

DESIGN OF TOLL CONNECTING TRUNKS  
 ASSOCIATED WITH 2-WIRE TOLL SWITCHING

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1. GENERAL

(A) Introduction

1.01 Issue 1 of Section AB22.128 entitled "Design of Toll Board Trunks" is replaced by a series of AB22.128.X sections dealing with the design of toll connecting trunks as follows:

- (a) This section, AB22.128.1, discusses the general transmission objectives and considerations applying to the design of toll connecting trunks associated with 2-wire switching offices.
- (b) Section AB22.128.2 covers the design of toll connecting trunks directly associated with 4-wire toll switching systems.
- (c) Section AB22.128.3 describes the transmission features of 2-wire switching offices where intertoll trunks terminate at via net loss.

1.02 Section AB22.127, Issue 1 - Design of Tandem Trunks - is canceled, since the AB22.128.X series together with Section AB22.126 - Design of Interlocal Trunks - includes information on tandem trunk design.

1.03 This section is based on the concept that trunk design should be entirely independent of loop design and that all trunks should be designed to the lowest losses

practicable if undesirable contrasts are to be avoided on alternate routes and if transmission is to be adequate on multi-link connections with nationwide toll dialing.

1.04 In the past, when toll traffic was handled manually, toll connecting trunks consisted largely of recording-completing, toll tandem, toll switching and tributary trunks all centered at one switching point. With toll dispersal, more liberal use of decentralized toll boards (DTO), and the introduction of AMA and CAMA points for customer dialing, there are now or will be several points of connection to the intertoll network within most metropolitan areas. Also, the point of connection commonly will be at a No. 5 crossbar or a crossbar tandem office not now generally classified as a toll office.

1.05 Tandem trunks, both incoming from and outgoing to a local office, fall into the toll connecting trunk category; except where separate groups are provided for local traffic only, in which case the local groups are designed as covered in Section AB22.126 - Design of Interlocal Trunks. Until new terminology is adopted for switching offices and trunks, any trunk that connects a subscriber's local office to an intertoll or intertandem trunk may be considered as being a toll connecting trunk.

1.06 Fig. 1 illustrates various types of toll connecting trunks associated with a toll switchboard and a crossbar tandem.

1.07 With local, tandem, and toll switching systems rapidly becoming integrated into one multi-office mechanical network of high usage and final trunk routes throughout the United States and in Canada, it is necessary to design all trunks, including toll connecting trunks, so that when switched together the over-all trunk loss will be as low as practicable regardless of the geographical distance. Toll connecting trunks constitute the first and last links in a switched intertoll connection. This is discussed further under the heading "Transmission Objective."

(B) Relationship of "S" to Connecting Trunks

1.08 Intertoll trunks are designed on the basis of "Via Net Loss Factors" which are dependent upon having a 2 db loss, known as "S," at each terminating end of an intertoll

connection (Section AB23.025.2). This 2 db loss might be obtained by (1) 2 db toll facility loss (end link), (2) switchable pads in the intertoll trunks, (3) fixed pads in the toll connecting trunks, or (4) using part of the toll connecting trunk facility loss, depending upon circumstances.

1.09 The design of toll connecting trunks is, therefore, influenced by whether the "S" loss is a part of the intertoll trunk or is associated directly with the toll connecting trunk. These design considerations are discussed later under separate headings.

## 2. TRANSMISSION OBJECTIVE

2.01 A fundamental transmission objective, as mentioned in the AB23.025.X series of the practices - Transmission Aspects of the General Toll Switching Plan - is to design and to operate trunks so that when they are interconnected the total over-all trunk loss will be the lowest consistent with circuit stability.

2.02 A switching plan based on this objective has been in effect for the intertoll trunk portion of an over-all connection. The plan provides for operating an intertoll trunk at a minimum loss when switched to another intertoll trunk at both ends. This loss is known as "Via Net Loss" (VNL). An additional loss of 2 db is required at each terminating end to meet singing, echo, noise and crosstalk limitations.

2.03 Via net loss (VNL), as explained fully in Section AB23.025.2, is computed by use of a VNL factor which has been worked out for each type of facility. These VNL factors and the 2 db terminating loss are mutually dependent. Via net loss is the product of a VNL factor and length of facility plus a statistical allowance of 0.4 db for circuit loss variations.

2.04 To operate a trunk at VNL always necessitates the application of gain. On voice-frequency facilities repeaters must be used in such a manner that singing and crosstalk will be effectively controlled, otherwise losses as low as VNL can not be attained.

