DRAFT 1

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Test Procedure to establish operating limits for the continuous DC current of copper components specified in TIA/EIA-568 and ISO/IEC 11801.

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1 INTRODUCTION

Recent developments in the standardization and application of DC powering over structured cabling has stimulated the need to further investigate the DC powering characteristics of cabling specified in both the TIA/EIA-568-B, and ISO/IEC 11801 telecommunication cabling standards.

2 OBJECTIVES

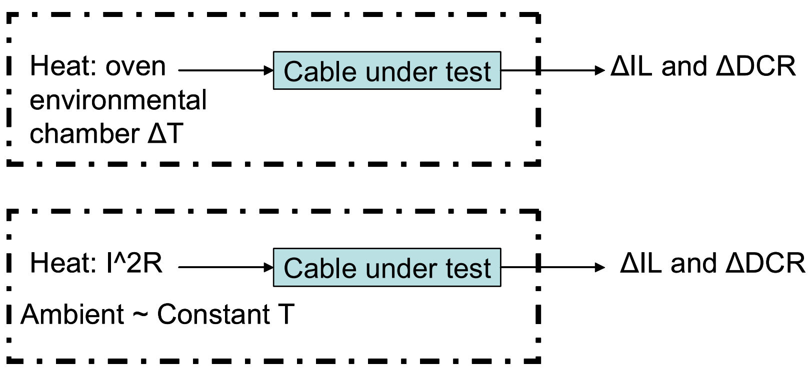
The objective of this test procedure is to determine acceptable operating limits for the continuous DC current of the copper components (e.g., cables and connectors) specified in TIA/EIA-568 and ISO/IEC 11801.

The connector test evaluates the increase in low level contact resistance (LLCR) due to the mating and unmating cycles under specified current and load conditions.

3 Cable Test

The continuous DC current rating of the cable is specified to limit the temperature dependent increases in attenuation and DC resistance as a result of the applied continuous DC current.

Figure 1 Cable test



Legend:
ΔIL = change in the insertion loss
ΔDCR= change in the DC resistance

The cable test evaluates the insertion loss, DC resistance, and temperature increases due to the application of a continuous DC current.

The cable test compares the changes of the attenuation and DC resistances due to increases in external temperature to the changes in attenuation and DC resistances due to the application of a continuous DC current where the ambient temperature is held constant.

Two methods for evaluating the change in attenuation are under consideration. In the first phase of testing both methods shall be used.

<u>Method 1:</u>

The changes in attenuation are determined utilizing equation 1[1].

$$\alpha T = \alpha Tref + \left[\Delta T \cdot \alpha Tref \cdot \left(\frac{k}{100}\right)\right] \quad [°C] \qquad \text{Equation 1}$$

Where:

- αT is the attenuation at an elevated temperature with respect to the reference temperature.
- κ is the temperature coefficient of attenuation increase in percent measured in step 1 – subclause 3.2. Bundle Cable Test Procedure
- $\alpha Tref$ is the attenuation at the reference temperature
- ΔT is the temperature differential between reference temperature and the test temperature determined utilizing equation 2.

The variable ΔT in equation 1 is determined utilizing equation 2[2] from the measured change in the DC resistance.

$$\Delta T = \frac{R - Ref}{Ref \cdot Tcoef} \quad [°C] \qquad \text{Equation 2}$$

Where:

- T is the conductor temperature in degrees Celsius
- Tref is the reference temperature that α is specified at for the conductor material
- R is the conductor resistance at temperature "T"
- Rref is the conductor resistance at reference temperature Tref
- Tcoef is the temperature coefficient of copper at 20 deg C is .00393

<u>Method 2.</u>

The changes in attenuation are measured utilizing a network analyzer. The powering circuit must be interrupted during the insertion loss measurements. The measurement of insertion loss during powering is under study.

3.1 Cable test configurations

The cable test configurations are designed to enable "worse case" analysis. Two distinct categories of testing are identified to facilitate the controlled experiments.

1. Tests will be performed on configurations representative of structured cabling environments and installation practices.
2. Tests will be performed on configurations constructed to control the physical size of the experiment (i.e., the cabling under test).

