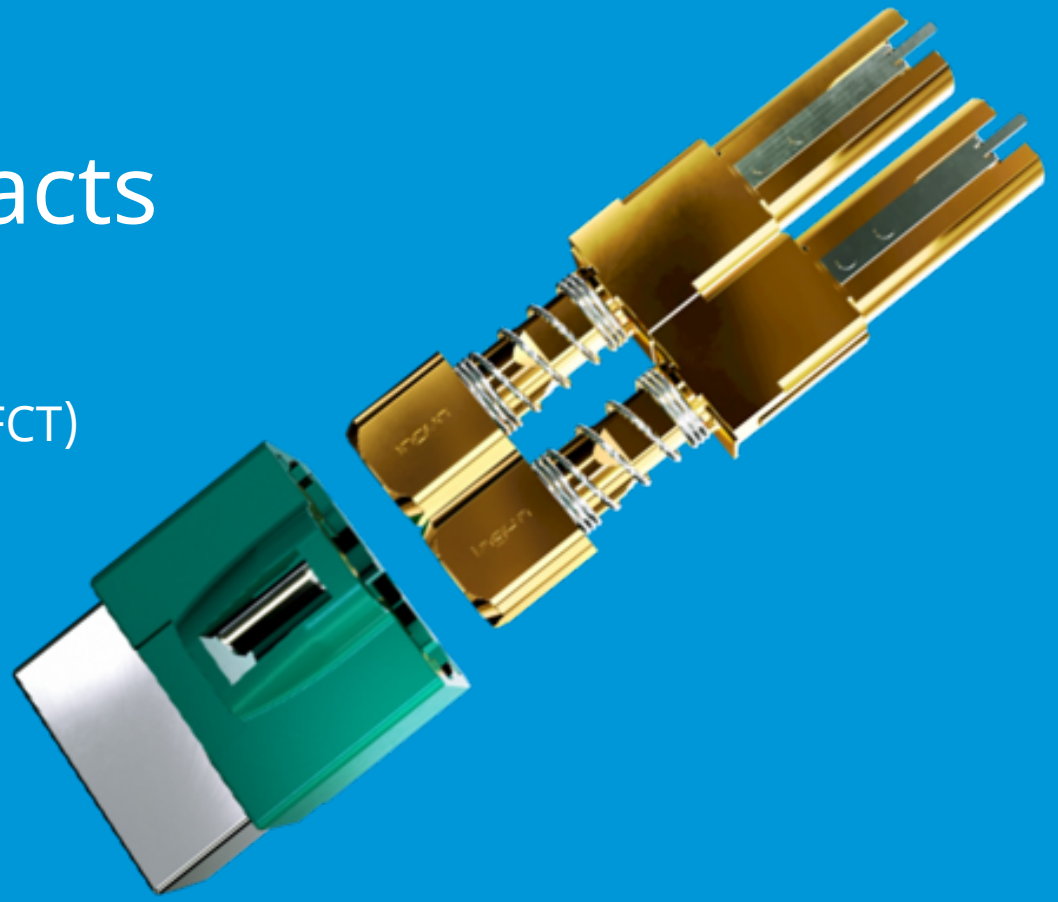
Usage of spring-loaded contacts for automotive applications.

For RF and general test applications – functional testing (FCT)



Matthias Zapatka, CIS | **Presentation at PCB Carolina, November 2022**|
INGUN USA Technical Service and Support Center

ingun.com

What we will cover today...

01 RF Automotive connectors and matching test probes and plugs

02 S-Parameters for RF test probes

03 Measuring high speed signals with breakout boards

04 Calibration with in-situ calibration modules

05 Shielded FCT test fixture for RF applications

06 ESD prevention on the test fixture

07 Guidelines for ESD fixture customization with test probes

08 Usage of test plugs

09 Cable guiding techniques inside the test fixture

10 Hi-pot and 4-wire testing on automotive connectors

11 Automotive harness testing

12 Continuity testing

RF Automotive connectors and matching test probes and plugs

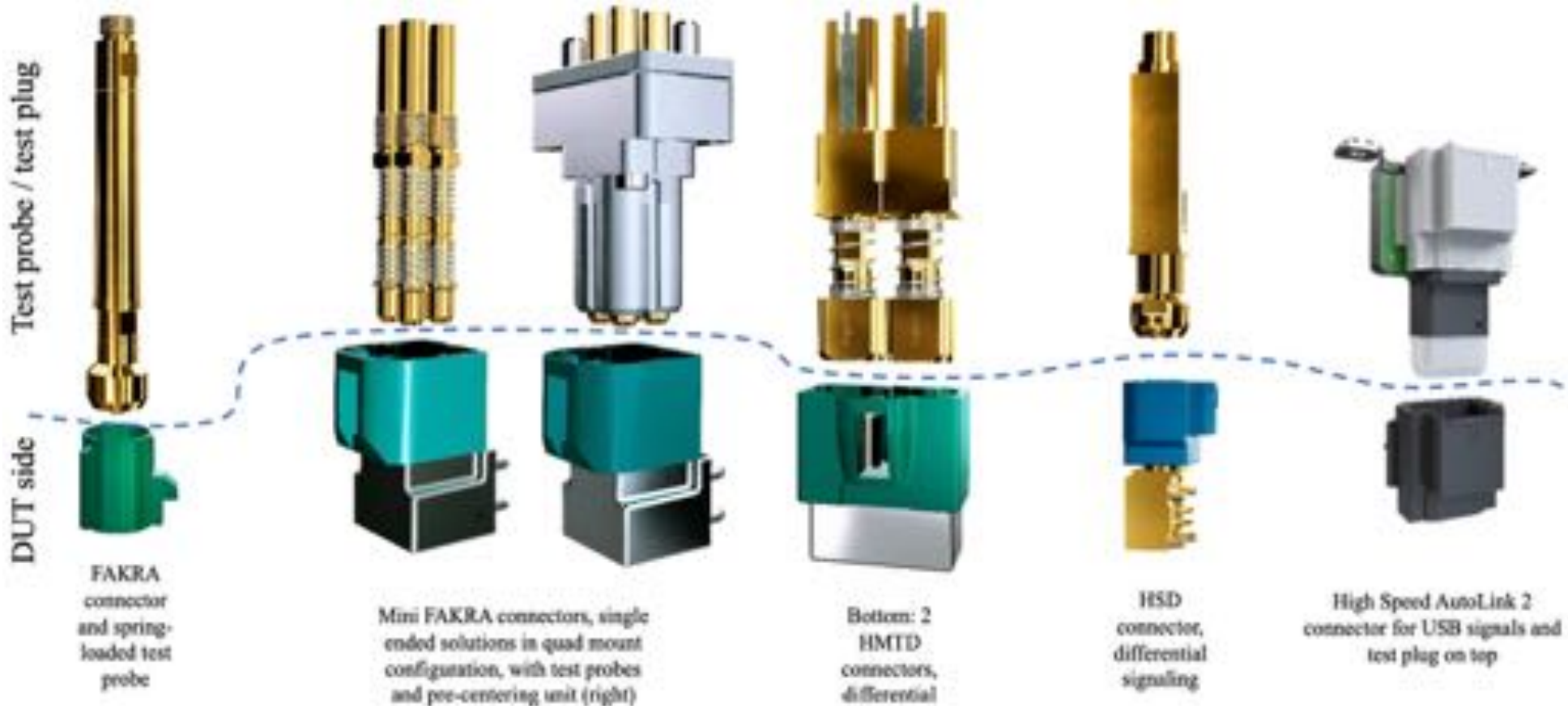
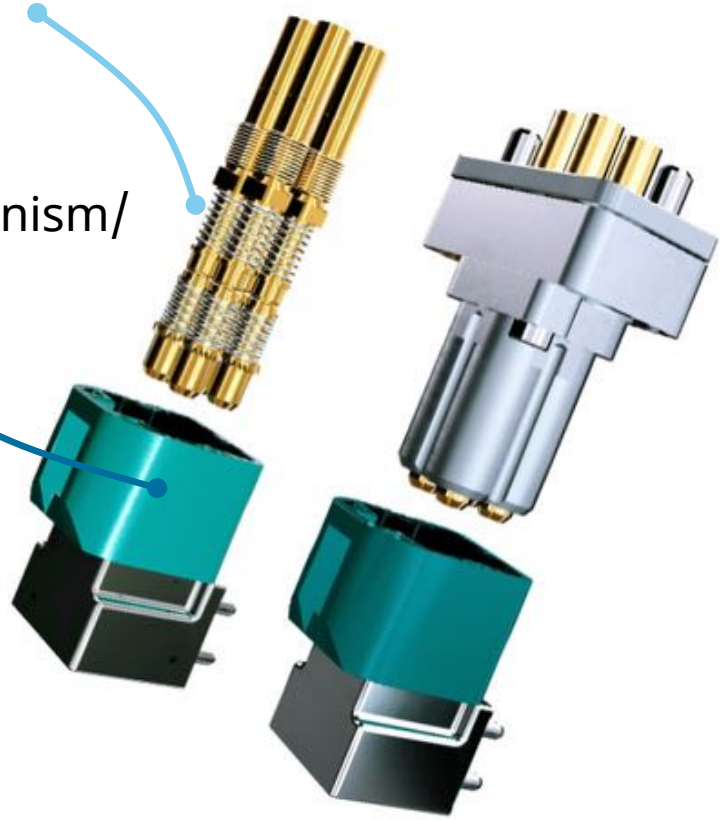


Illustration of **different RF automotive connectors**, single-ended and differential. The connectors are on the bottom. The top part shows the respective test probes to mate with these connectors for **production-line testing** inside a test fixture.

Difference between a connector and a test probe

Probe: Spring mechanisms

Connector:
Retention mechanism/
housing



A test probe is specifically made for ***repeated, automated testing*** on a connector

As such there is a ***spring-loaded mechanism*** inside the unit to mate with the DUT surface

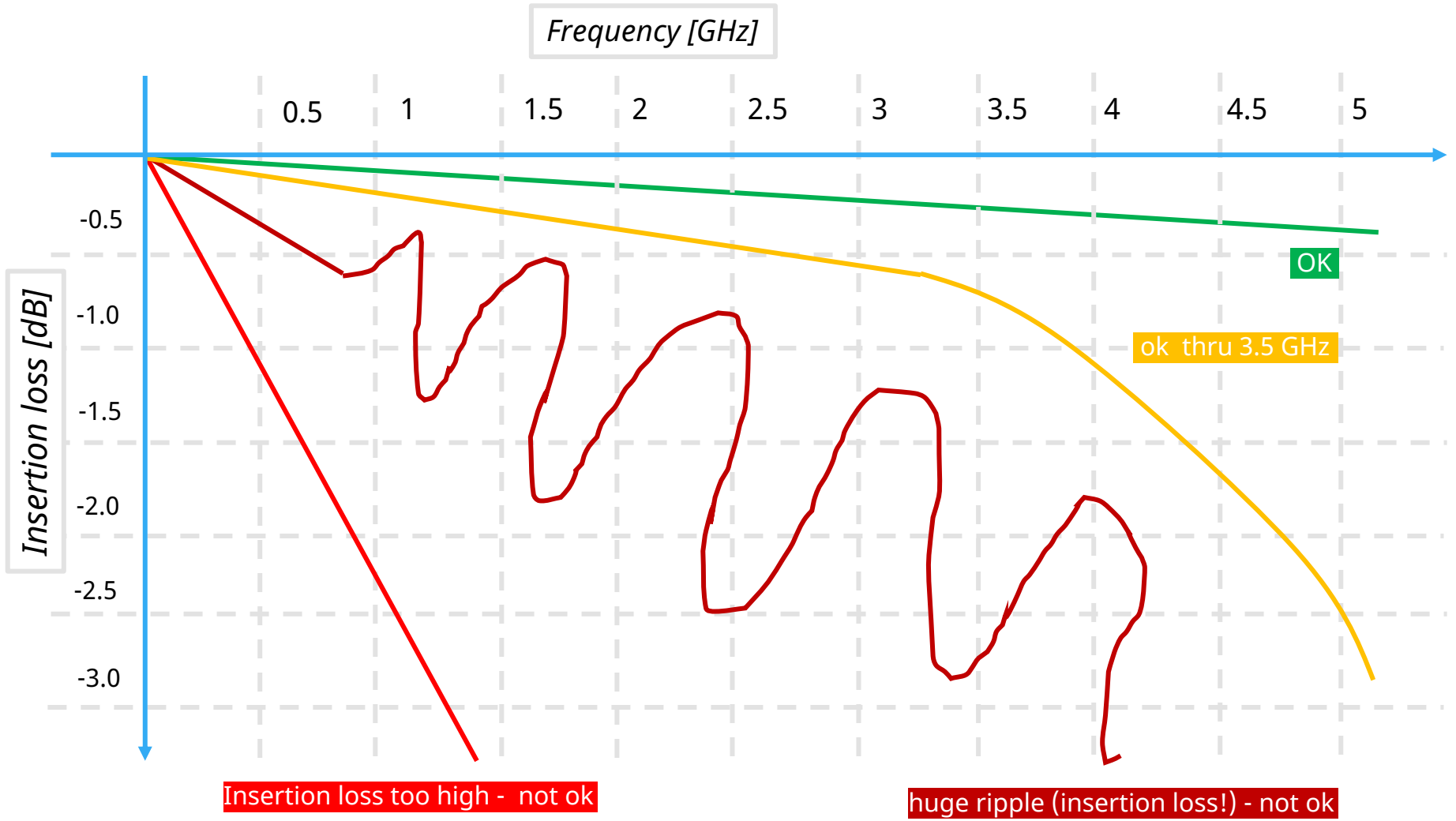
Most probes and test plugs are ***not self-retaining***, that means a test fixture must be used to hold the item in place for establishing electrical contact.

S-Parameters (electrical performance) must be carefully aligned inside the probe so that the internal spring mechanism does not cause degradation of the electrical performance. See next slides.

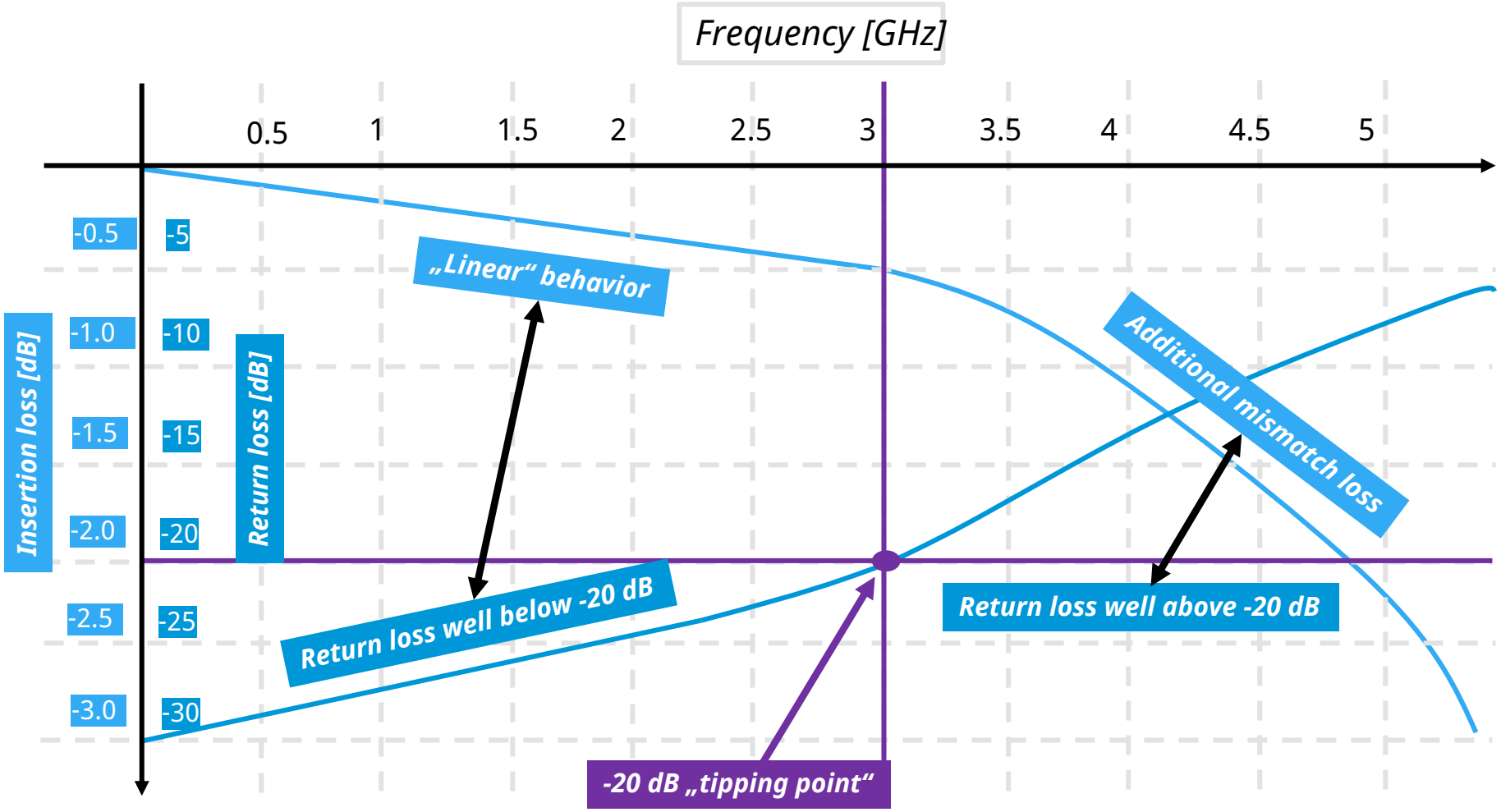
S-Parameters for RF test probes – insertion loss

Insertion loss graphs for a test probe measurement (without cabling attached).

