DATACOM CABLE SOLUTIONS

Power over Ethernet: A Consumer-Centric Development Perspective

Written by: Roy Kusuma, Engineer, Communications Products

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Power over Ethernet: A Consumer-Centric Development Perspective

OVERVIEW

Power over Ethernet (PoE) has been highlighted recently with promises of more power delivery for the sophisticated applications being developed. Its definition, requirements and output have been a large focus of many organizations including the Telecommunications Industry Association (TIA), the Institute of Electrical and Electronics Engineers (IEEE) and the International Electrotechnical Commission (IEC). However, with new information established each passing month, it has become difficult to maintain a good understanding.

PoE LANDSCAPE TODAY

	IEEE 802.3af (PoE)	IEEE 802.3at (PoE+)
Maximum Power at Power Sourcing Equipment (PSE)	15.4W	30.0W
Delivered Power to Powered Device (PD)	12.95 W	25.50 W
Allowed PSE Output voltage	44-57 VDC	50 – 57 VDC
Maximum DC cable current	350 mA per pair	600 mA per pair

Table 1: 802.3 standard power allocation and current requirements

In 2003 PoE was launched when IEEE issued 802.3af, allowing 12.95 watts to be delivered to a device through an Ethernet cable. This became the preferred choice for several devices such as Voice over Internet Protocol (VoIP) and IP cameras. These applications however were limited to low-power devices due to the maximum power output of which this protocol is capable. To include several emerging applications at the time, including 802.11n wireless and more sophisticated IP cameras, IEEE developed 802.3at in 2009, which not only addressed the power issue, but also created protocols to allow for continuous power negotiation to the device.

In the recent years of more sophisticated home and office devices such as cloud-integrated smoke alarms, thermostats, and IP cameras, the need for increased power delivery becomes more important to these devices that also require connectivity. IEEE is now under significant pressure from the industry to further advance the standards available to meet the new demand. In response, they are in the process of developing another revision to the 802.3 standards named 802.3bt in which the defined power delivery is expected to increase to at least 49 watts from the previous maximum of 25.5 watts. Current trends are leaning towards having all eight conductors delivering power, mimicking Cisco's UPoE system, while still carrying signals onto the edge device. By using this configuration, it is possible to double the power output of existing equipment. In addition, the proposed 802.3bt standards go one step further to classify a system with a power output between 60 and 100 watts.

HIGH-POWER PoE NEEDS

When considering a major increase in power, many key considerations have to be reevaluated and verified. The current load, in order to go from a four-pair 60-watt output to a 100-watt output, changes from 600mA/pair to 1000mA/pair when the voltage of the PSE is kept at 50 volts. At such a drastic current capacity change, issues such as heat generation, power losses and safety protocols at the equipment end need to be studied. These issues can also lead to secondary problems that require additional analysis as well. Heat generation for example can be a serious issue for cables as highlighted in the figure below.

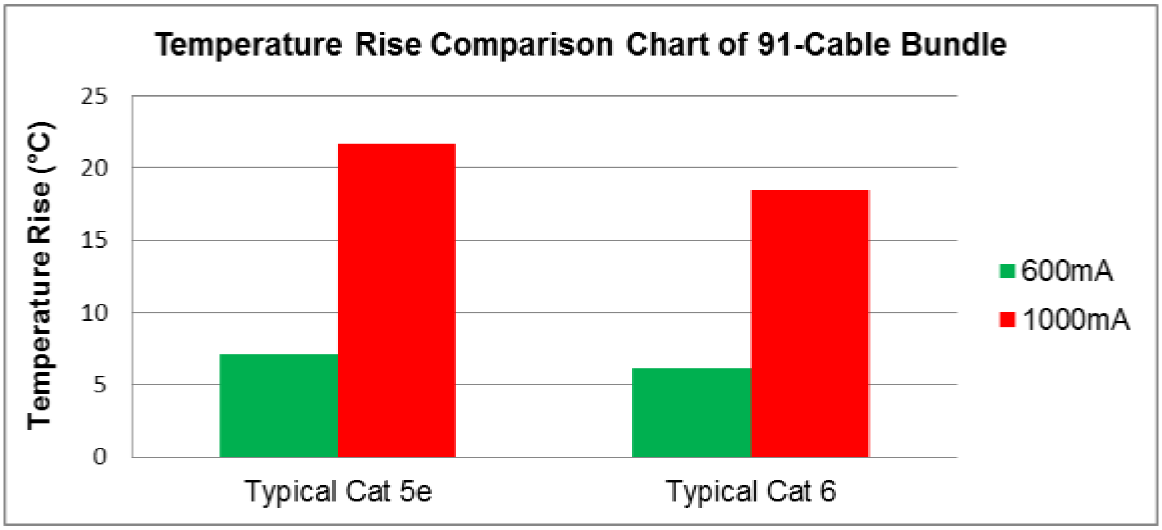
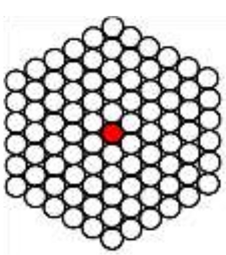