3.1.1. Bundled Cable configurations

The cables under test are organized in bundled cable configurations where the reference cable

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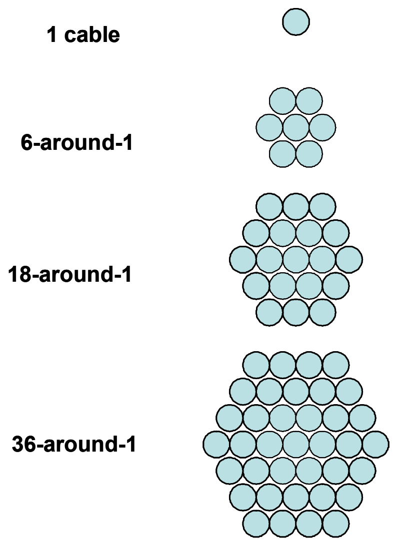
[1] Reference: IEC 61156 and ASTM D 4566

[2] The (Tcoef) constant is the temperature coefficient of copper and symbolizes the resistance change factor per degree of temperature change. The Temperature Coefficient of Copper (near room temperature) is +0.393 percent per degree C. This means if the temperature increases 1°C the resistance will increase 0.393%.

under test is the central cable and surrounded by all of the other cables. The cables are tie wrapped with placement of tie wraps every 1 ft (TBD). The cables are bundled by incrementally adding cable layers to construct a six-around-one (7 cables), an 18-around-1 (19 cables), and a 36-around-1 (37 cables) as illustrated in figure 2

Figure 2 Bundled cable configuration



3.2. Bundle Cable Test Procedure

Step 1.

- Measure the changes of attenuation and DC resistances due to increases in external temperature of the reference cable in an air-circulating oven or an environmental chamber and determine the temperature coefficient of attenuation increase per ANNEX A test procedure.

Step 2.

- Measure and record the changes in DC resistances and attenuation of the reference cable in an air conditioned room due to the application of a continuous DC current of 175 ma, 350 ma, 420 ma, and 500 ma utilizing the DC powering circuit illustrated in figure 4. Maintain a minimum conditioning period of period of 4 hours between the application of each current.

- Report a comparison of the changes in attenuation utilizing Method 1.and Method 2. .

Step 3.

- Organize cables in a 6-around-1 configuration where the reference cable is the central cable and adjacent to all of the other cables.

- Power the reference cable. Measure and record the attenuation and DC resistances of the reference cable due to the application of a continuous DC current of 175 ma, 350 ma, 420 ma, and 500 ma utilizing the DC powering circuit illustrated in figure 4. Maintain a minimum conditioning period of period of 4 hours between the applications of each current. The powering circuit is interrupted during the insertion loss measurements.

- Power the remaining 6 cables in the bundle. Measure and record the attenuation and DC resistances of the reference cable due to the application of a continuous DC current of 175 ma, 350 ma, 420 ma, and 500 ma utilizing the DC powering circuit illustrated in figure 4. Maintain a minimum conditioning period of period of 4 hours between the applications of each current. The powering circuit is interrupted during the insertion loss measurements.

- Report a comparison of the changes in attenuation utilizing Method 1.and Method 2. .

Step 4.

- Organize cables in an 18-around-1 configuration by adding cables to the 6-around-1 configuration

- Power the reference cable. Measure and record the attenuation and DC resistances of the reference cable due to the application of a continuous DC current of 175 ma, 350 ma, 420 ma, and 500 ma utilizing the DC powering circuit illustrated in figure 4. Maintain a minimum conditioning period of period of 4 hours between the application of each current. The powering circuit is interrupted during the insertion loss measurements.

- Power the 6 cables from step 3. Measure and record the attenuation and DC resistances of the reference cable due to the application of a continuous DC current of 175 ma, 350 ma, 420 ma, and 500 ma utilizing the DC powering circuit illustrated in figure 4. Maintain a minimum conditioning period of period of 4 hours between the application of each current. The powering circuit is interrupted during the insertion loss measurements.

- Power the remaining 12 cables in the bundle. Measure and record the attenuation and DC resistances of the reference cable due to the application of a continuous DC current of 175 ma, 350 ma, 420 ma, and 500 ma utilizing the DC powering circuit illustrated in figure 4. Maintain a minimum conditioning period of period of 4 hours between the application of each current. The powering circuit is interrupted during the insertion loss measurements.

- Report a comparison of the changes in attenuation utilizing Method 1.and Method 2. .

Step 5.

- Organize cables in a 36-around-1 configuration by adding cables to the 18-around-1 configuration

- Power the reference cable. Measure and record the attenuation and DC resistances of the reference cable due to the application of a continuous DC current of 175 ma, 350 ma, 420 ma, and 500 ma utilizing the DC powering circuit illustrated in figure 4. Maintain a minimum conditioning period of period of 4 hours between the application of each current. The powering circuit is interrupted during the insertion loss measurements.

