DETECTION, LOCATION AND CORRECTION OF IMPEDANCE IRREGULARITIES IN LOADED EXCHANGE TYPE CABLES—GENERAL CONSIDERATIONS

1.00 The remaining AB-lettered sections covering transmission engineering and data are hereby converted and are now assigned 9-digit numbers. The conversion has been accomplished by issuing these cover sheets which are to be attached to the applicable sections. This cover sheet provides the 9-digit number for the section formerly numbered AB22.401.1. The current issue number of the active AB will be used for the 9-digit practice.

1.01 This cover sheet should be attached to the corresponding AB practice, and they should be filed in the appropriate 9-digit number sequence.

1.02 Section 300-020-007, "Cross-Reference List AB Series to 9-Digit Numbering Plan," has been revised and now includes a complete list of all ABs which have been renumbered into the 9-digit BSP series. It also includes those AB sections designated as canceled. The use of this list is required to locate references given by AB numbers.

DETECTION, LOCATION AND CORRECTION OF IMPEDANCE IRREGULARITIES IN LOADED EXCHANGE TYPE CABLES - GENERAL CONSIDERATIONS

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1. GENERAL

(A) Introduction and Scope

1.01 This section introduces the Section AB22.401 series of practices concerning impedance irregularities and their detection, location and correction in loaded exchange type cables. A line discontinuity which imposes adverse effects on the transmission loss, impedance and return loss characteristics of a loaded cable is known as an impedance irregularity and is dealt with later in this section.

1.02 The subject matter is organized under separate sections as follows:

(1) Section AB22.401.2 - "Detection of Impedance Irregularities in Loaded Exchange Type Cables" describes the principles and techniques of various methods of detecting impedance irregularities. This practice partially replaces Section AB45.175 entitled "Detection and Location of Loading Faults Particularly in Exchange Area Cables."

(2) Section AB22.401.3 - "Location of Impedance Irregularities in Loaded Exchange Type Cables" covers the methods used in determining the location of impedance irregularities. This practice partially replaces Section AB45.175.

(3) Section AB22.401.4 - "Correction of Impedance Irregularities in Loaded Exchange Type Cables" describes various remedial methods applicable to impedance irregularities. This practice replaces Section AB45.035 entitled "Spacing Irregularities in Nonrepeatered Exchange Area Trunk Loading - Nos. 618 and 619 Loading Coils."

(B) Importance of Loading System Maintenance in the Exchange Area

1.03 The emphasis on obtaining and maintaining correctly loaded exchange type cables, free from the adverse effects of significant impedance irregularities, is initiated by the increasing application of gain to exchange type cables such as afforded by the E-type repeater and the use of high loss toll connecting trunks associated with the No. 4 Type Crossbar Toll Switching System. If the optimum gains are to be realized without singing and echo limitations particular attention must be paid to the structural return loss characteristics of the cable facilities and consequently the accuracy of the loading system within the limits specified in Section AB22.125.

2. IMPEDANCE IRREGULARITIES IN LOADED EXCHANGE TYPE CABLES

(A) General

2.01 Any condition that alters the impedance symmetry of a periodically loaded line is termed an impedance irregularity. For example, the impedance irregularities generally encountered in exchange type cables are due to (1) omitted loading coils or those of incorrect inductance, (2) incorrect or undesirable capacitance building-out arrangements and (3) loading sections of deficient or excess length. The most common source of impedance irregularities in exchange type cables is due to omitted loading coils or the incorrect connection of loading coils as illustrated in Fig. 1(a). Only those cases where the dc continuity of the circuit is maintained are shown. It may be observed that incorrect connections of loading coils always result in a deficiency of inductance at the loading point for paired cable. Inductances different from the value intended may also be due to an incorrect type of loading coil particularly where more than one weight of loading is involved on the same route. Not unusual is the case of a "double load."

2.02 Impedance irregularities produce reflection losses which result in:

(1) An increase in the transmission loss and distortion of the circuit particularly at frequencies near the cutoff point.

(2) A cyclic variation in the line impedance over the frequency range.

(3) A reduction in the structural return loss characteristics of the circuit.