Figure 1: Comparison chart of 600mA/pair versus 1000mA/pair on typical category 5e and 6 cables. Note that this is the heat rise over ambient temperature.

Due to concerns about increased temperature rise, IEEE commissioned TIA to not only to define the expectations and details of the new PoE system, but also the peak operating parameters and equipment requirements. The excess heat generated from cabling systems not designed for the increased power consumption can cause heat-aging degradation of the insulation and cable as well as attenuation issues in data transmission.

TEMPERATURE RISE CONSIDERATIONS

TIA had previously developed a method of testing and comparing heat rise performance in current-carrying category cables for the initial release of TIA TSB 184:2009 in order to provide guidelines for 802.3at standards.



The figure on the left shows the configuration for a 91-cable bundle. The test consists of powering each conductor of this bundle with a test current and measuring the temperature rise of the center cable at a steady state temperature. By assuming a 45°C maximum ambient temperature and a generalized cable operating rating of 60°C, they allowed for 15 degrees of heat rise for durability and effective use of data cabling.

In addition to this, the conventional recommendation of PoE systems is that increased power will relate to increased category cabling. For example in 802.3at PoE+, category 5e cabling is the most basic construction, which will provide sufficient conductivity to run with no heat generation issues, hence it became the minimum requirement. The same recommendation by TIA and the IEEE task force can then be expected with 802.3bt with the specified 600mA/pair maximum. The reduced heat generation of higher category cables is inferred mostly from the more stringent attenuation requirements of higher category cabling causing cable manufacturers to increase the conductor size. For example, a typical category 5e cabling is constructed with 24 AWG conductors, while typical category 6A has 23 AWG conductors. However, now that 1000mA/pair is a real possibility, it will redefine what is acceptable for PoE between 60 and 100 watts.

To better demonstrate the differences between these cabling types with the high-current load, we have performed an extensive analysis on the difference in heat generation.

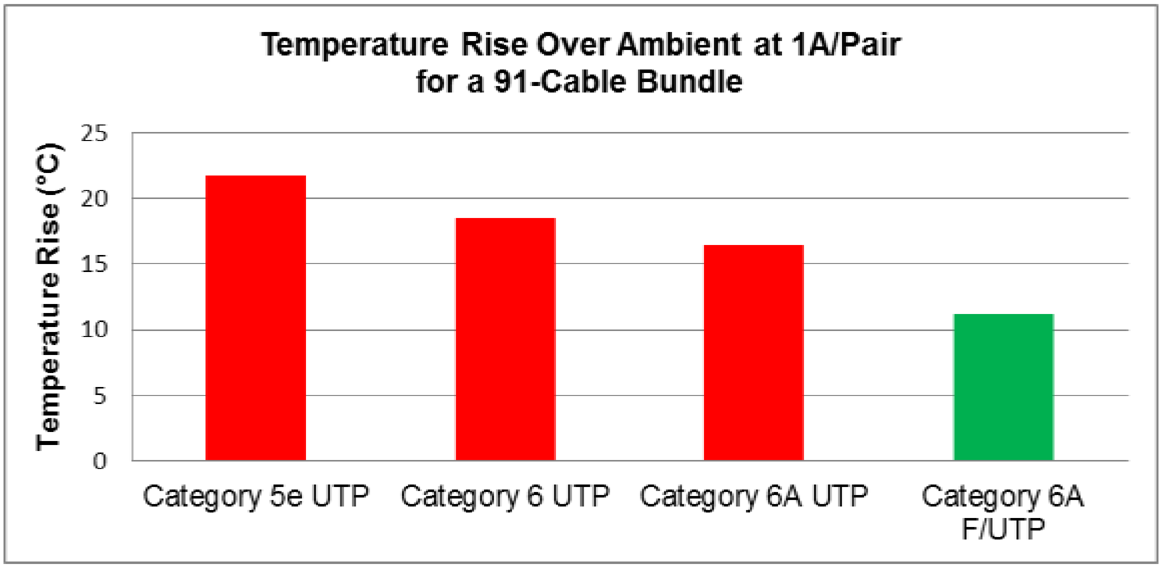


Figure 2: Observed temperature rise over ambient temperature of different category cables in a 91-cable bundle with 1000mA/pair power.

