Application Note **MSAN-168**

ZARLINK SEMICONDUCTOR

MT9122/MT9300 ITU-T G.165 Test Report

AN5247 ISSUE 2 September 1999

Contents

1.0 Introduction

The MT9122/MT9300 is a DSP based application specific device that provides 2 channels (MT9122) or 32 channels (MT9300) of echo cancellation. The following report shows the performance of the MT9122/MT9300 with respect to the ITU-T recommendation G.165.

These tests were performed using an MT9122 VEC, with power-up default register value. Since the MT9300 uses the same DSP core and algorithms as the MT9122, these test results will also apply to the MT9300 MCVEC.

Unless otherwise stated, all test signals used were band-limited Gaussian white noise.

2.0 Overview

This test report validates that the MT9122/MT9300 is completely conformant to ITU-T G.165. The following exceptions and exclusions are necessary:

Test #7. Non-convergence of echo cancellers on mono or bi-frequency signals transmitted in a handshaking protocol. This test is not included because the intended application for the MT9122/MT9300 is for locations that provide an ability to externally disable the echo canceller, and/or locations that are not concerned with operation with Signalling System No. 5, 6, 7 tones.

Test #8. Overload test for Type A and Type D cancellers. The MT9122/MT9300 is a type C canceller (all digital), therefore the overload test is not applicable. Type A and D cancellers are analog. Refer to G.165 for more information.

Test #10. Facsimile test. This test is still under study by the ITU at the time that G.165 was released.

Test #11. Tandem echo canceller test. This test is still under study by the ITU at the time that G.165 was released.

All tests have been carried out using µlaw coded pcm at all ports of the MT9122/MT9300 device. Results using alaw coded pcm are not available for the first issue of this report.

Full conformance to G.165 is not guaranteed in Extended Delay Mode (tail capacity of 128msec), although preliminary testing has shown that tests 1,2,3a,3b, and 4 pass with no difficulties.

3.0 Test Apparatus

An evaluation board specifically designed for the MT9122/MT9300 is used to perform the G.165 tests in this report. This board connects to an ISA peripheral connector in a PC. This board uses hardware fifos to allow PC software to transfer test signals between the MT9122/MT9300 device and hard disk in real time. All testing is performed with previously calculated µlaw coded signal files stored on the hard disk.

4.0 References

ITU-T Recommendation G.165, Echo Cancellers, CCITT-Blue Book, Volume III, Fasc. III.1, pp.225-243, Revised 03/93.

ITU-T Recommendation G.164, Echo Suppressors, CCITT-Blue Book, Volume III, Fasc. III.1, pp.186-221.

MT9122 Datasheet, Issue 5, September 1996.

MT9300 Datasheet, Issue 2, May 1999.

5.0 Definitions of Abbreviations

ERL — Echo Return Loss. The attenuation in dB of a return signal reflected from a hybrid including any loss/gain of circuits in the endpath. All frequencies in the 4khz voice-band are included. The reference points for measurement of ERL are across the ROUT and SIN ports of the echo canceller.

A_{ECHO} — Echo Loss. Same as ERL.

ERLE — Echo Return Loss Enhancement. Defined as the amount of echo signal level reduction between the echo signal and the error signal. The following definition is used to measure ERLE:

$$ERLE(dB) = 10\log\left(\frac{E[y^2(n)]}{E[e^2(n)]}\right) \cong 10\log\left(\frac{\sum_{i=0}^{N-1} y^2(n-i)}{\sum_{i=0}^{N-1} e^2(n-i)}\right)$$

Note: y(n) is the SIN signal in this equation, e(n) is the RES signal, and N is chosen to be 560 for the tests in this report.

RIN — Receive-in reference signal.

Lrin — Receive-in level.

ROUT — Reference signal output, same signal as RIN except auto-zeroed, and optional 12dB pad.

SIN — Send-in signal.

Lsin — Send-in signal level.

SOUT — Transmit output signal. Residual after NLP.

RES — Residual echo signal, same as ERR.

ERR — Residual echo signal, same as RES.

Lres — Residual echo level = Lrin - ERL - ERLE.

NLP — Non-Linear-Processor.

NLPloss — Amount of signal level reduction in dB provided by the NLP.

COM — Combined loss = ERL + ERLE + NLPloss.

RET — Returned echo level = Lrin - COM.

