



DATACOM CABLE SOLUTIONS

Comparative Power-Over-Ethernet (PoE) Testing Between Category 6A and Category 5e Cables

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INTRODUCTION

A Greener Alternative for PoE Applications

With the world becoming more conscious of energy consumption, “green” has become more than just a passing trend; it has become a responsibility of innovative companies. Power-over-Ethernet (PoE) run over Category 6A cable lends itself to being “green” by consolidating power and data over a single cable. Additionally, it performs more efficiently than a Category 5e cable by lowering power dissipation. PoE works by applying power on two pairs of the Ethernet cable via a switch or hub. Table 1 shows how PoE can be implemented on data communications cable.

PoE Standards for RJ-45									
Pin: Wire Color		1: O/W	2: O	3: G/W	4: B	5: B/W	6: G	7: Br/W	8: Br
Using Data Pairs	36-57 Volts	RX, DC+	RX, DC+	TX, DC-	Not Used	Not Used	TX, DC-	Not Used	Not Used
Using Spare Pairs	36-57 Volts	RX	RX	TX	DC+	DC+	TX	DC-	DC-

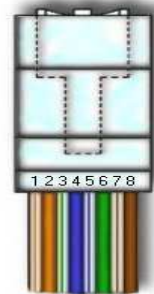


Table 1, PoE Standards

TX, Transmit Line	O/W, Orange/White wire	B/W, Blue/White wire
RX, Receive Line	O, Orange wire	G, Green wire
DC+, Direct Current Source	G/W, Green/White wire	Br/W, Brown/White wire
DC-, Direct Current Return	B, Blue wire	Br, Brown wire

PoE is able to power a variety of periphery including telephones, cameras, and wireless routers. The current standard for this technology is the IEEE 802.3af. The 802.3af includes the stages of powering up, and defining the different class rating and maximum power levels. Currently, a new standard is evolving, the IEEE 802.3at. This standard is designed to work with devices that require 25 to 30 watts of power. With the expanded power specification, a new generation of hardware will be designed. This may include advanced audio conferencing equipment, tilt and zoom cameras, powering laptop computers, and expanded wireless internet.



TESTING

To illustrate the enhanced efficiencies Cat 6A has over Cat 5e for PoE, DC resistance testing was completed with both cable types, end-span Power-Sourcing Equipment (PSE), and two different classes of Powered Devices (PDs). A Fluke NetTools Series II was used to monitor the current, voltage, and power demands of the PDs. For all tests, power was delivered on pins 1, 2, 3 and 6 over a 316-foot length of both Cat 6A and Cat 5e cable individually. First, the power requirements for the PDs were collected by connecting them via the Fluke meter to the PSE. The class two device was the Avaya phone drawing 4.93 watts, and the class three device was a Cisco Aironet 1200 drawing 7.50 watts. Second, the two test cables were placed inline with the PDs (see Figure 1). Power was monitored and recorded at the input to the PDs.

Class	Maximum Power Levels at Input to Powered Device in Watts [W]
0	0.44 to 12.94
1	0.44 to 3.84
2	3.84 to 6.49
3	6.49 to 12.95
4	Reserved (PSEs classify as Class 0)

Table 2, Power Classification

Equipment List

Cables under Test

- Cat 5e Cable
- Cat 6A Cable

Test Equipment

- Fluke NetTools Series II tester
- Fluke Digital Multimeter

PSE

- Cisco Catalyst 4500 (PSE)

