FAULT LOCATION ON CABLE PAIRS USING VOICE-FREQUENCY SWEEP TEST SETS — GENERAL THEORY

CONTENTS PAGE

1. GENERAL

1.01 This section discusses the general theory and techniques for location of faults in cable pairs using voice-frequency sweep test sets. The tests apply to cable pairs used for voice-band circuits.

1.02 Associated practices providing additional descriptive information are:

330-450-101 — Fault Location in Trunk Cable Pairs

330-450-102 — Fault Location in Subscriber Loops

Testing methods are covered in other sections of this series.

1.03 Until recently, detailed measurements across a voice-band circuit were tedious and time consuming because measurements had to be made manually at a series of frequencies and plotted on graph paper before the significant characteristics were obtained. The technique is covered in the AB22.401 series of practices. With the availability of sweep test sets, the data now are obtained and displayed automatically with great ease. It is possible, therefore, to examine the transmission characteristics of cable pairs in considerable detail.

2. TEST SET CHARACTERISTICS

(a) General

2.01 A voice-frequency sweep test set is usually a combined sending and measuring device. The sending and measuring sections are compatible and are capable of self-calibration.

2.02 The sending section is a variable frequency oscillator which may be swept across the frequency range of interest or may be tuned manually. The measuring section ordinarily is capable of being used separately. Its indicator is an oscilloscope which indicates frequency on the horizontal scale and a transmission characteristic on the vertical scale.

2.03 The test set may contain an internal hybrid for use in measuring return loss. The transhybrid loss should be constant across the frequency band, and the set should be adjustable to compensate for the transhybrid loss.

2.04 The set may also be arranged internally to be capable of impedance measurements. It should have a measurement range extending from short circuit to values well above those normally found in cable pairs.

(b) Sending Section

2.05 The sending section usually sweeps from 200 CPS to 4000 CPS or higher. It is desirable that the upper frequency limit be above the cutoff frequency of loaded cable pairs. It should be possible to set the frequency manually to any point in the sweep range. Means should also be provided for adjustment of the sweep limits at both ends of the range.

2.06 The oscillator will usually provide both 600-ohm and 900-ohm source impedances, essentially constant over the operating frequency range. It should also be capable of a suitable internal impedance for impedance measurements.

2.07 The output level should be easily adjustable up to +10 dbm in operation.

(c) Measuring Section

2.08 The measuring section should be capable of operation without synchronization from the sending section, i.e., it should respond to the frequency of the measured signal horizontally as well as indicate a transmission characteristic vertically.

2.09 The level measuring accuracy is limited by the readability of the oscilloscope, usually about ±0.2 db at the expanded portion of the scale.

2.10 The measuring range may be from +10 dbm to −40 dbm or greater. When measuring impedance values, the measuring section usually displays absolute impedance measurements varying from a short circuit to values well above those found in cable pairs (4000 ohms or better).

(d) Display

2.11 The display may be linear or logarithmic in either the vertical or horizontal direction, depending on the set used. In this section, the display figures are logarithmic on the horizontal scale. They are logarithmic on the vertical scale for loss in db and linear for impedance in ohms.

(e) Types of Tests

2.12 The test set may be used for straightaway measurement of loss-frequency characteristics. The arrangement is shown in Fig. 1. Two sets may be used or a manually operated oscillator of suitable characteristics may be used as the sending device.

2.13 When impedance measurements are made, the arrangement is as shown in Fig. 2. The sending section and the measuring section have impedance arrangements which make the voltage output of the oscillator dependent upon the impedance to be measured. The measuring section becomes in effect a voltmeter, interpreting the voltage in terms of absolute line impedance (magnitude only).

Fig. 1 — Loss-Frequency Measurement

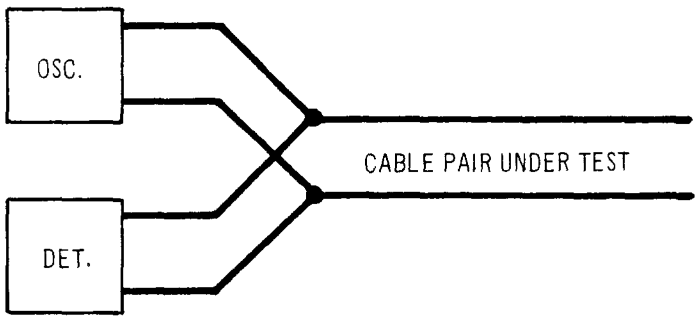


Fig. 2 – Impedance Measurement

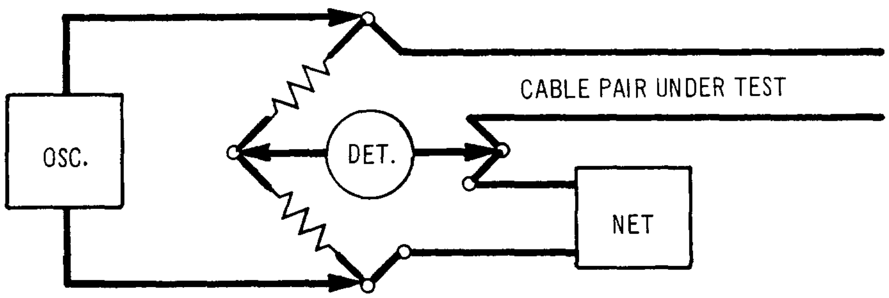


Fig. 3 – Return Loss Measurement

2.14 When return loss measurements are made, the arrangement is as shown in Fig. 3. The internal hybrid is fundamentally a bridge circuit. The internal elements usually are made resistive to prevent undesirable frequency characteristics in the set. There must, of course, be provisions for external connection to the line and net.

3. LOSS MEASUREMENTS

3.01 The insertion loss of a cable pair at any frequency is controlled by its overall primary constants. These are in turn determined by the structural make-up of the cable pair. A curve of insertion loss vs. frequency, therefore, should reveal something about the structure of a circuit. This is shown in Fig. 4.

