Typical residual error values in coaxial lines up to 65 GHz

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1 Introduction

The ripple technique is an established method of determining post-calibration residual errors on network analysers [1]. Previous investigations have provided typical error values in various coaxial connector [2] and waveguide [3] sizes at frequencies up to 110 GHz (up to 33 GHz in coaxial connector and above 33 GHz in rectangular waveguide).

No guide information exists for coaxial connector sizes smaller than 3.5 mm and hence the purpose of this paper is to provide this missing information for 2.92 mm, 2.4 mm and 1.85 mm connectors. As a comparison with the previous investigation, information has also been provided for 3.5 mm connectors. In each case, the residual directivity error term, *D*, and residual test port match error, *M*, are evaluated using the method given in [1].

2 Equipment used in the measurements

For each connector size, measurements were carried out on an Anritsu 37397C 65 GHz VNA, which was configured to measure from 100 MHz to the specified upper frequency limit of each connector size in 100 MHz steps.

Connector size	Nominal verification line length (mm)	Inner conductor type	Upper frequency (GHz)
3.5 mm	75	Slot-less	33
2.92 mm	70	Slotted	40
2.4 mm	50	Slot-less	50
1.85 mm	50	Slotted	65

Table 1 – Lines used to determine the ripple plot in the various connector sizes

The VNA was calibrated on Port 1 only with a Short-Open-Load (SOL) calibration using a lowband load below 2 GHz and a sliding load above 2 GHz. Table 1 shows the types and lengths of line used in the determination of the ripple, and the upper frequency limit of each connector size.

For the 3.5 mm and 2.92 mm connectors, both male and female test ports were considered. For the 2.4 mm and 1.85 mm connectors, only a male test port was considered. Also, for the 2.4 mm connectors only, supported and unsupported airlines were used to determine the ripple plots.

3 Results and Observations

Figures 1 – 4 show typical plots for each of the connector sizes obtained in this investigation, measured using the male test port and female standards. To maintain clarity in the graphs (there is often a spike at 2 GHz, i.e., the changeover between the fixed and sliding loads), they all start from 4 GHz.

The values of *D* and *M* obtained for each connector size are, surprisingly, not dissimilar and can be summarised together: see Table 2.

D	*M*
< 0.02 (slotted lines) < 0.01 (slot-less lines)	< 0.04 (excluding 1.85 mm) ≤ 0.05 (1.85 mm only)

Table 2 – Summary of typical residual errors in all line sizes

The results seen here agree in part with investigations carried out in the past, i.e., that the value of *M* is usually larger than *D* [2]. An interesting feature to note is that the values of *D* and *M* do not appear to increase as the connector size decreases as one might expect; this may suggest that the performance of slot-less lines is better than slotted lines.

A little care must be taken when interpreting the residual directivity plots. In Figs 1 – 4, the characteristic trace of the load used in the determination of the ripple plot is also included. Note that the ripple plot is, in most cases, superimposed on the trace of the load. In these cases, the ripple response should be de-embedded from the terminating load; in this instance, this was done by eye (although there are other methods that may be used [2]).

A point to mention is the presence of a spike at around 30 GHz in Fig 1a and at around 42 GHz in Fig 3a; these are not components of the ripple and are inherent in the standards used in the calibration.

4 Conclusion

This report has presented some typical plots for the post-calibration residual error terms in four different connector sizes. It would seem that there is no distinct trend with line size, as one might think, but the use of different line types (i.e., slotted or slot-less) in the different connector sizes may explain why the intuitive trend does not occur.

The values for the residual error terms presented here may be used as a guide to the magnitude of the same terms found on other VNAs.

References

[1] "EA Guidelines on the evaluation of Vector Network Analysers (VNA)", *European co-operation for Accreditation*, Publication Reference EA-10/12, May 2000.

[2] N M Ridler and C Graham, "Some typical values for the residual error terms of a calibrated vector automatic network analyser (ANA)", *BEMC'99 - 9th International Conference on Electromagnetic Measurement*, Conference Digest pp 45/1 – 45/4, Brighton Metropole Hotel, 2 – 4 November 1999.

[3] C P Eiø and N M Ridler, "Evaluating post-calibration residual errors using the ripple technique at millimetre wavelengths in rectangular waveguide", *ANAMET Report 048*, April 2005.

