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Optimally choosing your measuring cables

Ask BEFORE you buy.
Good-to-know facts given by instrumentation engineer Dipl. Ing. (FH) Stefan Burger
Delta Gamma RF-Expert

About the author

Stefan Burger received his engineering degree from the Offenburg University of Applied Science in 1986. He remained a research associate at the university until 1990. He then transferred to the research and development department of Endress + Hauser in Maulburg.

Until 2001, he was involved in the development of level measuring devices based on RADAR. Among other things, he was responsible for the support of the RADAR modules as well as the development of antennas and pressure-resistant RF components.

From 2001 to 2011, he worked on filters and duplexers for base stations as well as SAW filters at Panasonic Electronic Devices in Lüneburg. He was responsible for the "Lifetime and Power Durability" simulation.

In 2012, he founded his own company, Delta Gamma Consultant (www.delta-gamma.com), in Hampton, Australia. Since 2014, he has been working as an exclusive consultant in the area of RF and measurement technology for el-spec GmbH in Geretsried, Germany.

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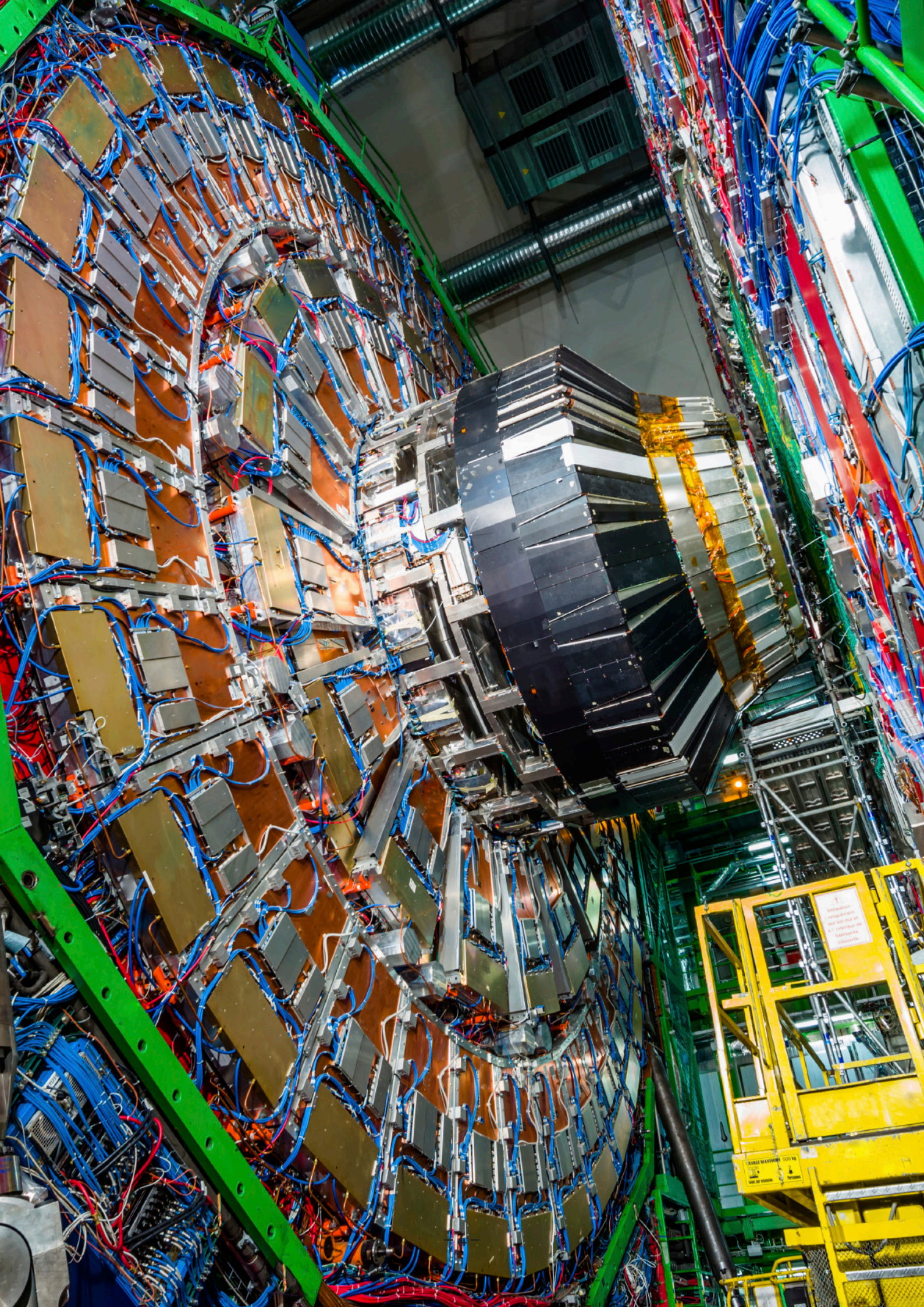
Content



