NOISE ENGINEERING

COMBINING PROPERTIES OF NOISE

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1. GENERAL

1.01 This section provides procedures for estimating the combined effect of various noise contributors in a common impedance at some particular point in a communications network. Noise from independent sources is present everywhere in the network. The particular points at which the combined effect of noise is of interest include subscriber stations, test boards, voice-frequency patch bays, and many others. Other sections in the 870 Division make use of the procedures provided in this section.

1.02 Several measurable properties characterize noise. However, not all of these properties will appear in a given noise voltage in measurable amounts. These properties of noise are: amplitude (or level), frequency, rise time, decay time, and duration. Amplitude, or the noise level in dBrn, is most frequently measured. Frequency is of interest when hum or tones dominate. The rise and decay times usually characterize impulse noise. Very short durations also characterize impulse noise. Noise phenomena lasting more than a few milliseconds will fall into the category of message noise. (Noise measuring sets, such as the 3 type, are designed with a meter that requires about 200 milliseconds to rise to 99 percent of its full scale when driven by a noise voltage of full scale level.)

1.03 For most purposes message noise amplitude is the parameter of most interest. The noise on a trunk consists of many random bursts, impulses, tones, and bits of crosstalk and babble which are unrelated in any way to each other in time, phase, or frequency. The individual amplitudes occur at random moments in time. Message noise measuring sets, such as the 3 type, are designed to indicate the approximate root mean square (rms) value of the power of the randomly occurring noise components as they come along. The approximation to the rms, called "quasi" rms, makes the noise measuring set assign nearly equal values to noise of differing characteristics but equivalent interfering effects.

1.04 Noise quantities to be combined as described in this section should have the same weighting. In general, C-message weighting applies to trunks, subscriber lines, and most other message circuits. Three-kHz flat weighting is appropriate for circuits assigned to data use exclusively. Program and 15-kHz flat weightings, or flat response in wider bandwidths, may also be assumed where appropriate. The essential consideration is that only one weighting be used.

2. COMBINING INDIVIDUAL NOISE CONTRIBUTIONS BY POWER SUMMATION

2.01 Because of the random nature of the noise as described in 1.03, the various contributions cannot be summed by the rules of normal algebraic addition. Instead, the power summation procedure gives the best numerical approximation of the combined effect of noise values measured or estimated on two or more contributors. Figure 1 illustrates typical situations in which noise contributions might combine.

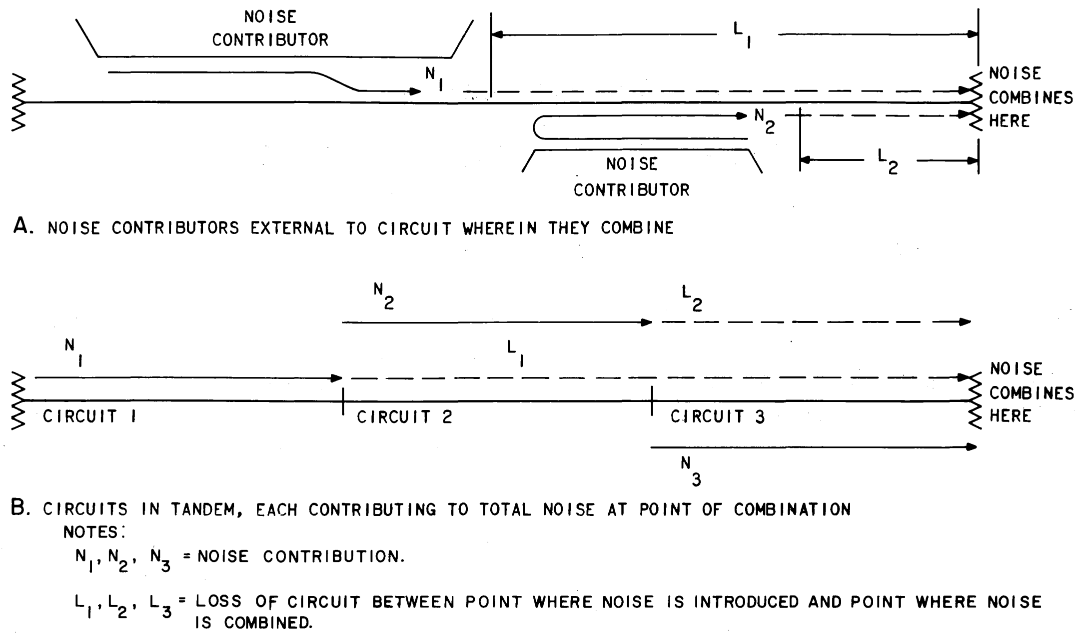

Fig. 1—Examples of Situations in Which Noise Contributions Combine

2.02 Power summation calculations do not apply directly to quantities expressed in dBrn. Such quantities must first be converted to their actual power. The expression

$$10^{-12} \log_{10}^{-1} \frac{\text{dBrn}}{10} = \text{Power (watts)}$$

makes this conversion. The resulting power values may be combined by simple arithmetic summation and reconverted to decibels by the inverse of the preceding procedure.