This gives a visual representation what is acceptable.

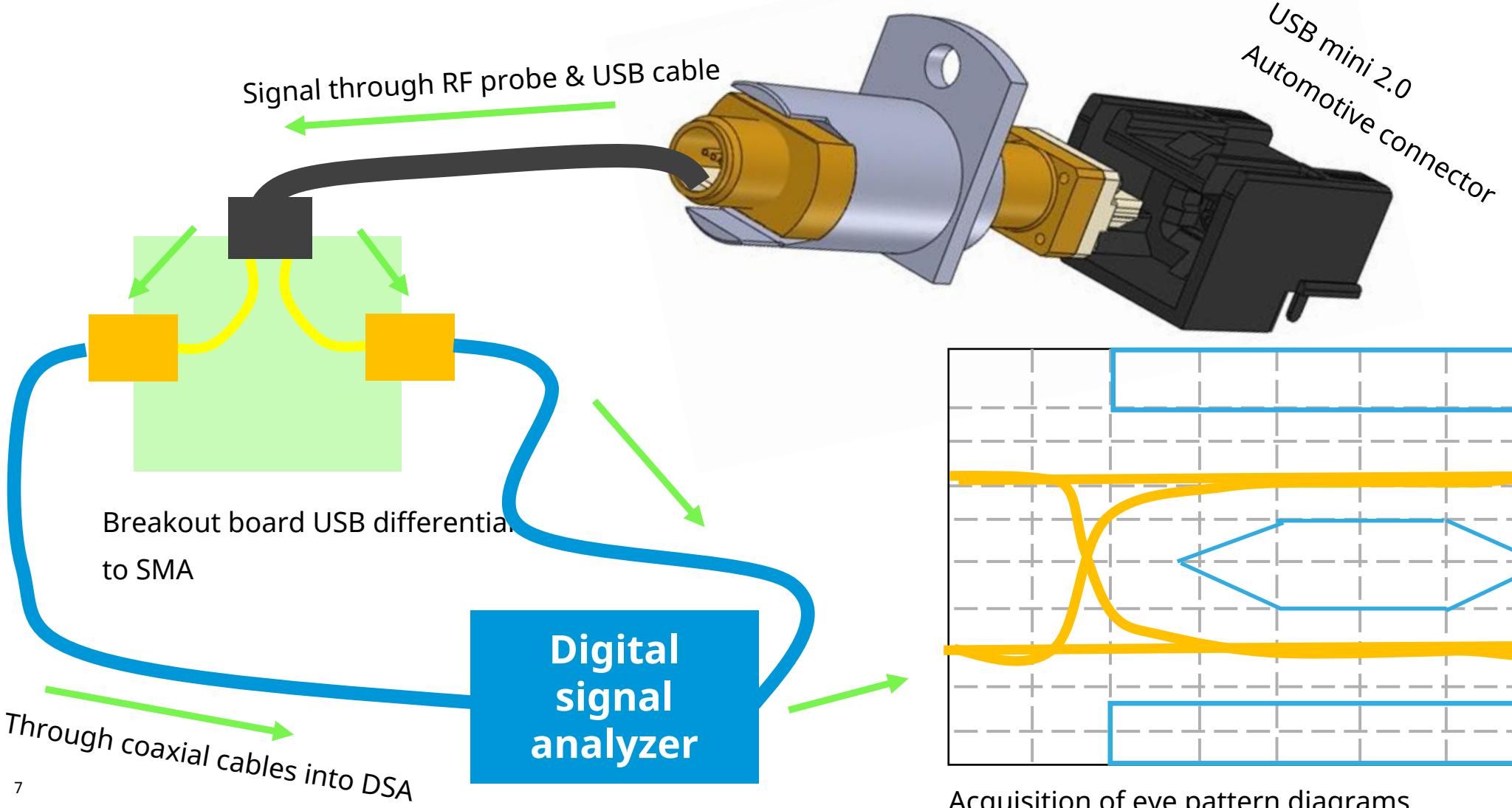


S-Parameters for RF test probes – return loss



This graph is for the **return loss (matching)** – but in addition we also show the correlation between the return loss and the insertion loss. Above the “tipping point” one can typically see additional mismatch losses. That happens roughly when the -20 dB line is crossed, however circuits typically **still can be used at -15 or even -10 dB return loss.**

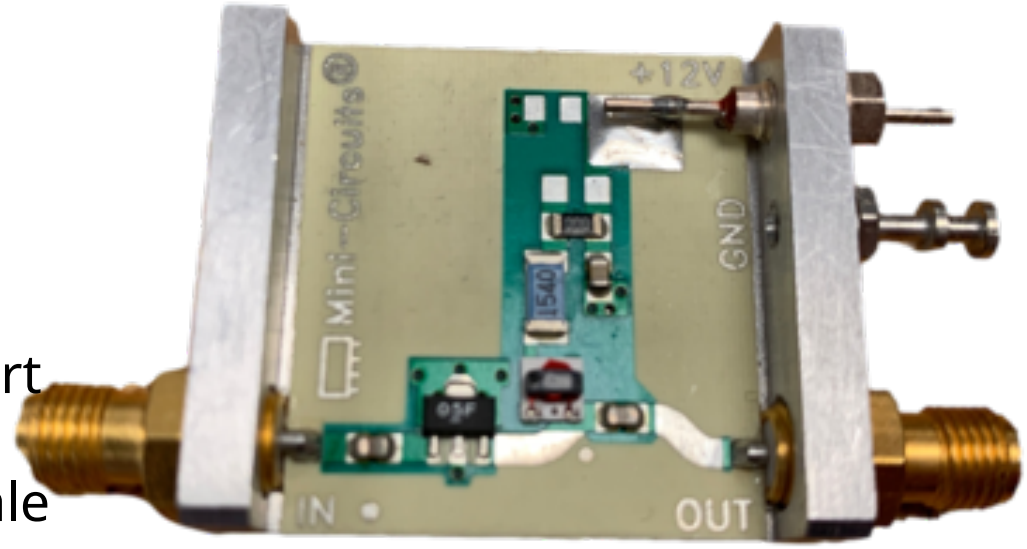
Measuring high speed signals with breakout boards



Acquisition of eye pattern diagrams

Calibration with in-situ modules (1)

RF test port
#1
SMA female



Device under test

RF test port
#2
SMA female

Idea / concept:

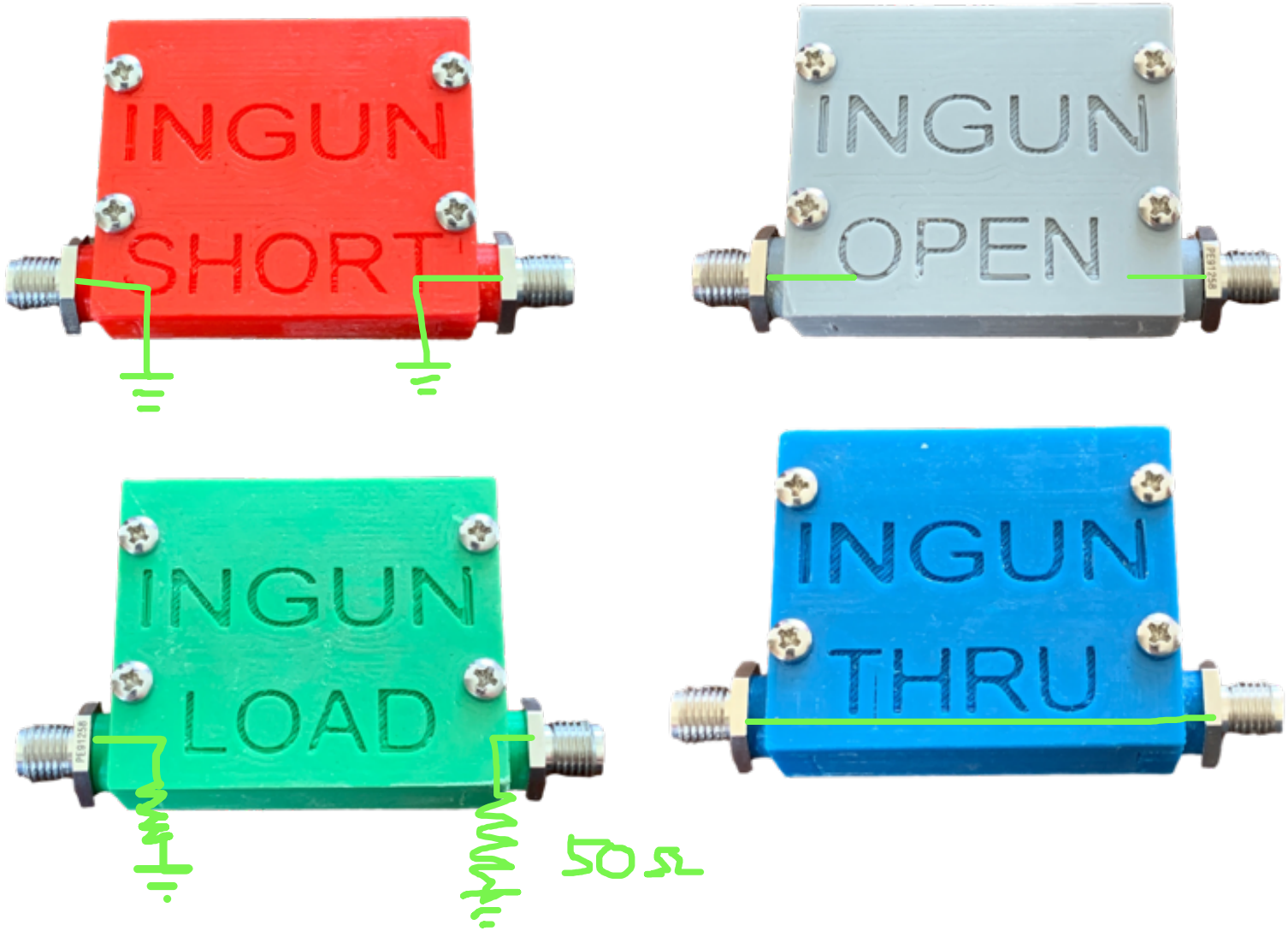
Duplicating the outline dimensions of the DUT and creating/ designing unique calibration modules for

Short
Open
Load
Thru

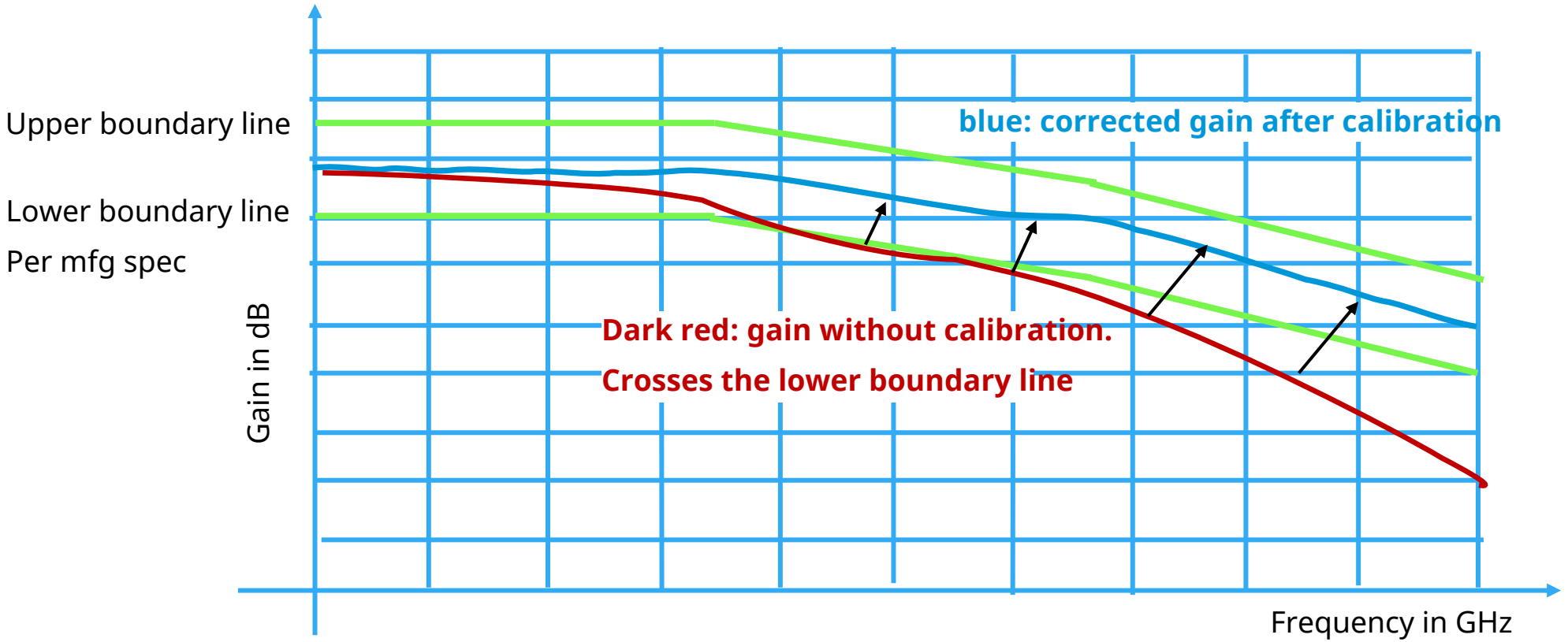
calibration. This would allow the S-Parameters to be corrected right at the DUT reference plane.

This is commonly used for on-wafer testing (calibration substrate), but the concept is not widely known yet for PCBA production test.

