Universal connector for quick measurement of coaxial cables

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Abstract

A new design of connector for the testing of coaxial cables is presented. It is universal in the sense that it can be used for any cable size (of up to 16mm over cable screen).

It is based on end-to-end connections and allows for a simple preparation and quick mating, making it ideal for the testing of non-connectorized cables.

Keywords: Connector; Coaxial; Cable; Testing.

1. Introduction

Testing of coaxial cables requires the use of dedicated connectors. These are usually specifically designed to perfectly suit each cable geometrical dimensions. In some cases, these connectors may be reused a certain amount of times. However, when crimped connectors are used, these latter need to be replaced after each use.

The connector described in this paper is fully compatible with all cable dimensions and can, practically, be reused "indefinitely".

The preparation of the cable is also greatly simplified and consequently, the assembling time is significantly reduced.

2. Principle of the connection

The design principle of this connector is based on the fact that a very short connection will only affect highest frequency spectrum; this as a direct consequence of wavelength and frequency being inversely proportional. By reducing the connection length to few tenths of a millimeter, perturbations linked to the connection only appear above some tens of GHz.

Hence, the cable end face is directly pressed against a specifically adapted connector plane, contacting both central pin to the inner conductor of the cable and the connector screen through a conductive plate to the cable screen.

This renders the connection quick and easy and the cable preparation straightforward.

3. Connector design

The connector is made of a panel connector type N or SMA (depending on the cable size to be measured), with its central conductor equipped with a "spring mounted pin", for the contact to the central conductor of the cable.

The connection to the cable screen is done through a metallic screen connection plate whose dimensions are designed to match the impedance of the connector.

The cable holder is built out of a standard ER25 holder where spring collets of different sizes can be inserted. Collets are cut in two pieces to ease the cable insertion.

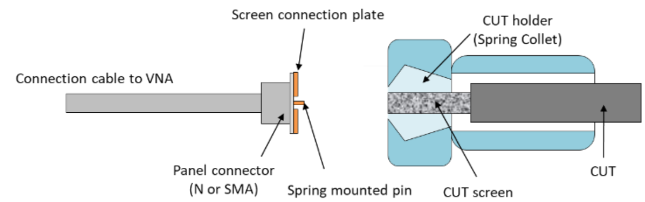


Figure 1: Sketch of the connector

Both 50 and 75Ω versions are available.

3 different sizes of panel connectors allow to adapt to any cable size accepted by the ER25 holder (diameter over screen below 16mm).

50W	CD<	CS>	CS<	T	Z	MF
S	0.5	0.7	16	SMA	50	18
M	2.3	1.6	16	N	50	11
L	4	2.5	16	N	50	11

75W	CD<	CS>	CS<	T	Z	MF
S	0.9	0.7	16	N	75	1.5
M	3.7	1.6	16	N	75	1.5
L	6.3	2.5	16	N	75	1.5

Figure 2: Connector size vs cable dimensions

With

- *CD<: Maximum Conductor Diameter (mm)*
- *CS>: Minimum Diameter under Screen (mm)*
- *CS<: Maximum Diameter over Screen (mm)*
- *T: connector type*
- *Z: Impedance (Ω)*
- *MF: Maximum Frequency (GHz)*

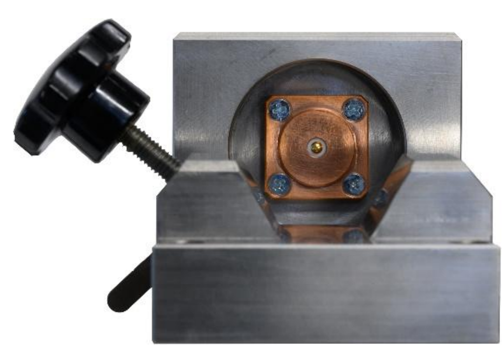


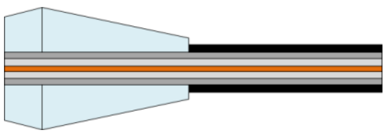
Figure 3: Cable connection side of the universal connector

The panel connector is fixed with 4 screws and can easily be interchanged.

4. Cable preparation / Installation

There are 2 different ways of preparing the cable :

1. Standard preparation
    a. The cable is cut.
    b. The outer sheath is removed over a few centimetres.
    c. The cable is placed in the collet.