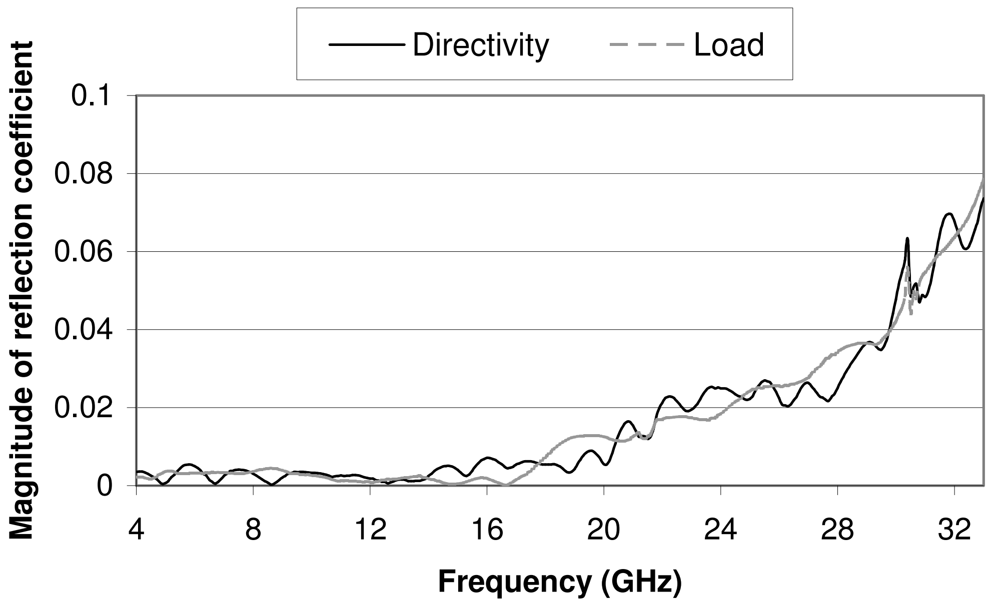

Fig 1a – Typical residual directivity plot for 3.5 mm connector

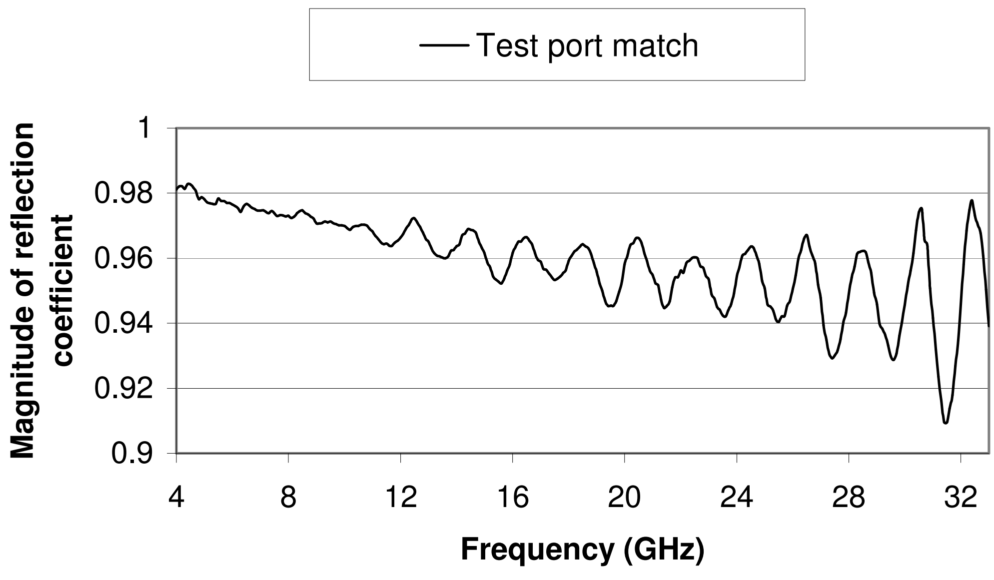

Fig 1b – Typical residual test port match plot for 3.5 mm connector

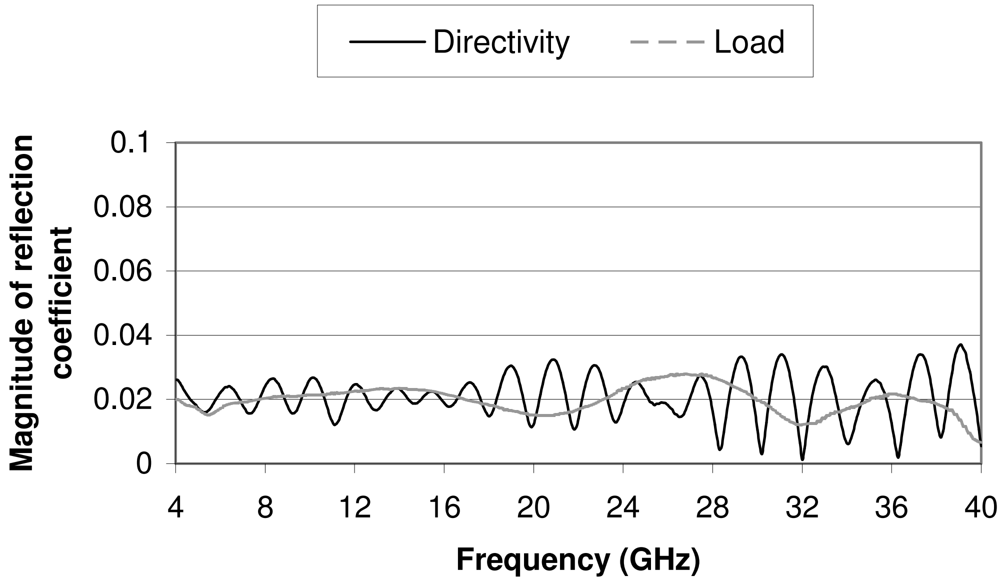

