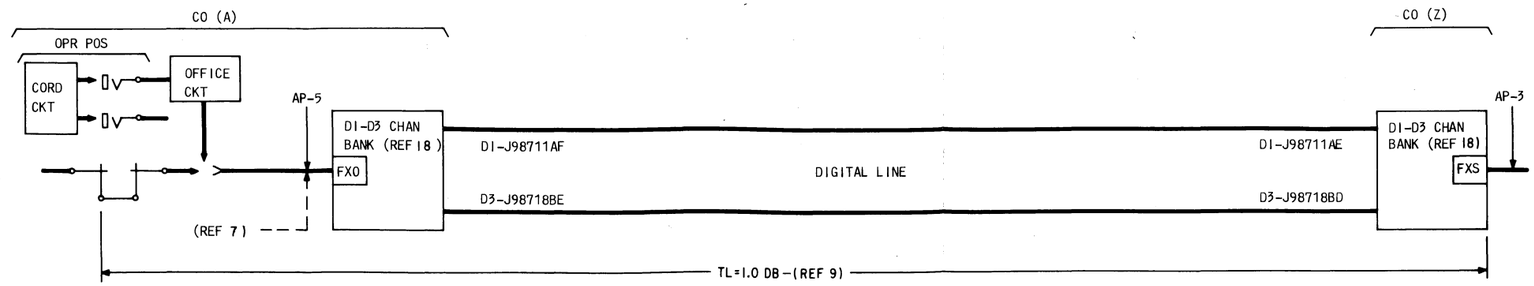
CODE 2-L



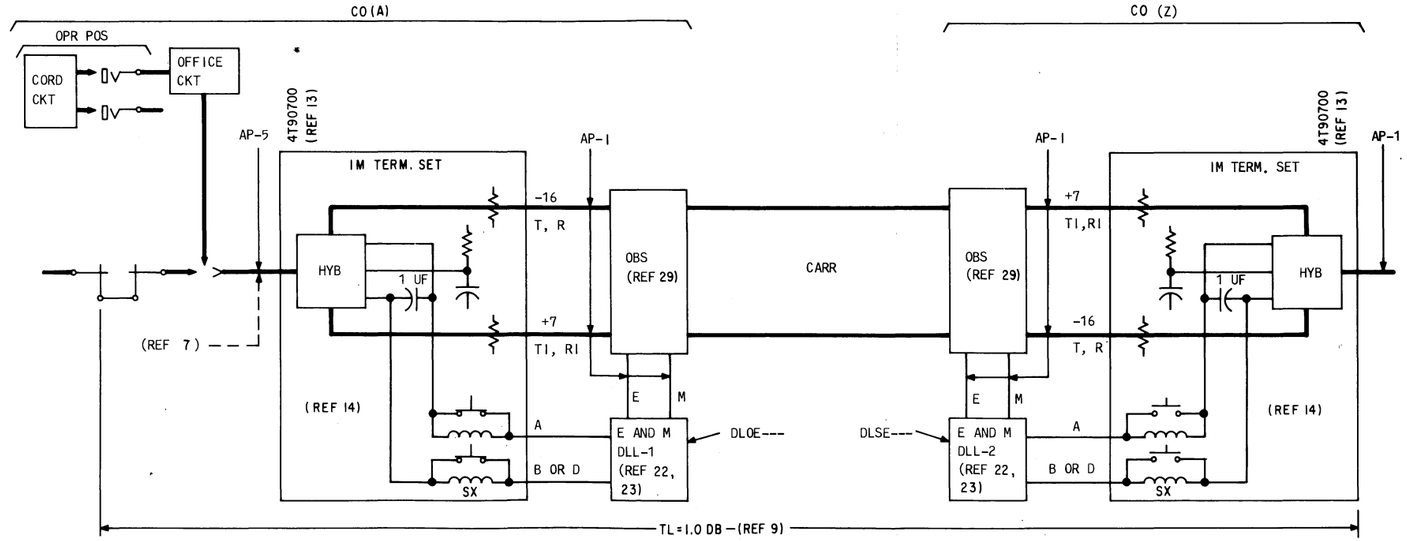
NOTES:
1. SEE CHART 2B FOR REFERENCE INFORMATION.
2. SEE FIG. 11 AND REF. 33 FOR SMAS-4A ACCESS POINTS.

CODE 6-L

Fig. 13—E6-V4 CO-CO Coded Links (Sheet 1 of 3)