The optimum measuring cable is not found by accident but is chosen after precise consideration of all relevant criteria.

How to pose the right questions, whether „more expensive" equals „better", etc. – we have put this together for you. To our aid came Instrumentation engineer Stefan Burger. Born in Freiburg, Germany, he owns the Delta Gamma RF-Expert consultancy in Hampton, Australia, and travels the world to give support for RF-solutions.

Question: Stefan, is it really that difficult to find the right combination of cable and connector? Isn't in fact always the same simple procedure: switch on the analyzer, connect the cable, connect the device to be measured and read the displayed values ....

Stefan Burger: I wish it were that simple! However, it is a fact that every type of cable is trimmed, by the manufacturer, to have specific, and different, capabilities and characteristics. This starts with the highly targeted choice of materials, continues with thoughtful processing and positioning of the various layers, and ends with the exact confectioning including the optimal connector. Indeed, there are massive differences between cables of the same type since not manufacturers work with the same dedication and using the same criteria. Also, much depends on the knowledge and the experience of the engineers: sometimes the job is totally non-critical and can in fact be done with simple, cheap cable bought in the discount store. However, in the majority of cases precision up to the decimal places is called for - and this is when the technician needs to rely on a dependable measuring cable is he is serious about his profession and his company.

Q.: A name-brand cable is - as a general rule - a more expensive cable. Would you day that ‚therefore, „expensive" is the best choice?

Stefan Burger: Well, it is true that the brand-name manufacturers such as Gore, Teledyne Storm or Harbour Industries commit considerable resources to Research and development, and that the measuring cables they offer are consequently sometimes of a significantly higher price than those of a no-name discounter. However, even between the cables of the top-manufacturers there are quite big differences and I would not always subscribe to the idea that the sometimes enormous premium charges are really worth it.

Q.: Let's be a bit more specific. What advice would you have for the measurement engineer? How does he find the optimal cable for the given special application?

Stefan Burger: During my visits to Germany I got to know the engineer and CEO of the el-spec GmbH company, Thomas Weber. He was, incidentally, just looking for an independent assessment of the products manufactured by one of his most important partners, the Teledyne Storm Microwave company.

Hence I concerned myself in particular with this manufacturer, made measurements and comparisons, and found a number of aspects which will surely help some of your readers.

The most important question which the technician has to confront him/herself at the very start is: which criteria are decisive for reaching the given objective, and how these criteria are ranked in importance. One-size-fits-all- and-every-circumstance does not exist - not with cables, anyway! One cable may withstand extreme temperatures but cannot deal with high pressure while the other cable may not be useable up to 50 GHz or may loose its phase-stability as it is moved and bent. Of course, the budget provided must not be forgotten, either.

Q.: In which ares is it purposeful to take advantage of the quality-portfolio of the US-manufacturer as you have investigated it, compared to the no-name products mentioned earlier?

