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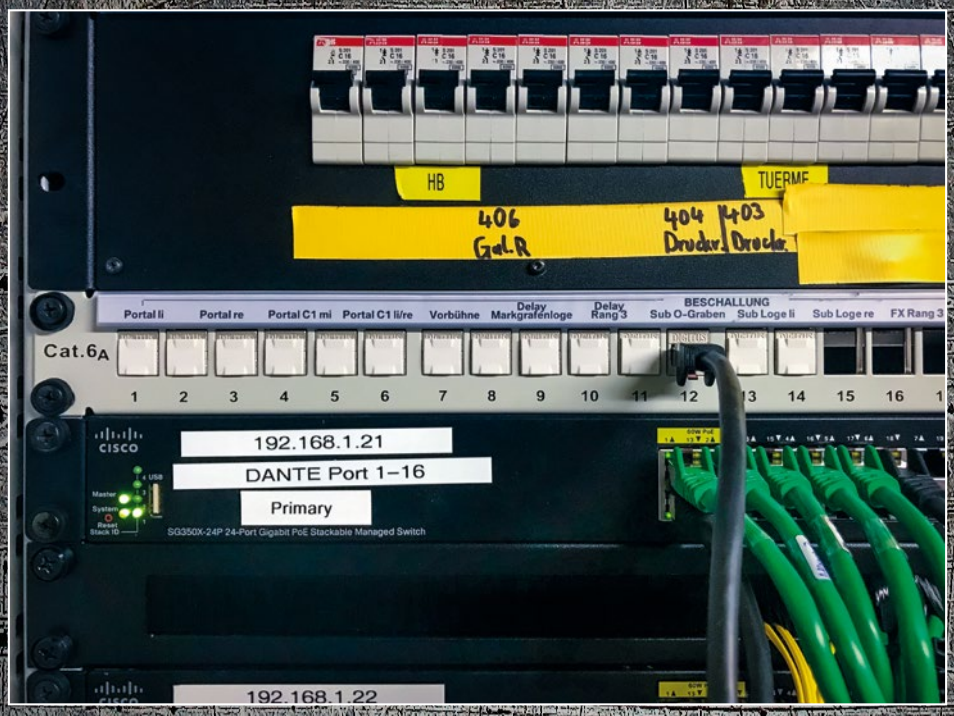
FACHMAGAZIN FÜR VERANSTALTUNGSTECHNIK