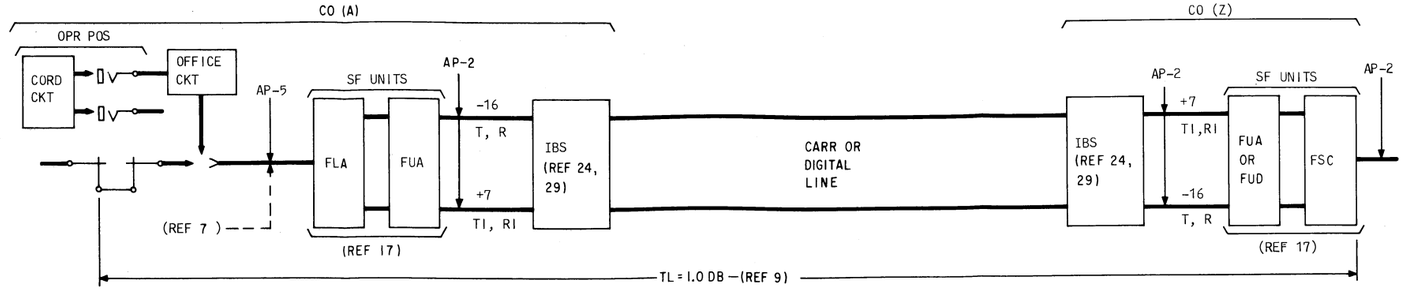
CODE 7-C



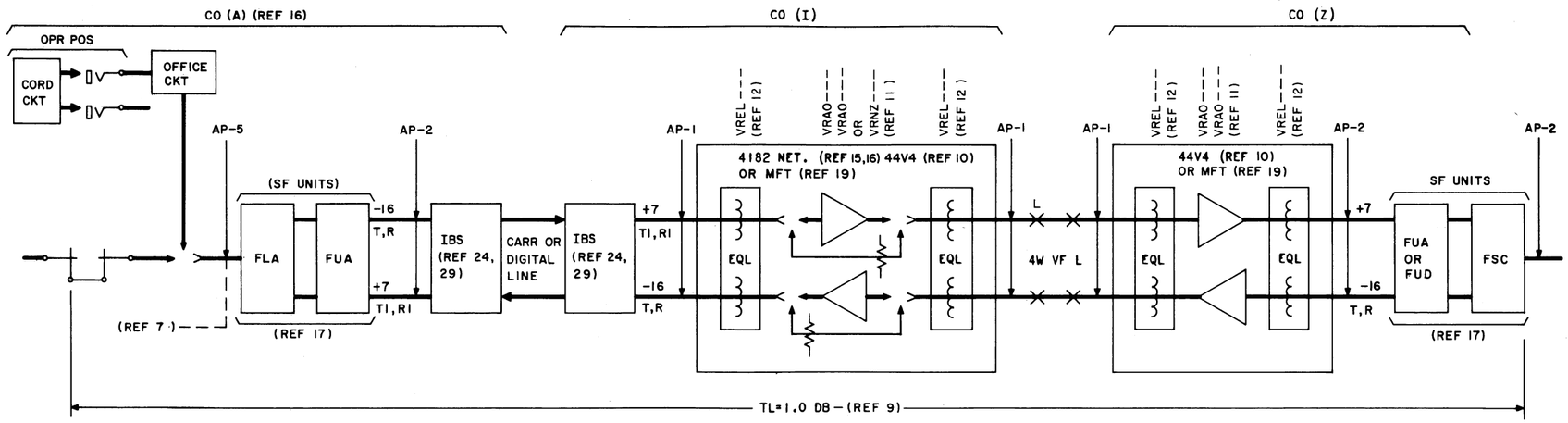
CODE 7-M

NOTES:
1. SEE CHART 2B FOR REFERENCE INFORMATION.
2. SEE FIG. 11 AND REF. 33 FOR SMAS-4A ACCESS POINTS.

Fig. 13—E6-V4 CO-CO Coded Links (Sheet 2 of 3)



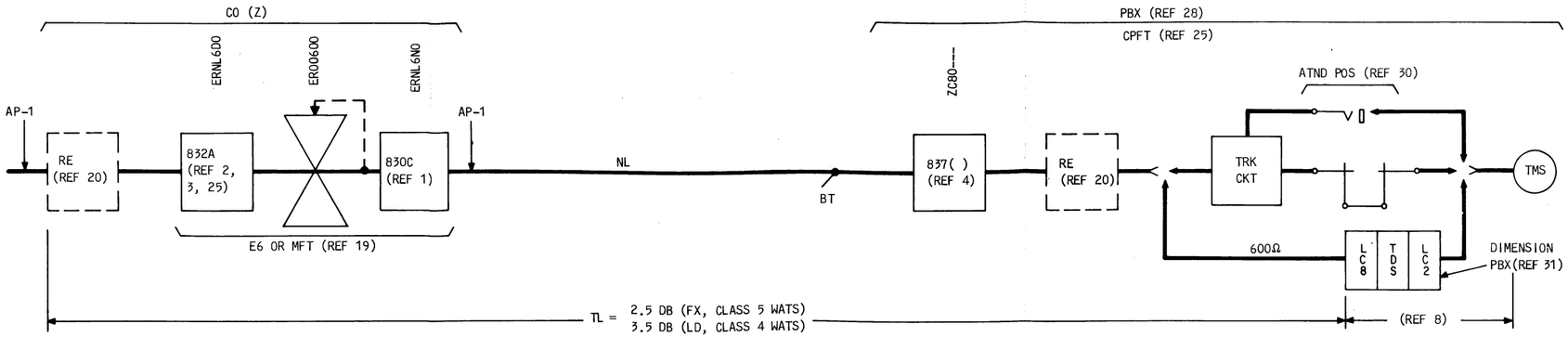
CODE 7-S



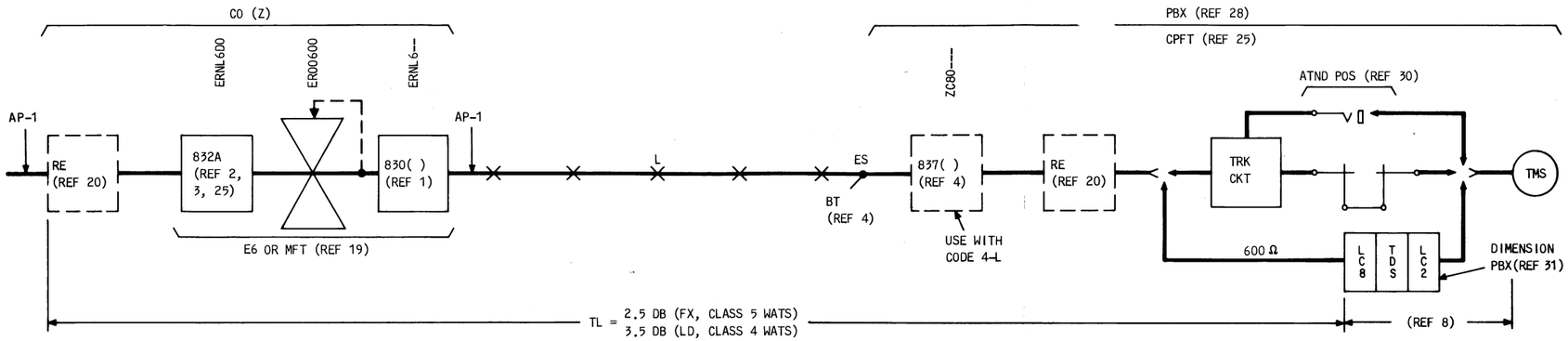
CODE 9-S

NOTES:
1. SEE CHART 28 FOR REFERENCE INFORMATION.
2. SEE FIG. 11 AND REF. 33 FOR SMAS-4A ACCESS POINTS.