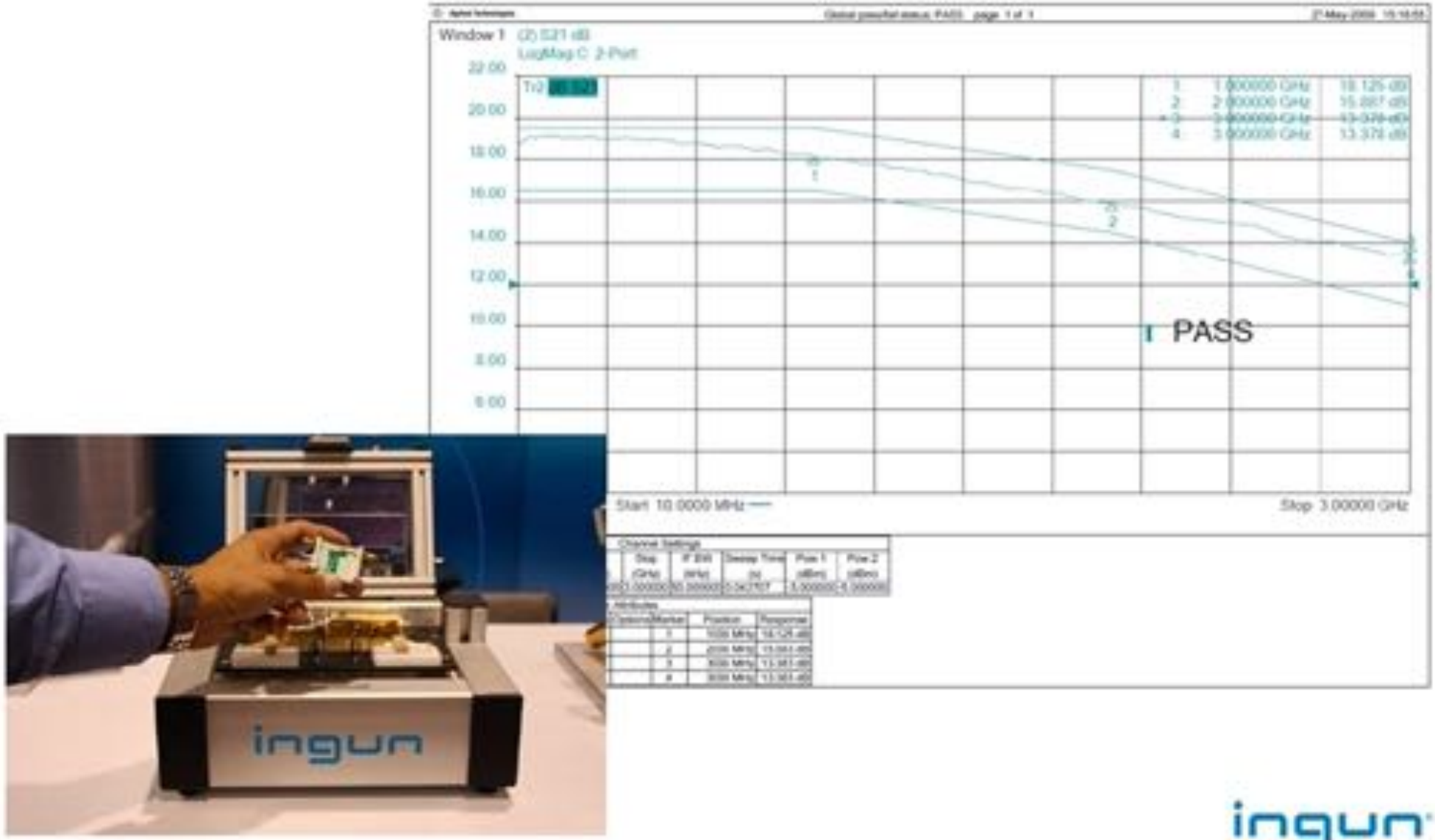
Calibration with in-situ modules (2)



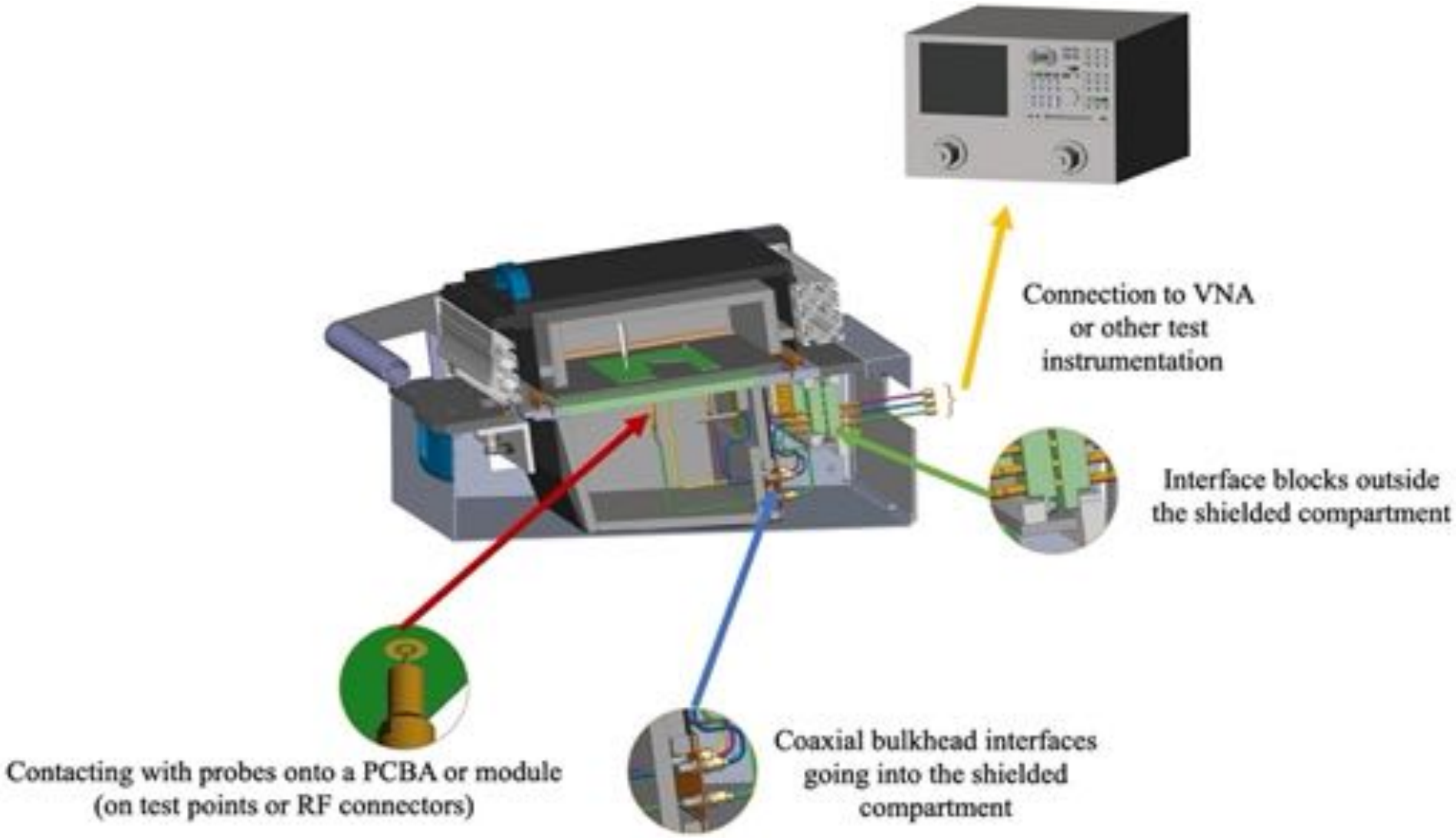
Calibration with in-situ modules (3)



Calibration with in-situ modules (4)



Shielded RF test fixture

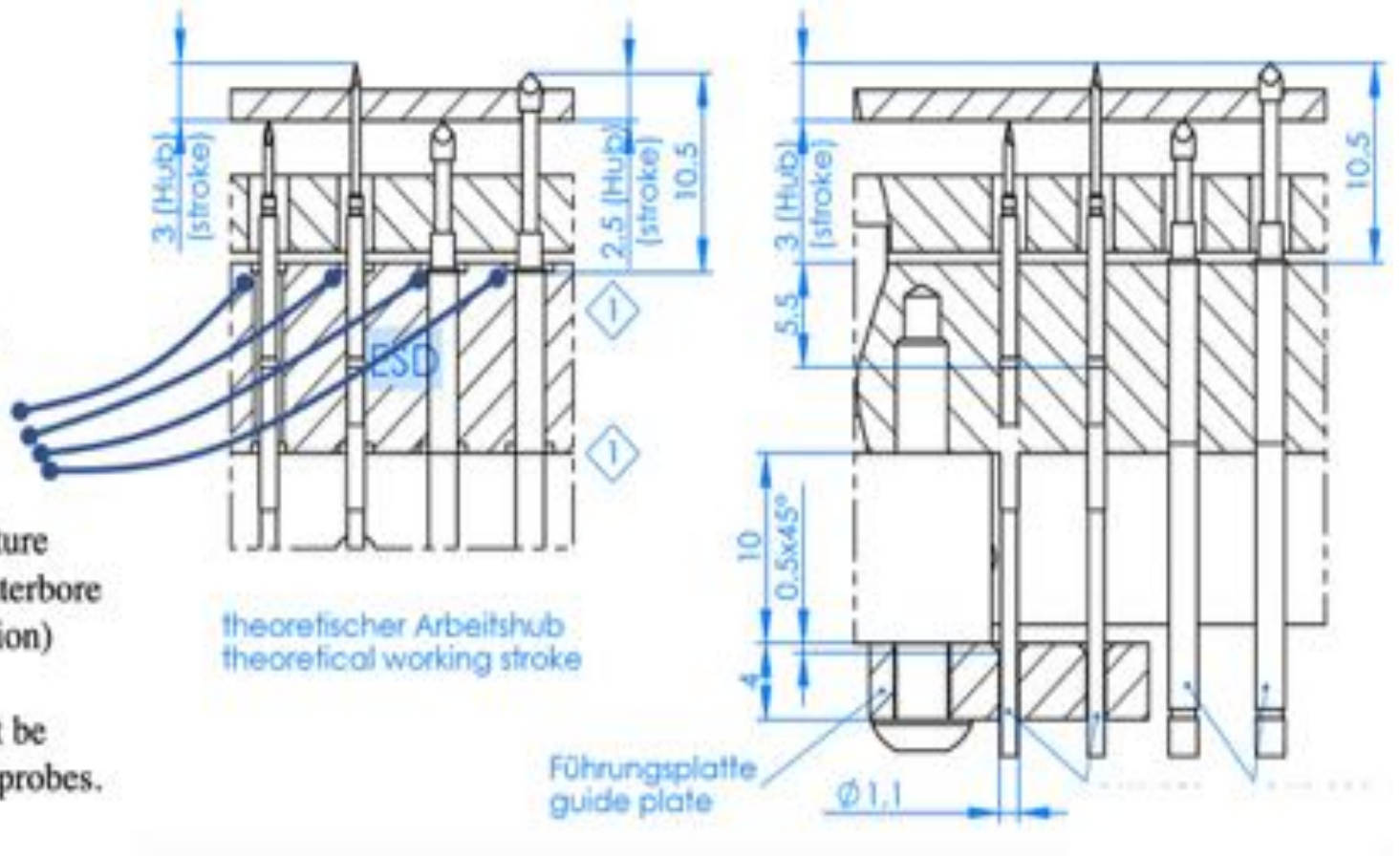


ESD customization with test probes

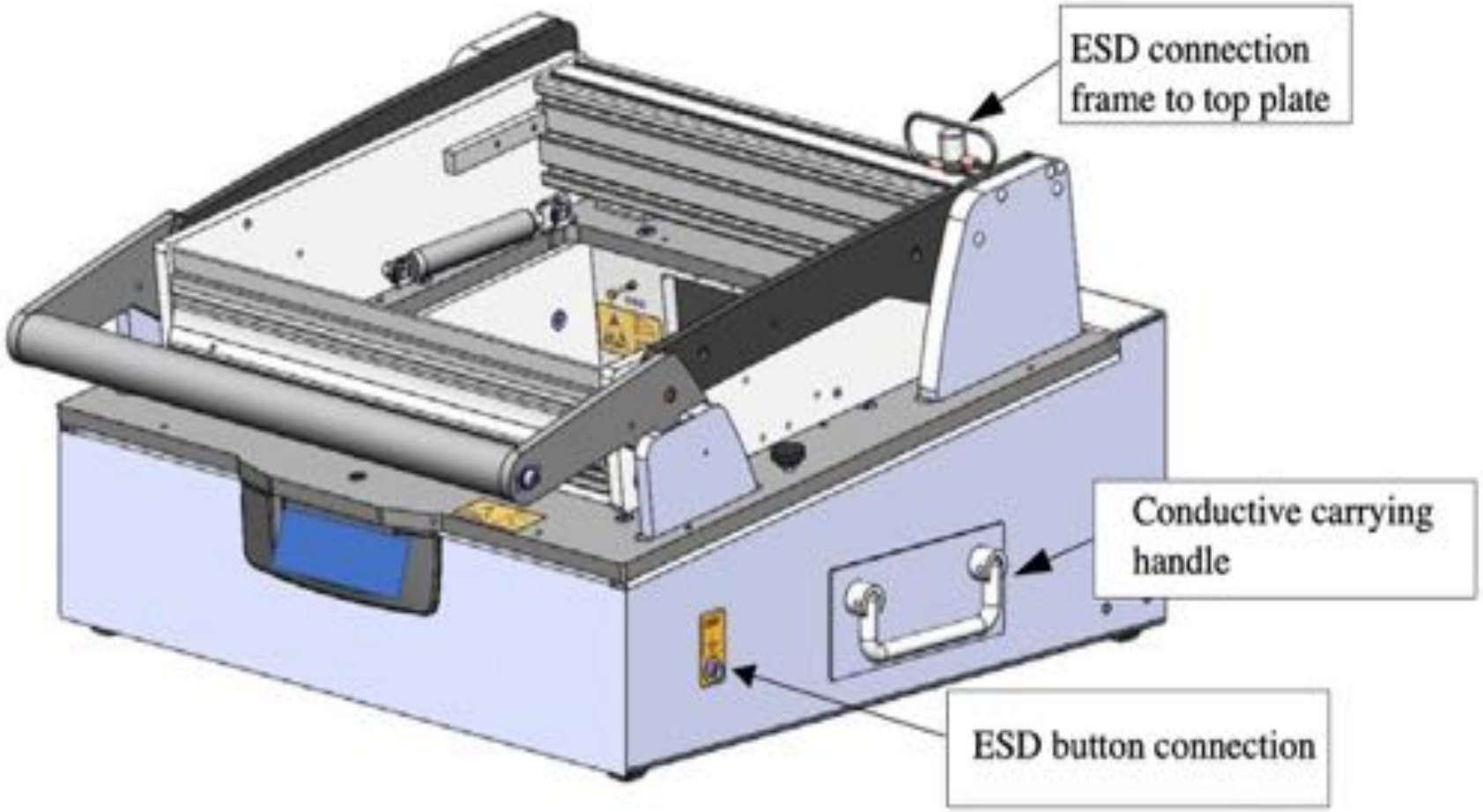
Note the counterbore
On this manufacturer
Guideline for ESD
customization .