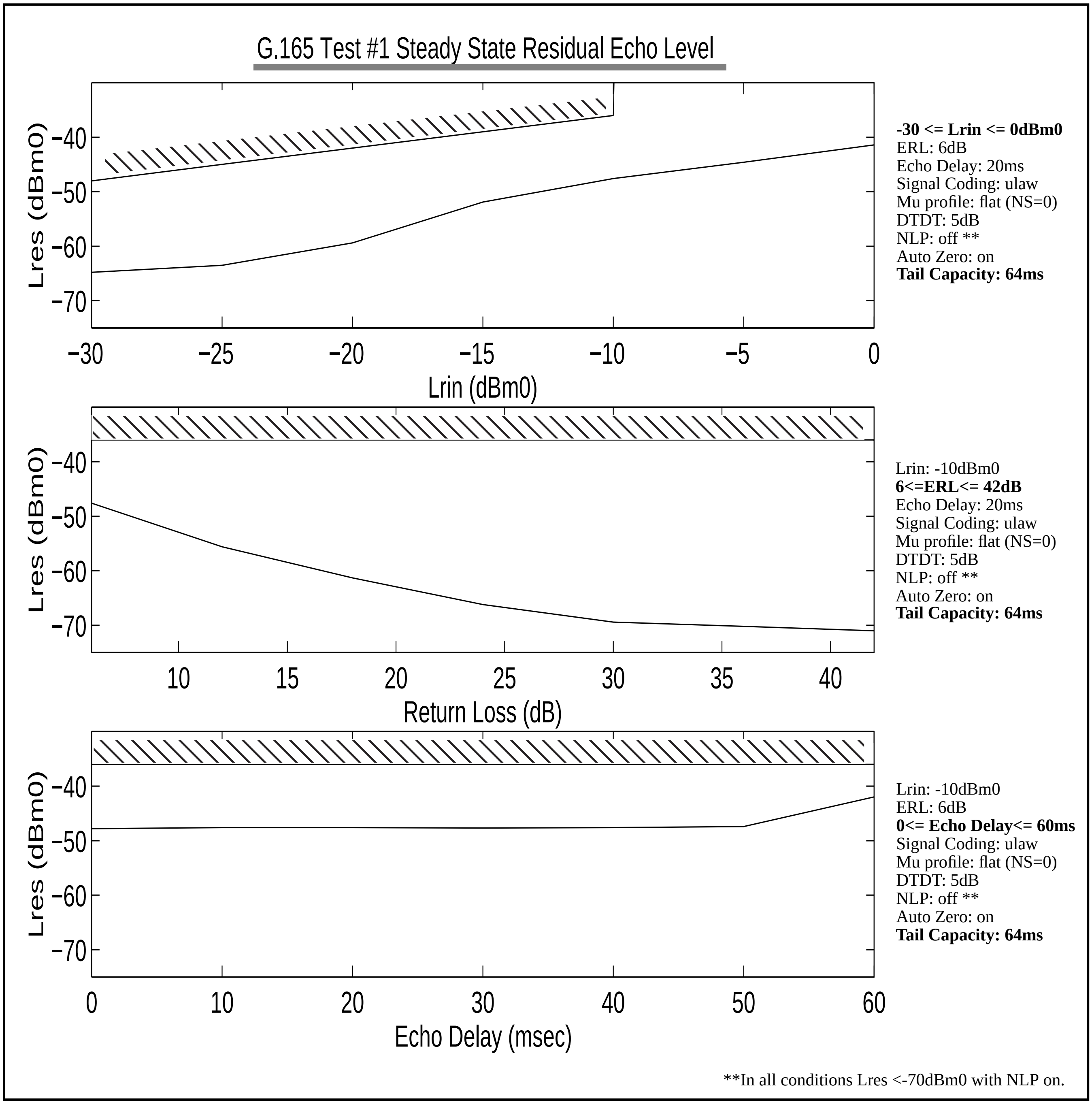
H register — The coefficients of the adaptive filter in the echo canceller.

6.0 Tests

Test #1: Steady State Residual and Returned Echo Level

Method: As defined by ITU-T G.165 test #1:

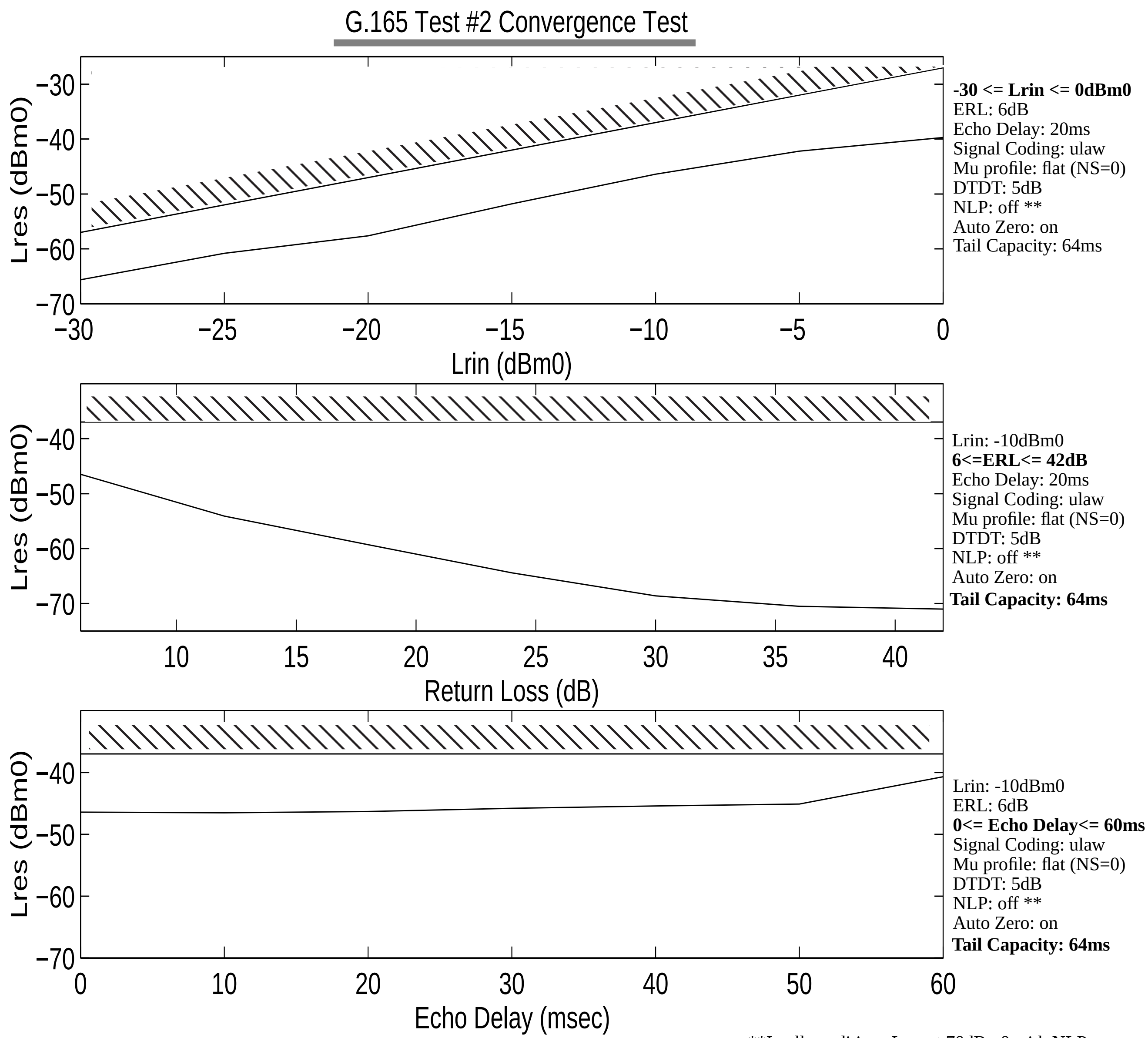
Steady state cancellation is tested with variation of Lrin, ERL, and Echo delay. The MT9122/MT9300 is initially placed in bypass mode, and then adaptation is enabled for a period of 2 seconds before the steady state residual level is measured.



