

tion, the office loss, and the hybrid loss. These determine the values of the T and R pads required to meet the -16 and +7 TLPs at the input and output of the carrier link. See Notes 1 and 2 of Fig. 1.

2.02 Assuming a switch pad loss of 2 dB in Fig. 1 and a hybrid loss of 4 dB on each side, the T and R pads at the switch must equal 3 and 8, respectively, (+7 - 3 - 4 - 2 = -2 and -16 + 8 + 4 - 2 = -2). Obviously, the values of T and R pads nearest the data set depend on the loop loss (X) of the 2-wire section.

2.03 Considering the portion of circuit identified in Note 2(K) of Fig. 1 and assuming a worst-case balance to exist at each hybrid (a short circuit on the 2-wire sections), this portion of the circuit would sing if the total gain exceeds the total loss. For example, the 23-dB carrier gain in each direction exceeds the sum of all losses (hybrid losses of 8 dB at each end plus all pads).

Example: $T + R + 8 + 5 + 8 + 10 = 23 + 23$

$$T + R = 46 - 27$$

$$T + R = 19$$

2.04 In order to meet the required TLPs, the T and R pad values at the data set depend on the loop loss (X) of the 2-wire section.

Example: $X + 4 + T = 21$ or $T = 17 - X$

$$X + 4 + R = 16$$
 or $R = 12 - X$

In the above equations, the practical values of X extend from 0 to 12 dB; anything greater than 12 produces a negative value for R. **However, T + R must (in this example) exceed 19 to satisfy the conditions for an acceptable singing margin.** See paragraph 2.03. In other words, there is a maximum 2-wire loop loss beyond which an acceptable singing margin will not exist.

2.05 The maximum permissible loss in the 2-wire section of the loop must be determined by

using the equation in paragraph 2.03 and substituting values for T and R in terms of X, as obtained in the equations in paragraph 2.04.

Example: $T + R = 19$

$$(17 - X) + (12 - X) = 19$$

$$2X = 29 - 19$$

$$2X = 10$$

$$X = 5 \text{ (Maximum 2-wire loss)}$$

2.06 Had the design required an end-to-end loss other than 6 dB, the maximum permissible loss in the 2-wire section would be some other value. The design shown in Fig. 2 of Section 880-440-103 would require an end-to-end loss of 4 dB since that design is shown terminating in a class 5 office. One should observe that the general rule is the maximum permissible loss in the 2-wire cable section is equal to overall loss less any loss in the 2-wire portion of the circuit at the switch.

2.07 The amount of singing margin achieved with this design depends entirely on the return losses of the two hybrids at each carrier terminal. A listener echo requirement for data sets exists which depends on their data rate. For data sets operating at 2400 bps and below, it is 12 dB; while for those operating above 2400 bps, it is 18 dB. When this requirement is combined with the expected long-term 1004-Hz loss variation of ± 4 dB on carrier facilities, the required singing margin of the carrier section is 20 dB for lower speed data sets and 26 dB for higher speed data sets. The combined return losses achieved in the hybrids at each end of the carrier section must equate to these values. If the return losses of each hybrid are assumed to be equal (not likely), they should each be 10 dB or 13 dB, depending on the highest speed of the data set using the facility.

2.08 If the 2-wire cable loss is less than 5 dB in the example, the difference between that loss and 5 dB can be inserted in each path of the 4-wire carrier section and the total return loss of the hybrids can be reduced by the increased loss inserted.