MEASUREMENTS

Hans Wagemans - ON4CDU and Peter Delmotte - ON4CDQ

I. Introduction

When building microwave equipment, learning from experience is an important factor. The normal evolution is to start on the lower microwave frequencies and when you are able to develop and build equipment for these you can move on to the “real” microwave frequencies. So when your 10 GHz equipment is finalised, the next natural step is building equipment for 24 GHz.

With every step towards higher frequencies, questions arise: is this connector, cable transistor, dummy load, power meter, etc. suitable for this frequency? During the development of our 24 GHz transverter, experience in this field has been gained, and this article tries to share some of it.

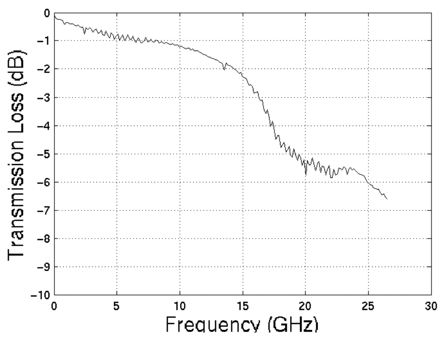
To document our experience, a measurement session was organized at the K.U.Leuven ESAT-Telemic lab, where measuring equipment up to 50 GHz is available. Measurements were done on a variety of components bought at flea markets in the Netherlands, Belgium and Germany. Most of these cables, connectors etc. are very cheap and originate from GSM base station equipment.
It is obvious that the measurement results have to be seen as indications only and cannot be taken as absolute values. It is also possible that components that look the same have been made by another company and behave differently.

The intention of this article is to provide the microwave experimenter with some guidance on buying components at flea markets.

II. Measurements

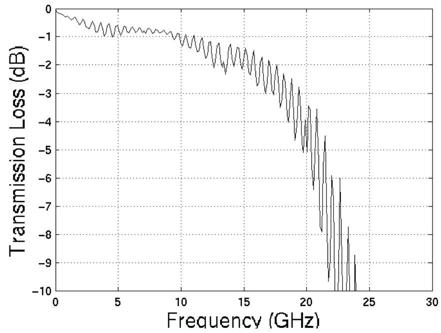
1. Flexible Cables

Flexible cables (RG-316) with SMA plugs are frequently used for the microwave bands.
The following results were obtained when these cables were measured with a network analyser.



Hans Wagemans ON4CDU
Peter Delmotte, ON4CDQ

Cable with right angle plug, length: 17 cm



Note: More cables of this kind have been measured, with about the same results as indicated.

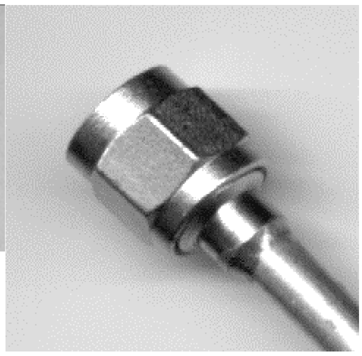
Conclusion: The measured losses of this type of flexible cable are more or less as was expected. Using this type of cable at frequencies up to 5 GHz should be done with care; in non-critical situations like the supply of the LO on 10 GHz, the attenuation can be accounted or compensated for. Measurements of the cable with the right angle cable plugs show that this type of connector introduces significant impedance changes.

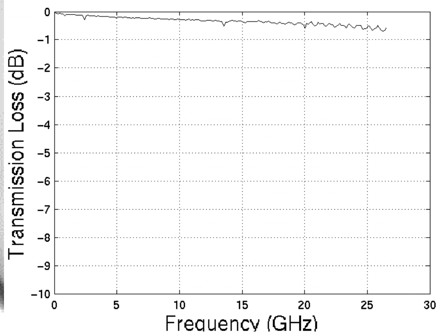
2. Semi-Rigid Cables with SMA Plugs

a) .141"

As shown above, there is a significant difference using straight or angle connectors. To highlight this, the following measurements were made (again using a network analyser and so terminated at 50 ohm):