Test #2: Convergence Speed Test

Method: As defined by ITU-T G.165 Test #2:

Combined loss is required to be >= 27dB after 500msec. This requirement is translated to Lres level and shown in the curves below. Convergence speed is tested with variation of Lrin, ERL, and Echo delay. The NLP is specified as ON for this test, but the OFF condition is also tested to show that there is no reliance on the NLP to pass this test. The MT9122/MT9300 is initially placed in bypass mode, adaptation is enabled for 500ms, after which the AdpDis control bit is asserted to freeze the adaptive filter. The residual level is then measured.

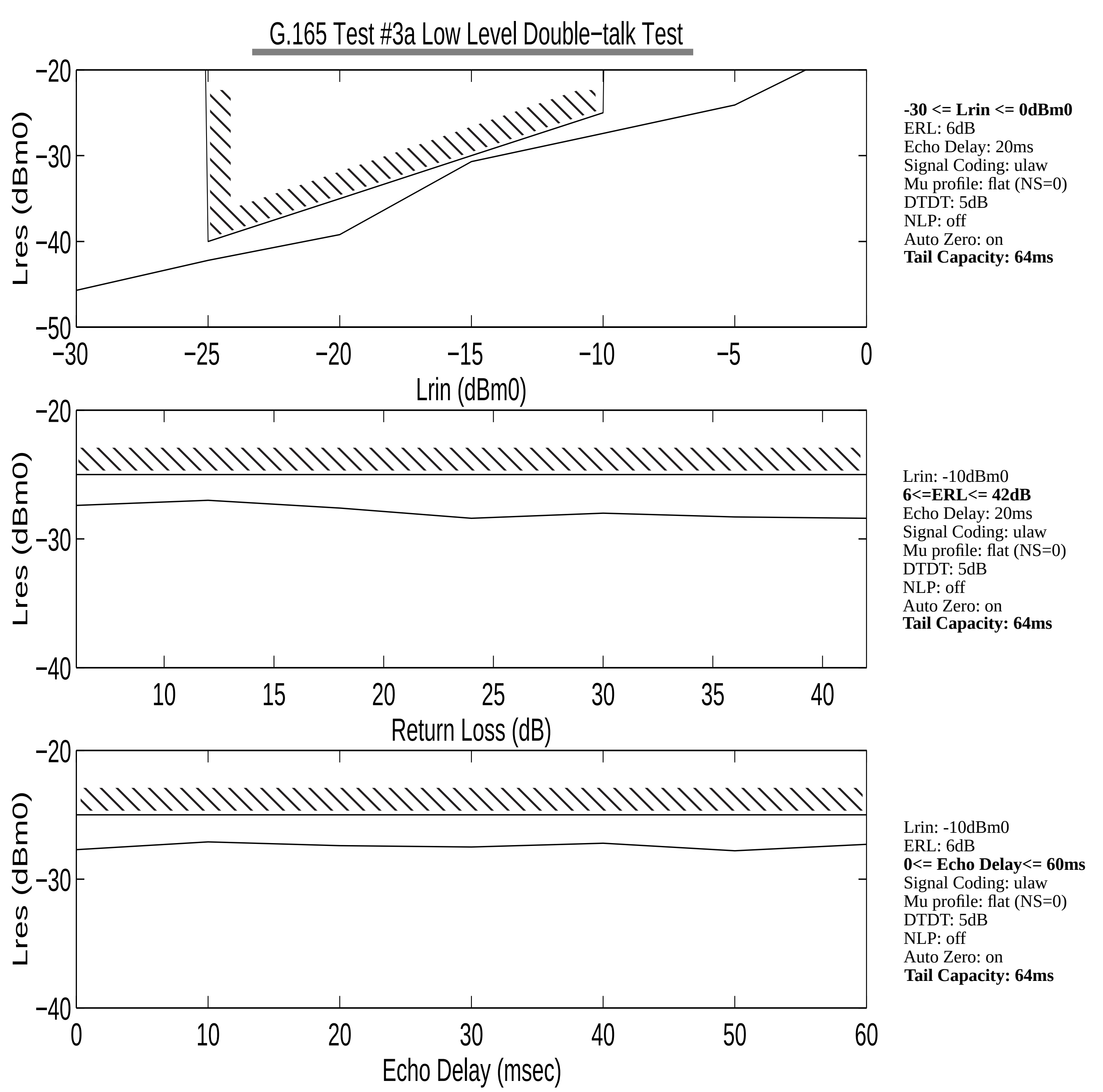


**In all conditions Lres <-70dBm0 with NLP on.

Test #3a: Low-Level Double-Talk Test

Method: ITU-T G.165 Test #3a.

