VOICE BANDWIDTH PRIVATE LINE DATA CIRCUITS

END-TO-END TRANSMISSION PERFORMANCE

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1. GENERAL

1.01 This section provides examples of the estimation of end-to-end transmission performance based on sectional measurements of a 2-point service, or measurements of end links and midlinks. These measurements are discussed in Section 314-410-300. All the methods of combining discussed in this section apply to one direction of transmission. In general, the results of using these methods are approximations. Therefore, if the results are out of limits, actual end-to-end measurements must be made.

1.02 The information provided in this section was previously contained in Appendix B of Section 314-410-500.

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2. ESTIMATION OF TRANSMISSION PERFORMANCE

2.01 This part provides examples of methods used in the estimation of overall circuit performance.

A. Attenuation Distortion

2.02 The sectional loss with respect to 1000 Hz measurements should be added algebraically for each frequency.

Note: Although test frequencies are shown here as precise multiples of 100 Hz, the actual test frequencies should be offset by 4 Hz (1004 Hz instead of 1000 Hz), due to level variations of as much as ±0.25 dB caused by the 8000-Hz sampling rate used on T carrier.

2.03 *Example:*

LOSS WITH RESPECT TO 1000 HZ (dB)

FREQUENCY* (HZ)	LINK A	LINK B	OVERALL
300	1.0	−0.3	0.7
500	0.8	−0.2	0.6
600	0.4	−0.2	0.2
800	0.2	−0.1	0.1
1000	0	0	0
1200	−0.1	−0.1	−0.2
1400	−0.1	0.1	0
1600	−0.2	0.2	0
1800	−0.1	0.2	0.1
2000	0	0.2	0.2
2200	0.1	0.1	0.2
2400	0.2	0	0.2
2500	0.3	0.1	0.4
2600	0.3	0.2	0.5
2700	0.5	0.4	0.9
2800	0.9	0.7	1.6
3000	1.3	1.4	2.7

* Refer to Table B of Section 314-410-500 for the required measuring frequencies.

If the overall measurement must be compared to the C2 conditioning specification, perform the following steps:

The minimum loss with respect to 1000 Hz between 500 to 2800 Hz = −0.2 dB
The maximum loss with respect to 1000 Hz between 500 to 2800 Hz = 1.6 dB
The minimum loss with respect to 1000 Hz between 300 to 3000 Hz = −0.2 dB
The maximum loss with respect to 1000 Hz between 300 to 3000 Hz = 2.7 dB

The overall attenuation distortion then is:

500-2800 Hz: −0.2 to +1.6 dB
300-3000 Hz: −0.2 to +2.7 dB

If comparing with conditioning other than C2, use appropriate bandwidths for comparison.

B. Envelope Delay Distortion

2.04 The sectional envelope delay measurements should be added algebraically for each frequency.

2.05 *Example:*

ENVELOPE DELAY (MICROSECONDS)

FREQUENCY (HZ)	LINK A	LINK B	OVERALL
500	410	380	790
600	320	270	590
800	180	170	350
1000	130	100	230
1200	80	50	130
1400	40	20	60
1600	20	0	20
1800	0	−30	−30
2000	15	−10	+5
2200	30	5	35
2400	70	30	100
2500	110	70	180
2600	160	120	280
2700	220	180	400
2800	290	260	550

If the overall measurements must be compared to the C2 conditioning specification, perform the following steps:

The minimum envelope delay between 1000 and 2600 Hz = −30 μsec
The maximum envelope delay between 1000 and 2600 Hz = 280 μsec
The minimum envelope delay between 600 and 2600 Hz = −30 μsec
The maximum envelope delay between 600 and 2600 Hz = 590 μsec
The minimum envelope delay between 500 and 2800 Hz = −30 μsec
The maximum envelope delay between 500 and 2800 Hz = 790 μsec

The overall envelope delay distortion between 1000 and 2600 Hz = 280− (−30) = 310 μsec
The overall envelope delay distortion between 600 and 2600 Hz = 590− (−30) = 620 μsec
The overall envelope delay distortion between 500 and 2800 Hz = 790− (−30) = 820 μsec

If comparing with conditioning other than C2, use appropriate bandwidths for comparison.

