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Recommendation G.161

ECHO-SUPPRESSORS SUITABLE FOR CIRCUITS HAVING EITHER SHORT OR LONG PROPAGATION TIMES

1.6 Apparatus associated with long-distance telephone circuits

(See Vol. III of the *Orange Book* , ITU, Geneva, 1977).

Recommendation G.162

CHARACTERISTICS OF COMPANDORS FOR TELEPHONY

(Geneva, 1964; amended at Mar del Plata, 1968)

These characterisics are applicable to compandors of modern design for use either on very long international circuits or on national and international circuits of moderate length.

Some of the clauses given below specify the joint characteristics of a compressor and an expander in the same direction of transmission of a 4-wire circuit. The characteristics specified in this way can be obtained more easily if the compressors and expanders are of similar design; in certain cases close cooperation between Administrations may be necessary.

It should also be noted that the equipement produced so far for circuits of moderate length may be completely satisfactory for those circuits and yet not quite meet the clauses of this Recommendation.

1 Definition and value of the unaffected level

The unaffected level is the absolute level, at a point of zero relative level on the line between the compressor and the expander of a signal at 800 Hz, which remains unchanged whether the circuit is operated with the compressor or not. The unaffected level is defined in this way in order not to impose any particular values of relative level at the input to the compressor or the output of the expander.

The unaffected level should be, in principle, 0 dBm0. Nevertheless, to make allowances for the increase in mean power introduced by the compressor, and to avoid the risk of increasing the intermodulation noise and the overload which might result, the unaffected level may, in some cases, be reduced by perhaps as much as 5 dB. However, this reduction of unaffected level entails a diminution of the improvement in signal-to-noise ratio provided by the compandor. This possible reduction should be made by direct agreement between the Administrations concerned. No reduction is necessary, in general, for systems with less than 60 channels.

Note — The increase in the mean power in the transmitted band determined by the compressor in the telephone channel depends on the value of the unaffected level, the attack and recovery times, the distribution of the speech volumes and the mean power level of transmitted speech. When 0 dBm0 is adopted for the unaffected level, it appears that the effective increase in the mean power level is of the order of 2 or 3 dB.

2 Ratio of compression and expansion

2.1 *Definition and preferred value of the* **ratio of compression**

The ratio compression of a compressor is defined by the formula:

$$\alpha = \frac{n_e - n_{e0}}{n_s - n_{s0}}$$

where:

n_e is the input level;

n_{e0} is the input level corresponding to 0 dBm0;

n_s is the output level;

n_{s0} is the output level corresponding to an input level of n_{e0}.

The preferred value of α is 2, though lower values are permissible, provided sufficient noise improvement is obtained. The value shall not exceed 2.5 for any level of input signal and at any temperature between +10 | (deC and +40 | (deC.

2.2 *Definition and preferred value of the* **ratio of expansion**

The ratio of expansion of an expander is defined by the formula:

$$\beta = \frac{n'_s - n'_{s0}}{n'_e - n'_{e0}}$$

where:

n'_e is the input level;

n'_{e0} is the input level corresponding to 0 dBm0;

n'_s is the output level;

n'_{s0} is the output level corresponding to an input level of n'_{e0}.

The preferred value of β is 2, though lower values are permissible, provided sufficient noise improvement is obtained. The value shall not exceed 2.5 for any level of input signal and at any temperature between +10 | (deC and +40 | (deC.

2.3 *Range of level*

The range of level over which the recommended value of α and β should apply should extend at least:

from +5 to —45 dBm0 at the input of the compressor, and

from +5 to —50 dBm0 at the nominal output of the expander.

2.4 *Variation of compressor gain*

The level at the output of the compressor, measured at 800 Hz, for an input level of 0 dBm0, should not vary from its nominal value by more than ± | .5 dB for a temperature range of +10 | (deC to +40 | (deC and a deviation of the supply voltage of ± | % from its nominal value.

2.5 *Variation of expander gain*

The level at the output of the expander, measured at 800 Hz for an input level of 0 dBm0, should not vary from its nominal value by more than ± | dB for a temperature range of +10 | (deC and +40 | (deC and a deviation of the supply voltage of ± | % from its nominal value.

Note — It is desirable, especially for compandors intended for very long circuits, to set stricter limits than the values of +0.5 dB and ± | dB given under § 2.4 and § 2.5; +0.25 dB and +0.5 dB respectively are preferable.

2.6 *Conditions for stability*

The insertion of a compandor shall not appreciably reduce the margin of stability. To ensure this, for the combination of an expander and a compressor on the same 4-wire circuit and at a given station, the error of the output level of the compressor with respect to any value of expander input level shall not exceed + | .5 dB. This error is referred to the level obtained at the compressor output when the input level is 0 dBm0. This limit shall be observed at all frequencies between 200 and 4000 Hz within the temperature range +10 | (deC to +40 | (deC. No negative limit is specified for the error. In this test an attenuator shall be inserted between the expander and the compressor, the value of which is to be set in accordance with the following Note 1.

Note 1 — This Note concerns the influence of a compandor on the loop gain of a 4-wire circuit and on the margin of stability.

In examining this problem, a connection was considered made up of three 4-wire circuits, *AB* , *BC* and *CD* , which link the terminal stations *A* and *D* (at which the terminating sets are located) through the intermediate stations *B* and *C* . It is assumed that the circuit *BC* is equipped with compandors. It is desired to determine the tolerances for the gain of the combination of expander and compressor at *C* in order to limit the reduction

in the margin of stability caused by their insertion. To facilitate study of this question it is assumed that, in normal use, the expander output and compressor input are points of the same relative level.

The following expression then gives the loss between the output of the expander at *C* and the input of the compressor at *C* :

$$a_s = a_0 + a_r + a_x + a_y$$

where

a_0 is the nominal transmission loss of the chain of circuits between the 2-wire terminals at *A* and *D* ;

a_r is the balance return loss at the terminating set at *D* ;

a_x is the departure of transmission loss of channel *CD* from its nominal value;

a_y is the departure of transmission loss of channel *DC* from its nominal value.

The two latter values may be positive or negative.

It may be concluded that, in order that the measurement of the gain of the combination of an expander and a compressor at the same station may satisfactorily determine the total effect on the margin of stability, the following conditions must be observed:

The expander must be connected to the compressor via an attenuator, the loss of which should cover the entire range of values for a_s which actually occur when there is a risk of instability. To take account of all practical conditions, it would probably be necessary to consider a very wide range.

However, considering only the important example of a terminal compandor and zero balance return loss, then $a_s = a_0$ and this is the value which is generally recommended for the loss of the attenuator between expander and compressor in this test.

Nevertheless, when it is possible to determine the exact values of a_r, a_x and a_y, corresponding to the most probable condition of instability, the exact value of a_s can be specified.

It has been assumed that the expander output and the compressor input are normally points of the same relative level. If this is not the case, and if the relative level at the expander output is a_c dB higher than the relative level at the compressor input, the loss in the attenuator should be increased by a_c (which may be positive or negative).

Note 2 — Cross-connection between the control circuits of the compressor and expander may have advantages from the point of view of circuit echoes; hence, its use should be allowed. On the other hand its use, which has some disadvantages from the point of view of signalling-to-voice break-in, will certainly be confined to exceptional cases. In consequence, there seems no need for any special recommendations on the subject.

2.7 *Tolerances on the output levels of the combination of compressor and expander in the same direction of transmission of a 4-wire circuit*

The compressor and expander are connected in tandem. A loss (or gain) is inserted between the compressor output and expander input equal to the nominal loss (or gain) between these points in the actual circuit in which they will be used. Figure 1/G.162 shows, as a function of level of 800-Hz input signal to the compressor, the permissible limits of difference between expander output level and compressor input level. (Positive values indicate that the

expander output level exceeds the compressor input level.)

figure 1/G.162, p.

The limits shall be observed at all combinations of temperature of compressor and temperature of expander in the range +10 | (deC to +40 | (deC. They shall also be observed when the test is repeated with the loss (or gain) between the compressor and expander increased or decreased by 2 dB.

Note — The change of gain (or loss) of 2 dB mentioned in § 2.7 above is equal to twice the standard deviation of transmission loss recommended as an objective for international circuits routed on single group links in Recommendation G.151, § 3.

3 Impedances and return loss

The nominal value of the input and output impedances of both compressor and expander should be 600 ohms (nonreactive).

The return loss with respect to the nominal impedance of the input and the output of both the compressor and the expander should be no less than 14 dB over the frequency range 300 to 3400 Hz and for any measurement level between +5 and —45 dBm0 at the compressor input or the expander output.

4 Operating characteristics at various frequencies

4.1 *Frequency characteristic with control circuit clamped*

The control circuit is said to be clamped when the control current (or voltage) derived by rectification of the signal is replaced by a constant direct current (or voltage) supplied from an external source. For purposes here, the value of this current (or voltage) should be equal to the value of the control current (or voltage) obtained when the input signal is 0 dBm0 at 800 Hz.

For the compressor and the expander taken separately, the variations of loss or gain with frequency should be contained within the limits of a diagram that can be deduced from Figure 1/G.132 by dividing the tolerance shown by 8, the measurement being made with a constant input level corresponding to a level of 0 dBm0.

These limits should be observed over the temperature range +10 | (deC and +40 | (deC.

4.2 *Frequency characteristic with control circuit operating normally*

The limits given in § 4.1 should be observed for the compressor when the control circuit is operating normally, the measurement being made with a constant input level corresponding to a level of 0 dBm0.

For the expander, under the same conditions of measurement, the limits can be deduced from Figure 1/G.132 by dividing the tolerances shown by 4.

These limits should be observed over the temperature range +10 **|** (deC to +40 **|** (deC.

5 Nonlinear distortion

5.1 *Harmonic distortion*

Harmonic distortion, measured with an 800-Hz sine wave at a level of 0 dBm0, should not exceed 4% for the compressor and the expander taken separately.

Note — Even in an ideal compressor, high output peaks will occur when the signal level is suddenly raised. The most severe case seems to be that of voice-frequency signalling, although the effect can also occur during speech. It may be desirable, in exceptional cases, to fit the compressor with an amplitude limiter to avoid disturbance due to transients during voice-frequency signalling.

