CCEM KEY COMPARISON CCEM.RF-K5b.CL (GT-RF/92-3)

Scattering Coefficients by Broad-Band Methods

2 – 18 GHz

Type N connector

Final Report of the Pilot Laboratory

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This report is dedicated to the memory of Dr. Johannes (Jan) Petrus Maria de Vreede (1945 – 2007).

ABSTRACT

A measurement comparison of scattering parameters has been carried out between nineteen national metrology laboratories in coaxial line using 50 Ω Type N precision connectors at frequencies between 2 GHz and 18 GHz. The identification of this intercomparison is CCEM.RF-K5b.CL. Seven devices have been measured: three attenuators (3 dB, 20 dB and 50 dB), two matched terminations (one male, one female) and two mismatched terminations (one male, one female). The National Physical Laboratory (United Kingdom) acted as the pilot laboratory for the comparison. This report contains the results of the measurements made at 2 GHz, 9 GHz and 18 GHz for a selection of the measured scattering parameters, chosen to give a sample of a low-, medium- and high-loss transmission coefficient, a nominally zero reflection coefficient and a non-zero reflection coefficient.

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[*] At the start of 2008, SPRING became the National Metrology Centre (NMC), part of the Agency for Science, Technology and Research (A*STAR) but will still be referred to as SPRING in this report.

[†] In May 2007, after the measurements in this key comparison were completed, CSIR-NML became National Metrology Institute of South Africa (NMISA) but will still be referred to as CSIR-NML in this report.

[‡] SP Sveriges Provnings- och Forskningsinstitutt have since changed their name to SP Sveriges Tekniska Forskningsinstitut. They are still referred to as SP in this report.

1 Introduction

This intercomparison, designated GT-RF/92-3 or CCEM.RF-K5b.CL, is the second of a series of three key comparisons[§] undertaken to measure scattering coefficients by broad-band methods at frequencies between 2 GHz and 18 GHz. This comparison, K5b, uses devices with 50 Ω Type N precision connectors; K5a (also known as GT-RF/83-4) used devices with PC-7 connectors [1] and K5c will use devices with PC-3.5 connectors and cover frequencies from 50 MHz to 33 GHz.

Nineteen laboratories have participated in this intercomparison, which took place between June 2003 and November 2006. These are (in alphabetical order by country):

- NMIA (Australia) – formerly CSIRO
- NRC (Canada)
- NIM (China)
- CMI (Czech Republic)
- LNE (France)
- PTB (Germany)
- SCL (Hong Kong)
- NPLI (India)
- INRIM (Italy)
- NMIJ (Japan)
- NMi-VSL (The Netherlands)
- SNIIM (Russia)
- SPRING (Singapore)
- CSIR-NML (South Africa)
- SP (Sweden)

[§] According to the BIPM's key comparison database (http://kcdb.bipm.org/AppendixB/default.asp), the first, CCEM.RF-K5a.CL has, at the time of writing, been approved for provisional equivalence and the third, CCEM.RF-K5c.CL, will commence upon completion of this comparison.

- METAS (Switzerland)
- UME (Turkey)
- NPL (United Kingdom – PILOT LABORATORY)
- NIST (United States of America)

The participants reported results for scattering parameter measurements of the seven travelling standards at 17 frequencies between 2 GHz and 18 GHz in 1 GHz steps and was chosen as such due to it being typical of a VNA measurement. However, due to the large amount of data involved, key comparison reference values and degrees of equivalence have only been calculated for the following measurands:

- S_{21} of each attenuator at frequencies 2 GHz, 9 GHz and 18 GHz
- S_{11} of the male matched load at frequencies 2 GHz, 9 GHz and 18 GHz
- S_{11} of the female mismatched load at frequencies 2 GHz, 9 GHz and 18 GHz

There are 15 measurands in total, for which a key comparison reference value (KCRV) will be determined. These values were chosen before any measurements were undertaken, as listed in the protocol [2], to give sample values of a high, medium and low transmission coefficient (nominal magnitude 0.71, 0.1 and 0.00316) and a medium and low reflection coefficient (nominal magnitude 0.33 and 0) at a high, medium and low frequency.

The other results were reported and used to monitor the stability of the devices but no further analysis was carried out. They are available as a separate document entitled "CCEM.RF-K5b.CL Appendix F: Results not reported in the main body".

2 Travelling Standards

Seven devices were used as the travelling standards in this intercomparison. Each standard is a commercially available artefact and was chosen specifically to be similar to devices used in a related exercise [3]. The recommendations made in [1] were also taken into consideration with regards to choosing appropriate standards (e.g., use only items in which the inner and outer conductors have a permanently fixed relationship). The devices are summarised in Table 1.

Identifier	**Description**	**Serial no.**	**Nominal value**	**No. of ports**
K5b.CL/1	HP 8491B Attenuator	52749	3 dB	2
K5b.CL/2	HP 8491B Attenuator	52676	20 dB	2
K5b.CL/3	HP 8491B Attenuator	52764	50 dB	2
K5b.CL/4	HP 909F matched termination (m)	17026	50 Ω	1
K5b.CL/5	HP 909F matched termination (f)	50761	50 Ω	1
K5b.CL/6	Maury 2562G mismatched termination (m)	7838	VSWR = 2.0	1
K5b.CL/7	Maury 2561G mismatched termination (f)	7847	VSWR = 2.0	1

Table 1 – List of standards used in the comparison

3 Comparison Protocol and Schedule

The travelling standards were circulated to the participants, who were asked to provide a measure of the scattering parameters of the travelling standards at frequencies between 2 GHz and 18 GHz in 1 GHz steps, hence measurements were taken at:

2 GHz, 3 GHz, 4 GHz, 5 GHz, 6 GHz, 7 GHz, 8 GHz, 9 GHz, 10 GHz,
11 GHz, 12 GHz, 13 GHz, 14 GHz, 15 GHz, 16 GHz, 17 GHz and 18 GHz

The participants were asked to provide results for the following measurands:

- For each of the three two-port devices (K5b.CL/1, K5b.CL/2 and K5b.CL/3): all four complex-valued S-parameters (S_{11}, S_{12}, S_{21} and S_{22});
- For each of the four one-port devices (K5b.CL/4, K5b.CL/5, K5b.CL/6 and K5b.CL/7): the complex-valued voltage reflection coefficient (S_{11}).

The complex-valued results were supplied in the form $S_{ab} = x + jy$ ($a = 1, 2$ and $b = 1, 2$), where x and y, respectively, are the real and imaginary components of the S-parameter expressed in linear units, and $j^2 = -1$.

To ensure the long-term mechanical stability of the devices, participants were asked to provide a measure of the connector pin depths for each device (see Appendix D for the reported pin depths). The devices were periodically returned to the pilot laboratory to monitor their long-term electrical stability and participants' reported results were monitored as they were submitted. The results of these repeat measurements can be seen in Appendix E.

Laboratory	Date of Measurement
NPL (UK) first measurement	June 2003
PTB (Germany)	September 2003
NMi-VSL (Netherlands)	November 2003
INRIM (Italy)	January 2004
NPL (UK) second measurement	February 2004
METAS (Switzerland)	March 2004
CMI (Czech Republic)	April 2004
UME (Turkey)	May 2004
NPL (UK) third measurement	July 2004
NMIA (Australia)	August 2004
SPRING (Singapore)	October 2004
SCL (Hong Kong)	December 2004
NPL (UK) fourth measurement	January 2005
SNIIM (Russia)	March 2005
NIM (China)	May 2005
NRC (Canada)	July 2005
NIST (USA)	September 2005
NPL (UK) fifth measurement	October 2005
CSIR-NML (South Africa)	December 2005
NPLI (India)	January 2006
NMIJ (Japan)	April 2006
NPL (UK) sixth measurement	May 2006
SP (Sweden)	June 2006
LNE (France)	July 2006
NPL (UK) final measurement	November 2006

Table 2 – Participants' measurement dates

Table 2 gives the date of measurement at each of the participating laboratories.

Laboratory	Hardware	Test set	Calibration kit	Calibration method	Test port connector
NPL (UK)	HP 8510C	8515A	Custom kit	LRL	(1) Male – (2) Female
PTB (Germany)	HP 8510B	8515A	HP 85054B	SOLT (sliding)	(1) Female – (2) Male
NMi-VSL (Netherlands)	HP 8510C	8517B	HP 85054B	SOLT (sliding)	(1) Female – (2) Male
INRIM (Italy)	HP 8510C	8517A	HP 85054B	SOLT (sliding)	(1) Male – (2) Female
METAS (Switzerland)	HP 8510C	8515A	HP 85054B and HP 85054B K42	SOLT (sliding) and LRL	(1) Male – (2) Female
CMI (Czech Republic)	HP 8510C	8515A	HP 85054B	SOLT (sliding)	(1) Female – (2) Male
UME (Turkey)	HP 8510C	8515A	HP 85054B	SOLT (sliding)	(1) Female – (2) Male
NMIA (Australia)	HP 8510C		HP 85054B	SOLT (sliding)	(1) Male – (2) Female
SPRING (Singapore)	HP 8510C	8515A	HP 85054B	SOLT (sliding)	(1) Male – (2) Female
SCL (Hong Kong)	HP 8510B	8515A	HP 85054B	SOLT (sliding)	(1) Male – (2) Female
SNIIM (Russia)	Own design measurement system	N/A	N/A	N/A	(1) Female – (2) Male
NIM (China)	HP 8722ES	N/A	Maury 8860	LRL	(1) Female – (2) Male
NRC (Canada)	HP 8510C	8517A	Maury	LRL	(1) Female – (2) Male
NIST (USA)	HP 8510C	8517B	Custom kit	LRL	(1) Male – (2) Female
CSIR-NML (South Africa)	HP 8510C	8515A	HP 85054B	SOLT (sliding)	(1) Male – (2) Female
NPLI (India)	Wiltron 37247B	N/A	Wiltron 3653	SOLT	(1) Female – (2) Male
NMIJ (Japan)	Agilent E8364B PNA	N/A	Custom kit	Quarter wave and TRL/LRL	(1) Male – (2) Female
SP (Sweden)	HP 8510C	8515A	HP 85054B (characterised)	SOLR (unknown thru)	(1) Female – (2) Male
LNE (France)	HP 8510XF	8517B	HP 85054B	SOLT (sliding)	(1) Male – (2) Female

Table 3 – Overview of the participants' measurement method

4 Methods of Measurement

With one exception, all participants performed their measurements using a vector network analyser. The equipment used by each participant is summarised in Table 3. The full reports from each of the participants can be found in Appendix C.

The protocol did not state the measurement orientation of the two-port devices, resulting in reversed *S*-parameters reported by some participants. Table 3 also shows the orientation of the two-port devices as reported by each participant.

For the purposes of this exercise, test port 1 is chosen as the male port and test port 2 as the female for two-port measurements. This means that, for some participants, the reported uncertainty budget is actually for S_{12} and not S_{21}. Owing to the reciprocal nature of the two-port travelling standards, it is fair to compare the uncertainty budgets of these parameters.

5 Problems encountered during the Comparison

A couple of problems were encountered during the measurement phase, similar to those experienced during this comparison's predecessor [1].

Firstly, a step change was observed in the measurements of the 3 dB attenuator (K5b.CL/1) after the measurements were made at UME, the cause of which is unclear. However, the device subsequently remained stable during the rest of the comparison. The change observed here is similar to that seen in item 1 of GT-RF/83-4 [1]. The loss of the continuity of this device has an effect on the intercomparison but it is not disastrous and some benefit can still be gained through the NPL measurements of both states of the device.

The second problem, and common to many comparisons [1, 10], was down to shipping and customs procedures in the various participants' countries. ATA Carnets were used during shipment to those participants outside the European Union[**] (EU) with the exception of SNIIM, NIM, NRC and NIST, where temporary export was used. The use of carnets had a huge impact on the cost of shipping, appeared to lengthen the time taken to go through the customs process and, in two instances, the carnet was not filled in correctly during transit,

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[**] At the start of the comparison, the Czech Republic was not an EU member but became a member whilst the devices were at CMI.

thus causing further delays. On top of this, the carnet became separated from the devices in one instance during shipment, delaying the release of the devices further.

6 Discussion of the Results

The results were presented to the pilot laboratory in the format of the real and imaginary components of their estimates of the travelling standards' scattering parameters and the associated standard uncertainties.

Due to the large amount of data involved, just a small sample of the results is used in determining key comparison reference values and degrees of equivalence. The chosen measurands are:

- S_{21} of each attenuator (3 dB, 20 dB and 50 dB) at frequencies 2 GHz, 9 GHz and 18 GHz
- S_{11} of the male matched load at frequencies 2 GHz, 9 GHz and 18 GHz
- S_{11} of the female mismatched load at frequencies 2 GHz, 9 GHz and 18 GHz

S_{21} of each attenuator was chosen to provide a sample of low-, medium- and high-loss transmission coefficient, S_{11} of the male matched connector chosen to provide a sample of a nominally zero reflection coefficient and S_{11} of the female mismatched connector chosen to provide a sample of a non-zero reflection coefficient.

The key comparison reference value (KCRV) was determined using an unweighted (arithmetic) mean of the participants' reported measurements, chosen due to the variation of uncertainties reported, as it was felt that, although not necessarily suitable for all of the KCRVs[††], it would give a fair judgement of the KCRV for the the highest number of the measurands over other methods.

Any data identified as inconsistent [4, 5] was excluded from the determination of the KCRV. Inconsistent data is highlight in *italics* in the results tables. Appendix A provides a more

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[††] Particularly those for K5b.CL/7, where the KCRV is skewed by INRIM's results, which, despite being far removed from the rest, is consistent with the others within its uncertainty. Exact reasons for these results appearing anomalous are unknown but they are believed to have been caused by poor connection repeatability due to an improper use of the torque wrench.

detailed insight into the method and formulae used. Although this method does not follow that described in [9], the two methods were carried out in parallel. Where inconsistencies were identified, both methods identified the same elements as inconsistent.

Participants who are not a member of CCEM are not included in the determination of the KCRV; these include CMI and UME, both of whom are observers, and SCL. These are marked with an asterisk (*) in the results tables.

Participants were also asked to provide combined standard uncertainties (broken down in an uncertainty budget) for the aforementioned measurands and, where possible, the correlation coefficient associated with the real and the imaginary component of each measurand. As it transpired, fewer than half of the participants were able to provide any estimate of these correlation coefficients. Where a participant did not report correlation coefficients, the correlation coefficients were assumed to be zero.

Other correlation effects, such as correlation associated with the different *S*-parameter measurements of a two-port device [6], and correlation between individual participants, has been neglected. It has been shown that, in some cases, taking correlation into account has little effect on the reference value [7] and it is assumed that this is one such case.

It was left to the discretion of each laboratory as to whether or not they provided uncertainty budgets for any of the other measurands. The measurement results and associated uncertainties together with the reference values and associated uncertainties are shown graphically in Figs 1 – 15 and tabulated in Tables 3 – 17.

Please note: the reported uncertainties have been rounded to two significant figures and the associated measured values rounded accordingly in the tables. The analysis was carried out with the results as reported by the participants with no rounding.

Due to the two-dimensional nature of the measurands, graphical representation of the degrees of equivalence requires a reduction in dimensions, which has been done following the procedure outlined in [8]. The degrees of equivalence are shown graphically in Figs 16 – 30 and tabulated in Tables 18 – 32. Degrees of equivalence between participants with common traceability paths have not been included, owing to the difficulty in quantifying correlation coefficients and the significant effect of an inaccurate estimate of the correlation coefficient on the combined standard uncertainty in the degrees of equivalence [7].

The properties of the device designated K5b.CL/1 (3 dB attenuator) changed between the measurements made at UME (May 2004) and the third measurement made at NPL (July 2004) for reasons unknown. Therefore, this device has two reference values: one for measurements made before July 2004 and one for measurements made after. Since NPL measured the device in both periods, NPL's measurements contribute separately to both reference values. This change is highlighted in Appendix E.

All uncertainty budgets provided by the participants can be found in Appendix B.

7 Conclusions

An international comparison of scattering coefficients at microwave frequencies has been carried out among nineteen laboratories around the world. The parameters compared were *S*-parameters relative to 50 Ω for items fitted with 50 Ω Type N precision connectors. The frequency range was 2 – 18 GHz but a detailed analysis is provided only for a choice of parameters at 2, 9 and 18 GHz.

Seven items, consisting of three attenuators, two matched terminations and two mismatched terminations were measured for the purposes of this comparison. The characteristics of the 3 dB attenuator underwent a step change; despite this, the device was stable in both states and is represented by two KCRVs in this comparison.

The size of the uncertainties in the measurements of the transmission coefficients of the attenuators varies somewhat amongst the participants but, with two or three exceptions, the reported values are consistent within those uncertainties.

8 Recommendations

A recommendation made by this comparison's predecessor [1] was that the objectives of the comparison should be defined sufficiently, i.e., it should be known right from the start which measurands will be compared, analysed, etc. Whilst objectives were defined for this comparison (e.g., it was stated in the protocol which measurands will be analysed before the measurement stage began), one thing missing from the protocol was the measurement orientation of the two-port devices. This was missed out, probably due to the sexed nature of Type N connectors and an assumption made that each participant would use the same port orientation. In future, this ought to be defined clearly in the protocol, regardless of whether the device is sexed or not.

Although [1] suggests that the number of requested data points be limited, this is not necessarily a good thing. In this comparison, the characteristics of the 3 dB attenuator changed but this may not have been highlighted if a limited data set had been provided. In this case it didn't help, but providing a full data set can prove useful in identifying why a device's characteristics may have changed (including any effects caused by a slow time drift, which may be corrected for in the KCRV or included in the KCRV's uncertainty budget).

The number of participants in this comparison meant that the measurement stage lasted longer than the preferred two years and, with delays, eventually lasted 39 months. The number of participants should be kept to a more manageable figure, perhaps containing one or two from each RMO, who may then participate in a regional comparison. Alternatively, two comparisons could be undertaken in parallel, with a bi-lateral comparison between the two pilots.

Serious thought should be given before undertaking a comparison of this magnitude to the method of shipping. It is standard practice to use carnets when shipping between countries without a common agreement on movement of goods in order to ease the customs process. In fact, the opposite has been experienced here with the carnet lengthening the customs process; this is not a unique experience [10]. It appears to be just as cost effective (and certainly more time effective) to ship the comparison devices using a temporary import/export procedure in a star formation, i.e., each participant returns the devices to the pilot upon completion of their measurements.

9 Acknowledgements

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Contributions to this comparison were made by (in no particular order):
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[‡‡] In June 2007, the Department of Trade and Industry became the Department for Innovation, Universities and Skills.