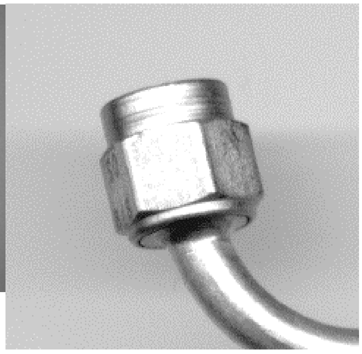
Length: 10 cm

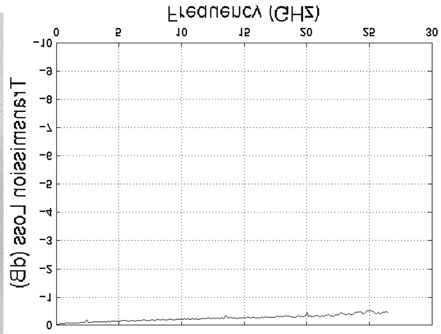




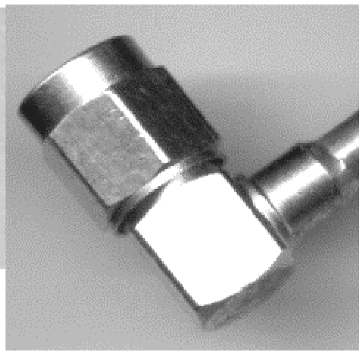
Hans Wagemans ON4CDU
Peter Delmotte, ON4CDQ

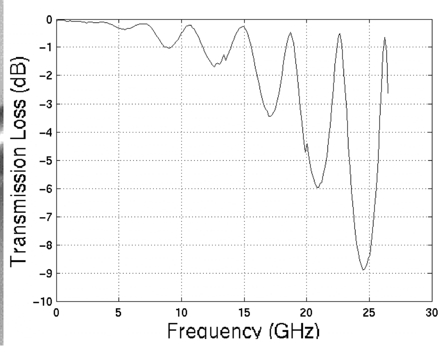
Length: 10 cm





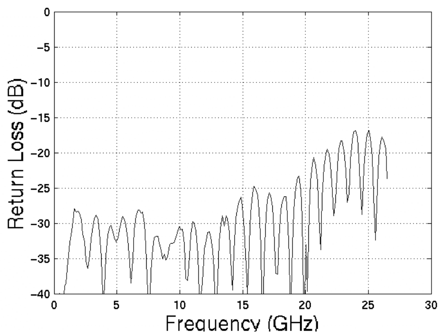
Length: 3 cm



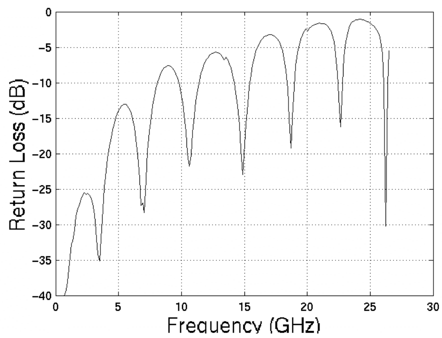


Note: More cables of this kind have been measured, with about the same results as indicated.

The reflection coefficient (S11) behaviour of these cables is also interesting: It is clear that the large transmission losses (S21) of the 3 cm right angle connector cable are not caused by absorption but rather by reflection at the connectors.



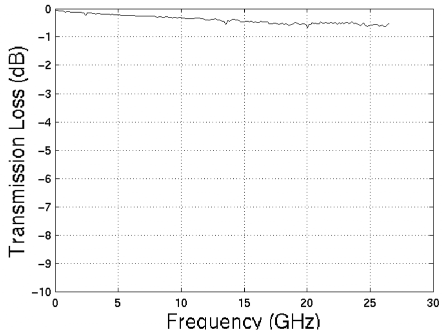
S11 of the first cable with the straight plug



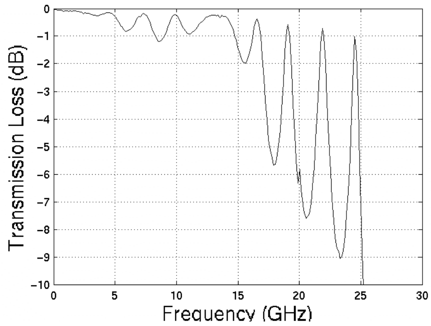
S11 of the cable with the right angle plug

Conclusion: Using semi-rigid cables with straight cable plugs at frequencies up to 24 GHz causes some signal loss, but this was expected. Semi-rigid cables with right angle cable connectors have unpredictable impedances at higher frequencies and are, therefore, not recommended to be used above 5 GHz. These unpredictable impedances can lead to difficulties i.e. in tuning and non-reproducible results when exchanging cables.