On the right-hand picture
There is no such counterbore
(non-ESD customization)

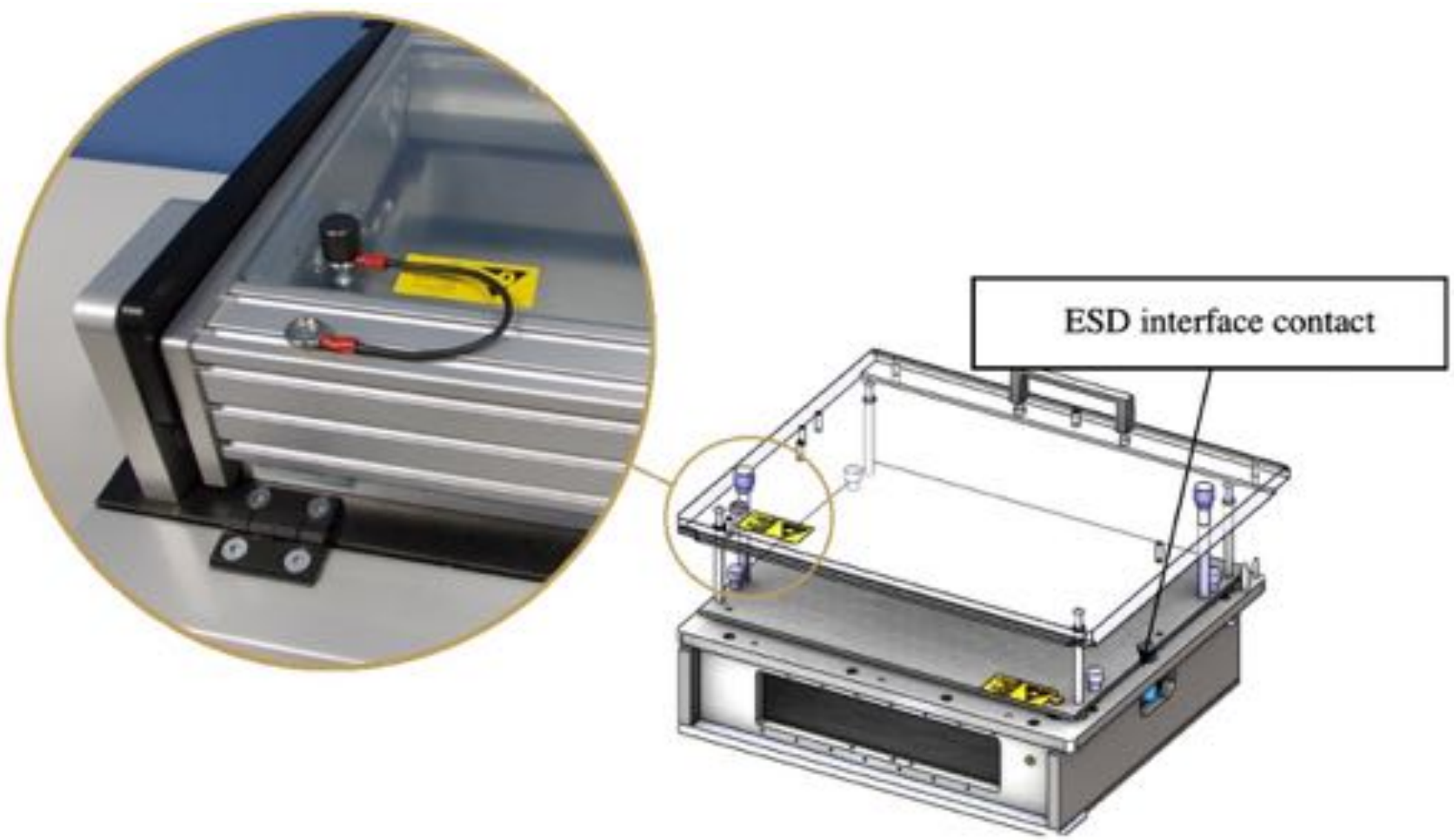
Counterbores may not be
necessary for coaxial probes.



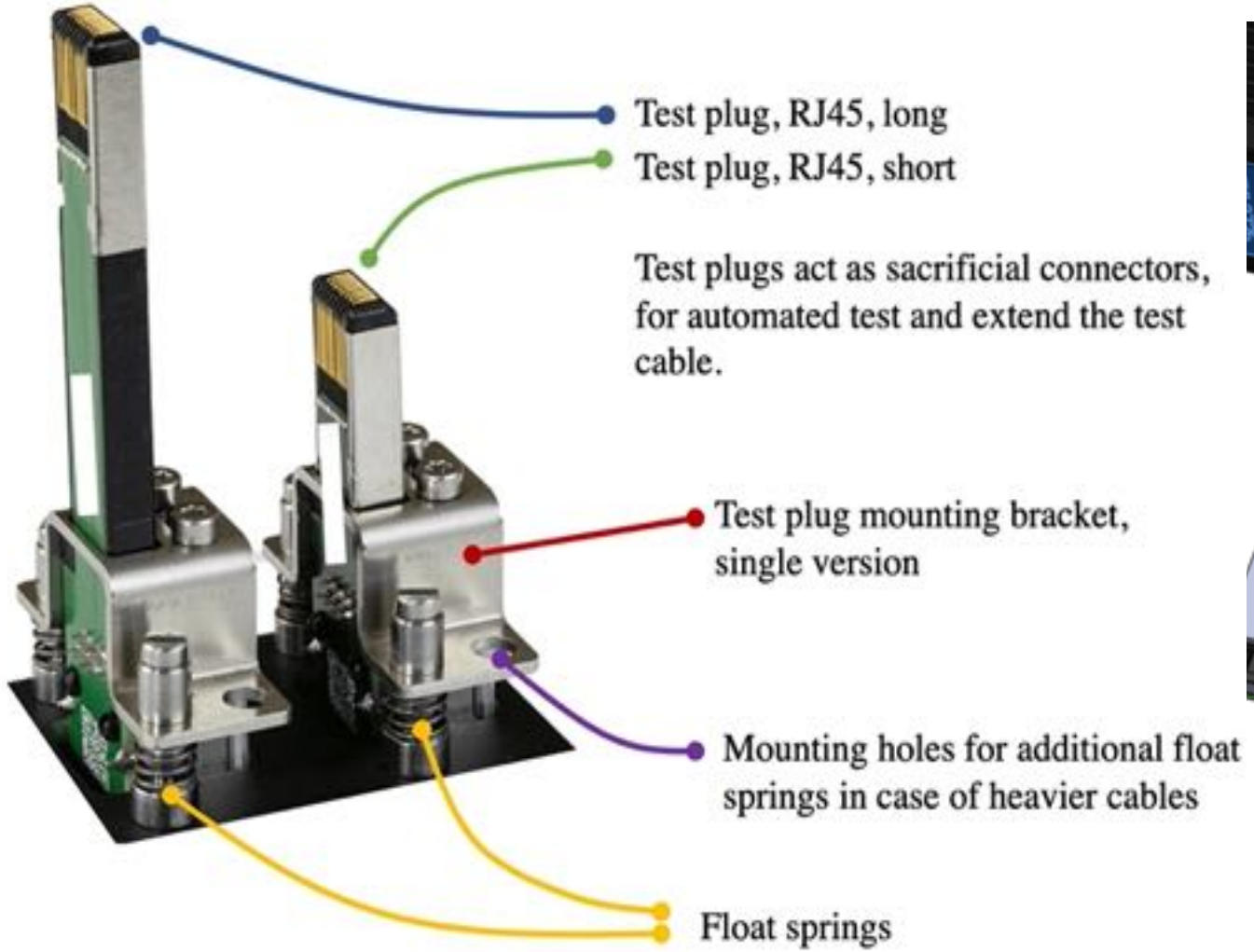
ESD prevention on the test fixture (1)



ESD prevention on the test fixture (2)

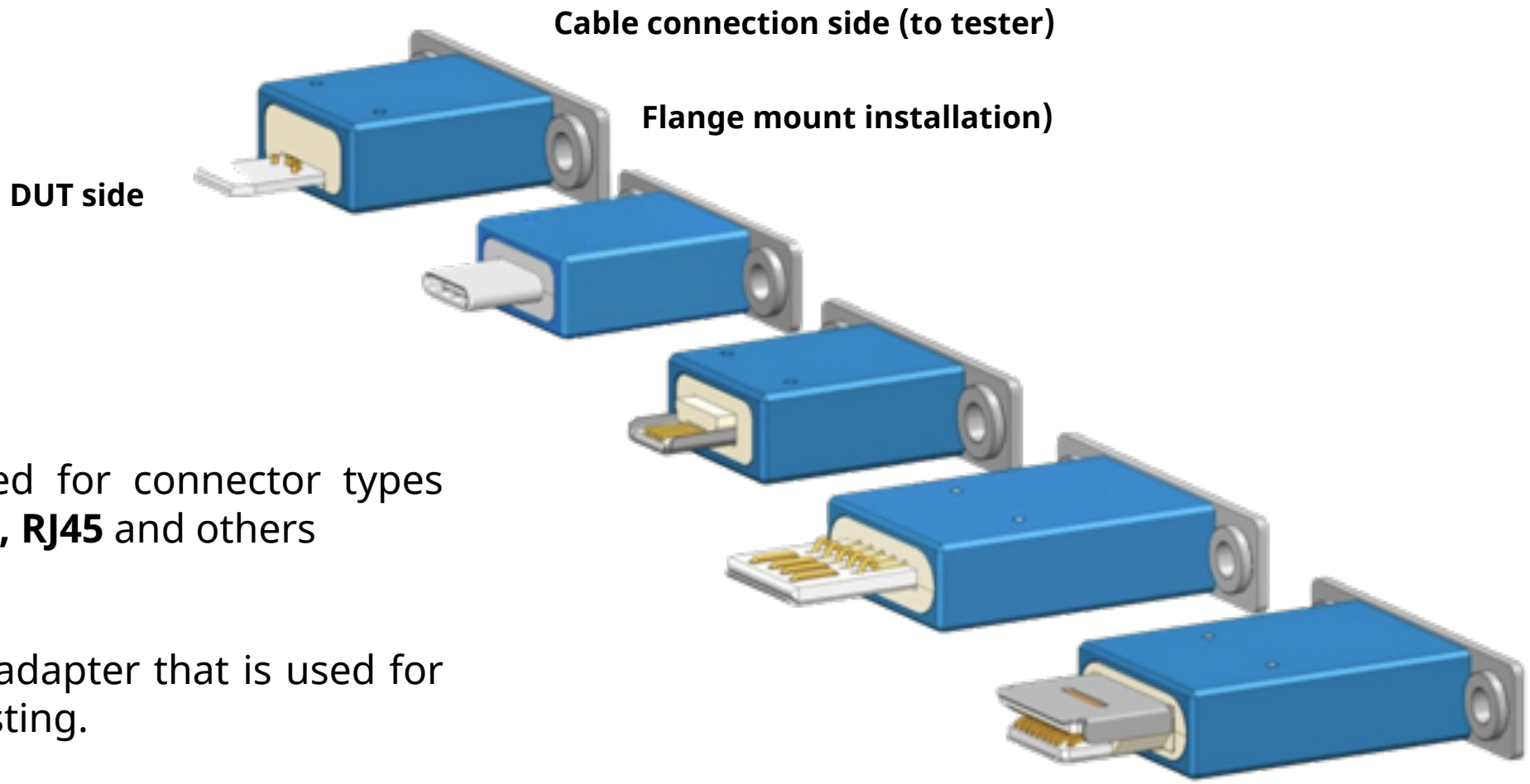


Usage of test plugs; here: For RJ45



Test plug variations for different connector types

Test plugs

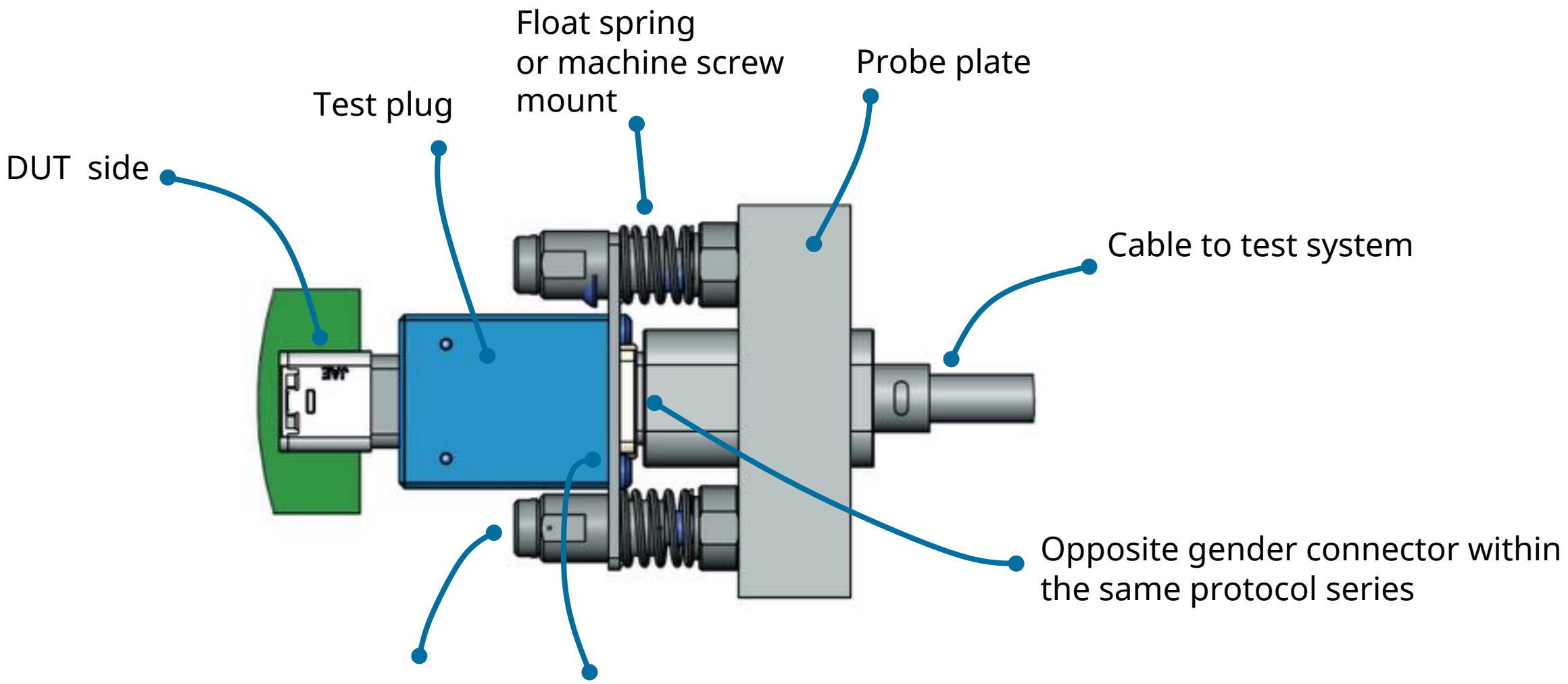


- Test plugs are used for connector types such as **USB, HDMI, RJ45** and others

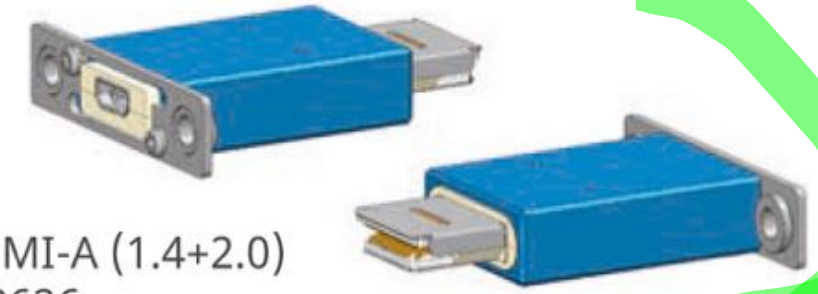
- Idea: **“sacrificial”** adapter that is used for high cycle count testing.

- Float mount options are available.