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Lab I	Measurement and Combined Standard Uncertainty of S_{21} of 3 dB attenuator (K5b.CL/1) at 2 GHz			
	x_i	$u(x_i)$	y_i	$u(y_i)$
NPL	-0.64313	0.00015	-0.30099	0.00015
PTB	-0.6426	0.0021	-0.3021	0.0021
NMi-VSL	-0.6436	0.0016	-0.3020	0.0016
INRIM	-0.64339	0.00026	-0.30091	0.00027
METAS	-0.6429	0.0019	-0.3019	0.0019
*CMI	-0.64296	0.00085	-0.3022	0.0011
*UME	-0.6436	0.0014	-0.3027	0.0014
	x_M	$u(x_M)$	y_M	$u(y_M)$
Reference value	-0.64312	0.00019	-0.30158	0.00026
	Mag	u(Mag)	Phase	u(Phase)
Reference value	0.71032	0.00017	-154.877°	0.022°

Table 3a – Measurements before July 2004

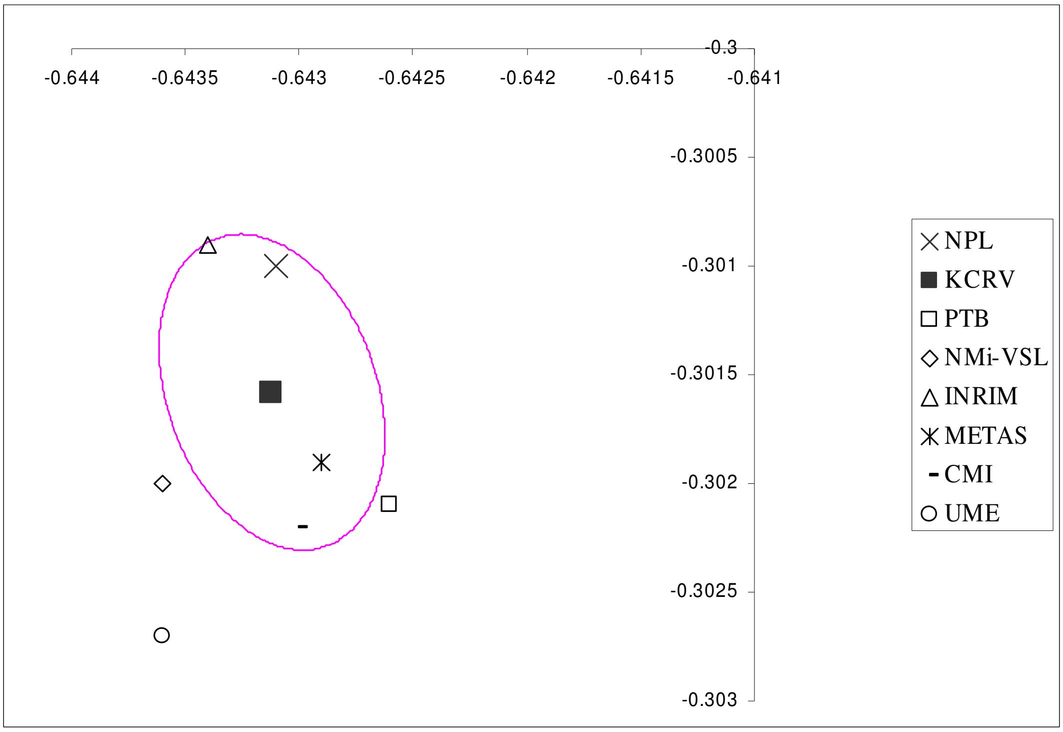

Fig 1a – Plot of measurements of S_{21} of device K5b.CL/1 (3 dB attenuator) at 2 GHz made before July 2004 along with the KCRV and its expanded uncertainty (k = 2.5[§§])

[§§] Refer to Appendix A.

Lab I	Measurement and Combined Standard Uncertainty of S_{21} of 3 dB attenuator (K5b.CL/1) at 2 GHz			
	x_i	$u(x_i)$	y_i	$u(y_i)$
NMIA	-0.64282	0.00082	-0.30423	0.00082
SPRING	-0.6428	0.0018	-0.3045	0.0037
*SCL	-0.6430	0.0044	-0.3041	0.0078
SNIIM	-0.6425	0.0043	-0.2993	0.0043
NIM	-0.6437	0.0015	-0.3069	0.0015
NRC	-0.6426	0.0010	-0.3053	0.0010
NIST	-0.6436	0.0010	-0.3031	0.0017
CSIR-NML	-0.64329	0.00082	-0.30447	0.00082
NPLI	-0.6440	0.0011	-0.3047	0.0011
NMIJ	-0.6427	0.0018	-0.3047	0.0018
SP	-0.6429	0.0019	-0.3048	0.0019
LNE	-0.64279	0.00043	-0.30527	0.00043
NPL	*-0.64269*	*0.00019*	*-0.30552*	*0.00019*
	x_M	$u(x_M)$	y_M	$u(y_M)$
Reference value	-0.64305	0.00016	-0.30430	0.00057
	Mag	u(Mag)	Phase	u(Phase)
Reference value	0.71141	0.00032	-154.676°	0.040°

Table 3b – Measurements after July 2004

The correlation coefficient, $r(x_M, y_M)$, for measurements before July 2004 is –0.33 and for measurements after July 2004 is 0.37. The table below shows the correlation coefficients for those participants who chose to report this.

NMi-VSL	**INRIM**	**CMI**	**UME**	**SPRING**	**NIM**	**NPLI**	**NMIJ**
0.28	-0.00064	-0.34	-0.068	-0.93	-0.0052	0.83	0.00

Table 3c – Reported correlation coefficients

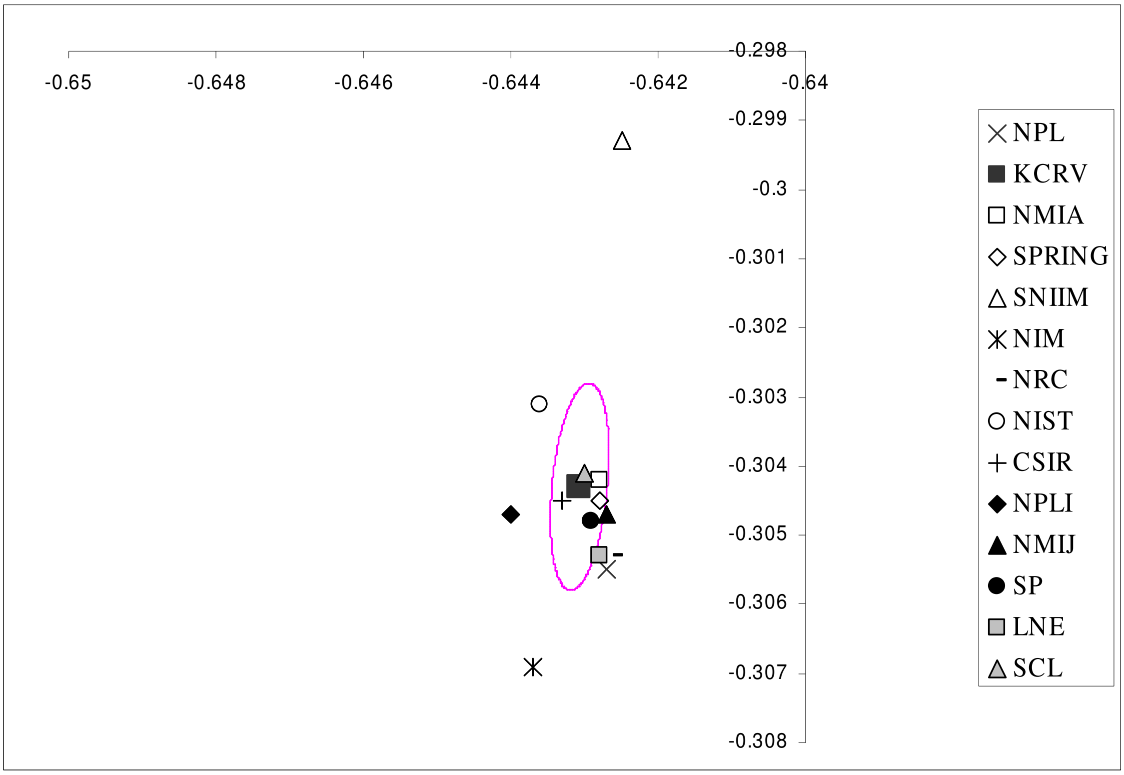

Fig 1b – Plot of measurements of S_{21} of device K5b.CL/1 (3 dB attenuator) at 2 GHz made after July 2004 along with the KCRV and its expanded uncertainty ($k = 2.5$)

Lab i	Measurement and Combined Standard Uncertainty of S_{21} of 3 dB attenuator (K5b.CL/1) at 9 GHz			
	x_i	$u(x_i)$	y_i	$u(y_i)$
NPL	0.68252	0.00051	0.22377	0.00051
PTB	0.6824	0.0021	0.2261	0.0021
NMi-VSL	0.6830	0.0016	0.2250	0.0016
INRIM	*0.68386*	*0.00036*	*0.22134*	*0.00054*
METAS	0.6830	0.0027	0.2251	0.0027
*CMI	0.6824	0.0016	0.2278	0.0035
*UME	0.6840	0.0014	0.2250	0.0014
	x_M	$u(x_M)$	y_M	$u(y_M)$
Reference value	0.68274	0.00016	0.22499	0.00047
	Mag	u(Mag)	Phase	u(Phase)
Reference value	0.71886	0.00021	18.239°	0.036°

Table 4a – Measurements before July 2004

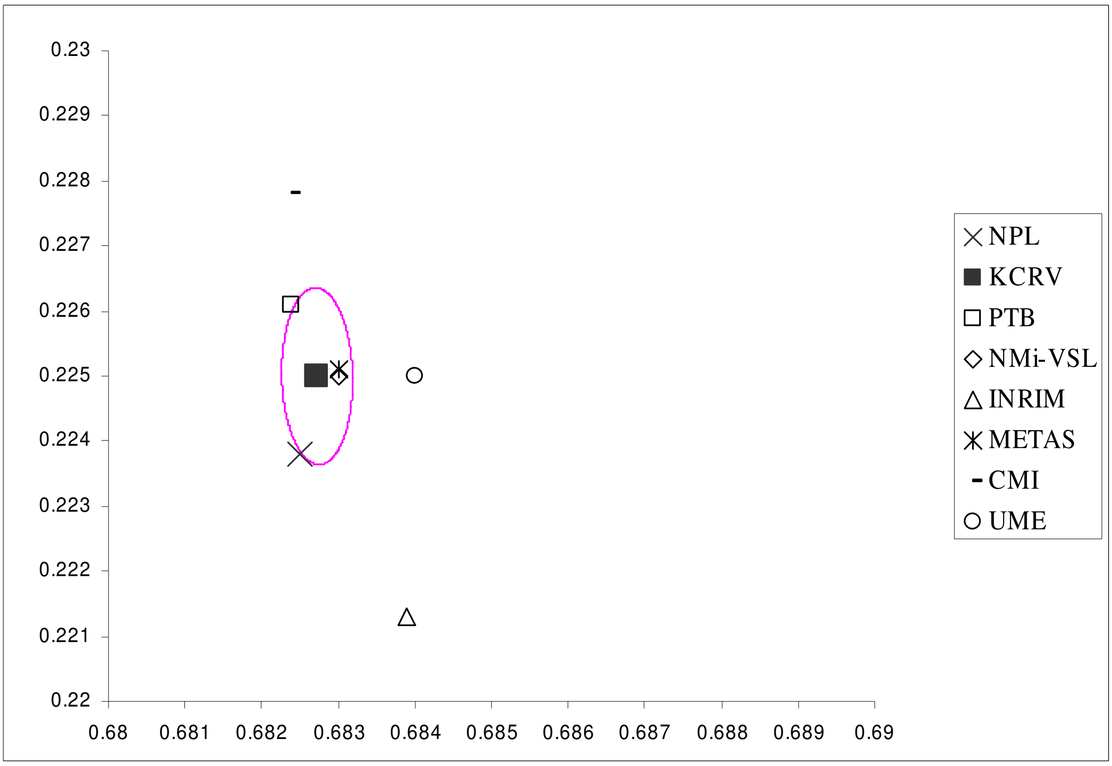

Fig 2a – Plot of measurements of S_{21} of device K5b.CL/1 (3 dB attenuator) at 9 GHz made before July 2004 along with the KCRV and its expanded uncertainty (k = 2.5)

Lab i	Measurement and Combined Standard Uncertainty of S_{21} of 3 dB attenuator (K5b.CL/1) at 9 GHz			
	x_i	$u(x_i)$	y_i	$u(y_i)$
NMIA	0.6898	0.0011	0.2276	0.0011
SPRING	*0.6892*	*0.0035*	*0.223*	*0.010*
*SCL	0.6900	0.0077	0.228	0.018
SNIIM	0.6927	0.0047	0.2244	0.0047
NIM	0.6925	0.0019	0.2308	0.0020
NRC	*0.6881*	*0.0010*	*0.2340*	*0.0010*
NIST	0.6922	0.0020	0.2228	0.0056
CSIR-NML	0.6916	0.0034	0.2278	0.0034
NPLI	0.6933	0.0019	0.2257	0.0018
NMIJ	0.6918	0.0015	0.2288	0.0015
SP	0.6919	0.0032	0.2298	0.0032
LNE	0.69169	0.00078	0.22899	0.00078
NPL	*0.69096*	*0.00031*	*0.23148*	*0.00031*
	x_M	$u(x_M)$	y_M	$u(y_M)$
Reference value	0.69194	0.00033	0.22739	0.00087
	Mag	u(Mag)	Phase	u(Phase)
Reference value	0.72823	0.00036	18.192°	0.068°

Table 4b – Measurements after July 2004

The correlation coefficient, $r(x_M, y_M)$, for measurements before July 2004 is –0.06 and for measurements after July 2004 is –0.38. The table below shows the correlation coefficients for those participants who chose to report this.

NMi-VSL	**INRIM**	**CMI**	**UME**	**SPRING**	**NIM**	**NPLI**	**NMIJ**
0.053	-0.0027	-0.64	-0.22	-0.98	-0.038	-0.74	-0.0034

Table 4c – Reported correlation coefficients

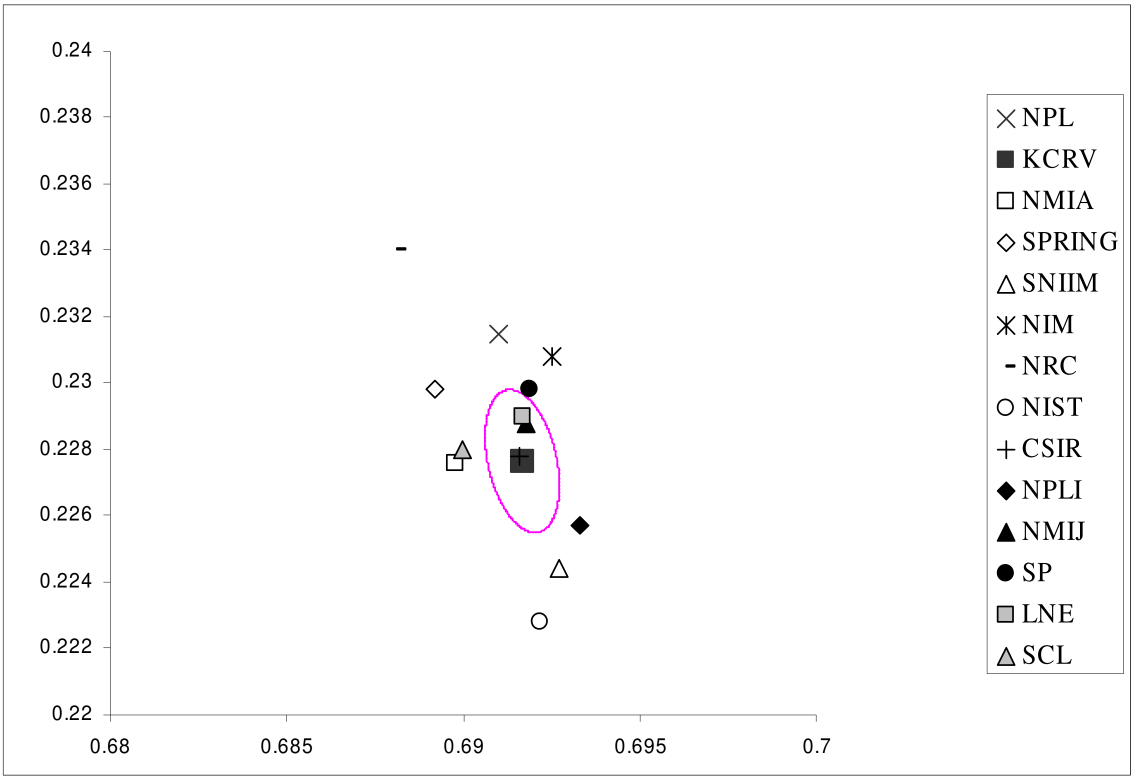

Fig 2b – Plot of measurements of S_{21} of device K5b.CL/1 (3 dB attenuator) at 9 GHz made after July 2004 along with the KCRV and its expanded uncertainty (k = 2.5)

Lab i	Measurement and Combined Standard Uncertainty of S_{21} of 3 dB attenuator (K5b.CL/1) at 18 GHz			
	x_i	$u(x_i)$	y_i	$u(y_i)$
NPL	0.7125	0.0011	0.0397	0.0011
PTB	0.7134	0.0022	0.0409	0.0022
NMi-VSL	0.7138	0.0021	0.0408	0.0021
INRIM	*0.71374*	*0.00052*	*0.0330*	*0.0012*
METAS	0.7141	0.0027	0.0406	0.0027
*CMI	0.7145	0.0020	0.0457	0.0074
*UME	0.7160	0.0018	0.0369	0.0020
	x_M	$u(x_M)$	y_M	$u(y_M)$
Reference value	0.71341	0.00035	0.04049	0.00026
	Mag	u(Mag)	Phase	u(Phase)
Reference value	0.71456	0.00036	3.248°	0.020°