C. C-Message Noise, C-Notched Noise, and Single Tone Interference

2.06 Combine the sectional measurements on a power basis using Table A.

2.07 *Example:* C-Message Noise

Link A 31 dBrnc0
Link B 36 dBrnc0

Difference between quantities = 36 — 31 = 5 dB
From Table A combining term = 1.2 dB
Add combining term to the higher number: 36 + 1.2 = 37.2

The overall noise should be 37 dBrnc0 (rounded off).

TABLE A

COMBINING POWERS

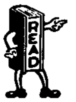
DIFFERENCE IN dB BETWEEN TWO QUANTITIES	COMBINING TERM IN dB	DIFFERENCE IN dB BETWEEN TWO QUANTITIES	COMBINING TERM IN dB	DIFFERENCE IN dB BETWEEN TWO QUANTITIES	COMBINING TERM IN dB
0—0.1	3.0	2.2—2.4	2.0	5.7—6.1	1.0
0.2—0.3	2.9	2.5—2.7	1.9	6.2—6.6	0.9
0.4—0.5	2.8	2.8—3.0	1.8	6.7—7.2	0.8
0.6—0.7	2.7	3.1—3.3	1.7	7.3—7.9	0.7
0.8—0.9	2.6	3.4—3.6	1.6	8.0—8.6	0.6
1.0—1.2	2.5	3.7—4.0	1.5	8.7—9.6	0.5
1.3—1.4	2.4	4.1—4.3	1.4	9.7—10.7	0.4
1.5—1.6	2.3	4.4—4.7	1.3	10.8—12.2	0.3
1.7—1.9	2.2	4.8—5.1	1.2	12.3—14.5	0.2
2.0—2.1	2.1	5.2—5.6	1.1	14.6—19.3	0.1
				19.4—Up	0

2.08 *Example of C-Notched Noise Estimation:*

Line A S/N = 28 dB
Line B S/N = 27 dB

Difference between quantities = 28 — 27 = 1 dB
From Table A combining term = 2.5 dB
Subtract combining term from the lower S/N figure: 27 dB —2.5 = 24.5 dB

The overall S/N ratio (rounded off) is 25 dB.



If the C-notched noise measurement is dominated by 3rd order harmonic distortion (commonly found on some short haul carrier systems), then the tone measurements will add on a voltage basis and Table B should be used. A harmonic or intermodulation distortion measurement is therefore recommended and should be made in conjunction with C-notched noise measurements.

D. Nonlinear Distortion (Harmonic Distortion)

2.09 Combine the sectional second order distortion measurements on a power basis using Table A. Combine the sectional third order distortion measurements on a voltage basis using Table B.

2.10 ***Example:***

	RATIO OF FUNDAMENTAL TO SECOND ORDER DISTORTION
Link A	35 dB
Link B	38 dB

Difference between quantities = 38 — 35 = 3 dB
From Table A combining term = 1.8 dB (power addition)
Subtract combining term from the lower number (representing the highest distortion) = 35 — 1.8 = 33.2 dB
The overall ratio of the fundamental to the second order distortion is 33 dB (rounded off).

	RATIO OF FUNDAMENTAL TO THIRD ORDER DISTORTION
Link A	37 dB
Link B	41 dB

Difference between quantities = 41 — 37 = 4 dB
From Table B combining term = 4.2 dB (voltage addition)
Subtract combining term from the lower number (representing the highest distortion) = 37 — 4.2 = 32.8 dB
The overall ratio of the fundamental to the third order distortion is 33 dB.