Stefan Burger: the use of the higher-price Teledyne cables is purposeful under following circumstances:

- extrememem reliability and long service-life are important

- aerospace-, military- or other safety-standards are necessary

- where extremely exact HF- or instrumentation parameters are the decisive factors, such as lowest losses, highly effective shielding, very good phase-stability or very good reproducibility, or a combination of some of these characteristics.

Especially the first point is a good example for what makes a difference, it actually starts at a place that is rarely paid much attention: the kink protection. As everybody knows, the transition from cable to connector is the most delicate point of a measurement cable. The mechanical stress is particularly heavy here, and of course it has an influence on the electrical properties of the connection.

Among the cables I assessed were name-products with a kink-protection of no more than a measly 3 cm which is inadequate. On the other hand, some cable assemblies included a relatively long and stiff kink protection - at first glance this would protect the connection quite well. However, the contrary is the case since the mechanical load is now shifted to the cable and provided with an increased lever-action. Especially with small plugs such as the SMA, the combination with a stiff kink-protection can result in considerable forces impacting on the plug - which result in strong stress and can even cause damage.

Q.: In you opinion, what does the correct kink-protection have to look like?

Stefan Burger: A good kink-protection is robustly connected to the plug to impart on the plug any forces caused by bending the cable while keeping the-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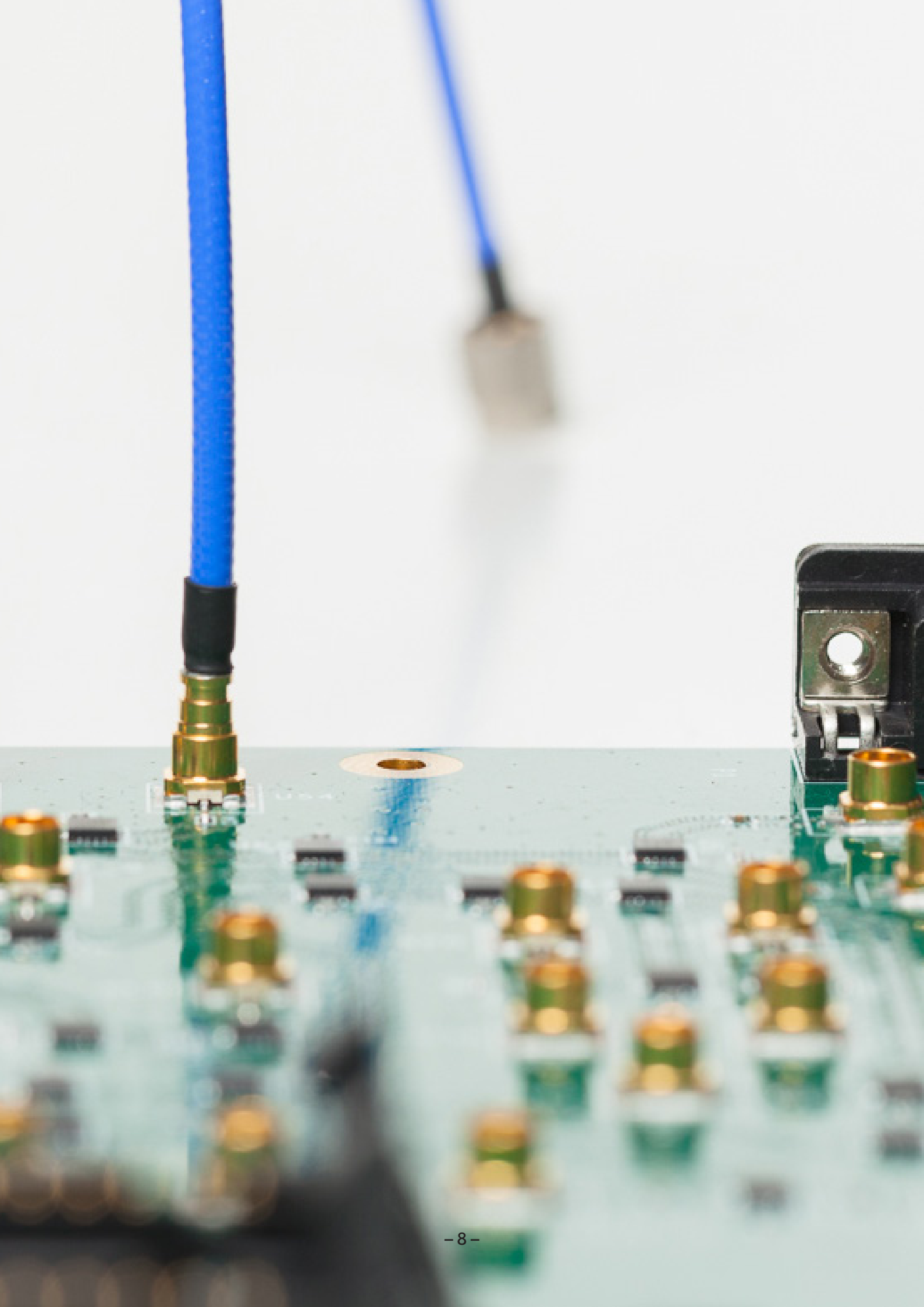