Table 5a – Measurements before July 2004

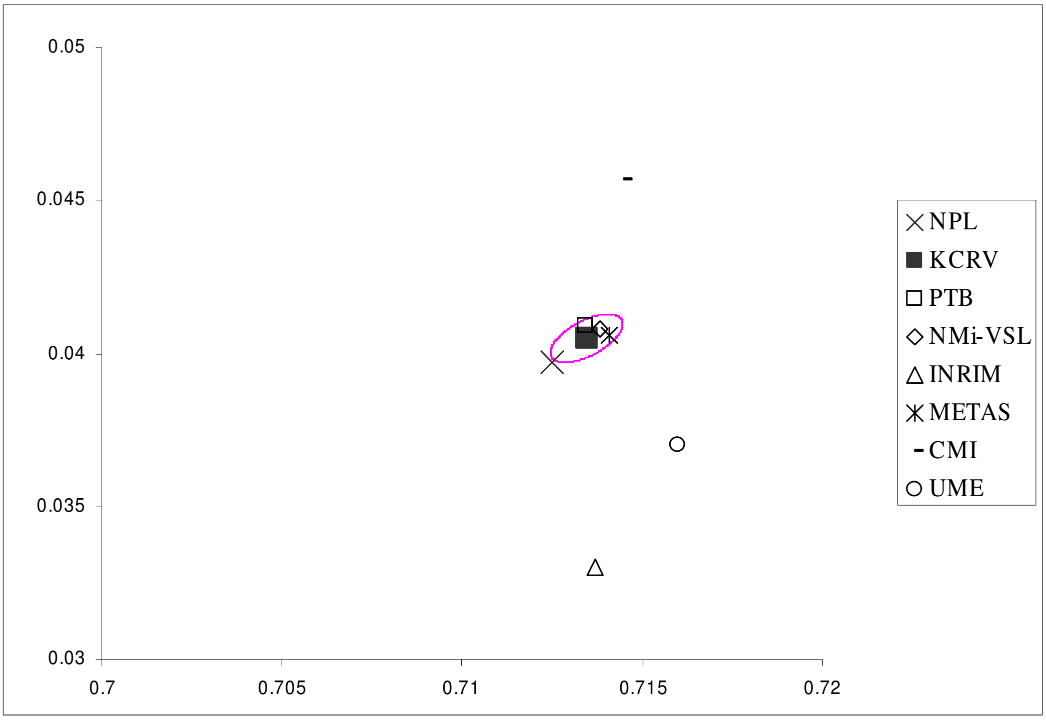

Fig 3a – Plot of measurements of S_{21} of device K5b.CL/1 (3 dB attenuator) at 18 GHz made before July 2004 along with the KCRV and its expanded uncertainty (k = 2.5)

Lab *i*	Measurement and Combined Standard Uncertainty of S_{21} of 3 dB attenuator (K5b.CL/1) at 18 GHz			
	x_i	$u(x_i)$	y_i	$u(y_i)$
NMIA	*0.7196*	*0.0014*	*0.0332*	*0.0014*
SPRING	0.7216	0.0014	0.038	0.019
*SCL	0.7225	0.0059	0.033	0.032
SNIIM	0.7186	0.0051	0.0292	0.0051
NIM	*0.7285*	*0.0021*	*0.0254*	*0.0022*
NRC	*0.7221*	*0.0010*	*0.0402*	*0.0010*
NIST	0.7219	0.0016	0.016	0.011
CSIR-NML	0.7235	0.0042	0.0260	0.0042
NPLI	0.7227	0.0041	0.0257	0.0041
NMIJ	0.7242	0.0019	0.0275	0.0020
SP	0.7248	0.0049	0.0272	0.0049
LNE	0.72366	0.00069	0.02586	0.00069
NPL	0.72358	0.00082	0.02962	0.00082
	x_M	$u(x_M)$	y_M	$u(y_M)$
Reference value	0.72273	0.00062	0.0273	0.0019
	Mag	*u*(Mag)	Phase	*u*(Phase)
Reference value	0.72324	0.00061	2.16°	0.15°

Table 5b – Measurements after July 2004

The correlation coefficient, $r(x_M, y_M)$, for measurements before July 2004 is 0.80 and for measurements after July 2004 is –0.14. The table below shows the correlation coefficients for those participants who chose to report this.

NMi-VSL	**INRIM**	**CMI**	**UME**	**SPRING**	**NIM**	**NPLI**	**NMIJ**
-0.42	-0.0023	-0.22	-0.16	-0.65	-0.0060	0.33	0.012

Table 5c – Reported correlation coefficients

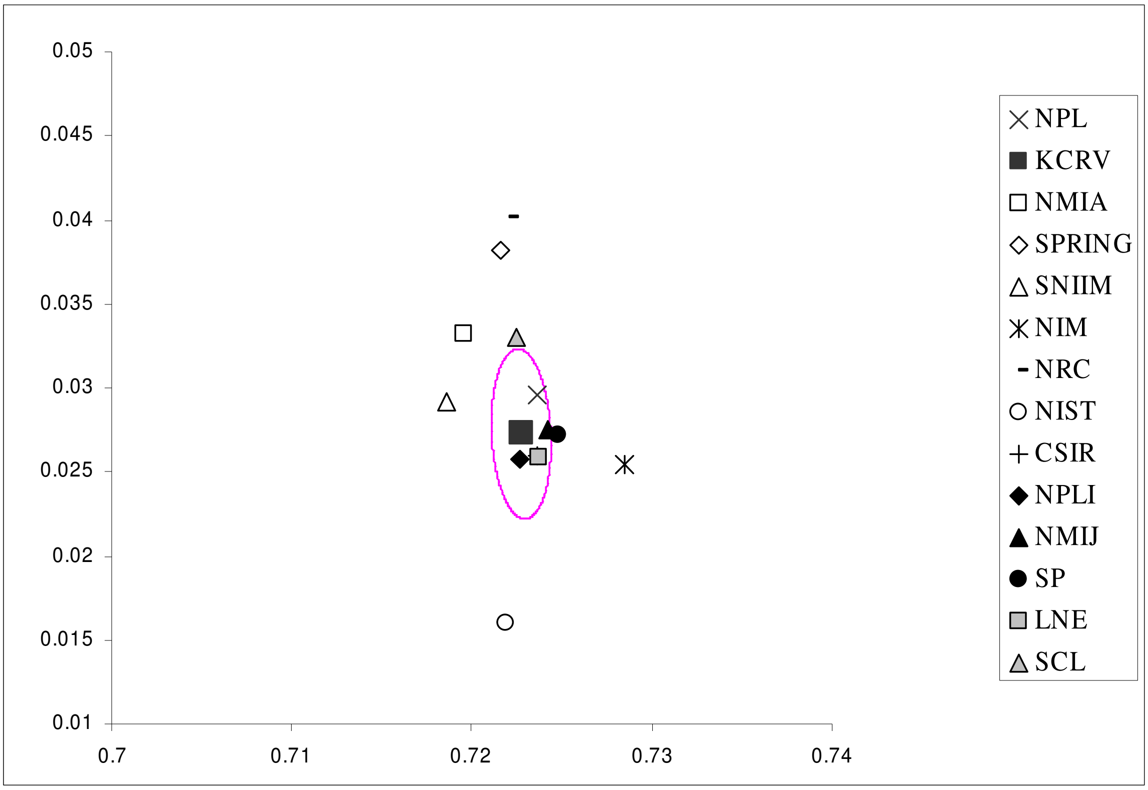

Fig 3b – Plot of measurements of S_{21} of device K5b.CL/1 (3 dB attenuator) at 18 GHz made after July 2004 along with the KCRV and its expanded uncertainty (k = 2.5)

Lab i	Measurement and Combined Standard Uncertainty of S_{21} of 20 dB attenuator (K5b.CL/2) at 2 GHz			
	x_i	$u(x_i)$	y_i	$u(y_i)$
NPL	-0.086411	0.000071	-0.050822	0.000071
PTB	-0.08634	0.00030	-0.05084	0.00030
NMi-VSL	-0.08644	0.00029	-0.05086	0.00029
INRIM	-0.08641	0.00019	-0.05071	0.00019
METAS	-0.08636	0.00028	-0.05089	0.00028
*CMI	-0.08642	0.00026	-0.05083	0.00029
*UME	-0.08653	0.00042	-0.05096	0.00042
NMIA	-0.08635	0.00015	-0.05091	0.00015
SPRING	-0.08641	0.00039	-0.05081	0.00054
*SCL	-0.08643	0.00068	-0.0508	0.0011
SNIIM	-0.08668	0.00048	-0.05067	0.00048
NIM	-0.08642	0.00021	-0.05118	0.00021
NRC	-0.08635	0.00020	-0.05102	0.00020
NIST	-0.08648	0.00016	-0.05088	0.00023
CSIR-NML	-0.08650	0.00012	-0.05078	0.00012
NPLI	-0.08680	0.00040	-0.05060	0.00040
NMIJ	-0.08640	0.00026	-0.05080	0.00026
SP	-0.08640	0.00027	-0.05086	0.00027
LNE	-0.08645	0.00025	-0.05078	0.00025
	x_M	$u(x_M)$	y_M	$u(y_M)$
Reference value	-0.086449	0.000031	-0.050838	0.000033
	Mag	u(Mag)	Phase	u(Phase)
Reference value	0.100290	0.000021	-149.542°	0.023°

Table 6a

The correlation coefficient, $r(x_M, y_M)$, is –0.63.

NMi-VSL	**INRIM**	**CMI**	**UME**	**SPRING**	**NIM**	**NPLI**	**NMIJ**
0.13	-0.000090	-0.15	-0.20	-0.63	-0.00013	0.47	-0.0003

Table 6b – Reported correlation coefficients

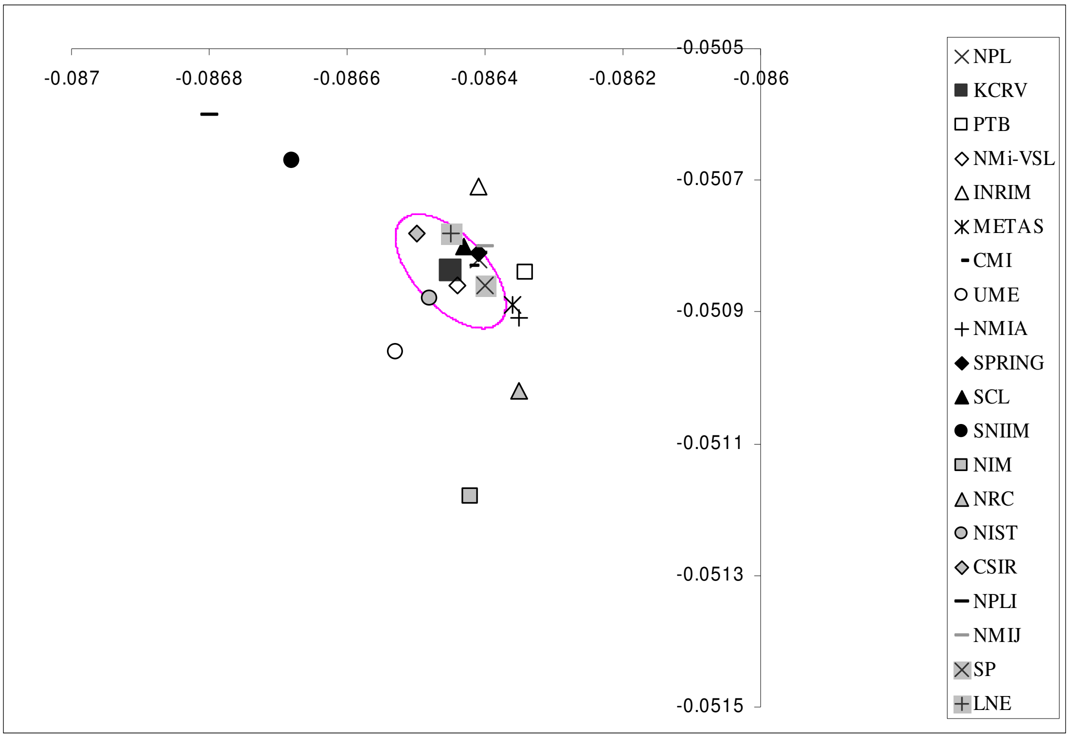

Fig 4 – Plot of measurements of S_{21} of device K5b.CL/2 (20 dB attenuator) at 2 GHz along with the KCRV and its expanded uncertainty (k = 2.5)

Lab *i*	Measurement and Combined Standard Uncertainty of S_{21} of 20 dB attenuator (K5b.CL/2) at 9 GHz			
	x_i	$u(x_i)$	y_i	$u(y_i)$
NPL	0.070674	0.000089	0.069602	0.000089
PTB	0.07062	0.00032	0.06963	0.00032
NMi-VSL	0.07071	0.00036	0.06965	0.00036
INRIM	0.07093	0.00019	0.06929	0.00020
METAS	0.07073	0.00037	0.06964	0.00037
*CMI	0.07062	0.00052	0.06970	0.00052
*UME	0.07085	0.00042	0.06950	0.00042
NMIA	0.07070	0.00018	0.06961	0.00018
SPRING	0.0705	0.0011	0.0698	0.0011
*SCL	0.07090	0.00190	0.06940	0.00190
SNIIM	0.07058	0.00055	0.07009	0.00055
NIM	0.07063	0.00025	0.06988	0.00025
NRC	*0.07022*	*0.00020*	*0.07037*	*0.00020*
NIST	0.07092	0.00058	0.06979	0.00059
CSIR-NML	0.07091	0.00046	0.06958	0.00046
NPLI	0.0718	0.0011	0.0694	0.0011
NMIJ	0.07080	0.00021	0.06950	0.00021
SP	0.07078	0.00044	0.06969	0.00044
LNE	0.07051	0.00064	0.06895	0.00064
	x_M	$u(x_M)$	y_M	$u(y_M)$
Reference value	0.070784	0.000081	0.069605	0.000068
	Mag	*u*(Mag)	Phase	*u*(Phase)
Reference value	0.099274	0.000066	44.519°	0.048°

Table 7a

The correlation coefficient, $r(x_M, y_M)$, is –0.22.

NMi-VSL	**INRIM**	**CMI**	**UME**	**SPRING**	**NIM**	**NPLI**	**NMIJ**
-0.94	-0.00023	-0.70	-0.31	-0.84	-0.0015	0.33	0.0048

Table 7b – Reported correlation coefficients

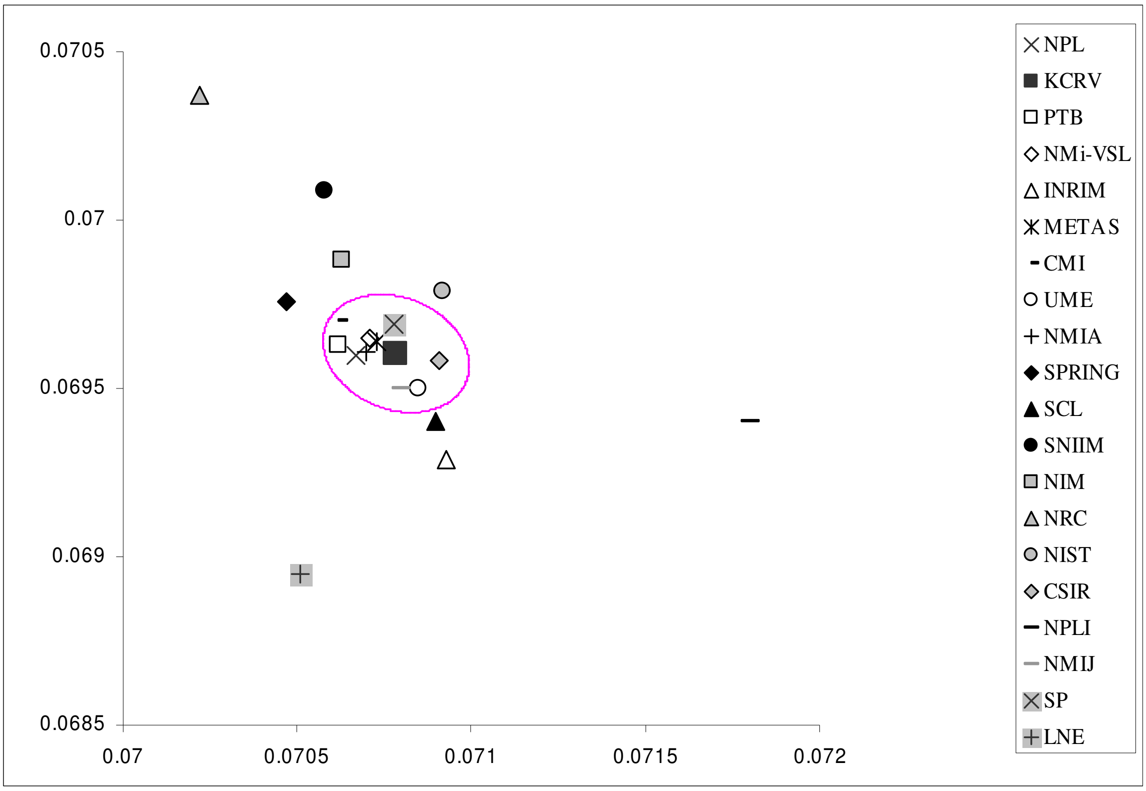

Fig 5 – Plot of measurements of S_{21} of device K5b.CL/2 (20 dB attenuator) at 9 GHz along with the KCRV and its expanded uncertainty (k = 2.5)

Lab i	Measurement and Combined Standard Uncertainty of S_{21} of 20 dB attenuator (K5b.CL/2) at 18 GHz			
	x_i	$u(x_i)$	y_i	$u(y_i)$
NPL	0.02673	0.00016	0.10082	0.00016
PTB	0.02684	0.00038	0.10062	0.00038
NMi-VSL	0.02671	0.00039	0.10063	0.00039
INRIM	*0.02752*	*0.00026*	*0.10030*	*0.00022*
METAS	0.02673	0.00041	0.10067	0.00041
*CMI	0.0264	0.0013	0.10077	0.00049
*UME	0.0272	0.0011	0.1005	0.0011
NMIA	0.02665	0.00022	0.10048	0.00022
SPRING	0.0260	0.0027	0.10067	0.00075
*SCL	0.0275	0.0045	0.1004	0.0015
SNIIM	0.02577	0.00063	0.10118	0.00063
NIM	*0.02739*	*0.00027*	*0.10100*	*0.00027*
NRC	*0.02531*	*0.00050*	*0.10117*	*0.00050*
NIST	0.0271	0.0016	0.10066	0.00049
CSIR-NML	0.02767	0.00060	0.10038	0.00060
NPLI	0.0276	0.0021	0.1006	0.0022
NMIJ	0.02670	0.00028	0.10060	0.00028
SP	0.02660	0.00071	0.10055	0.00071
LNE	0.02671	0.00043	0.10015	0.00043
	x_M	$u(x_M)$	y_M	$u(y_M)$
Reference value	0.02676	0.00014	0.100615	0.000065
	Mag	u(Mag)	Phase	u(Phase)
Reference value	0.104112	0.000054	75.106°	0.082°

Table 8a

The correlation coefficient, $r(x_M, y_M)$, is –0.52.