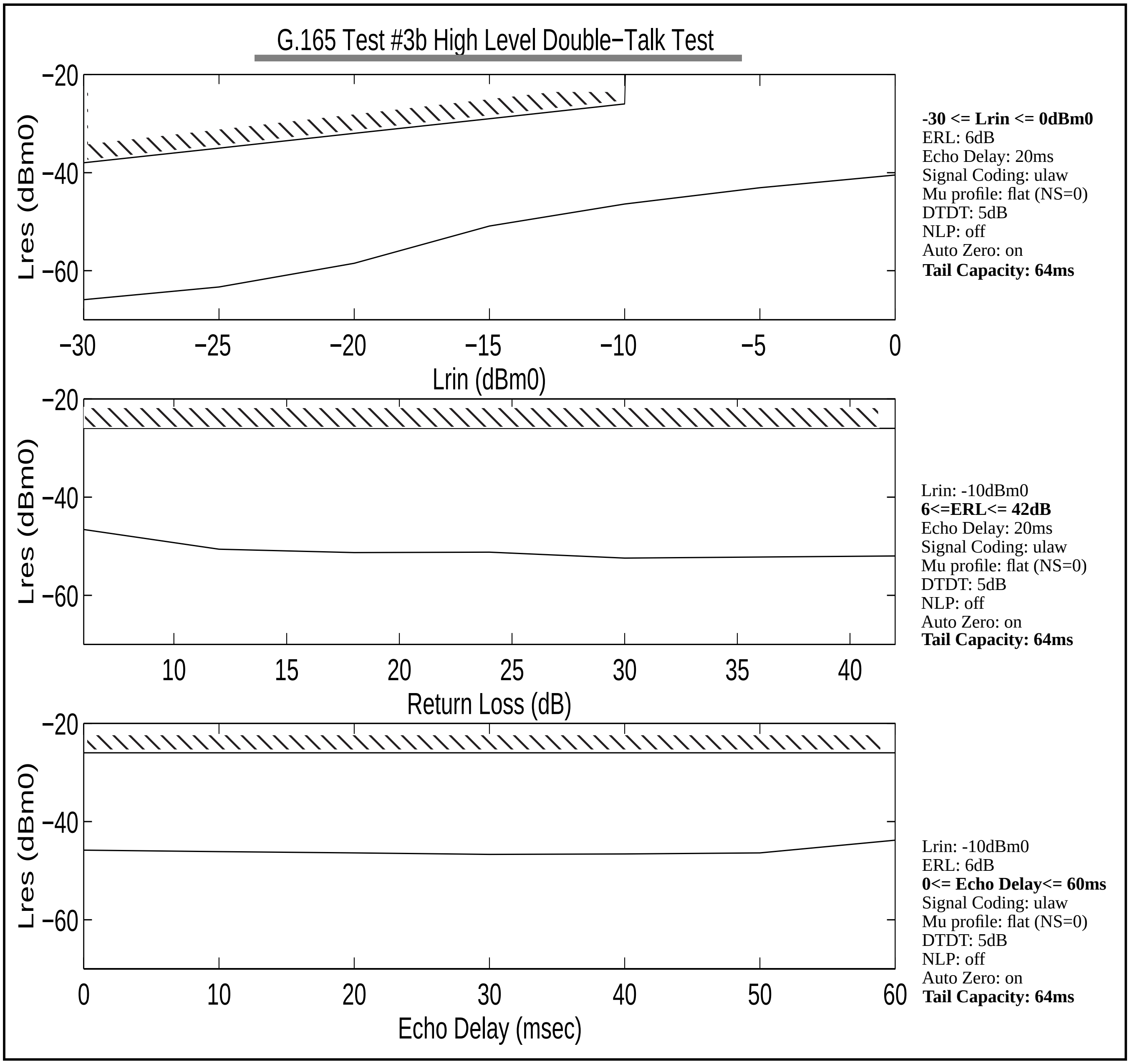
Residual level is measured after convergence has taken place in the presence of an interfering noise signal at Sin. This test is performed with variation of Lrin, ERL, and Echo delay. The MT9122/MT9300 is initially placed in bypass mode, adaptation is enabled for 1s, after which the AdpDis control bit is asserted to freeze the adaptive filter. The interfering noise is then removed and the residual level is measured.



Test #3b: High Level Double-Talk Test

Method: ITU-T G.165 Test #3b.

Residual level is measured after a high level interfering signal has been present at Sin. This test is performed with variation of Lrin, ERL, and Echo delay. The MT9122/MT9300 is initially placed in bypass mode, adaptation is enabled for 2s, after which the high level interfering signal is added at the Sin port for a duration of 1000 samples (0.125 s). The AdpDis control bit is then asserted to freeze the adaptive filter, the interfering noise is removed, and the residual signal level is measured.



Test #4: Leak Rate Test

Method: ITU-T G.165 Test #4.

After being fully converged initially, the adaptive filter coefficients are tested for leakage using 2 minutes of zero signal input at Rin. After the 2 minute period, adaptation is frozen, and noise is again provided at Rin. The residual signal level is then measured and compared to the residual achieved before the leakage test.

The results of this test show no measurable effect due to leakage, and the residual signal levels before and after leakage are the same within measurement error.

The following setup conditions were used for this test:

-30 <= Lrin <= 0dBm0
ERL: 6dB
Echo Delay: 20ms
Signal Coding: ulaw
Mu profile: flat (NS=0)
DTDT: 5dB
NLP: off
Auto Zero: on
Tail Capacity: 64ms