It is quite clear that heat generation becomes a real issue in many of the most common cable constructions installed or available today. However, it is not an ideal assumption to use category designation as a PoE classification rating because the majority of the heat generated from running amperage is due to conductor size or the presence of a shield.

There is an important additional complication to heat generation that has not been discussed: the environment in which the cable bundle is located. All the data presented above is in open air, however, in many cases a large cable bundle may be present under the floors, behind walls or enclosed in an insulated space. In the last circumstance, the heat rise figures are significantly worse with numbers as high as 50°C above ambient temperature for the typical worst-case category 5e construction.

Currently, in applications where higher power usage is expected in excess of 50 watts, yet higher data transmission rates are not required, there are few, if any, options. To appropriately address the increased temperature rise, one could be confined to using category 6A or category 6A F/UTP. The limiting factor of many devices, especially IP cameras, nurse call systems, building management controls and point-of-sale is power consumption, not data. This places a difficulty on premise designers to justify the use of higher category cabling or the need to pull a power source onto a location.

CABLES SPECIFICALLY DESIGNED FOR PoE

General Cable has created a new product line of EfficienC™ Max cables, designed for high-powered PoE applications with superior performance on insertion loss, heat rise and temperature capabilities.

Specifically designed with larger conductors, these EfficienC Max cables offer reduced resistances, which directly reduces the amount of heat generated within a current-carrying cable. The large conductors also provide improved attenuation (insertion loss) performance to further protect against higher temperature data transmission losses.

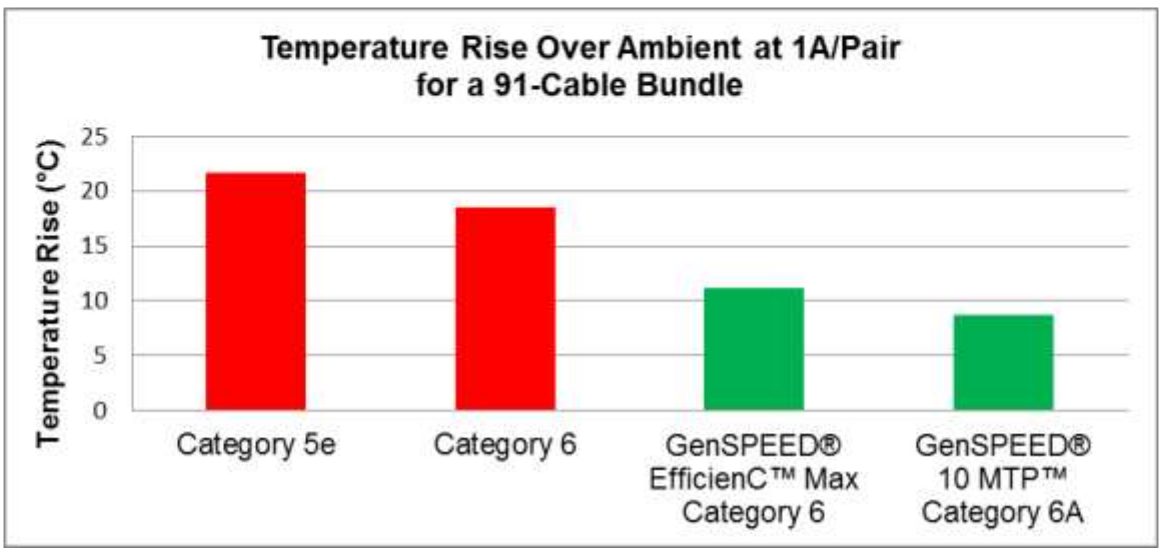


Figure 3: Temperature rise comparison between standard cabling and EfficienC Max line of products

There are real benefits to using specially designed PoE cabling with properties such as larger, lower-gauge conductors and higher temperature cable ratings for the majority of PoE applications. Aside from having confidence that the cable will withstand higher temperature operations and generate lower temperatures, energy savings and efficiency are also considerations when deploying a large scale PoE infrastructure.