Fig. 4A shows the typical insertion loss characteristics of a nonloaded cable measured at 600 ohms, and Fig. 4B shows the typical insertion loss characteristics of a loaded cable pair measured at 900 ohms.

3.02 Comparison of the two curves shows a difference in loss characteristics. The curves are typical for the two types of cable pairs. Differences in length, wire size, loading plan, etc, will not change the general shapes of the curves as long as the structure is uniform.

3.03 Loss measurements are not extremely sensitive to structural irregularities, however. This is shown in Fig. 5. Note that either the first or last load missing produces the same effect. The middle load missing is not significantly different. The curves are illustrative for a cable pair with five load points.

3.04 The sensitivity of "loss-frequency" tests does not decrease with increased distance from the point of test to the fault location. Therefore, this test is valuable when impedance tests and return loss tests are in doubt because of the distance from the point of test to the fault.

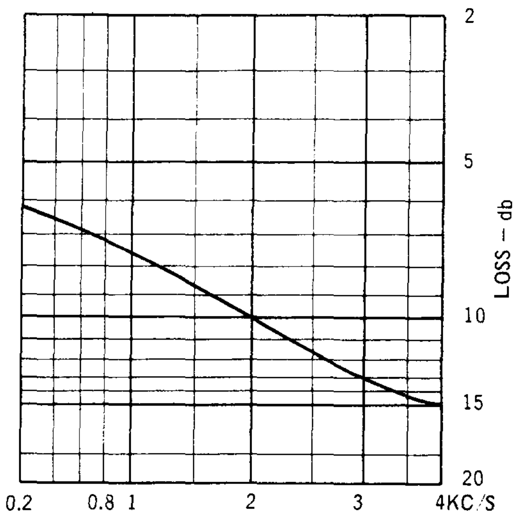


Fig. 4A – Nonloaded Cable Insertion Loss Characteristic

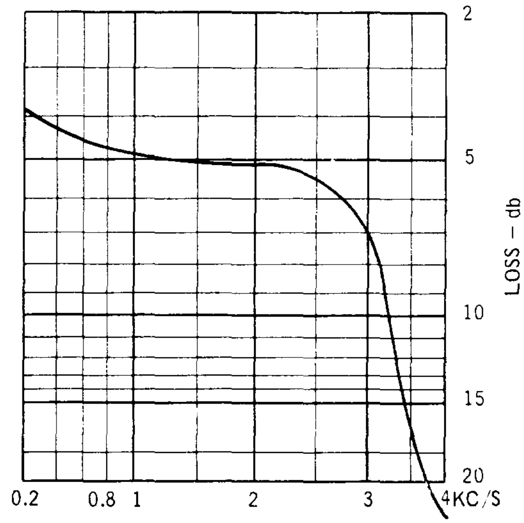


Fig. 4B – Loaded Cable Insertion Loss Characteristic

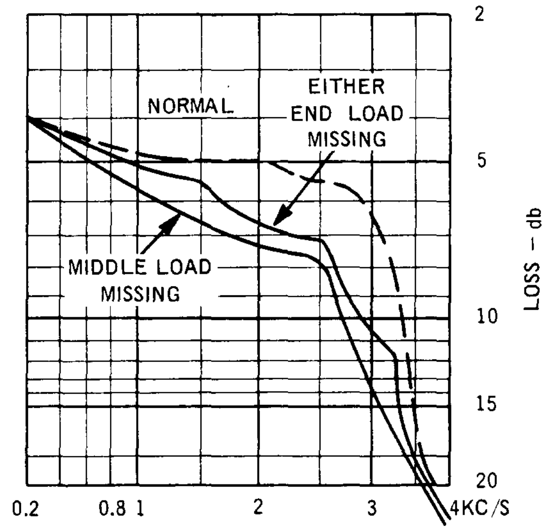


Fig. 5 – Loss Characteristics of a Loaded Cable with Irregularities

4. IMPEDANCE MEASUREMENTS

(a) General

4.01 When a cable pair is terminated in its characteristic impedance, it appears to be infinitely long, and the characteristic impedance also appears at the sending end. When the terminal impedance has some other value, the sending end value will be a function of the line and terminal impedances, approaching the characteristic impedance of the line as the line length increases.

4.02 When the line has an irregularity, its characteristic impedance is changed. The change in impedance may, therefore, be used as an indication of the irregularity. Irregularities may be located by interpretation of the impedance curve. When a dual trace sweep set is available, they may be located by comparison of the impedance curve with that of a similar artificial line.

4.03 Impedances are complex and have angles as well as magnitudes. Voice-frequency sweep test sets usually measure magnitude only and have no means of detecting phase angle. Further discussion will, therefore, be concerned only with absolute values of impedance (magnitude).

(b) Terminated Measurements

4.04 Sweep impedance measurement of a properly terminated line should produce an impedance curve similar to the characteristic impedance of the cable pair, and a smooth curve would be expected. An approximation of this is shown in Fig. 6. Terminated measurements may be used on cable pairs where a precision analysis of the impedance is required.

4.05 Fig. 6A shows the impedance curve for a 12KF nonloaded cable pair terminated in its characteristic impedance (an extremely long line), and Fig. 6B shows the curve for a 30KF H88 loaded cable terminated in a precision network. The curves are quite smooth and typical for their types. Tests of nonloaded cable pairs with precision terminations have no practical application.

4.06 If a circuit is not terminated in its characteristic impedance, some or all of the signal is reflected back toward the sending end. The reflected signal at the sending end is weaker than the sent signal by the sum of the round trip attenuation and the echo return loss of the termination. It may be in phase with the sent signal or out of phase, depending on the round trip delay. Since the round trip delay varies over the frequency band, it may be expected that a mismatched termination will create ripples in the impedance curve.