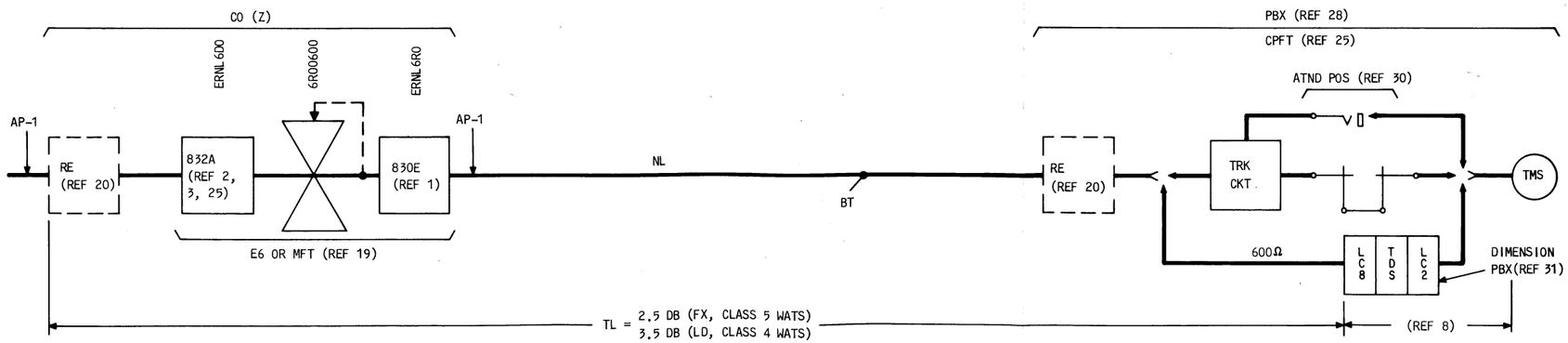
Fig. 13—E6-V4 CO-CO Coded Links (Sheet 3 of 3)