- Power the 6 cables from step 3. Measure and record the attenuation and DC resistances of the reference cable due to the application of a continuous DC current of 175 ma, 350 ma, 420 ma, and 500 ma utilizing the DC powering circuit illustrated in figure 4. Maintain a minimum conditioning period of period of 4 hours between the application of each current. The powering circuit is interrupted during the insertion loss measurements.

– Power the 12 additional cables from step 4. Measure and record the attenuation and DC resistances of the reference cable due to the application of a continuous DC current of 175 ma, 350 ma, 420 ma, and 500 ma utilizing the DC powering circuit illustrated in figure 4. Maintain a minimum conditioning period of period of 4 hours between the application of each current. The powering circuit is interrupted during the insertion loss measurements.

– Power the remaining 18 cables in the bundle. Measure and record the attenuation and DC resistances of the reference cable due to the application of a continuous DC current of 175 ma, 350 ma, 420 ma, and 500 ma utilizing the DC powering circuit illustrated in figure 4. Maintain a minimum conditioning period of period of 4 hours between the application of each current. The powering circuit is interrupted during the insertion loss measurements.

– Report a comparison of the changes in attenuation utilizing Method 1.and Method 2. .

Figure 3 Cable Test Procedure

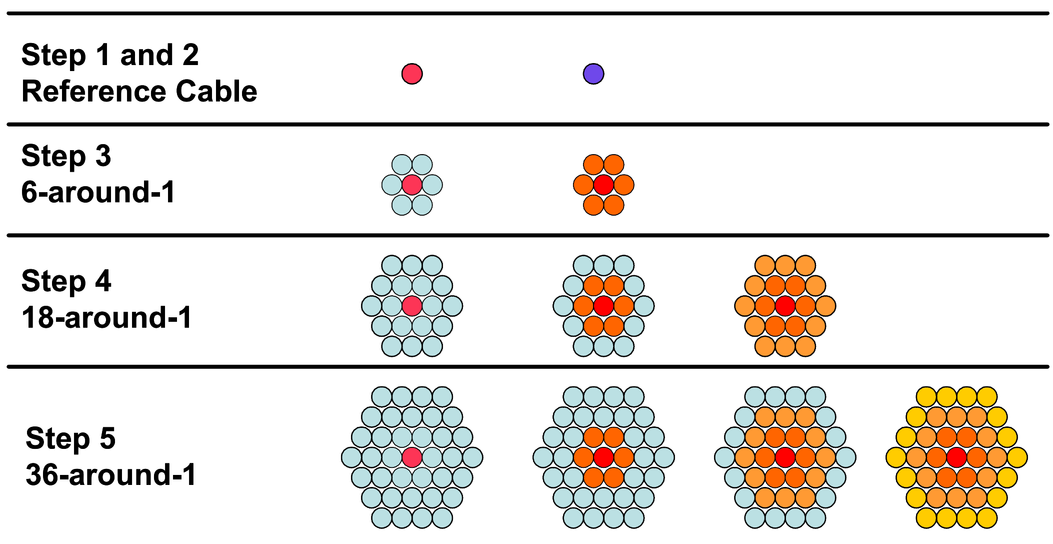
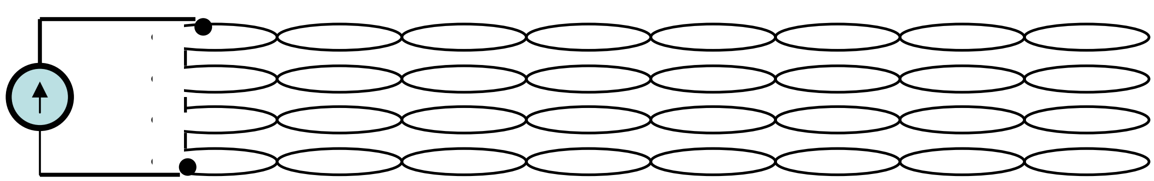


Figure 4 DC powering circuit for each cable



4. Connector Testing

To ensure reliable operation over the usable life of the 8-position modular connectors used in TIA and ISO cablings systems, the modular connections are required to comply with reliability requirements.