5.2 *Intermodulation tests*

It is necessary to add a measurement of intermodulation to the measurements of harmonic distortion whenever compandors are intended for international circuits (regardless of the signalling system used), as well as in all cases where they are provided for national circuits over which multi-frequency signalling, or data transmission using similar types of signals, is envisaged.

The intermodulation products of concern to the operation of multi-frequency telephone signalling receivers are those of the third order, of type $(2f_1 - f_2)$ and $(2f_2 - f_1)$, where f_1 and f_2 are two signalling frequencies.

Two signals at frequencies 900 Hz and 1020 Hz are recommended for these tests.

Two test conditions should be considered: the first, where each of the signals at f_1 and f_2 is at a level of —5 dBm0 and the second, where they are each at a level of —15 dBm0. These levels are to be understood to be at the input to the compressor or at the output of the expander (uncompressed levels).

The limits for the intermodulation products are defined as the difference between the level of either of the signals at frequencies f_1 or f_2 and the level of either of the intermodulation products at frequencies $(2f_1 - f_2)$ or $(2f_2 - f_1)$.

A value for this difference which seems adequate for the requirements of multi-frequency telephone signalling (including end-to-end signalling over three circuits in tandem, each equipped with a compandor) is 26 dB for the compressor and the expander separately.

Note 1 — These values seem suitable for Signalling System No. 5, which will be used on some long international circuits.

Note 2 — It is inadvisable to make measurements on a compressor plus expander in tandem, because the individual intermodulation levels of the compressor and of the expander might be quite high, although much less intermodulation is given in tandem measurements since the characteristics of compressor and expander may be closely complementary. The compensation encountered in tandem measurements on compressor and expander may not be encountered in practice, either because there may be phase distortion in the line or because the compressor and expander at the two ends of the line may be less closely complementary than the compressor and expander measured in tandem.

Hence the measurements have to be performed separately for the compressor and the expander. The two signals at frequencies f_1 and f_2 must be applied simultaneously, and the levels at the output of the compressor or expander measured selectively.

6 Noise voltages

The effective value of the sum of all noise voltages referred to a zero relative level point, the input and the output being terminated with resistances of 600 ohms, shall be less than or equal to the following values:

— at the output of the compressor: (10 | mV unweighted —38 dBm0)

(7 | mV weighted —41 dBm0p)

— at the output of the expander: (0.5 mV weighted —84 dBm0p)

It is not considered useful to specify a value of unweighted noise voltage for the expander.

7 Transient response

The overall transient response of the combination of a compressor and expander which are to be used in the same direction of transmission of a 4-wire circuit fitted with compandors shall be checked as follows:

The compressor and expander are connected in tandem, the appropriate loss (or gain) being inserted between them as in § 2.7.

A 12-dB step signal at a frequency of 2000 Hz is applied to the input of the compressor, the actual values being a change from —16 to —4 dBm0 for attack, and from —4 to —16 dBm0 for recovery. The envelope of the expander output is observed. The overshoot (positive or negative), after an upward 12-dB step expressed as a percentage of the final steady-state voltage, is a measure of the overall transient distortion of the compressor-expander combination for attack. The overshoot (positive or negative) after a downward 12 dB step, expressed as a percentage of the final steady-state voltage is a measure of the overall transient distortion of the compressor-expander combination for recovery. For both these quantities the permissible limits shall be ± | 0%. These limits shall be observed for the same conditions of temperature and of variation of loss (or gain) between compressor and expander as for the test in § 2.7.

In addition, the attack and recovery times of the compressor alone shall be measured as follows:

Using the same 12-dB steps as above for attack and recovery respectively, the attack time is defined as the time between the instant when the sudden change is applied and the instant when the output voltage envelope reaches a value equal to 1.5 times its steady-state value. The recovery time is defined as the time between the instant when the sudden change is applied and the instant when the output voltage envelope reaches a value equal to 0.75 times its steady-state value.

The permissible limits shall be not greater than:

— 5 ms for attack,

— 22.5 ms for recovery.

The following additional test shall be used to check the effect of the compandor on certain signalling systems which may be sensitive to envelope distortion immediately following the sudden application of a sinusoidal signal.

The overall transient response of the combination of a compressor and expander which are to be used in the same direction of transmission on a 4-wire circuit is measured with an ‘‘infinite’’ upward input step, i.e. with a signal applied after a period with no input.

The level of the signal to be applied is —5 dBm0.

Provided the measurement is effected with an interval of at least 50 ms between the pulses, the limits shown by an unbroken line in Figure 2/G.162 should be observed for the overshoot of the final voltage V_1; in most cases an attempt should be made if possible to observe the narrower limits, indicated in the figure by a broken line.

These limits shall be observed for the same conditions of temperature loss (or gain) between compressor and expander as for the tests with 12-dB steps.

Note 1 — The tests of transient distortion described involve the measurement of the overshoot or undershoot of the envelope of the applied sinusoidal signal. It may happen that, due to small unbalances in the variable loss device, very-low-frequency components of the control current appear at the output. These are not a modulation of the signal frequency, but they produce an unsymmetrical waveform and render it difficult to determine the overshoot or undershoot of the envelope. While it is undesirable that these low-frequency components should be so large as to increase significantly the risk of overload of the line equipment, they are of no importance for speech transmission and will not affect tuned signalling receivers. However, it is desirable to consider whether these components may affect the guard circuits of some signalling receivers. If so, it may be necessary to specify a maximum value for these components and to include an appropriate test in this Recommendation.

Figure 2/G.162 p. 2

To simplify the measurement of the true envelope amplitude in the presence of these unbalance components, it is admissible and convenient to insert at the input to the measuring oscillograph a high-pass filter having a cut-off frequency of about 300 Hz. However, a filter which is effective in removing unbalance components may itself introduce additional transient distortion in the signal envelope. To avoid this difficulty, the following method of calculation may be adopted which does not require a filter.

If at any instant the amplitude of the envelope in a positive direction is $+E_1$, and in the negative direction is $-E_2$ then the two-envelope amplitude is given by

[Formula Deleted]

$$\left[(+E_1) - (-E_2) \right] \equiv$$

[Formula Deleted]

$$\left[\left| fIE_1 \right| \,|\,|\, \left| f\,\mathrm{IE}_2 \right| \right]$$

and the unbalance component is given by

[Formula Deleted]

$$\left[(+E_1) + (-E_2) \right] \equiv$$

[Formula Deleted]

$$\left[\left| fIE_1 \right| \,|\,(\mathrm{em}\,|\, \left| f\,\mathrm{IE}_2 \right| \right]$$

This method is not only simple and free of the transient distortion problem which occurs with a filter, but it also provides direct information on the unbalance which, as indicated above, may be important.

Note 2 — The time constants of the expander control circuit should in principle be equal to those of the compressor control circuit so as to avoid any overshoot (positive or negative) in the transient response.

Note 3 — If an Administration prefers to use a direct method of measuring expander attack and recovery times, the following might be adopted:

To define the attack and recovery times of the expander, a sudden change in level from —8 to —2 dBm0 should be applied to its input for measurement of the attack time, and from —2 to —8 dBm0 for measurement of the recovery time. The attack time is represented by the time between the moment when the abrupt variation is applied and the moment when the output voltage reaches a value *x* times its final value. The recovery time is represented by the time between the moment when the abrupt variation is applied and the moment when output voltage reaches a value *y* times its final value. The times thus measured should lie between the same limits as those shown for the compressor. Bearing in mind detailed differences in the construction of the various compandors now in use, specific figures for *x* and *y* cannot be given. Hence, each Administation will have to determine the correct values of *x* and *y* for the type of compandor concerned.

For an ideal expander, 0.57 and 1.51 are valid for *x* and *y* ; by way of example, the Italian Administation has found 0.65 for *x* and 1.35 for *y* for a certain type of construction.

Some Administrations have said that it might be preferable to specify fixed values of *x* and *y* , for all types of expander, leaving Administrations free to choose the limit values for attack and recovery times according to the different types of expander. Values of 0.75 and 1.5 are proposed for *x* and *y* in this method of measurement.

Note 4 — The ‘‘infinite’’ step transient response measurements refer to a compressor-expander combination connected in tandem; moreover, several Administrations have investigated the possibility of meeting the limits shown in the Figure 2/G.162, even for a chain of three compandors in tandem, by bringing also the channel modulating and demodulating equipment into the connection. This modem equipment may cause an undesirable transient phenomenon in the step at the expander output; this phenomenon, and the intermodulation of the third order associated with it, may influence the multi-frequency signalling.

Recommendation G.163

CALL CONCENTRATING SYSTEMS

(Mar del Plata, 1968)

1 Characteristics

The characteristics of the TASI system which is now in operation on submarine cable systems are given in references [1] and [2].

The characterisitics of the CELTIC system are given in reference [3].

ATIC (Time Assignment with Sample Interpolation) is a time assignment system for pulse code transmission. A description of the basic function is given in reference [4] and another article on its statistical efficiency is quoted in reference [5].

Note — The use of these concentrating systems involves various restrictions; for example, they may call for a special signalling system and they increase system loading (see the Recommendation cited in [6]).

2 Possibility of interconnection

To ensure satisfactory speech quality when call concentrating systems of the TASI type are operated in tandem, it is necessary that each concentrator introduce only a very small speech impairment at the peak of the busy hour. The present TASI concentrators were designed with the objective that the average speech lost during the peak of the busy hour will be approximately 0.5%. In addition, the interpolation process in TASI is designed so that there is a very small probability that the amount of speech lost in any speech spurt will be greater than the length of an average syllable (about 250 ms). Subjective tests [7] have been made on individual working TASI systems and the results, obtained by interviewing customers, show that the impairment due to a properly loaded and maintained TASI is essentially undetectable by the customer. No such tests have been carried out on call concentration systems in tandem.

Because of the subjective problems involved, estimates made of the speech impairment that would result from tandem call concentration systems must be qualitative without subjective tests. The probability of excessive clipping, even in a system of three concentrators in tandem with each having the same busy hour, can be kept to a satisfactory level by arranging the system so that the impairment introduced by each concentrator is small, as in the case of the present TASI system. If the tandem concentrators are located in different time zones or in areas with different peak traffic hours, the lighter loaded concentrators will cause negligible additional impairment.