NMi-VSL	**INRIM**	**CMI**	**UME**	**SPRING**	**NIM**	**NPLI**	**NMIJ**
-0.98	-0.000097	-0.65	-0.29	-0.91	-0.00087	-0.74	-0.042

Table 8b – Reported correlation coefficients

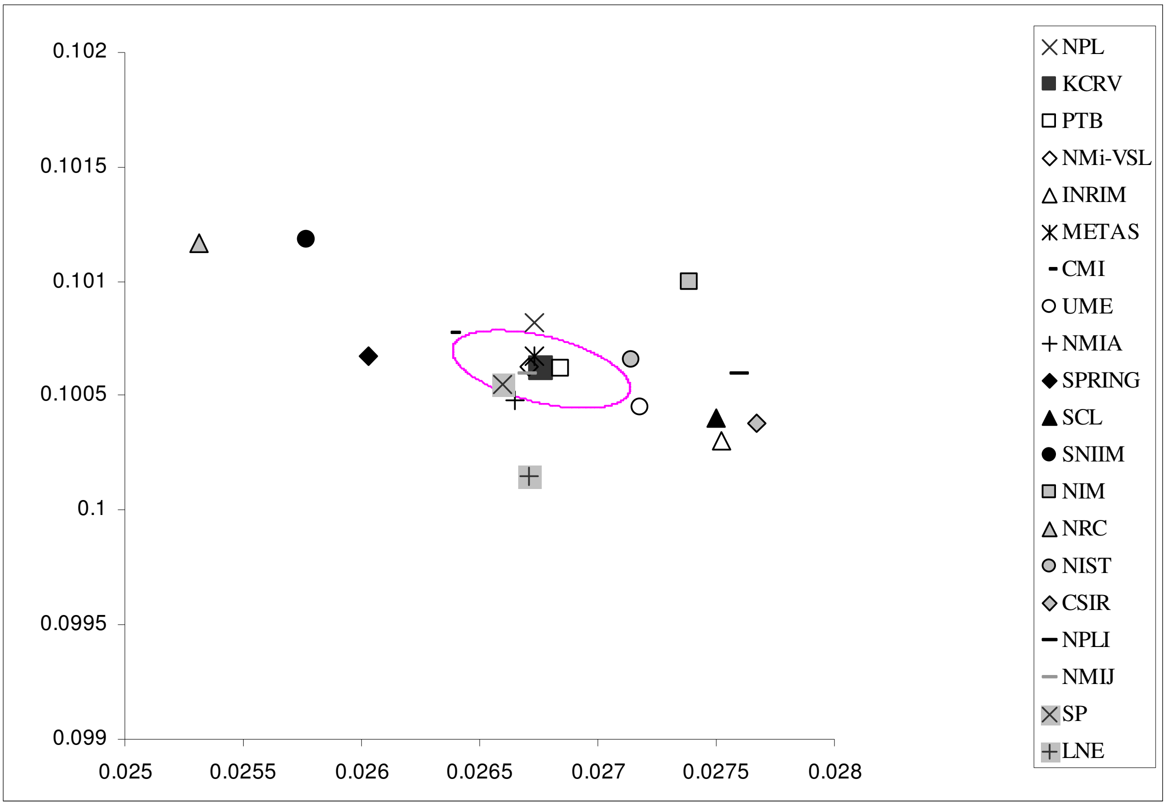

Fig 6 – Plot of measurements of S_{21} of device K5b.CL/2 (20 dB attenuator) at 18 GHz along with the KCRV and its expanded uncertainty (k = 2.5)

Lab i	Measurement and Combined Standard Uncertainty of S_{21} of 50 dB attenuator (K5b.CL/3) at 2 GHz			
	x_i	$u(x_i)$	y_i	$u(y_i)$
NPL	-0.0021688	0.0000088	-0.0021626	0.0000088
PTB	-0.0021678	0.0000091	-0.0021687	0.0000091
NMi-VSL	-0.002176	0.000023	-0.002170	0.000023
INRIM	-0.002170	0.000019	-0.002165	0.000019
METAS	-0.002169	0.000012	-0.002166	0.000012
*CMI	-0.002166	0.000021	-0.002171	0.000021
*UME	-0.002175	0.000038	-0.002171	0.000038
NMIA	-0.002166	0.000012	-0.002177	0.000012
SPRING	-0.002174	0.000022	-0.002171	0.000022
*SCL	-0.002176	0.000033	-0.002166	0.000033
SNIIM	-0.002171	0.000027	-0.002167	0.000027
NIM	-0.002166	0.000006	-0.002179	0.000006
NRC	-0.002190	0.000021	-0.002162	0.000021
NIST	-0.002172	0.000012	-0.002166	0.000012
CSIR-NML	-0.002171	0.000007	-0.002163	0.000007
NPLI	-0.00220	0.00040	-0.00220	0.00040
NMIJ	-0.002170	0.000020	-0.002170	0.000020
SP	-0.002158	0.000021	-0.002156	0.000021
LNE	-0.002170	0.000020	-0.002170	0.000020
	x_M	$u(x_M)$	y_M	$u(y_M)$
Reference value	-0.0021725	0.0000025	-0.0021696	0.0000025
	Mag	u(Mag)	Phase	u(Phase)
Reference value	0.0030703	0.0000031	-135.038°	0.029°

Table 9a

The correlation coefficient, $r(x_M, y_M)$, is 0.60.

NMi-VSL	**INRIM**	**CMI**	**UME**	**SPRING**	**NIM**	**NPLI**	**NMIJ**
-0.27	-0.0000014	-0.16	-0.046	0.19	0.000028	0.96	0.0006

Table 9b – Reported correlation coefficients

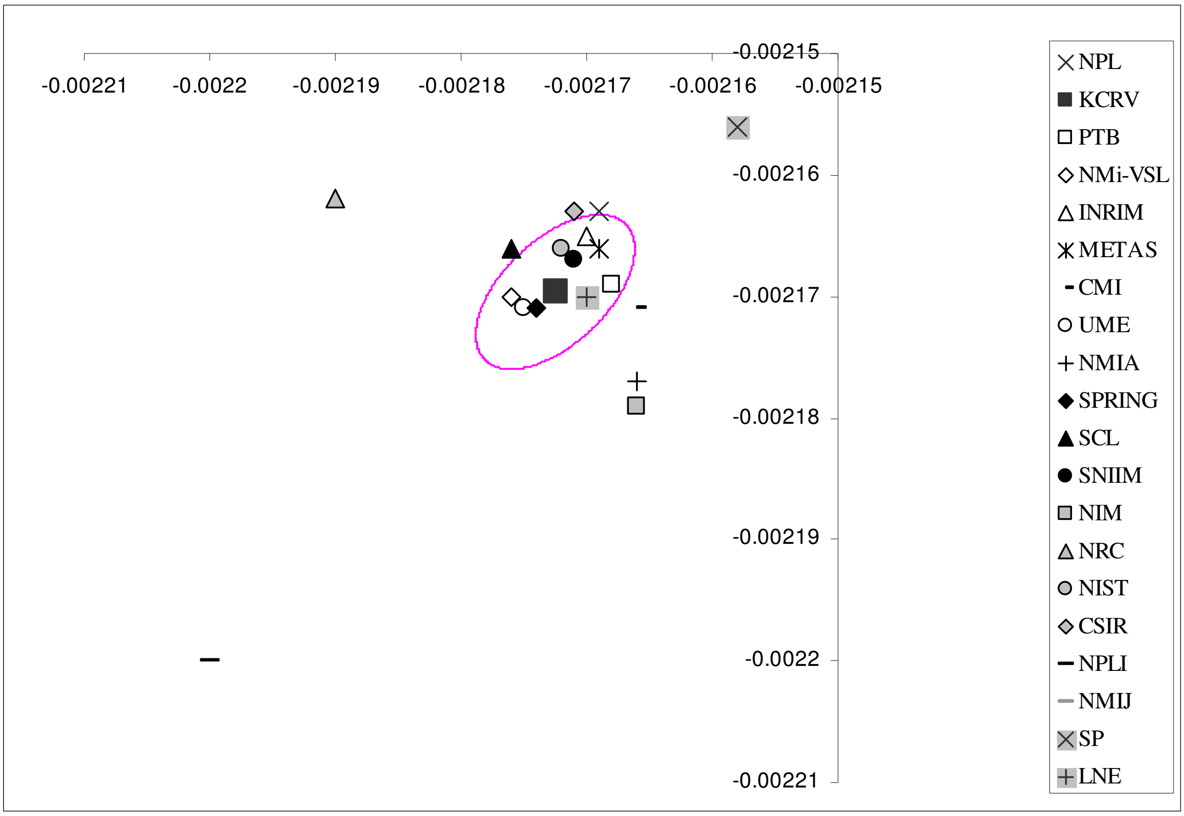

Fig 7 – Plot of measurements of S_{21} of device K5b.CL/3 (50 dB attenuator) at 2 GHz along with the KCRV and its expanded uncertainty (k = 2.5)

Lab i	Measurement and Combined Standard Uncertainty of S_{21} of 50 dB attenuator (K5b.CL/3) at 9 GHz			
	x_i	$u(x_i)$	y_i	$u(y_i)$
NPL	-0.001182	0.000016	0.002798	0.000016
PTB	-0.001195	0.000011	0.002803	0.000011
NMi-VSL	-0.001191	0.000024	0.002804	0.000024
INRIM	-0.001176	0.000020	0.002800	0.000019
METAS	-0.001190	0.000024	0.002801	0.000024
*CMI	-0.001197	0.000026	0.002804	0.000031
*UME	-0.00119	0.00015	0.00281	0.00015
NMIA	-0.001185	0.000013	0.002798	0.000013
SPRING	-0.001207	0.000043	0.002802	0.000028
*SCL	-0.001184	0.000089	0.002804	0.000058
SNIIM	-0.001218	0.000040	0.002815	0.000040
NIM	-0.0012055	0.0000075	0.0028074	0.0000074
NRC	-0.001217	0.000030	0.002800	0.000030
NIST	-0.001196	0.000026	0.002810	0.000016
CSIR-NML	-0.001182	0.000014	0.002803	0.000014
NPLI	-0.0011	0.0016	0.0029	0.0015
NMIJ	-0.001190	0.000020	0.002800	0.000020
SP	-0.001183	0.000042	0.002825	0.000042
LNE	-0.001190	0.000040	0.002800	0.000040
	x_M	$u(x_M)$	y_M	$u(y_M)$
Reference value	-0.0011881	0.0000066	0.0028104	0.0000062
	Mag	u(Mag)	Phase	u(Phase)
Reference value	0.0030512	0.0000039	112.92°	0.15°

Table 10a

The correlation coefficient, $r(x_M, y_M)$, is 0.82.

NMi-VSL	**INRIM**	**CMI**	**UME**	**SPRING**	**NIM**	**NPLI**	**NMIJ**
0.49	-0.000032	-0.18	-0.060	0.51	0.0072	-0.14	0.0004

Table 10b – Reported correlation coefficients

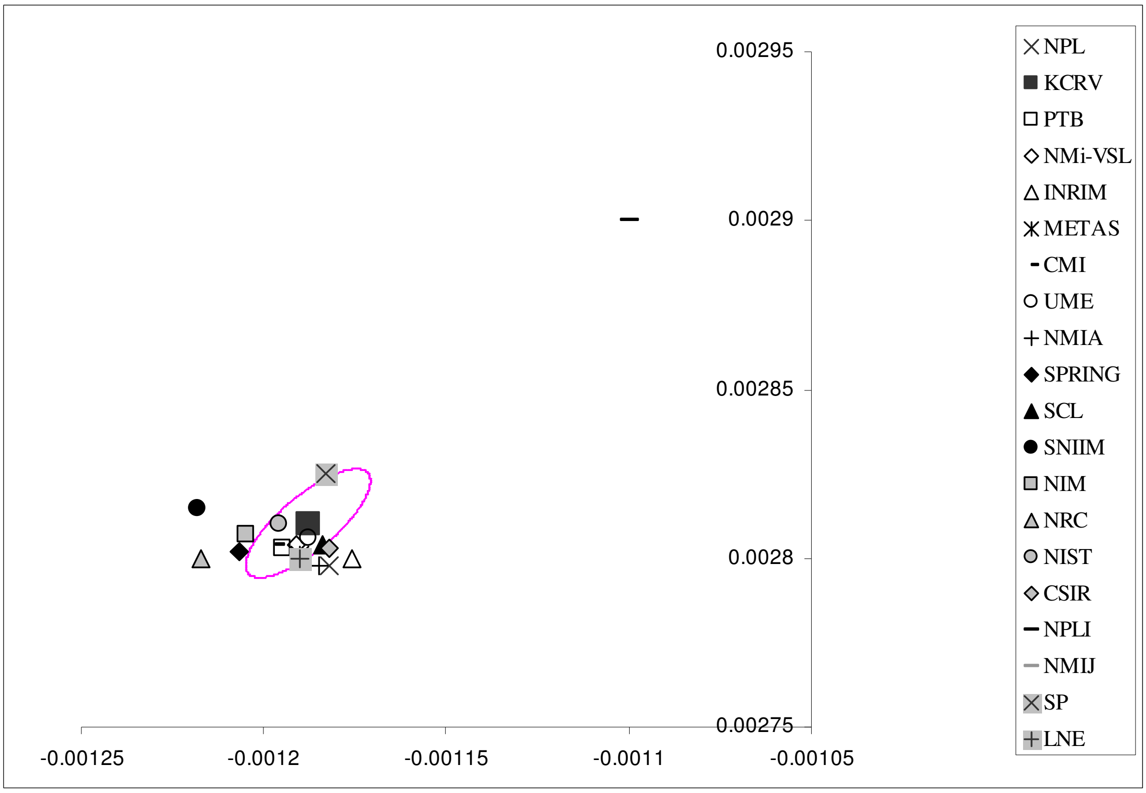

Fig 8 – Plot of measurements of S_{21} of device K5b.CL/3 (50 dB attenuator) at 9 GHz along with the KCRV and its expanded uncertainty (k = 2.5)

Lab *i*	Measurement and Combined Standard Uncertainty of S_{21} of 50 dB attenuator (K5b.CL/3) at 18 GHz			
	x_i	$u(x_i)$	y_i	$u(y_i)$
NPL	-0.001949	0.000038	-0.003016	0.000038
PTB	-0.001924	0.000020	-0.002982	0.000020
NMi-VSL	-0.001923	0.000027	-0.002976	0.000027
INRIM	-0.001943	0.000022	-0.002960	0.000022
METAS	-0.001936	0.000028	-0.002974	0.000028
*CMI	-0.001922	0.000041	-0.002977	0.000039
*UME	-0.00195	0.00024	-0.00299	0.00024
NMIA	-0.001922	0.000017	-0.002954	0.000017
SPRING	-0.001899	0.000082	-0.003002	0.000056
*SCL	-0.00196	0.00014	-0.00296	0.00010
SNIIM	-0.001939	0.000046	-0.003004	0.000046
NIM	-0.0019483	0.0000091	-0.0029959	0.0000091
NRC	-0.001897	0.000050	-0.003000	0.000050
NIST	-0.001936	0.000051	-0.002984	0.000035
CSIR-NML	-0.001967	0.000021	-0.002959	0.000021
NPLI	-0.0019	0.0010	-0.0030	0.0012
NMIJ	-0.001930	0.000020	-0.002980	0.000020
SP	-0.00197	0.00016	-0.00300	0.00016
LNE	-0.001930	0.000025	-0.002980	0.000025
	x_M	$u(x_M)$	y_M	$u(y_M)$
Reference value	-0.0019323	0.0000055	-0.0029854	0.0000045
	Mag	*u*(Mag)	Phase	*u*(Phase)
Reference value	0.0035561	0.0000045	-122.912°	0.090°

Table 11a

The correlation coefficient, $r(x_M, y_M)$, is –0.15.

NMi-VSL	**INRIM**	**CMI**	**UME**	**SPRING**	**NIM**	**NPLI**	**NMIJ**
-0.64	-0.000029	-0.13	-0.052	-0.13	0.00068	0.35	-0.008

Table 11b – Reported correlation coefficients

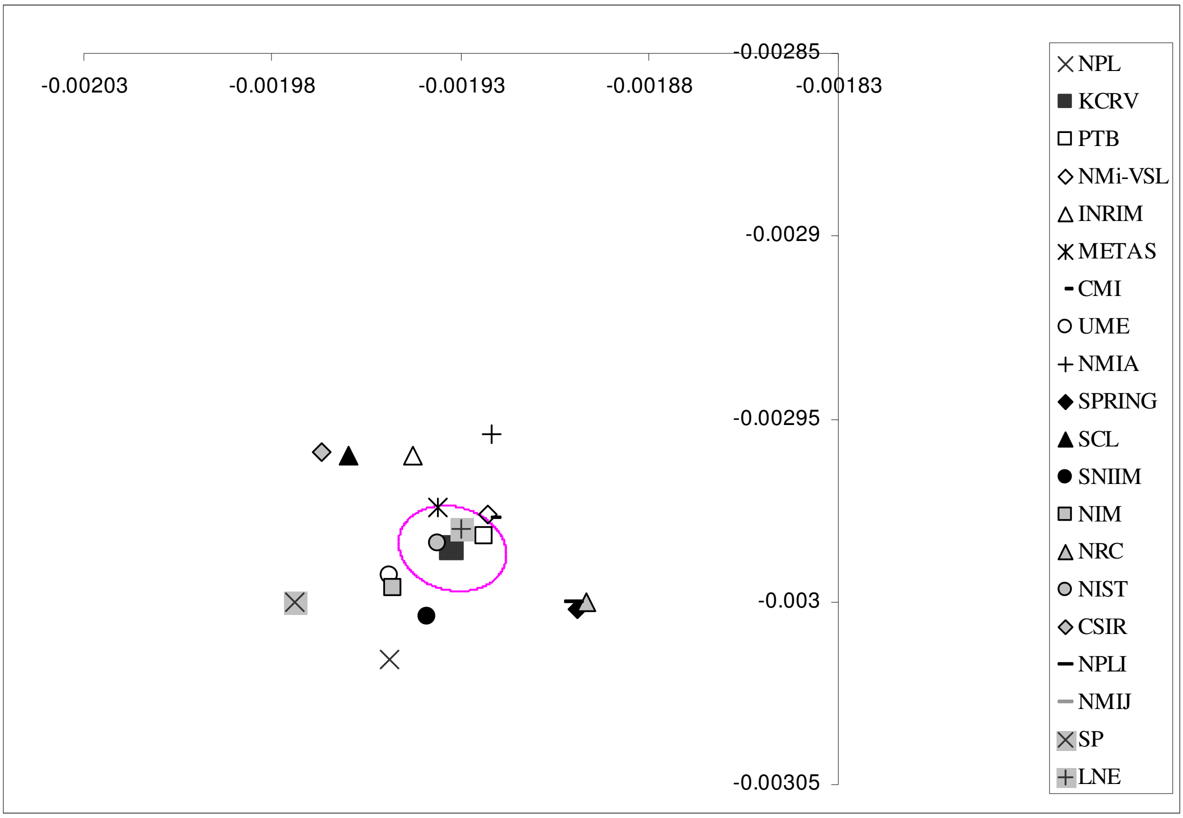

Fig 9 – Plot of measurements of S_{21} of device K5b.CL/3 (50 dB attenuator) at 18 GHz along with the KCRV and its expanded uncertainty (k = 2.5)

Lab i	Measurement and Combined Standard Uncertainty of S_{11} of male matched load (K5b.CL/4) at 2 GHz			
	x_i	$u(x_i)$	y_i	$u(y_i)$
NPL	0.0021	0.0011	0.0003	0.0011
PTB	0.0004	0.0013	-0.0002	0.0013
NMi-VSL	0.0020	0.0037	0.0027	0.0037
INRIM	0.0030	0.0055	-0.0017	0.0055
METAS	0.0022	0.0020	0.0000	0.0020
*CMI	0.0014	0.0046	0.0001	0.0046
*UME	0.0021	0.0054	-0.0011	0.0054
NMIA	0.0015	0.0014	-0.0004	0.0014
SPRING	0.0022	0.0066	-0.0011	0.0047
*SCL	0.0013	0.0033	0.0013	0.0033
SNIIM	0.0026	0.0017	0.0019	0.0017
NIM	0.00158	0.00065	0.00050	0.00065
NRC	0.0001	0.0052	-0.0003	0.0052
NIST	0.0012	0.0018	0.00013	0.00084
CSIR-NML	0.0017	0.0025	0.0006	0.0025
NPLI	0.0038	0.0072	-0.0002	0.0072
NMIJ	0.0016	0.0011	0.0006	0.0011
SP	0.0014	0.0022	0.0010	0.0022
LNE	0.0009	0.0043	0.0007	0.0043
	x_M	$u(x_M)$	y_M	$u(y_M)$
Reference value	0.00176	0.00023	0.00028	0.00027
	Mag	u(Mag)	Phase	u(Phase)
Reference value	0.00179	0.00023	9.0°	8.6°

Table 12a

The correlation coefficient, $r(x_M, y_M)$, is –0.078.