se forces away from the actual connection between cable and plug. Towards its end, the kink-protection becomes increasingly soft to enable the cable to form a curve. If the kink-protection is just stiff, the cable buckles at the end of the protection. Quality manufacturer achieve the desired effect via a shrink-tube of at least three layers, each layer extending a bit further than the last. This absorbs the shear forces and conducts them away from a single locations while the cable remains uniformly flexible up to the plug. In summary, one can claim that a detail as small as the correctly constructed kink-protection is responsible for an extended service-life of the cable..

To my knowledge there are globally very few manufacturers which can do without this actually indispensable protection - and even this can be done only for certain non-standard types and to reach special properties. I have investigated the StormFlex® cable by TSM: this indeed does deliberately not have any visible kink protection. Using special material, this cable designed such that even an angle adapter can be dispensed with. Indeed, the cable may be actually be buckled by 90° without any loss or change of electrical or mechanical properties.

Q.: Another basic question is how far cost dominates performance when acquiring cables for measurement or transmission?

Stefan Burger: The engineer does not always have freedom of choice. Often requirements are issued by controlling which make it difficult for the technician to solve a given problem with the desired precision and with the available means.

In some areas, such as the military, or aerospace, or in research depending on absolute reliability and precision, this issue does not present itself to the extent it is present in the industrial everyday-life, where we have semiskilled workers without much feeling for instrumentation calibrating boards on the assembly line. Still, it would be a conducive exercise for procurement to do a precise calculation whether a (necessary) higher number of no-names is really less expensive than durable brand-name cables. Large differences manifest themselves in particular in the following domains:

domain 1: electrical (RF-) parameters, e.g.

- highest operation frequency (Max. Frequency GHz)
- matching of the confectioned line (Return Loss dB)
- maximum power to be transmitted at the operational frequency (CW Power Handling W)
- how small is the overall attenuation given the desired cable length (Loss dB)
- how strong is the cross-feed attenuation (Isolation dB)?
- how well is the measurement result reproduced after moving the cable (repeatability)?

In this area, Teledyne has really done great work and offers very good solutions for every use and for various combinations. For example, the „StormFlex" cable is outstandingly suitable at frequencies above 50 GHz.

domain 2: other significant criteria with respect to service-life and stress, e. g.

- are the cables subjected to strong mechanical or thermal stress (to be defined via mil specs?)?
- how big is the tensile stress (tensile load [N])?
- is there (even very small) shock or vibration?
- what about the phase fidelity after moving the cable (phase stability)?
- how strong are phase changes dependent on temperature (Phase Change vs. Temperature ppm)?

Especially in the industrial every-day routine the bending frequency (flex lifetime, e.g. due to set-up and disassembly, movement during measurements) have a crucial significance. Therefore it is mandatory to ask: how often is a cable net during the process of use? More than 5000 cycles? More than 10000 cycles? More than 25000 cycles? Or even more than 50000 cycles?

