EDGES MEMO #270

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December 18, 2017

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To: EDGES Group

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Subject: Tests of the midband balun and connector loss

1] Resistance measurements

The resistance of various ports on the balun was measured by passing a current of 540 ma through the balun using a 22Ω in series with a 12 v DC power supply and measuring the voltage drop across various sections with center conductor shorted to the balun tube at the antenna port.

	Calculated	Measured	Estimated conductivity
Portion	Resistance μΩ	μΩ	% relative to Cu
Center conductor	110	555	20
Balun tube	40	185	22
Connector 0.425”	144	734	20
Connector outer 0.425”	26	343	6

Table 1 Midband balun resistance

Table 1 shows the calculated resistance of balun parts, assuming pure copper, based on the component dimensions. The measured resistances are 5 times larger which is consistent with the use of brass in the balun and beryllium copper in the SMA.

2] Connector repeatability

The connector resistance was measured over a distance of 2.4” and corrected to 0.425” which is the distance between the reference plane and the outer plane of the panel mount of the Amphenol 132144 connector.

In measuring the resistance of a number of SMA connectors a potential problem was discovered. In some cases the connection between the outer conductors was made through the connector nut rather by the contact of the outer conductors at the connector reference plane. Upon further reading about the SMA connector I find it is not recommended for laboratory metrology. For metrology the APC-3.5 mm connector is recommended instead.

To investigate the SMA connector problem further I set-up the test chain shown in Figure 1.

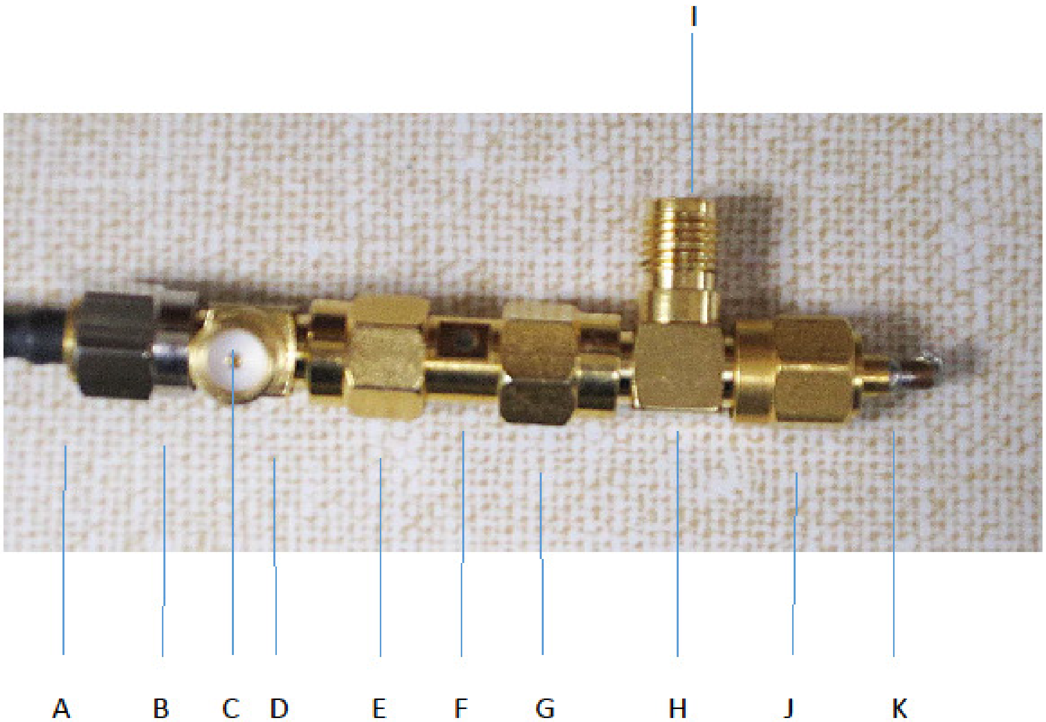

Figure 1. Connector setup with -0.54 amp current into A and short at K.