Test plugs - general definition of parts (independent of the specific series)

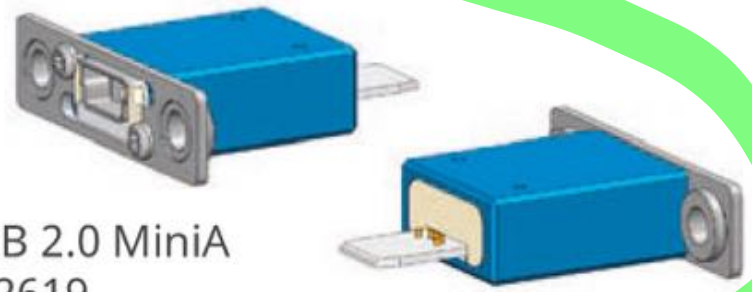


Test plug variety
(aluminum-body versions)



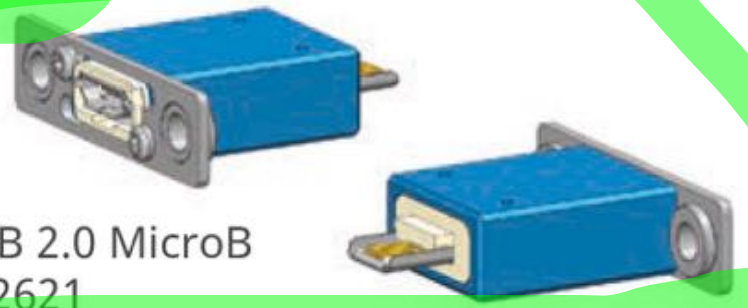
HDMI-A (1.4+2.0)
112626

USB 3.1C
112622



USB 2.0 MiniA
112619

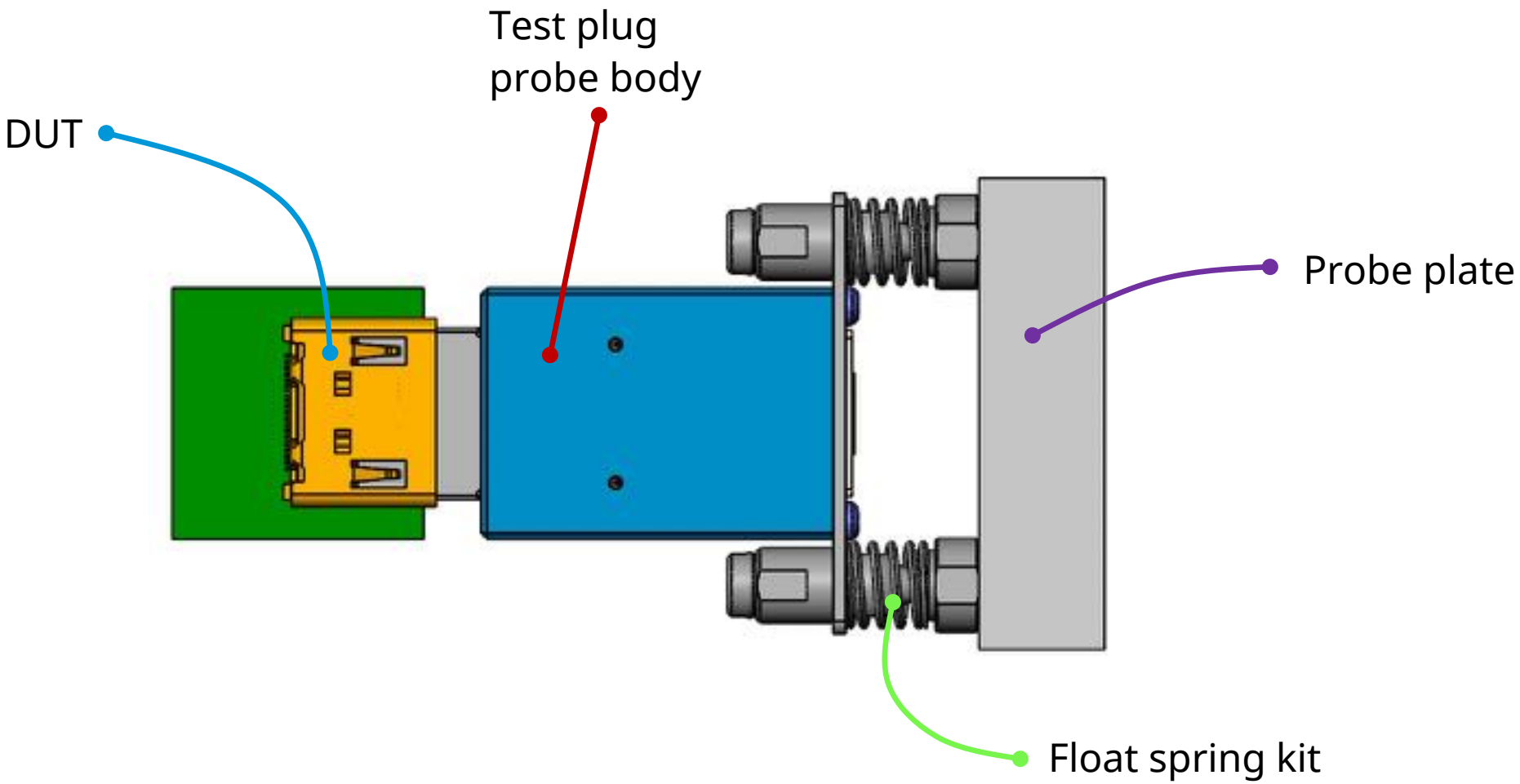
USB 3.0A
112624



USB 2.0 MicroB
112621

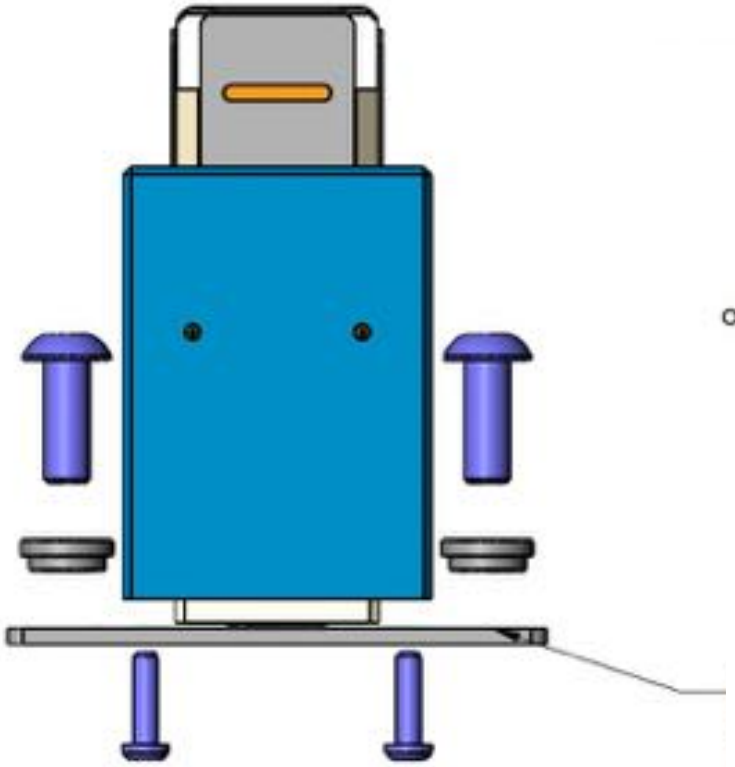
Test plug installation

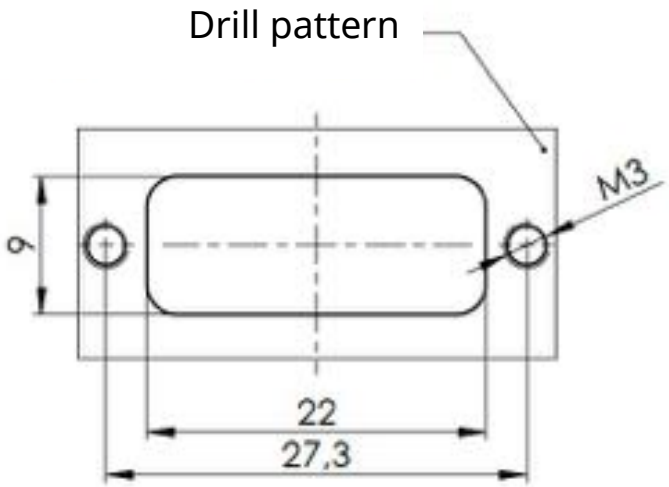
Here: Shown with type HDMI plug. Similar operation with other test plugs



Test plug installation – using standard machine screws (no float)

This option requires float to be built into the probe plate, for example by the fixture house.

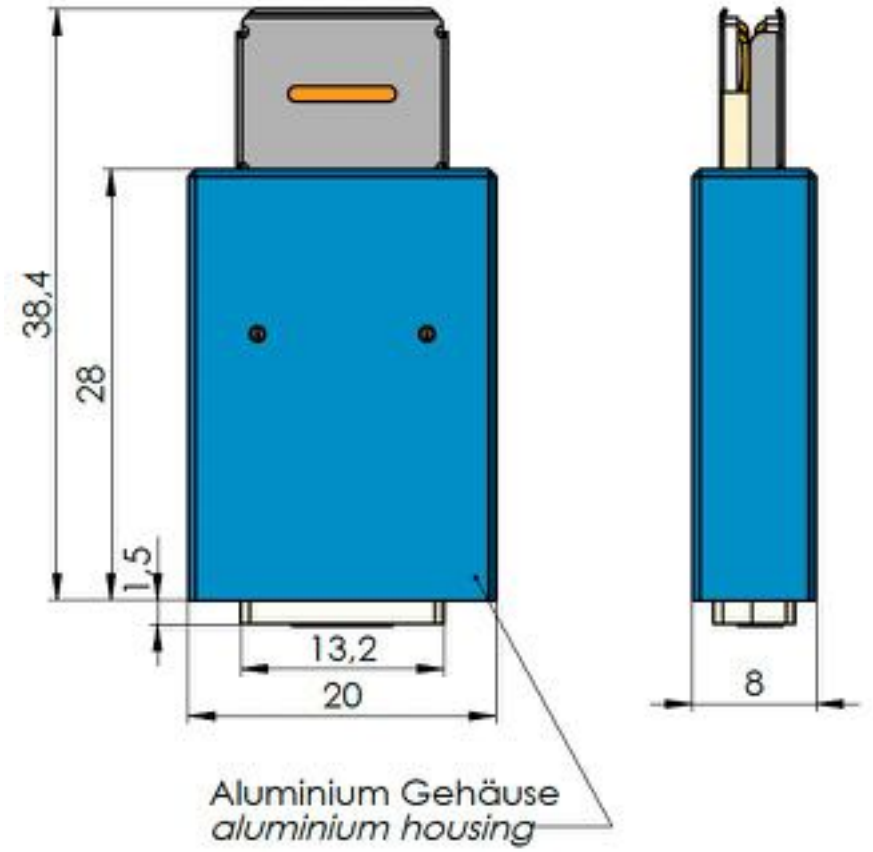


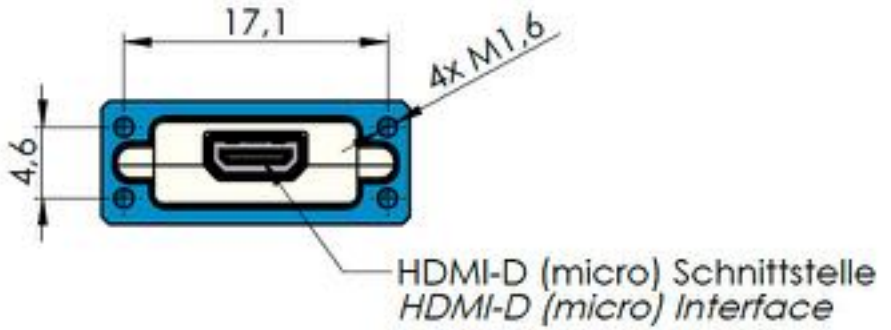


Mounting plate – can be detached and change

All units: metric / decimal separator = “,”

Test plug installation – standalone configuration and interface



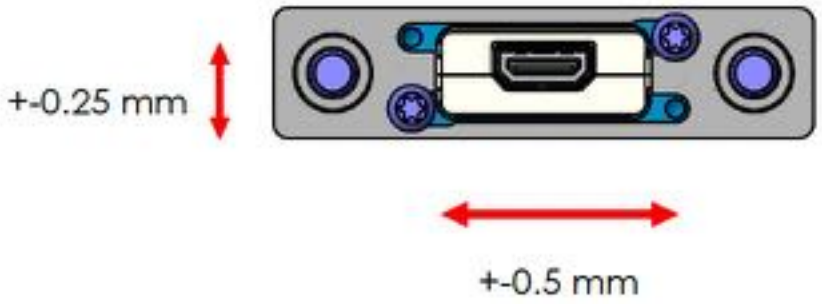


- **Left:** Test plugs can also be used in its **“standalone configuration”** and be mounted to custom holdings brackets.
- Be careful: The parts are not meant to be self-retaining, even though some “lock in”- a **test fixture is required** for proper operation
- **Upper figure:** Test plugs are “extenders” but some have smaller form factor connectors on the back for the cable. Here: HDMI micro D for a HDMI type A DUT. Reason: Space restrictions.

Test plug installation – adjustability

Option 1 : Screws in center position in mounting plate

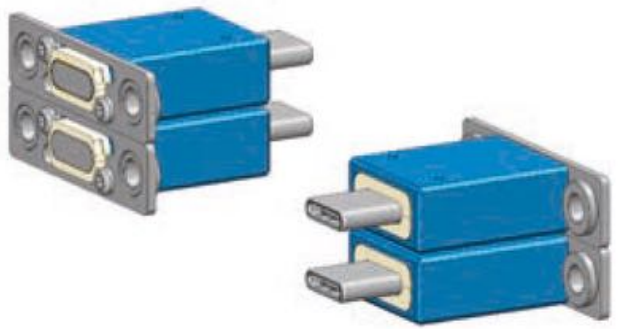
Option 2 : Screws in adjustable position in mounting plate



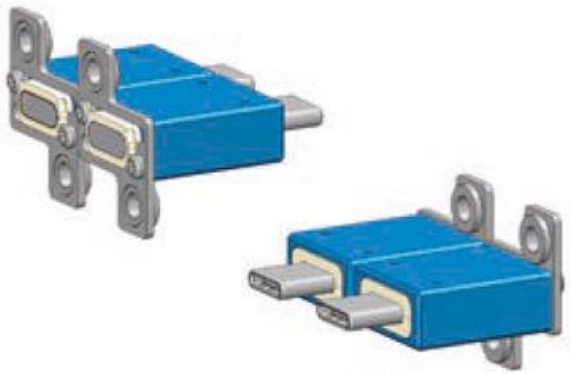
- Test plugs are adjustable, some up to +/- 0.25 … 0.5 mm to adjust for tolerances.
- Useful for example if no float mechanism is used (even though we highly recommend it) OR to manually pre-align the test plug after customizing the test fixture

Test plug installation – mounting options

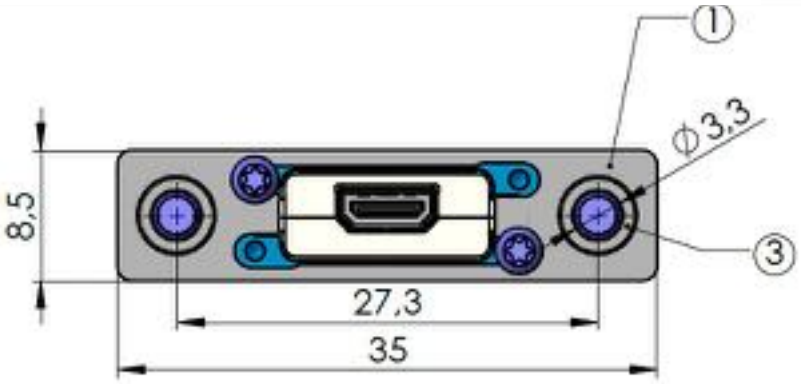
- Test plugs can be mounted **side-by-side** or **stacked**
- **Both mounting plates** are included in the delivery, some exceptions apply (please check datasheet)



