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SERIES G: TRANSMISSION SYSTEMS AND MEDIA,
DIGITAL SYSTEMS AND NETWORKS

International telephone connections and circuits –
Apparatus associated with long-distance telephone circuits

Automatic level control devices

Recommendation ITU-T G.169



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Recommendation ITU-T G.169

Automatic level control devices

Summary

Recommendation ITU-T G.169 applies to the testing of automatic level control (ALC) devices intended for use in digital network-based equipment. It does not apply to subscriber-based level control devices, devices that operate in the analogue domain, or any means of fixed level control within the network which may be part of an overall network transmission plan.

The scope of this Recommendation is to define certain performance constraints for network ALC devices and, where appropriate, to define laboratory tests that may be performed on an ALC device to verify that these constraints are met.

An ALC device that satisfies all the constraints and passes all of the tests in this Recommendation should ensure (but will not guarantee) that the pre-existing standard of overall network performance (e.g., the transmission of speech, voiceband data and other voiceband signals, ISDN, etc.) is not degraded when the ALC device is installed in the network.

This Recommendation also describes the general characteristics of ALC devices and indicates what characteristics are important to provide acceptable performance in the network. Issues relating to the interaction of ALC devices with other network and subscriber equipment are also discussed in this Recommendation.

This Recommendation does not define a standard algorithm.

This Recommendation does not define planning rules, deployment aspects, or target levels for ALC devices.

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T G.169	1999-07-02	15
2.0	ITU-T G.169	2011-05-14	16

FOREWORD

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As of the date of approval of this Recommendation, ITU had received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at <http://www.itu.int/ITU-T/ipr/>.

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Recommendation ITU-T G.169

Automatic level control devices

1 Scope

This Recommendation applies to the testing of automatic level control (ALC) devices intended for use in digital network-based equipment.

An ALC device is defined as any signal processing function located in the digital transmission path which automatically adjusts the level of a signal towards a predetermined value. Devices which modify the frequency response or spectral content of the signal in such a way as to affect the overall level of the signal are also defined as ALC devices for the purpose of this Recommendation.

This Recommendation does not apply to subscriber-based level control devices, devices that operate in the analogue domain, or any means of fixed level control within the network which may be part of an overall network transmission plan.

The scope of this Recommendation is to define certain performance constraints for network ALC devices and, where appropriate, to define laboratory tests that may be performed on an ALC device to verify that these constraints are met.

An ALC device that satisfies all the constraints and passes all of the tests in this Recommendation should ensure (but will not guarantee) that the pre-existing standard of overall network performance (e.g., the transmission of speech, voiceband data and other voiceband signals, ISDN, etc.) is not degraded when the ALC device is installed in the network.

This Recommendation also describes the general characteristics of ALC devices and indicates what characteristics are important to provide acceptable performance in the network. Issues relating to the interaction of ALC devices with other network and subscriber equipment are also discussed in this Recommendation.

This Recommendation does not define a standard algorithm.

This Recommendation does not define planning rules, deployment aspects, or target levels for ALC devices. This information may be found in [ITU-T G.136].

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

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|---------------|--|
| [ITU-T G.115] | Recommendation ITU-T G.115 (1996), <i>Mean active speech level for announcement and speech synthesis systems.</i> |
| [ITU-T G.121] | Recommendation ITU-T G.121 (1993), <i>Loudness ratings (LRs) of national systems.</i> |
| [ITU-T G.122] | Recommendation ITU-T G.122 (1993), <i>Influence of national systems on stability and talker echo in international connections.</i> |
| [ITU-T G.136] | Recommendation ITU-T G.136 (1999), <i>Application rules for automatic level control devices.</i> |