(B) Effect of Impedance Irregularities on Transmission Loss

2.03 Impedance irregularities whether due to excess or deficient inductance or capacitance will introduce reflection effects that increase the over-all transmission loss of a circuit. The additional loss, with respect to that of a normal line, increases uniformly with frequency as shown in Fig. 1(b), and is essentially independent of the location of the irregularity. Therefore, transmission loss measurements can not be used to locate impedance irregularities but only to detect their presence. The increase in transmission loss is scarcely discernible at a frequency of one kilocycle but is easily noticeable at frequencies in the order of 0.75 to 0.85 of the cutoff point as shown by the curves in Fig. 1(b). An attempt to use a frequency closer than about 85 per cent of the cutoff point may lead to difficulties owing to terminal reflection effects or any irregularly spaced loading coils which reduce the cutoff frequency of the loading system. The marked increase in transmission loss at the higher frequencies is employed in certain methods of detecting impedance irregularities described in Section AB22.401.2.

2.04 The effect of terminal irregularities, occasioned by impedance mismatches between the cable circuit and the equipment necessary for measuring transmission losses, is to cause the excess transmission loss resulting from one or more impedance irregularities to vary somewhat, for a given frequency, depending upon the location of the irregularities. In the case of large terminal impedance discontinuities, the transmission loss-frequency curve will exhibit a wavy characteristic.

2.05 The effect on the transmission loss due to incorrect or undesirable capacitance building-out arrangements may be evaluated by determining the equivalent excess loading section and employing Fig. 1(b).

(C) Effect of Impedance Irregularities on Impedance Characteristics

2.06 The presence of an impedance irregularity will cause the normally smooth impedance characteristics of a uniform periodically loaded line to be distorted into a series of peaks and valleys as shown in Fig. 2(a). The variations in line impedance are due to the reflected currents from the impedance irregularity as discussed in Section AB92.077. The number of peaks or valleys over the entire frequency range and the frequencies at which the peaks and valleys occur bear a definite relation to the position of the impedance irregularity and form a basis for the location methods described in Section AB22.401.3.

(D) Effect of Impedance Irregularities on Structural Return Loss Characteristics

2.07 The manner in which impedance irregularities affect the structural return loss of a loaded cable pair is discussed in some detail in Section AB93.126 where it is shown that, among other factors, the structural return loss is dependent upon the combined effect of three kinds of impedance irregularities namely:

(1) Deviation of the loading coil inductance from the nominal value.

(2) Deviation of the loading coil spacing from the nominal value.

(3) Deviation of the loading section pair capacitance from the nominal value.

The larger any one of these deviations the smaller will be the structural return loss of the cable pair. The structural return loss due to the combined effect of the above factors decreases with frequency as shown in curve A of Fig. 2(b). This illustrates the distribution of the structural return loss with frequency assuming certain load coil and capacitance variations. Where a single impedance irregularity is present the structural return loss curve remains smooth but is displaced below the normal distribution, whereas for two impedance irregularities the return loss characteristic becomes wavy. Fig. 2(b) illustrates the above discussion with the structural return loss frequency curves for two irregularities considered separately and of the two combined, all referred to the sending end of the line.

3. REFERENCES

Section	Title
AB22.401.2	Detection of Impedance Irregularities in Loaded Exchange Type Cables
AB22.401.3	Location of Impedance Irregularities in Loaded Exchange Type Cables
AB22.401.4	Correction of Impedance Irregularities in Loaded Exchange Type Cables
AB92.077	Location of Line Faults - Analysis of Impedance and Impedance Unbalance Curves
AB93.126	Theory of Return Loss and Singing Points

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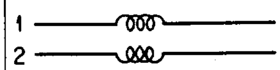
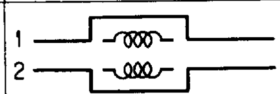
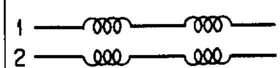
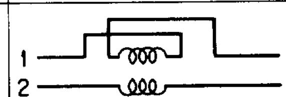
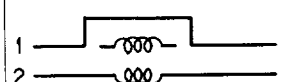
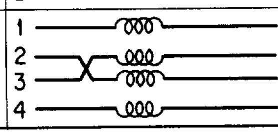
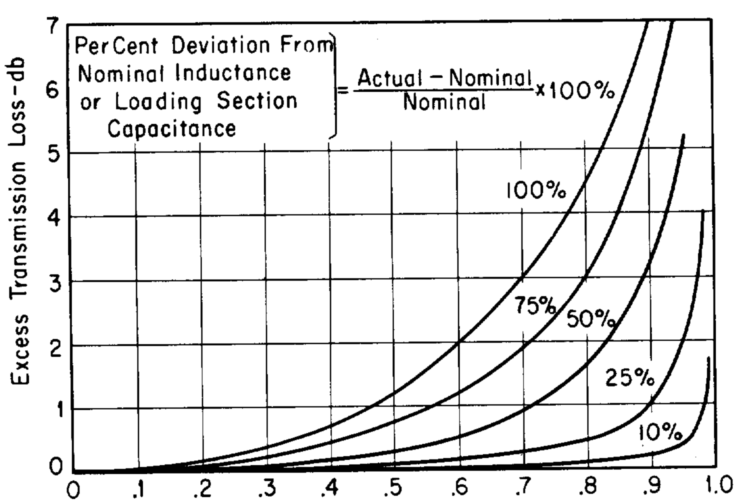
		Resistance	Inductance	Inductance
Normal Loading		100	100	0%
Omitted Coil		0	0	100%
Double Coil		200	200	100%
Reversed Line Winding		100	14	86%
Omitted Line Winding		50	29	71%
Split Pair		100 100	58 58	42%