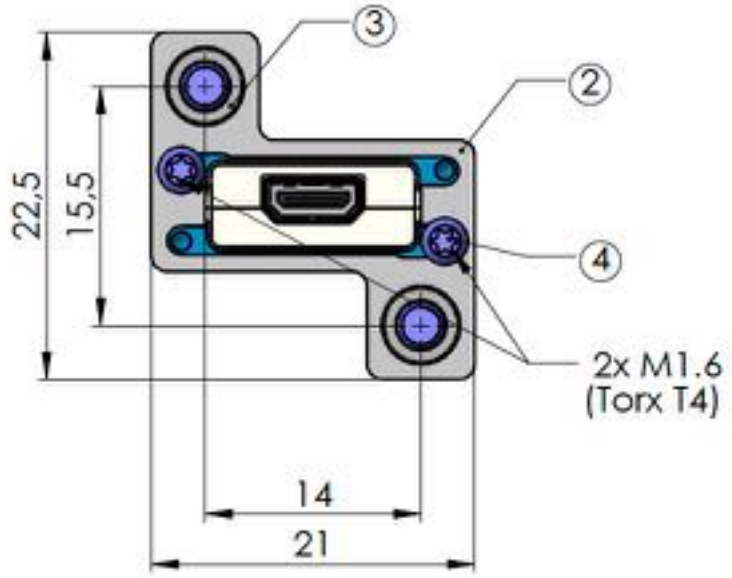
vertical mounting



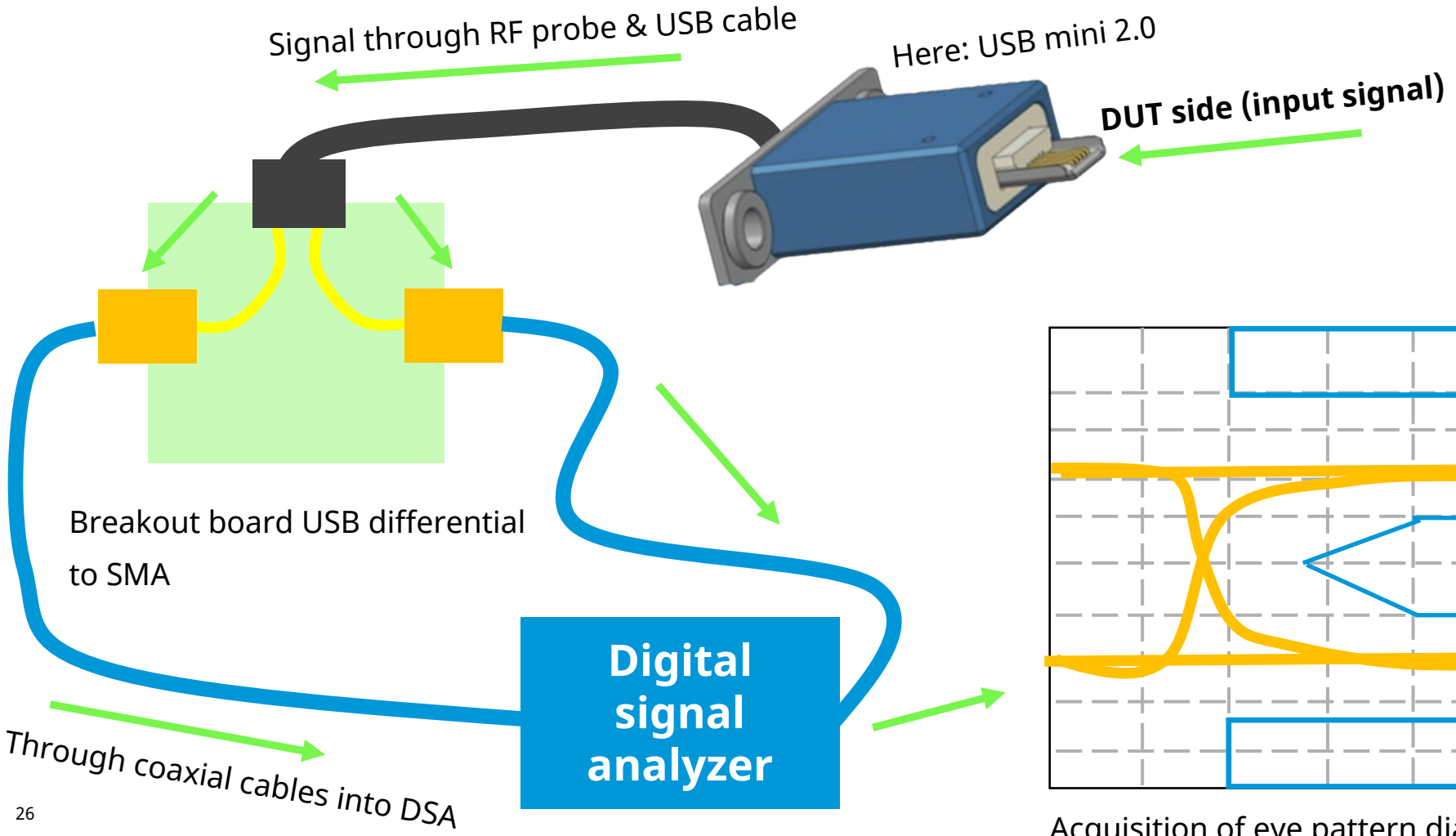
horizontal mounting

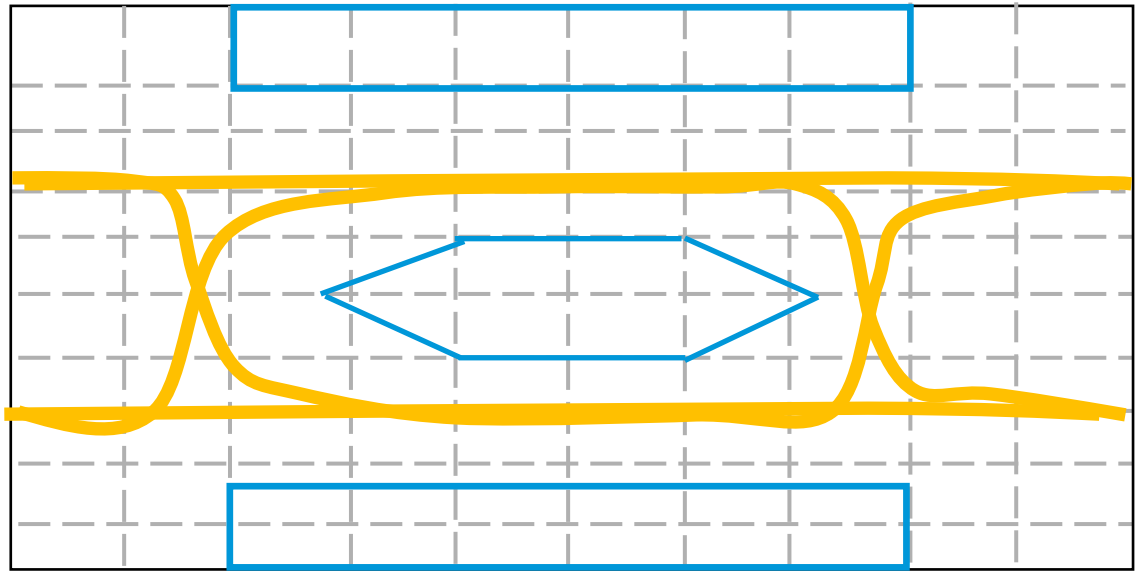


nm)



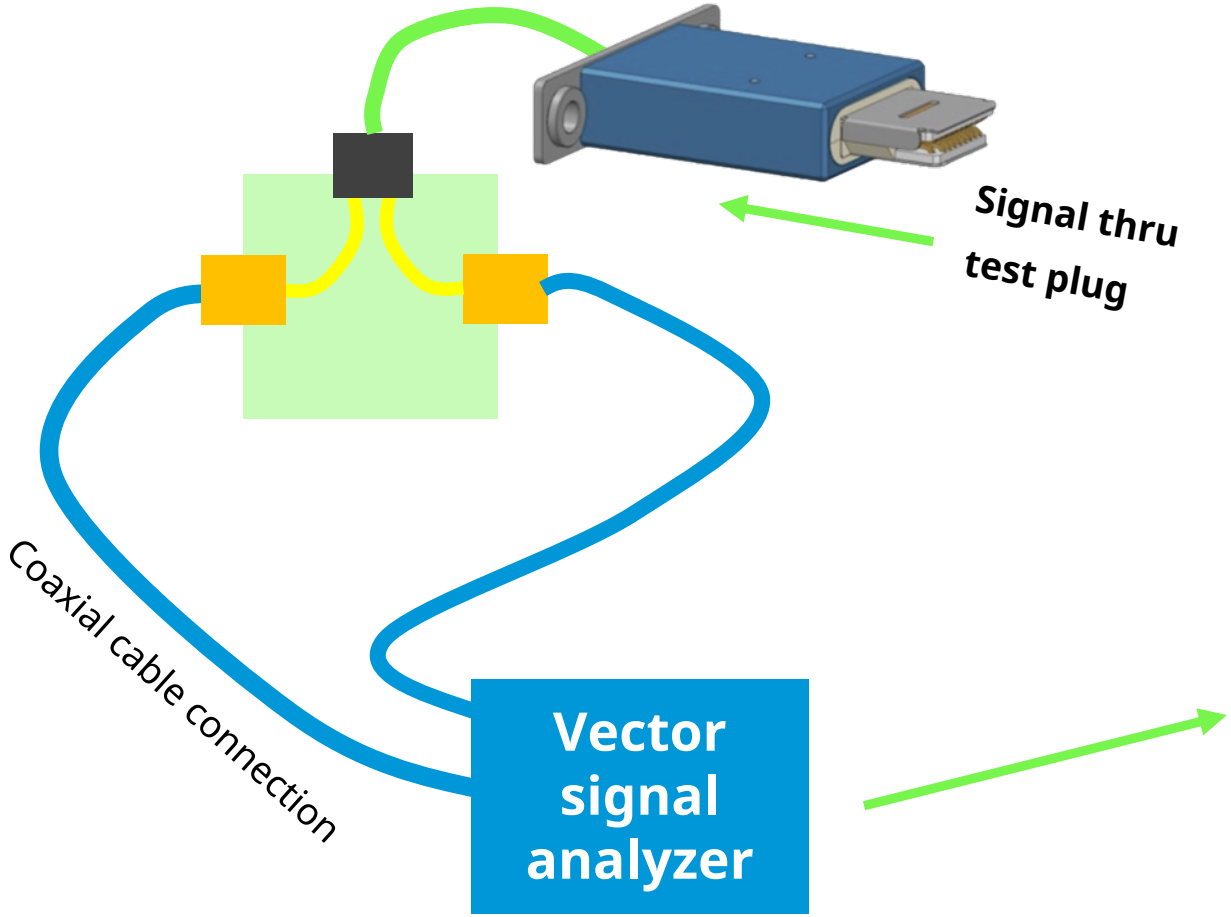
Application example: Using a test plug for eye pattern test

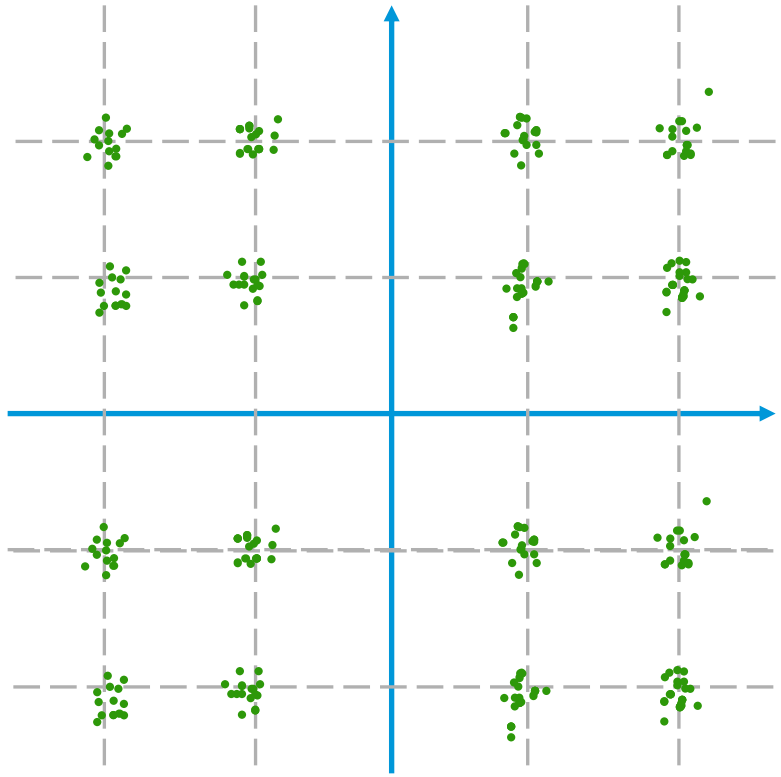




Acquisition of eye pattern diagrams

Application example: Using a test plug for error vector magnitude test / constellation diagram test