[ITU-T G.160]	Recommendation ITU-T G.160 (2008), <i>Voice enhancement devices</i> .
[ITU-T G.164]	Recommendation ITU-T G.164 (1988), <i>Echo suppressors</i> .
[ITU-T G.165]	Recommendation ITU-T G.165 (1993), <i>Echo cancellers</i> .
[ITU-T G.168]	Recommendation ITU-T G.168 (2009), <i>Digital network echo cancellers</i> .
[ITU-T G.763]	Recommendation ITU-T G.763 (1998), <i>Digital circuit multiplication equipment using G.726 ADPCM and digital speech interpolation</i> .
[ITU-T P.56]	Recommendation ITU-T P.56 (1993), <i>Objective measurement of active speech level</i> .
[ITU-T P.501]	Recommendation ITU-T P.501 (2007), <i>Test signals for use in telephony</i> .
[ITU-T P.561]	Recommendation ITU-T P.561 (2002), <i>In-service non-intrusive measurement device – Voice service measurements</i> .
[ITU-T Q.24]	Recommendation ITU-T Q.24 (1988), <i>Multifrequency push-button signal reception</i> .
[ITU-T T.4]	Recommendation ITU-T T.4 (2003), <i>Standardization of Group 3 facsimile terminals for document transmission</i> .
[ITU-T T.30]	Recommendation ITU-T T.30 (2005), <i>Procedures for document facsimile transmission in the general switched telephone network</i> .
[ITU-T V.8]	Recommendation ITU-T V.8 (2000), <i>Procedures for starting sessions of data transmission over the public switched telephone network</i> .
[ITU-T V.25]	Recommendation ITU-T V.25 (1996), <i>Automatic answering equipment and general procedures for automatic calling equipment on the general switched telephone network including procedures for disabling of echo control devices for both manually and automatically established calls</i> .

3 Terms and definitions

This Recommendation defines the following terms:

3.1 ALC device: A signal processing function located in the digital transmission path which automatically adjusts the level of a signal towards a predetermined value. Devices which modify the frequency response or spectral content of the signal in such a way as to affect the overall level of the signal are also defined as ALC devices for the purpose of this Recommendation. An ALC device is designed to process signals in one direction of transmission. See Figure 1.

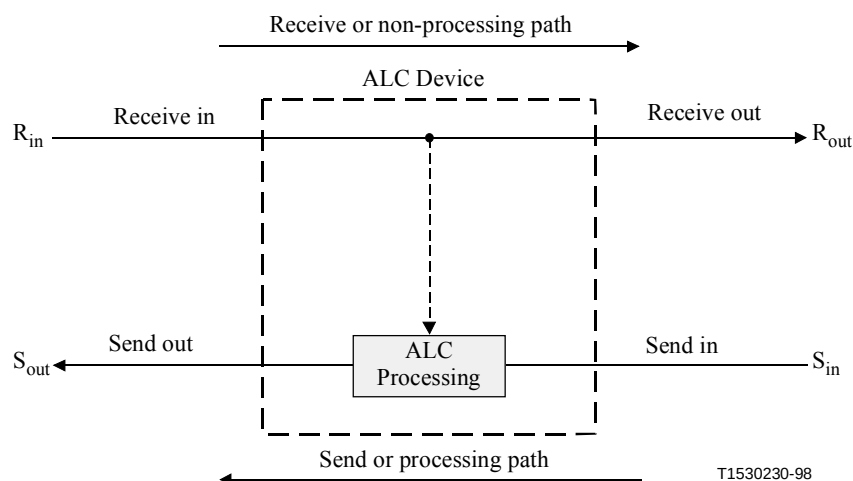


Figure 1 – Block diagram of an ALC device

3.2 disabled ALC device: An ALC device that has been forced into a 64 kbit/s bit-sequence integrity mode of operation, by whatever means.

3.3 echo canceller: A device placed in the 4-wire portion of a circuit and used for reducing cancelled-end echo present on the send path by subtracting an estimation of that echo from the cancelled-end echo.

3.4 full ALC device: An ALC device designed to process signals in both directions of transmission.

3.5 full echo canceller: An echo canceller designed to cancel echoes in both directions (i.e., near-end and far-end echoes).

3.6 laboratory tests: Tests which may be performed in a laboratory or any environment where the ALC device is not installed in the network and is therefore not 'in service'.

3.7 Target level: For a particular signal type, the input signal level for which an active (enabled) ALC device will progress to unity gain. At other input signal levels, the output level of the ALC device will be adjusted towards the target level.

NOTE – With some ALC devices, the target level may be different for different types of signals, e.g., the target level for speech may be different from the target level for a tone. Also, the treatment of signals which are above the target level may be different from the treatment of signals which are below the target level. In principle, an advanced ALC device may feature more than one target level, depending on the transmitted signal (e.g., speech, data, or DTMF tones).