2.05 A single or multi-link toll connection designed by the VNL factor method results in an over-all trunk connection having a loss of 4 db plus the summation of the VNL's of the individual links. The design assumes a distribution of terminal return losses in the subscriber loop and connecting trunk plant having an average of 11 db with a standard deviation of 3 db in the echo range (500 to 2500 cycles).

2.06 In the intertoll design that has been in effect the 2 db terminating loss (known as S) has been associated with the intertoll trunks either as a switchable pad at a through intertoll switching point or as 2 db of facility loss in an end link intertoll trunk.

2.07 As discussed informally from time to time recently with transmission engineers in the Operating Companies, and as presented in the series of Long Range Planning Conferences during 1952, transmission improvements and savings can be made by a change in the switching pad plan. This change will in effect transfer the 2 db loss from the intertoll trunk to the connecting trunk which is the true terminal or end link of an over-all connection. The 2 db loss that is needed between the VNL point and the subscriber's loop will be obtained by use of a fixed pad in the connecting trunk or by 2 db of facility loss.

2.08 Incorporating the 2 db with the terminal link permits the design of all trunks for minimum loss on switched connections and at the same time places the 2 db loss in the connecting trunk where in many cases 2 db of facility loss can be utilized and where a loss is needed anyway for circuit stability when the connecting trunk is also used for non-switched connections. On the other hand, with the 2 db in the intertoll trunk an over-all connection of minimum loss is attained only where the intertoll trunk terminates in the building at which the subscriber's local office is located.

2.09 A practical switching plan, therefore, would assign all trunks that are used in an over-all switched connection in one of two classes: intermediate links or terminal links. Intermediate links, whether called intertoll or intertandem trunks, would be designed to terminate on the switches at via net loss. Terminal links (toll or tandem connecting trunks or intraoffice paths between an intermediate link and a subscriber's local office) would be VNL plus 2 db. The via net loss factors (VNLF) published in Section AB47.651 are applicable to terminal links as well as to intermediate links. VNLF's for exchange type facilities where not now available will be included in a revision of Section AB47.651 or given in other information. Switching offices will, of course, continue to be classified according to rank in order to maintain a definite routing of traffic over the so-called "final" and "high usage" trunk groups.

2.10 The ultimate transmission objective of VNL plus 2 db for the terminal trunk is a definite value for each type of facility which, in many cases, if obtained on the shorter trunks with currently available gain instrumentalities, would result in excessive costs. This

objective has been stated here as a basis for engineering judgment so that best use can be made of available facilities and every opportunity will be taken of new instrumentalities and techniques that will permit economic realization of VNL plus 2 db.

2.11 In the interim where VNL plus 2 db may not be readily attainable, a value of 4 db may be used as the limiting design value. In many instances this will represent a substantial saving for a period of years pending later plant changes which will economically provide the ultimate figure. It will be recognized that at most the 4 db figure departs from the ultimate by only 1 or 2 db.

2.12 The VNL plus 2 db applies to the entire trunk between the point of connection with the intertoll or intertandem trunk and the local office. Equipment and office loss at the switching end are included as part of the trunk loss so that the sum of the trunk losses in an over-all connection will represent the total loss between local offices. This is in accordance with the customary method of lining up intertoll trunks from switchboard to switchboard.

2.13 The 4 db interim limiting value, however, may be considered as facility net loss (conductor loss minus gain) rather than total trunk loss. This simplifies the procedure and recognizes that since central office equipment and wiring losses are fixed by design, the control of trunk loss is largely a matter of selection of facilities.

2.14 The 4 db limiting value assumes the use of facilities that have no distortion transmission impairment, such as H88. Negative values of DTI are not applicable to toll connecting trunk facilities because a toll connecting trunk constitutes only one of what may be as high as 12 links in an over-all connection. Where it is necessary temporarily to use existing low cutoff facilities the effect of the distortion transmission impairment can be accounted for to some extent by limiting the maximum loss to 3 db.

2.15 Where two toll connecting trunks are used in tandem to reach an intertoll trunk, such as a recording-completing trunk and a tandem trunk to a manual toll tandem, the 4 db value applies to the sum of the two facility losses. Although it would be desirable to include the loss of the intermediate office in the 4 db limiting value, this would not be generally practicable. In the ultimate this arrangement would develop into a terminal link of VNL plus 2 db and an intermediate link of VNL.