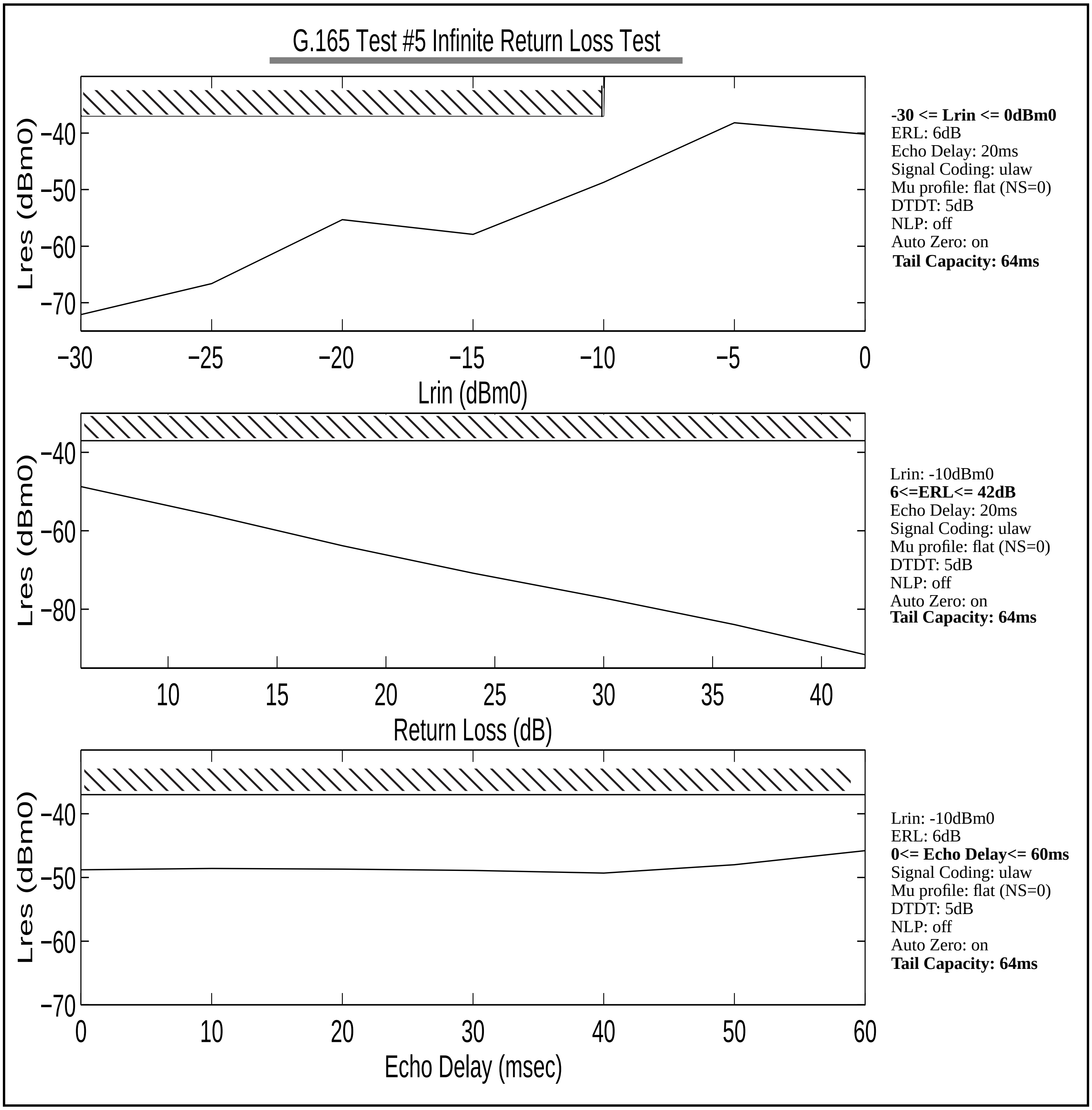
Lrin (dBm0)	Lres before leak test (dBm0)	Lres after 2 minute leak test (dBm0)
-10	-47.0	-47.6
-15	-52.2	-51.6
-20	-59.8	-57.9
-25	-63.9	-64.8
-30	-65.5	-66.2

Table 1 - Leak Rate Test Results

Test #5: Infinite Return Loss Convergence Test

Method: ITU-T G.165 Test #5.

Re-convergence capability is tested after the echo path becomes open circuit. The residual level (Lres) is measured after 500msec from the time that the echo path is opened. This test is performed with variation of Lrin, ERL, and Echo delay.



Test #6: Non-Divergence on Narrow-Band Signals

Method: ITU-T G.165 Test #6.

Nondivergence on narrow-band signals is tested to confirm that echo cancellation is not degraded as a result of sinusoidal signals being present at the reference input for an extended period of time. The echo canceller is fully converged initially, and then a sinusoidal signal is provided at the RIN port for a duration of 3 minutes. The results of this test show that there is no measurable difference after the 3 minute test, from results presented for Test #1.

A Narrow-band signal detector is used by the MT9122/MT9300 to detect narrow-band signals and freeze adaptation. The narrow-band signal detector has been characterized for detection capability, and detection is confirmed for 100% detection of single and dual tone sinusoidal signals according to the following specifications:

Mono or Bi-Freq Tone Characteristic	Min	Max	Comment
Frequency (f_1 or f_2)	200Hz	3500Hz	
Amplitude (mono or bi-freq)	-30dBm0	-10dBm0	as recommended by G.165
Amplitude Twist $\lvert f_{1\ (dB)} - f_{2\ (dB)} \rvert$	0dB	20dB	
Frequency Difference $\lvert f_1 - f_2 \rvert$	170Hz		as recommended by G.165
Signal to noise ratio	30 dB		

Table 2 - Narrowband Signal Detector Characteristics

Test #9: Comfort noise test

Part 1 (matching):

White noise was used to generate noise signals between -40dBmo and -60dBmo. A Gaussian distribution was used with variance 0.1. This test was done without the echo canceller initially just to show that the matched noise level is within +/-2dB of the original background noise level

Sin Noise Level dBm0	-59.6	-53.5	-50.0	-47.5	-45.5	-42.6	-40.1
Matched Noise Steady State Level dBm0	-59.5	-53.6	-50.3	-47.8	-45.9	-42.9	-40.7

The following procedure was used to test part #1 of Test #9 G.165.

1) Set N to -50dBmo. (N is applied to Sin in addition to echo signal).
2) Set Lrin to -10dBmo and set the echo loss to 8dB, and fully converge the echo canceller for 2 seconds.
3) Set Lrin to silence and hold for 1 second. This allows the noise level detector to converge properly without the presence of an echo signal in the residual.
4) Set Lrin to -10dBmo and then measure Lsout.

Sin Noise level (N)	Matched Noise Level
-50.0dBm0	-50.1 dBm0

Part 2 (adjustment down):

This test is set up to change the background noise level from -50dBmo to -60dBmo, and the time to adapt the matched noise to the correct level is measured.