TABLE B

COMBINING VOLTAGES

DIFFERENCE IN dB BETWEEN TWO QUANTITIES	COMBINING TERM IN dB	DIFFERENCE IN dB BETWEEN TWO QUANTITIES	COMBINING TERM IN dB	DIFFERENCE IN dB BETWEEN TWO QUANTITIES	COMBINING TERM IN dB
0—0.1	6.0	4.6—4.7	4.0	11.5—11.9	2.0
0.2—0.3	5.9	4.8—5.0	3.9	12.0—12.5	1.9
0.4—0.5	5.8	5.1—5.3	3.8	12.6—13.0	1.8
0.6—0.7	5.7	5.4—5.6	3.7	13.1—13.5	1.7
0.8—0.9	5.6	5.7—5.9	3.6	13.6—14.1	1.6
1.0—1.1	5.5	6.0—6.2	3.5	14.2—14.8	1.5
1.2—1.3	5.4	6.3—6.5	3.4	14.9—15.4	1.4
1.4—1.6	5.3	6.6—6.8	3.3	15.5—16.1	1.3
1.7—1.8	5.2	6.9—7.1	3.2	16.2—16.9	1.2
1.9—2.0	5.1	7.2—7.4	3.1	17.0—17.8	1.1
2.1—2.2	5.0	7.5—7.7	3.0	17.9—18.7	1.0
2.3—2.5	4.9	7.8—8.1	2.9	18.8—19.7	0.9
2.6—2.7	4.8	8.2—8.5	2.8	19.8—20.9	0.8
2.8—2.9	4.7	8.6—8.9	2.7	21.0—22.2	0.7
3.0—3.2	4.6	9.0—9.3	2.6	22.3—23.6	0.6
3.3—3.4	4.5	9.4—9.7	2.5	23.7—25.4	0.5
3.5—3.7	4.4	9.8—10.1	2.4	25.5—27.6	0.4
3.8—3.9	4.3	10.2—10.5	2.3	27.7—30.7	0.3
4.0—4.2	4.2	10.6—11.0	2.2	30.8—35.1	0.2
4.3—4.5	4.1	11.1—11.4	2.1	35.2—44.9	0.1

E. Phase Jitter

2.11 Table C may be used to add phase jitter measurements expressed in degrees.

2.12 *Example:*

Link A = 3°
Link B = 5°

From Table C the overall phase jitter would be expected to approximate 7°.

TABLE C

COMBINING TWO PHASE JITTER MEASUREMENTS EXPRESSED IN DEGREES PEAK-TO-PEAK

	LINK A									
LINK B	1	2	3	4	5	6	7	8	9	10
1	2	3	4	4	5	6	7	8	9	10
2	3	3	4	5	6	7	8	9	10	11
3	4	4	5	6	7	8	9	10	11	12
4	4	5	6	7	8	8	9	10	11	12
5	5	6	7	8	8	9	10	11	12	13
6	6	7	8	8	9	10	11	12	13	14
7	7	8	9	9	10	11	12	13	13	14
8	8	9	10	10	11	12	13	13	14	15
9	9	10	11	11	12	13	13	14	15	16
10	10	11	12	12	13	14	14	15	16	17

F. Impulse Noise

2.13 Use an impulse noise threshold setting of 71 dBrnc0 on each link or section. Algebraically add the number of impulses recorded in 15 minutes on each section to obtain the overall counts.

2.14 *Example:*

Link A = 5 counts
Link B = 2 counts
Overall = 7 counts

G. Frequency Shift

2.15 Add the frequency shift for each section algebraically. Note whether the shift for each link is + or − with respect to the source.

2.16 *Example:*

Link A = +1 Hz
Link B = −2 Hz
Overall = −1 Hz

3. MAXIMUM POWER PER TONE IN MULTICHANNEL MODEMS

3.01 In the case of multichannel modems, it may become necessary to determine the level to which each tone should be adjusted, to ensure the total output power of the modem will not exceed −13 dBm0. If equal-level tones are used, the output of any single tone with reference to 0 TLP (relative power) should not exceed −13 − 10 log (number of channels). Logarithms to the base 10 are given in Table D for from two to thirty channels.

3.02 *Example of Test:* A modem that will use a maximum of four equal-level tones is to be connected to a Telco channel. The relative power permitted per tone is as follows:
Relative power per tone = −13 − 10 log (4)
Log 4 from Table D = .602
Relative power per tone = −13 − 10 (.602) = −13 − 6.02 = − 19.02 dBm

Note: The power of each tone at the standard transmit modem interface (+13 TLP) may be determined by adding the relative power per tone to the TLP value where measured as follows:

−19.02 + 13 = −6.02 dBm

TABLE D

LOGARITHMS

CHANNELS	LOGARITHMS	CHANNELS	LOGARITHMS	CHANNELS	LOGARITHMS
2	0.301	12	1.079	22	1.342
3	0.477	13	1.114	23	1.362
4	0.602	14	1.146	24	1.380
5	0.699	15	1.176	25	1.398
6	0.778	16	1.204	26	1.415
7	0.845	17	1.230	27	1.431
8	0.903	18	1.255	28	1.447
9	0.954	19	1.279	29	1.463
10	1.000	20	1.301	30	1.477
11	1.041	21	1.322		

NOTES