b) .086”



Length: 8 cm

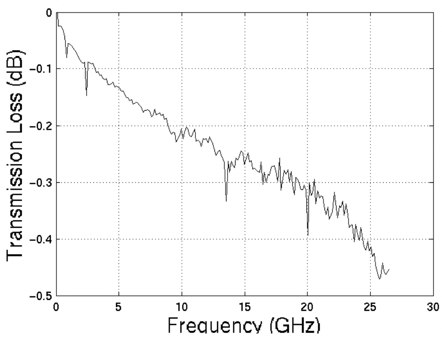


Length: 4 cm

Note: More cables of this kind have been measured, with about the same results as indicated.

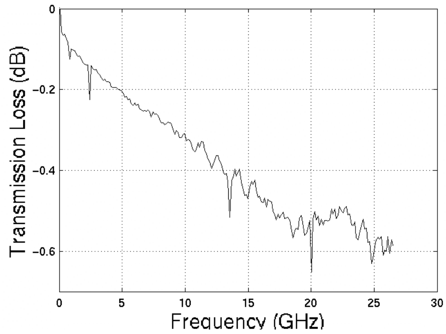
Conclusion: There is no big difference in the measurements compared to the thicker semi-rigid. The slightly higher losses were again expected. So the same conclusions apply as with 0.141” semi-rigid cables.

Some additional measurements on semi-rigid cables with straight connectors.



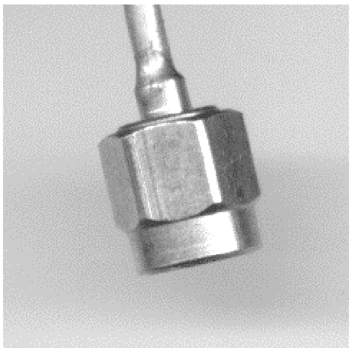
Length: 5 cm

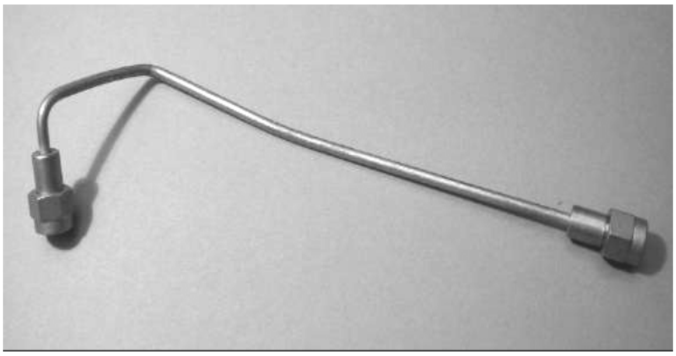
Hans Wagemans ON4CDU
Peter Delmotte, ON4CDQ

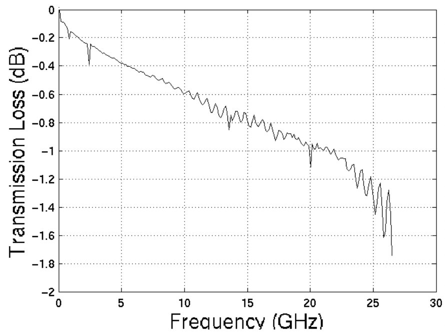


Length: 8 cm

Both cables above have the same type of connector.

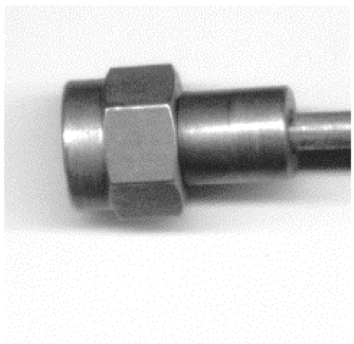






Length: 15 cm

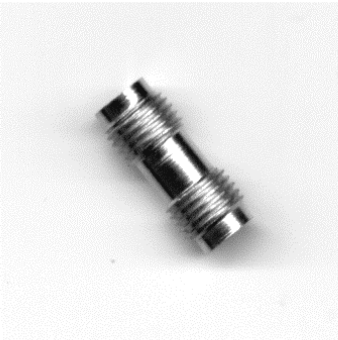
<u>*Conclusion*</u>: Although SMA plugs are specified up to 18 GHz, straight connectors can be used up to 24 GHz for amateur purposes. The soldered ones are superior to the clamp types.