Sin Noise Level **old level -> new level**	**Time to reach -60dBmo level**
-50.0dBm0 -> -60dBm0	0.125 seconds

Part 3(adjustment up):

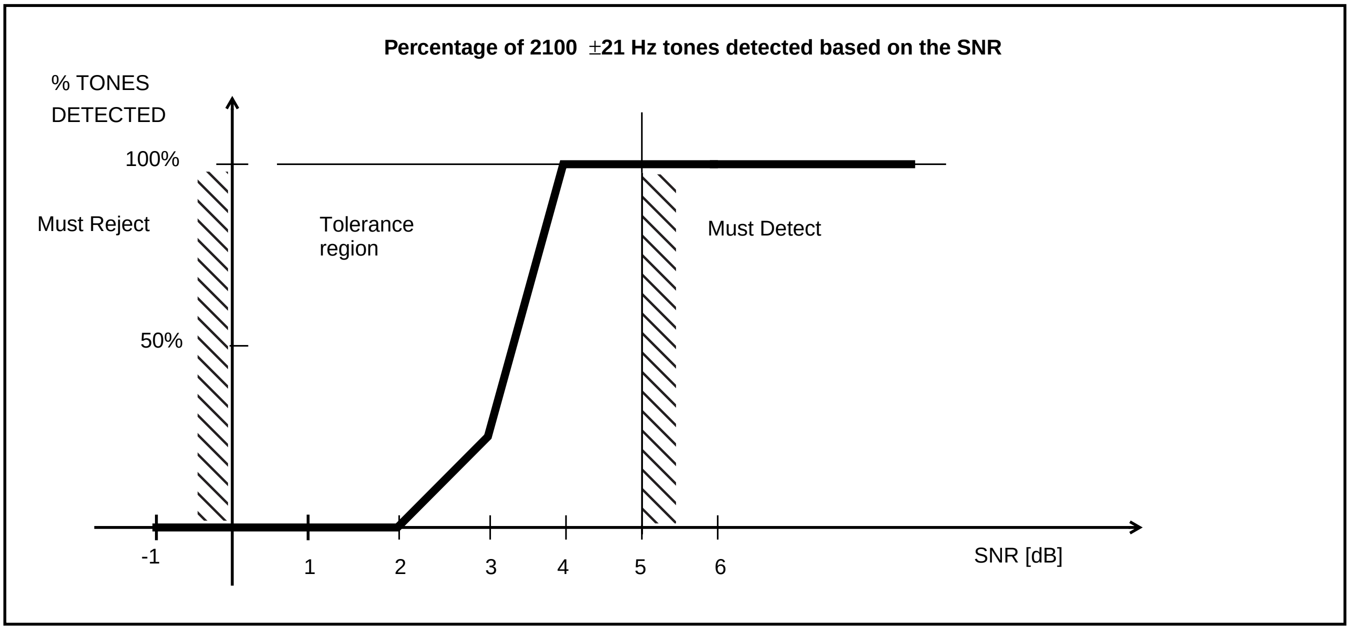
This test is set up to change the background noise level from -50dBmo to -40dBmo, and the time to adapt the matched noise to the correct level is measured.

Sin Noise Level **old level -> new level**	**Time to reach -40 dBm0 level**
-50.0dBm0 -> -40.0dBm0	56 seconds

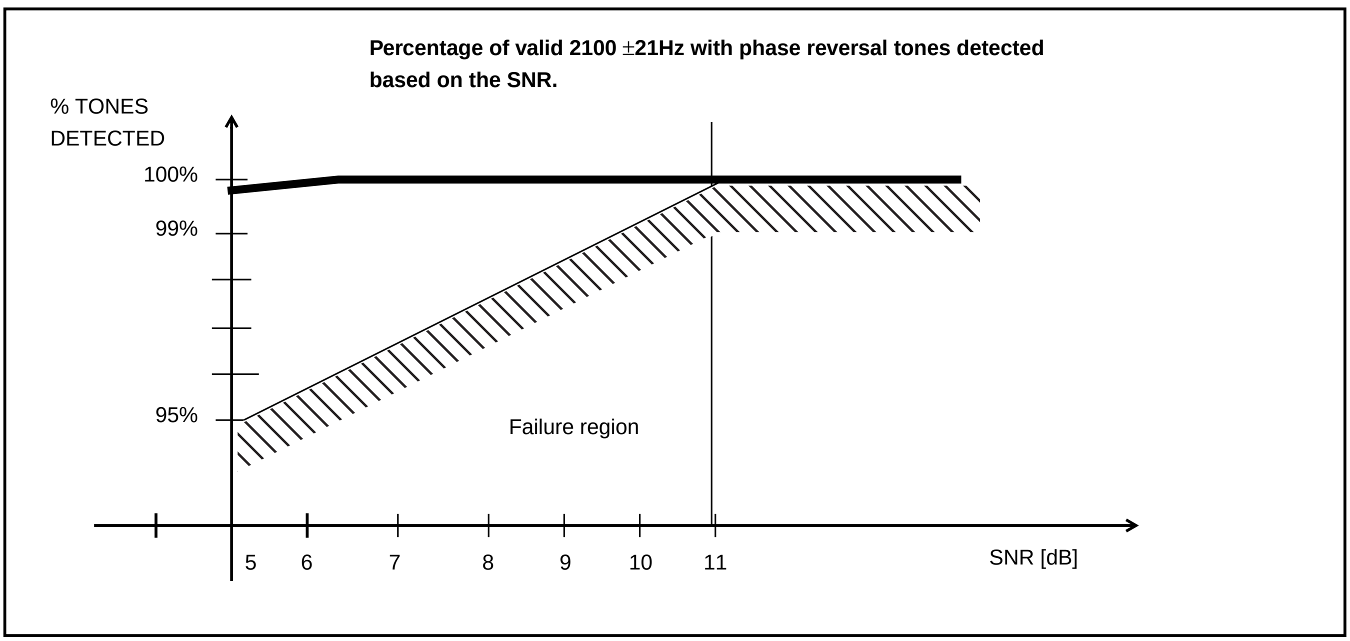
7.0 G.164/G.165 Disable Tone Tests

Tone detection vs SNR:

The following curve shows the percentage of pure 2100Hz tones detected vs SNR of the tone.