PD

- Avaya phone Model 9620
Class 2
- Cisco Aironet 1200 Wireless Router
Class 3

Support Equipment

- Three 4-foot patch cables
- RJ-45 connectors and receptacles

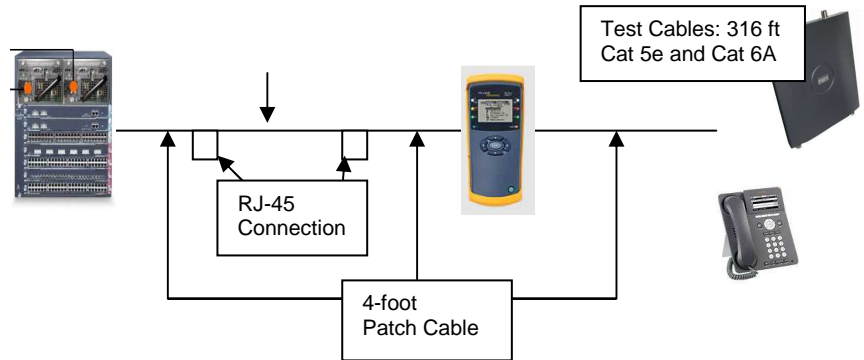


Figure 1 Test Setup

Theoretical Calculations of the DC Resistance

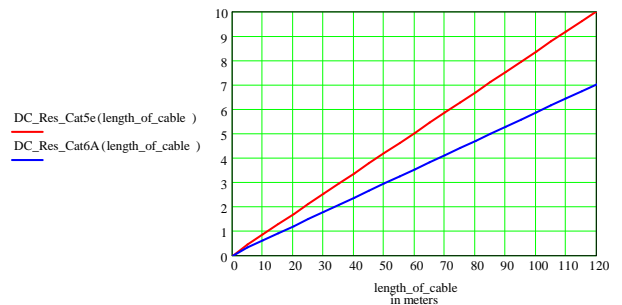
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Diameter_of_Conductor := .02 inches      Resistivity := 1.68 · 10-8
Diameter_of_Dielectric := .04 inches
Cable_length := 316 feet
Pair_twist_length := .3 inches

radius :=  $\frac{\text{Diameter\_of\_Conductor}}{2}$ 
Area :=  $\pi \cdot \text{radius}^2$ 
Area_convert_to_meters_from_inches :=  $\frac{\text{Area}}{(39.370079)^2}$ 
Extended_Length_of_pair_twist :=  $\frac{\text{Cable\_length}}{\cos\left(\text{atan}\left(\pi \cdot \frac{\text{Diameter\_of\_Dielectric}}{\text{Pair\_twist\_length}}\right)\right)}$ 
Extended_Length_of_pair_twist = 342.603 feet
length_of_cable_in_meters := Extended_Length_of_pair_twist · .3048

DC_Res (length_of_cable_in_meters) :=  $\frac{\text{Resistivity} \cdot \text{length\_of\_cable\_in\_meters}}{\text{Area\_convert\_to\_meters\_from\_inches}}$ 
DC_Res (length_of_cable_in_meters) = 8.66 ohms

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Formulas used to calculate the total resistance for both cables. Numbers shown in calculations are based on a typical Category 5e cable.



Measured DC Resistance

Pins 3 and 6 source the current required to power the external device and are in parallel. Pins 1 and 2 are the return lines and are also in parallel. Since the two pins are in parallel, their resistances are added in parallel.

**Category 5e
total measured
resistance**

$$\begin{aligned} \text{pin1} &:= 8.9 \text{ ohms} & \text{pin3} &:= 9.0 \text{ ohms} \\ \text{pin2} &:= 8.9 \text{ ohms} & \text{pin6} &:= 9.0 \text{ ohms} \\ \text{DC_Res_Measured} &:= \frac{1}{\left(\frac{1}{\text{pin1}} + \frac{1}{\text{pin2}}\right)} + \frac{1}{\left(\frac{1}{\text{pin3}} + \frac{1}{\text{pin6}}\right)} \\ \text{DC_Res_Measured} &= 8.95 \text{ ohms} \end{aligned}$$

Resistance Measurements in ohms using Fluke DMM		
	Cat 5e	Cat 6A
Pin 1	8.9	6.0
Pin 2	8.9	6.0
Pin 3	9.0	6.2
Pin 6	9.0	6.2

Table 3, Measured Cable Resistance

TEST RESULTS

Class 2 Test @ 328 feet: Avaya Phone

The Avaya phone required 4.93 watts of power from the PSE without the test cable connected. With the test cable connected, the Avaya phone sourced .096 amps. With the DC resistance of the test cables known:

$$\begin{aligned} \text{Current_draw_of_Avaya} &:= .096 \text{ amps} \\ \text{DC_Res_Cat5e} &:= 8.95 \text{ ohms} & \text{DC_Res_Cat6A} &:= 6.10 \text{ ohms} \\ \text{Power_dissipated_in_Cat5e} &:= \text{Current_draw_of_Avaya}^2 \cdot \text{DC_Res_Cat5e} \\ \text{Power_dissipated_in_Cat6A} &:= \text{Current_draw_of_Avaya}^2 \cdot \text{DC_Res_Cat6A} \\ \text{Power_dissipated_in_Cat5e} &= 0.082 \\ \text{Power_dissipated_in_Cat6A} &= 0.056 \end{aligned}$$

Cat 5e results:

- Power dissipated is approximately 82 milliwatts.

Cat 6A results:

- Power dissipated is approximately 56 milliwatts.

