ATX LABS TECH BRIEF

ATX HAS DEVELOPED A SUSTAINABLE MICROWAVE CABLE ASSEMBLY WITH MODULAR CONSTRUCTION IN SEVERAL EMBODIMENTS

This Technique Results in the Realization of a Microwave Test Cable with Connectors and Sub-components that are Easily Replaced Across the Major Sub-miniature Classes as well as Type N and NMD

It has long been an elusive goal to make a precision microwave test cable that has the ability to change connectors and/or the transmission line in a robust and relatively straightforward manner, thereby sustaining the assembly over a longer operational period than normally possible, and in so doing bending the cost-performance curve in a favorable direction. Another benefit is the creation of a smaller waste footprint as a function of husbandry and wear management. Since cable assemblies do not wear uniformly, it's a net benefit to both the environment and the bottom line to keep an assembly in working condition for as long as possible provided there is no performance penalty.

The Legacy Art

To the extent that sustainability options exist – at least with regard to connector replacement, the capability is realized by two techniques: one involves changing the connector heads on semi rigid and hand formable assemblies in the sub-miniature classes like 2.4mm and 2.92mm; the second involves using a faux adapter as a host for a second front end component that serves as the primary mating interface. The limitations in the former is that it tends to be limited to semi rigid and hand formable coaxial cables only and doesn't offer a full proof alignment guide during line-connector mating; thus is not rugged enough to serve as a platform for the field swapping of connectors on flexible larger diameter cables. It tends to be used for internal interconnect applications where the terminating connectors may experience enough use to require periodic maintenance and replacement under conditions where expert tech care is commonplace.

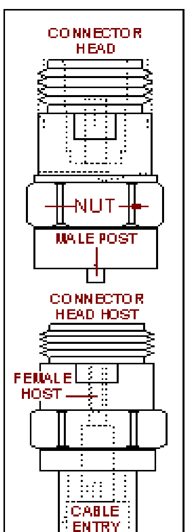


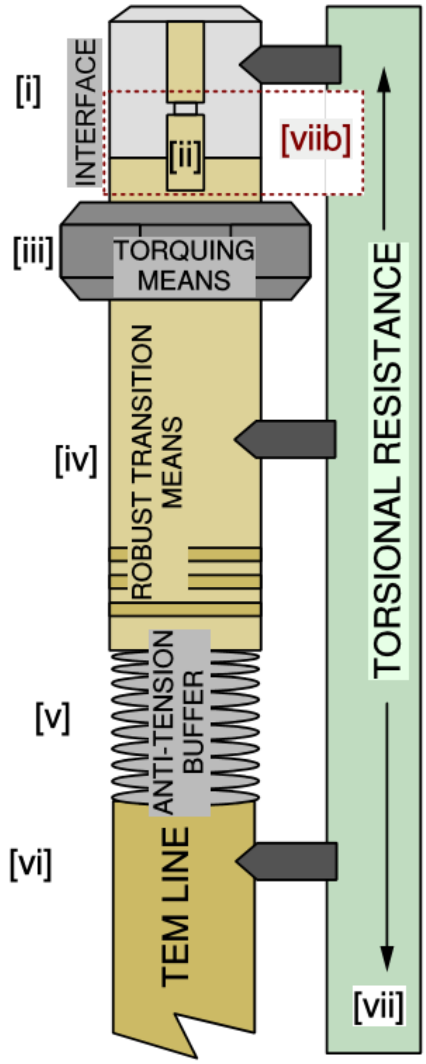
FIGURE 1

The limitation of the host adapter design is that it tends to be bandwidth limited by virtue of the introduction of a second interface which makes the assembly similar to a cascade of adapters (as illustrated in Figure 1). Moreover, it tends to have a high acquisition and replacement cost. The requirement of extended bandwidth in a host adapter system – without performance limitation – requires a cost penalty that will scale with frequency. The higher the operating frequency, the higher the cost.