Hans Wagemans ON4CDU
Peter Delmotte, ON4CDQ

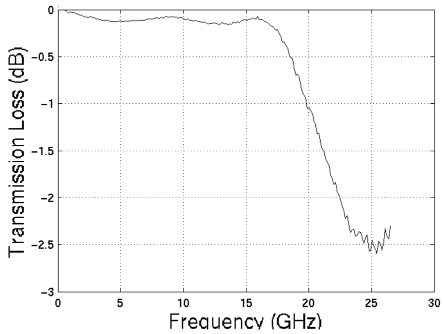
3. Straight Adapters

a) Straight Adapter Jack/Jack



A brand-new, shiny, nickel-plated jack/jack adapter.

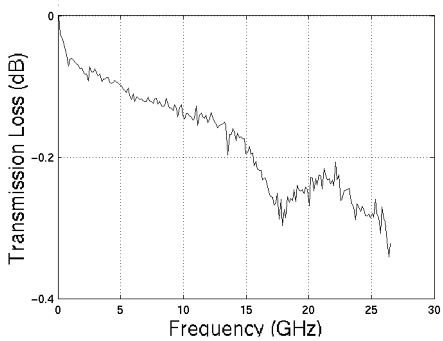
<u>*Conclusion*</u>: Can be used up to 18 GHz for non-critical applications. Not recommended at 24 GHz.



b) Straight Feed-Through Panel Adapter Jack/Jack

A second-hand gold-plated adapter.

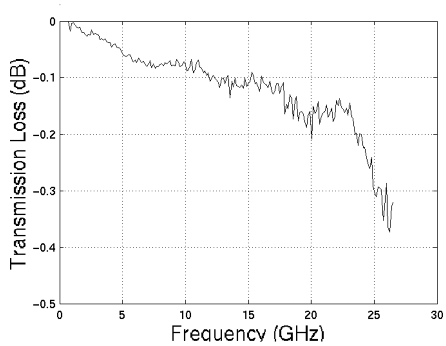
<u>*Conclusion:*</u> a very nice adapter, no real problem to use this type at 24 GHz.

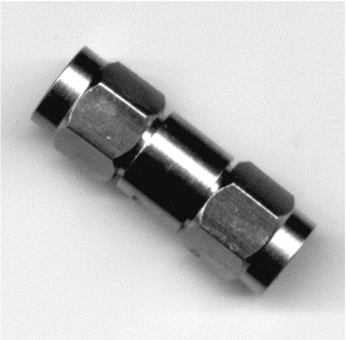


c) Straight Adapter Plug/Plug

A second-hand stainless steel plug/plug adapter

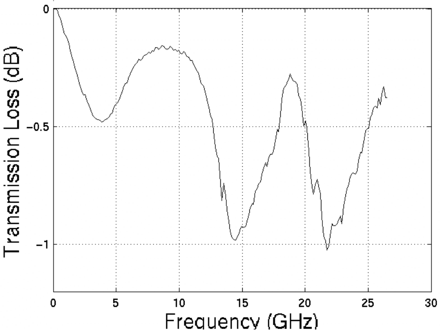
<u>*Conclusion:*</u> a nice adapter, no real problem to use this type at 24 GHz.

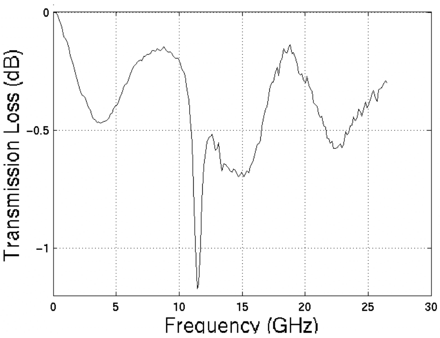




A brand-new shiny nickel-plated plug/plug adapter. It is slightly longer than the previous one. Measurements on different samples show similar behaviour. Two representative measurements are shown in the plots.

Conclusion: It is better not to use this type of adapter.

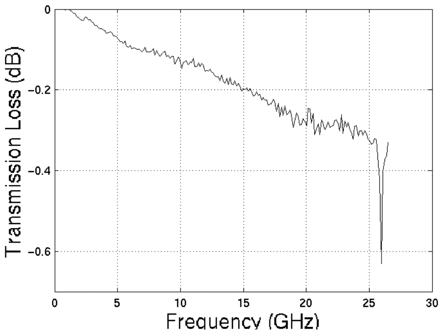




d) Straight Adapter Plug/Jack

Second-hand gold-plated adapter.