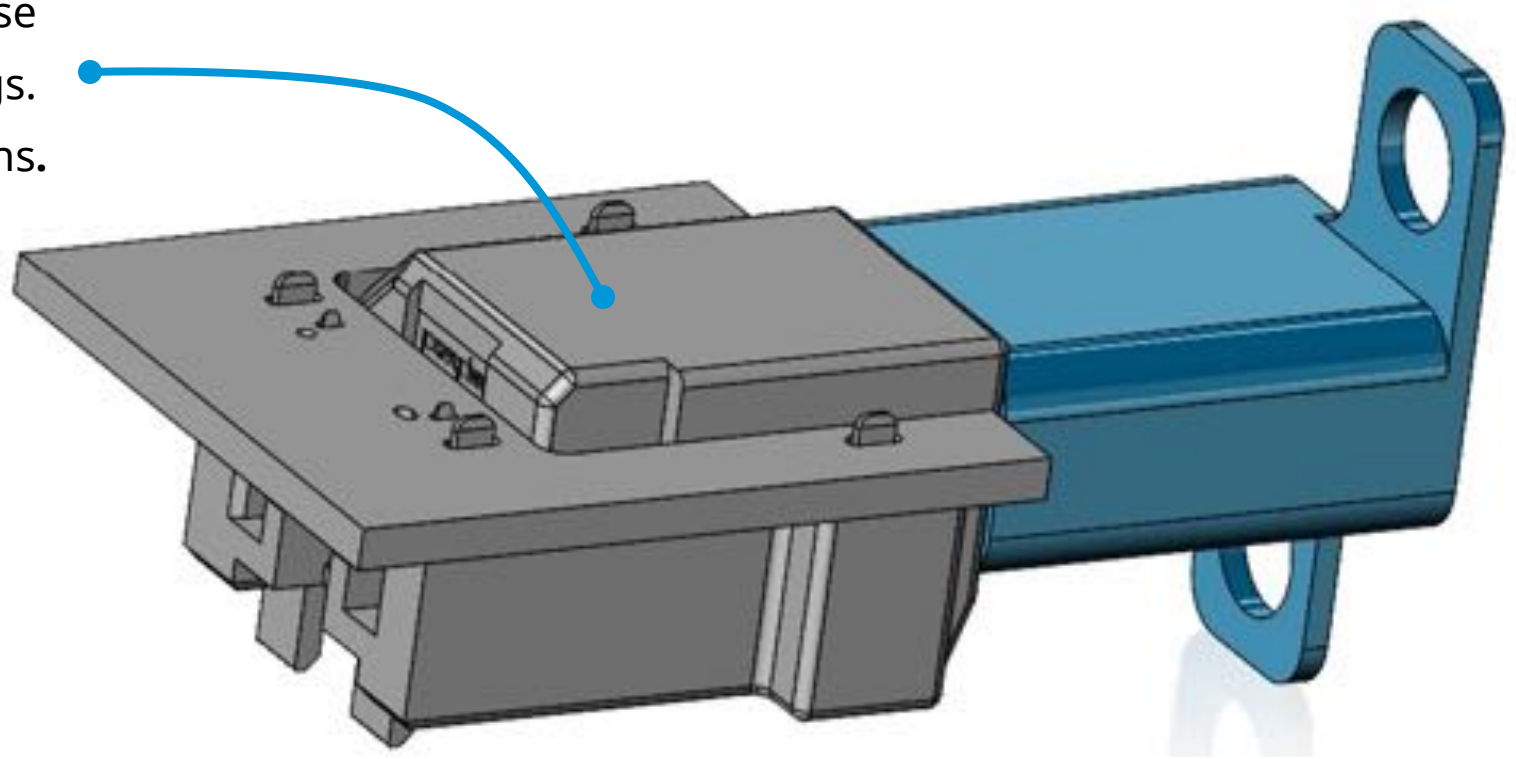


Constellation diagram of a QAM signal / **EVM analysis**

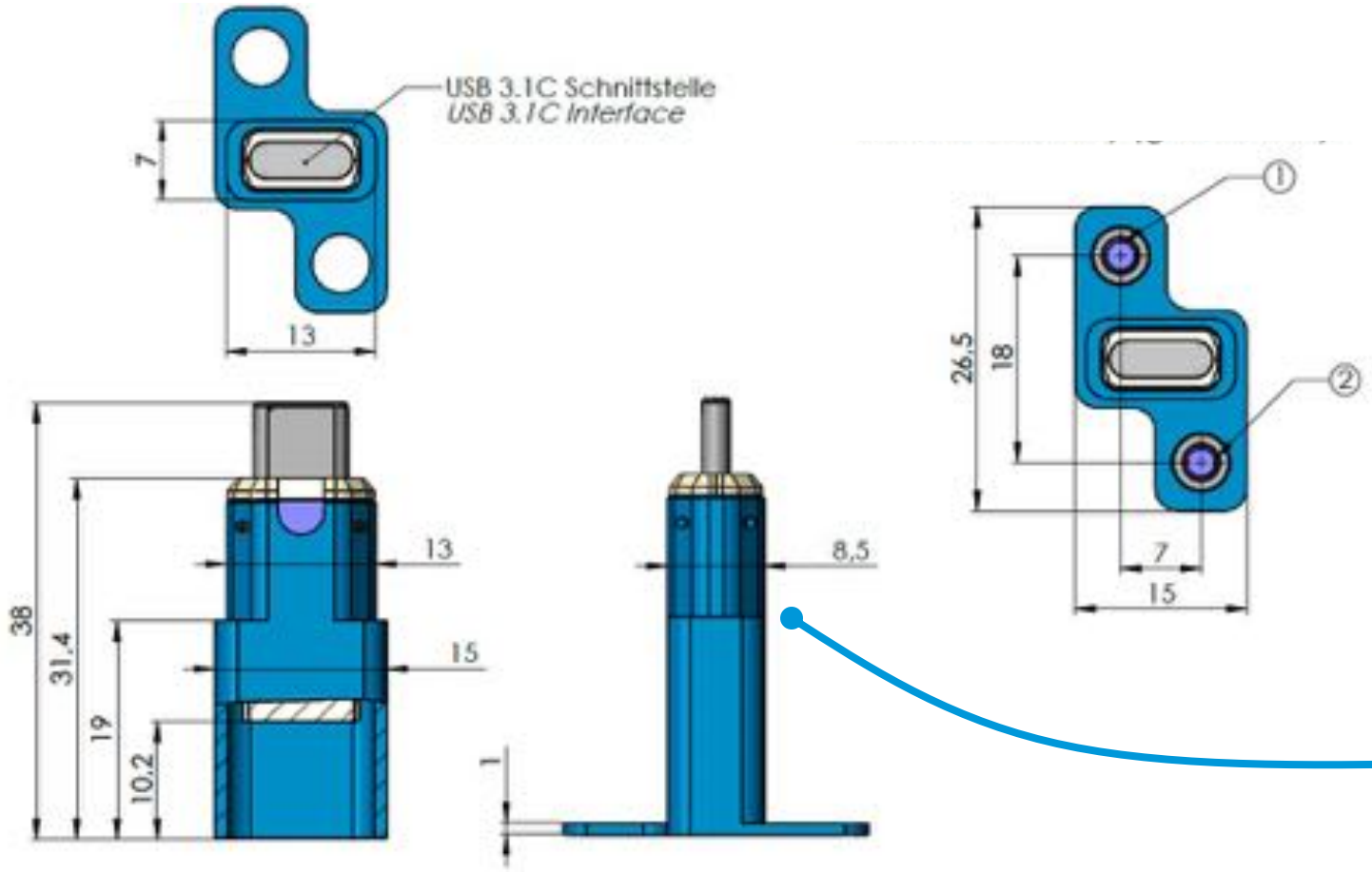
The problem with RF automotive connectors for FCT for common USB and other protocols…. The plastic housing!

Plastic housing does not allow the use of standard test plugs.

Plugs need to be extended versions.



The problem with RF automotive connectors for FCT for common USB and other protocols…. The plastic housing!



USB 3.1C
112622

Standard version.

Would collide with housing.

Extended version

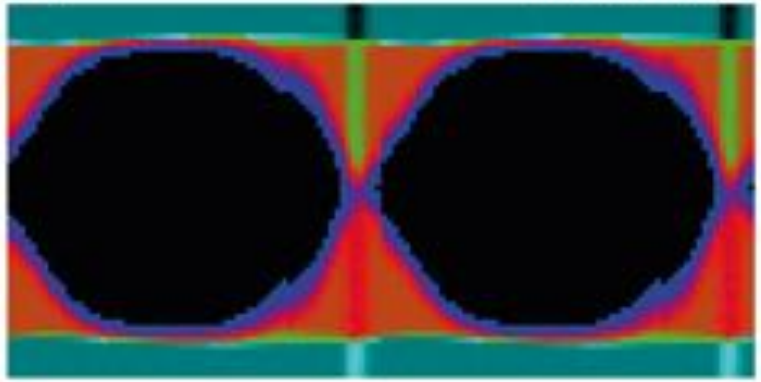
Test plugs – electrical performance

Measured with TotalPhase signal analyzer. “Pre-compliance” test

Eye diagram for USB3.1C, 5 Gbit/s and 10 Gbit/s, & USB3.0A, 5 Gbit/s

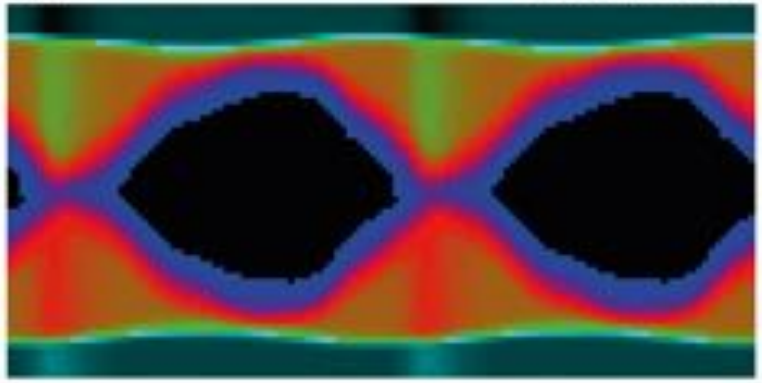
USB3.1C (112622) - 5 Gbit/s

TX1 5000.65 Mbps



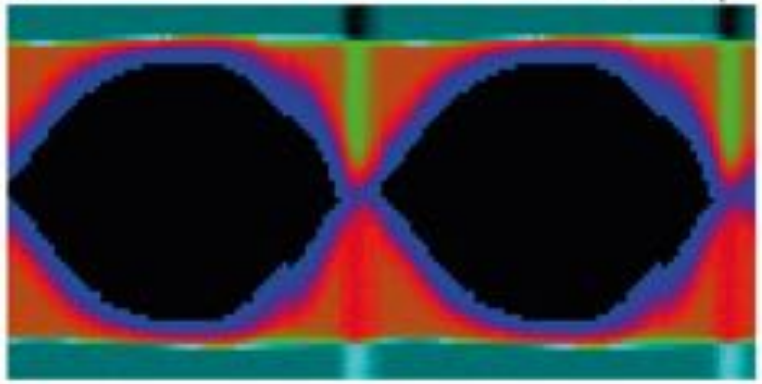
USB3.1C (112622) - 10 Gbit/s

TX1 10001.29 Mbps



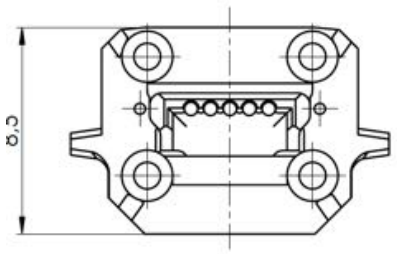
USB3.0A (112624) - 5 Gbit/s

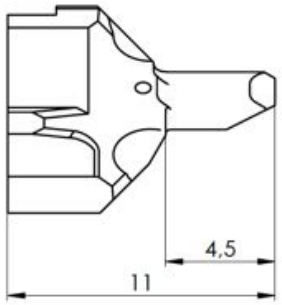
TX1 5000.65 Mbps

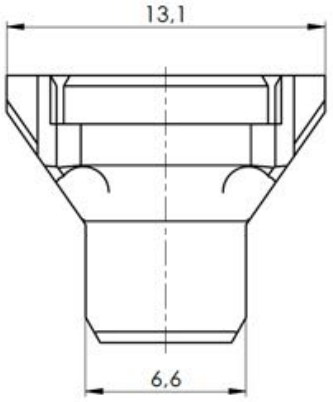


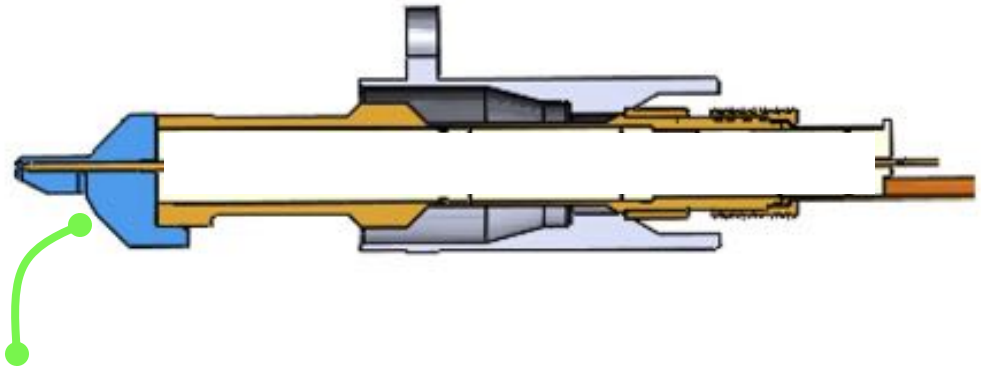
Preventive maintenance and parts replacement

Look out for options with field replaceable components









Replaceable head

A probe is a consumable item!
Side loading etc. can contribute to higher wear and tear.

If possible, look out for options that are field replaceable and serviceable.

RF connector installation on the probe

Here: Threaded connection

Photo shows tightening of the coupling nut of an SMA connector when used on an RF probe.

Correct installation of the SMA cable connector

1. Hold probe at the flats with an open-end wrench

2. Use a torque wrench (45 Ncm for SMA to tighten the coupling nut

Always tighten the nut, do not use the open-end wrench to hold the nut while trying to tighten the probe body "into" the male SMA.

(as a safety feature this probe has 7mm flats whereas the SMA nut has 8mm width-across-flats, to prevent a mix-up, however not all probes across manufacturers may have that specific feature)

Cable and adapter choices

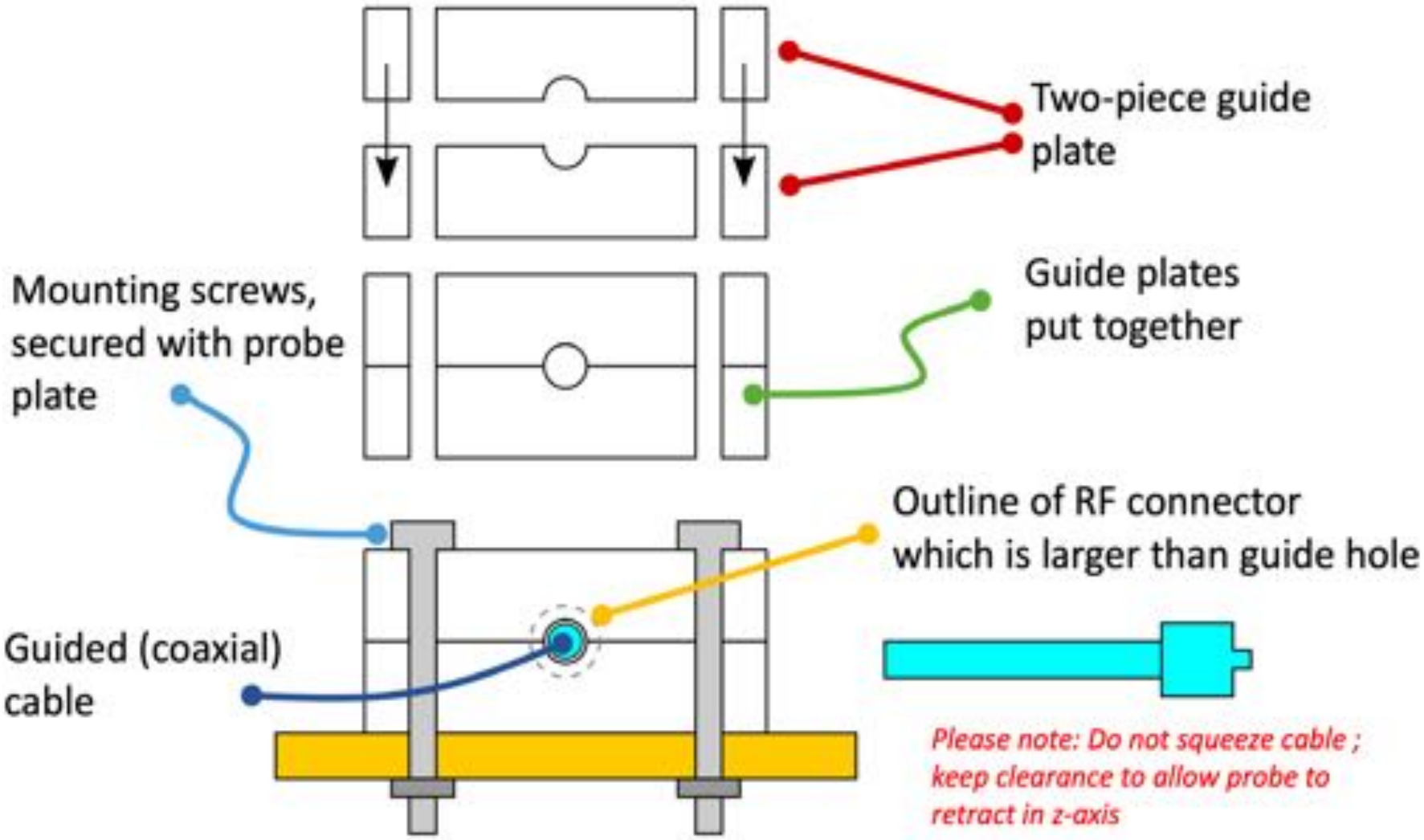
Application: Usage of a probe with built in float that retracts in z-axis during compression. Note the float to the side to catch misaligned connectors

1. Right cable type and size (flexible wiring, thin)

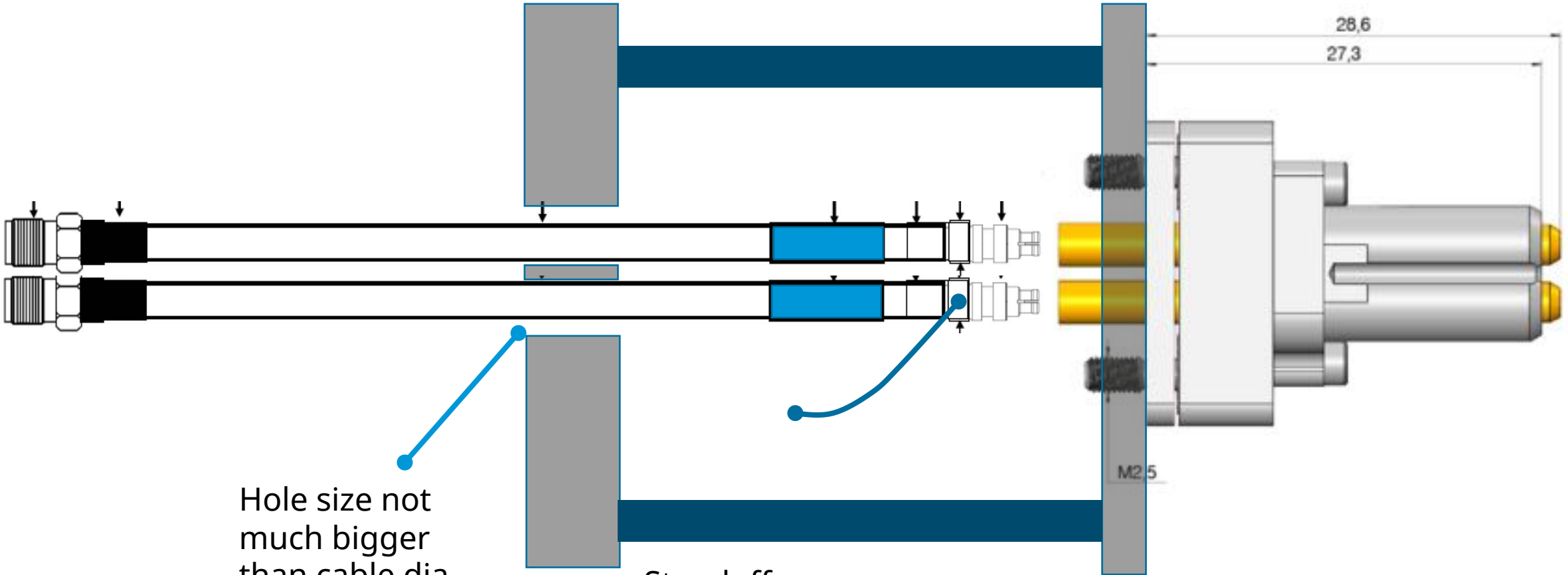
2. Wrong cable type (hand formable semi rigid)