2.16 Trunks designed to 4 db facility loss will meet the objective for tributary-tributary traffic which is 8 to 10 db maximum loss including the equipment loss at the switching office.

### 3. CHANGE IN PLAN FOR 2 DB "S" LOSS

3.01 As a step toward the achievement of the ultimate objective a change in the switching pad plan has been worked out which in conjunction with new techniques for improving the return loss of connecting trunks against compromise networks, will eliminate the "S" loss from intertoll trunks at 2-wire switching points.

3.02 The plan contemplates omitting switching pads from intertoll trunks at new installations and terminating intertoll trunks on 2-wire switches at via net loss. Two db fixed pads will be put in connecting trunks having less than 2 db loss.

3.03 At existing switching pad offices, the pads will be retained where it is cheaper to provide them on intertoll trunk additions than it is to put fixed pads in all connecting trunks of less than 2 db loss. Where switching pads are retained, they should be switched out on connections to connecting trunks that have a loss of 2 db or more.

3.04 Where the 2 db loss is part of the intertoll facility loss, consideration should be given to reducing the loss by 2 db so that the intertoll trunks may be terminated at VNL. However, if all connecting trunks at such a point are less than 2 db and would require a fixed 2 db build-out the VNL design would not, of course, be applicable.

3.05 The advantage of transferring the 2 db terminating loss from an intermediate link to the terminal link and the termination of the intermediate link at VNL will be evident by comparing Figs. 2A and 2B.

3.06 Fig. 2A shows an example of a single link toll connection based on the switching pad method of operation. The example shows that the 2 db "S" loss in each end of the intertoll trunk together with the loss of the toll connecting trunks account for 14 db of the total 15 db over-all trunk loss. It is apparent that these elements on the ends of the connection are the ones from which further reductions in over-all trunk loss must come.

3.07 Fig. 2B illustrates the effect on over-all trunk loss of eliminating the 2 db switching pads. It will be noted that while

the minimum over-all loss is the same in both cases the maximum loss has now been reduced by 4 db. With the "S" loss removed from the intertoll trunks the maximum over-all trunk loss between local (or tributary) offices served by different switching offices connected by a direct intertoll trunk, need not be more than a db or so higher than between local (or tributary) offices served by a common switching office. This is also the case for double tandeming in the same metropolitan area.

#### 4. DESIGN CONSIDERATIONS

##### (A) Trunks that Connect to Via Net Loss Intertoll Trunks

###### Non-repeated Trunks

4.01 The following treatment is needed on non-repeated toll connecting trunks that connect to intertoll trunks terminated at via net loss:

- (a) Provide 2 db fixed pads on connecting trunks of less than 2 db 1000-cycle loss, and on non-loaded trunks of any loss.
- (b) On loaded trunks where the loss is equal to or greater than 2 db provide impedance compensators in accordance with information in Section AB22.128.3 to obtain a better match between the sending end impedance of the trunks and the compromise networks in the terminating sets of intertoll trunks in the frequency range above 1000 cycles.
- (c) To improve the impedance match in the low-frequency range (below 1000 cycles) the capacitor in the drop side of the repeating coil in the connecting trunk (on the switchboard or switching side of the coil) should be changed to 1 mf. The standard drawings will be changed to show the above capacitor and pad arrangements.
- (d) Consider provision of a building-out capacitor on each trunk in offices where drop B.O. capacitors are provided in accordance with Section AB23.331.

#### Repeated and Carrier Derived Trunks

4.02 Toll connecting trunks that utilize toll type facilities such as 22-or V-type repeaters or carrier channels may be designed as terminal links in accordance with the AB23.025.X series of the practices. In some cases of repeated voice-frequency trunks, crosstalk, singing, or tube overload considerations may limit the amount of usable gain and prevent obtaining trunk losses as low as VNL plus 2 db.