NMi-VSL	**INRIM**	**CMI**	**UME**	**SPRING**	**NIM**	**NPLI**	**NMIJ**
-0.72	0.00015	0	-0.0047	-0.35	0.000064	0.62	0.0001

Table 12b – Reported correlation coefficients

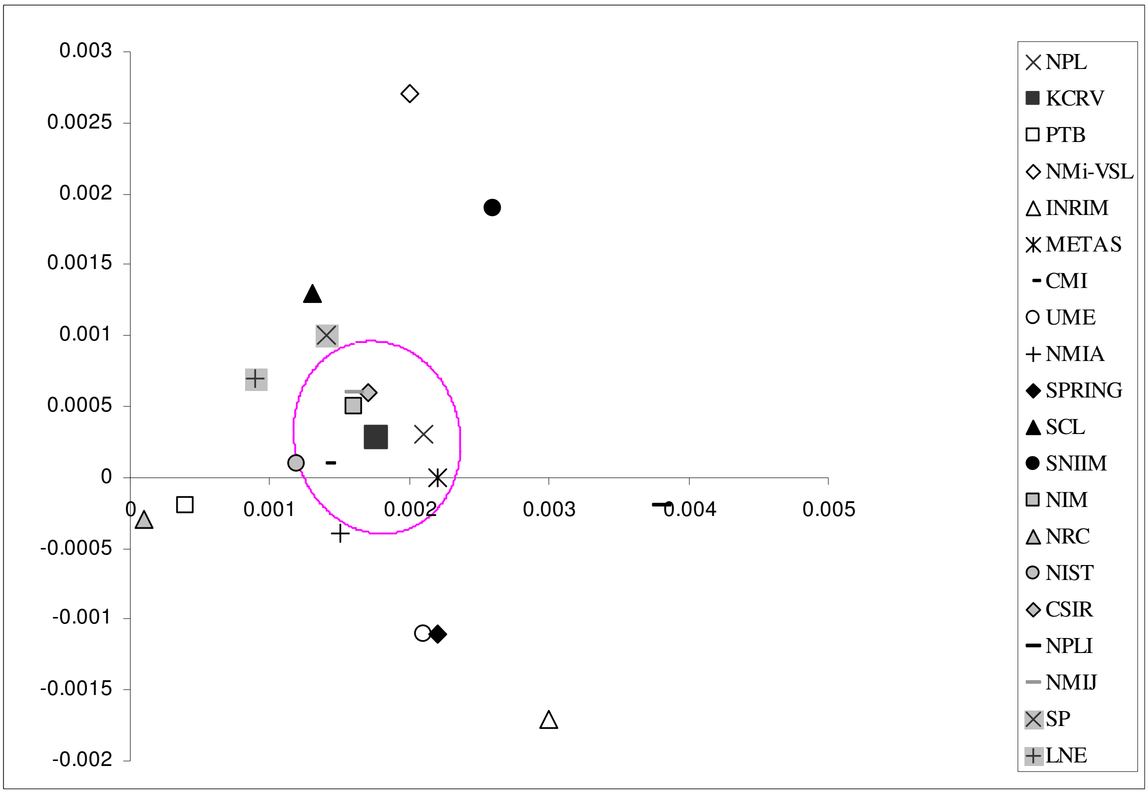

Fig 10 – Plot of measurements of S_{11} of device K5b.CL/4 (male matched load) at 2 GHz along with the KCRV and its expanded uncertainty (k = 2.5)

Lab i	Measurement and Combined Standard Uncertainty of S_{11} of male matched load (K5b.CL/4) at 9 GHz			
	x_i	$u(x_i)$	y_i	$u(y_i)$
NPL	-0.0020	0.0011	0.0061	0.0011
PTB	-0.0024	0.0013	0.0099	0.0013
NMi-VSL	-0.0036	0.0086	0.0077	0.0086
INRIM	-0.0048	0.0055	0.0084	0.0055
METAS	-0.0052	0.0040	0.0084	0.0040
*CMI	-0.0050	0.0047	0.0086	0.0047
*UME	-0.0051	0.0059	0.0075	0.0059
NMIA	-0.0043	0.0022	0.0083	0.0022
SPRING	-0.0039	0.0048	0.0067	0.0064
*SCL	-0.005	0.010	0.007	0.010
SNIIM	0.0013	0.0019	0.0058	0.0019
NIM	*0.0027*	*0.0017*	*0.0049*	*0.0017*
NRC	0.0000	0.0054	0.0075	0.0054
NIST	-0.0018	0.0017	0.0072	0.0022
CSIR-NML	-0.0034	0.0025	0.0068	0.0025
NPLI	0.000	0.014	0.010	0.014
NMIJ	*0.0011*	*0.0011*	*0.0043*	*0.0011*
SP	0.0015	0.0033	0.0040	0.0033
LNE	-0.0007	0.0050	0.0052	0.0050
	x_M	$u(x_M)$	y_M	$u(y_M)$
Reference value	-0.00208	0.00059	0.00725	0.00044
	Mag	u(Mag)	Phase	u(Phase)
Reference value	0.00755	0.00052	106.0°	4.0°

Table 13a

The correlation coefficient, $r(x_M, y_M)$, is –0.48.

NMi-VSL	**INRIM**	**CMI**	**UME**	**SPRING**	**NIM**	**NPLI**	**NMIJ**
-0.29	-0.00032	0	-0.83	-0.63	0.00025	0.57	-0.0022

Table 13b – Reported correlation coefficients

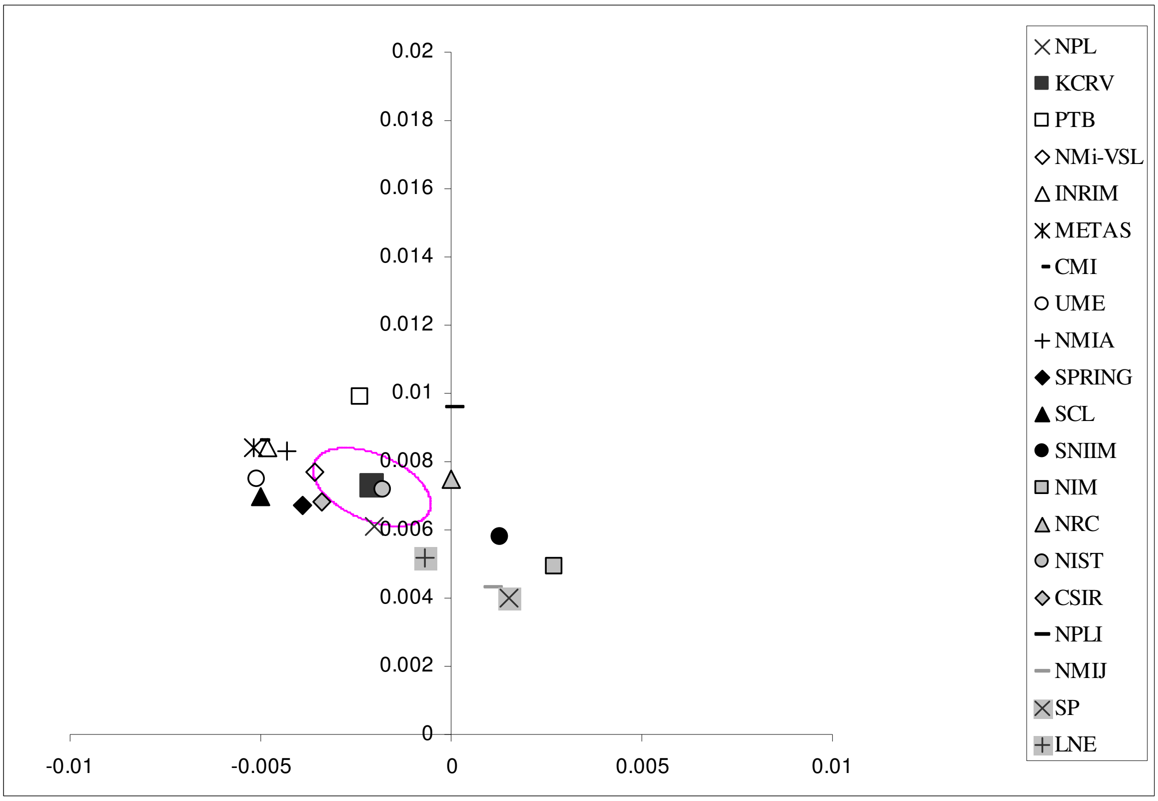

Fig 11 – Plot of measurements of S_{11} of device K5b.CL/4 (male matched load) at 9 GHz along with the KCRV and its expanded uncertainty (k = 2.5)

Lab i	Measurement and Combined Standard Uncertainty of S_{11} of male matched load (K5b.CL/4) at 18 GHz			
	x_i	$u(x_i)$	y_i	$u(y_i)$
NPL	-0.0016	0.0019	0.0553	0.0019
PTB	-0.0015	0.0014	0.0565	0.0014
NMi-VSL	-0.0028	0.0087	0.0563	0.0087
INRIM	-0.0012	0.0055	0.0588	0.0055
METAS	0.0004	0.0040	0.0585	0.0040
*CMI	0.0013	0.0048	0.0584	0.0048
*UME	0.0005	0.0073	0.0592	0.0073
NMIA	0.0023	0.0031	0.0569	0.0031
SPRING	0.0023	0.0016	0.0575	0.0072
*SCL	0.000	0.010	0.057	0.010
SNIIM	-0.0034	0.0023	0.0534	0.0023
NIM	-0.0037	0.0019	0.0564	0.0019
NRC	0.0034	0.0080	0.0609	0.0080
NIST	0.0029	0.0019	0.0553	0.0037
CSIR-NML	0.0030	0.0030	0.0629	0.0035
NPLI	-0.009	0.010	0.056	0.010
NMIJ	*0.0038*	*0.0013*	*0.0522*	*0.0014*
SP	0.0027	0.0047	0.0536	0.0047
LNE	0.0053	0.0063	0.0554	0.0063
	x_M	$u(x_M)$	y_M	$u(y_M)$
Reference value	-0.00007	0.00097	0.05695	0.00065
	Mag	u(Mag)	Phase	u(Phase)
Reference value	0.05695	0.00065	90.07°	0.98°

Table 14a

The correlation coefficient, $r(x_M, y_M)$, is 0.25.

NMi-VSL	**INRIM**	**CMI**	**UME**	**SPRING**	**NIM**	**NPLI**	**NMIJ**
-0.86	-0.0042	0	0.18	-0.48	0.000030	-0.46	0.0009

Table 14b – Reported correlation coefficients

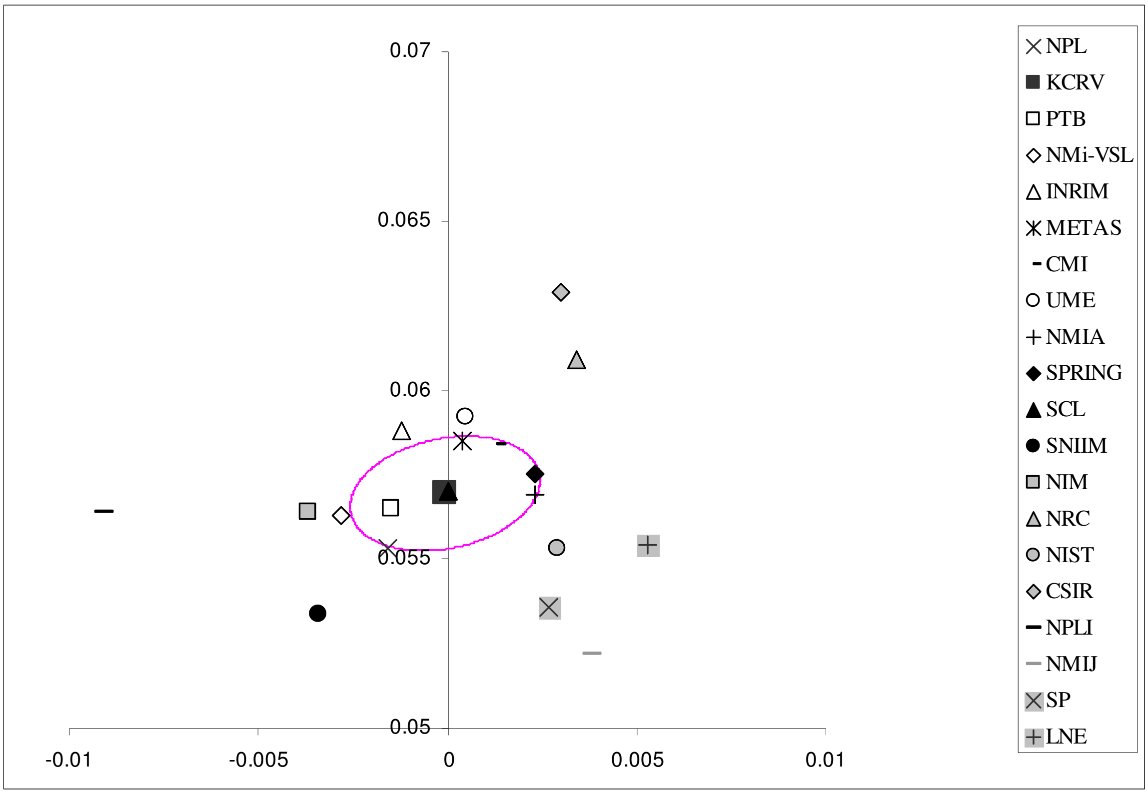

Fig 12 – Plot of measurements of S_{11} of device K5b.CL/4 (male matched load) at 18 GHz along with the KCRV and its expanded uncertainty (k = 2.5)

Lab i	Measurement and Combined Standard Uncertainty of S_{11} of female mismatched load (K5b.CL/7) at 2 GHz			
	x_i	$u(x_i)$	y_i	$u(y_i)$
NPL	0.2463	0.0012	0.2276	0.0012
PTB	0.2441	0.0021	0.2296	0.0021
NMi-VSL	0.2482	0.0046	0.2279	0.0046
INRIM	0.2205	0.0164	0.1404	0.0622
METAS	0.2464	0.0021	0.2278	0.0021
*CMI	0.2449	0.0050	0.2276	0.0050
*UME	0.2464	0.0048	0.2278	0.0048
NMIA	0.2440	0.0019	0.2289	0.0019
SPRING	0.2473	0.0065	0.2267	0.0064
*SCL	0.2509	0.0048	0.2264	0.0049
SNIIM	0.2453	0.0020	0.2267	0.0020
NIM	*0.24451*	*0.00063*	*0.22836*	*0.00063*
NRC	0.2461	0.010	0.2248	0.010
NIST	0.2454	0.0018	0.2272	0.0018
CSIR-NML	0.2464	0.0057	0.2275	0.0081
NPLI	0.2497	0.0032	0.2296	0.0032
NMIJ	0.2464	0.0026	0.2260	0.0026
SP	0.2450	0.0025	0.2272	0.0025
LNE	0.2461	0.0047	0.2269	0.0047
	x_M	$u(x_M)$	y_M	$u(y_M)$
Reference value	0.2445	0.0018	0.2216	0.0058
	Mag	u(Mag)	Phase	u(Phase)
Reference value	0.3300	0.0052	42.20°	0.55°

Table 15a

The correlation coefficient, $r(x_M, y_M)$, is 0.98.

NMi-VSL	**INRIM**	**CMI**	**UME**	**SPRING**	**NIM**	**NPLI**	**NMIJ**
0.99	0.35	-0.079	0.74	-0.67	-0.0033	0.76	-0.001

Table 15b – Reported correlation coefficients

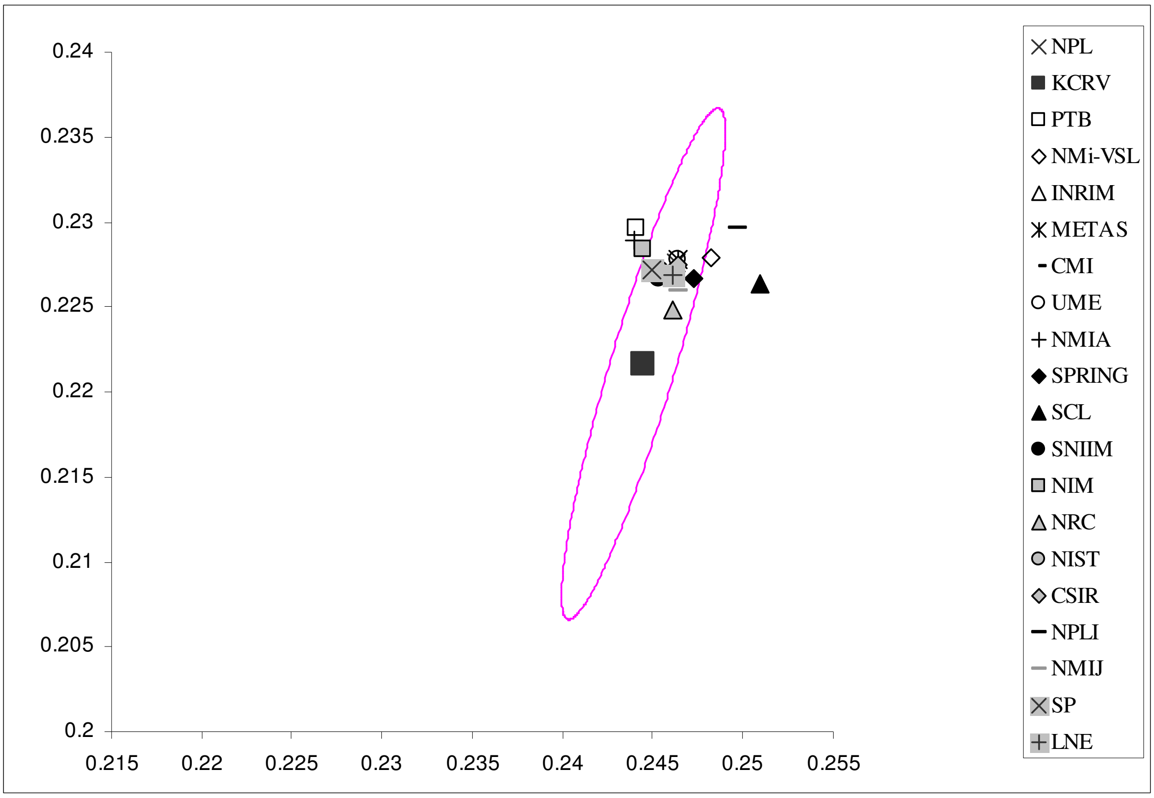

Fig 13 – Plot of measurements of S_{11} of device K5b.CL/7 (female mismatched load) at 2 GHz along with the KCRV and its expanded uncertainty (k = 2.5)

Note: Owing to the scaling of the graph, INRIM's result is not shown in this graph

Lab i	Measurement and Combined Standard Uncertainty of S_{11} of female mismatched load (K5b.CL/7) at 9 GHz			
	x_i	$u(x_i)$	y_i	$u(y_i)$
NPL	*0.0288*	*0.0016*	*-0.3343*	*0.0016*
PTB	*0.0281*	*0.0021*	*-0.3348*	*0.0021*
NMi-VSL	0.032	0.012	-0.332	0.012
INRIM	0.005	0.022	-0.227	0.071
METAS	0.0312	0.0043	-0.3321	0.0043
*CMI	0.0327	0.0060	-0.3325	0.0050
*UME	0.032	0.011	-0.333	0.012
NMIA	0.0330	0.0025	-0.3338	0.0025
SPRING	0.0362	0.0050	-0.3314	0.0071
*SCL	0.0380	0.0140	-0.3330	0.0120
SNIIM	0.0376	0.0022	-0.3341	0.0022
NIM	*0.0434*	*0.0017*	*-0.3321*	*0.0017*
NRC	0.047	0.010	-0.330	0.010
NIST	0.0309	0.0020	-0.3339	0.0022
CSIR-NML	0.0322	0.0037	-0.3335	0.0037
NPLI	0.0322	0.0062	-0.3331	0.0062
NMIJ	0.0325	0.0026	-0.3330	0.0026
SP	0.0320	0.0037	-0.3321	0.0037
LNE	0.0340	0.0055	-0.3310	0.0055
	x_M	$u(x_M)$	y_M	$u(y_M)$
Reference value	0.0319	0.0025	-0.3244	0.0081
	Mag	u(Mag)	Phase	u(Phase)
Reference value	0.3260	0.0083	-84.38°	0.33°

Table 16a

The correlation coefficient, $r(x_M, y_M)$, is –0.88.