Assuming that present and future concentrators will be operated and designed so as to meet the criterion of very small speech impairment during the peak of the busy hour, it is recommended that no restrictions be imposed on tandem operation of concentrators at this time. In addition, it is recommended that no test on tandem operation should be made until tandem operation of concentrators is a reality. At such time, tests could be made under working conditions to determine the effects of tandem concentrators on speech and to establish whether any adjustment of the ratio of number of simultaneous calls to the number of channels would be required to keep speech clipping to a negligible amount.

The estimated probability that the forward-transfer pulse for the CCITT No. 5 Signalling System will be clipped for a certain length of time in one, two, and three TASIs in tandem can be found in [8].

References

[1] FRASER (J. | .), BULLOCK (D. | .) and LONG (N. | .): Overall characteristics of a TASI system, *Bell System Technical Journal* , Vol. XLI, No. 4, July 1962.

[2] MIDEMA (H.) and SCHACHTMAN (M. | .): TASI quality-effect of speech detectors and interpolation, *B.S.T.J.* , *ibid* .

[3] DAYONNET (F. | .), JOUSSET (A.) and PROFIT (A.): Le CELTIC: Concentrateur exploitant les temps d'inactivit´e des circuits, *L'Onde Electrique* , Vol. XLII, No. 426, pp. 675-687, September 1962.

[4] LYGHOUNIS (E.): Il sistema A.T.I.C., *Telecommunicazioni* , No. 26, pp. 21-29, March 1968.

[5] BONATTI (M.) and MOTOLESE (F.): Probabilit`a di attivit`a delle giunzioni di un doppio fascio telefonico, *Telecommunicazioni* , No. 23, pp. 24-28, June 1967.

[6] CCITT Recommendation *FDM carrier systems for submarine cable* , Vol. III, Fascicle III.2, Rec. G.371, § 3.

[7] HELDER (G. | .): Customer evaluation of telephone circuits with delay, *B.S.T.J.* , Vol. XLV, No. 7, September 1966.

[8] *TASI characteristics affecting signalling* , Green Book, Vol. VI.4, Supplement No. 2, ITU, Geneva, 1973.

Recommendation G.164

ECHO SUPPRESSORS

(Geneva, 1980; amended at Malaga-Torremolinos, 1984 and at Melbourne, 1988)

1 General

1.1 *Application*

This Recommendation is applicable to the design of echo suppressors used on international telephone connections which have:

1.1.1 mean one-way propagation times between subscribers of up to the maximum regarded as acceptable in Recommendation G.114. (The design of the echo suppressor should not impose any lower limit of delay on its use);

1.1.2 a level of circuit noise entering the send-in port ($S_{i\dn}$) or receive-in port ($R_{i\dn}$) of up to —40 dBm0p;

1.1.3 round trip end delays between the receive-out port ($R_{o\du\dt}$) and $S_{i\dn}$port of the echo suppressor of up to 24 ms (including all transmission and switching plant).

Note — Recommendation G.161 [1] refers to 25 ms. The value of 24 ms, a multiple of 2, is used in this Recommendation as being more applicable to the design of digital echo suppressors;

1.1.4 a loss of the echo path in dB (see the Recommendation cited in [2] that is likely to be such that the minimum loss from $R_{\mathrm{o\backslash du\backslash dt}}$ to $S_{\mathrm{i\backslash dn}}$ of the echo suppressor will be equal to the difference between relative levels at these two ports plus 6 dB.

Echo suppressors must be designed to perform in a satisfactory manner under all the conditions described above.

1.2 *Design features*

Echo suppressors conforming to the characteristics given in this Recommendation are terminal, half-echo suppressors having differential operation and a break-in algorithm which incorporates a partial break-in state transmission paths, the logic functions and the speech processing (suppression and receive loss) use analogue or digital techniques. The combinations of these which are most likely to be practicable and to which this Recommendation is particularly addressed are shown in Figures 1/G.164, 2/G.164, 3/G.164 and 4/G.164 as Types A, B, C and D. All the requirements of this Recommendation apply equally to Types A, B, C and D except where noted.

Figure 1/G.164, p.

Figure 2/G.164, p.

Figure 3/G.164, p.

Figure 4/G.164, p.

1.3 *Variants*

1.3.1 Recommendation G.161 [1] is still applicable for the design of analogue echo suppressors. Analogue echo suppressors must conform to either Recommendation G.164 in its entirety or Recommendation G.161 [1] in its entirety.

1.3.2 This Recommendation is applicable to echo suppressors that employ fixed differential sensitivity , see § 3, and those that employ adaptive differential sensitivity , see § 4.

1.4 *Compatibility*

It is necessary for all echo control devices used on international connections to be compatible with each other. Echo suppressors designed according to this Recommendation will be compatible with each other, with echo suppressors conforming to Recommendation G.161 [1] and with echo cancellers designed to Recommendation G.165. Compatibility is defined as follows:

Given:

1) that a particular type of echo control device (say Type I) has been designed so that satisfactory performance is achieved when any practical connection is equipped with a pair of such devices, and

2) that another particular type of echo control device (say Type II) has been likewise designed;

then Type II is said to be compatible with Type I if it is possible to replace an echo control device of one type with one of the other type, without degrading the performance of the connection to an unsatisfactory level.

In this sense compatibility does not imply that the same test apparatus or methods can necessarily be used to test both Type I and Type II echo control devices.

1.5 *Need for test methods*

Objective test methods are very important to permit measurement of essential operating characteristics of echo suppressors. Suitable test methods are therefore given in § 6 of this Recommendation. Echo suppressors must operate properly in response to speech signals. Because of the difficulty of defining a speech test signal, the following tests are type tests and rely on the use of sine wave signals for convenience and repeatability. These tests should be performed on echo suppressors only after the design has been shown to properly operate on speech input signals.

1.6 *Enabling/disabling*

Each echo suppressor should be equipped with:

a) a facility which provides for enabling or disabling by an externally derived ground (earth) from the trunk circuit. The enabler should function to permit or prevent normal echo suppressor operation. Certain Type C echo suppressors may be disabled directly by a digital signal.

Some digital data signals may require type C echo suppressors to provide 64 kbit/s bit sequence integrity in the externally disabled state.

b) a tone disabler which functions to prevent the introduction of the suppression and receive loss when specified disabling tone signals are transmitted through the suppressors. Thus it should disable for specified tones but should not disable on speech. (See § 5.)

1.7 *Explanatory notes*

1.7.1 When an echo suppressor is in its suppression mode, it places a large loss in the return path which, besides suppressing echo, prevents the speech of the second party of the conversation from reaching the first party when both parties are talking simultaneously (termed ‘‘double-talking’’). To reduce this effect (called ‘‘chopping’’) during double-talking, the echo suppressor must be able to operate in a second mode when both parties are talking simultaneously. The terminology usually used is that the second party must be able to ‘‘break-in’’ or remove suppression when the second party interrupts during an utterance by the first party.

1.7.2 The result of break-in is to transform the circuit from one permitting speech in one direction to one permitting speech on both directions simultaneously, and a necessary consequence of this action is to permit echo to return unsuppressed. To reduce the amount of echo returned during break-in, loss is inserted in the receive path. This, of course, attenuates the received speech. If the break-in action is adjusted to minimize the echo, the speech of one or both double-talking parties will still be chopped to some extent as the control of the echo suppressor transfers from one party to the other. The basic requirements in the design of an echo suppressor are therefore two:

1) to provide adequate suppression of echo when speech from one talker only is present;

2) to provide ease and unobtrusiveness of break-in during double-talking.

The second requirement involves two mutually exclusive functions:

a) avoidance of chopping of double-talking speech;

b) elimination of echo during and after double-talking.

1.7.3 A differential circuit is used to detect the condition when break-in should take place. The level of the speech in the send path is compared with the level of the speech in the receive path to determine whether the send speech is the echo of the first party, or speech of the second party. Echo is reduced in level by the echo path loss and is delayed by twice the propagation time between the echo suppressor and the points of reflection. (The round trip delay in the echo path is called ‘‘ end-delay in the design of the differential circuit.

1.7.4 Echo suppressors with fixed differential sensitivity are designed such that if speech in the send path is below the level of the expected echo (considering the minimum echo path loss), suppression will not be removed. If speech in the send path is above the level of the expected echo, break-in will occur and the suppression will be removed.

1.7.5 Echo suppressors with adaptive differential sensitivity are designed to adapt to the actual echo path loss on the connection (which is usually substantially higher than the minimum value, see Recommendation G.122, § 2). Speech in the send path is thus more often above the level of the expected echo, and break-in occurs more easily. The adaptation time is typically less than one second and adaptation is stopped or slowed down during double-talking. The adaptive function reduces the degradation in the send path due to speech chopping

1.7.6 Break-in hangover is used to minimize chopping of double-talking speech protection against false break-in due to echo or to impulse noise:

a) The state of partial break-in is entered initially. This state is characterized by short break-in hangover times. The receive loss may or may not be inserted but, if used, must have an equally short break-in hangover time

b) After the signal conditions producing break-in have persisted for some time, the full break-in state is entered. Receive loss must be inserted and longer break-in hangover times applied.

2 Definitions relating to echo suppressors

2.1 echo suppressor

F: suppresseur d’´echo

S: supresor de eco

A voice-operated device placed in the 4-wire portion of a circuit and used for inserting loss in the transmission path to suppress echo. The path in which the device operates may be an individual circuit path or a path carrying a multiplexed signal.

2.2 full echo suppressor

F: suppresseur d’´echo complet

S: supresor de eco completo

An echo suppressor in which the speech signals on either path control the suppression loss in the other path.

2.3 half-echo suppressor

F: demi-suppresseur d‘´echo

S: semisupresor de eco

An echo suppressor in which the speech signals of one path control the suppression loss in the other path but in which this action is not reciprocal.

2.4 **differential echo suppressor**

F: suppresseur d’´echo diff´erentiel

S: supresor de eco diferencial

An echo suppressor whose operation is controlled by the difference in level between the signals on the two speech paths.

2.5 **partial break-in echo suppressor**

F: suppresseur d‘´echo à intervention partielle

S: supresor de eco con intervenci´on parcial

An echo suppressor which includes partial and full break-in functions.