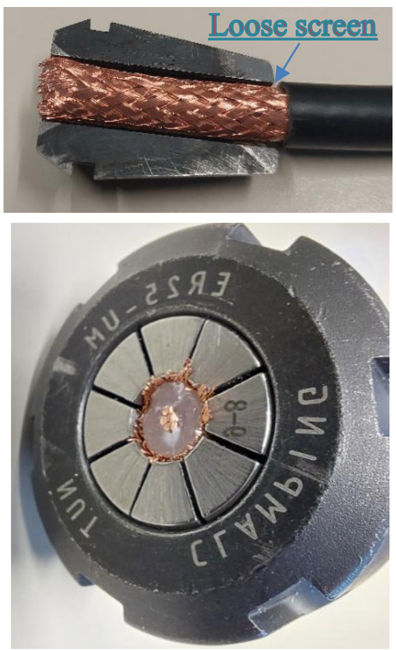


Figure 4: Standard preparation and cable end face after installation in cable holder

2. Folded screen
    a. The sheath is removed over a short length.
    b. The screen is folded over the outer sheath.
    c. The Insulation + inner conductor are cut at the folding position.
    d. The cable is placed in the collet

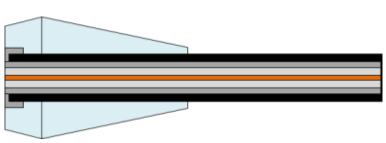


Figure 5: Folded screen preparation and cable end face after installation in cable holder

Although apparently simpler, the Standard preparation, where the sheath is removed, leaves a part of the screen loose. This is well-known to affects local impedance and then the reflection measurements. Subsequent manipulations of the cable/connector, particularly when using flexible cables, may further amplify this phenomenon. Even if limiting the removal of the sheath to the shortest possible length will minimize this effect, the Folded screen procedure, with the sheath covering the conductor over it whole length, remains the preferred one.

Figure 6: Installation of cable in collet holder

The collet is then placed in the holder and the screw tightened, so that the cable is firmly attached to the universal connector.

The connector is finally placed on the device and pushed forward by a dedicated finger that applies pressure between the cable and the SMA/N connector-.

Figure 7: The universal connector (with N interface) with cable in place

5. Calibration

SOLT Calibration can be done directly at the connector's end using dedicated artefacts, and so placing the calibration plan at the connector end face.

The artefacts are placed in collets and connected is the same way as the cable to the connector

- SHORT consists of a copper flat surface
- OPEN is usually done without artefact - but can also be done using the SHORT artefact that consists of a copper flat surface integrating a insulating layer at its center.
- LOAD consists of a high precision 50/75W load artefact whose end face is adapted for direct connection to the universal connector
- THROUGH is built out of 2 connectors placed in direct contact.

Figure 8: Calibration artefacts (N and SMA)

For the SMA connector, a comparison between OPEN with and without artefact shows that the difference mainly lies in a phase shift between the curves, corresponding to a different length of OPEN configurations due to a larger extension of the field outside of the connector without artefact.