4.07 Fig. 7 shows typical impedance curves for a loaded cable pair with compromise termination. Comparison of Fig. 7 with Fig. 6B (dotted) shows the ripple effect for a smoothly loaded cable. The velocity of propagation is low, and the round trip delay is sufficient to cause cancellation at some frequencies and addition at others due to the mismatch. The measuring section of the set translates the sending-end voltage ripples into impedance variations. Because of this effect, compromise terminations should

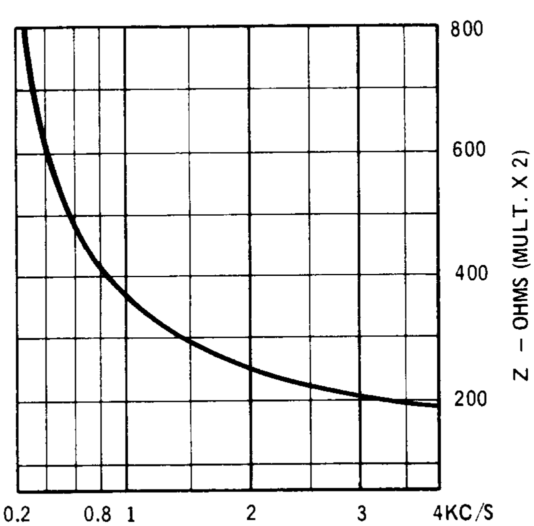


Fig. 6A – Impedance Curve for Nonloaded Cable Pair with Characteristic Termination

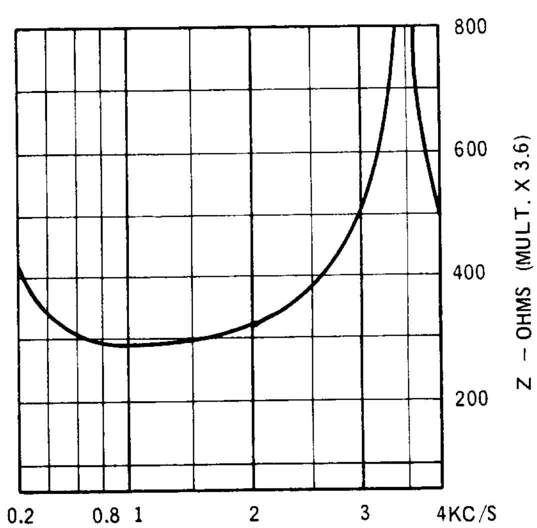


Fig. 6B – Impedance Curve for H88 Loaded Cable Pair with Characteristic Termination

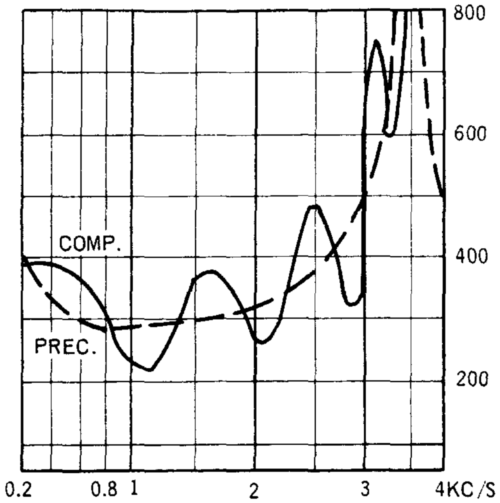


Fig. 7 – Impedance Curve for H88 Loaded Cable Pair with Compromise Termination

not be used in terminated impedance measurements to locate faults.

4.08 A precision termination for a loaded cable pair is designed to terminate a smoothly loaded line. A method for use of precision terminations to locate faults in toll cables is discussed in Section E31.130. When the line is not smoothly loaded, the irregularity will cause reflections. The reflections due to the irregularity should create ripples in the impedance curve which are indicative of the irregularity. This is shown in Fig. 8.

4.09 Comparisons shown in Figs. 8A and 8B demonstrate that irregularities in loaded cable pairs produce distortions or ripples in the impedance curve, and that the effect varies with the type of irregularity. This sensitivity to irregularities exists when the far end is open or shorted. It may, therefore, be more convenient to make fault location tests in this fashion than to use precision terminations.

(c) Open Circuit Measurements

4.10 The maximum mismatch is an open circuit at the distant end. This is a convenient condition for working purposes, because the circuit may be normally open or can be readily made open. For the normally open condition, assistance is not required at the distant end. For the normally terminated condition, it is necessary only to have the termination removed by removing heat coils, etc.

4.11 From the previous discussion, it is expected that the open circuit impedance curves would have typical shapes. Some of these are shown in Fig. 9.