CODE 2-L



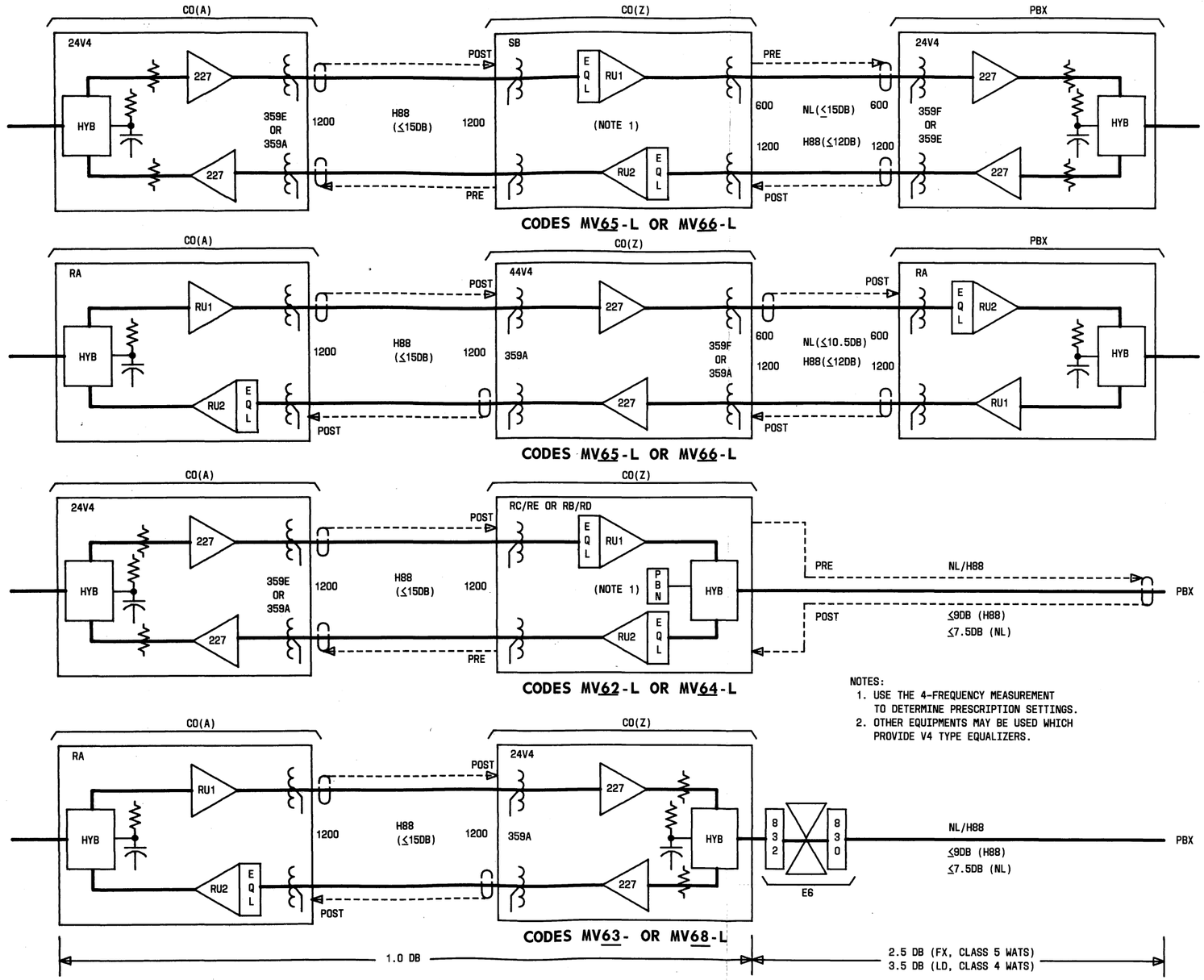
CODE 4-L, 4A-L



CODE 8A-L

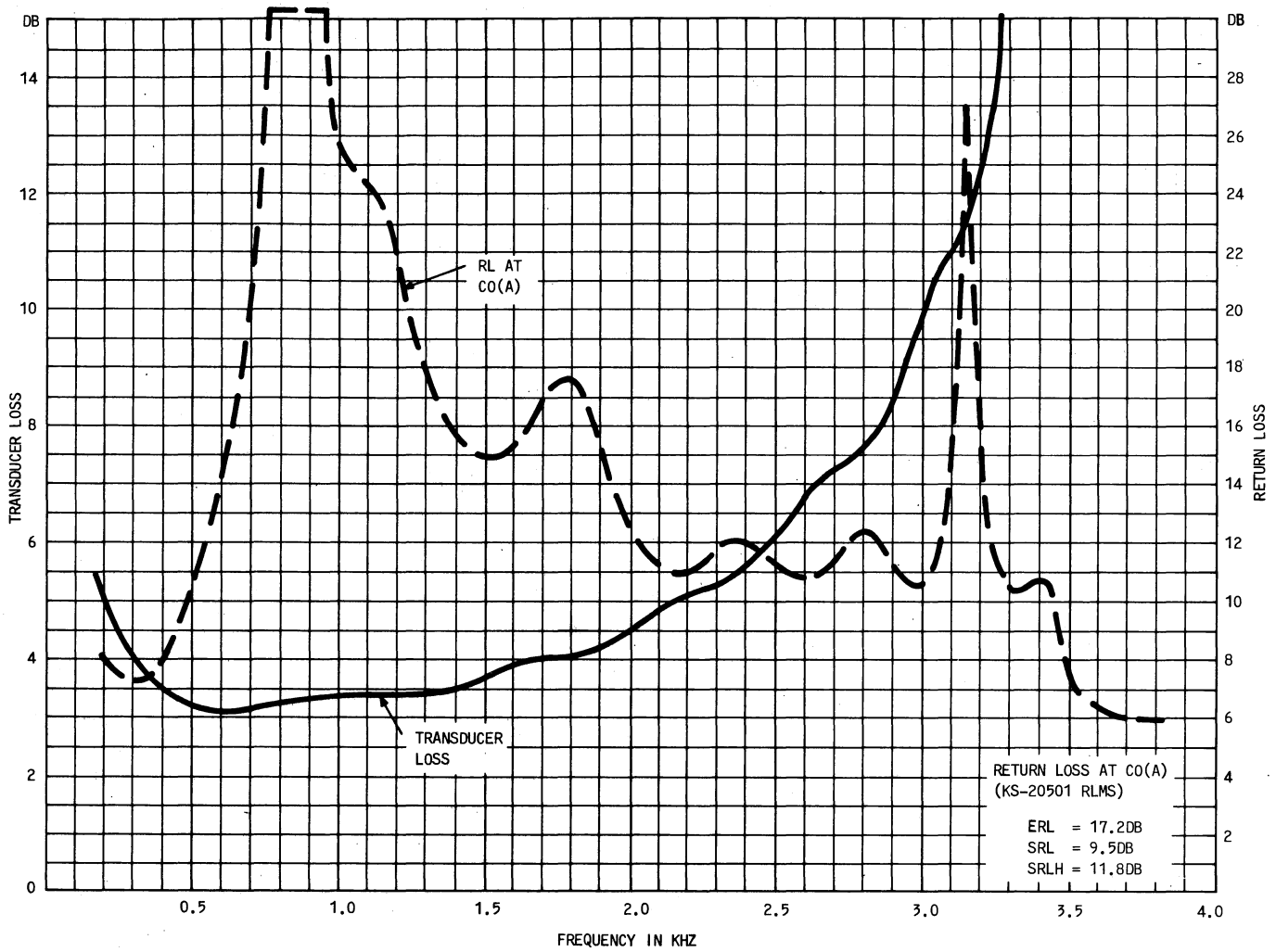
NOTES:
1. SEE CHART 2B FOR REFERENCE INFORMATION.
2. SEE FIG. 11 AND REF. 33 FOR SMAS-4A ACCESS POINTS.

Fig. 14—E6-V4 CO-PBX Coded Links



NOTES:
1. USE THE 4-FREQUENCY MEASUREMENT TO DETERMINE PRESCRIPTION SETTINGS.
2. OTHER EQUIPMENTS MAY BE USED WHICH PROVIDE V4 TYPE EQUALIZERS.