2.6 **adaptive break-in echo suppressor**

F: suppresseur d’´echo à intervention adaptable

S: supresor de eco con intervenci´on adaptativa

An echo suppressor in which the break-in differential sensitivity is automatically adjusted according to the attenuation of the echo path.

2.7 **suppression loss**

F: affaiblissement de blocage

S: atenuaci´on para la supresi´on

The specified minimum loss which an echo suppressor introduces into the send path (of the echo suppressor) to reduce the effect of echo currents.

2.8 **receive loss**

F: affaiblissement à la r´eception

S: atenuaci´on en la recepci´on

The specified loss which an echo suppressor introduces into the receive path (of the echo suppressor) to reduce the effect of echo currents during break-in.

2.9 **terminal echo suppressor** (see Figure 5/G.164)

F: suppresseur d’´echo terminal

S: supresor de eco terminal

An echo suppressor designed for operation at one or both terminals of a circuit.

Figure 5/G.164, p. 7

2.10 **suppression operate time**

F: temps de fonctionnement pour le blocage

S: tiempo de funcionamiento para la supresi´on

The time interval between the instant when defined test signals, applied to the send- and/or receive-in ports, are altered in a defined manner and the instant when the suppression loss is introduced into the send path of the echo suppressor.

2.11 **suppression hangover time**

F: temps de maintien pour le blocage

S: tiempo de bloqueo para la supresi´on

The time interval between the instant when defined test signals applied to the send- and/or receive-in ports are altered in a defined manner, and the instant when the suppression loss is removed from the send path.

2.12 **partial break-in**

F: intervention partielle

S: intervenci´on parcial

A temporary condition of break-in which exists at the onset of break-in. This state is characterized by a short break-in hangover time. The receive loss may be inserted during partial break-in provided it also has the short break-in hangover time.

2.13 **partial break-in operate time**

F: temps de fonctionnement pour l'intervention partielle

S: tiempo de funcionamiento para la intervenci´on parcial

The time interval between the instant when defined test signals, applied to the send- and/or receive-in ports, are altered in a defined manner such as to remove suppression and the instant when suppression is removed. Insertion of loss in the receive path may occur at the same time or slightly after removal of suppression.

2.14 **full break-in**

F: intervention totale

S: intervenci´on total

A stable condition of break-in which follows the partial break-in condition once it has been determined, with high probability, that the signal causing break-in is speech. This state is characterized by the insertion of receive loss and longer break-in hangover times.

2.15 **full break-in operate time**

F: temps de fonctionnement pour l'intervention totale

S: *tiempo de funcionamiento para la intervenci´on total*

The time interval between the instant when defined test signals, applied to the send- and/or receive-in ports, are altered in a defined manner such as to remove suppression and extend the hangover time and the instant when the extended hangover time is applied. Removal of suppression occurs at the same time as for partial break-in. Insertion of loss in the receive path may occur at the same time or slightly after removal of suppression.

2.16 **break-in hangover time**

F: *temps de maintien pour l'intervention*

S: *tiempo de bloqueo para la intervenci´on*

The time interval between the instant when defined test signals, applied to the send- and/or receive-in ports, are altered in a defined manner such as to restore suppression and the instant when suppression is restored. The hangover time for removal of loss in the receive path may be longer than that for restoration of suppression.

2.17 **differential sensitivity**

F: sensibilit´e diff´erentielle

S: sensibilidad diferencial

The difference, in dB, between the relative level of the test signals applied to the send path and receive path when break-in occurs.

3 Characteristics of echo suppressors with fixed break-in differential sensitivity

3.1 *Transmission performance*

The performance characteristics apply, unless otherwise noted, when steady state signals are separately applied to the send and receive paths.

The limits on transmission characteristics specified below shall be observed over the temperature range +10 **|** (deC to 40 **|** (deC and over the power supply variations permitted by individual Administrations.

Echo suppressors of Types A, B and D are placed in the voice-frequency portion of a 4-wire circuit which is nominally of 600-ohms impedance. The send (transmit or office-to-line) and the receive (line-to-office) paths are at different relative levels in different national networks; two such sets of levels are:

1) send, —16 dBr; receive, +7 dBr;

2) send, —4 dBr; receive, +4 dBr.

Test tone frequencies are 800 Hz or 1000 Hz, nominal. To avoid submultiples of the 8000-Hz sampling frequency, test tone frequencies should fall within the ranges 804 to 860 Hz and 1004 to 1020 Hz respectively.

3.1.1 *Type A and B echo suppressors*

3.1.1.1 *Insertion loss*

The insertion loss at 800 Hz (or 1000 Hz) of an echo suppressor in an unoperated condition shall be 0 ± 0.3 dB, for test tone levels < **|** dBm0.

3.1.1.2 *Attenuation distortion*

The attenuation distortion shall be such that if Q dB is the loss at 800 Hz (or 1000 Hz), the loss shall be within the range (Q + 0.3) dB to (Q — 0.2) dB at any frequency in the band 300-3400 Hz, and at 200 Hz within the range of (Q + 1.0) dB to (Q — 0.2) dB.

3.1.1.3 *Delay distortion*

The delay distortion shall not exceed 30 µs measured between any two frequencies in the band 1000-2400 Hz and 60 µs in the band 500-3000 Hz.

3.1.1.4 *Impedance*

The values of impedance and return loss shall apply to all states of operation of the echo suppressors.

1) The nominal value of the inputs and outputs shall be 600 ohms (nonreactive).

2) The return loss with respect to the nominal impedance shall not be less than 20 dB from 300-600 Hz nor less than 25 dB from 600-3400 Hz.

3) The impedance unbalance to earth of each port shall not be less than 50 dB over the frequency range 300 to 3400 Hz.

3.1.1.5 *Overload*

The insertion loss at 800 Hz (or 1000 Hz) shall not increase by more than 0.2 dB for test tone levels from 0 to +5.0 dBm0.

3.1.1.6 *Harmonic distortion*

The total harmonic distortion power, for a pure 800 Hz (or 1000 Hz) sine wave at a level of 0 dBm0, shall not exceed —34 dBm0.

3.1.1.7 *Intermodulation*

For frequencies f_1 = 900 Hz and f_2 = 1020 Hz applied simultaneously each at a level of —5 dBm0, the difference between the output levels of either frequency f_1 or f_2 and the level of either of the intermodulation products at $(2 f_1 — f_2)$ or $(2 f_2 — f_1)$ should be at least 45 dB. When speech compressors are used to provide loss during break-in, this requirement is reduced during the break-in mode to 26 dB for the receive path (W-state receive path).

3.1.1.8 *Transient response*

If loss devices which are inserted in the receive path operate at a syllabic rate, the transient performance of such devices should conform to Recommendation G.162 which deals with the overall transient response of compandors.

3.1.1.9 *Noise*

The mean weighted psophometric power introduced by an echo suppressor shall not exceed —70 dBm0p. The mean unweighted noise power in a band of 300-3400 Hz introduced by an echo suppressor shall not exceed —50 dBm0.

3.1.1.10 *Crosstalk*

When an echo suppressor is installed in a working circuit, the crosstalk attenuation between the send path and the receive path (and conversely) shall be such that the signal power in the disturbed path due to crosstalk from the disturbing path shall not exceed —65 dBm0 for any sinusoidal signal in the disturbing path having a power of +5 dBm0 or less and within the band 300-3400 Hz.

3.1.1.11 *Spurious outputs produced by the echo suppressor*

The various operations of the echo suppressor must not result in any appreciable spurious outputs such as internally generated impulses due to transient conditions. In particular these must not be of such magnitude as would be likely to falsely operate the suppression or break-in feature of any other echo suppressor that might be in the connection. Consideration must include that of multilink connections having several pairs of echo suppressors in tandem.

To prevent false operation of other echo suppressors in a built-up connection, the zero-to-peak voltage of any transient output produced in the receive or transmit paths (terminated in 600 ohms) due to echo suppressor operation caused by signals in the opposite path should not exceed 20 mV at a point of zero relative level (—34 dBV0) after first filtering the transient to a 500 to 3000 Hz bandwidth. Additionally, the duration of any such transient should be such that it is not audible in the presence of normal levels of noise (e.g. —50 dBm0p).

3.1.2 *Type C echo suppressor*

3.1.2.1 *General*

An echo suppressor of Type C inserted into a digital transmission path between codecs meeting the performance characteristics of Recommendation G.712 [3] should not alter such performance.

3.1.2.2 *Group delay*

The group delay through the echo suppressor shall not exceed 0.25 ms.

3.1.2.3 *Effect of digital loss pads*

Digital loss pads inserted into the receive path during the break-in mode may increase the quantizing distortion. Type C echo suppressors, which maintain signalling bit integrity for channel associated signalling for systems in accordance with Recommendation G.733 [4] by bypassing the least significant bit, are likely to exhibit a greater increase in quantizing distortion during the break-in mode than Type C echo suppressors used in systems with common channel signalling. See Footnote c) to Table 1/G.164.

3.1.2.4 *Effect of instantaneous digital compressors*

When an instantaneous compressor is employed in the receive path of the suppressor during break-in, it shall not produce distortion exceeding the following limits:

a) *Harmonic distortion*

With a sinusoidal input signal of 0 dBm0 at any frequency between 300 Hz and 1 KHz, the third harmonic distortion produced should not exceed —30 dBm0.

b) *Intermodulation distortion*

With an input signal of two equal amplitude sinusoids at f_1 = 900 and f_2 = 1020 Hz at levels of —3 to —35 dBm0, the distortion products at ($2f_1 - f_2$) and ($2f_2 - f_1$) should not exceed a level of —16 dB relative to the output level of each tone. For input levels below —35 dBm0 this ratio should be at least —20 dB.

3.1.3 *Type D echo suppressors*

3.1.3.1 *General*

The performance characteristics of Recommendation G.712 [3] apply for the codecs.

3.1.3.2 *Group delay*

The group delay shall not exceed that of the codecs alone by more than 0.25 ms.

3.1.3.3 *Effect of digital loss pads*

Digital loss pads inserted into the receive path during the break-in mode may increase the quantization distortion over the limits specified in Recommendation G.712 [3]. See Footnote c) to Table 1/G.164.

3.1.3.4 *Effect of instantaneous digital compressors*

See § 3.1.2.4.