If a cable is permanently mounted, the number of plug-cycles is of course not as important. If the cable is, however, used in production and connected several time a day, the maximum number of cycles can easily be surpassed.

Another consideration is the phase stability hone a cable is bent. If calibrations are done and – as typically will be the case – the cables are moved, the phase can change. Should this change remain permanent after the bending, the calibration could be void.

Even higher demands are put on the cable if it needs to be stable during the bending. This is the case e.g. for moving phase-array antennas. Consequently we need to ask ourselves:

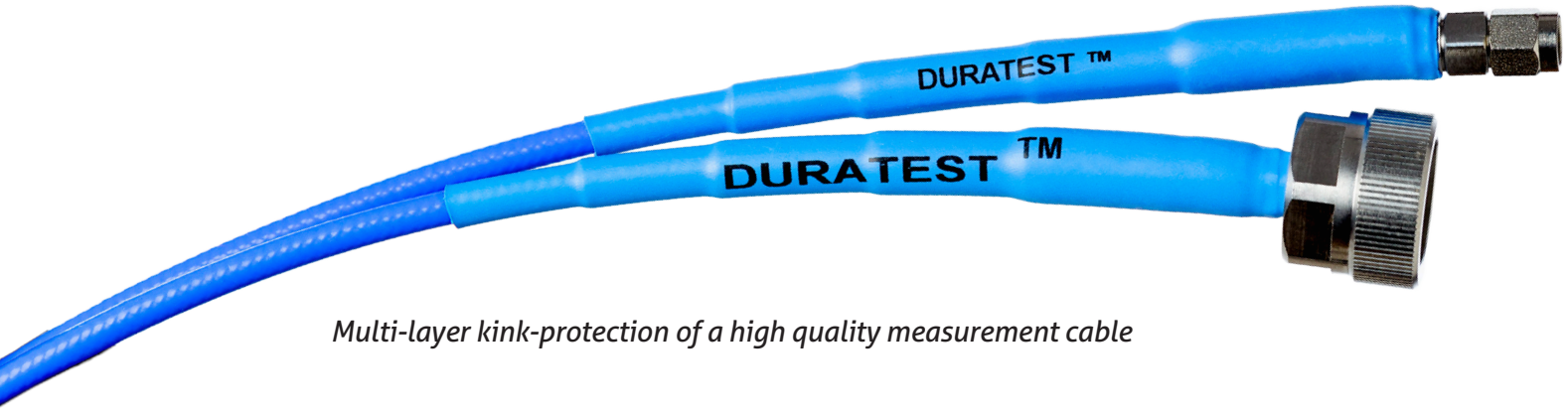
- how important is high bending strength and longevity of the plug-to-cable transition (Stability of strain critical connector /cable interface)?
- which phase changes result in dependance of temperature (phase change vs. temperature ppm)?
- is resistance against abrasion required (abrasion resistance)?
- are the cables subjected to high outer pressure (ressure on cable diameter)?
- are the cables subjected to mechanical pressure (crush resistance [kN/m])
- how often may the cable be bent (flex life cycles)?

The measurement engineer should have thoroughly considered these question and searched for answers even before stating to think about the pure costs. Otherwise – as in all areas of life – one will have to purchase the same thing over, plus, in areas where cables of the criteria listed above are deployed follow-up costs may be several times what the expenses would have been, had a high-quality product been acquired to begin with. Also, Murphy's law dictates that especially of nothing must go wrong, it will!

According to my assessment there are only a few manufacturers listing, in their portfolio, cable types which enable you to master the aforementioned scenarios without problem. These manufacturers operate, without exception, not in the lower price categories – that much is clear. However, even with the

premium manufacturers there are price differences. The most expensive cable is not necessarily the one best suited. To me – and in fact that is an opinion I do share with many others – the US manufacturer TSM Teledyne Storm Microwave is, for example, a good choice regarding the criteria performance, selection, service life at an excellent price.

Q.: thank you, Stefan, for this talk!



Multi-layer kink-protection of a high quality measurement cable

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