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PART II

SUPPLEMENTS TO RECOMMENDATIONS IN

SECTIONS 2 TO 5 OF THE SERIES G RECOMMENDATIONS

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Supplement No. 4

CERTAIN METHODS OF AVOIDING THE TRANSMISSION

OF EXCESSIVE NOISE BETWEEN INTERCONNECTED SYSTEMS

(referred to in Recommendation G.221;

for this Supplement see page 572, Volume III of the Green Book, Geneva, 1973)

Supplement No. 5

MEASUREMENT OF THE LOAD OF TELEPHONE CIRCUITS | fR UNDER FIELD CONDITIONS

(referred to in Recommendations G.223 and H.51;

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EXAMPLE SHOWING HOW THE TOTAL VALUE OF LINE NOISE SPECIFIED FOR THE HYPOTHETICAL REFERENCE CIRCUIT ON OPEN-WIRE LINES MIGHT BE BROKEN DOWN

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(referred to in Recommendations G.223 and G.311;

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(referred to in Recommendation G.229;

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(referred to in Recommendations G.233 and G.242;

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MATHEMATICAL MODELS OF MULTIPLEX SIGNALS

(referred to in Recommendation G.223;

for this Supplement see page 326, Fascicle III.2 of the Red Book,
Geneva, 1985)

Supplement No. 23

EXPLANATORY NOTES FOR THE INFORMATION OF DESIGNERS

OF A MARITIME MOBILE SATELLITE SYSTEM

(Geneva, 1980; referred to in Recommendation G.473)

1 Allocation of losses in the maritime system

1.1 *Complying with Recommendations*

1.1.1 Figure 1 illustrates the nomenclature adopted in this Supplement and the arrangements for a 2-wire switched shipboard installation.

Note of the Secretariat — A revision of Recommendations G.111 [1] and G.121 [2] has been adopted introducing the new concept of corrected reference equivalents. The values of reference equivalents are maintained here for the next Study Period to give planners sufficient time to become acquainted with the new concepts.

Figure 1 p.

1.1.2 The CCITT Recommendations which jointly influence the choice of the losses in the path (a — b) and the reference equivalents of the local system referred to an appropriate set of terrestrial virtual switching points are as follows:

Recommendation G.122 [3] — To ensure that international connections have an adequate stability the loss (a — b) at any frequency in the band 0 to 4 kHz should not be less than ($6 + n$) dB where n is the number of 4-wire circuits in the national chain.

Recommendation G.131 [4] — When calculating stability the variations of loss in the two directions of direction are taken to be fully correlated.

Recommendation G.151 [5] — The standard deviation of transmission loss for modern national and international circuits should not exceed 1 dB.

We seek a prima-facie assurance that the contribution of the maritime extension to the stability of the 4-wire chain is not worse than that of a comparable national extension. The factors affecting the stability are mean departure from nominal, standard deviation of loss, and attenuation distortion. The mean departure from nominal and standard deviation are expected to be about twice the corresponding values for a terrestrial circuit so that the one satellite circuit can be regarded as having the same effect as four terrestrial FDM circuits when full correlation is assumed. As far as attenuation distortion is concerned, since the channel equipments in the shore station are not in permanent association with those on board ship, between-channel variations manifest themselves as another source of variance among the connections and an allowance of 1 dB is made for this effect.

The formula in the Recommendation cited in [3] can be rewritten as ($6 + 1n$) in which the coefficient 1 dB/circuit is explicit rather than implicit, and we have derived the coefficient 4 + 1 = 5 dB/circuit for the case of the satellite circuit. Hence, with $n = 1$ we obtain the condition:

$$S + R + B \geq 11$$

Recommendation G.161, Test 8 [6] — The equivalent level go/return loss on the office-side of the echo suppressor should not be less than 6 dB. In principle, this quantity, which can be derived from the relative levels at the 2-wire switch point, is to be evaluated under conversational conditions at any frequency within the detection band of the echo suppressor.

Recommendation G.121 [2] — The various constraints on the reference equivalents and losses of national systems are as follows, in which the over-bar indicates an average value:

SRE: | fR preferred range: 10 to 13 dB

permissible range: 10 to 16 dB

RRE: | fR preferred range: 2.5 to 4.5 dB

permissible range: 2.5 to 6.5 dB

i.e.: 10 *S + s | fR 13 or 16; 2.5 R + r | fR 4.5 or 6.5*

These values obviously take into account variations although we shall assume that the variability of *s* and *r* are small, i.e. that *s | fR = s* and *r | fR = r* .