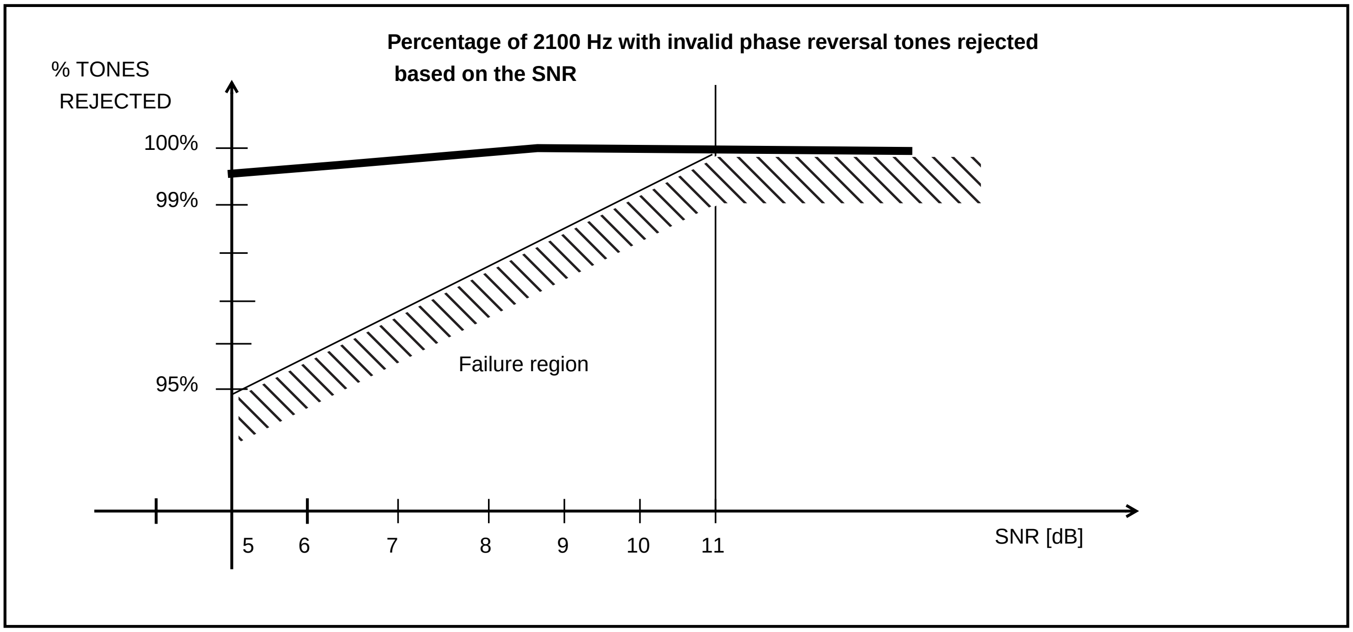


The following graph shows the percent of phase reversed 2100Hz tones detected vs SNR.



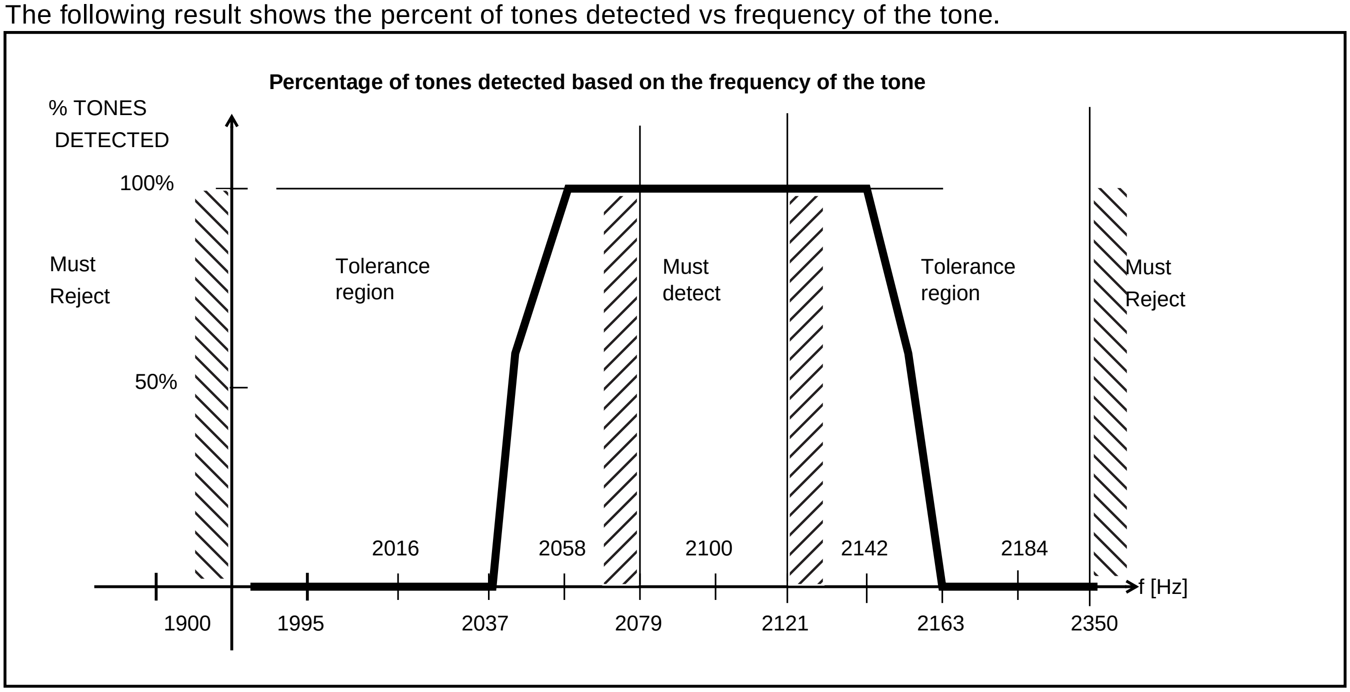
Rejection of invalid phase reversal tones:

The following result shows the percent of invalid phase reversal tones rejected vs SNR. An invalid tone has a phase reversal of 110 degrees or less.



Tone Detection vs frequency:

The following result shows the percent of tones detected vs frequency of the tone.