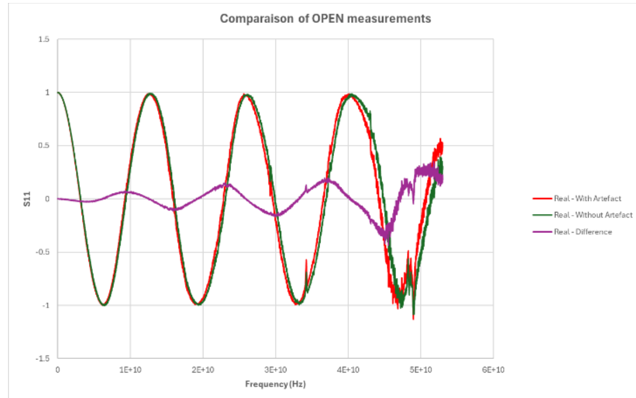


Figure 9: Comparison of OPEN with and without artefact

6. Measurement of the connector

A set of connectors have been measured individually to check

- The ability of the connector to measure up to the designed frequency (no large reflection/attenuation peaks)
- The homogeneity of behavior between different connectors of the same design
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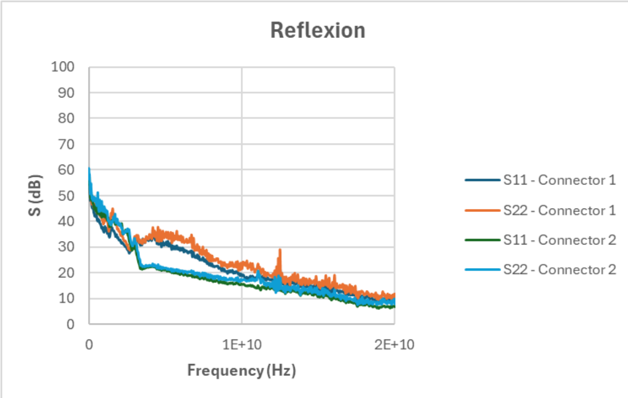
For the connection on the cable side, a "truncated" female adapter was used, milling down to the insulating surface and filling the inner connection with a pin so to stay as close as possible to the geometry of the interface used during the calibration.

Figure 10: Standard and truncated adapter

The calibration was done on both the SMA connector of the connecting cable on one side and the full adapter on the other side, using standard SMA calibration kit.

Measurements were then conducted replacing the standard adapter by the truncated adapter, inserted in a collet, and connected directly to the universal connector.

Measurement results are shown below for 2 different pieces of SMA connectors.



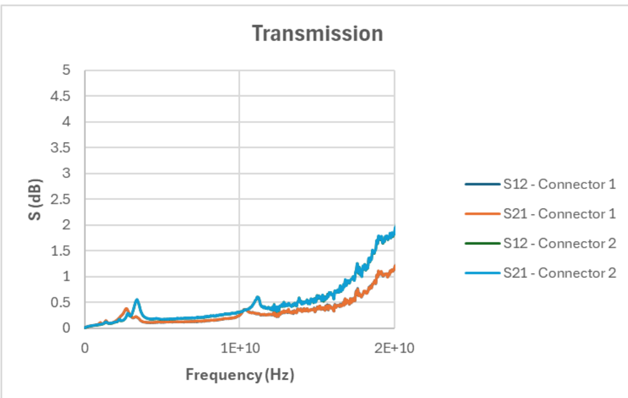
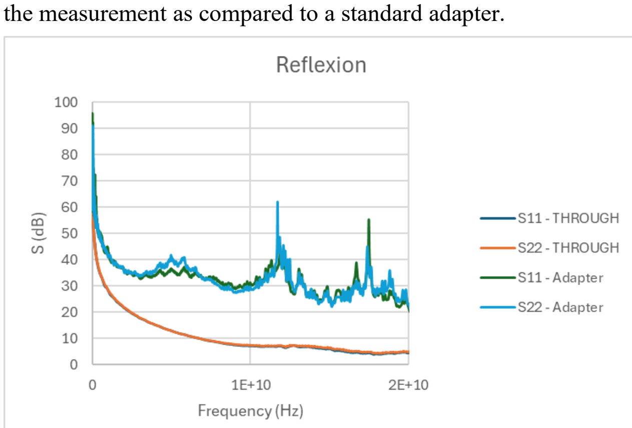


Figure 11: Standard and truncated adapter S-Parameters

It demonstrates that the manufacturing of the connector is not fully reproducible and brings some inconsistency in the different characteristics. These remains however relatively small and can be removed by calibration for the part regarding the reflection properties.

For transmission, as the truncation of the adapter may also lead to some difference in the measurements, another solution was used to estimate the connector effect. THROUGH connector based on 2 back-to-back connections were used for evaluation.

A first test shows that THROUGH has a relatively large impact on the measurement as compared to a standard adapter.



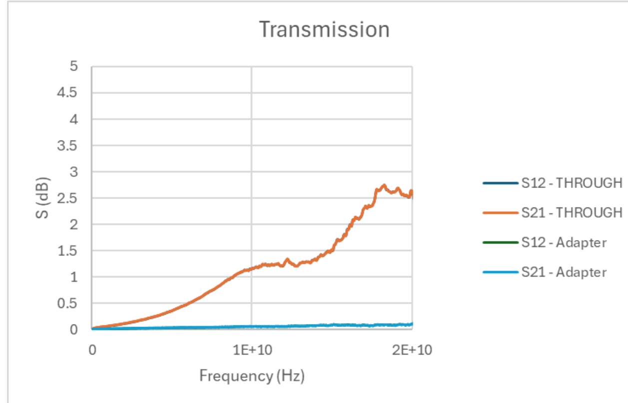


Figure 10: Comparison of THROUGH Artefact and bare adapter

Different THROUGHs build from different SMA connectors with spring loaded pin have been compared to evaluate the possible error on the calibration dure to differences in the connectors.