SRE_{max} = 21 dB, i.e.: *S + s* 21

RRE_{max} = 12 dB, i.e.: *R + r* 12

These are 97% planning values but we shall take them as 100% planning values.

SRE_{min} = 6 dB, i.e.: *S + s* ≥" 6

Ideally this should take variations into account but the recommendation is in terms of a planning value.

Difference between the losses (*a* — *t*) and (*t* — *b*) should not exceed 4 dB, i.e.: | fIS — *R* | 4.

1.1.3 The Recommendations do not enable us to ascertain the separate values of *S* and *R* because the CCITT does not specify any particular subdivision of national reference equivalents as between the local system and the circuits in the remainder of a national extension.

We may simplify the problem by assuming that during the set-up or clear-down of the connection it is not possible to prevent *B* = 0, so that *S + R* = 11 and furthermore we shall aim to stay within the preferred ranges of mean values of the reference equivalents recommended for a national system.

1.1.4 It is clear that within the constraints of:

S + R = 11; | fIS — *R* | 4; | fIS
—
S | fR |
0.5; | fIR —
R | fR | 0.5; 10
SRE | fR 13; 2.5
RRE | fR 4.5

the individual values of *S* and *R* can be chosen to permit a range of reference equivalents for the shipboard local system as illustrated by the solution domains shown in Figure 2. We must therefore seek other criteria on which to base a decision.

Figure 2 p.

1.2 *Subjective criteria*

1.2.1 Figure 3, which is based on the corresponding one in Recommendation G.473, illustrates various minimum, average, and maximum configurations utilizing the information concerning traffic routing contained in [7]. These routings have been used to develop hypothetical reference connections based on Recommendation G.103 [8] to enable the effects of loss, noise, and distortion to be studied in accordance with the principles outlined in the CCITT manual cited in [9].

Figure 3 p.

1.2.2 A few *S, R* and hence *s, r* values within the permitted solution domains have been studied in order to determine an optimum set from the point of view of subscriber opinion. The results of two such calculations are recorded in Table 1.

In one calculation the *S* and *R* values were equal (i.e.: the *S/R* differential was zero) and the *SRE | fR and RRE | fR values were in the middle of their preferred ranges (SRE | fR = 11.5; RRE | fR = 3.5; S* = 5.5; *R* = *s* = 6; *r* = —2). In the other calculation half the permitted *S/R* differential was introduced reducing the *RRE | fR at the expense of the SRE | fR but nevertheless keeping their values within 0.5 dB of the extrema of their preferred ranges to allow for the 0.5 dB mean departure from nominal in the values of S* and *R* . (*SRE | fR = 12.5; RRE | fR = 3; S* = 6.5; *R* = 4.5; *s* = 6; *r* = 1.5).

Table 1 T1.23, p.

1.2.3 Table 1 shows that moving from the centre of the preferred ranges has hardly any effect on the opinion scores of the shipboard customer but has a somewhat greater, worsening effect on the inland customer particularly on the maximum routing. Hence we advocate arrangement B in which the *SRE | fR and RRE | fR are at the middle of their preferred ranges. This arrangement also has the advantage that the inland and ship-board customers' opinions are more nearly equal in the case of the average routing (which we must assume will carry the most traffic). This is only true for %D* , not for %*P + B*

1.2.4 Figure 4 illustrates how opinion worsens as the design noise power of the maritime satellite system increases from 10 | 00 pW0p (—50 dBm0p) to 100 | 00 pW0p (—40 dBm0p). These are the effective design noise power levels, i.e.: either an uncompandored noise power level, or the result of a 2:1 compandor with a 0 dBm0 unaffected level operating on a higher noise power level, in which case the empirical rule one-third speech-on noise power level plus two-thirds speech-off noise-power level was used to calculate the effective noise (see [11]).

Note — The reference equivalents of the maritime system are *SRE | fR = 11.5 and RRE | fR = 3.5. Only the effects of loss, noise, bandwidth limitation, and attenuation/distortion have been estimated. The effects of delay and imperfectly-suppressed echo could not be taken account of in the calculations but they should not be disregarded.*

Figure 4 p.

1.3 *The preferred arrangement with 2-wire switching*

1.3.1 Figure 5 illustrates the preferred arrangements upon which Recommendation G.473 is based. All the arrangements are in terms of the CCITT quantities which relate to virtual switching points on the international circuit.