3.2 *Characteristics with steady-state input signals applied independently to the send and receive paths*

3.2.1 The action of an echo suppressor with fixed differential sensitivity which incorporates the general features described in § 1 is explained below with the aid of the idealized operational diagram shown in Figure 6/G.164. The significant combinations of input signals are represented by the areas X, Y, Z, W and V.

3.2.2 The area X corresponds to the absence of any appreciable signal on either the send or the receive path. The area Y corresponds to the presence of signals only on the send path. The area Z represents those combinations of signal levels for which the echo suppressor should provide suppression in the send path. The area W corresponds to break-in when the suppression should be absent. The area V corresponds to hysteresis that is provided to ensure that the break-in condition is retained when the signal on the send path has fallen slightly below the minimum level at which break-in would be initiated; the area V therefore represents a bistable condition. Table 1/G.164 shows the losses that should be inserted in the two paths, when each of the five areas X, Y, Z, W and V is occupied continuously. The right hand column of the table refers to tests described in § 6. Figure 7/G.164 shows the boundaries for the receiving loss *C* , that should be inserted in the receive path during break-in. The information given in Figures 6/G.164 and 7/G.164 and in Table 1/G.164 applies for steady-state signals with the inter-area boundaries being crossed very slowly.

Figure 6/G.164, p. 8

H.T. [T1.164]

TABLE 1/G.164

Key to operational diagram Figure 6/G.164

Area	Loss in send path (dB)	Loss in receive path (dB)	Test No.
X	0	0	1
Y	0	b) 0 b)	2
W	0	{	
Within limits for *C* shown in Figure 7/G.164 c)			
}	2		
Z	50 minimum a)	0	1
V	{		
As W, if entered from W			
As Z, if entered from Z			
}			

[a] When echo suppressors are used on low noise circuits, suppression of the far end noise may be objectionable due to noise contrast. Two administrations have shown that this impairment may be reduced by the insertion of noise, equivalent to far end noise, during suppression.

[b] When the loss in the receive path is provided by a speech compressor, the loss should be zero for receive signals | (em36 dBm0.

[c] Information given in Supplement No. 21 at the end of this fascicle indicates that for A-law encoded telephone signals, the additional quantizing distortion due to a fixed digital loss pad is minimum for a loss value of 6 dB. For high level receive signals this will also apply to loss values which are an integer multiple of 6 dB. For μ-law encoded telephone signals the additional quantizing distortion is practically independent of the digital loss pad value.

Tableau 1/G.164 [T1.164], p. 9

Figure 7/G.164, p. 10

3.2.3 The features shown in Figure 6/G.164 are concerned only with characteristics that can be determined without knowledge of, or access to, the internal circuits of echo suppressors. These characteristics are determined by application of test signals to the external terminals of the echo suppressor and observation of its state by external measurements. Test methods for measurements to verify compliance with the requirements are given in § 6.

3.2.4 The signal levels that define the various thresholds are given in Table 2/G.164.

3.2.4.1 The nominal suppression threshold is —31 dBm0 when there is essentially no speech in the send path. The release from suppression is also nominally —31 dBm0 but can be as much as 3 dB below the suppression threshold. When signals above the threshold exist in both the send and receive paths, the intent of the requirement is that the echo suppressor be in the suppress (Z) state if $L_R \geq$" L_S, should transfer to the break-in (W) state for $L_S \geq$" L_R and should revert to the suppression state for $L_R \geq$" $L_S + C$. Tolerances are provided to account for filter, power supply and temperature variations.

3.2.4.2 The frequency response limits of the suppression control path are given in Figure 8/G.164. The frequency response limits of the break-in control paths are given in Figure 9/G.164. It is desirable to provide such filtering in echo suppressors. However, this is difficult to implement in the case of Types C and D. Therefore, for these types, this filtering may be omitted where Administrations can ensure that any interfering signals are at such a low level that they do not adversely affect echo suppressor operation. Tests 1 and 3 of § 6 can be used to measure the frequency responses.

H.T. [T2.164]

TABLE 2/G.164

Inter-area threshold levels

Boundary At 1000 Hz (see Note 1) dBm0 at 20 ± 5 | (deC } At 1000 Hz (see Note 1) dBm0 between 10 and 40 | (deC }	Symbol of threshold { Variation with frequency	{ Test No.
Suppression X to Z —33 | fIT xz | (em29 for *L* S | | (em40 } *T* ‘xz | | fIT xz | (+- | } Z to X *T* zx max. *T* zx min. } *T* xz — 0 dB *T* xz — 3 dB } *T* ‘xz — 0 dB *T* ‘xz — 3 dB }	*T* xz { { { { Figure 8/G.164	{ 1 1
Break-in V to W (previous input Z) *L* R | (em 3 | (= | fIL S *L* R (see Notes 3, 4, 5 and 6) (—26.5 | (= | fIL R | (= | 3) } *T* ‘vw | | fIT vw | (+- | .5 dB between 500 and 3000 Hz (see Note 2) }	*T* vw { 3	{
V to Z (previous input W) *T* vz max. *T* vz min. }	{ {	

T vw — *C* + 2 dB (see Notes 3, 4 and 5) *T* vw — *C* — 3 dB (—26.5 | (= | fIL R | (= | 3) } *T* ‘vz | | fIT vz | (+- | .5 dB between 500 and 3000 Hz (see Note 2) } 3 *L* S Level (dBm0) at send- in port. *L* R Level (dBm0) at receive- in port. *C* }	{ {				

Le loss inserted in the receiving path during break-in. This characteristic must comform with the limits shown in Figu re 7/G.164.

Note 1 — The test frequency is 1004 to 1020 Hz to avoid submultiples of the 8000 Hz sampling frequency.

Note 2 — Tolerances in the attenuation/frequency characteristics of the two filters of the break-in detector must be taken into account, but it is desirable that the break-in threshold should be as independent of frequency as possible; a tolerance of ± | .5 dB should apply if *L* S and *L* R are varied together over the frequency range 500-3000 Hz.

Note 3 — This excludes tolerances due to codecs (± | .5 dB in Recommendation G.712 [3]).

Note 4 — The *T* vw and *T* vz tolerance limits may occasionally be exceeded by up to 1 dB in the range —26.5 | fIL R | 3 dBm0 due to quantizing effects. This can, in theory, cause false retention of break-in when using steady state test signals (see test 8). This does not occur for speech signals.

Note 5 — The limiting values of the *T* vw and *T* vz thresholds combined with small values of echo path loss and small values of *C* can, in theory, cause oscillation between suppression and break-in for tests using low-level steady state signals. This has not been observed on existing echo suppressors and does not occur for speech signals.

Note 6 — The fixed *T* vw threshold, symbolizing differential sensitivity having a nominal value of 0 dB, ensures against false break-in due to echo for a minimum echo path loss of 6 dB (see § 1.1.4).

Tableau 2/G.164 [T2.164], p. 11

Figure 8/G.164, p. 12

Figure 9/G.164, p. 13

k19 3.3 *Dynamic characteristics when signals are applied, removed or changed in the send and receive paths independently*

3.3.1 The dynamic characteristics can be specified by stating the time that elapses when the conditions of the signals pass from a point in one area to one in another before the state appropriate to the second area is established (Figure 6/G.164 and Figure 12/G.164). When passing from X to Z, this is termed the suppression operate time and when passing in the opposite direction it is termed suppression hangover time. When passing from the Z area through V to W (or Y) it is termed the break-in operate time and when passing from W through V to Z it is termed the break-in hangover time. The V/W and V/Z boundaries may, in practice, be crossed at any angle; the requirements in Table 3/G.164 deal with vertical and horizontal directions.

3.3.2 The suppression (X/Z) operate time should be nearly constant for the sudden application of any signal in the receive path greater than the threshold (—31 dBm0) in the absence of any appreciable signal in the send path. Similarly, for transitions from suppression to break-in for L_R constant (Z/V/W), the operate times shown in Table 3/G.164 should in general apply to the complete range of possible signal pairs (L_R and L_S) and not just to the two pairs shown in Table 3/G.164.

3.3.3 The hangover times shown in Table 4/G.164 should in general apply whenever suppression or break-in has occurred irrespective of the levels of the causative signals.

3.3.4 When sudden changes are made in the levels of sinusoidal test signals at a frequency of 1000 Hz, the times of operation given in Table 3/G.164 apply and the recommended values of hangover given in Table 4/G.164 apply. The right-hand part of each table refers to tests described in § 6.

3.3.5 The operate times of the receive pad in the Y/W transition is not separately stated or tested, but should be within the limits allowed for the suppression operate time.

3.4 *Performance under conditions of small echo-path loss and when end-delay may be present*

The foregoing requirements apply when the echo suppressor is tested under conditions such that the signals in the send and receive paths are independent. In practice, satisfactory performance must also be maintained when the send path is connected to the receive path through an echo path that may have end-delay and low loss. Three features of the dynamic performance must be checked under these conditions. § 6 describes test arrangements suitable for measuring these conditions. The three conditions are described as follows:

3.4.1 An echo (leakage through the echo path) must not cause false operation of the break-in condition when the echo-path loss is low and the end-delay is zero. The trouble could be caused by inappropriate design of the control path time constants. When a signal is suddenly applied to $R_{i\backslash dn}$, this trouble would show itself as a temporary false operation of the break-in condition, persisting for the duration of the break-in hangover time (see Test No. 7).

3.4.2 If insufficient protection against end-delay is incorporated in the echo suppressor, the break-in circuit may operate on the trailing edge of the echo. This can occur with the sudden removal of a signal at $R_{i\backslash dn}$ when the echo-path loss is low and the end-delay is large (see Test No. 7).

3.4.3 In certain designs it can happen that the hysteresis represented by the bistable area V (see Figure 6/G.164) is excessive in relation to the amount of loss inserted in the receive path. This can result in the false retention of break-in by echo occurring under the following conditions: A steady-state signal is present at $R_{i\backslash dn}$ port and is coupled to $S_{i\backslash dn}$ port via the echo path. A signal of sufficient amplitude and duration to cause break-in is then applied to $S_{i\backslash dn}$ port. Upon cessation of this signal, the echo of the receive signal falsely maintains the break-in condition (see Test No. 8).