REPORT FROM ISSUE **1 I 2023**



USE OF TWISTED PAIR CABLES

Understanding CAT Cables

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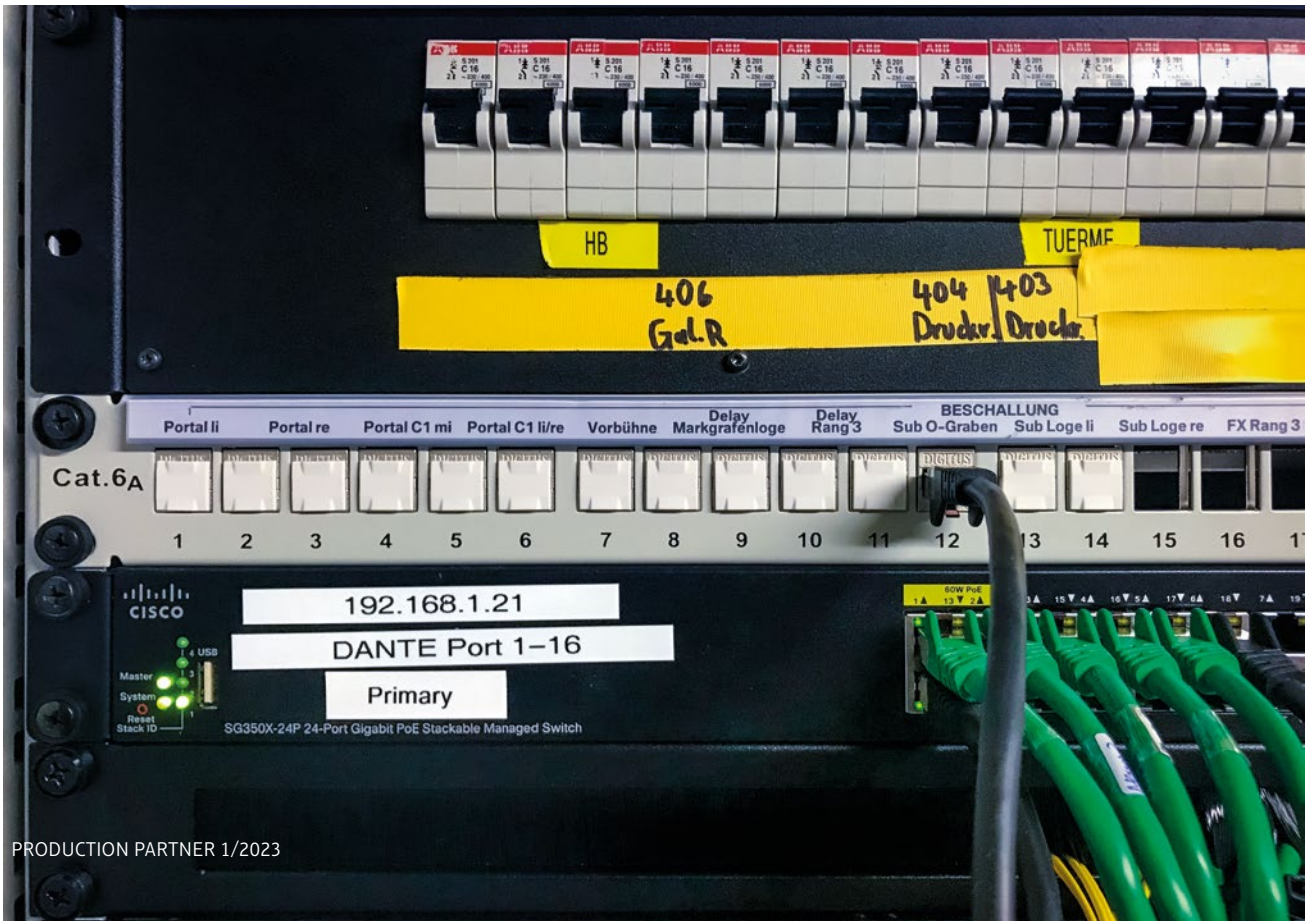
Due to standards like CAT6a or CAT8.1, wirings by means of twisted pair cables enable continuously rising bandwidths. So it's all the more important to know the distinction between category and network application class or how the increasingly popular PoE causes cable aging. Even gold-plated contacts are not immune to hazards, as Peter Rieck reports from his network practice.

Author: Thomas Zahn | Photos: Thomas Zahn, Sommer Cable | Tables: Peter Rieck



Networks according to CAT definition – hence requirement categories for twisted-pair cables – are gaining more and more importance in the event technology sector. Many areas are hard to imagine without them. As a developer and manufacturer of cable and connection components and other products for audio, video, broadcast, studio and media technology, Sommer Cable has been dealing intensely with the CAT subject for many years. No less intense is their exchange with users, designers and system integrators, but also manufacturers and distributors. Key Account & Product Manager Peter Rieck outlines the current network chances and pain points.