2. Wrong cable type (too thick, cable dia > probe dia. Also: Avoid use of adapter)

Cable routing (1)



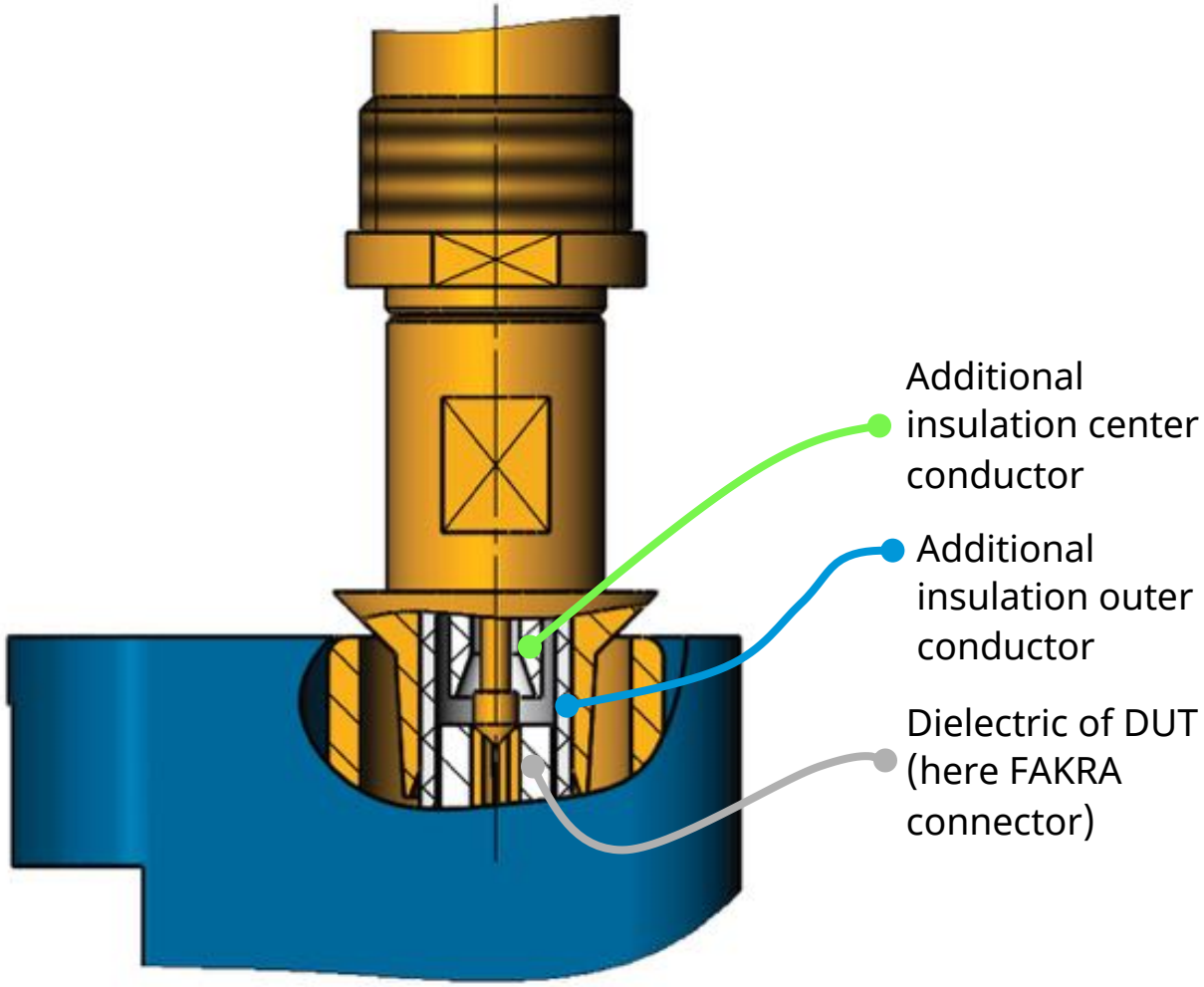
Cable routing (2)



Hole size not much bigger than cable dia.
Use multi-piece Plates if necessary

Standoffs
Spaced apart from probe plate
preferably 1” / 2.54 cm or more

Hi pot and 4 wire testing



Maximizing the use of dielectric insulators for hi-pot testing. Here: Transition zone (front plunger area) of a coaxial probe for testing a FAKRA connector

Automotive harness testing

Cable harness connectors are tested

a. on cable harness test tables (automated testing of the complete assembly)

b. with hand-plugs (testing of individual plugs)

Different connector types amongst the same connector series: here: Regular FAKRA vs. sealed/ insulated versions.

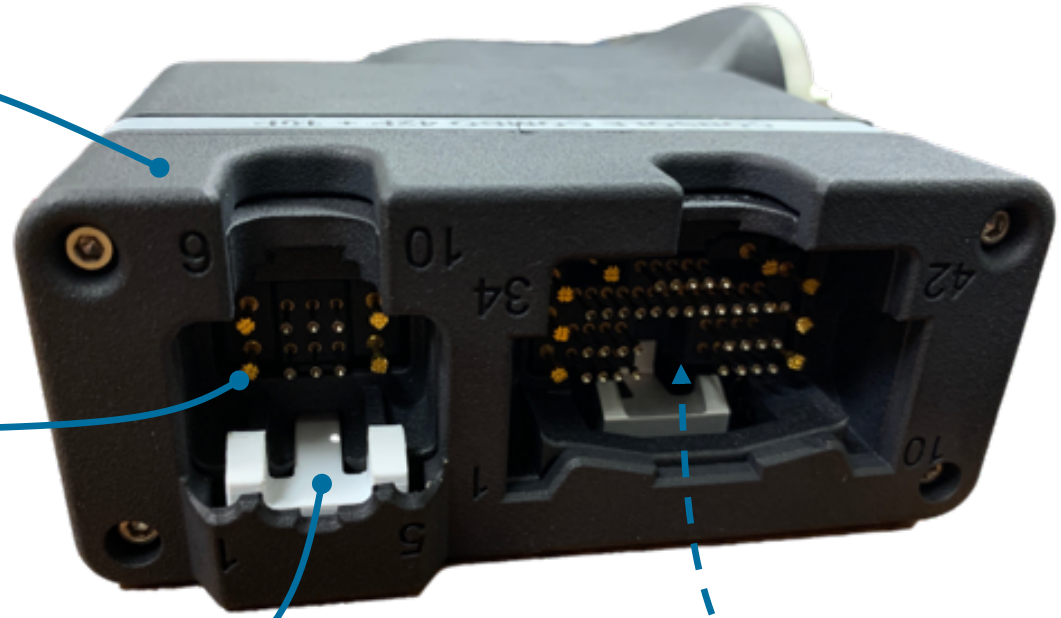
The sealed types can make test probe connections very difficult.

Automotive harness testing, professional test plug

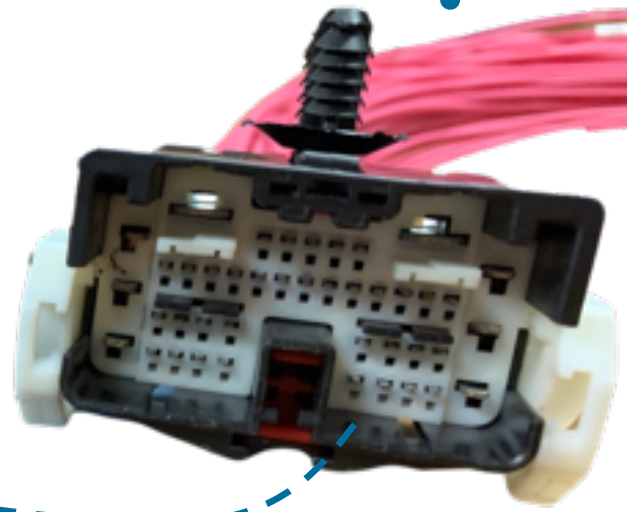
Ruggedized 3D printed or machined housing

Spring loaded probes, Can be DC types or RF, Thread mount preferred

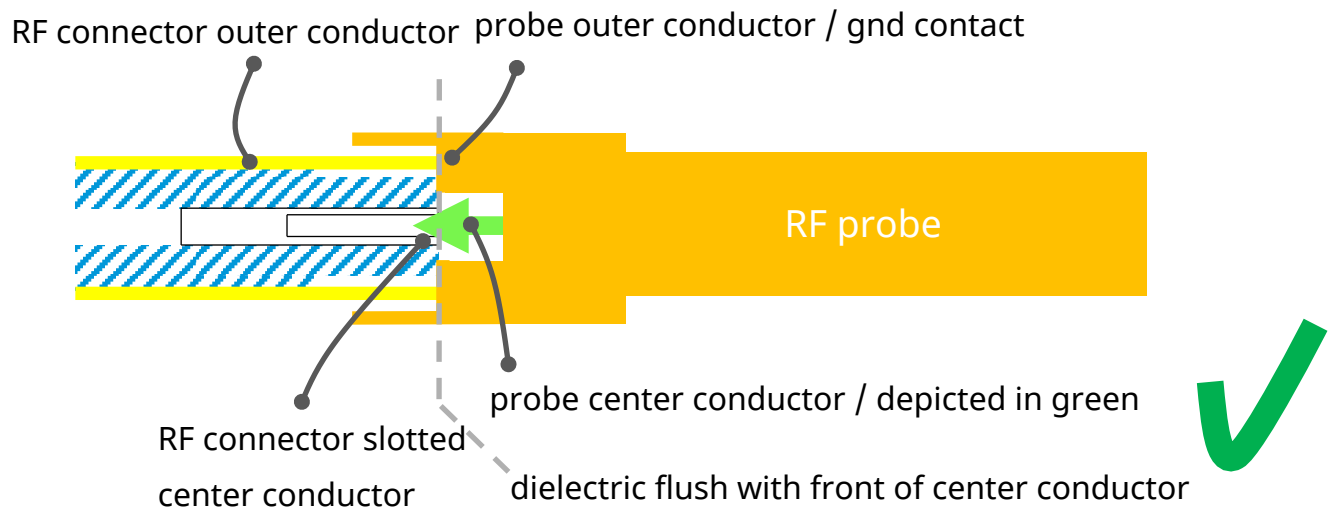
Retention mechanism of the “fixture” (hand plug) to secure the connector while testing by hand

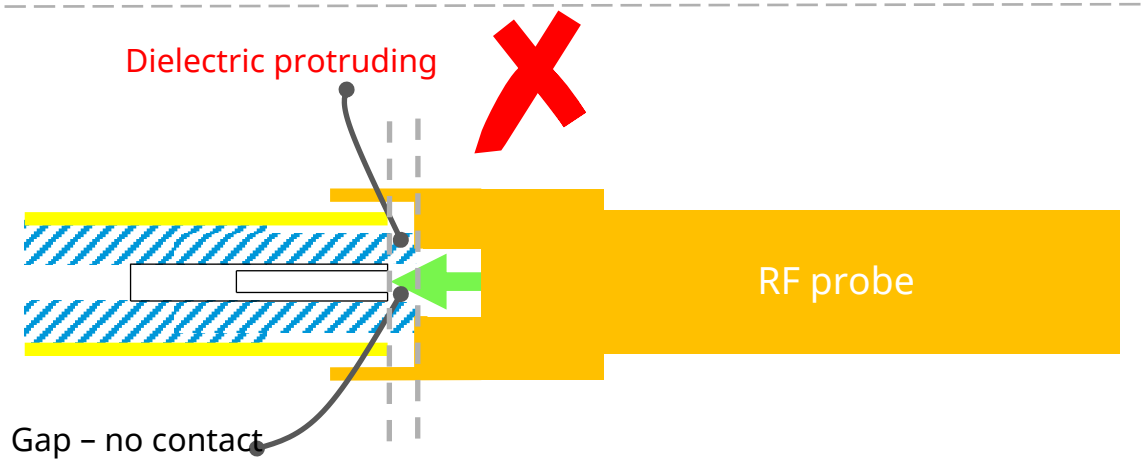


Typical automotive connectors on harnesses, with or without RF



Continuity testing





Application:
- Test if dielectric is protruded (faulty RF connector)

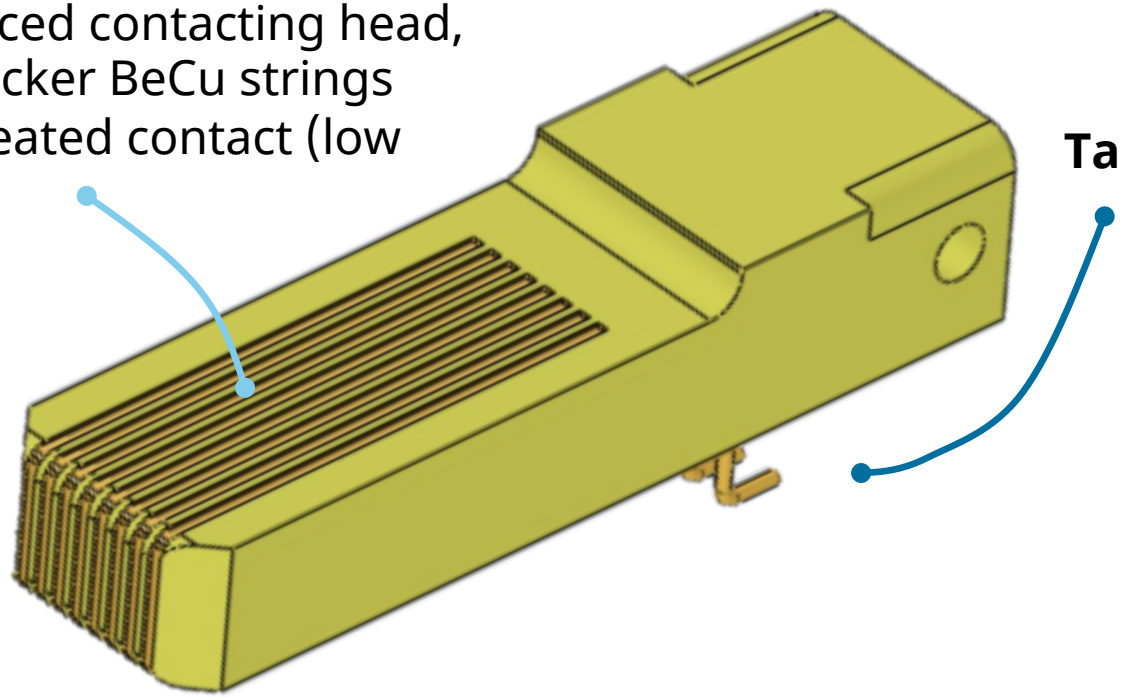
Reason:
- Some stamped and formed connectors have poor tolerances

Test method:
- Coaxial probe, made for that particular connector type
- Continuity tester to check if center conductor makes contact.
- If contact is made, dielectric is flush or within tolerance.

Test plug options for **“continuity only”**-testing

From the INGUN Fixtures Catalog. Here #17826 RJ45 test plug

Mating portion:
Reinforced contacting head, with thicker BeCu strings for repeated contact (low wear)



Tail: Cable is soldered to plug

- Those plugs are specifically made for ***repeated, automated continuity testing*** on a connector.
- Those options maybe used for some ”at-speed” applications as well, but high-speed performance is typically not guaranteed on those.
- “at speed” performance is also dependent on the wiring job (shielding, soldering etc.)

Questions & remarks?

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