<u>ISO/IEC 11801 2nd</u> edition specifies that: Connecting hardware (per IEC 60603-7 for unscreened or IEC 60603-7-1 for screened) must withstand ≥ 750 cycles for telecommunication outlet type interfaces and must withstand ≥ 200 cycles for other connections.

Note: Mating and unmating under load is for further study in ISO/IEC 11801 2nd edition.

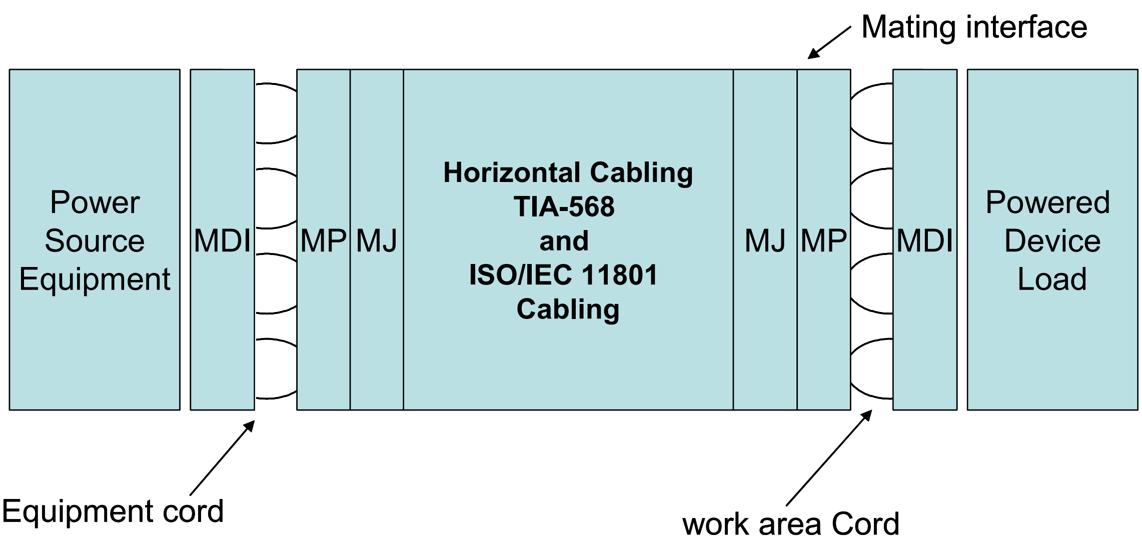
<u>TIA/EIA-568-B.2</u> specifies that: For connecting hardware with 8-position modular connectors, the modular connection shall comply with Level A reliability requirements of IEC 60603-7 (i.e., ≥ 750 cycles).

4.1 Mating and unmating under load for 802.3af applications

Figure 6 illustrates an example connector cycling test configuration. The power source is connected to the powered device load via the horizontal cabling. The modular plug at the mating interface is mated and unmated. The connector must withstand TBD cycles of mating and unmating with ≤ 20-milliohm increase in low level contact resistance (LLCR).

For 802.3af, the power sourcing equipment turns power on (≤ 400 ms) after a valid powered device has been detected i.e., the power is applied “after” mating. Therefore, the mating half of the cycle is not tested with voltage applied.

Figure 6 Connector test topology



Where:

MDI – 802.3.af meda dependent interface
MP – 8-position modular plug
MJ – 8-postion modular jack