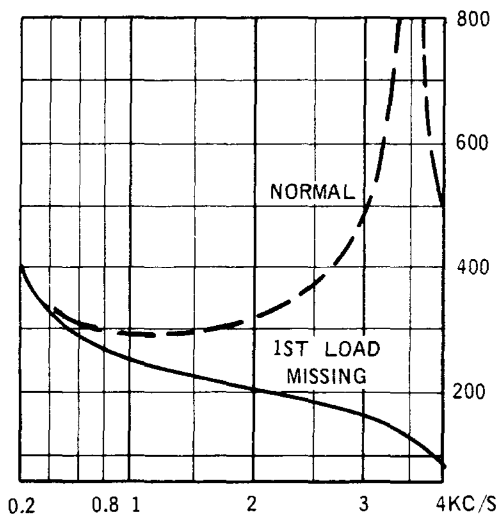


Fig. 8A – Impedance Curve for H88 Loaded Cable Pair with First Load Missing

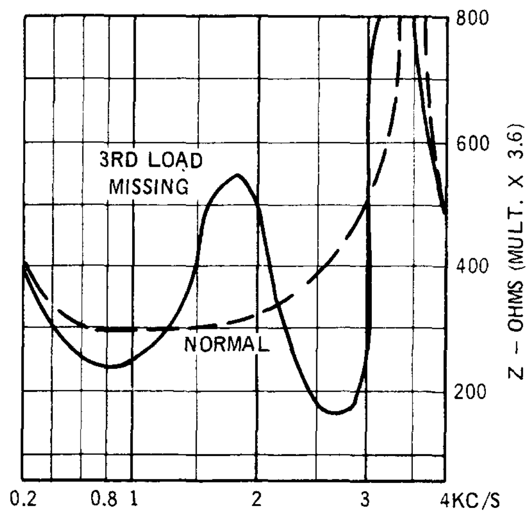


Fig. 8B – Impedance Curve for H88 Loaded Cable Pair with Third Load Missing

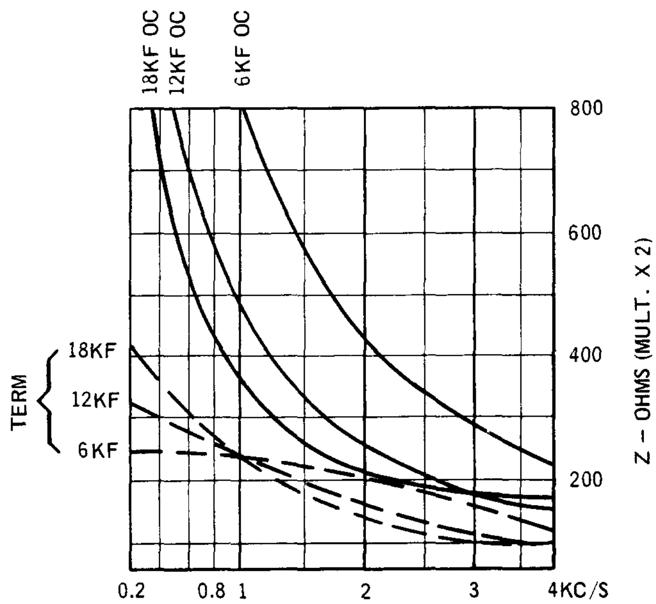


Fig. 9A – Comparison of Impedance Curves for Nonloaded Cable Pair — Open Circuit and Terminated

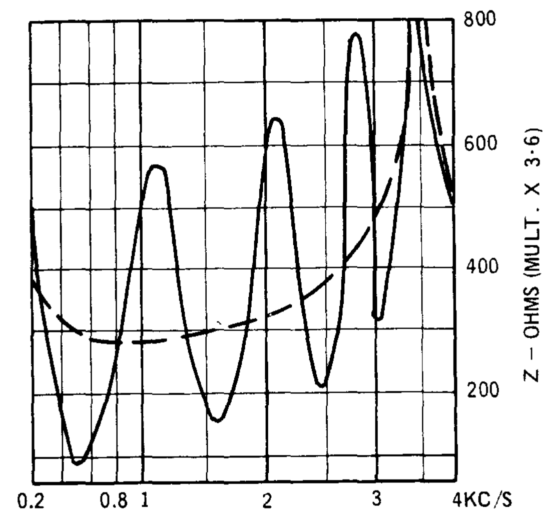


Fig. 9B – Comparison of Impedance Curve for H88 Loaded Cable Pair — Open Circuit and Terminated

4.12 Fig. 9A shows some typical open circuit impedance curves for various lengths of nonloaded cable. For comparison, the curves for similar lengths with 600-ohm terminations are also shown. Note that the total cable length can be estimated by noting the point at which the trace crosses the uppermost line of the grid. The indicated length will be affected by the shunt capacitance of the cable.

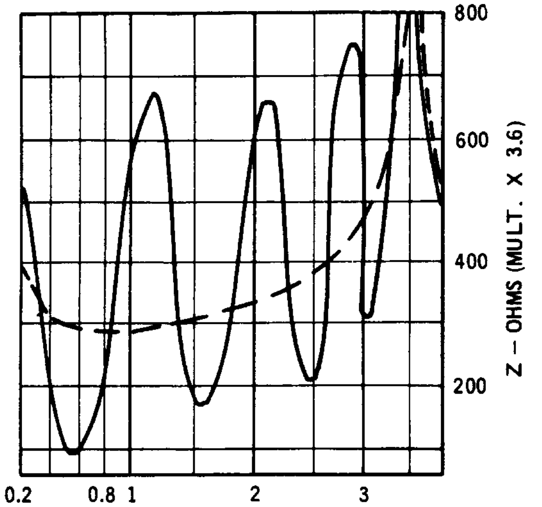
4.13 Fig. 9B shows an open circuit impedance curve for an H88 loaded cable pair with five loads. For comparison, the terminated impedance curve is also shown. Note that the peaks and dips are uniform and tend to rise smoothly toward the high frequencies.

4.14 Loading irregularities tend to upset the uniformity of the peaks and dips of open circuit impedance curves. This is illustrated in Fig. 10. Fig. 10A is the open circuit impedance curve for an H88 smoothly loaded cable pair with five load coils. The succeeding figures show the effects of omission of the various load coils. Doubled coils also tend to produce these types of impedance irregularities.

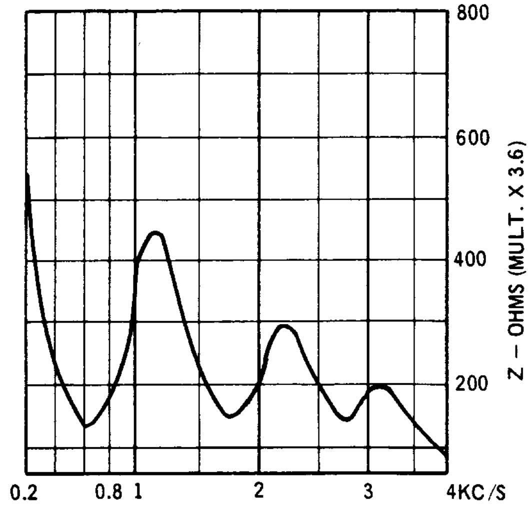
4.15 Fig. 10B shows that the impedance curve tends to slope downward toward the high frequencies when the first load is missing. This is a typical situation whenever the near-end section has excessive capacitance, such as when the first load is missing or a bridged tap has been placed. Build-out capacitors may also produce this effect. In any case, the downward tilt of the curve is indicative of high capacitance in the near-end section, because the shunt capacitance tends to hide the characteristics of the rest of the pair at high frequencies.

4.16 It is difficult to establish rules for interpretation of all the aspects of loaded pair impedance curves. The number of peaks and dips is affected by the number of loads, the cutoff frequency, and the insertion loss when the sweep frequency range is limited. In general, it can be said that the peaks and dips should present a smooth pattern, rising toward the high frequencies. When irregularities are noted, return loss tests may be necessary to locate the trouble.