Fig. 15—Examples of Combined MFT and E6-V4 Repeatered Layouts



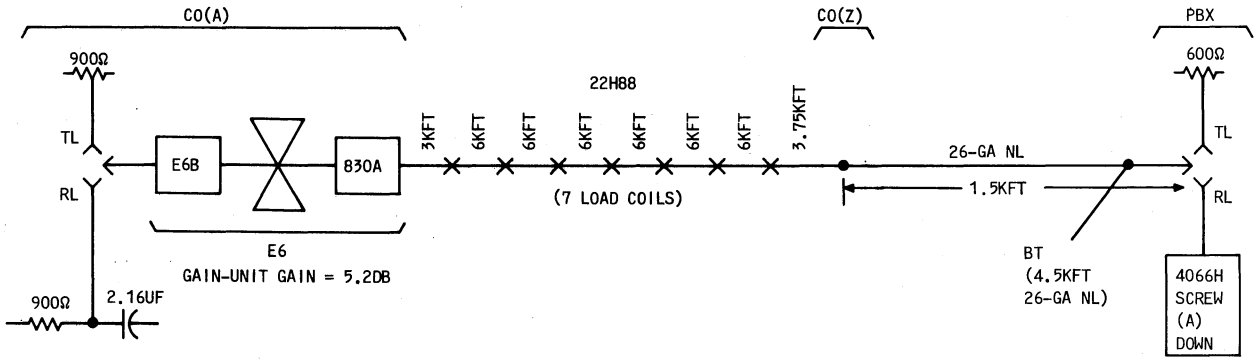
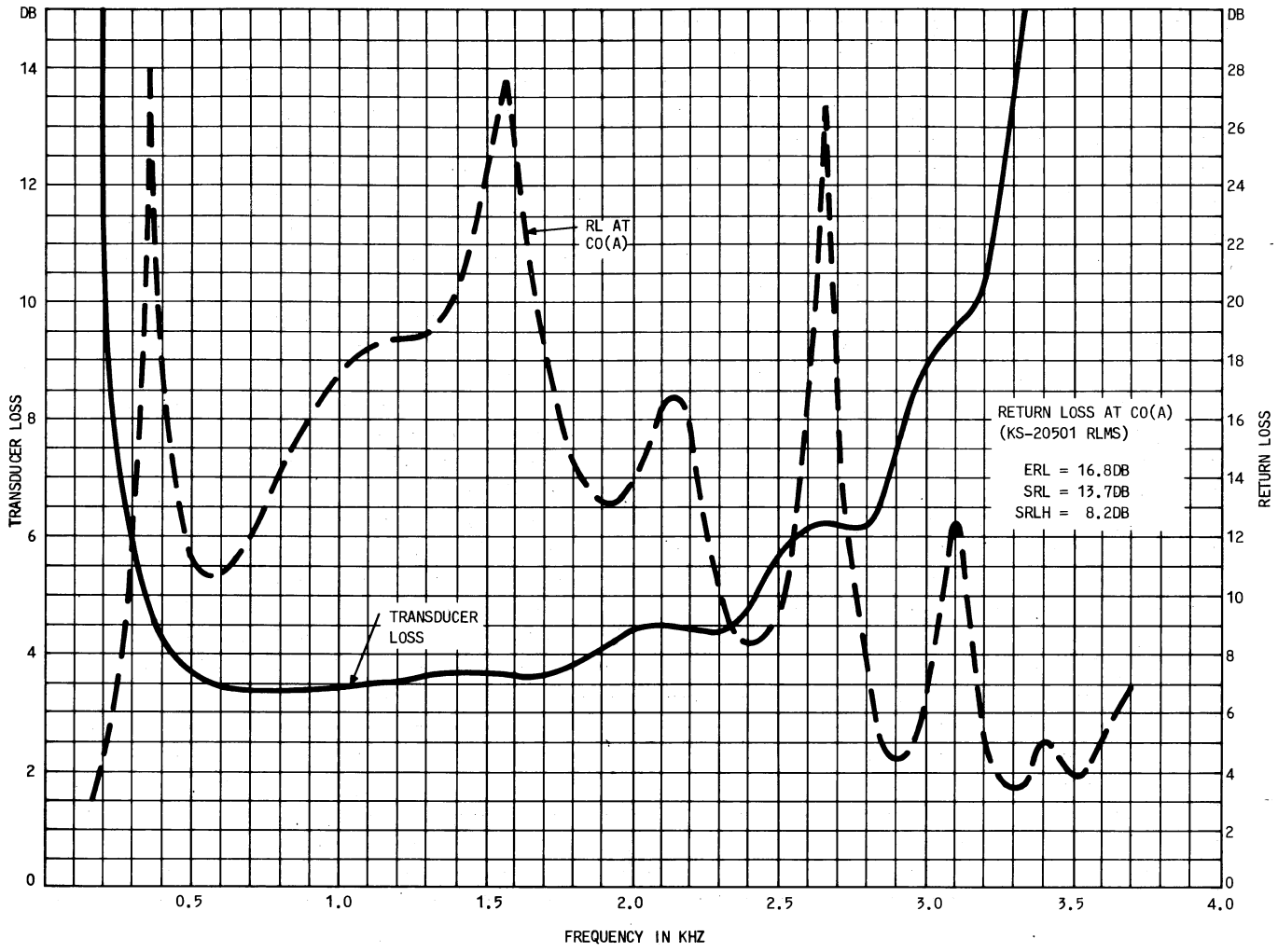


Fig. 16—Transducer and Return Losses for E6 Repeatered Code 11A-L (No Repeating Coil DLL)