$$\text{dBrn} = 10 \log_{10} \frac{P_1 + P_2 + \cdots + P_n}{10^{-12}}$$

Where P_1, P_2, and P_n are in watts.

2.03 The procedure described in 2.02 may become quite tedious, especially when several dB quantities are combined. Therefore, both tables and curves have been prepared which provide dB corrections for the difference between two dB quantities that, when added algebraically to the larger of the two, approximate the result of power summation. The largest dB increment is 3.0 dB, corresponding to a 0 dB difference, or equal noise contributors. As the difference between the two quantities being summed becomes larger, the correction becomes smaller until it is negligible for differences larger than 12 dB. Table A gives dB corrections for power summation of quantities expressed in dBrn.

2.04 Power summation provides for combining noise contributions from individual sources, lines, or trunks. This is adequate for estimating the noise (or crosstalk) resulting when two circuits, each contributing a certain known noise level, are connected together in tandem, or when a circuit is exposed to noise from two or more sources. This procedure is applicable to the problem of estimating noise on individual trunks or on groups of trunks using identical facilities. In the latter case, the term "identical" implies an assumption that the noise on each circuit of the channel group is the same.

2.05 The procedure for combining noise values given in dBrn by power summation using

TABLE A

POWER SUMMATION OF TWO UNEQUAL NOISE QUANTITIES EXPRESSED IN dB WITH SAME WEIGHTING*

AMOUNT BY WHICH TWO QUANTITIES DIFFER (dB)	CORRECTION FACTOR (dB)
0 — 0.5	3.0
0.6 — 1.6	2.5
1.7 — 3.0	2.0
3.1 — 4.7	1.5
4.8 — 7.2	1.0
7.3 — 12.2	0.5
Over 12.2	0

* Not suitable for quantities measured in terms of peak power, such as impulse noise.

the tables or curves reduces to a rather simple process as follows:

(a) Be sure that all noise values have been adjusted to a common transmission level point.

(b) Subtract the smaller noise value in dBrn or dBrnc from the larger.

(c) From Table A select the range in which the difference falls. Read the corresponding dB correction from Table A.

(d) Add the dB correction factor to the higher of the two noise values being combined. This is the desired combined value in dBrn.

2.06 As an example, three contributors of 18, 19, and 23 dBrnc combine in a trunk. The resulting value will be determined. To demonstrate that the order in which the original values are chosen is unimportant, the calculation is done three different ways.

(a) Beginning with 18 and 19,

(1) 19 − 18 = 1; from Table A, add 2.5.

(2) 19 + 2.5 = 21.5.

(3) 23 − 21.5 = 1.5; from Table A, add 2.5.

(4) 23 + 2.5 = 25.5 dBrnc.

(b) Beginning with 19 and 23,

(1) 23 − 19 = 4; from Table A, add 1.5.

(2) 23 + 1.5 = 24.5.

(3) 24.5 − 18 = 6.5; from Table A, add 1.0.

(4) 24.5 + 1.0 = 25.5 dBrnc.

(c) Beginning with 18 and 23,

(1) 23 − 18 = 5; from Table A, add 1.0.

(2) 23 + 1.0 = 24.0.

(3) 24.0 − 19 = 5; from Table A, add 1.0.

(4) 24.0 + 1.0 = 25.0 dBrnc.

As noted, these examples demonstrate that the actual order in which the noise values are taken is not important. Further, the differences caused by using the tabular values should seldom exceed half a dB. This combining process is illustrated in Fig. 2. The dashed lines indicate that the result could be combined with additional quantities.

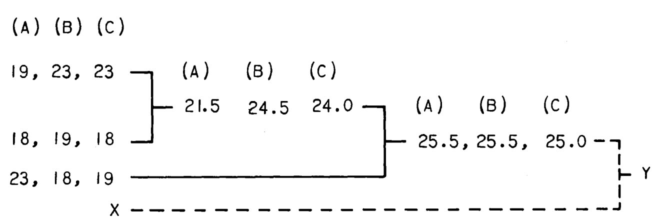

Fig. 2—Combining Three dBrn Quantities