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APPARATUS ASSOCIATED WITH LONG - DISTANCE TELEPHONE CIRCUITS AND OTHER TERMINAL EQUIPMENTS

ECHO SUPPRESSORS

ITU-T Recommendation G.164

(Extract from the *Blue Book*)

NOTES

1 ITU-T Recommendation G.164 was published in Fascicle III.1 of the *Blue Book*. This file is an extract from the *Blue Book*. While the presentation and layout of the text might be slightly different from the *Blue Book* version, the contents of the file are identical to the *Blue Book* version and copyright conditions remain unchanged (see below).

2 In this Recommendation, the expression “Administration” is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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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_{in}) or receive-in port (R_{in}) of up to -40 dBm0p;

1.1.3 round trip end delays between the receive-out port (R_{out}) and S_{in} port of the echo suppressor of up to 24 ms (including all transmission and switching plant).

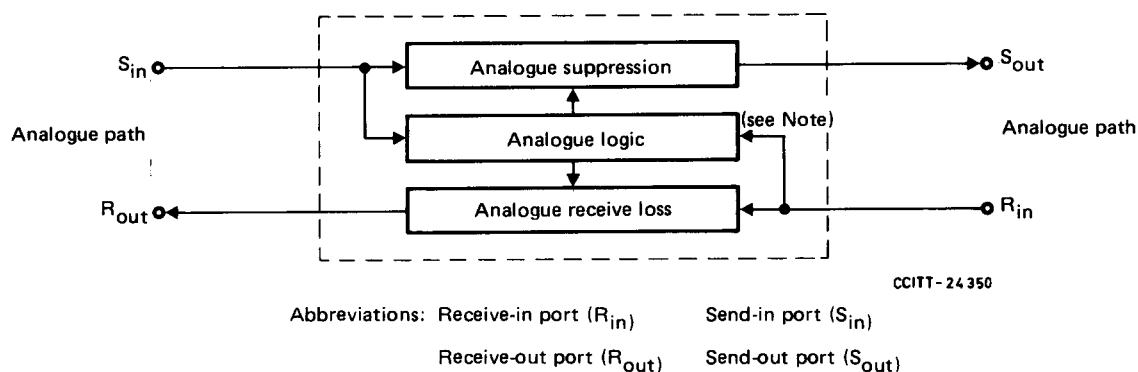
Note - Recommendation G.161 [1] refers to 25 ms. The value of 24 ms, a multiple of 2, is used in this Recommendation as being more applicable to the design of digital echo suppressors;

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_{out} to S_{in} 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

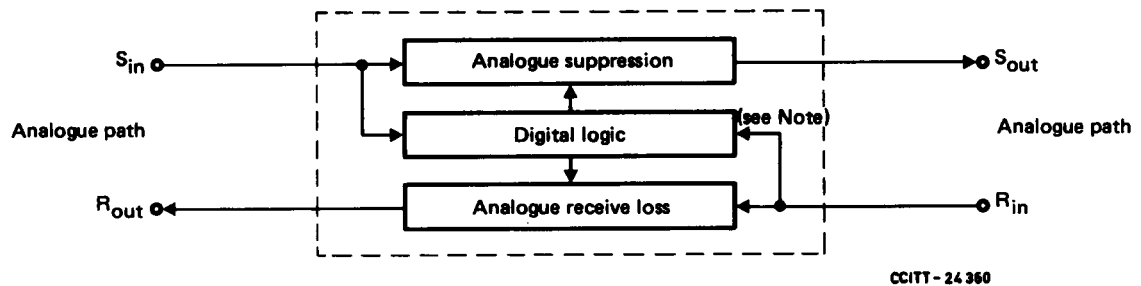
Echo suppressors conforming to the characteristics given in this Recommendation are terminal, half-echo suppressors having differential operation and a break-in algorithm which incorporates a partial break-in state. They may be further characterized by whether the transmission paths, the logic functions 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.



Note – This input may be connected to either side of the receive loss, depending on the logic circuitry.

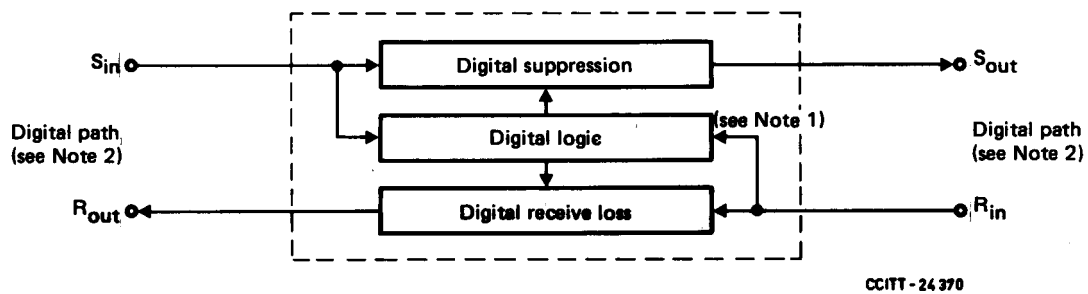
FIGURE 1/G.164

Type A echo suppressor



Note - This input may be connected to either side of the receive loss, depending on the logic circuitry.