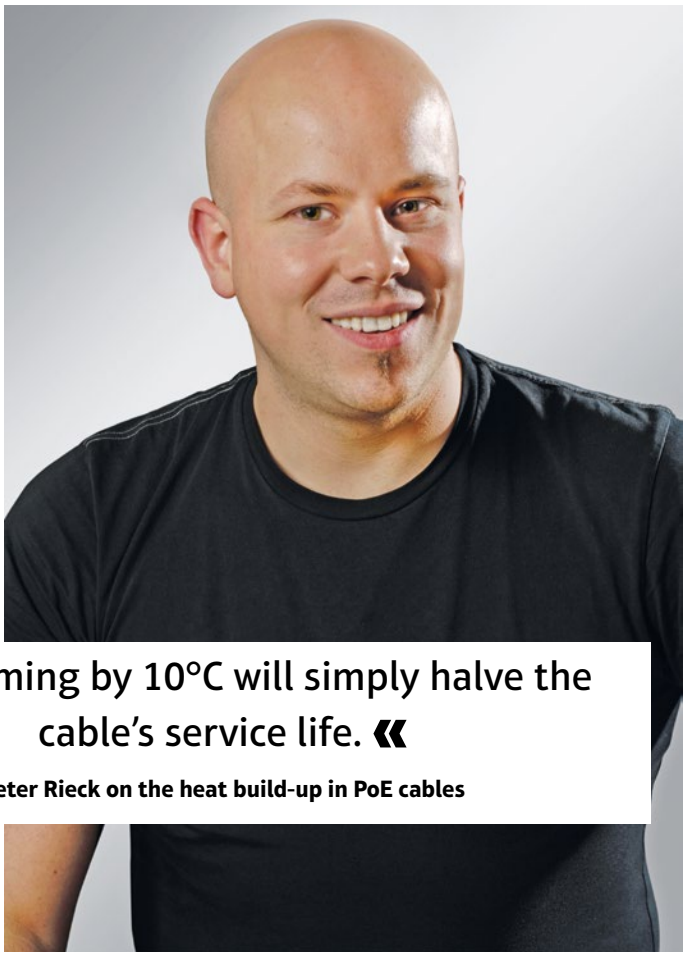
CAT vs. fiber optics

Peter, our topic is CAT networks. First a basic question: instead of CAT – and thus copper – we can also use fiber optics to build a powerful network. What do you think are the pros and cons of the respective variants?

Peter Rieck: The advantages of the optical fiber are not far to seek: here – especially in the future – even much higher bandwidths will be possible, the segment length is uncritical in every respect, and then there is the 100% electrical isolation! On the other hand, there are also some drawbacks: end points can only be terminated with greater effort, there is no PoE option, and you'll always need active signal converters or small switches, because only very few terminal devices are equipped with onboard fiber optical connections.

In a sense, the disadvantages of the optical fiber reflect the advantages of the copper line. PoE is becoming more and more the absolute standard for supplying terminal equipment, basically all stationary end devices feature an appropriate connection, and for carrying out the termination only little effort and no special tools are required. And owing to the classes Ea or 8.1. resp., the bandwidth issue is also very future-proof. By contrast, the drawbacks are manageable: the segment length provisions are stricter, the minimum bending radii, which are partly greater than with optical fibers, must be adhered to during installation, and the potential equalization needs to be observed.

From my point of view, the advantages mentioned clearly speak in favor of the CAT line. And still one other factor comes into play since a copper cable offers definitely more universal applications than a fiber optical cable. So the components mostly don't care about the protocol or the signal type on that line. And especially the PoE topic is really important – this can only be handled with copper lines.



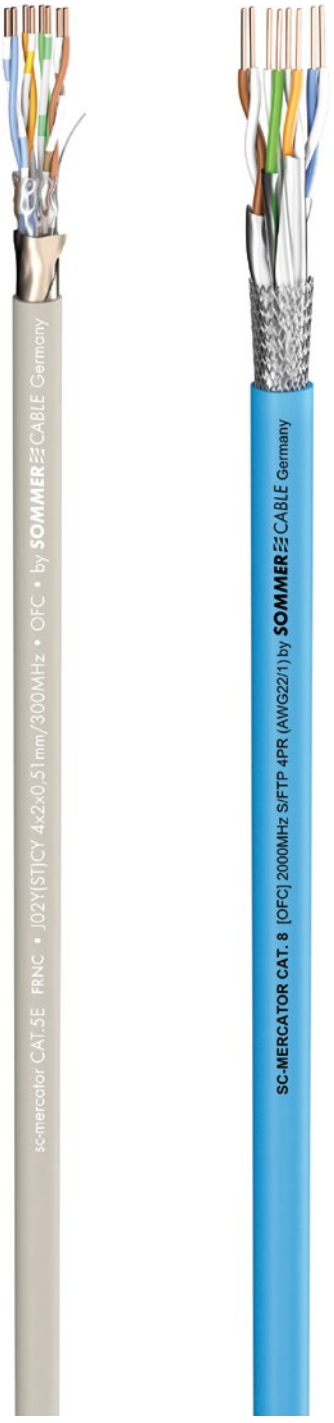
> »A warming by 10°C will simply halve the cable's service life.«
>
> **Peter Rieck on the heat build-up in PoE cables**

Peter Rieck does not only point to the high bandwidths made possible by the CAT6a (class Ea) or CAT8.1 (class I) standards – but also knows such everyday problems

A contemporary buzzword is "sustainability". What does this aspiration mean to Sommer Cable as a cable manufacturer?