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations:

ALC	Automatic Level Control
A/D	Analogue-to-Digital converter
CSS	Composite Source Signal
D/A	Digital-to-Analogue converter
DCME	Digital Circuit Multiplication Equipment
DTMF	Dual-Tone Multi-Frequency
ERL	Echo Return Loss
ISDN	Integrated Services Digital Network

5 **Characteristics of ALC devices**

5.1 **General**

This Recommendation is applicable to automatic level control (ALC) devices installed in digital network-based equipment. An ALC device is defined as any signal processing function located in the digital transmission path which automatically adjusts the level of a signal towards a predetermined value. Devices which modify the frequency response or spectral content of the signal in such a way as to affect the overall level of the signal are also defined as ALC devices for the purpose of this Recommendation.

5.2 **ALC characteristics**

ALC devices installed in the network should have the following characteristics:

- 1) The ability to introduce restricted gain or loss in the circuit to maintain the level of a call at a predetermined value.
- 2) The ability to maintain the stability of a connection at all times (both during call set-up and for the duration of the call), in cases with and without associated echo control.
- 3) The ability to maintain proper operation during facsimile and voiceband data transmission.
- 4) The ability to operate with realistic levels of background and circuit noise (e.g., mobile networks).
- 5) The ability to operate correctly in the presence of echo.
- 6) The ability not to interfere with the correct operation of signalling tones used in the network.
- 7) The ALC device, when disabled, should provide a 64 kbit/s bit-sequence integrity mode of operation.

5.3 **Tandemed operation**

There are significant issues related to the tandemed operation of ALC devices. All tandemed ALC devices should have the capability of being disabled. Methods for disabling ALC devices and the tests to ensure proper operation of tandemed ALC devices are for further study.

5.4 **Delay performance**

The delay in the processing path and the non-processing path of an ALC device should be kept to a minimum. For ALC devices used in networks that do not incorporate echo cancellers, the delay in the processing path should be kept to a minimum and should not exceed 1 ms. The delay in the non-processing path of the ALC device should not exceed 250 μ s for interface frame alignment. As a result, there should be no additional or incremental processing delay added in the non-processing direction of the ALC function.

For ALC devices used in networks that incorporate echo cancellers, the above constraints on the ALC processing do not apply. This is to allow flexibility in the design of algorithms that may perform functions other than simple ALC, but which are still covered by this Recommendation. In this case, the delay performance of the algorithm in the processing path should be clearly stated. The delay in the non-processing path of the ALC device should not exceed 250 μ s for interface frame alignment. As a result, there should be no additional or incremental processing delay added in the non-processing direction of the ALC function. Designers are reminded that the delay in the processing path of all such devices should be kept to a minimum.

6 Test signals

6.1 Test signal for level and gain checks

The ALC response to speech signals may be significantly different from the response to stationary periodic test signals (e.g., sinusoidal test signals). Consequently, if periodic test signals are used for level and gain measurements, the ALC device must respond to the chosen test signal in the same manner as it would to a speech signal. Otherwise, the results might not represent the actual performance in regard to speech signals. For example, certain ALC devices may respond to particular frequencies by resetting the gain to unity or disabling themselves, in which case the test results are not indicative of its performance with actual speech signals.

Also, some designs of ALC devices do not make gain changes while a continuous signal persists. In this case, it would be necessary to provide a means of turning the modulation of the test signal on or off so that gain changes can occur, but return to continuous signal mode when making the level or gain measurements. In the case of an on/off modulated test signal, references to the level of the signal within this Recommendation relate to the "on" portion of the test signal (i.e., measurements made on the unmodulated signal).

For some ALC device designs, the target level (as defined in clause 3) may be dependent on the characteristics of the applied signal, i.e., the target level with a speech signal may differ, in practice, from the target level with a tone. For such an ALC device, this aspect does not prevent the use of a sine wave signal in the tests described in clause 7.

A suitable test signal must be selected by reference to the specifications for the ALC device under test. In most cases, suitable test signals for level and gain checks would be provided by a set of sinusoids (e.g., 204 Hz, 304 Hz, 504 Hz, 1004 Hz, 1804 Hz and 2804 Hz), on/off modulated, if necessary, at the rate 1 second on/1 second off.

In principle, an advanced ALC device may feature more than one target level depending on the transmitted signal. Such an ALC device would have the ability to discriminate between different signal types, e.g., speech, data, or DTMF tones. In this situation, for tests on the performance of the ALC device with a speech signal, care must be taken that the selected test signal is identified by the ALC device as speech.