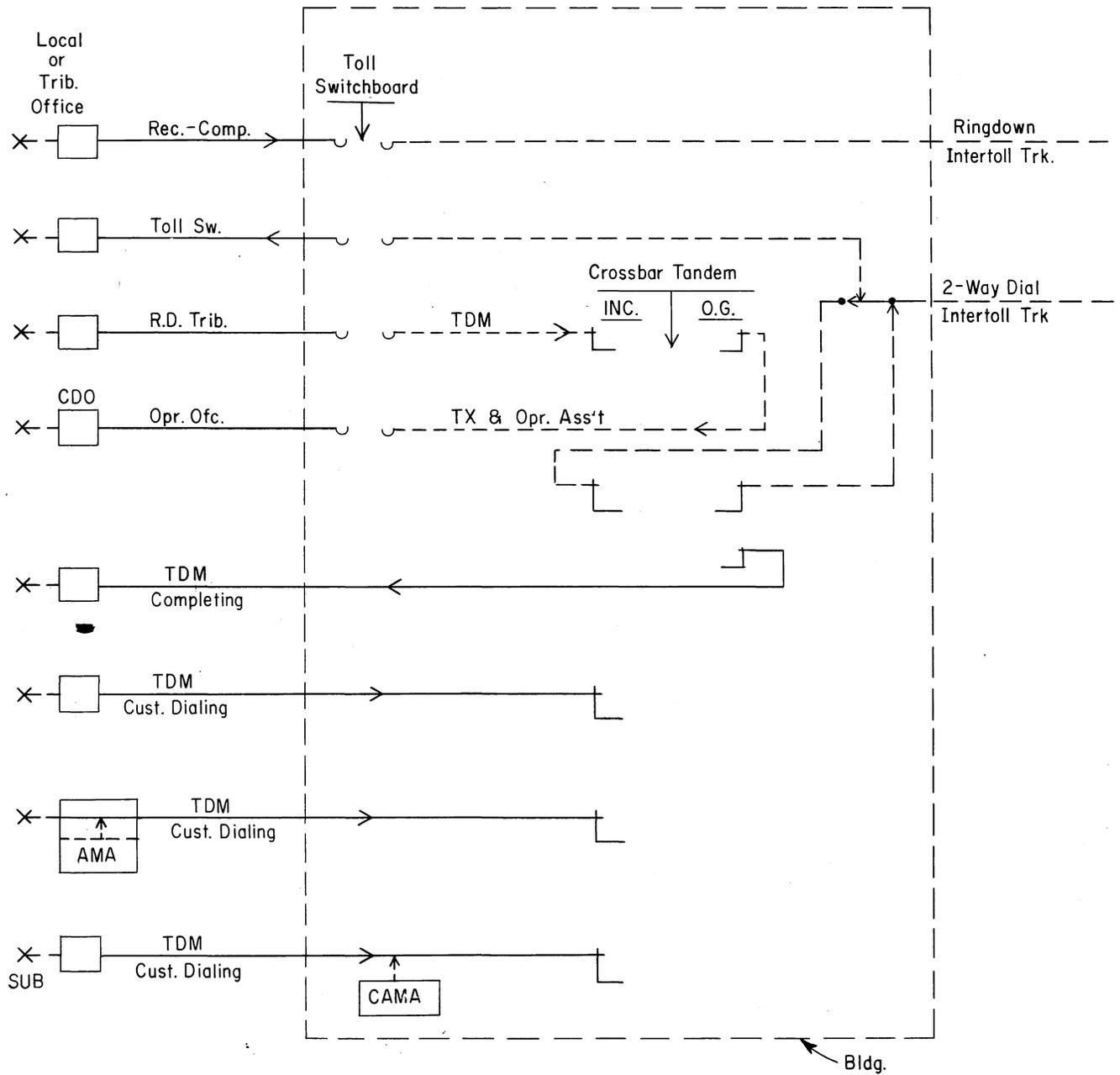
4.03 Toll connecting trunks assigned to toll type facilities will use E and M lead signaling circuits and composite type trunk circuits which will permit the same degree of office balance as regular intertoll trunks if no repeating coil appears in the office path. This can usually be accomplished by avoiding loop to composite converter trunk circuits and using a type of terminating set or drop hybrid arrangement that will provide for A and B leads where required without the addition of a repeating coil.

4.04 Toll connecting trunks equipped with E-type repeaters will usually require considerations from an impedance standpoint in order to obtain a better return loss in the echo range against the compromise networks. The design information on E-type repeaters is contained in a series of AB22.151.X sections.