Fig 2a – Typical residual directivity plot for 2.92 mm connector

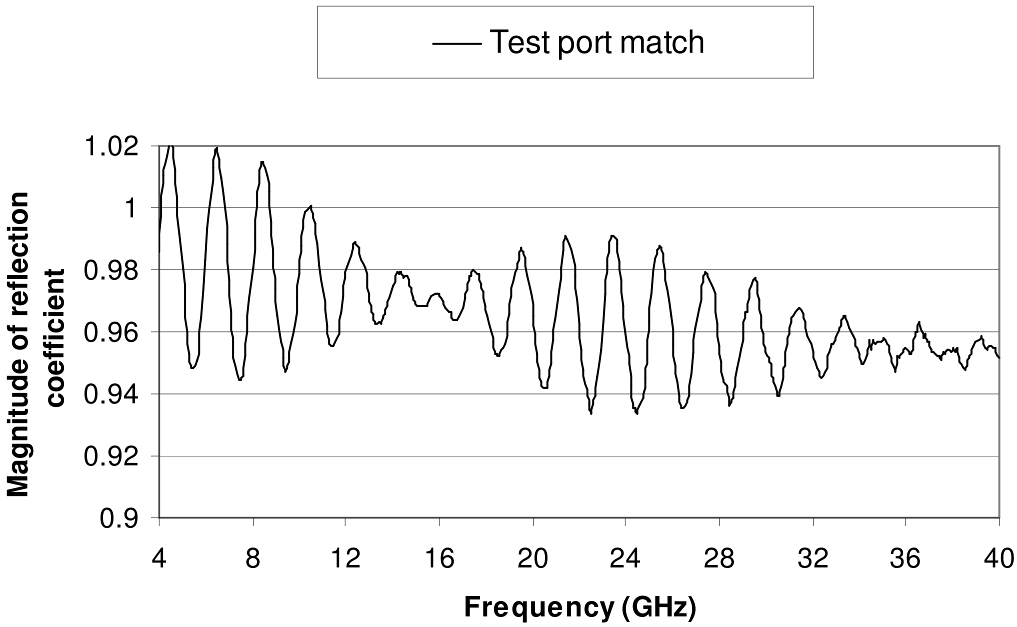

Fig 2b – Typical residual test port match plot for 2.92 mm connector

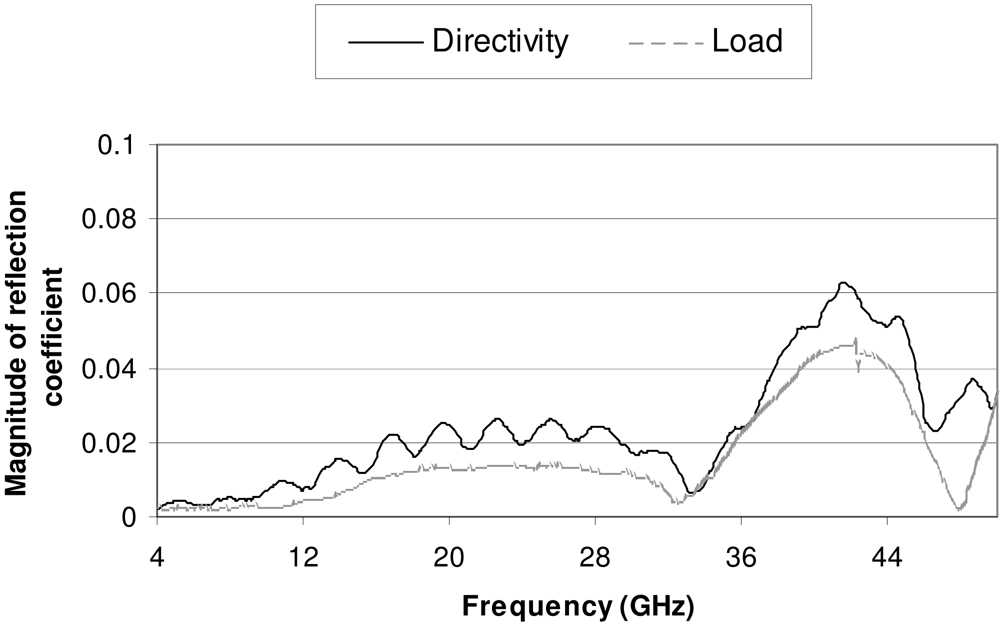

Fig 3a – Typical residual directivity plot for 2.4 mm connector