4.2 Test procedure circuit diagrams

4.2.1 Test load circuit to set variable current and mating cycle load

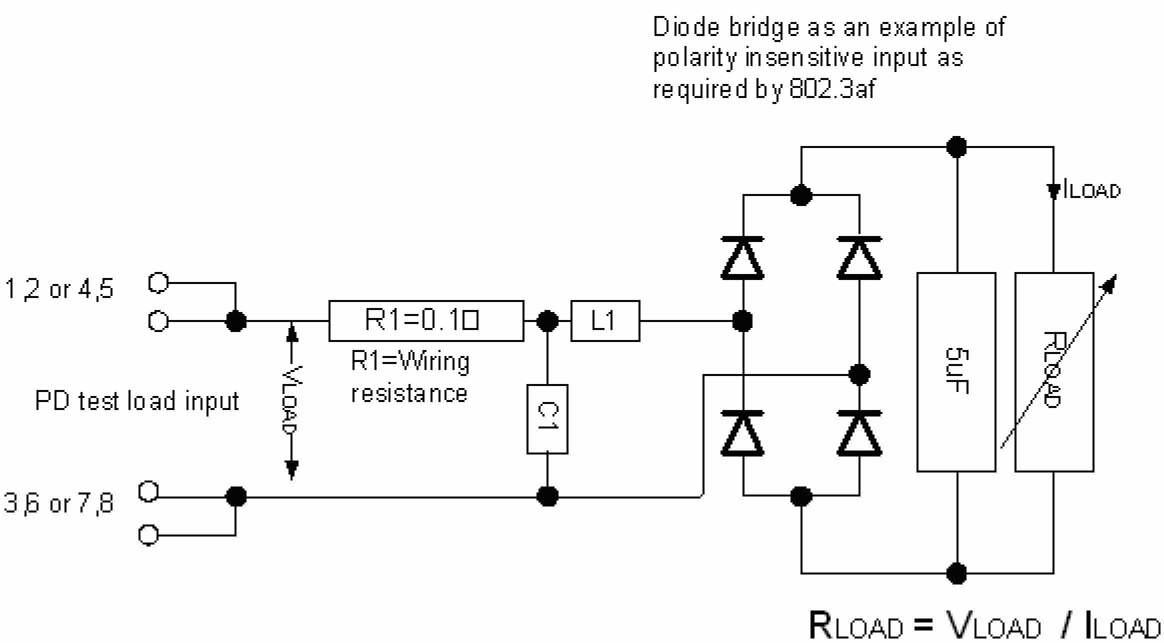
4.2.1.2 Setting the test current

Rmin of the Figure 7 load circuit is adjusted to set the test currents in steps 2-5.

4.2.1.3 Mating cycle load

The load circuit used for evaluating increases in the low level contact resistance (LLCR) testing during unmating is illustrated in Figure 7.

Figure 7 Circuit to set variable current and mating cycle load



Notes: L1 and C1 forms possible EMI filter components in the PD.
L1max=100 uH, C1 (typical)=0.1 uF.
Rload is a variable load that is used to set the load currents in subclause 3.2 steps 2-5.

ANNEX A Temperature coefficient of the attenuation and DC resistance

A.1 Test Chamber

Either an air-circulating oven or an environmental chamber can be used as follows.

- Air circulating oven conforming to ASTM D 5423, Type II with vents either open or closed.
- Temperature and relative humidity (RH) shall be maintained within ± 2ºC (TBD) and ± 5% RH respectively for the duration of a test cycle

A.2 Sample Preparation

Sample length shall be 100 m ± 10 cm. The ends of the cable shall be placed such that they are accessible outside of the oven. The length of sample outside the oven shall be less than 2 m for each end.

A.3 Test Equipment

The equipment used for measuring attenuation (insertion loss) over the specified frequency range shall be a network analyzer with an S-parameter test set and unbalanced to balanced impedance matching transformers.

A.4 Test Procedure

Step 1: Measure the initial insertion loss and DC resistance of the reference cable at or corrected to 20ºC and at TBD% ± TBD% relative humidity after a minimum conditioning period of 4 hrs over the specified frequency range.

Step 2. Increase the temperature of the oven or chamber to the maximum specified temperature ± TBDºC. At this temperature, the relative humidity is unspecified. The cable shall be exposed to this condition for a minimum of 4 hours and a maximum of 24 hours. Measure the insertion loss and DC resistance of the cable

Step 3. Determine the temperature coefficient of attenuation increase of the cable by application of equation 3[3]. αTref is the attenuation at the reference temperature 20 °C from Step 1. and αT is the attenuation at the specified maximum temperature with respect to the reference temperature.

$$k = \frac{(\alpha T - \alpha Tref)}{\alpha Tref \cdot \Delta T} \cdot 100$$

[% / °C]   equation 3

- κ - is the temperature coefficient of attenuation increase in percent
- αTref - is the attenuation at the reference temperature, generally 20 °C
- αT - is the attenuation at an elevated temperature with respect to the reference temperature.
- ΔT - is the temperature differential between reference temperature and test temperature.

A.5 Effects of Aging On Cable Attenuation (TBD)

The effects of aging on attenuation is evaluated by comparing the attenuation of the cable sample measured at ambient temperature to the attenuation of the cable sample exposed to an oven temperature of 100ºC ± 2ºC for a period of 168 hours. The cable is allowed to cool down to ambient conditions for a minimum of 24 hours before the attenuation measurement is performed.

[3] Reference: IEC 61156 and ASTM D 4566