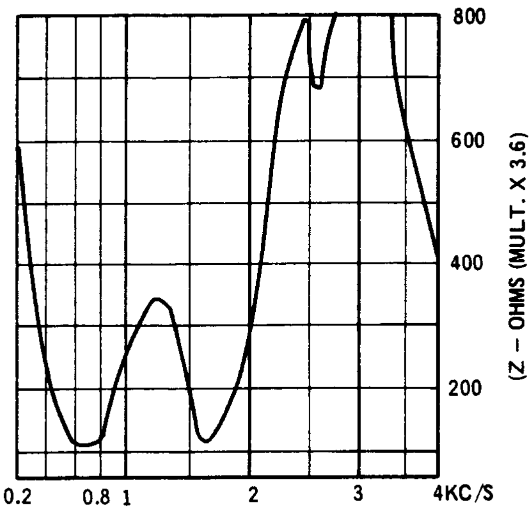
4.17 The pattern of curves for H88 loaded cable pairs ***does not*** apply to other loading plans, such as H44 and B88 when the sweep fre-



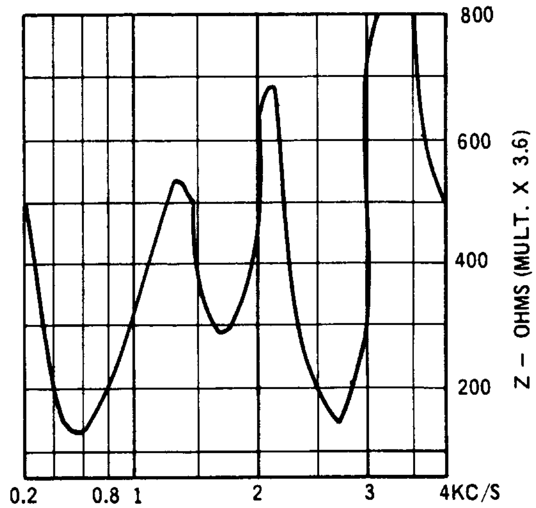
(A) Normal Loading



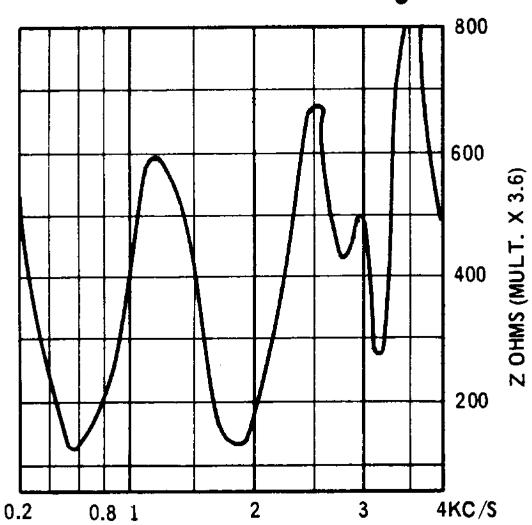
(B) First Load Missing



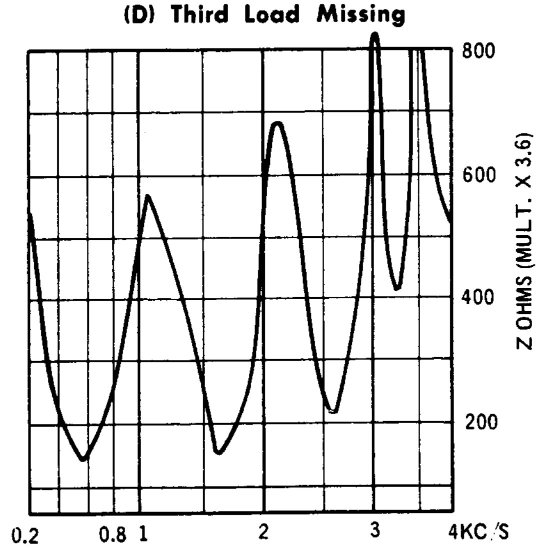
(C) Second Load Missing



(D) Third Load Missing



(E) Fourth Load Missing



(F) Fifth Load Missing

Fig. 10 – Open Circuit Impedance Curves for H88 Loaded Cable Pair (5 Loads)

quency range is fixed. The open circuit impedance is dependent on velocity of propagation and insertion loss. Therefore, the pattern which fits H88 loading will not apply to other schemes, but it is convenient to know because of the predominance of H88 loading in the cable plant. The patterns for other loading schemes will be similar only if the sweep range of the set extends above the cutoff frequency of the cable pair.

4.18 Some of the things which produce impedance irregularities are missing loads, doubled loads, misspaced loads, missing build-out capacitors, doubled build-out capacitors, misplaced build-out capacitors, long end sections, bridged tap between loads, etc. Because of the great variety of possible irregularities, it is not possible to define all of them exactly by examination of the impedance curves. Considerable skill can be developed with experience, but some of the irregularities can be defined exactly only by making further tests.

4.19 When bridged tap is present, it has the same effect as the addition of a build-out capacitor of the same value as the shunt capacitance of the bridged tap. When placed between load points, it has the effect of lengthening the load section and has the same effect on the open circuit impedance curve as a long load section. When bridged tap is present in the end sections, it has the same effect as long end sections.

4.20 The open circuit impedance curve is more sensitive to irregularities near the sending end than those near the distant end. Irregularities near the distant end have less effect on the impedance curve when the pair is short than when it is long. The range of sensitivity is greater in a long pair than in a short pair. For example, it may be difficult to detect a missing fifth load coil if it is the last coil, but it may be readily detected in a cable pair with eight load points.

4.21 An open at the distant end will make the test more sensitive to shunt irregularities nearest the distant end than a short-circuit test. It will be less sensitive to series irregularities than a short-circuit test. The open circuit impedance test is not as sensitive as the tests discussed in Part 5.