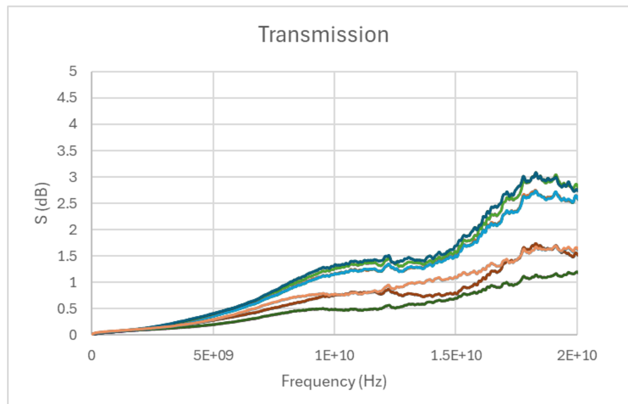


Figure 11: THROUGH curves of different adapters

The calculation shows that the difference between the maximum and minimum measured values is less than 1dB up to 10 GHz and less than 2dB up to at least 20GHz.

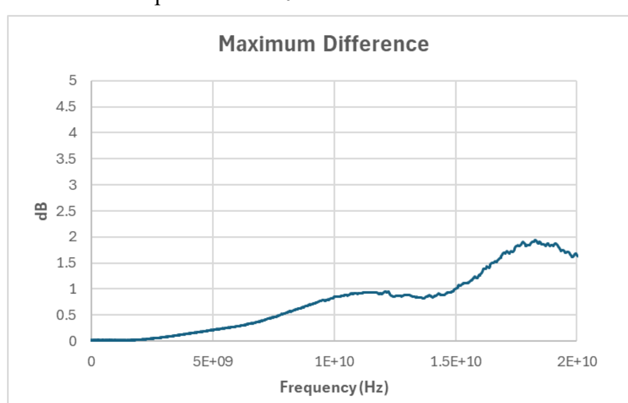


Figure 12: Estimation of the maximum effect of the THROUGH calibration on the measurement results

This gives a estimation of the possible error related to the difference in the behavior of the connectors used for the measurement and the connectors used for the THROUGH calibration. The final impact on the cable measurement itself will then depend on cable attenuation and measured length.

7. Measurements

Measurement on a 10m long RG174 cable, using SMA interface, have been conducted using different configurations:

- A full cable with Folded screen preparation
- An unsheathed cable with Standard screen preparation
- A full cable equipped with crimped SMA connectors and measured directly on a calibrated VNA

Although the connector is designed only up to 18GHz, measurements up to 53GHz have been conducted.