The goal that emerges from these legacy limitations is whether it is possible to design and build a robust field re-configurable and/or repairable test cable with wide bandwidth, easy field decomposition and long service life by satisfying several constraints. To this end the cable construction described below has been realized.

The Sustainable Assembly Stage 1: Canonical

The first design goal of note is the avoidance of the adapter host paradigm, or the relatively fragile unguided means of attaching a center conductor to a captivated socket. The full realization of solution can be characterized as a stack up of functions and features – as illustrated in the drawing at right, that in the aggregate satisfies two conditions: [1] the assembly is robust over time and satisfies the traditional yardsticks associated with best of breed electrically stable assemblies; [2] it is realized as a modular platform that **Figure 2**



allows relatively straightforward decomposition and reintegration with only mechanical means. With these constraints in mind, the following feature set is a reasonable guide.

[i] A first feature is an interface with a captivation means that is advantaged by features that hold the primary conductors harmless on both sides of a line/connector intersection. These features would include, though

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not be limited to sizing, scaling, bore depths and location constraints that conspire to avoid premature contact of the critical conductors upon first mechanical contact. For example, a period of threaded pre-engagement and axial alignment prior to any conductor/socket contact can be achieved by careful machining, thereby ensuring that the connector is held without injury at first contact, and the entry trajectory is fully parallel to the main axis of the connector to avoid the sectional loading of a socket by off axis forces leading to potential breakage.

[ii] A second feature set is a conductor of scale and shape that supports the intent of the first feature to achieve harmless mating that can be repeated in the interest of either repair or scaling to a different species – and this feature, along with the first, is sufficiently robust to support long term service and an attract cost benefit.

[iii] A third feature is a torquing and engagement means that is either easily accessible or is built into an overall geometry such that decomposition can be easily achieved, followed by straightforward replacement of any sub-component without sacrificing the assembly. This feature includes a stabilizing means to fix the site of torque application so there is no longitudinal slippage, thereby putting a *forward* force on a connector that achieves separation without compromising the conductors. Time is of the essence, hence the modularity must be flexible enough to make the removal and replacement of any sub-component of the assembly, from connectors to ancillary components like grips, to the line itself – a simple exercise at a test bench and well within the art of any bench tech.

[iv] A fourth feature is a robust extended transition that separates the line and interface conductors, and is of sufficient scale and surface geometry, to allow a bridging by other means – like semi rigid polyvinyl boots – and at the very least gets any potential pivot point well away from the critical line/connector junction which is the crown jewel in a cable assembly

[v] A fifth feature is a reloading and/or prefixing means. This is designed to accomplish one or both of two things: {a} absorb or inhibit initial conditions that decrease electrical stability; {b} buffer against potential tension forces that result from inadvertently pulling on a cable assembly. This feature {b} is not essential to creating a repairable assembly, but it is a feature that relates to some of the more advanced constructions using grips as described below in feature seven. It creates a more survivable assembly to the extent that it is better able to absorb impulse or static tension loads.

[vi] A sixth feature is a line component with an optionally integrated copper clad and steel anti-compression geometry that connects firmly to feature four – thus adding an anti-torsion component - as opposed to a not uncommon floating alternative. This feature, like that of feature five above, enhances survivability.

The Sustainable Assembly Stage 2: Booster

[vii] A seventh feature is a anti-torsion locking means that prevents the rotation of the connector body or interior mechanical locking, not unlike what is pictured in figure 3. Even if the interior locking that unites connector and line is secured to the connector body by some conventional locking means, there still resides a slip region between the inner surface of the bored and threaded connector and the top plane of the line's ferrule at the common mating plane – leading to a possible rotation of both the trace that mimics the loss spikes due to mode behavior. This