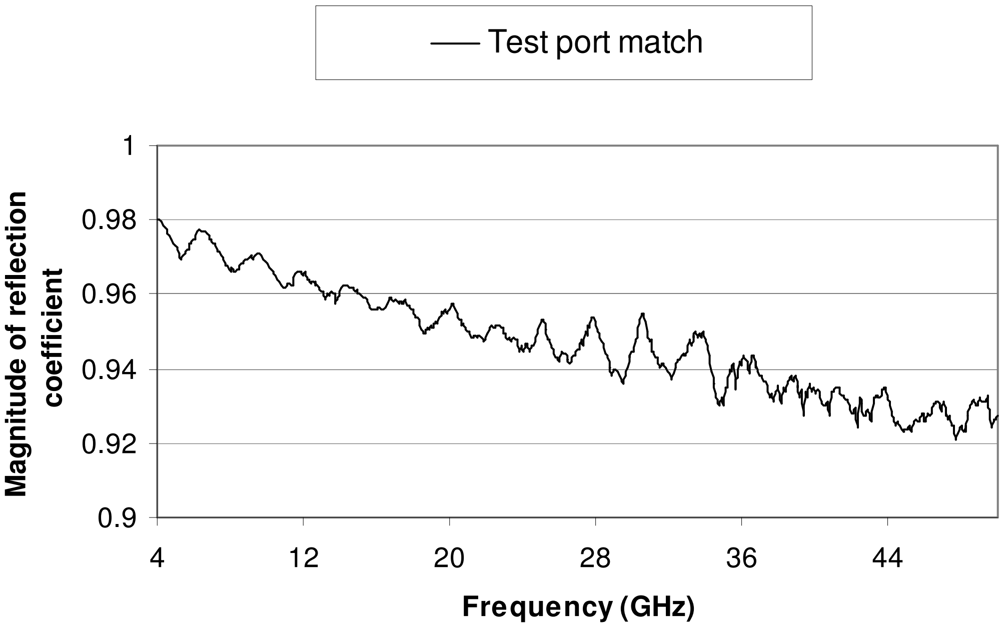

Fig 3b – Typical residual test port match plot for 2.4 mm connector

Figs 3a and 3b were measured using an unsupported airline; measurements made using a supported airline gave similar plots.