Contact points	Voltage mV	Distance (inches)	Comment
A-K	1.0	2.3	Outer conductor
A-B	0.1		
B-D	0		
D-E	0		
E-F	0.3		Contact via nut
F-G	0.3		Contact via nut
G-H	0		
H-F	0		
H-K	0.2		Contact via nut
C-I	1.1	1.18	Inner conductor

Figure 1 shows the connector test set-up. Connectors were all tightened to the SMA specifications, measurements were taken and the tightened again with a little added torque. The measurements did not change with added torque. From this test it is clear that in junctions at A-B, E-F, F-G and H-K the outer conductors of the coaxial line are connected via the nuts and not by direct contact. This is a clear deficiency of the SMA design which is fixed in the 3.5 mm connector. Since the 3.5 mm connectors are expensive it may be possible to fix the problem by using Super-SMA connectors (MIL-STD-348). If the problem is repeatable, that is if the correction is always either direct or via the nut it would be acceptable at most connector interfaces except at the receiver input. Figure 2 shows a simulations of the effect of a change in the antenna connection based on an additional resistance of $2645\ (f/50)^{1/2}$ where f= frequency in MHz to approximate the added resistance of the path through the SMA nut accounting for the skin depth. This added loss is only 0.00025 dB at 60 MHz and 0.00044 dB at 180 MHz but has a substantial effect on the spectrum shown for GHA 0, 6, 12, 18 hrs and 5 polynomial terms removed.

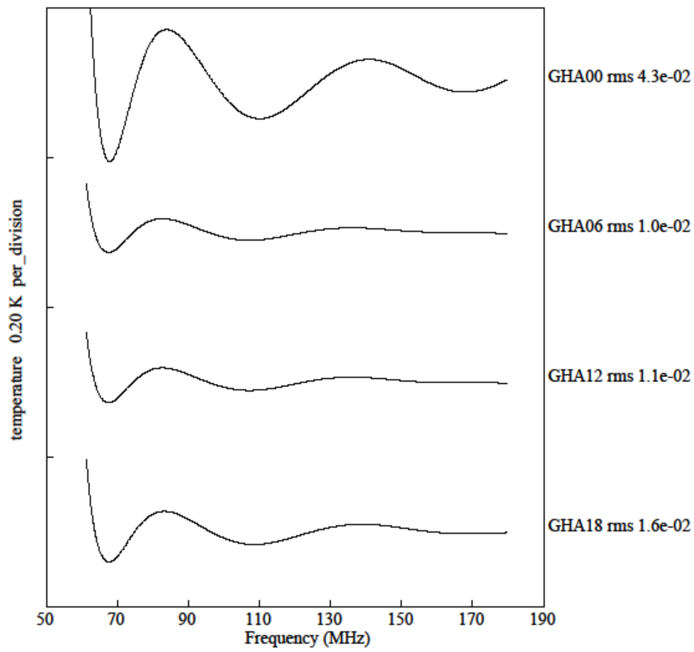

Figure 2. Simulated effect on mid band data of added balun loss due to lack of direct contact of outer conductor.

Another test was made of the effect of lack of direct contact was made using clamps to short the sections shown in Figure 3a attached to the VNA with an additional clamp show in Figure 3b.

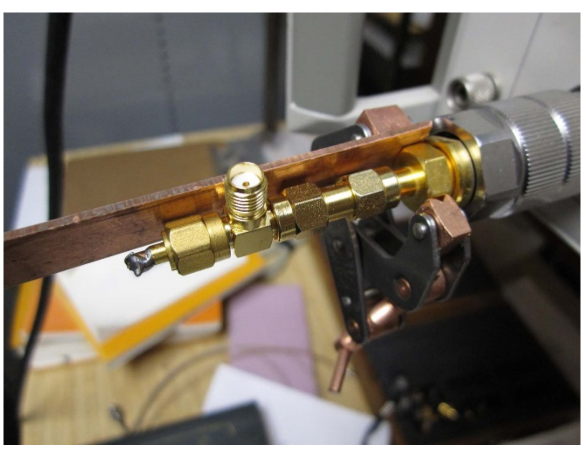

Figure 3a.