H.T. [T3.164]

lw(48p) | lw(24p) sw(30p) | lw(24p) sw(30p) | lw(36p) | lw(18p) | lw(36p) | lw(42p) | lw(42p) , ^ | l | l | l | l | ^ | ^ | ^ | ^ | ^ .
cw(48p) | cw(24p) sw(30p) | cw(24p) sw(30p) | cw(36p) | cw(18p) | cw(36p) | cw(42p) | cw(42p) , ^ | c | c | c | c | ^ | ^ | ^ | ^ | ^ . Boundary Initial signals (see Note) Final signals (see Note) Recommended value (ms) Test No. { Excursion (see Figure 12/G.164)
} Test circuit (Figure number) { Oscilloscope trace (Figure number)
} Send *L* S (dBm0) { Receive *L* R (dBm0)
} Send *L* S (dBm0) Receive *L* R (dBm0) _ lw(48p) | cw(24p) | cw(30p) | cw(24p) | cw(30p) | lw(36p) | cw(18p) | cw(36p) | cw(42p) | cw(42p) . Suppression X/Z —40 —40 —40 —40 —40 —40 —25 —11 2 4 a > b a > d 14/G.164 15/G.164 _ lw(48p) | cw(24p) | cw(30p) | cw(24p) | cw(30p) | lw(36p) | cw(18p) | cw(36p) | cw(42p) | cw(42p) .
{ Break-in Z/V/W *L* S constant
} —15 —15 —15 —10 — 5 0 —15 —15 —15 —25 —25 —25 24-36 5 h > i g > i f > i 14/G.164 16/G.164 _ lw(48p) | cw(24p) | cw(30p) | cw(24p) | cw(30p) | lw(36p) | cw(18p) | cw(36p) | cw(42p) | cw(42p) .
{ Break-in Z/V/W *L* R constant
} —40 —40 —25 —15 —19 — 9 —25 —15 { Partial: 2 Full: 6-10
} 6 b > k c > j 17/G.164 17/G.164

Note — See also § 3.3.2.

H.T. [T4.164]

lw(48p) | lw(24p) sw(30p) | lw(24p) sw(30p) | lw(36p) | lw(18p) | lw(36p) | lw(42p) | lw(42p) , ^ | l | l | l | l | ^ | ^ | ^ | ^ | ^ .
cw(48p) | cw(24p) sw(30p) | cw(24p) sw(30p) | cw(36p) |
cw(18p) | cw(36p) | cw(42p) | cw(42p) , ^ | c | c | c | c | ^ | ^ | ^ | ^ | ^ . Boundary Initial signals Final signals Recommended value (ms) Test No. { Excursion (see Figure 12/G.164)
} Test circuit (Figure number) { Oscilloscope trace (Figure number)
} Send *L* S (dBm0) Receive *L* R (dBm0) Send *L* S (dBm0) { Receive

L R(dBm0)
} _ lw(48p) | cw(24p) | cw(30p) | cw(24p) | cw(30p) | lw(36p) | cw(18p) | cw(36p) | cw(42p) | cw(42p) . Suppression Z/X —40 —40 —25 —11 —40 —40 —40 —40 24-36 4 b > a d > a 14/G.164 15/G.164 _ lw(48p) | cw(24p) | cw(30p) | cw(24p) | cw(30p) | lw(36p) | cw(18p) | cw(36p) | cw(42p) | cw(42p) .
{ Break-in W/V/Z *L* R constant
} —19 — 9 —25 —15 —40 —40 —25 —15 { Partial: 26 Full: 48-66
} 6 k > b j > c 17/G.164 18/G.164 _

Tableau 4/G.164 à l'italienne [T4.164], p. 15

4 Characteristics of echo-suppressor with adaptive break-in differential sensitivity

4.1 *Provisions of § 3*

The provisions of § 3 apply to echo suppressors with adaptive break-in differential sensitivity when $a_x = 0$ (see below). Tests 1 through 8 (see § 6) must be performed and the requirements in Tables 1/G.164 and 2/G.164 apply only when $a_x = 0$.

4.2 *Characteristics of the adaptive function with signals applied independently to the send and receive paths*

4.2.1 The action of the adaptive function is explained below with the aid of the idealized operational diagram shown in Figure 10/G.164.

Figure 10/G.164, p.

4.2.2 The adaptive function automatically adjusts the differential sensitivity to the echo path loss. The adaptation characteristic a_x is used to describe this change in sensitivity, and the T vw threshold (see Table 2/G.164) becomes the T $v_i w_i$ threshold given by

$$L_R - a_x - 3\, L_S$$
$$L_R - a_x,$$

a_x is such that, for echo path losses of 6 dB, it equals 0 and the equation reduces to:

$$L_R - 3\, L_S\, L_R$$

as given in Table 2/G.164.

4.2.3 When the echo suppressor is in the suppression mode (area Z_i, Figure 10/G.164) the adaptive function will cause rapid convergence of a_x to the value of the echo path loss a_E minus 6 dB, i.e.:

$$a_x = L_R - L_S - 6 \text{ dB.}$$

a_x may be quantized with up to approximately 3 dB steps. In this case the value of a_x after convergence shall be:

$$a_E - 9 \; a_x \; a_E$$
$$- 6$$

except that $a_x \geq$" 0. This equation shall hold for a_E at least up to 26 dB i.e. for $a_{xm\backslash da\backslash dx} \geq$" 20 dB (see Table 5/G.164). The rate of convergence is given in Table 6/G.164.

H.T. [T5.164]

TABLE 5/G.164

Loss value of

a

after convergence

in Z↓i state

{ Echo path loss, *a* (dB) }	*a* (dB)
|	*0*
7	*0 to 1*
8	*0 to 2*
9	*0 to 3*
10	*1 to 4*
x	{
x	
-9 to *x*	
-6	
}	
26	17 to 20
{	
a	
x max + |	
}	{
a	
x max —3 to *a*	
x max	
}	
{	
a	
x max + |	
}	{
a	
x max —2 to *a*	
x max	
}	
{	
a	
x max + |	
}	{
a	
x max —1 to *a*	
x max	
}	
{	
≥"*a*	
x max + |	

} a x max }	{

Table 5/G.164 [T5.164], p.

H.T. [T6.164]

TABLE 6/G.164

Rate of change of adaptation characteristic

a

{ Operational states (see Figure 10/G.164) } Variations of adaptation characteristic a }	{ Rate of change	Test No.	
Z i *Adapting to the echo return loss (increasing or decreasing)* *(a a — 6 dB)* *}*	*{* *> | dB/s (See Note 1)*	*10 b)*	
Y	*Storing the last value*	*—*	*—*
{			
X *Clearing the last value (a 0 dB)* *}*	*{* *> | dB/s*	*10 c)*	
V i *As Z i, if entered from Z i* *As W i, if entered from W i* *}*	*{*		

Note 1 — Rates of adaptation on speech for *a x* of approximately 10 dB/s have been shown to be subjectively acceptable.

Note 2 — If *a x* is decreased in the W A i region, the rate of change should not exceed the rate of adaptation for *a x* in the Z i region.

Table 6/G.164 [T6.164] p.

4.2.4 The break-in mode of the echo suppressor (area W_i) is divided into two sub-areas W and $W_{A\backslash di}$.

4.2.4.1 In the W area the last value of a_x should be stored.

4.2.4.2 In the $W_{A\backslash di}$ area two different strategies are possible. The first is to store the last value of a_x. The second is to permit a_x to decrease toward zero. The rate of change of a_x should preferably be slower than the rate of adaptation (see Table 6/G.164, Note 2). Experience has shown that these two strategies perform very similarly when the echo suppressor is operating on speech rather than test sine waves.

4.2.5 When no speech is present (X area), a_x should decrease to zero (see Table 6/G.164).

4.2.6 Tests 9 and 10 in § 6, may be used to measure the dynamic characteristics of the adaptive function.

5 Characteristics of echo-suppressor tone disablers

5.1 *General*

Each echo suppressor should be equipped with a tone disabler which functions to prevent the introduction of the suppression and receive loss when data or other specified tone signals are transmitted through the suppressor. Thus it should disable for specified tones but should not disable on speech. The tone disabler should detect and respond to a disabling signal which may be present in the send or receive path.

5.2 *Disabling characteristics* | see Figure 11/G.164)

The disabling tone transmitted is 2100 Hz ± 15 Hz at a level of —12 ± 6 dBm0. The frequency of the tone applied to the disabler is 2100 Hz ± 21 Hz (see Recommendation V.21 [5]). The disabling channel bandwidth should be chosen wide enough to encompass this tone (and possibly other disabling tones used within national networks). At the same time, the

disabling channel bandwidth should be such that, in conjunction with guard action and timing, adequate protection is provided against false operation of the disabler by speech signals. The disabling channel sensitivity (threshold level) should be such that the disabler will operate on the lowest expected power of the disabling tone. The band characteristics shown in Figure 11/G.164 will permit disabling by the 2100-Hz disabling tone as well as others used in North America. The figure indicates that in the frequency band 2079 Hz to 2121 Hz disabling *must* be possible whilst in the band 1900 Hz to 2350 Hz it *may* be possible.

Providing that only the recommended 2100-Hz disabling tone is used internationally, interference with signalling equipment will be avoided. Unintentional disabling of the echo suppressor by signalling tones is not considered detrimental, since the echo suppressor serves no needed functions during the time when signalling tones are present on the circuit.

Figure 11/G.164 p.

5.3 *Guard band characteristics*

Energy in the voice band, excluding the disabling band , must be used to oppose disabling so that speech will not falsely operate the tone disabler. The guard band should be wide enough and with a sensitivity such that the speech energy outside the disabling band is utilized.

The sensitivity and shape of the guard band must not be such that the maximum idle or busy circuit noise will prevent disabling. In the requirement, white noise is used to simulate speech and circuit noise. Thus, the requirement follows:

Given that white noise (in a band of approximately 300-3400 Hz) is applied to the tone disabler simultaneously with a 2100-Hz signal, the 2100-Hz signal is applied at a level 3 dB above the midband disabler threshold level. The white noise energy level required to inhibit disabling should be no greater than the level of the 2100-Hz signal and no less than a level 5 dB below the level of the 2100-Hz signal. As the level of the 2100-Hz signal is increased over the range of levels to 30 dB above the midband disabler threshold level, the white noise energy level required to inhibit disabling should always be less than the 2100-Hz signal level.