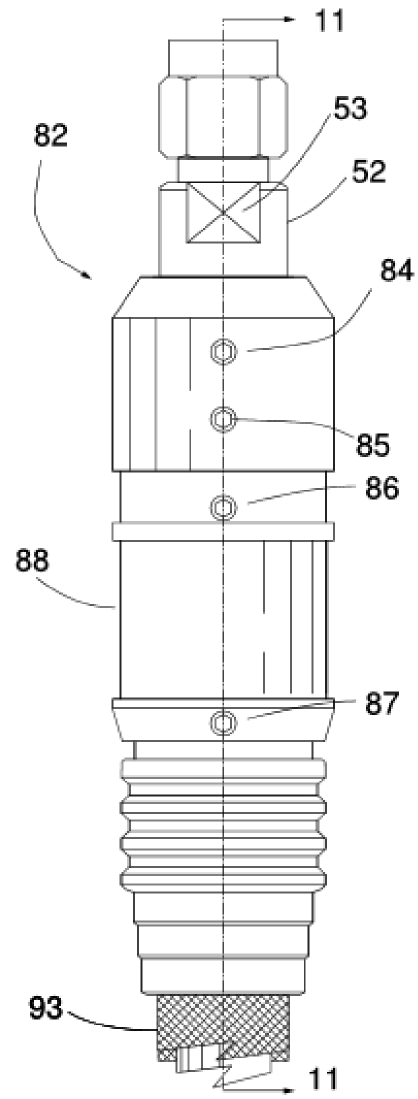

Figure 3

can also be seen when the front nut of a male connector is under torqued leading to nonuniform electrical engagement between the male and female reference planes. Slippage reduction of the connector body under torsional loads is normally accomplished by binding techniques that make repair difficult. The use of a gripping technique eliminates this problem by putting normal forces on the assembly in two

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spots: at the connector and downstream of connector at the second anti-torsion point. With this form, the connector becomes a solid volume wherein the external parts cannot be individually torqued because they are held harmless by an outer casing designed to absorb the rotational loads along the line in the region of the connector to a predetermined point downstream.

[viib] This feature is an enhancement to viii above that converts the previous feature into a form with wrench action such that, when the anti-torsional points at the connector and downstream are relaxed, viii converts to a wrench that facilitates the addition and removal of connectors for repair or scaling.

ATX machines on a Swiss lathe a number of grips in SS303 and AL6061T6 similar to the one illustrated in figure 3 and in those below. They are consistent with the anti-torsion feature discussed above, though they tend to reflect different mechanical objectives.

Summary

Features one through six, in the aggregate, represent the basic canonical form, finessed in such way that repair is relatively straightforward. The seventh feature is a protection mechanism that further ensures both anti-torsion resistance and axial alignment upon mating and unmaking.

The system is fully modular and completely decomposable, making possible the repair or replacement of the shell, connectors, or coaxial line. In addition, since the system is hardened – though largely by mechanical means - there is no loss in the kind of integrity one could achieve with non-replaceable or not easily replaceable materials.

Finally, note that the wear properties of cable assemblies are not uniform. The connectors (one often dedicated to a device under test and seeing greater use, one often dedicated to an instrument and seeing less frequent use) do not necessarily wear or fail at the same time, nor does the transmission line forming the basic TEM element of the system wear at the same rate as the connectors. A number of wear permutations are possible.

The ATX system outlined above, whether conceived for purposes of repair - or refined as in feature seven for purposes of field re-configurability - offers the promise of extended operational life. This has both cost implications, as well as e-waste implications. Husbandry - in this case implying the management of sustainability features in the interest of preservation, leads to a smaller waste footprint over time through what is effectively wear management.

Testing that consists of repeated matings has been conducted up to 500 cycles with no deterioration in performance over a period of twelve months that exceeds initial specifications for return or insertion loss.

In balance, experience over an extended period has given evidence of the utility of having a modular decomposable system, one that is hardened though mechanical means, one that allows easy decomposition for

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repair or scaling, and one that has cost/performance benefits as well as e-waste benefits. A modular construction as described herein also makes possible a more robust warranty and sustainability program.

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