Conclusion: a very nice adapter; no problem to use this type at 24 GHz. The plot also shows a resonance at a frequency above 25 GHz.

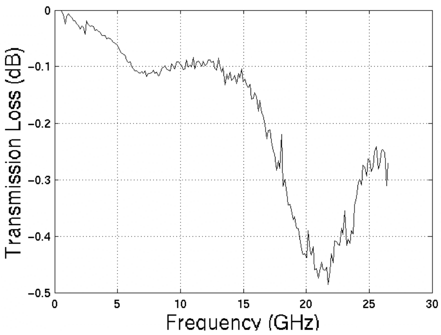


4. L-Adapters

a) L-Adapter Jack/Jack

Second-hand gold-plated adapter.

Conclusion: reasonable behaviour for a right angle adapter!

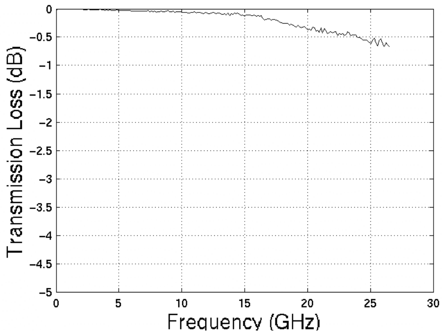


b) L-Adapter Plug/Jack

Note: *the scale of the plots is different.*
The next measurements show quite big differences in behaviour between the measured plugs. Detailed photographs of some of the adapters show the small differences.

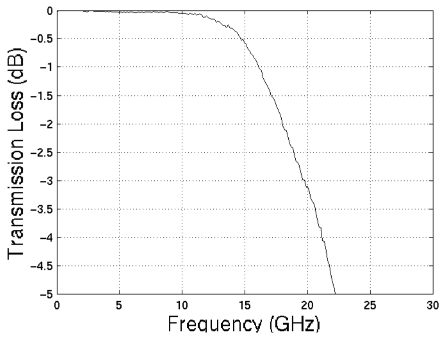
Second-hand gold-plated adapter.

<u>*Conclusion:*</u> this is a reasonably nice one and can be used on 24 GHz when a right angle adapter is needed.



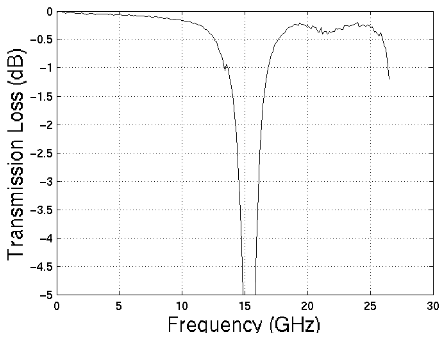
Second-hand gold-plated part.

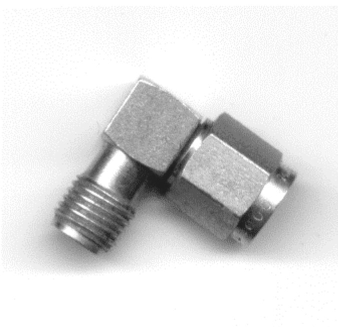
<u>*Conclusion:*</u> the look is only slightly different from the adapter above but the behaviour is quite different. This adapter cannot be used at 24 GHz!



Second-hand gold-plated adapter.

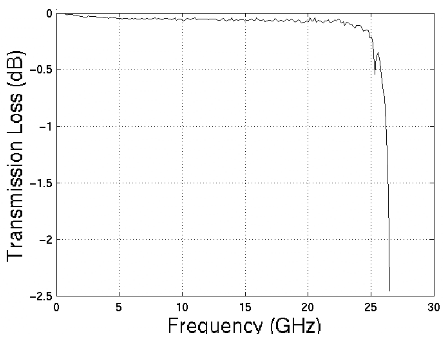
<u>*Conclusion:*</u> a resonance just above 15 GHz.





Second-hand gold-plated adapter.