Because tone signals may prove unsuitable or inadequate for a particular design of ALC device, consideration is given to the use of band-limited noise as the test signal. Consideration is also given to the use of the composite source signal (CSS) defined in [ITU-T P.501]. As a last resort, pre-recorded speech may be used as the test signal, in conjunction with speech level measurement facilities such as those defined in [ITU-T P.56]. However, the use of speech will make certain tests difficult to perform.

6.2 Electrical circuit noise

When required in the tests, electrical circuit noise should be emulated by a continuous, white Gaussian noise signal, band-limited to the frequency range 0-3.4 kHz at source. References to the level of this noise test signal relate to the mean power of the signal, measured flat (i.e., without psophometric weighting). The level, type and time structure of this test signal is for further study.

6.3 Environmental noise

When required in the tests, environmental noise should be emulated by a white Gaussian noise signal, band-limited to the frequency range 0-800 Hz at source, and on/off modulated at the rate 1 second on/1 second off. References to the level of this noise test signal relate to the "on" portion of the signal, equivalent to the mean power of the unmodulated signal, measured flat (i.e., without psophometric weighting). The level, type and time structure of this test signal is for further study.

7 Tests

In many of the following tests, it is necessary to check the gain of the ALC device at various times to see whether any change in gain has occurred. In the test procedures, it is assumed that the ALC device has no provision that would allow its gain to be interrogated at arbitrary points in time. If a particular ALC device does include such provision, then this feature may be used to simplify aspects of the following tests, and may lead to more accurate results.

The tests relate to ALC devices installed in digital networks; therefore, the tests require the injection and measurement of signals in digital circuits. This implies the use of digital test equipment, or of suitable analogue-to-digital (A/D) and digital-to-analogue (D/A) converters.

In some cases, the ALC device under test may be integrated with, or required to work with, other network equipment such as an echo canceller. This implies a capability to inject and monitor test signals in a primary rate multiplexed bitstream. In the case of echo cancellers, it will be necessary to ensure that these devices are fully converged before conducting any of the following tests. For this purpose, it is recommended that a white Gaussian noise signal at an approximate level of -10 dBm0 be injected into the test circuit. The noise signal should be applied first to one direction of transmission for a minimum period of 10 seconds, with no signal in the other direction; it should then be removed and applied to the other direction of transmission for at least 10 seconds.

An ALC device adjusts the level of a signal towards a target level. Typically, the target level will be user selectable within a certain range. In networks where the objectives for send loudness rating (SLR) and receive loudness rating (RLR) are 8 dB and 2 dB respectively (i.e., at the mid-point of the long term objectives for these loudness ratings specified in [ITU-T G.121]), the desired target level with a speech signal is -19 dBm0. This level is based on the approximate relationship between SLR and speech level presented in [ITU-T G.115]. In some devices, the target level will be dependent on the characteristics of the input signal (e.g., the target level with a speech signal may be different from the target level with a tone). In the following test procedures, references to "target level" relate to the target level appropriate to the particular test signal in use (i.e., the level of the test signal at the input to the ALC device that would cause the device to progress to unity gain).

In the tests, it is assumed that the same target level is used in all the individual tests. The selected target level should be realistic in terms of network level objectives, bearing in mind that, for some ALC devices, the target level may be dependent on the nature of the test signal. The use of unrealistic target levels may invalidate some of the tests. Compliance tests on a device should record the target level adopted, and the type of signal to which this target level relates.

7.1 Stability

Network stability issues are addressed in [ITU-T G.122]. With regard to 4-wire circuits with 2-wire end paths, it is normal practice to ensure (as far as is practicable) that there is always a net loss associated with the 4-wire loop. In this way, stability is achieved even for conditions of severe impedance mismatch at the 2-wire/4-wire terminating units.

ALC devices that can introduce significant amounts of gain threaten to reduce or cancel the stability margin of a connection, particularly if ALC is installed in both directions of transmission. The problem is further exacerbated if cascaded ALC systems are permitted. The maximum gain introduced by ALC systems must be restricted to prevent instability, having regard to worst-case conditions for a connection.

ALC may be deployed in two separate network scenarios:

- a) networks without pre-existing echo control;
- b) networks with echo control.

Stability issues associated with full echo cancellation are not discussed in this clause – refer to clause II.1.