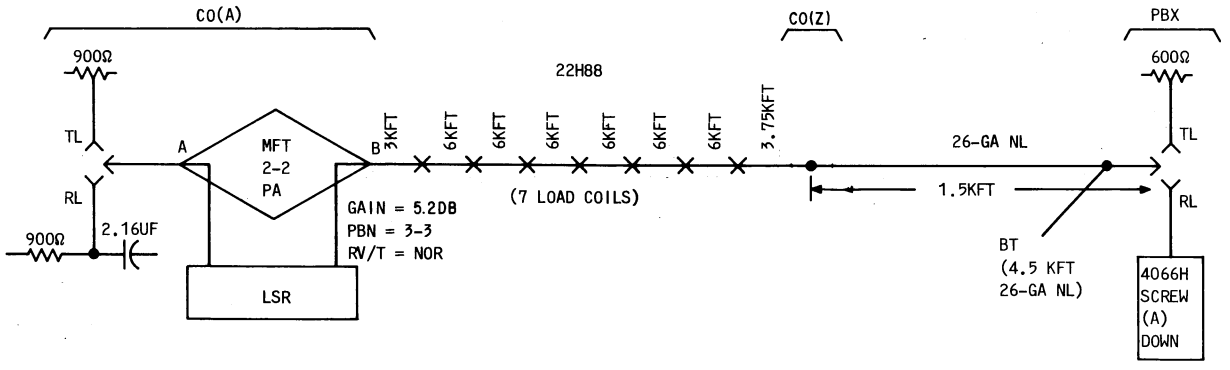


Fig. 17—Transducer and Return Losses for MFT Repeatered Code 11-L

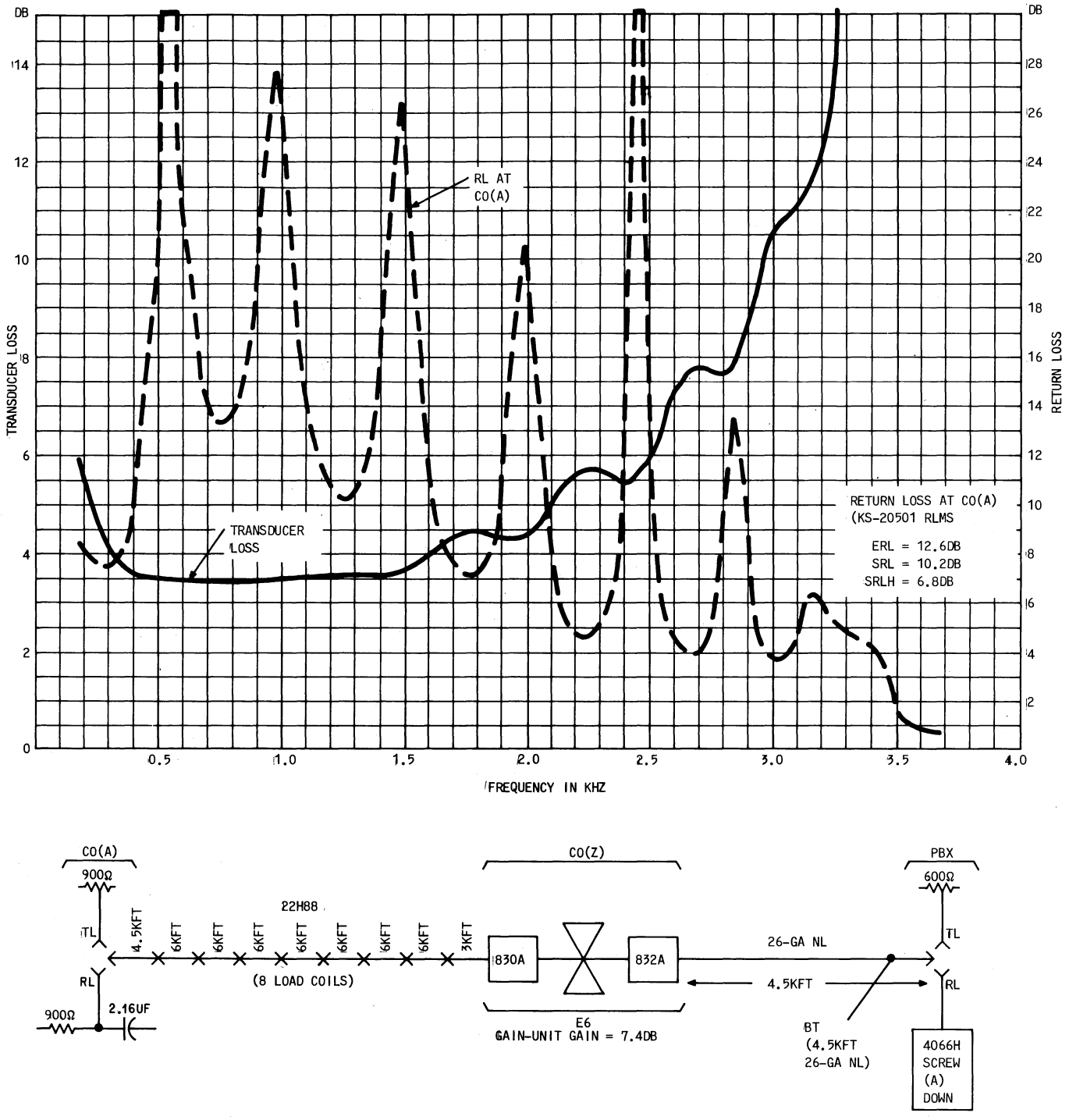
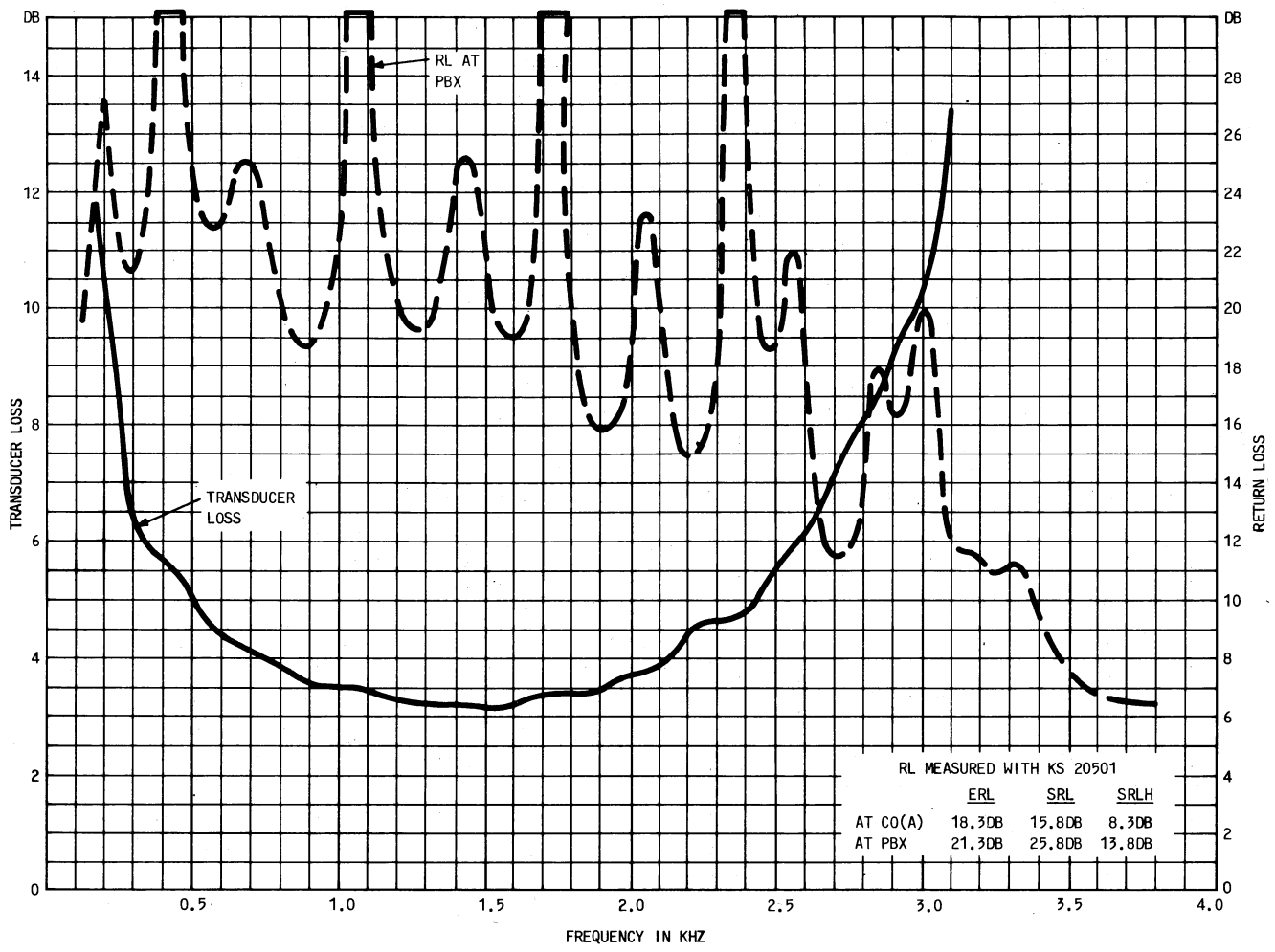