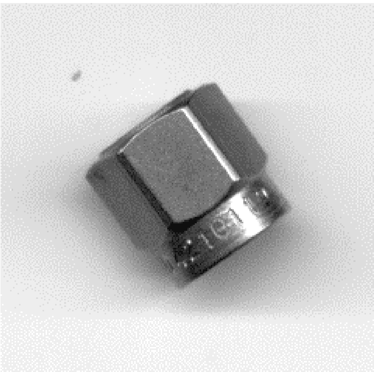
<u>*Conclusion:*</u> a very nice part, no problem to use this type at 24 GHz.

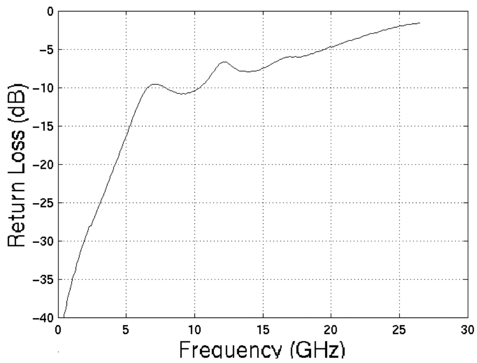


<u>End conclusion for L-adapters</u>: There is a big difference in behaviour of this type of adapter. A relation between the physical properties and the measurements could not be found, as we did not have enough material to check our conclusions. For frequencies up to 10 GHz these right angle adapters can be used without any problem. When using the adapters at 24 GHz it is recommended to buy different types and do your own tests.

5. Loads

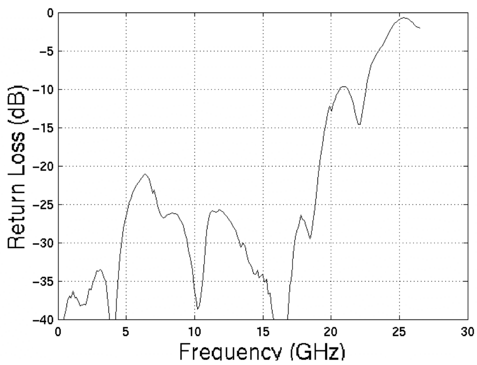
a) Second-hand, stainless steel, small SMA load





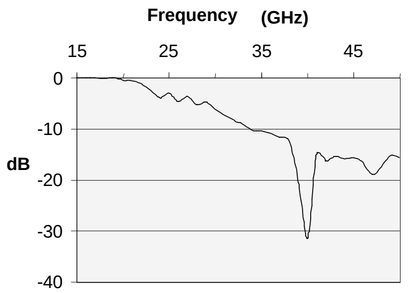
The photograph shows an inexpensive load as sold at flea markets. This load type exists in different quality ranges. For inexperienced people it is difficult to distinguish between these types. The measured one is certainly a ‘low’ frequency type and should not be used at frequencies above 5 GHz

b) Professional load with a professional specification

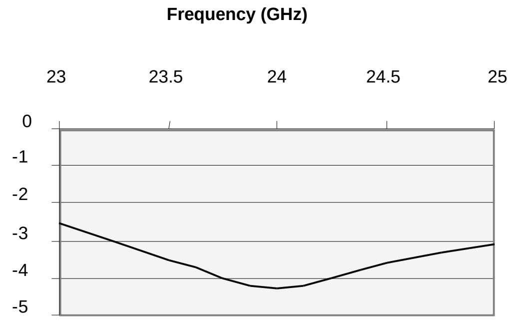


Above 18 GHz the return loss is higher than -20dB. This comes as no surprise. N-connector devices usually cannot be used above 18 GHz without performance degradation