NMi-VSL	**INRIM**	**CMI**	**UME**	**SPRING**	**NIM**	**NPLI**	**NMIJ**
-0.16	-0.45	0.039	0.41	-0.010	0.0061	-0.24	-0.0017

Table 16b – Reported correlation coefficients

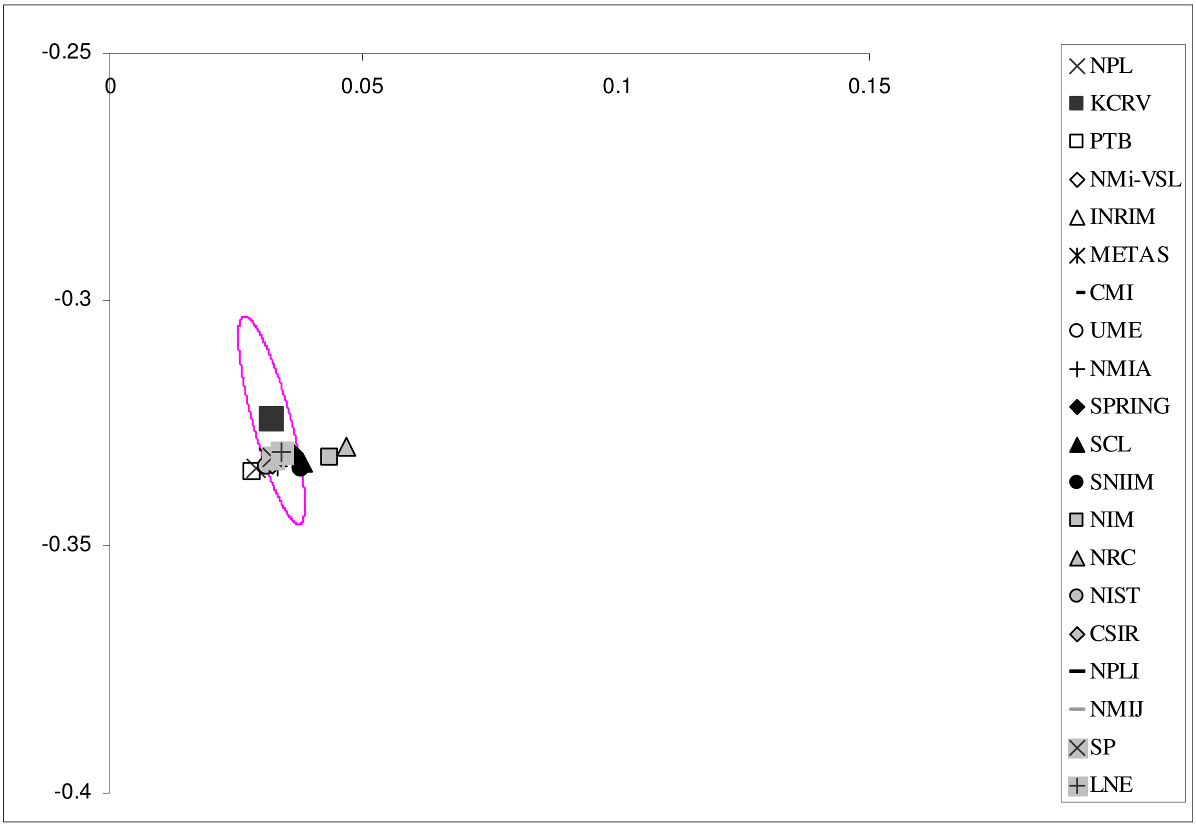

Fig 14 – Plot of measurements of S_{11} of device K5b.CL/7 (female mismatched load) at 9 GHz along with the KCRV and its expanded uncertainty (k = 2.5)

Note: Owing to the scaling of the graph, INRIM's result is not shown in this graph

Lab i	Measurement and Combined Standard Uncertainty of S_{11} of female mismatched load (K5b.CL/7) at 18 GHz			
	x_i	$u(x_i)$	y_i	$u(y_i)$
NPL	0.3024	0.0040	-0.1867	0.0040
PTB	*0.3011*	*0.0022*	*-0.1914*	*0.0022*
NMi-VSL	0.301	0.012	-0.185	0.012
INRIM	0.3123	0.0076	-0.1357	0.0288
METAS	0.3026	0.0044	-0.1810	0.0044
*CMI	0.3004	0.0061	-0.1798	0.0072
*UME	0.299	0.013	-0.183	0.012
NMIA	0.3052	0.0033	-0.1824	0.0033
SPRING	0.3047	0.0085	-0.179	0.010
*SCL	0.296	0.014	-0.179	0.016
SNIIM	0.3054	0.0025	-0.1800	0.0025
NIM	0.3058	0.0017	-0.1699	0.0017
NRC	0.310	0.010	-0.159	0.010
NIST	0.3094	0.0036	-0.1759	0.0031
CSIR-NML	0.3070	0.0042	-0.1759	0.0039
NPLI	*0.3197*	*0.0069*	*-0.1527*	*0.0069*
NMIJ	0.3090	0.0027	-0.1765	0.0027
SP	0.3080	0.0054	-0.1797	0.0054
LNE	0.3081	0.0066	-0.1758	0.0066
	x_M	$u(x_M)$	y_M	$u(y_M)$
Reference value	0.30649	0.00087	-0.1745	0.0035
	Mag	u(Mag)	Phase	u(Phase)
Reference value	0.3527	0.0013	-29.65°	0.55°

Table 17a

The correlation coefficient, $r(x_M, y_M)$, is 0.76.

NMi-VSL	**INRIM**	**CMI**	**UME**	**SPRING**	**NIM**	**NPLI**	**NMIJ**
0.66	0.13	0.32	0.99	0.35	0.022	0.53	-0.018

Table 17b – Reported correlation coefficients

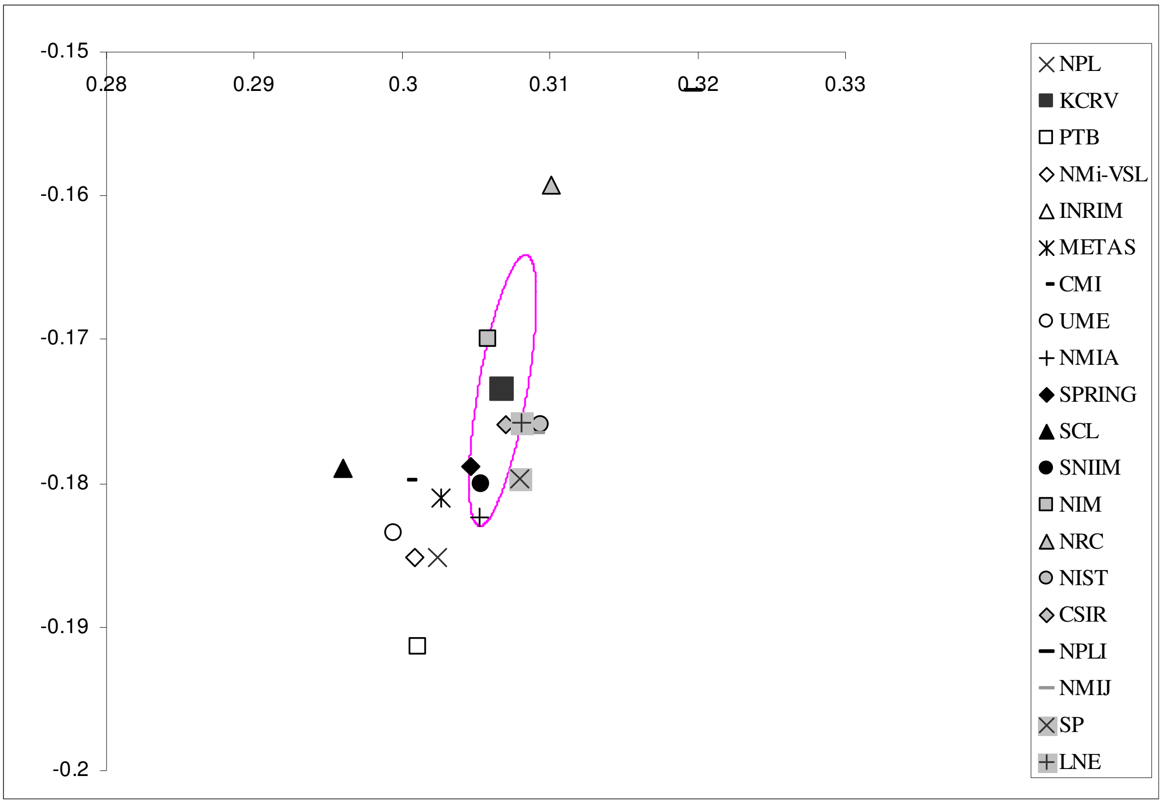

Fig 15 – Plot of measurements of S_{11} of device K5b.CL/7 (female mismatched load) at 18 GHz along with the KCRV and its expanded uncertainty (k = 2.5)

Lab j ⇒

Lab i ⇓	KCRV		NPL		PTB		NMi-VSL		INRIM		METAS		CMI		UME	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.00059	0.00068			0.0012	0.0051	0.0011	0.0043	0.00031	0.00073	0.0010	0.0046	0.0012	0.0028	0.0014	0.0033
PTB	0.0007	0.0040	0.0012	0.0051			0.0011	0.0064	0.0014	0.0051	0.0004	0.0068	0.0004	0.0054	0.0012	0.0060
NMi-VSL	0.0007	0.0035	0.0011	0.0043	0.0011	0.0064			0.0011	0.0041	0.0007	0.0061	0.0007	0.0044	0.0007	0.0051
INRIM	0.00073	0.00084	0.00031	0.00073	0.0014	0.0051	0.0011	0.0041			0.0011	0.0046	0.0014	0.0030	0.0018	0.0034
METAS	0.0004	0.0036	0.0010	0.0046	0.0004	0.0068	0.0007	0.0061	0.0011	0.0046			0.0003	0.0052	0.0011	0.0056
CMI	0.0007	0.0029	0.0012	0.0028	0.0004	0.0054	0.0007	0.0044	0.0014	0.0030	0.0003	0.0052			0.0008	0.0037
UME	0.0012	0.0033	0.0014	0.0033	0.0012	0.0060	0.0007	0.0051	0.0018	0.0034	0.0011	0.0056	0.0008	0.0037		

Table 18a – Degrees of equivalence for S_{21} measurements of device K5b.CL/1 (3 dB attenuator) at 2 GHz before July 2004

Lab j ⇒

Lab i ⇓	KCRV		NPL		NMIA		SPRING		SCL		SNIIM		NIM		NRC	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.0012	0.0011			0.0013	0.0021	0.0011	0.0038	0.001	0.018	0.006	0.011	0.0017	0.0038	0.0003	0.0025
NMIA	0.0003	0.0020	0.0013	0.0021			0.0002	0.0087	0.000	0.012	0.005	0.011	0.0028	0.0042	0.0011	0.0032
SPRING	0.0003	0.0019	0.0011	0.0038	0.0002	0.0087			0.000	0.017	0.005	0.013	0.0026	0.0051	0.0009	0.0085
SCL	0.000	0.019	0.001	0.018	0.000	0.012	0.000	0.017			0.005	0.022	0.003	0.018	0.001	0.017
SNIIM	0.0051	0.0096	0.006	0.011	0.005	0.011	0.005	0.013	0.005	0.022			0.008	0.011	0.006	0.011
NIM	0.0026	0.0036	0.0017	0.0038	0.0028	0.0042	0.0026	0.0051	0.003	0.018	0.008	0.011			0.0020	0.0045
NRC	0.0010	0.0025	0.0003	0.0025	0.0011	0.0032	0.0009	0.0085	0.001	0.017	0.006	0.011	0.0020	0.0045		
NIST	0.0014	0.0034	0.0026	0.0038	0.0013	0.0040	0.0016	0.0095	0.001	0.016	0.004	0.011	0.0038	0.0056	0.0024	0.0045
CSIR-NML	0.0003	0.0019	0.0012	0.0021	0.0005	0.0028	0.0005	0.0027	0.000	0.014	0.005	0.011	0.0025	0.0042	0.0011	0.0032
NPLI	0.0010	0.0021	0.0015	0.0012	0.0013	0.0036	0.0013	0.0038	0.001	0.012	0.006	0.011	0.0022	0.0046	0.0016	0.0036
NMIJ	0.0004	0.0041	0.0008	0.0044	0.0005	0.0048	0.0002	0.0098	0.001	0.017	0.005	0.011	0.0024	0.0058	0.0006	0.0050
SP	0.0005	0.0044	0.0007	0.0047	0.0006	0.0051	0.0004	0.0064	0.001	0.019	0.006	0.012	0.0022	0.0060	0.0006	0.0053
LNE	0.0009	0.0015	0.0003	0.0011	0.0010	0.0023	0.0008	0.0036	0.001	0.019	0.006	0.011	0.0019	0.0039	0.0002	0.0027

Table 18b – Degrees of equivalence for S_{21} measurements of device K5b.CL/1 (3 dB attenuator) at 2 GHz after July 2004

Lab j ⇒

Lab i ⇓	NIST		CSIR-NML		NPLI		NMIJ		SP		LNE	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.0026	0.0038	0.0012	0.0021	0.0015	0.0012	0.0008	0.0044	0.0007	0.0047	0.0003	0.0011
NMIA	0.0013	0.0040	0.0005	0.0028	0.0013	0.0036	0.0005	0.0048	0.0006	0.0051	0.0010	0.0023
SPRING	0.0016	0.0095	0.0005	0.0027	0.0013	0.0038	0.0002	0.0098	0.0004	0.0064	0.0008	0.0036
SCL	0.001	0.016	0.000	0.014	0.001	0.012	0.001	0.017	0.001	0.019	0.001	0.019
SNIIM	0.004	0.011	0.005	0.011	0.006	0.011	0.005	0.011	0.006	0.012	0.006	0.011
NIM	0.0038	0.0056	0.0025	0.0042	0.0022	0.0046	0.0024	0.0058	0.0022	0.0060	0.0019	0.0039
NRC	0.0024	0.0045	0.0011	0.0032	0.0016	0.0036	0.0006	0.0050	0.0006	0.0053	0.0002	0.0027
NIST			0.0014	0.0045	0.0016	0.0048	0.0018	0.008	0.0019	0.0061	0.0023	0.0039
CSIR-NML	0.0014	0.0045			0.0007	0.0034	0.0006	0.0048	0.0005	0.0051	0.0009	0.0023
NPLI	0.0016	0.0048	0.0007	0.0034			0.0013	0.0052	0.0011	0.0054	0.0013	0.0029
NMIJ	0.0018	0.0058	0.0006	0.0048	0.0013	0.0052			0.0002	0.0064	0.0006	0.0045
SP	0.0019	0.0061	0.0005	0.0051	0.0011	0.0054	0.0002	0.0064			0.0004	0.0048
LNE	0.0023	0.0039	0.0009	0.0023	0.0013	0.0029	0.0006	0.0045	0.0004	0.0048		

Table 18b cont'd – Degrees of equivalence for S_{21} measurements of device K5b.CL/1 (3 dB attenuator) at 2 GHz after July 2004

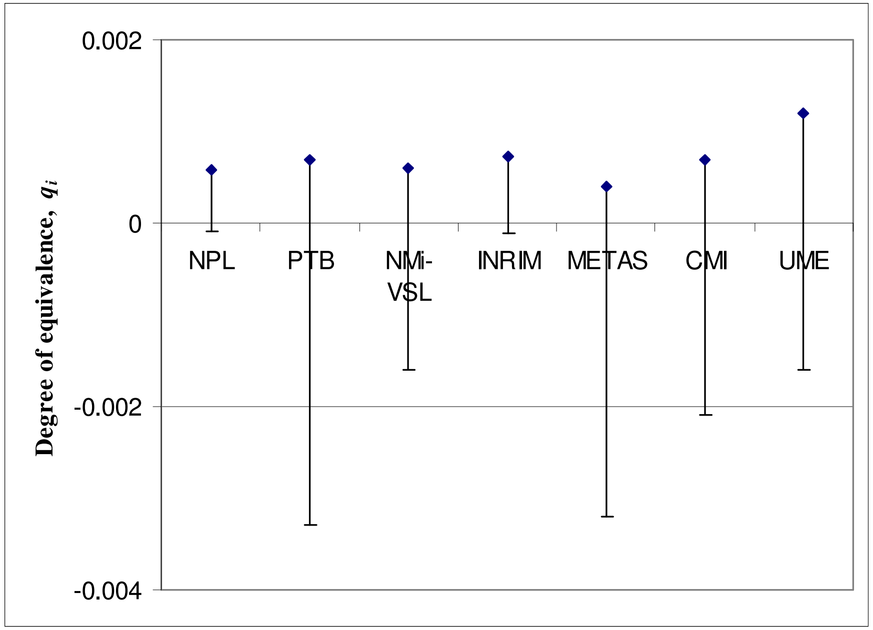

Fig 16a – Reduced dimension degrees of equivalence and their confidence indicators for S_{21} measurements of device K5b.CL/1 (3 dB attenuator) at 2 GHz made before July 2004