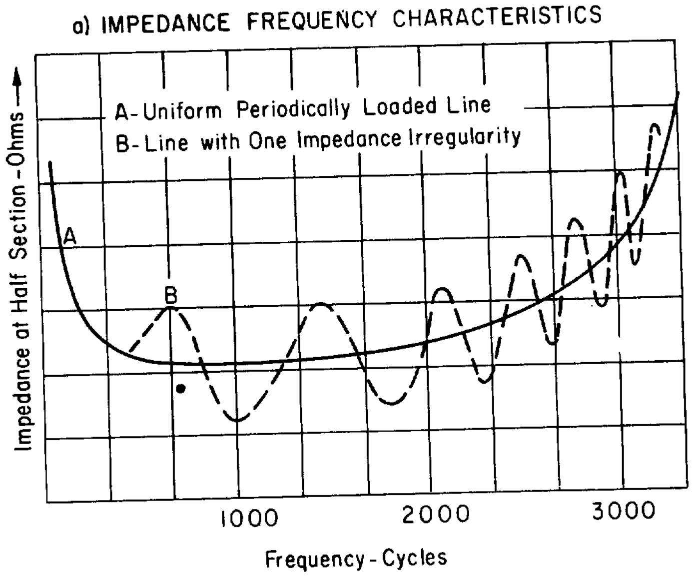
(a) TYPES OF LOADING COIL IRREGULARITIES



Frequency Relative to Cutoff Frequency (f/f_c)

(b) EXCESS TRANSMISSION LOSS DUE TO LOADING COIL OR LOAD SPACING IRREGULARITIES

Fig. 1 - Impedance Irregularities - Effects on Transmission Loss Characterist



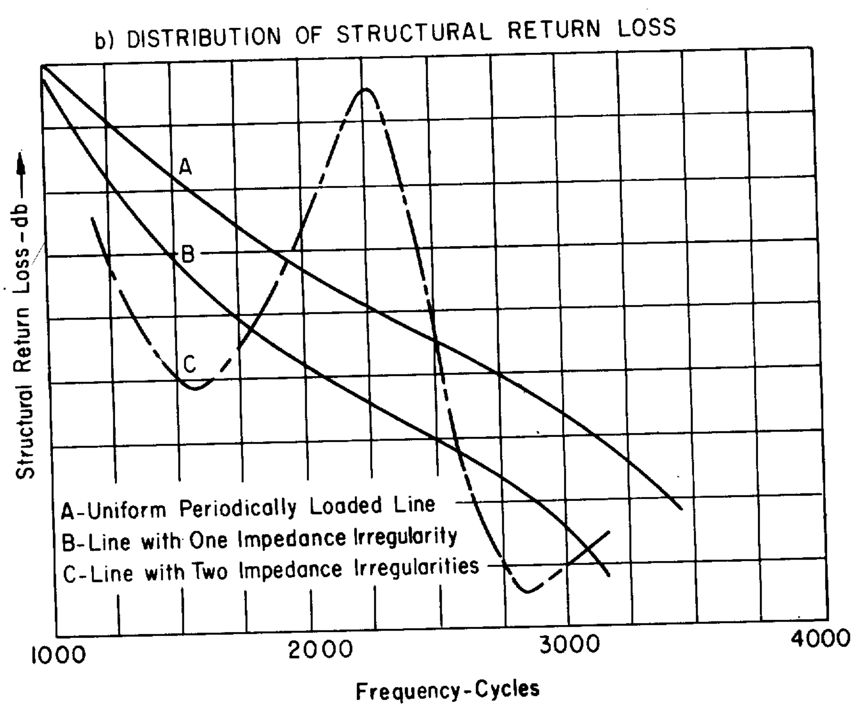


Fig. 2 - Impedance Irregularities - Effects on Impedance and Structural Return Loss Characteristics