Class 3 Test @ 328 feet: Cisco Aironet 1200

The Cisco Aironet 1200 required 7.47 watts of power from the PSE without the test cable connected. With the test cable connected the Cisco Aironet 1200 sourced .150 amps.

$$\begin{aligned} \text{Current_draw_of_Avaya} &:= .150 \text{ amps} \\ \text{DC_Res_Cat5e} &:= 8.95 \text{ ohms} & \text{DC_Res_Cat6A} &:= 6.10 \text{ ohms} \\ \text{Power_dissipated_in_Cat5e} &:= \text{Current_draw_of_Avaya}^2 \cdot \text{DC_Res_Cat5e} \\ \text{Power_dissipated_in_Cat6A} &:= \text{Current_draw_of_Avaya}^2 \cdot \text{DC_Res_Cat6A} \\ \text{Power_dissipated_in_Cat5e} &= 0.201 \\ \text{Power_dissipated_in_Cat6A} &= 0.137 \end{aligned}$$

Cat 5e results:

- Power dissipated is approximately 201 milliwatts.

Cat 6A results:

- Power dissipated is approximately 137 milliwatts.

Calculated Savings Based on Measured Data:

Number of Avaya phones: 384
 Number of Cisco WAN: 100
 Average cable length between nodes: 150 feet
 Total number of cables: 484

Since the average length of the cable was halved (tested at 316 feet), the total resistance would be reduced.

**Resistance with 150 feet of cable:**

The category 5e's total resistance would now be ~4.48 ohms.

The category 6A's total resistance would now be ~3.05 ohms.

Power dissipated:

Cat5e_Resistance := 4.48

Cat6A_Resistance := 3.05

Phone_current := .096

WAN_current := .15

Avaya Phone

Power_dissipated_by_phone_Cat5e := Phone_current²·Cat5e_Resistance

Power_dissipated_by_phone_Cat6A := Phone_current²·Cat6A_Resistance

Power_dissipated_by_phone_Cat5e = 0.041

Power_dissipated_by_phone_Cat6A = 0.028

Power difference between the two = .013 watts.

Cisco WAN

Power_dissipated_by_WAN_Cat5e := WAN_current²·Cat5e_Resistance

Power_dissipated_by_WAN_Cat6A := WAN_current²·Cat6A_Resistance

Power_dissipated_by_WAN_Cat5e = 0.101

Power_dissipated_by_WAN_Cat6A = 0.069

Power difference between the two = .032 watts.

Yearly Energy Savings:

*((Watts x hours per day x days of the year) / 1000 (convert to Kilowatts)) * Kilowatts per hour charge * number of devices*
The figure below are based on a kilowatt per hour charge of .20 charge.

Avaya Phone

$((.013 \times 24 \times 365) / 1000) * .2 * 384 = \8.75 a year savings.

Cisco WAN

$((.032 \times 24 \times 365) / 1000) * .2 * 100 = \5.61 a year savings

Over twenty years, the total savings with an average cable length of 150 feet would be:

$\$175.00 + \$112.20 = \underline{\$287.20}$

Over twenty years, the total savings with an average cable length of 316 feet would be:

$\$353.4 + \$224.69 = \underline{\$578.09}$

**Expanded to POE+:**

The expanded devices that will be created as a result of the POE+ standard when finalized will possibly source 30 watts of power or 0.6 amps (~51 volts).

Next generation device requiring 30 watts with an average cable length of 150 feet.

Category 5e = $0.6^2 \text{ amps} * 4.48 \text{ ohms} \rightarrow 1.61 \text{ watts}$.

Cat 6A = $0.6^2 \text{ amps} * 3.05 \text{ ohms} \rightarrow 1.10 \text{ watts}$.

Power difference between the two = .51 watts.

For 100 devices at \$0.20 per kilowatt hour:

$((.51 * 24 * 365) / 1000) * .2 * 100 = \89.35 a year savings

Over twenty years, the estimated total savings with a cable at 150 feet would be -> \$1,787.00

Over twenty years, the estimated total savings with a cable at 328 feet would be -> \$3,595.10

CONCLUSION

The expanding field of PoE technology currently allows external periphery to be powered by the Ethernet cable instead of the normal AC (alternating current) wall socket. With the world's ever growing demand for energy, finding new and more efficient ways to deliver it is essential. PoE not only decreases infrastructure material, when run over Cat 6A, it delivers power more efficiently. For customers seeking high efficiency and future growth potential with their networks, one choice for PoE stands above the rest, Cat 6A cable.