6. Power Sensor HP8484A



HP powermeter sensitivity

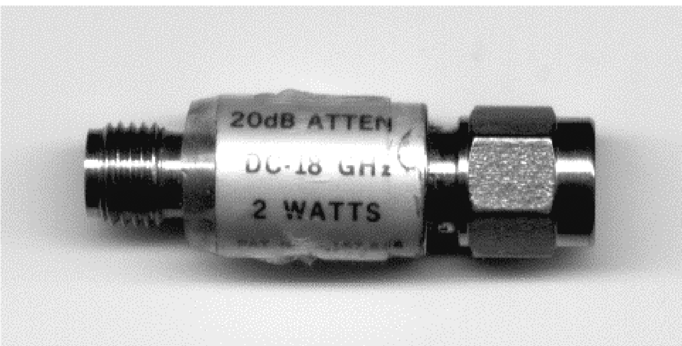


Around 24 GHz

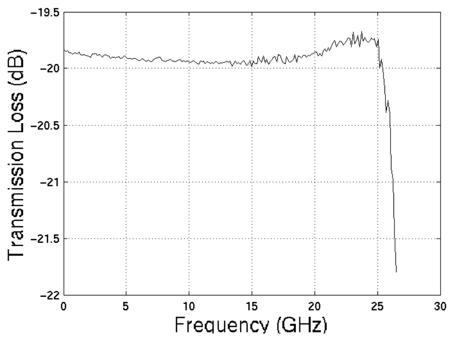
The HP8484A sensor is specified up to 18 GHz. When used at 24 GHz, the sensitivity of the sensor is about 4 dB less than at 18 GHz. For frequencies up to 35 GHz an indication of power can be achieved. Above 35 GHz resonances make the indication very unreliable.

7. Attenuators

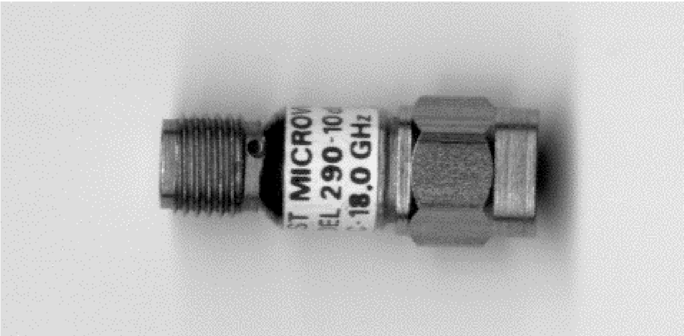
Some measurements were carried out on the behaviour of attenuators specified up to 18 GHz. Two typical measurements are presented.

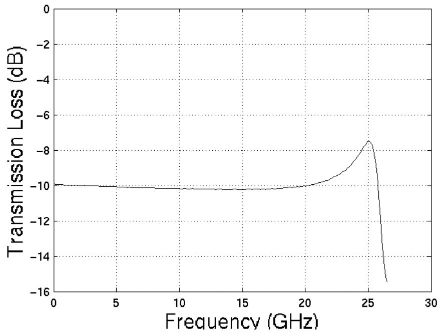


Narda Attenuator



<u>*Conclusion*</u>: this attenuator can be used without any problem at 24 GHz.





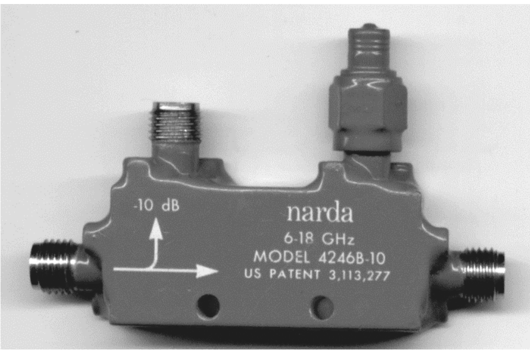
Midwest Microwave10 dB attenuator model 290

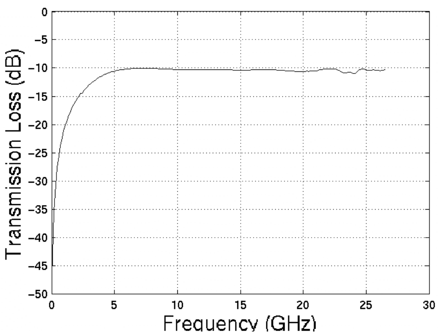
Conclusion: the plot shows a significant deviation above 18 GHz due to some self-resonance.

General conclusion: when using attenuators out of the specified frequency range, individual measurements for calibration are needed.

8. Coupler

One measurement was carried out on a 10 dB coupler of NARDA. It shows that with this coupler accurate measurements can be carried out up to 24 GHz.





III. Conclusions

In general, the use of SMA connectors at 10 and even at 24 GHz is possible. To be avoided are 90 degree bends, either as an L-adapter or as a connector. If you look at manufacturer specifications, the maximum useable frequency of bends is rarely specified.

N-Connectors, at least quality ones, can be used up to 18 GHz. A high precision N-connector that is guaranteed up to 26.5 GHz does exist, but is rarely found on flea markets. This type of connector has the advantage of being very rugged and is often found on test equipment. The precision N-type will mate with a standard version.