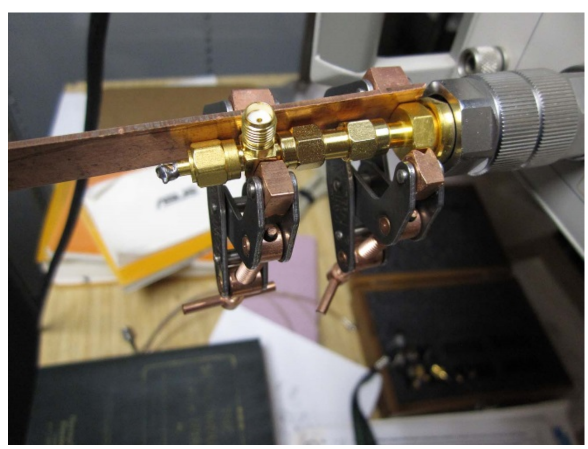

Figure 3b.

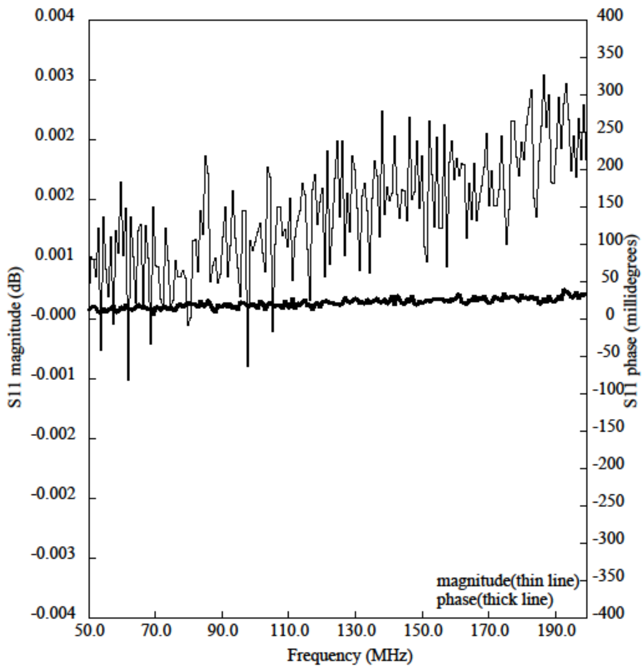

Figure 4. Measured S11 difference between in set-up in Figure 3b and 3a.

Figure 4 shows the difference in S11 between that with both clamps (Fig 3b) and that with one clamp (Fig 3a) in which the added copper strip is only in contact at the end attached to the VNA. The loss without both clamps was 0.036 dB and 0.1156 dB at 60 and 180 MHz respectively.

The added loss, due to the lack of direct contact is about 0.0008 dB and 0.0020 dB at 60 and 180 MHz which is about 1.5 times larger per interface than the estimate for one interface based on the resistance measurements.

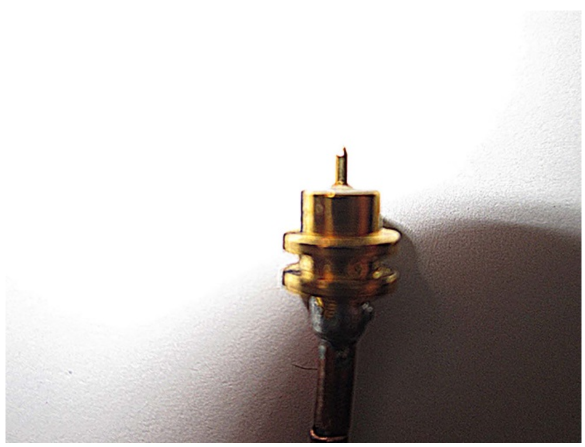

Figure 5. Example of SMA connector with raised dielectric which presents metal-to-metal contact of the outer conductor at the reference plane.

Additional notes:

1] Most SMA connectors which meet the MIL-STD-348 should have metal-to-metal contact at the reference plane.

2] The problem with individual SMA connectors can be checked by using the tip of a sharpened stick, toothpick or pin to check that the dielectric is below the inner metal ridge where the metal-to-metal contact is supposed to occur. In many cases, especially in SMA bends the dielectric is above the ridge looking down into the connector is one or both the ends of the connector. Figure 5 shows an example of SMA with raised dielectric. The nut has been cut away in order to see the inner and outer conductors.