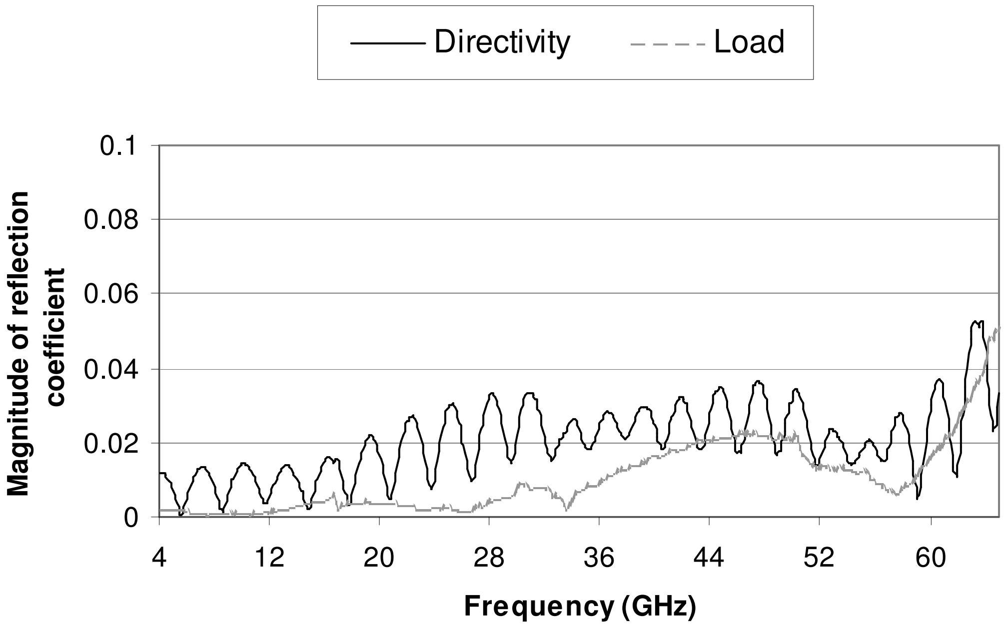

Fig 4a – Typical residual directivity plot for 1.85 mm connector

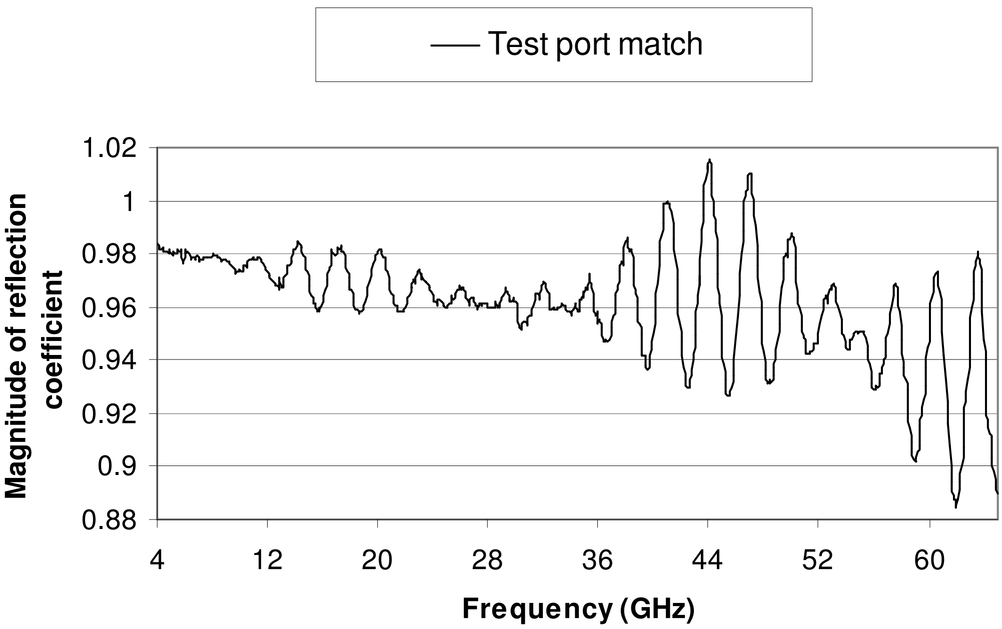

Fig 4b – Typical residual test port match plot for 1.85 mm connector