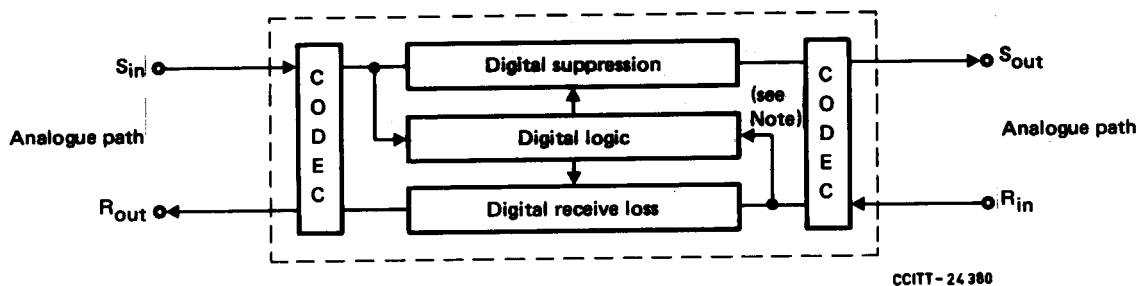
FIGURE 2/G.164
Type B echo suppressor



Note 1 - This input may be connected to either side of the receive loss, depending on the logic circuitry.

Note 2 - The digital path may be at any digital interface, i.e. 64 kbit/s, 1544 or 2048 kbit/s or at any higher order interface.

FIGURE 3/G.164
Type C echo suppressor



Note - This input may be connected to either side of the receive loss, depending on the logic circuitry.

FIGURE 4/G.164
Type D echo suppressor

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".) The minimum echo path loss and the maximum end-delay must be considered 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. A two step process is recommended as a 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'écho

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'écho 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'écho

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'écho différentiel

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: supprimeur d'écho à intervention partielle

S: supresor de eco con intervención parcial

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

2.6 adaptive break-in echo suppressor

F: supprimeur d'écho à intervention adaptable

S: supresor de eco con intervención 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: atenuación para la supresión

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 réception

S: atenuación en la recepción

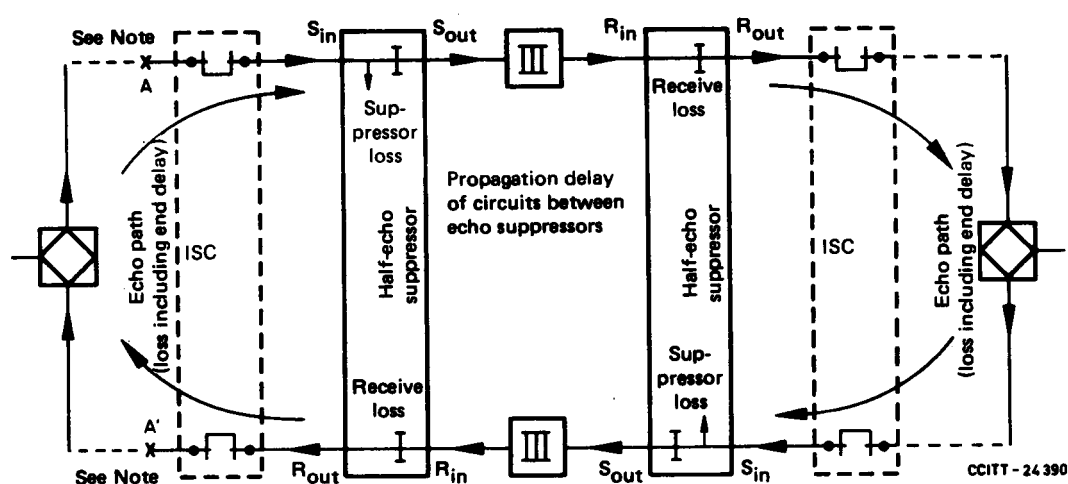
The specified loss which an echo suppressor introduces into the receive path (of the echo suppressor) to reduce the effect of echo currents during break-in.

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

F: supprimeur d'écho terminal

S: supresor de eco terminal

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



ISC International switching centre

Note - In some applications the echo suppressor is inserted at point A, A'.

FIGURE 5/G.164

2.10 **suppression operate time**

F: temps de fonctionnement pour le blocage

S: tiempo de funcionamiento para la supresión

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 supresión

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: intervención 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 intervención 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: intervención 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 intervención 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 intervención

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: sensibilité différentielle

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 °C to 40 °C 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 < 0 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 μ s measured between any two frequencies in the band 1000-2400 Hz and 60 μ s 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 $(2f_1 - f_2)$ or $(2f_2 - f_1)$ 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 companders.

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.