It is clear that SRE_{min} ≥" 6 is comfortably met in these arrangements, using planning values. We note that the limit is also met even when variation is allowed for; the 2.33 σ value for the mid-range value of the *SRE* is 11.5 — 0.5 — 2.33(2) = 6.3 (rounding down to the nearest 0.1).

1.3.2 Diagram I of Figure 6 gives an example of how Arrangement I could be realized in a practical installation. We have assumed the following:

— actual 4-wire switching levels of —2 dBr, which is typical of many international switching centres;

— a 2-wire sending level of 0 dBr, which is suitable for a local system with a nominal mid-range value of sending reference equivalent of 6 dB (*SRE*) connected to that point;

— symmetrical 3.5 dB terminating units;

— channel translating equipments operated at relative levels of +4 dBr/—14 dBr, a pair of levels appearing in Recommendation G.232;

— far-end operated, half-echo suppressors introducing 0 dB transmission loss at the appropriate relative levels.

1.3.3 It remains to calculate the equal-level go/return loss on the office side of the echo suppressor which is seen to be

$$9.5 + 3.5 + B + 3.5 + 10.5 — 18 = 9 + B$$

thus complying with the test conditions of Recommendation G.161 [12] (assuming no negative B-values). The quantity 10 can be obtained with more insight and less arithmetic by taking the difference of the two relative levels at the 2-wire switch point.

Figure 5 p.

Figure 6 p.

1.4 *Arrangements with 4-wire switching*

1.4.1 Figure 5 also illustrates two other arrangements which incorporate 4-wire switching: Arrangement II which retains a 2-wire handset, and Arrangement III which is wholly 4-wire. Examples (for guidance only) of the corresponding practicable realizations are shown in Figure 6.

1.4.2 A half-echo suppressor is shown in Figure 6 for the wholly 4-wire case. This is to control, if necessary, the echo that might arise from the acoustical path via the handset of the shipboard subscriber. The total echo loss demanded between virtual switching points is effectively 56 dB (a consequence of the Recommendations cited in [15] and [3]). The minimum (electrical) go/return loss is required to be of the same order (the Recommendation cited in [16]) so as not to nullify the effect. It is clear that the shipboard installation should aim at a comparable performance. The recommended values of *RRE* and *SRE* shown in Figure 5 add up to 15 dB which implies that the acoustic go/return loss must fall below 41 dB. As the

system designer has no control over how the ordinary subscriber uses his handset there is a prima facie case for assuming little possibility of being able to guarantee this value. However, there is little experimental data on this topic and further study is desirable. The results of such a study may indicate that suppressors can be dispensed with in wholly 4-wire installations. Four-wire head and breast sets (or press-to-speak handsets) used for special purposes by trained persons would be less troublesome in this regard and it is unlikely that a ship-board suppressor would be needed for these cases.

1.5 *Taking advantage of a non-zero stability balance return loss*

1.5.1 All the allocations of loss shown for a 2-wire local system tacitly assume that during set-up or clear-down there is the possibility of zero balance return loss at the 2-wire/4-wire terminating set. However, if special arrangements are made, as indicated for example in Recommendation Q.32 [14] so that at all times a certain minimum positive value is assured, there can be corresponding reductions of the *S* , *R* values and increases of the *s* , *r* values.

1.5.2 The arrangements of Recommendation Q.32 [14] introduce a minimum of 6 dB balance return loss and assuming this to be less than the off-hook balance return loss of the shipboard local system, the *S* and *R* values could be reduced by 3 dB each and the *s* , *r* values correspondingly increased. Other partitions are possible, provided they comply with constraints given in § 1.2 above. It is clear that if *S* and *R* can be reduced in this way there is more scope for catering for a range of existing shipboard local systems.

2 Estimated speech power levels and signal-to-noise ratios

2.1 *Speech power levels entering the maritime system at the shore station*

2.1.1 We can estimate the mean and standard deviation of the speech power levels at the shore station by considering the relevant Recommendations. Naturally this is not claimed to be the same as measured values, but it is probably the best we can do for planning purposes, particularly since traffic-weighted values are not really appropriate for equipment design if a worldwide service is planned for.

2.1.2 *Recommendation G.121* [2]: National systems

Mean *SRE* calculated to international virtual analogue switching points: 13 dB

Range is (21 — 6) = 15 dB from which, as an approximation, standard deviation = ¼ (range) = 3.8 dB.