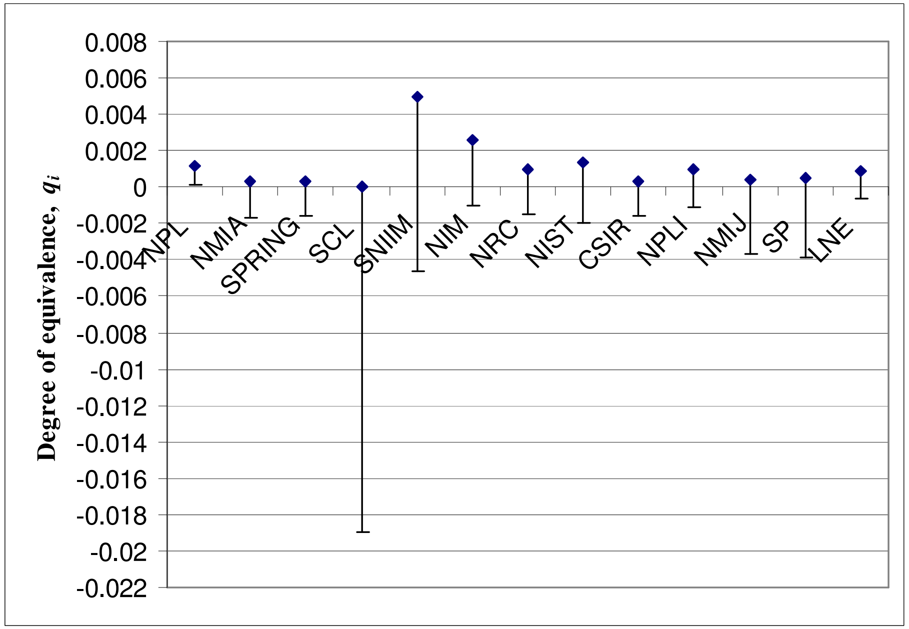

Fig 16b – Reduced dimension degrees of equivalence and their confidence indicators for S_{21} measurements of device K5b.CL/1 (3 dB attenuator) at 2 GHz made after July 2004

Lab $j \Rightarrow$

Lab $i \Downarrow$	KCRV		NPL		PTB		NMi-VSL		INRIM		METAS		CMI		UME	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.0012	0.0014			0.0023	0.0054	0.0014	0.0042	0.0028	0.0017	0.0014	0.0067	0.0041	0.0071	0.0019	0.0032
PTB	0.0011	0.0039	0.0023	0.0054			0.0012	0.0065	0.0049	0.0054	0.0011	0.0084	0.0017	0.0094	0.0019	0.0064
NMi-VSL	0.0003	0.0029	0.0014	0.0042	0.0012	0.0065			0.0038	0.0041	0.0001	0.0076	0.0028	0.0097	0.0009	0.0052
INRIM	0.0038	0.0016	0.0028	0.0017	0.0049	0.0054	0.0038	0.0041			0.0038	0.0067	0.0066	0.0087	0.0036	0.0035
METAS	0.0003	0.0047	0.0014	0.0067	0.0011	0.0084	0.0001	0.0076	0.0038	0.0067			0.003	0.011	0.0010	0.0074
CMI	0.0028	0.0077	0.0041	0.0071	0.0017	0.0094	0.0028	0.0097	0.0066	0.0087	0.003	0.011			0.0032	0.0092
UME	0.0012	0.0033	0.0019	0.0032	0.0019	0.0064	0.0009	0.0052	0.0036	0.0035	0.0010	0.0074	0.0032	0.0092		

Table 19a – Degrees of equivalence for S_{21} measurements of device K5b.CL/1 (3 dB attenuator) at 9 GHz before July 2004

Lab $j \Rightarrow$

Lab $i \Downarrow$	KCRV		NPL		NMIA		SPRING		SCL		SNIIM		NIM		NRC	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.0042	0.0022			0.0041	0.0028	0.0024	0.0018	0.004	0.038	0.007	0.012	0.0017	0.0048	0.0038	0.0026
NMIA	0.0022	0.0025	0.0041	0.0028			0.002	0.021	0.001	0.031	0.004	0.012	0.0042	0.0054	0.0066	0.0037
SPRING	0.0036	0.0035	0.0024	0.0018	0.002	0.021			0.002	0.042	0.006	0.025	0.0034	0.0049	0.004	0.024
SCL	0.002	0.020	0.004	0.038	0.001	0.031	0.0020	0.042			0.004	0.031	0.0038	0.026	0.006	0.037
SNIIM	0.003	0.010	0.007	0.012	0.004	0.012	0.006	0.025	0.004	0.031			0.006	0.012	0.011	0.012
NIM	0.0034	0.0047	0.0017	0.0048	0.0042	0.0054	0.0034	0.0049	0.004	0.026	0.006	0.012			0.0054	0.0054
NRC	0.0076	0.0031	0.0038	0.0026	0.0066	0.0037	0.004	0.024	0.006	0.037	0.011	0.012	0.0054	0.0054		
NIST	0.005	0.012	0.009	0.013	0.0054	0.0098	0.008	0.025	0.006	0.035	0.002	0.017	0.008	0.015	0.012	0.011
CSIR-NML	0.0005	0.0075	0.0038	0.0082	0.0019	0.0087	0.003	0.015	0.002	0.021	0.004	0.014	0.0031	0.0095	0.0071	0.0086
NPLI	0.0022	0.0055	0.0062	0.0043	0.0040	0.0061	0.0058	0.0085	0.004	0.023	0.001	0.012	0.0051	0.0065	0.0098	0.0060
NMIJ	0.0014	0.0039	0.0028	0.0038	0.0024	0.0046	0.0028	0.0051	0.002	0.021	0.004	0.012	0.0021	0.0060	0.0064	0.0044
SP	0.0024	0.0073	0.0020	0.0080	0.0031	0.0084	0.0027	0.0085	0.003	0.026	0.005	0.014	0.0011	0.0092	0.0057	0.0083
LNE	0.0016	0.0027	0.0026	0.0021	0.0024	0.0033	0.0026	0.0030	0.002	0.021	0.005	0.012	0.0019	0.0051	0.0061	0.0031

Table 19b – Degrees of equivalence for S_{21} measurements of device K5b.CL/1 (3 dB attenuator) at 9 GHz after July 2004

Lab j ⇒

Lab i ⇓	NIST		CSIR-NML		NPLI		NMIJ		SP		LNE	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.009	0.013	0.0038	0.0082	0.0062	0.0043	0.0028	0.0038	0.0020	0.0080	0.0026	0.0021
NMIA	0.0054	0.0098	0.0019	0.0087	0.0040	0.0061	0.0024	0.0046	0.0031	0.0084	0.0024	0.0033
SPRING	0.008	0.025	0.003	0.015	0.0058	0.0085	0.0028	0.0051	0.0027	0.0085	0.0026	0.0030
SCL	0.006	0.035	0.002	0.021	0.004	0.023	0.002	0.021	0.003	0.026	0.002	0.021
SNIIM	0.002	0.017	0.004	0.014	0.001	0.012	0.004	0.012	0.005	0.014	0.005	0.012
NIM	0.008	0.015	0.0031	0.0095	0.0051	0.0065	0.0021	0.0060	0.0011	0.0092	0.0019	0.0051
NRC	0.012	0.011	0.0071	0.0086	0.0098	0.0060	0.0064	0.0044	0.0057	0.0083	0.0061	0.0031
NIST			0.005	0.016	0.003	0.011	0.006	0.014	0.007	0.016	0.006	0.014
CSIR-NML	0.005	0.016			0.003	0.010	0.0011	0.0090	0.002	0.011	0.0012	0.0084
NPLI	0.003	0.011	0.003	0.010			0.0034	0.0064	0.0043	0.0095	0.0037	0.0052
NMIJ	0.006	0.014	0.0011	0.0090	0.0034	0.0064			0.0010	0.0087	0.0002	0.0041
SP	0.007	0.016	0.002	0.011	0.0043	0.0095	0.0010	0.0087			0.0008	0.0082
LNE	0.006	0.014	0.0012	0.0084	0.0037	0.0052	0.0002	0.0041	0.0008	0.0082		

Table 19b cont'd – Degrees of equivalence for S_{21} measurements of device K5b.CL/1 (3 dB attenuator) at 9 GHz after July 2004

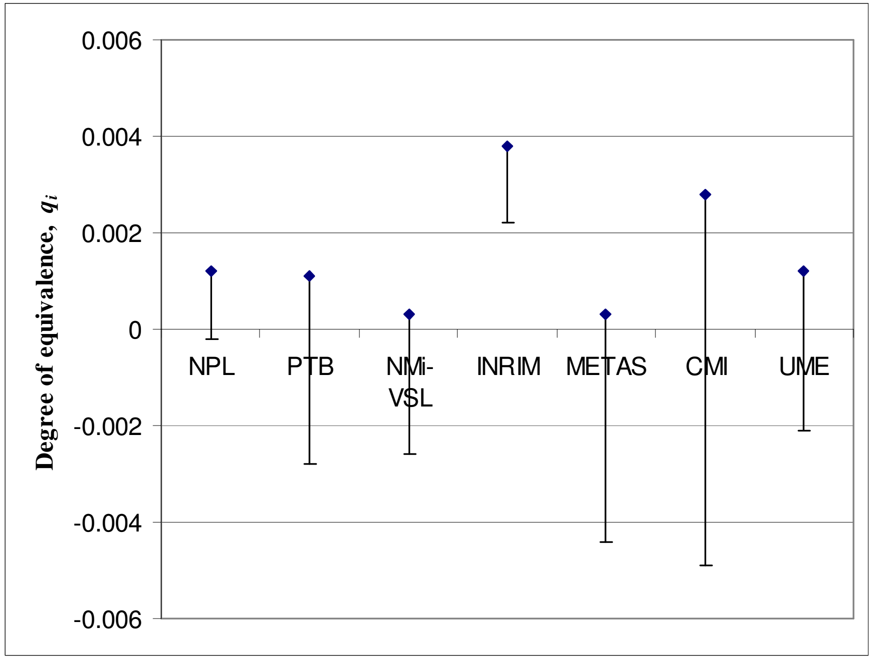

Fig 17a – Reduced dimension degrees of equivalence and their confidence indicators for S_{21} measurements of device K5b.CL/1 (3 dB attenuator) at 9 GHz made before July 2004

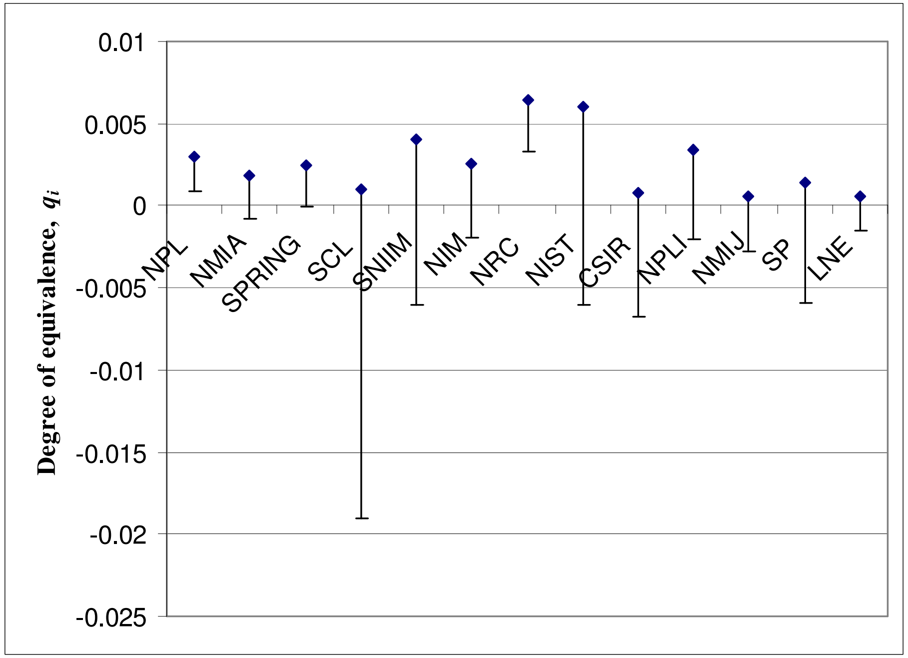

Fig 17b – Reduced dimension degrees of equivalence and their confidence indicators for S_{21} measurements of device K5b.CL/1 (3 dB attenuator) at 9 GHz made after July 2004

Lab $j \Rightarrow$

Lab $i \Downarrow$	KCRV		NPL		PTB		NMi-VSL		INRIM		METAS		CMI		UME	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.0012	0.0021			0.0015	0.0061	0.0017	0.0047	0.0069	0.0039	0.0018	0.0070	0.006	0.011	0.0045	0.0056
PTB	0.0004	0.0039	0.0015	0.0061			0.0004	0.0078	0.0079	0.0062	0.0007	0.0085	0.005	0.016	0.0047	0.0074
NMi-VSL	0.0005	0.0029	0.0017	0.0047	0.0004	0.0078			0.0078	0.0055	0.0004	0.0089	0.005	0.016	0.0044	0.0078
INRIM	0.0075	0.0030	0.0069	0.0039	0.0079	0.0062	0.0078	0.0055			0.0076	0.0071	0.013	0.017	0.0046	0.0050
METAS	0.0006	0.0047	0.0018	0.0070	0.0007	0.0085	0.0004	0.0089	0.0076	0.0071			0.005	0.018	0.0041	0.0082
CMI	0.005	0.013	0.006	0.011	0.005	0.016	0.005	0.016	0.013	0.017	0.005	0.018			0.009	0.018
UME	0.0044	0.0051	0.0045	0.0056	0.0047	0.0074	0.0044	0.0078	0.0046	0.0050	0.0041	0.0082	0.009	0.018		

Table 20a – Degrees of equivalence for S_{21} measurements of device K5b.CL/1 (3 dB attenuator) at 18 GHz before July 2004

Lab $j \Rightarrow$

Lab $i \Downarrow$	KCRV		NPL		NMIA		SPRING		SCL		SNIIM		NIM		NRC	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.0025	0.0042			0.0054	0.0040	0.009	0.017	0.004	0.041	0.005	0.013	0.0065	0.0056	0.0107	0.0032
NMIA	0.0067	0.0049	0.0054	0.0040			0.005	0.010	0.003	0.015	0.004	0.013	0.0119	0.0063	0.0075	0.0042
SPRING	0.011	0.031	0.009	0.017	0.005	0.010			0.005	0.065	0.009	0.029	0.015	0.013	0.002	0.012
SCL	0.006	0.077	0.004	0.041	0.003	0.015	0.005	0.065			0.005	0.026	0.010	0.024	0.007	0.075
SNIIM	0.005	0.011	0.005	0.013	0.004	0.013	0.009	0.029	0.005	0.026			0.011	0.014	0.012	0.013
NIM	0.0061	0.0049	0.0065	0.0056	0.0119	0.0063	0.015	0.013	0.010	0.024	0.011	0.014			0.0162	0.0059
NRC	0.0130	0.0051	0.0107	0.0032	0.0075	0.0042	0.002	0.012	0.007	0.075	0.012	0.013	0.0162	0.0059		
NIST	0.011	0.023	0.014	0.023	0.017	0.023	0.022	0.054	0.017	0.082	0.014	0.027	0.011	0.011	0.024	0.028
CSIR-NML	0.0015	0.0098	0.004	0.010	0.008	0.011	0.012	0.043	0.007	0.066	0.006	0.016	0.005	0.011	0.014	0.011
NPLI	0.0016	0.0097	0.004	0.010	0.0081	0.0092	0.013	0.047	0.007	0.078	0.005	0.015	0.006	0.011	0.0145	0.0097
NMIJ	0.0015	0.0044	0.0022	0.0053	0.0073	0.0059	0.011	0.024	0.006	0.044	0.006	0.013	0.0048	0.0070	0.0129	0.0055
SP	0.002	0.011	0.003	0.012	0.008	0.012	0.011	0.036	0.006	0.044	0.007	0.017	0.004	0.013	0.013	0.012
LNE	0.0017	0.0033	0.0038	0.0026	0.0084	0.0038	0.012	0.022	0.007	0.060	0.006	0.013	0.0049	0.0054	0.0144	0.0030

Table 20b – Degrees of equivalence for S_{21} measurements of device K5b.CL/1 (3 dB attenuator) at 18 GHz after July 2004

Lab $j \Rightarrow$

Lab $i \Downarrow$	NIST		CSIR-NML		NPLI		NMIJ		SP		LNE	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.014	0.023	0.004	0.010	0.004	0.010	0.0022	0.0053	0.003	0.012	0.0038	0.0026
NMIA	0.017	0.023	0.008	0.011	0.0081	0.0092	0.0073	0.0059	0.008	0.012	0.0084	0.0038
SPRING	0.022	0.054	0.012	0.043	0.013	0.047	0.011	0.024	0.011	0.036	0.012	0.022
SCL	0.017	0.082	0.007	0.066	0.007	0.078	0.006	0.044	0.006	0.044	0.007	0.060
SNIIM	0.014	0.027	0.006	0.016	0.005	0.015	0.006	0.013	0.007	0.017	0.006	0.013
NIM	0.011	0.011	0.005	0.011	0.006	0.011	0.0048	0.0070	0.004	0.013	0.0049	0.0054
NRC	0.024	0.028	0.014	0.011	0.0145	0.0097	0.0129	0.0055	0.013	0.012	0.0144	0.0030
NIST			0.010	0.028	0.010	0.030	0.012	0.021	0.012	0.027	0.010	0.019
CSIR-NML	0.010	0.028			0.001	0.015	0.002	0.011	0.002	0.016	0.000	0.010
NPLI	0.010	0.030	0.001	0.015			0.002	0.013	0.003	0.017	0.001	0.010
NMIJ	0.012	0.021	0.002	0.011	0.002	0.013			0.001	0.013	0.0017	0.0052
SP	0.012	0.027	0.002	0.016	0.003	0.017	0.001	0.013			0.002	0.012
LNE	0.010	0.019	0.000	0.010	0.001	0.010	0.0017	0.0052	0.002	0.012		

Table 20b cont'd – Degrees of equivalence for S_{21} measurements of device K5b.CL/1 (3 dB attenuator) at 18 GHz after July 2004

