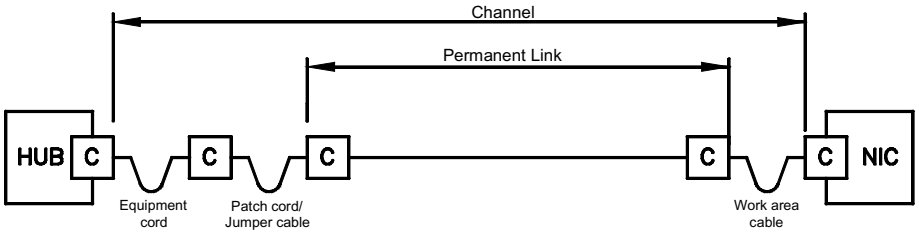
Annex 33e (informative)

The proposed standard sets the maximum current that can be continuously drawn by the powered device at 350 milliamps total or 175 milliamps per individual conductor of the differential pair. One drawback to implementing this scheme and should always be considered is the DC resistance imbalance between the two conductors. A typical channel can contain up to 5 interconnects and 100 meters of wire (see Figure 1).



Where: C=connection (mated pair); NIC=Network Interface Card

FIGURE 33e-1, CHANNEL CONFIGURATION

Per the standard, the resistance balance between the channel's two paths is specified to be better than 3 percent. At the maximum current allowed this imbalance equates to a 10.5 mA difference between the two paths.

Significant work on current imbalance in transformers has shown that certain data patterns induce a large base line wander. Base line wander induced a DC offset comparable to 6mA. The transformer specification that resulted is 350 μH under all conditions of tolerance, temperature, and with 8mA of DC bias.

Using a transformer that can only tolerate this amount of DC bias reduces the maximum current the PSE can deliver without saturating the transformer to:

(33e-1): $$350\ \text{mA} \bullet \left(\frac{8\ \text{mA}}{10.5\ \text{mA}} \right) = 267\ \text{mA}$$

In order to restore the current capability to 350 milliamps some form of ballast circuitry must be employed. Figure 2 details a method for resolving cable and connector imbalances by using two resistors. Note that these ballast resistors are required at each end of both the transmit and receive channels. The addition of the capacitor in parallel with the resistors helps to minimize the signal loss induced by the balancing resistors and should be selected to present a low impedance at the lowest signal frequency.

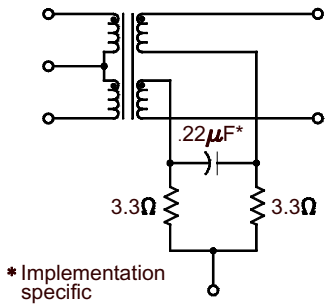


FIGURE 33e-2, TRANSFORMER DETAIL

Table 33e-1 details the resistance of different cable sizes over minimum and maximum temperature ranges. These resistance values are used in calculations to resolve connector imbalance and voltage drops.

AWG	Min @ 0 C	Max @ 0 C	Nominal Ω	Min @ 50 C	Max @ 50 C
26	12.18	12.79	13.47	14.70	15.43
24	7.65	8.03	8.42	9.14	9.60
22	4.81	5.05	5.31	5.79	6.08

Table 33e-1, Cable Resistance in ohms at 100 Meters

For purposes of calculating the ballast resistors, a typical maximum configuration of five connectors is used. Each connection point has one contact measuring zero ohms with the other contact measuring .02 ohms, the maximum allowed resistance per IEC 512-2. Furthermore, a five-meter length of 22 AWG cable is used because longer lengths reduce the imbalance. The equations describing this interaction are:

(33e-2): $$\left(\frac{I_{out}+I_{imbal}}{2}\bullet\left(\frac{R_c}{1.03}+\frac{R_b}{1.01}\right)\right)=\left(\frac{I_{out}-I_{imbal}}{2}\bullet\left(R_c\bullet 1.03+R_b\bullet 1.01+R_{conn}\right)\right)$$

Where: I_{out} = 350 mA, (maximum current from PSE)
I_{imbal} = 8 mA, (current difference between the 2 paths)
R_c = .24 Ω, (5 meters of 22 AWG cable)
R_b = 6.6 Ω, (ballast resistance)
R_{conn} = .1 Ω, (total contact resistance for 5 connectors)

Under these conditions the worst case current imbalance is 6.2 mA and using 3.3 ohm ballast resistors increases the total voltage drop associated with the cabling by:

(33e-3): $$\left(175+\frac{6.2}{2}\right)\text{mA}\bullet\left(4\bullet 3.3\ \Omega\right)=2.35\ \text{V}$$

Per the standard the minimum voltage sourced by the PSE must be greater than 44 volts and that the maximum voltage presented by the PD must be less than 36 volts. This 8 volt margin permits up to 45.7 ohms of resistance to exist between the PSE and PD under maximum current conditions. Even under worst case conditions of

temperature and tolerance, using 3.3 ohm ballast resistors in series with 100 meters of 26 AWG cable (see Table 33e-1) still provides a margin of:

(33e-4): $8\ V - (175\ mA \bullet (30.86\ \Omega \bullet 1.03 + .1 + 4 \bullet 3.3\ \Omega \bullet 1.01) = .28\ V$

The ballast resistors will dissipate worst case power during an over-current condition, which the standard has set at 500 mA. In this case the wattage rating of the ballast resistors would be:

(33e-5): $\left(\frac{450\ mA}{2}\right)^2 \bullet 3.3\ \Omega = .17$ watts

Or using standard sizes, .25 watts.