Fig. 18—Transducer and Return Losses for E6 Repeatered Code 21A-L (No Repeating Coil DLL)



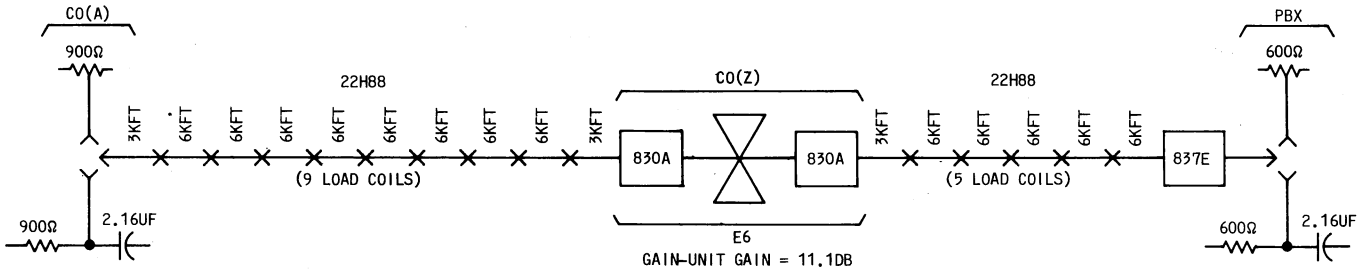


Fig. 19—Transducer and Return Losses for E6 Repeatered Code 24-L Requiring PBX Terminal Balance (No Repeating Coil DLL)