Test Name	Test Description	Results	G.164/ G.165
Low Signal Level Rejection	Tone level $\leq$ -35 dBm0	0 tones detected	passed
Detection of Valid Tones	Tone levels $\geq$-31 dBm0 2079 Hz $\leq$ tone frequency $\leq$ 2121 Hz SNR $\geq$ 5 dB	all tones detected in 300$\pm$100 [ms]	passed
Low SNR rejection	Tone levels $\geq$-31 dBm0 2079 Hz $\leq$ tone frequency $\leq$ 2121 Hz SNR $\leq$ 0 dB	0 tones detected	passed
Invalid Tone Frequency rejection	Tone levels $\geq$ -31 dBm0 1900 Hz $\geq$ tone frequency $\geq$ 2350 Hz SNR $\geq$ 5 dB	0 tones detected	passed
Holding State Test	Tone detector in holding state, input signal components 390 Hz $\leq f_1 \leq$ 700 Hz and/or 700 Hz $\leq f_2 \leq$ 3400 Hz level $f_1 \geq$ -27 dBm0, level $f_2 \geq$ -31 dBm0	all tones holding in the disabled state	passed
Release Test	Tone detector in holding state, input signal components 390 Hz $\leq f_1 \leq$ 700 Hz and/or 700 Hz $\leq f_2 \leq$ 3400 Hz, level $f_1 <$-30 dBm0, level $f_2 <$ -34 dBm0	disabler released in all cases within 250$\pm$150 [ms] after the release conditions were met	passed

Table 3 - Additional G.164 Disable Tone Detection Test Results

Test Name	Test description	Results	G.165
Invalid Phase Jump 11dB SNR	Tone levels $\geq$-31 dBm0, 2079 Hz $\leq$ tone frequency $\leq$ 2121 Hz, two phase jumps ($\leq$110^o) at interval of 450$\pm$25 [ms], SNR=11dB	0 tones detected	passed
Invalid Phase Jump 10dB SNR	Tone levels $\geq$-31 dBm0, 2079 Hz $\leq$ tone frequency $\leq$ 2121 Hz, two phase jumps ($\leq$110^o)at interval of 450$\pm$25 [ms], SNR=10dB	less than 1% failures to reject	passed
Invalid Phase Jump 9dB SNR	Tone levels $\geq$-31 dBm0, 2079 Hz $\leq$ tone frequency $\leq$ 2121 Hz, two phase jumps ($\leq$110^o) at interval of 450$\pm$25 [ms], SNR=9dB	less than 1% failures to reject	passed
Invalid Phase Jump 8dB SNR	Tone levels $\geq$-31 dBm0, 2079 Hz $\leq$ tone frequency $\leq$ 2121 Hz, two phase jumps ($\leq$110^o) at interval of 450$\pm$25 [ms], SNR=8dB	less than 1% failures to reject	passed
Invalid Phase Jump 7dB SNR	Tone levels $\geq$-31 dBm0, 2079 Hz $\leq$ tone frequency $\leq$ 2121 Hz, two phase jumps ($\leq$110^o) at interval of 450$\pm$25 [ms], SNR=7dB	less than 1% failures to reject	passed
Invalid Phase Jump 6dB SNR	Tone levels $\geq$-31 dBm0, 2079 Hz $\leq$ tone frequency $\leq$ 2121 Hz, two phase jumps ($\leq$110^o) at interval of 450$\pm$25 [ms], SNR=6 dB	less than 1% failures to reject	passed
Invalid Phase Jump 5dB SNR	Tone levels $\geq$-31 dBm0, 2079 Hz $\leq$ tone frequency $\leq$ 2121 Hz, two phase jumps ($\leq$110^o) at interval of 450$\pm$25 [ms], SNR=5 dB	less than 1% failures to reject	passed

Table 4 - Additional G.165 Disable Tone Rejection vs. SNR Test Results

Test Name	Test description	Results	G.165
Valid Tone 11dB SNR	Tone levels $\geq$-31 dBm0, 2079 Hz $\leq$ tone frequency $\leq$ 2121 Hz, two phase jumps (180$\pm$25 ^{o}) at interval of 450$\pm$25 [ms], SNR=11dB	all tones detected in less than 1 sec	passed
Valid Tone 10dB SNR	Tone levels $\geq$-31 dBm0, 2079 Hz $\leq$ tone frequency $\leq$ 2121 Hz, two phase jumps (180$\pm$25 ^{o}) at interval of 450$\pm$25 [ms], SNR=10dB	less than 1% failures to detect in less than 1 sec	passed
Valid Tone 9dB SNR	Tone levels $\geq$-31 dBm0, 2079 Hz $\leq$ tone frequency $\leq$ 2121 Hz, two phase jumps (180$\pm$25 ^{o}) at interval of 450$\pm$25 [ms], SNR=9dB	less than 1% failures to detect in less than 1 sec	passed
Valid Tone 8dB SNR	Tone levels $\geq$-31 dBm0, 2079 Hz $\leq$ tone frequency $\leq$ 2121 Hz, two phase jumps (180$\pm$25 ^{o}) at interval of 450$\pm$25 [ms], SNR=8dB	less than 1% failures to detect in less than 1 sec	passed
Valid Tone 7dB SNR	Tone levels $\geq$-31 dBm0, 2079 Hz $\leq$ tone frequency $\leq$ 2121 Hz, two phase jumps (180$\pm$25 ^{o}) at interval of 450$\pm$25 [ms], SNR=7dB	less than 1% failures to detect in less than 1 sec	passed
Valid Tone 6dB SNR	Tone levels $\geq$-31 dBm0, 2079 Hz $\leq$ tone frequency $\leq$ 2121 Hz, two phase jumps (180$\pm$25 ^{o}) at interval of 450$\pm$25 [ms], SNR=6dB	less than 1% failures to detect in less than 1 sec	passed
Valid Tone 5dB SNR	Tone levels $\geq$-31 dBm0, 2079 Hz $\leq$ tone frequency $\leq$ 2121 Hz, two phase jumps (180$\pm$25 ^{o}) at interval of 450$\pm$25 [ms], SNR=5dB	less than 1% failures to detect in less than 1 sec	passed

Table 5 - Additional G.165 Disable Tone Detection vs. SNR Test Results

Talk-Off Speech Tests

The Bellcore speech test tapes P/N SR-TSY-002568 were used for testing talk-off performance with speech. These tapes contain 95 hours of speech, music, and other sounds. There were 0 false tone detects for the MT9122 tone detectors operating in either G.164 or G.165 mode, for the entire duration of the tapes.

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