2.1.3 *Recommendation P.16* [17]: Crosstalk

Conversational speech power level from an active median talker via a 0 dB *SRE* end is —6 dBm; standard deviation is 4.8 dB.

2.1.4 *Annex 2, Question 1/XVI* [7]: International 4-wire chain

From the statistics of the international 4-wire chain recorded in [7] we obtain the estimate of the mean and the variance of the transmission loss of this portion of the connection shown in Table 2, assuming that the circuits comply with the provisions of Recommendation G.151 [18] in respect of standard deviation.

Table 2 T2.23, p.

2.1.5 Combining all these estimates, the distribution of speech power levels at the input to the maritime system at the shore station we obtain:

$$\text{Mean} = —13—6—0.6 = —19.6 \text{ dBm}$$

$$\text{Standard deviation} = \sqrt{.8^2 + 4.8^2 + 1.108} = 6.2 \text{ dB}$$

2.1.6 We can reasonably assume —3.5 dBr to be the relative level at the input to the maritime system directly connected to the receive virtual switching point of the international circuit delivering the signal, although strictly speaking there is no recommendation concerning the relative level at these points on the ‘‘national’’ side of the virtual switching points.

2.1.7 Hence we finally obtain as a defensible system planning value:

Mean = Median = —16.1 dBm0

Standard Deviation = 6.2 dB.

2.2 *Speech power level at the input to the maritime system from the shipboard local system*

In any studies concerning a fixed threshold setting (e.g. for echo suppressor or noise squelch circuit) it should be noted that the mid-range value of the sending reference equivalent referred to a 0 dBr point for the shipboard local systems illustrated in Figure 6 is 6 dB corresponding to a mean active speech power level of —11.5 dBm0, so that 99% of talkers would not fall below —12 — 2.33(4.8) = —23.5 dBm0. This would thus be a suitable level for a threshold detector based on mean active power level. A detector responding to syllabic power levels would need to be set somewhat lower if centre clipping effects are to be avoided. If an increase of the *s* value is foreseen (as a result of the considerations outlined in § 1.5.2 above) the mean active speech power level will be correspondingly reduced.

2.3 *Distribution of speech signal-to-noise ratios at the output of the maritime system on board ship*

2.3.1 What follows is an elementary estimate of the distribution of the speech signal-to-noise ratio in a switched telephone network, in which there is a distribution of speech volumes, using a maritime satellite system achieving the long-term aim of a design noise power level of —50 dBm0p (10 | 00 pW0p) regarded as essentially constant for most of the time. This, of course, represents a reversal of the basis on which conventional HF radio circuits are designed in which the speech volume is assumed to be held substantially constant by means of a constant volume amplifier (or a technical operator), and the noise being regarded as the variable.

2.3.2 *Signal* — Since the distribution of speech volumes is substantially log-normal, the speech power level of the active median talker is given by:

$$10 \log_{10}(\text{mean power}/1 \text{ mW}) - 0.115\, \sigma^2$$

where σ^2 is the variance of the distribution of speech power levels. Allowing, say 2 microwatts for echos and other currents, the conventional load for the speech power at a 0 dBr point averaged over all channels is 20 microwatts and the conventional activity factor is 0.25. Hence the (conventional) mean active speech power is 80 microwatts. The standard deviation of speech volumes is of the order of 6.2 dB (see § 2.1.5 above). We obtain from these figures:

speech power level of the active median talker

$= 10 \log_{10}(80/1000) - 0.115(38.44) = -15.4$ dBm0

Noise — In the case being considered, i.e. the long-term aim, the constant equivalent value is —50 dBm0p.

2.3.3 Hence, the mean signal-to-noise ratio Q_{R}, is $Q_{R} = S_{R} - N_{R} = -15.4 - (-50) = 34.6$ dB. Q is normally distributed with a standard deviation of 6.2 dB, and the principal source of variation in the signal level will arise either from different talkers on the various channels provided by the maritime satellite link, or from successive talkers on a particular channel, i.e.: it is assumed that the process is essentially ergodic. Hence we can construct Table 3 showing the various percentages of time (to the nearest 1%) for which particular values of signal-to-noise ratios are exceeded by setting $k = (Q - 34.6)/6.2$ and consulting tables of the normal variate.

Table 3 T3.23, p.

2.3.4 In the case of the short-term limits for noise, Figure 4/G.473 defines the following functional relationships between S (speech signal) and Q (signal/noise ratio) as

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