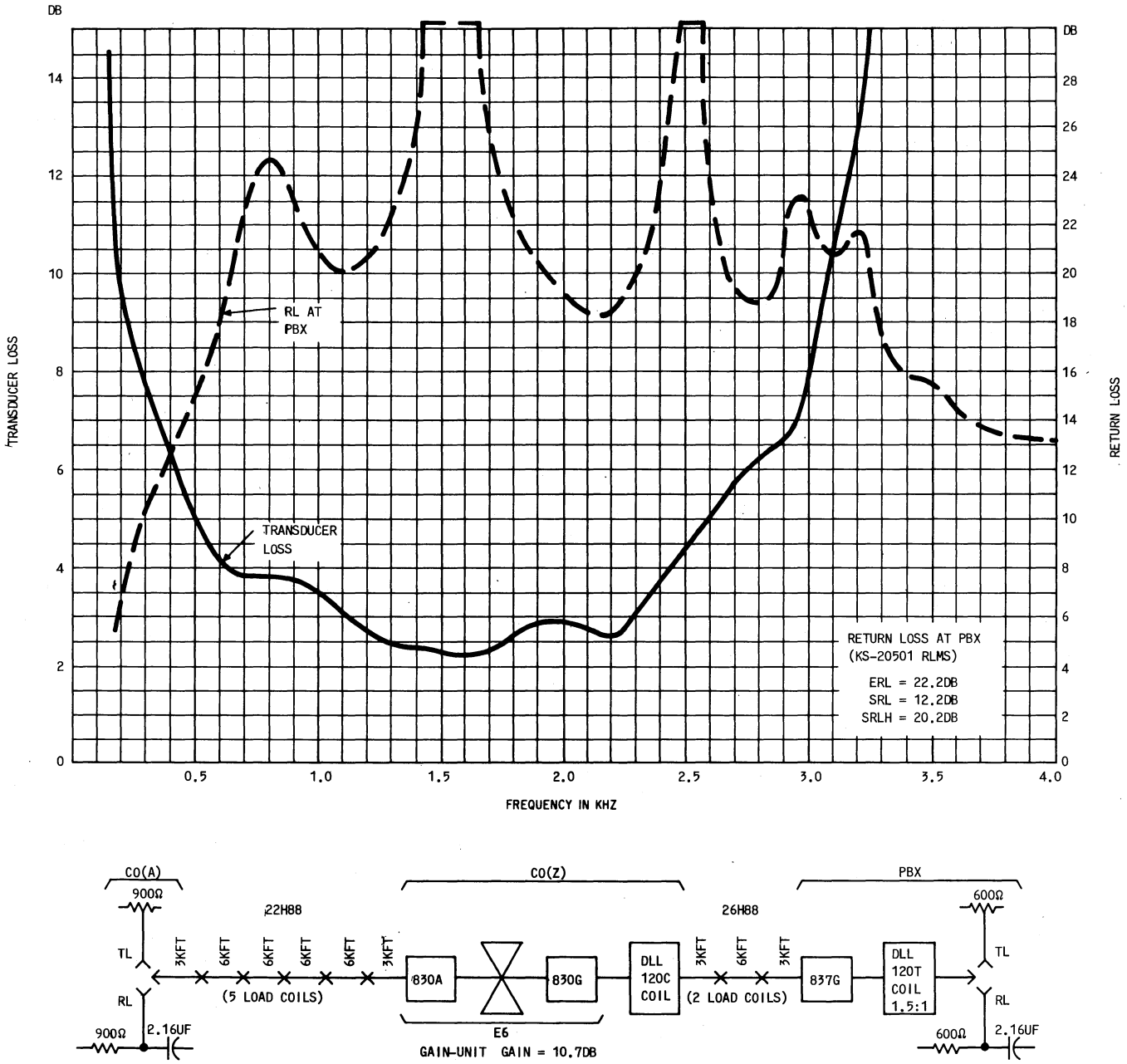
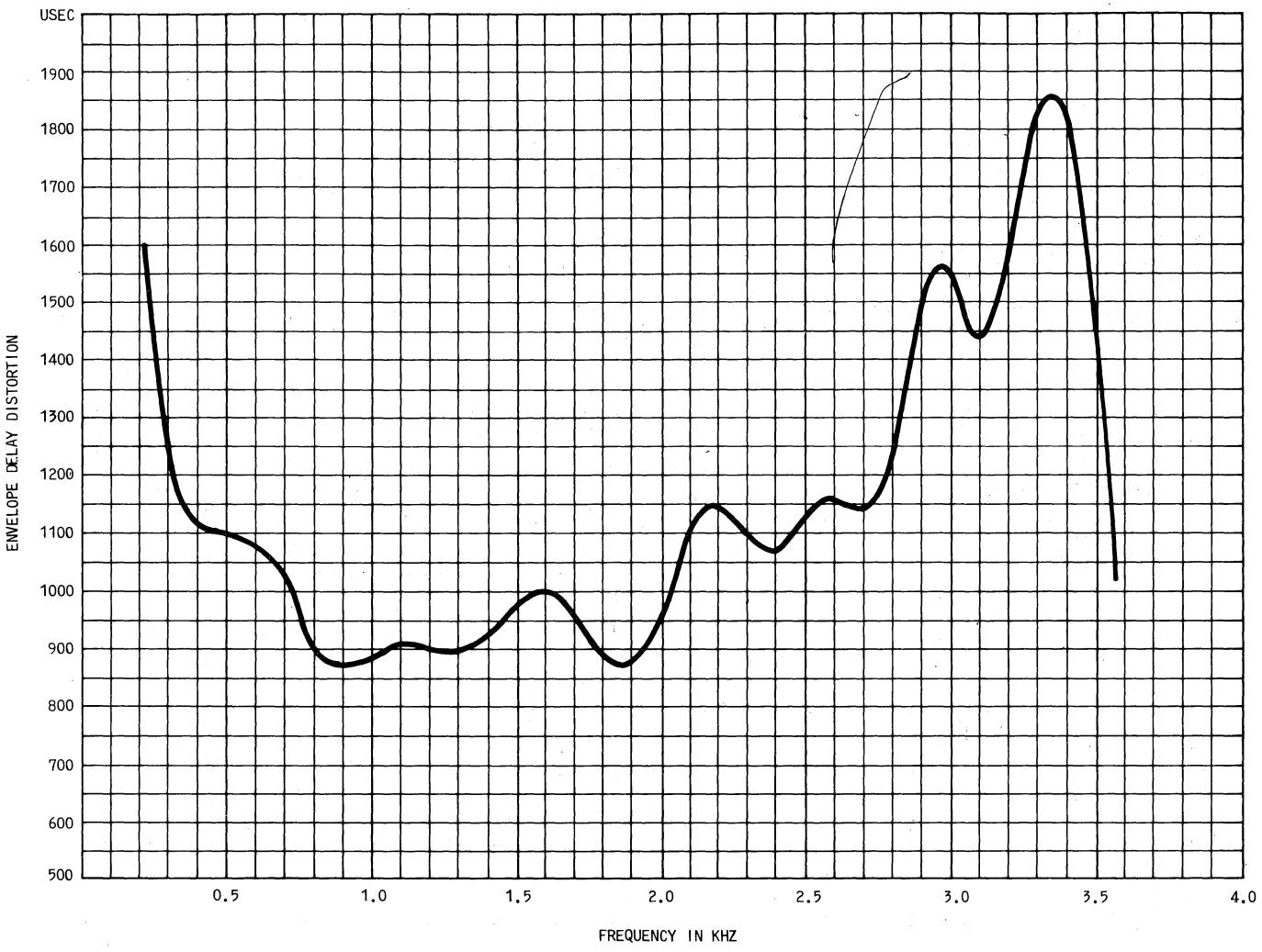


Fig. 20—Transducer and Return Losses for E6 Repeatered Code 24-L Requiring PBX Terminal Balance (With Repeating Coil DLLs)



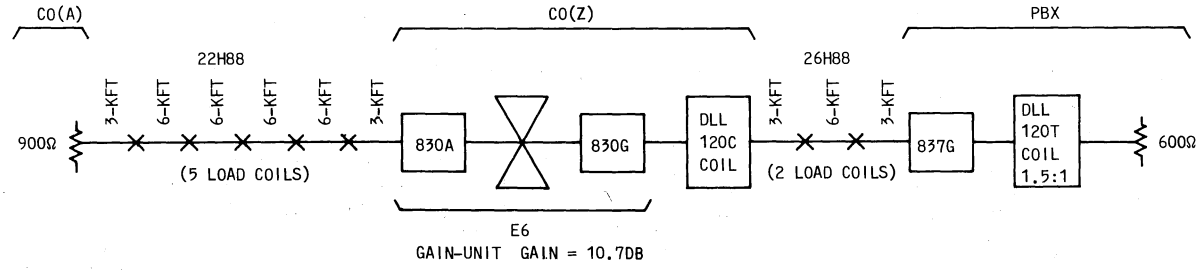


Fig. 21—Envelope Delay Distortion for E6 Repeatered Code 24-L Requiring PBX Terminal Balance (With Repeating Coil DLLs)