ENERGY COST ANALYSIS

	Cat 5e (Typical)	Cat 6 (Typical)	Cat 6A (Typical)	EfficienC™ Max Cat 6
DC Resistance Per Conductor at 100m	9 Ω	7.5 Ω	6.5 Ω	6 Ω

Table 2: Resistance figures of typical category 5e, cat 6, cat 6A and EfficienC Max cat 6

Running 100 devices at 100 watts at a 100-meter distance can translate to significant savings in power simply in resistance losses through the cables alone.

Circuit calculations for a four-pair PoE system can be made multiple different ways depending on the protocol used. One way to calculate power losses across the cable would be to assume two circuits, each having one pair as live and a second pair as neutral. Each circuit resistance would be:

$$\frac{1}{\left(\frac{1}{R}+\frac{1}{R}\right)}+\frac{1}{\left(\frac{1}{R}+\frac{1}{R}\right)}=R$$

Where R is DC resistance per conductor at 100m

Assuming $0.15/KWh, the power loss by driving 100 watts through a cable would be given by:

$$1A^2 \times Circuit\,Resistance \times 2\ Circuits \times 24\,h \times 365\ Days \times \frac{1\,KW}{1000\,W} \times \frac{\$0.15}{kWh} \times 100\ Devices$$

**Four-pair PoE will yield equivalent resistance losses regardless of circuit connection method as long as voltage and power delivered are kept constant and calculations are adjusted accordingly.*

	Cat 5e (Typical)	Cat 6 (Typical)	Cat 6A (Typical)	EfficienC™ Max Cat 6
Annual Power Consumption	$2365.2	$1971	$1708.2	$1576.8

Table 3: Annualized cost to power 100 100-wattW devices over different cables

With just 100 devices, the annual energy cost savings between category 5e and EfficienC Max Category 6 cable is estimated at $780. Considering the rapid growth of powered devices and the cost difference of higher-end cables, General Cable's EfficienC Max line of cables provides a viable alternative to optimizing infrastructure cost and building energy efficiency.

In addition to direct power loss savings, reducing heat in temperature sensitive areas such as data centers can contribute to a significant reduction in power consumption. Using the same parameters as above, the heat generated annually by each cable type is given below.

	Cat 5e (Typical)	Cat 6 (Typical)	Cat 6A (Typical)	EfficienC™ Max Cat 6
Annualized energy loss for each 100m cable at 100 W	157.7 kW	131.4 kW	113.9 kW	105.12 kW

Table 4: Annualized energy loss for each 100m cable at 100 watts power.

All of the energy loss presented in Table 4 is converted into heat energy per energized cable that will have to be accounted for when considering the cooling load of a server room. This is especially important when considering that server rooms could potentially have thousands of these cables converging where temperature is most sensitive.

By assuming three percent improved power usage efficiency for each degree Celsius reduced, we can quantify some significant savings from mitigating the heating of a server room. Taking a case study baseline from Panduit's white paper titled "Impact of Air Containment Systems," we can expect a data center with 182 cabinets and parameters specified in that paper to consume a total of 4,251,250 kWh. Even a one degree Celsius drop in the heat generated could translate to an annualized energy savings of $19,130.

CONCLUSIONS

High-power PoE is an area of much new information and consideration. The proposed IEEE802.3bt will address some of the demand for increased power delivery to the device, but several applications have already extended to 100 watts. Due to the ever- increasing current capacity that is being applied onto Ethernet cabling, many of the previous recommendations and safety issues need to be re-evaluated.

This study has shown some of the key areas that are most significantly impacted, such as heat generation and insulation degradation, in order to highlight the necessary consideration when choosing the right cable for premise wiring.

For applications requiring beyond 60 watts and approaching 100 watts, much benefit can be gained from using cabling designed to handle the increased current capacity such as reduced temperature rise, optimal power delivery efficiency and improved efficiency in operating costs. Furthermore, there is merit in ensuring that a cable will withstand elevated temperatures in order to prevent breakdown of existing installed cabling.

General Cable's EfficienC Max line of products are specifically designed to mitigate, prevent and withstand the harsh conditions brought to cabling infrastructure by high powered PoE.

Referenced Documents

Impact of Air Containment Systems, Reducing Energy Consumption in the Data Center, Panduit Corporation, June 2012 www.panduit.com

Guidelines for Supporting Power Delivery Over Balanced Twisted-Pair Cabling, Telecommunications Industry Association TSB-184, July 2009 www.tiaonline.org