5.4 *Holding-band characteristics*

The tone disabler, after disabling, should hold in the disabled state for tones in a range of frequencies. The bandwidth of the holding mode should encompass all present or possible future data frequencies. The release sensitivity should be sufficient to maintain disabling for the lowest level data signals expected, but should be such that the disabler will release for the maximum idle or busy circuit noise. Thus the requirement follows:

The tone disabler should hold in the disabled mode for any single-frequency sinusoid in the band from 390-700 Hz having a level of —27 dBm0 or greater, and from 700-3000 Hz having a level of —31 dBm0 or greater. The tone disabler should release for any signal in the band from 200-3400 Hz having a level of —36 dBm0 or less.

5.5 *Operate time*

The operate time must be sufficiently long to provide talk-off protection, but less than the CCITT recommended limit of 400 ms. Thus the requirement is that the tone disabler operate within 300 ± 100 ms after receipt of the sustained disabling signal having a level in the range between a value 3 dB above the midband disabler threshold level and a value of 0 dBm0.

5.6 *False operation due to speech currents*

It is desirable that the tone disabler should rarely operate falsely on speech. To this end, a reasonable objective is that, for an echo suppressor installed on a working circuit, usual speech currents should not on the average cause more than 10 false operations during 100 hours of speech. In addition to the talk-off protection supplied by the disabling channel bandwidth, by guard band operation and by the operate time, talk-off protection can be supplied by recycling. That is, if speech which simulates the disabling signal is interrupted because of inter-syllabic periods, before disabling has taken place the operate timing mechanism should reset. However, momentary absence or change of level in a true disabling signal should not reset the timing.

5.7 *Release time*

The disabler should not release for signal drop-outs less than the CCITT recommended value of 100 ms. To cause a minimum of impairment upon accidental speech disabling, it should release within 250 ± 150 ms after a signal in the holding band falls at least 3 dB below the maximum holding sensitivity.

6 Test arrangements to measure essential operating characteristics of echo suppressors

6.1 *General considerations*

6.1.1 An echo suppressor with sinusoidal signals applied to its $S_{i\backslash dn}$ and $R_{i\backslash dn}$ ports will assume one of a number of states depending on the relative levels of the two signals. Any given combination of levels of the two input signals may be represented by a point on a typical operational diagram (see, for example, Figure 12/G.164). Each area on this diagram corresponds (under steady conditions) to a particular state identified by the losses in the two speech paths and the internal organization of its logic.

Figure 12/G.164 p.

6.1.2 The tests described here assume the use of analogue test signals. In the case of Type C echo suppressors, codecs meeting Recommendation G.712 [3] will be required to interface the suppressor to the analogue test equipment. When tests are performed on Types C and D echo suppressors, due account must be made for the added propagation delays due to the codecs when measuring operate times by the observation of output signals. Further, in level measurements due account must be made for codec tolerances. Frequencies which are submultiples of the sampling frequency may give misleading results and should be avoided in these tests. Note that if external filtering is required to meet the requirements of § 3.2.4.2, it should be included when these tests are performed.

6.1.3 The *static* characteristics of an echo suppressor are specified by stating the inter-area boundaries and the losses in the two speech paths when signals pass slowly from one area to another.

The *dynamic* characteristics of both echo suppressors with fixed and adaptive differential sensitivity are specified by stating the time that elapses when a signal passes suddenly from a point in one area to one in a second area before the state appropriate to the second area is established.

All characteristics unique to echo suppressors with adaptive differential sensitivity are dynamically tested.

The various tests described in § 6 are summarized in Table 7/G.164.

H.T. [T7.164]
TABLE 7/G.164
Recommended tests for echo suppressors

Test Type of echo suppressor: N: non-adaptive, A: adaptive }	Characteristic measured	Block diagram (Figure)	Oscilloscope trace (Figure)	{
1 Suppression threshold and loss }	{ 13/G.164	—	N, A	
2 Y/W threshold and receive loss }	{ 13/G.164	—	N, A	
3 Break-in differential sensitivity }	{ 13/G.164	—	N, A	
4 Suppression operate and hangover times }	{ 14/G.164	15/G.164	N, A	
5 Break-in *L* S constant }	{ 14/G.164	16/G.164	N, A	
6 Partial and full break-in *L* R constant }	{ 17/G.164	18/G.164	N, A	
7	False break-in protection	19/G.164	—	N, A
8	Test for excessive hysteresis	20/G.164	21/G.164	N, A
9 Adaptive break-in differential sensitivity }	{ 22/G.164	23/G.164	A	
Rate of decrease of *a in the W A i state }* *10* *Rate of increase of a in the Z i state }* *Rate of clearing of a in the X state }*	a) *22/G.164* *b)* *25/G.164* *c)* *27/G.164*	{ *24/G.164* *{* *26/G.164* *{* *28/G.164*	*A*	

Table 7/G.164 [T7.164], p.

6.1.4 The descriptions of the test circuits presented here are given so as to indicate a possible method for the application of the appropriate test signals. Other techniques for producing these signals (for example, the use of separate sine wave generators for send and receive) may be employed. Although the test frequency is nominally 1000 Hz, a frequency in the range of 1004-1020 Hz should be chosen to avoid a submultiple of the sampling frequency.

6.2 *Measurement of static characteristics*

The static characteristics measured are losses in the send and receive paths and the inter-area threshold levels (Tables 1/G.164 and 2/G.164). The equipment required is:

— one oscillator with 600-ohm balanced output impedance;

— two 600-ohm balanced attenuators;

— one 600-ohm mixing pad;

— two level-measuring sets with 600-ohm balanced input impedance.

The diagram of connections is shown in Figure 13/G.164.

Figure 13/G.164, p.

6.2.1 *Test No. 1 — Suppression threshold and loss*

1) Set the oscillator to 1000 Hz (for tolerances, see § 6.1.4).

2) Adjust *A* and *B* so that $L_S = L_R =$ —40 dBm0.

3) Note that no loss is inserted in the send and receive paths. Requirement: See Table 1/G.164 (X area).

4) Increase L_R until suppression occurs and note the value of L_R and the suppression loss. Requirement: —33 (L_R = *T* xz) —29 dBm0 (see Table 2/G.164).

5) Decrease L_R until suppression releases and note the value of L_R. Requirement: *T* xz —3 L_R *T* xz (see Table 2/G.164).

6) Set the oscillator to appropriate frequencies to check for conformity within the bounds shown in Figure 8/G.164 and repeat steps 2 to 5.

6.2.2 *Test No. 2 — Y/W threshold and receive loss in break-in state*

1) Set the oscillator to 1000 Hz (for tolerances, see § 6.1.4).

2) Adjust *A* so that L_S= +3 dBm0.

3) Adjust *B* so that L_R varies over the range —40 dBm0 $L_R L_S$. Operation within the boundaries of Figure 7/G.164 is observed by monitoring $L_{R\backslash di\backslash dn}$ — $L_{R\backslash do\backslash du\backslash dt}$ which equals loss *C* . Y/W threshold occurs where *C* > 0 dB.

Note — Record values of *C* as a function of L_R for use in Test No. 3, step 5.

6.2.3 *Test No. 3 — Break-in differential sensitivity*

1) Set the oscillator to 1000 Hz (for tolerances, see § 6.1.4).

2) Adjust *A* so that L_S = —40 dBm0.

3) Adjust B so that L_R = —26.5 dBm0.

4) Increase L_S until suppression is removed and loss is inserted in the receive path. Note the value of L_S. Requirement: see T vw, Table 2/G.164.

5) Decrease L_S until suppression is inserted and loss is removed from the receive path. Note the value of L_S. Requirement: see *T* vz, Table 2/G.164.

6) Increase L_R in appropriate steps up to +3 dBm0 and repeat steps 4 and 5.

7) Set the oscillator to appropriate frequencies to check for the conformity within the bounds shown in Figure 9/G.164 and repeat steps 2 to 6.

6.3 *Measurement of dynamic characteristics when L applied independently*

The dynamic characteristics measured are the suppression and break-in operate and hangover times (Tables 3/G.164 and 4/G.164). The equipment required is:

— one oscillator with 600-ohm balanced output impedance, set to 1000 Hz;

— three 600-ohm balanced attenuators;

— three 600-ohm mixing pads;

— two tone-burst generators, the ON and OFF periods of which must be independently variable from zero to at least 200 ms each, and which are capable of being held manually in either state. The input and output impedance in both states must be 600 ohms. One tone-burst generator is driven by the other and has 100 ms delay such that it turns ON 100 ms after the other turns ON;

— two 600-ohm terminating resistors;

— one dual beam oscilloscope, preferably with long persistence screen.

Note — If the ON or OFF periods of the tone pulses are not stated then the value of 200 ms for either should be assumed. Refer to Tables 3/G.164 and 4/G.164 for appropriate performance requirements for Test Nos. 4, 5 and 6.

6.3.1 *Tests in which L*

6.3.1.1 *Test No. 4 — Suppression operate and hangover times*

1) Adjust attenuators P, Q and R shown in Figure 14/G.164 to produce the L_R and L_S values of Tables 3/G.164 and 4/G.164.

2) Read times as shown in Figure 15/G.164.

Figure 14/G.164, p.

Figure 15/G.164, p.

6.3.1.2 *Test No. 5 — Break-in operate time, L*

In this test, L_R is decreased while a constant L_S is maintained, and a break-in operate time is measured. Since break-in hangover with L_S constant is difficult to measure (due to the difficulty of ensuring a return to the Z state), it is not possible to distinguish between partial and full break-in. This is not considered to be important for break-in with L_S constant.

1) Adjust attenuators P, Q and R shown in Figure 14/G.164 to produce the L_R and the L_S values of Table 3/G.164.

2) Read times as shown in Figure 16/G.164.

Figure 16/G.164, p.

6.3.2 *Test in which L*

6.3.2.1 *Test No. 6 — Partial and full break-in operate and hangover times, L*

The equipment required is the same as for Test Nos. 4 and 5, set up according to Figure 17/G.164. In this test L_R is kept constant, L_S is increased, and the partial and full break-in operate and hangover times are measured. To test for partial and full break-in, the duration of time L_S is in the ON state must be varied.