Rieck: In the final analysis, our products are part of the infrastructure in an installation – without which nothing goes, as everybody knows. In fact, when selecting products, one should make sure to pick high-quality, durable products and install them correctly as well. This is also essential when it comes to choosing the connectors or the mechanical design of the interfaces.

With PoE applications the factor of aging e.g. can have a much greater impact on a CAT line than one might think.



Examples and cross-sections
pursuant to CAT5.E or CAT.8.1

Are CAT-based infrastructures really more straightforward and clearer than conventional solutions – as is often heard? Or are there more or less hidden pitfalls you might eventually step into as a user/system integrator/designer? What should we absolutely pay attention to, and where?

Rieck: First it needs to be stated that things are already becoming much easier. We have all signal types which can be transmitted via the infrastructure. The power supply can be integrated, in most cases much longer cable routes are possible, and we have standardized physical interfaces and connectors. The pitfalls can be spotted when looking at the details. For instance, the power supply over CAT contains some problem zones, and also the classification of the networks must be observed at all times.

When it comes to networks, often the IT department would also like to have a say. Reasonable? What should you pay attention to as a non-IT person, what needs to be known?

Rieck: One challenge here is that the networks can soon become pretty complex. And since more and more applications are mapped over them, we need to keep that in mind. From what order of magnitude a consultation with the IT department is required, is very individual and difficult to generalize.

One possible future trend are unified networks. So far every discipline (sound, light, video, stage engineering etc.) has its own network. Will it make sense in the future to provide one single network for all disciplines to share? And what would it mean with regard to the cables to be used?

Rieck: Here we must keep an eye on how the transmission standards will further develop. From my point of view things are already clearly moving into the direction that everything is based on native ethernet. That way one can, of course, use standardized cables, lines, and patch panels etc. Due to the CAT6a (class Ea) or also CAT8.1 (class I) standards, it will definitely not fail because of the available bandwidth. So we are only talking about the subject of signal management since the infrastructure will be the same for all by then.

Power over Ethernet

The subject of power supply over CAT is not quite as trivial as one might assume upon superficial examination. From PoE (Power over Ethernet) to numerous proprietary "standards" there is quite a lot happening in the market. This does not only pose certain challenges to the terminal devices, but also to the employed infrastructure, i.e. the wiring … And quite a bit of power is also lost on the way.

Rieck: In fact, this depends on the field of application. In pure ethernet environments we mostly talk about standardized PoE protocols where we can be sure that the compatibility is assured, and thus the danger of damages to equipment doesn't exist. But if we take a look at alternative application fields now such as HDBaseT, we see quite some of the above-mentioned proprietary solutions. Here it can by no means taken for granted that no smoke will go up when devices are simply connected.

What should be heeded to avoid unnecessary strain on the cable, in particular concerning service life? There is quite a bit of heat lost in the process, especially with larger cable bundles. Just think of wire cross-sections in different cable types.

Rieck: Yes indeed, for PoE is not exactly an efficiency wonder. Here it may well happen that 30 % of the energy – in the truest sense of the word – fall by the wayside. This energy must simply go somewhere. Now, when I find myself in an S/UTP or even U/UTP environment, this is more than problematic! Compared to foil-shielded cables, these heat up more than twice as fast. And you should know that a warming by 10°C will simply halve the cable's service life.

Consequently, this also puts higher demands on the plug-in connections. Does it make sense to use optimized connectors?

Rieck: Absolutely! Especially with PoE applications we are facing considerable problem potentials here as a result of flashovers that may occur when unplugging. In non-optimized connectors this will erode the gold plating already after a few mating cycles, making the connections unreliable. Likewise, we must keep in mind what data bandwidths we're talking about in current networks! Here's no getting around connectors with a built-in compensation. Notably crosstalk between pairs 3/6 and 4/5 is a big problem. Fortunately there are independent test institutes – like e.g. the GHMT – which issue certificates to give the integrators some guidance.

> »The category always relates only to theindividual component. That is, the connector or the cable. «
>
> **Peter Rieck**

Usually one talks about CAT5, CAT6, CAT7 or even CAT8 – but strictly speaking this is basically not quite correct. What needs to be known about the topic Category vs. Network Application Class?

Rieck: Exactly, the category always relates only to the individual component. That is, the connector or the cable. The system or the network resp. is always subdivided into application classes which definitely has parallels to the component category. However, a network may also contain components from different categories – hence the network class is always a general overview.