4.22 The field of use for open circuit tests includes subscriber loops where a far-end termination is not practical, and trunk cable pairs may be tested quickly when testing time is limited. The tests may also be useful during corrective work when a termination is not practical.

(d) Short-Circuit Measurements

4.23 There may be situations when it is desirable to measure impedance characteristics with a short-circuit termination at the distant end of the cable pair. Some typical short-circuit impedance curves are shown in Fig. 11.

4.24 Fig. 11A shows the short-circuit impedance curve for some lengths of nonloaded 24-gauge cable. The open circuit impedance curves are also indicated for comparison. Note that the short-circuit impedance at low frequencies approaches the dc loop resistance. When the gauge is known, the low frequency measurement will determine approximately the path length to the short circuit.

4.25 Fig. 11B shows a typical short-circuit impedance curve for an H88 loaded cable pair. The open circuit impedance curve is also shown for comparison. Note the uniformity of the curves although the peaks and dips are reversed.

4.26 Short-circuit tests are more sensitive to series irregularities near the distant end than open circuit tests, but less sensitive to shunt irregularities.

5. RETURN LOSS MEASUREMENTS

(a) General

5.01 Return loss measurements are very effective because they make use of a hybrid which is basically a bridge-type circuit. The bridge permits the use of gain in the detector, thus increasing the ability to detect small unbalances. Sweep measurements of return loss are the most effective of all sweep tests in location of irregularities, particularly when used with an artificial line.

5.02 Return loss measurements eliminate a disadvantage of impedance measurements with sweep sets, i.e., sweep impedance measure-

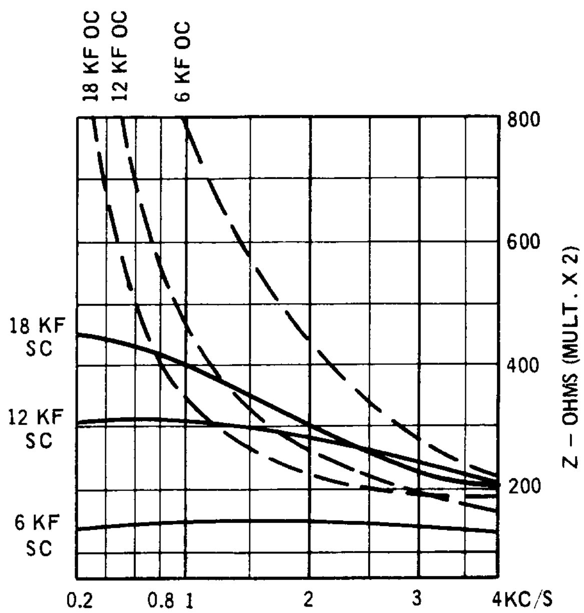


Fig. 11A – Comparison of Impedance Curves for Nonloaded Cable with Open Circuit and Short-Circuit Terminations

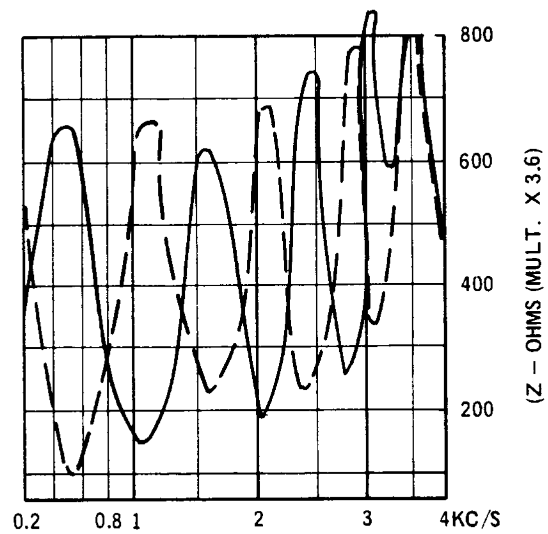


Fig. 11B – Comparison of Impedance Curve for H88 Loaded Cable with Open Circuit and Short-Circuit Terminations

ments do not indicate phase angles. To obtain high return loss at any frequency, the bridge must be balanced both with respect to magnitude and phase angle of the compared impedances.

5.03 Return loss measurements have a disadvantage from the standpoint that voice bandwidth displays are more difficult to interpret in terms of transmission characteristics of the pair under test. When a low return loss indicates an irregularity, it is difficult to say from the curve shape what characteristic irregularity exists. However, there is a great deal more information available than can be obtained with standard return loss measuring techniques.

5.04 Return loss measurements can be made in the regular manner, using precision or compromise network terminations. In addition, measurements can be made on an open circuit or short-circuit basis. Measurements can also be made in a manner which connects the sweep set as a resistance, inductance, or capacitance bridge. This is done by using a resistor, inductor, or capacitor as the balancing network for the hybrid.

5.05 Return loss measurements, as displayed by a sweep set, are unweighted. They cannot be directly compared with echo return loss measurements of the type made during office balance or during structural acceptance tests on facilities. This type of measurement will sometimes reveal resonant conditions hidden by the averaging type measurements.

5.06 Coil hybrids and resistance hybrids are commonly used for return loss measurements. The resistance hybrid is preferred for sweep-type measurements because it is simple, compact, and has no varying frequency characteristics in the voice range. Sweep sets with built-in hybrids generally have resistance hybrids.