Results are shown in the following figure

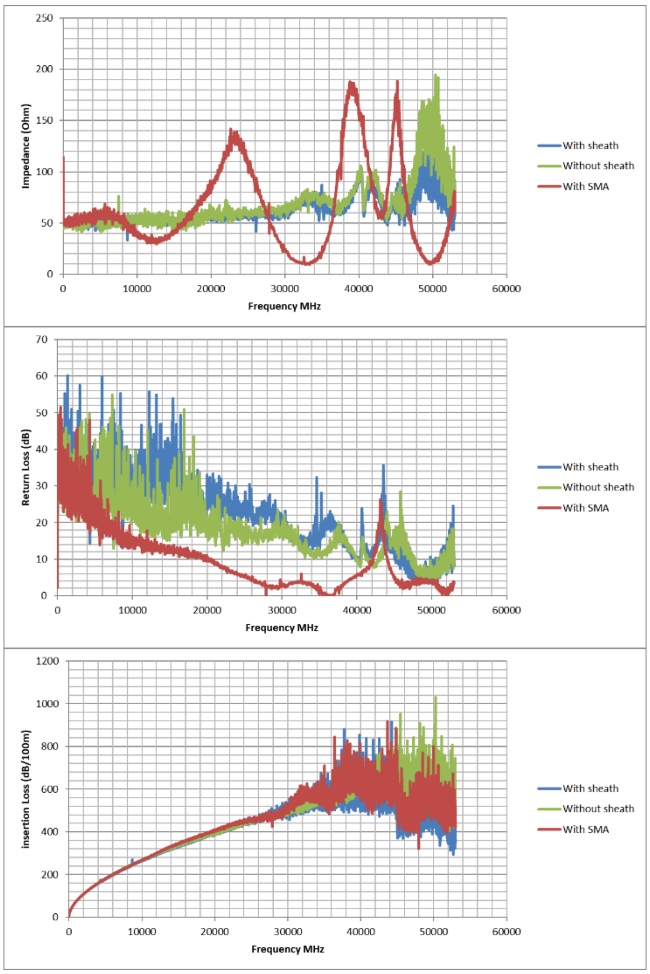


Figure 13: Measurement results

Measurements done using the universal connector show a reflection above 15dB up to about 30GHz, while the pre-connectorized cable return losses are about 10dB at 20GHz, probably reflecting the cable deformation due to crimping of the connector.

8. Conclusion

The universal connector provides a very easy and effective way to quickly test coaxial cables.

It renders the preparation of the cable straightforward and as such, reduces the preparation time.

It is adapted to coaxial cables with diameter over screen up to 16mm.

A dedicated system integrating all functions from calibration to parameter evaluation is readily available.

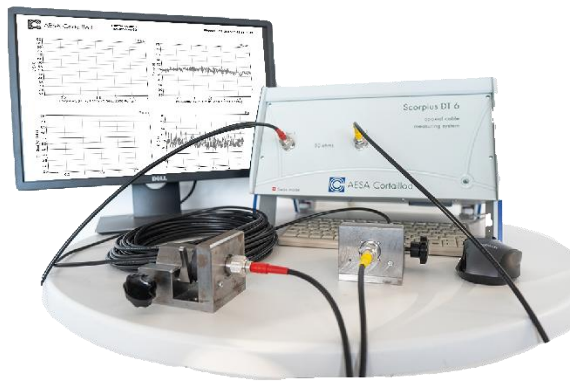
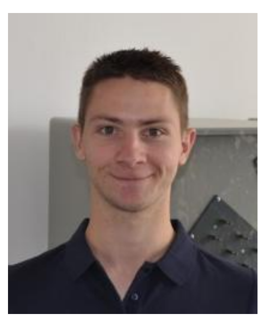


Figure 15: Scorpius device with Universal connectors

9. Authors

Boris Dardel obtained his PhD in physics in 1994 at the University of Neuchatel (Switzerland) in Condensed Matter Phys ics. He then joined the cable manufacture of Nexans Suisse SA in Cortaillod (Switzerland) where he managed different technical departments linked with materials, cable designs, testing and R&D. In 2016, Dr. Dardel came to AESA SA in Colombier (Switzerland) as R&D Manager, responsible for designing and leading R&D processes, specifically linked to the measurement of electrical resistance for energy cables.



Fabrice Pfefferli owns an MSc in in biomedical engineering from the University of Bern. He joined AESA in 2020 as electronics and software engineer. He is in charge of the development of AESA new measuring software for automated test equipment (ATE).

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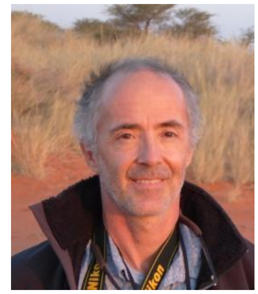
Denis Milz is the Area Sales Manager at AESA. He joined the company in June 1997. Owner of a Bachelor of Science in Electronics and electrical engineering from the Ecole d'Ingénieurs du Locle, Neuchâtel, he began his career at AESA as a software developer. He was then put in charge of the after-sales service department for a few years before moving to a more commercial position.

Denis Milz is in parallel responsible for the product line of automated test equipment (ATE) for Copper communication cables

Vincent Arbet-Engels is the CEO/Managing Director of AESA, a leading manufacturer of test equipment for the cable industry. Prior to AESA, he held various scientific and management positions at CERN, IBM, and Abilis Systems, in both the USA and Europe.



Dr Arbet-Engels graduated from the University of California, Los Angeles (UCLA) in 1992, with a Ph.D. in Electrical Engineering. He also earned a M.S. from UCLA, as well as a M.S. and B.S. from the Swiss Federal Institute of Technology in Lausanne (EPFL) in Microengineering.