##### (B) Trunks that Connect to Terminal Net Loss Intertoll Trunks

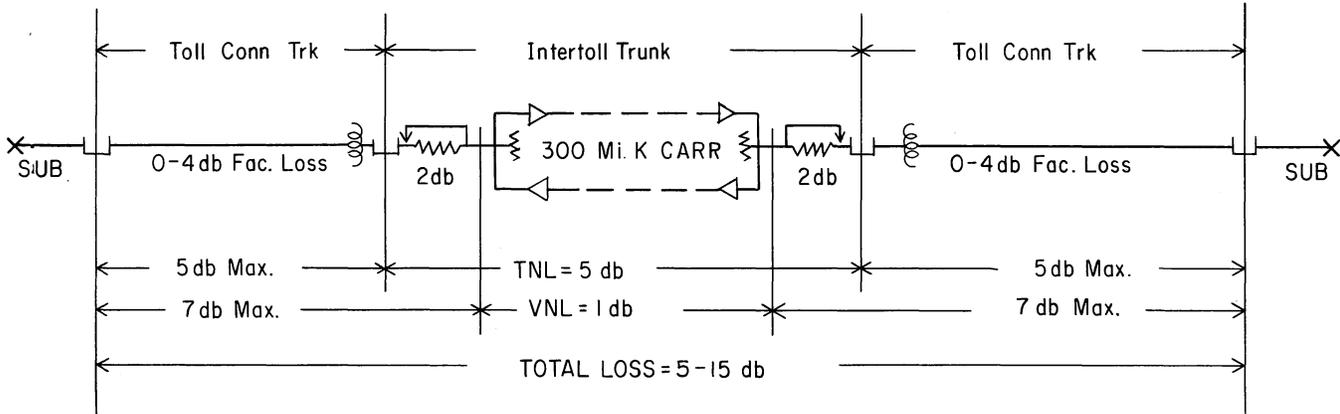
4.05 The design of toll connecting trunks to connect to intertoll trunks terminated in the terminal net loss condition (2 db "S" loss in the intertoll trunk) is the method that has been in general use with existing toll offices. The design considerations are the same as for connecting trunks that connect to VNL intertoll trunks; except that, since the 2 db loss needed between the VNL point and the subscriber's loop is contained in the intertoll trunk, the items referred to in Paragraph 4.01 need not be supplied.

4.06 Connecting trunks that are repeated or carrier derived should be operated at the lowest net loss that will meet singing, echo, crosstalk and noise objectives. For repeated trunks the minimum attainable loss is usually dependent upon singing limitations when used in the terminal condition, that is, connected to a subscriber's loop or another connecting trunk at the switching office end.

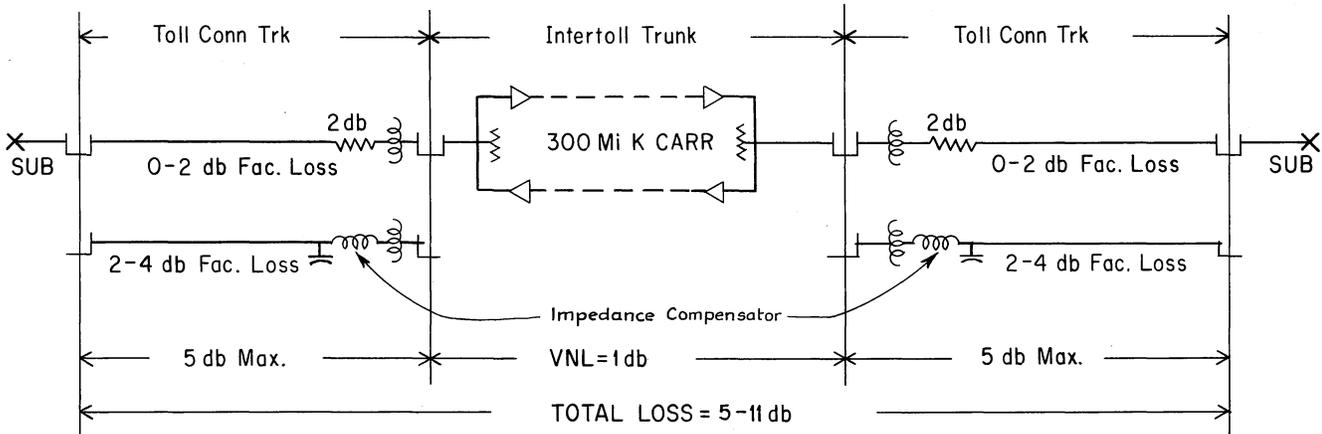


Toll Connecting Trunks Represented By Solid Lines

Fig. 1 - Various Types of Connecting Trunks at a Crossbar Tandem Location



A - Intertoll Trunks Terminated at Terminal Net Loss



B - Intertoll Trunks Terminated at Via Net Loss

Fig. 2 - Benefit of Transferring Pads from Intertoll to Connecting Trunks