(b) Terminated Measurements

5.07 Fig. 12 shows some characteristic return loss curves. In Fig. 12A, curves are shown for a 30KF 22H88 loaded cable pair with precision and compromise networks, both as terminations and balancing networks. This shows that the best results will be obtained with precision

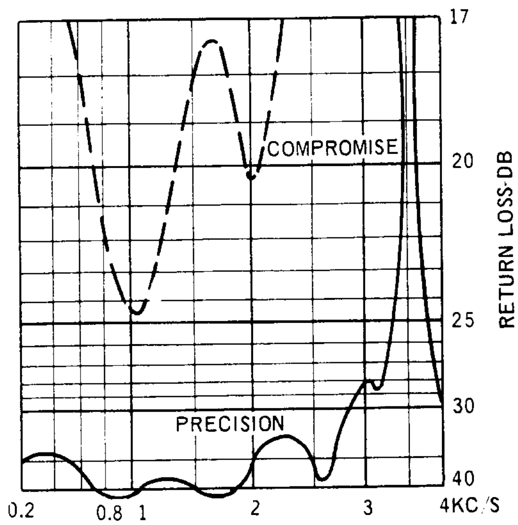


Fig. 12A — Return Loss of a Loaded Cable Pair against Terminations

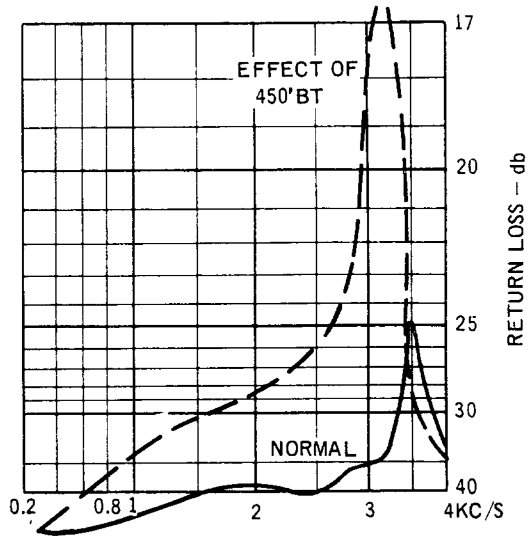


Fig. 12B — Return Loss of a Loaded Cable Pair against Matched Pair

networks on this type of test. Fig. 12B shows the return loss curve for the same cable pair when the network consisted of an identical pair. Both pairs were terminated in identical networks.

5.08 The dotted line in Fig. 12B illustrates the effect on the return loss curve when an irregularity exists in the tested pair (450′ bridged tap in midsection). This suggests that the use of an artificial line as the network would permit a highly effective fault location test. Various irregularities could be inserted in the artificial line until a high return loss is obtained, thus identifying the irregularity in the pair under test.

5.09 In the discussion of impedance measurements, it was pointed out fault indications could be obtained effectively by using an open or short circuit at the distant end of the pair under test. This technique can also be applied to return loss tests using a matched pair or artificial line, and it makes the procedure simpler.

(c) Open Circuit Measurements

5.10 Open circuit return loss measurements can be used on either loaded or nonloaded cable pairs. Some typical examples are shown in Fig. 13.

5.11 Fig. 13A illustrates the return loss curve obtained by matching a 15KF nonloaded 24-gauge cable pair against a nearly identical artificial line with both lines open at the distant end. The return loss for a normal line is as near infinity as can be practically measured. The dotted lines illustrate the effect of 3KF of unsuspected bridged tap and also of a misplaced load coil.

5.12 Fig. 13B illustrates a typical return loss curve for a loaded cable pair matched with an artificial line made as near identical as possible. The dotted line illustrates the effect of an irregularity. In this case, the irregularity is a build-out capacitor on the wrong side of a load coil.

5.13 The ability to detect the effect of an irregularity is obvious, but the nature of the irregularity is not so obvious from the curves. The identification can usually be done through a logical trial method. The desired pair structure should be found from cable records or job order sketches, etc. The artificial line should then be set up to look like the desired structure. If the return loss is poor, an irregularity exists, and one or more irregularities may be introduced into the artificial line systematically until a combination is found which improves the re-

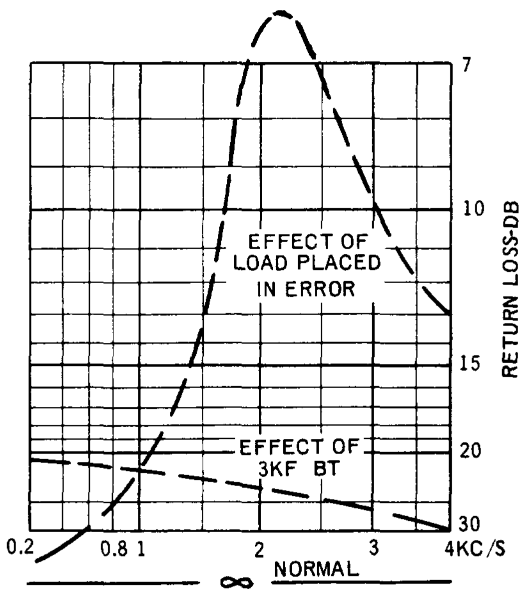


Fig. 13A – Comparison Return Loss Tests on a Nonloaded Cable Pair

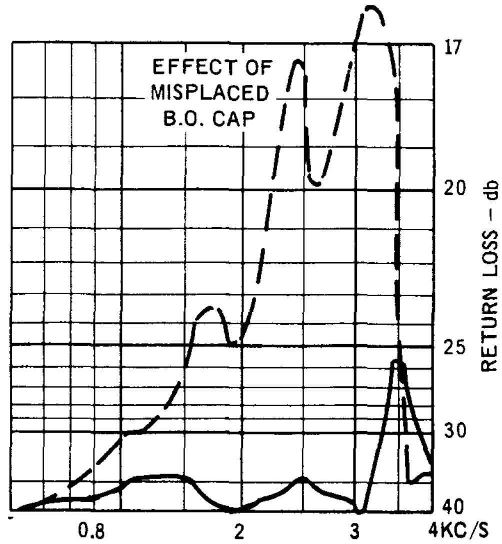


Fig. 13B – Comparison Return Loss Tests on a Loaded Cable Pair

turn loss. Irregularities in the artificial line can produce good return losses only if they are matched by similar irregularities in the actual cable pair.

5.14 A common trouble found in nonloaded cable pairs will be unsuspected bridged tap. This will tend to make the cable pair look longer by the amount of the bridged tap. A good test would be to vary the length of the artificial line until the best match is found.

5.15 Another common trouble in nonloaded cables is load coils installed in error. This condition should be readily revealed by looking at the open circuit impedance curves. If such an irregularity exists, it can then be located by a return loss test, with a coil inserted in the line at the various likely points until a good match is found. The accuracy will usually be good enough, if loading points in the cable are known, to identify the proper splice to be opened.