1) Set oscillator to 1000 Hz (for tolerances, see § 6.1.4).

2) Adjust attenuator P of Figure 17/G.164 to produce L_R = —25 dBm0.

3) Adjust attenuators Q and R of Figure 17/G.164 to produce L_S = —40 dBm0 in the OFF state and L_S = —19 dBm0 in the ON state.

4) Starting with a 0 ms duration ON state for L_S, increase the duration of the ON state until partial break-in occurs. Partial break-in is characterized by the short operate and hangover times given in Tables 3 and 4/G.164. Note the oscilloscope traces in a) of Figure 18/G.164 for the definitions of the times.

5) Continue to increase the duration of L_SON until full break-in, characterized by the extended operate and hangover times of Tables 3/G.164 and 4/G.164 occurs. Note the oscilloscope traces in b) of Figure 18/G.164 for the definitions of the times.

6) Repeat steps 3 to 5 for other pairs of levels given in Tables 3/G.164 and 4/G.164. Note that for all values of L_R > —26.5 dBm0 and $L_S$increasing from below threshold to a value > L_R, partial and full break-in should occur.

Figure 17/G.164, p.

Figure 18/G.164, p.

6.4 *Measurement of echo-suppressor operation when the* $S_{i\backslash dn}$ *is connected to R* $_{o\backslash du}$ *may include delay as well as loss*

In this test, the echo suppressor is checked for false break-in on returning echo.

6.4.1 *Test No. 7 — False operation of break-in*

The diagram of connections is shown in Figure 19/G.164, and the equipment required is:

— one oscillator with 600-ohm balanced output impedance;

— three 600-ohm balanced attenuators;

— one 600-ohm terminating resistor;

— two 600-ohm mixing pads;

— one tone-burst generator;

— one audio-frequency delay device variable in the range 0-24 ms;

— one dual beam oscilloscope.

1) Set oscillator to 1000 Hz, and delay element to zero delay (for tolerances, see § 6.1.4).

2) Adjust X so that the total loss of echo path (a -t -b) is equal to the difference in test levels on the send and receive path, plus 6 dB.

3) Adjust Y so that the OFF signal is —26 dBm0.

4) Adjust Z so that the ON signal is —20 dBm0.

5) While the pulsed signal is applied to $R_{i\backslash dn}$, check for absence of signal on Trace 2 of the oscilloscope, indicating correct operation.

6) Reduce X until false break-in occurs, and note that the decrease in echo path loss is not less than 2 dB.

7) Repeat steps 4, 5 and 6 with signals at $R_{i\backslash dn}$of —10 and 0 dBm0 when the pulse generator is ON.

8) Repeat steps 2, 4 and 7 with signals at $R_{i\backslash dn}$of —40 dBm0 when the pulse generator is OFF.

9) Repeat steps 2 to 8 with the delay set to 24 ms.

Note that false break-in should not occur for *any* | pulsed pair of signal levels at $R_{i\backslash dn}$with the delay set at up to 24 ms, and the echo path loss 6 dB or greater.

Figure 19/G.164, p.

6.4.2 *Test No. 8 — False retention of break-in due to provision of excessive hysteresis*

The diagram of connections is shown in Figure 20/G.164 and the equipment required is:

— one oscillator with 600-ohm balanced output impedance;

— three 600-ohm balanced attenuators;

— two 600-ohm mixing pads;

— one 600-ohm terminating resistor;

— one tone-burst generator;

— one amplifier (used as buffer);

— one dual beam oscilloscope.

1) Set the oscillator to 1000 Hz (for tolerances, see § 6.1.4).

2) Adjust Q so that the path loss between $R_{\mathrm{o\backslash du\backslash dt}}$ and $S_{\mathrm{i\backslash dn}}$ is equal to the difference in test levels at these points plus 6 dB.

3) Adjust R so that L_R = —28 dBm0.

4) Adjust P so that $L_S = (L_R + 3)$ dBm0.

5) Check that the signal on trace 2 of the oscilloscope is proper (see Figure 21/G.164) denoting non-occurrence of false retention of break-in.

6) Repeat steps 3 to 5 for values of L_R of —16 and 0 dBm0.

Figure 20/G.164 p.

Figure 21/G.164 p.

6.5 *Measurements of the specific dynamic characteristics of adaptive break-in echo suppressors*

6.5.1 *Test No. 9 — Adaptive break-in differential sensitivity*

The connection diagram is shown in Figure 22/G.164 and the equipment required is:

— one oscillator with 600-ohm balanced impedance;

— three 600-ohm balanced attenuators;

— one 600-ohm terminating resistor;

— two 600-ohm mixing pads;

— two tone-burst generators with period variable up to 10;

— one inverter;

— one amplifier (used for buffer);

— one dual beam oscilloscope.

1) Set the oscillator to 1000 Hz (for tolerances, see § 6.1.4);

2) Adjust *R* | so tha L_{R}= 0 dBm0;

3) Adjust *Q* | so that the attenuation between $R_{o\backslash du\backslash dt}$ and $S_{i\backslash dn}$ is equal to the difference in test levels at these points plus 6 dB (a_E= 6 dB);

4) With *P* | initially set to at least 55 dB, reduce *P* | to increase L_{S} until suppression is removed. On trace 2 of the oscillo-scope (see Figure 23/G.164) verify that *T* v$_i$w$_i$satisfies L_{R} — a_E + 3 < L_{S} < L_{R} — a_E + 6;

5) Repeat steps 2 to 4 for L_{R}= —8 dBm0;

6) Repeat steps 2 to 4 for L_{R}= —15 dBm0;

7) Repeat steps 2 to 6 for a_E= 15 dB;

8) Repeat steps 2 to 5 for a_E= 24 dB;

9) Repeat steps 2 to 4 for a_E= 26 dB;

Explanation: Test No. 9 checks that the minimum range of a_x is at least 20 dB ($a_{xm\backslash da\backslash dx}$> 20 dB).

Figure 22/G.164, p.

 t port through an echo path that

Figure 23/G.164, p.

6.5.2 *Test No. 10 — Measurement of rates of change for* a_x

6.5.2.1 *Measurement of the rate of decrease of a W* $_A$

The connection diagram (Figure 22/G.164) and the required equipment are the same as in Test No. 9.

1) Set the oscillator to 1000 Hz (for tolerances, see § 6.1.4.)

2) Adjust *R* | so that L_R = 0 dBm0

3) Adjust *Q* | so that a_E = 20 dB [after convergence in state Z_i, a_x must be equal to 14 dB nominally ($a_{x\backslash dC}$)]

4) Using *P* , increase L_S until suppression is removed and loss *C* | inserted in the receive path (see Figure 7/G.164). Check that *T* v$_i$w$_i$ satisfies —17 L_S —14 (dBm0)

5) Repeat step 4 to obtain traces of Figure 24/G.164. When break-in elapses (end of T_2) before end of t_2, the echo suppressor makes a_x decrease in the W$_{A\backslash di}$ area. Then measure T_2.

6) The end of break-in occurs when a_x has decreased to threshold level $a_{x\backslash dE}$ where

$$L_R — C — L_S — 3 \;\; a_{x\backslash dE}$$
$$L_R — C — L_S.$$

Check that the theoretical decreasing speed of a_x in the $W_{A\backslash di}$ state is approximately given by:

$$V = \frac{f\,Ia \quad xC \quad — a \quad xE}{f\,IT \quad 2} \quad \text{dB/s}$$

where $a_{x\backslash dC} = 14$ dB.

Figure 24/G.164, p.

6.5.2.2 *Measurement of the rate of increase of a_i state (see Figure 25/G.164 and Figure 26/G.164), Test No. 10* |

The connection diagram is shown Figure 25/G.164 and the equipment required is:

— one oscillator with 600-ohm balanced impedance;

— three 600-ohm balanced attenuators;

— two 600-ohm mixing pads;

— one 600-ohm terminating resistor;

— two tone-burst generators with period variable up to 10 s;

— one inverter;

— one amplifier (used as a buffer);

— one audio-frequency delay device with 500 ms delay;

— one dual beam oscilloscope.

1) Set the oscillator to 1000 Hz (for tolerances, see § 6.1.4);

2) Adjust *R* | so that L_R= 0 dBm0;

3) Adjust *Q* | so that a_E= 20 dB;

4) Adjust *P* | so that L_S= —12 dBm0;

5) Adjust the tone ‘‘ON’’ and ‘‘OFF’’ periods of $P_0$to 3.5 s;

6) Check that t_1 and t_2 are respectively equal to 3.5 and 0.5 s;

7) Check that break-in occurs on trace 2 of the oscilloscope (see Figure 26/G.164).

Figure 25/G.164, p.

Figure 26/G.164, p.

6.5.2.3 *Measurement of the rate of clearing of a (see Figures 27/G.164 and Figure 28/G.165), Test No. 10* |

The diagram of connection is shown in Figure 27/G.164 and the equipment required is the same as for Test No. 10 | .

1) Set the oscillator to 1000 Hz (for tolerances, see § 6.1.4);

2) Adjust Q | so that a_E= 20 dB;

3) Adjust R | so that L_R= 0 dBm0;

4) Adjust P | so that L_S= —12 dBm0;

5) Adjust the tone ''ON'' and ''OFF'' periods of P_0 to 3.5 s;

6) Check that t_1 and t_2 are respectively equal to 3.5 and 0.5 s;

7) Check that break-in does not occur on trace 2 of the oscilloscope.

Figure 27/G.164, p.

Figure 28/G.164, p.

References

[1] CCITT Recommendation *Echo suppressors suitable for circuits having either short or long propagation times* , Orange Book, Vol. III, Rec. G.161, ITU, Geneva, 1977.

[2] CCITT Recommendation *Influence of national networks on stability and echo in international connections* , Orange Book, Vol. III, Rec. G.122, Part B, b), ITU, Geneva, 1977.

[3] CCITT Recommendation *Performance characteristics of PCM channels between 4-wire interfaces at voice frequencies* , Vol. III, Rec. G.712.

[4] CCITT Recommendation *Characteristics of primary PCM multiplex equipment operating at 1544 kbit/s* , Vol. III, Rec. G.733.

[5] CCITT Recommendation *300-baud modem standardized for use in the general switched telephone network* , Vol. VIII, Rec. V.21.

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