Properly speaking, the industry's standard language use (CAT5, CAT6 or CAT7) is not correct, either. Calling it a class D, E or F network would be accurate.

Funny enough, there are e.g. no RJ45 connectors to comply with the category 7. At that time the industry had tried in vain to establish a new connector. Now with the class I or category 8.1 the RJ45 is back again.

Bandwidths and signal types

According to Peter Rieck's experience, network application classes are rather a theoretical thing; here's his view of the "true" frequencies.

Typ	Signal type	Baud rate	Signal bandwidth
10BASE-T	Manchester Code – PE	10 MBd	2 × 10 MHz
100BASE-TX	MLT-3	125 MBd	2 × 62.5 MHz
1000BASE-T	PAM-5	125 MBd / wire pair	4 × 62.5 MHz
10GBASE-T	PAM-16	800 MBd / wire pair	4 × 417 MHz
40GBASE-T	PAM-16	3.200 MBd	1.600 MHz
HDBase-T	PAM-16	500 MBd (TX), 25 MBd (RX)	300 MHz

Signal distribution using CAT infrastructures

Link classes network application class ≠ category, in current language terms like "CAT5", "CAT6" etc. are common, yet class D, class E, class EA or class F would be more correct

Wiring classes pursuant to IEC/ISO

Class D: up to 100 MHz, for max. 1 Gbit/s
Class E: up to 250 MHz, for max. 1 Gbit/s
Class EA: up to 500 MHz, for max. 10 Gbit/s
Class F: up to 600 MHz, for multimedia applications
Class F: up to 1,000 MHz, for multimedia applications A
Class I/II: up to 2,000 MHz, for max. 40 GBit/s

Component category pursuant to IEC/ISO

CAT5e: up to 100 MHz, suitable up to max. 1 GBit/s
CAT6: up to 250 MHz, suitable up to max. 1 GBit/s
CAT6A: up to 500 MHz, suitable up to max. 10 GBit/sw
CAT7: up to 600 MHz, for multimedia applications
CAT7A: up to 1,000 MHz, for multimedia applications
CAT8: up to 2,000 MHz, suitable up to max. 40 GBit/s

Another interesting fact is that there are actually no applications for class E or CAT6 respectively in practice – this class doesn't require a standardized protocol! Nonetheless many people – including some manufacturers or distributors – occasionally refer to CAT6 as a prerequisite. Yet only the classes D (CAT5), EA (CAT6a) and now the I (CAT8.1) are truly relevant.

Also when talking about the subject of cable lengths, there are some misunderstandings. AWG24, 23 or 22? 100 m or rather less? What should, by all means, be taken into account?

Rieck: Basically the classes stipulate maximum link lengths. Which means that when building up a network as an integrator, and I have to meet the target to comply e.g. with class I, I need to know that the link length must not exceed 30 m. But when I have to comply with class EA using the same network cable, I can figure on 90 m of link length. Cables of the categories 7A and 8 come with a large AWG22 cross-section anyway – so it's uncritical. However, if we have an old class D network with AWG24 cables that needs to be converted to PoE, we really need to think hard! The combination of – presumably – unshielded twisted pairs and a low cross-section makes the situation quite problematic. Here I advise to considerably lower the link lengths.

Finally, one more question which has nothing to do with the network topic in the first place: in the fixed installation sector people now and then like to use CAT7 or CAT7 duplex cables for transmitting analog audio. Seems to be quite reasonable at first sight. Also with regard to the price point this solution doesn't seem uninteresting. What do you think?

Rieck: Here one needs to keep in mind that with the four audio channels that can be transmitted via a CAT cable, the shields are combined. The cross-section isn't smaller, either, but rather larger. With a CAT7 or CAT7a installation cable we're talking about AWG 23 or even AWG 22 here. Usually a modulation cable for analog or digital audio applications has a smaller cross-section. Except for the meshed shields, which are only connected via the RJ45 housing, there are no significant drawbacks. You know, these cables are designed for much higher frequencies indeed and boast outstanding crosstalk values.

Peter, thank you very much for your time and the insightful conversation! ■

> »Except for the meshed shields, which are only connected via the RJ45 housing, there are no significant drawbacks. «
>
> **Peter Rieck on the transmission of analog audio via CAT7 cable**