5.16 The common troubles in loaded cable pairs are omitted or improper loads, improper use of build-out capacitors, and improper bridged tap. They should be checked in about that order, depending on what knowledge is available about the facilities.

5.17 Missing or doubled loads can be checked directly by the matching process. Improper use of build-out capacitors will have the same effect as improper load spacing. A build-out capacitor on the wrong side of a load coil will have the same effect as if a load coil had been installed with improper spacing. Unsuspected bridged tap between loads will have the effect of making a load section look longer.

5.18 The return loss obtained by matching a cable pair against an artificial line, will depend on the uniformity of the cable pair and the degree of similarity between the artificial line and the real pair. In general, it should be about 20 to 30 db but never less than 10 db at any frequency in the echo range (500 to 2500 CPS). Some approximate requirements have been developed for various general types of facilities, based on limited field experience. They are shown in Table I. Irregularities will usually produce values much less than those shown. When minimum or higher values are obtained, any irregularities existing will have little effect on transmission.

TABLE I

TYPE OF CABLE PAIR	MINIMUM PAIR RETURN LOSS — db
Nonloaded	
0 to 4 miles	10
5 to 10 miles	15
H88 Loaded or Similar	
Up to 4 loads	10
5 to 10 loads	12
11 to 15 loads	15

5.19 The sensitivity of the open circuit test is greater than the short-circuit test for location of shunt irregularities near the distant end. It is less sensitive to series irregularities.

5.20 The return loss measurement is effective up to about the distances of 10 to 15 miles. The effectiveness is limited by the loss of the cable pair. At extreme lengths, pairs can be tested at both ends or sectionalized. When the irregularity is in the distant end section, or located far out on a long pair, it may be more useful to make tests on a short-circuit basis.

(d) Short-Circuit Measurements

5.21 Cable pairs may be tested as discussed above, but with the distant end short-circuited. The matching artificial line must also be short-circuited. This test has the disadvantage that assistance is momentarily required at the distant end, but it has the advantage of greater sensitivity to troubles at the distant end of the pair. It is more sensitive to series irregularities but less sensitive to shunt irregularities than open circuit tests.

5.22 The short-circuit test is more sensitive than the open circuit test to distant series irregularities, because the current in the end section is higher and the IR drop is increased in the area of the irregularity. It also has the advantage of insuring pair continuity. Opens can be found in the distant end section which may not be found by open circuit tests.

(e) Bridge Measurements

5.23 When the sweep set is equipped with a hybrid, it can be readily used to obtain bridge-type measurements. This involves setting up the equipment for return loss measurement but operating at a single frequency. The sending section becomes the bridge oscillator, and the receiving section replaces the galvanometer.

5.24 Resistance measurements can be made by using a decade resistor as the network of the hybrid. The distant end of the pair must be shorted. The oscillator should be set to its lowest frequency. The setting of the decade resistor which produces the greatest return loss is the approximate loop resistance.

5.25 The resistance bridge measurement is of value when the apparent cable length is greater than is shown on records. The loop resistance of bridged taps will not appear in the resistance measurement.

5.26 The set can be used as a capacity bridge, if a decade capacitor is used as the network of the hybrid and the distant end of the pair under test is left open. The frequency should be set at about 200 CPS.

5.27 The capacitor setting which produces the greatest return loss is equivalent to the shunt capacitance of the cable pair, including the shunt capacitance of bridged tap. Excess balancing capacitance would indicate the presence of unwanted build-out capacitors or bridged tap. Low capacitance might indicate failure to install build-out capacitors.

5.28 The sweep set may be used as an inductance bridge, but it cannot be successfully used to measure inductance in cable pairs. At low frequencies, the series reactance is small compared to the series resistance. At the high end of the voiceband, the series reactance is large, but is masked by the low shunt reactance.

5.29 The set may be used to compare the steady state response of two electrical structures. Balance is achieved when ***both*** the amplitude and phase response (transit time) of the two structures are the same. In testing cable pairs, it is possible to test the pair structure by matching the cable pair against an artificial line. Loading and other irregularities can be detected by this method, because the phase angles (transit times) as well as the impedance magnitudes are balanced.

5.30 The sweep set can be used in the bridge arrangement to test pair balance. Pair balance as used here means the comparison of impedance characteristics of the tip and ring sides of a cable pair. For this test, the pair should have the tip and ring grounded at the distant end. The tip-ground combination is matched against the ring-ground combination. The oscillator should be sweeping. With the tip and ring grounded, the test is sensitive to series irregularities. If the tip and ring are open at the distant end, the test is sensitive to shunt irregularities, such as crossed pairs.

5.31 In the pair balance test, the tip and ring must be balanced in all respects to provide high return loss throughout the voiceband. When an unbalance is detected, it may be desirable to locate it by simulation on an artificial line. Most unbalances are resistive and can be detected by standard tests. The primary feature of the bridge test is that it can be done without sealing current on the pair. Many unbalanced pairs will be detected by noise indications as discussed in Part 6.

6. NOISE INDICATIONS

6.01 Noise indications are sometimes found when sweep testing cable pairs. A steady noise voltage will be indicated by a widening of the trace. Intermittent noise, such as might be caused by dial pulses, will be indicated by intermittent tearing of the trace.

6.02 Steady noise voltages will not appear unless they are far beyond the values accepted as satisfactory. Since the noise indication may be 60-cycle noise or an out-of-band noise voltage, the noise indication may not be an indication that objectionable noise is present.

6.03 Noise can occur on open circuit tests when an exposure exists and there is a noise source at the point of exposure. It may or may not be objectionable when measured in the terminated condition with a properly weighted noise measuring set. The presence of noise on the trace may be due to an unbalance which can be detected by testing the tip and ring to ground, but this condition may not exist with sealing current on the line.

6.04 The best approach to noise investigation is to make tests for unbalance, test to a termination with or without sealing current, and make standard tests with a 3A NMS if the noise indication persists.