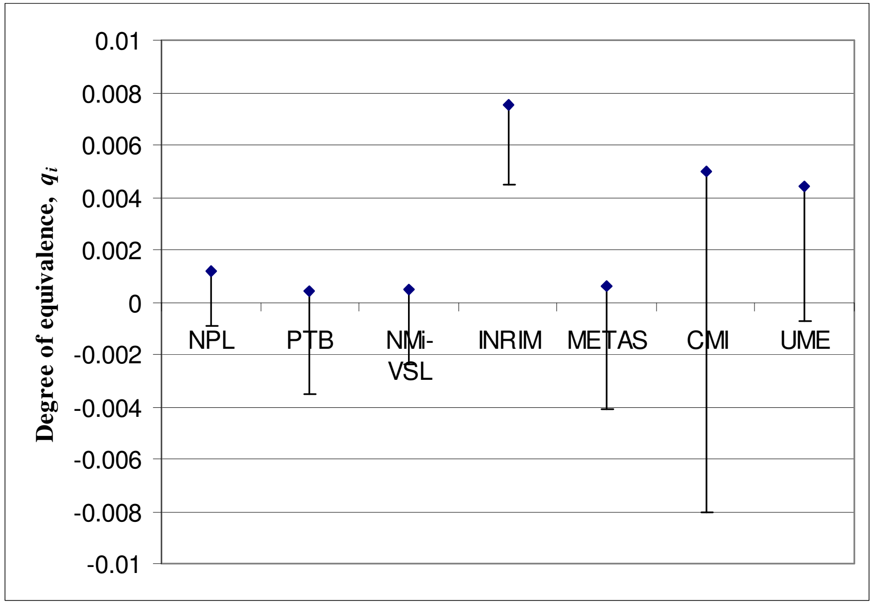

Fig 18a – Reduced dimension degrees of equivalence and their confidence indicators for S_{21} measurements of device K5b.CL/1 (3 dB attenuator) at 18 GHz made before July 2004

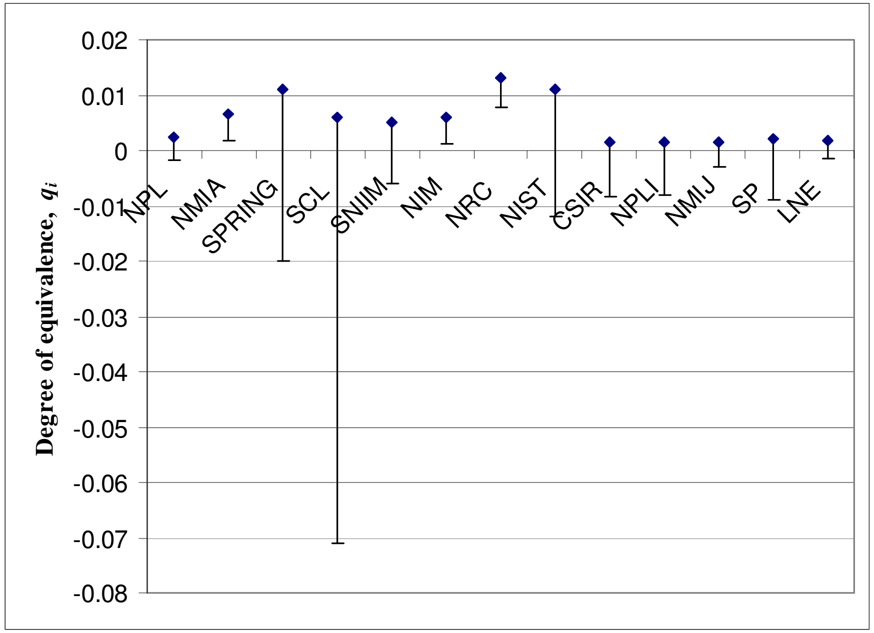

Fig 18b – Reduced dimension degrees of equivalence and their confidence indicators for S_{21} measurements of device K5b.CL/1 (3 dB attenuator) at 18 GHz made after July 2004

Lab $j \Rightarrow$

Lab $i \Downarrow$	KCRV		NPL		PTB		NMi-VSL		INRIM		METAS		CMI		UME	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.00004	0.00018			0.00008	0.00074	0.00005	0.00077	0.00011	0.00050	0.00008	0.00071	0.00001	0.00064	0.00018	0.00093
PTB	0.00011	0.00068	0.00008	0.00074			0.0001	0.0010	0.00015	0.00086	0.0001	0.0010	0.00009	0.00097	0.0002	0.0012
NMi-VSL	0.00002	0.00064	0.00005	0.00077	0.0001	0.0010			0.00015	0.00086	0.00008	0.00096	0.00004	0.00098	0.0001	0.0012
INRIM	0.00013	0.00044	0.00011	0.00050	0.00015	0.00086	0.00015	0.00086			0.00019	0.00083	0.00012	0.00083	0.0003	0.0010
METAS	0.00010	0.00065	0.00008	0.00071	0.0001	0.0010	0.00008	0.00096	0.00019	0.00083			0.00008	0.00099	0.0002	0.0012
CMI	0.00003	0.00058	0.00001	0.00064	0.00009	0.00097	0.00004	0.00098	0.00012	0.00083	0.00008	0.00099			0.0002	0.0011
UME	0.00014	0.00086	0.00018	0.00093	0.0002	0.0012	0.0001	0.0012	0.0003	0.0010	0.0002	0.0012	0.0002	0.0011		
NMIA	0.00012	0.00036	0.00011	0.00041	0.00007	0.00081	0.00010	0.00076	0.00021	0.00059	0.00002	0.00078	0.00011	0.00081	0.0002	0.0010
SPRING	0.00004	0.00062	0.0000	0.0014	0.0001	0.0012	0.0001	0.0011	0.0001	0.0012	0.0001	0.0016	0.0000	0.0010	0.0002	0.0012
SCL	0.0000	0.0022	0.0000	0.0021	0.0001	0.0019	0.0001	0.0027	0.0001	0.0027	0.0001	0.0023	0.0000	0.0027	0.0002	0.0025
SNIIM	0.0003	0.0012	0.0003	0.0012	0.0004	0.0014	0.0003	0.0013	0.0003	0.0013	0.0004	0.0014	0.0003	0.0014	0.0003	0.0016
NIM	0.00034	0.00048	0.00035	0.00053	0.00035	0.00088	0.00032	0.00086	0.00046	0.00069	0.00029	0.00085	0.00034	0.00086	0.0002	0.0012
NRC	0.00021	0.00050	0.00021	0.00052	0.00018	0.00087	0.00019	0.00083	0.00032	0.00068	0.00013	0.00085	0.00021	0.00087	0.0002	0.0012
NIST	0.00005	0.00048	0.00009	0.00047	0.00015	0.00082	0.00004	0.00085	0.00018	0.00071	0.00012	0.00078	0.00007	0.00076	0.0001	0.0011
CSIR-NML	0.00008	0.00030	0.00010	0.00033	0.00017	0.00078	0.00010	0.00072	0.00010	0.00054	0.00017	0.00074	0.00009	0.00076	0.0002	0.0010
NPLI	0.00042	0.00073	0.00045	0.00075	0.0005	0.0010	0.00044	0.00098	0.00040	0.00091	0.0005	0.0010	0.0004	0.0013	0.0004	0.0013
NMIJ	0.00006	0.00064	0.00002	0.00066	0.00008	0.00096	0.00007	0.00098	0.00009	0.00079	0.00010	0.00094	0.00004	0.00090	0.0002	0.0011
SP	0.00006	0.00063	0.00004	0.00069	0.00007	0.00098	0.00005	0.00097	0.00015	0.00081	0.00005	0.00095	0.00004	0.00098	0.0002	0.0011
LNE	0.00006	0.00061	0.00006	0.00062	0.00013	0.00094	0.00008	0.00092	0.00008	0.00076	0.00014	0.00091	0.00006	0.00094	0.0002	0.0011

Table 21 – Degrees of equivalence for S_{21} measurements of device K5b.CL/2 (20 dB attenuator) at 2 GHz

Lab $j \Rightarrow$

Lab $i \Downarrow$	NMIA		SPRING		SCL		SNIIM		NIM		NRC		NIST		CSIR-NML	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.00011	0.00041	0.0000	0.0014	0.0000	0.0021	0.0003	0.0012	0.00035	0.00053	0.00021	0.00052	0.00009	0.00047	0.00010	0.00033
PTB	0.00007	0.00081	0.0001	0.0012	0.0001	0.0019	0.0004	0.0014	0.00035	0.00088	0.00018	0.00087	0.00015	0.00082	0.00017	0.00078
NMi-VSL	0.00010	0.00076	0.0001	0.0011	0.0001	0.0027	0.0003	0.0013	0.00032	0.00086	0.00019	0.00083	0.00004	0.00085	0.00010	0.00072
INRIM	0.00021	0.00059	0.0001	0.0012	0.0001	0.0027	0.0003	0.0013	0.00046	0.00069	0.00032	0.00068	0.00018	0.00071	0.00010	0.00054
METAS	0.00002	0.00078	0.0001	0.0016	0.0001	0.0023	0.0004	0.0014	0.00029	0.00085	0.00013	0.00084	0.00012	0.00078	0.00017	0.00074
CMI	0.00011	0.00081	0.0000	0.0010	0.0000	0.0027	0.0003	0.0014	0.00034	0.00086	0.00021	0.00087	0.00007	0.00076	0.00009	0.00076
UME	0.0002	0.0010	0.0002	0.0012	0.0002	0.0025	0.0003	0.0016	0.0002	0.0012	0.0002	0.0012	0.0001	0.0011	0.0002	0.0010
NMIA			0.0001	0.0015	0.0001	0.0022	0.0004	0.0012	0.00028	0.00062	0.00011	0.00061	0.00013	0.00053	0.00020	0.00046
SPRING	0.0001	0.0015			0.0000	0.0023	0.0003	0.0017	0.0004	0.0012	0.0002	0.0015	0.00009	0.00081	0.0001	0.0010
SCL	0.0001	0.0022	0.0000	0.0023			0.0003	0.0022	0.0004	0.0027	0.0002	0.0025	0.0001	0.0023	0.0001	0.0017
SNIIM	0.0004	0.0012	0.0003	0.0017	0.0003	0.0022			0.0006	0.0013	0.0005	0.0013	0.0003	0.0013	0.0002	0.0012
NIM	0.00028	0.00062	0.0004	0.0012	0.0004	0.0027	0.0006	0.0013			0.00017	0.00070	0.00030	0.00075	0.00040	0.00058
NRC	0.00011	0.00061	0.0002	0.0015	0.0002	0.0025	0.0005	0.0013	0.00017	0.00070			0.00020	0.00068	0.00029	0.00057
NIST	0.00013	0.00053	0.00009	0.0081	0.0001	0.0023	0.0003	0.0013	0.00030	0.00075	0.00020	0.00068			0.00010	0.00062
CSIR-NML	0.00020	0.00046	0.0001	0.0010	0.0001	0.0017	0.0002	0.0012	0.00040	0.00058	0.00029	0.00057	0.00010	0.00062		
NPLI	0.00055	0.00081	0.0004	0.0015	0.0004	0.0020	0.0001	0.0014	0.00069	0.00089	0.00062	0.00087	0.00043	0.00086	0.00035	0.00078
NMIJ	0.00012	0.00073	0.00002	0.00093	0.00003	0.00182	0.0003	0.0013	0.00038	0.00081	0.00023	0.00080	0.00011	0.00079	0.00010	0.00070
SP	0.00007	0.00076	0.0001	0.0016	0.0001	0.0024	0.0003	0.0013	0.00032	0.00083	0.00017	0.00082	0.00008	0.00077	0.00013	0.00072
LNE	0.00016	0.00070	0.0000	0.0015	0.0000	0.0021	0.0003	0.0013	0.00040	0.00078	0.00026	0.00077	0.00010	0.00081	0.00005	0.00066

Table 21 cont'd – Degrees of equivalence for S_{21} measurements of device K5b.CL/2 (20 dB attenuator) at 2 GHz

Lab j ⇒

Lab i ⇓	NPLI		NMIJ		SP		LNE	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.00045	0.00075	0.00002	0.00066	0.00004	0.00069	0.00006	0.00062
PTB	0.0005	0.0010	0.00008	0.00096	0.00007	0.00098	0.00013	0.00094
NMi-VSL	0.00044	0.00098	0.00007	0.00098	0.00005	0.00097	0.00008	0.00092
INRIM	0.00040	0.00091	0.00009	0.00079	0.00015	0.00081	0.00008	0.00076
METAS	0.0005	0.0010	0.00010	0.00094	0.00005	0.00095	0.00014	0.00091
CMI	0.0004	0.0013	0.00004	0.00090	0.00004	0.00098	0.00006	0.00094
UME	0.0004	0.0013	0.0002	0.0011	0.0002	0.0011	0.0002	0.0011
NMIA	0.00055	0.00081	0.00012	0.00073	0.00007	0.00076	0.00016	0.00070
SPRING	0.0004	0.0015	0.00002	0.00093	0.0001	0.0016	0.0000	0.0015
SCL	0.0004	0.0020	0.0000	0.0018	0.0001	0.0024	0.0000	0.0021
SNIIM	0.0001	0.0014	0.0003	0.0013	0.0003	0.0013	0.0003	0.0013
NIM	0.00069	0.00089	0.00038	0.00081	0.00032	0.00083	0.00040	0.00078
NRC	0.00062	0.00087	0.00023	0.00080	0.00017	0.00082	0.00026	0.00077
NIST	0.00043	0.00086	0.00011	0.00079	0.00008	0.00077	0.00010	0.00081
CSIR-NML	0.00035	0.00078	0.00010	0.00070	0.00013	0.00072	0.00005	0.00066
NPLI			0.00045	0.00098	0.00048	0.00099	0.00039	0.00096
NMIJ	0.00045	0.00098			0.00006	0.00092	0.00005	0.00087
SP	0.00048	0.00092	0.00006	0.00094			0.00010	0.00089
LNE	0.00039	0.00096	0.00005	0.00087	0.00010	0.00089		

Table 21 cont'd – Degrees of equivalence for S_{21} measurements of device K5b.CL/2 (20 dB attenuator) at 2 GHz

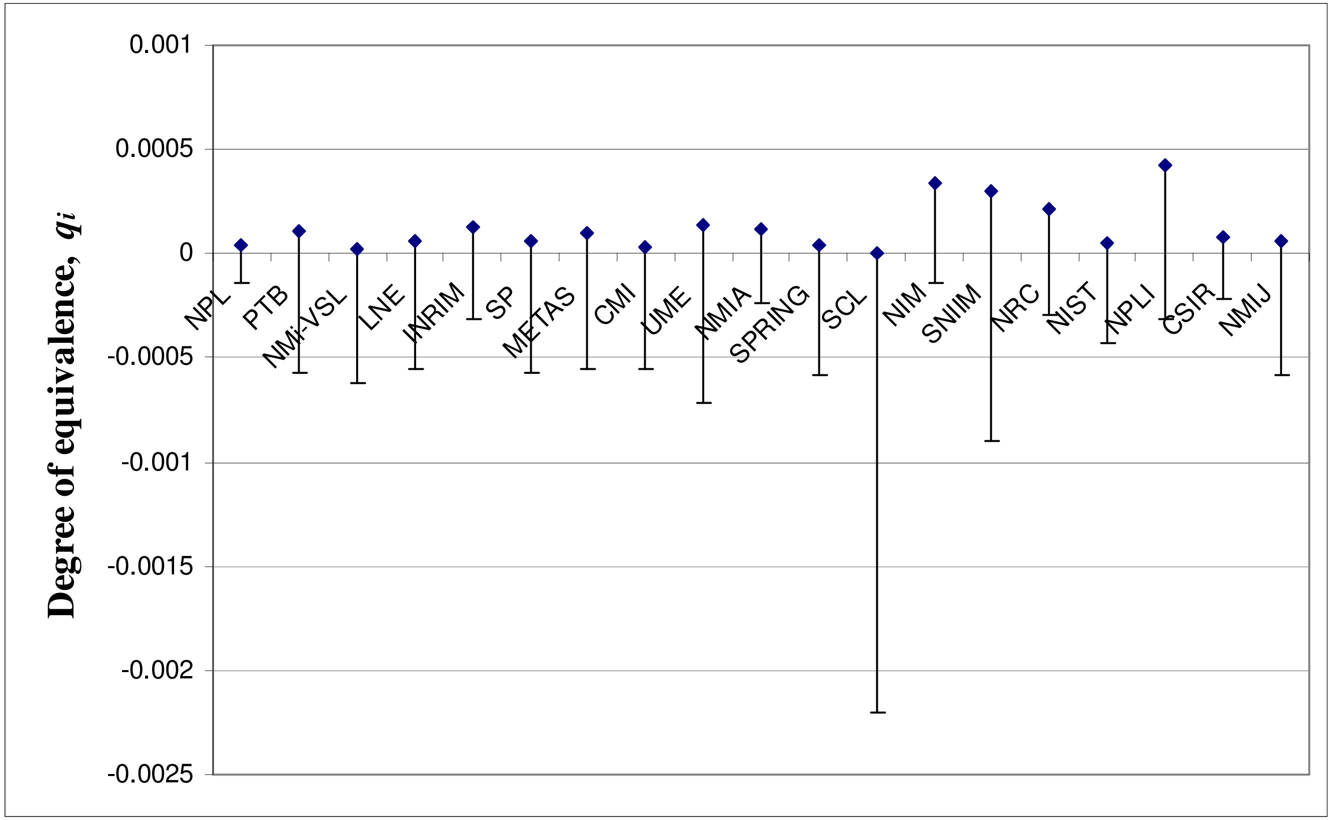

Fig 19 – Reduced dimension degrees of equivalence and their confidence indicators for S_{21} measurements of device K5b.CL/2 (20 dB attenuator) at 2 GHz

Lab j ⇒

Lab i ⇓	KCRV		NPL		PTB		NMi-VSL		INRIM		METAS		CMI		UME	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.00011	0.00029			0.00007	0.00081	0.00007	0.00031	0.00040	0.00053	0.00007	0.00093	0.0001	0.0015	0.0002	0.0012
PTB	0.00017	0.00075	0.00007	0.00081			0.00010	0.00091	0.00046	0.00091	0.0001	0.0012	0.0001	0.0013	0.0003	0.0014
NMi-VSL	0.00009	0.00083	0.00007	0.00031	0.00010	0.00091			0.0004	0.0012	0.0000	0.0014	0.0001	0.0016	0.0002	0.0017
INRIM	0.00034	0.00049	0.00040	0.00053	0.00046	0.00091	0.0004	0.0012			0.0004	0.0010	0.0005	0.0017	0.0002	0.0012
METAS	0.00007	0.00086	0.00007	0.00093	0.0001	0.0012	0.0000	0.0014	0.0004	0.0010			0.0001	0.0017	0.0002	0.0015
CMI	0.0002	0.0013	0.0001	0.0015	0.0001	0.0013	0.0001	0.0016	0.0005	0.0017	0.0001	0.0017			0.0003	0.0020
UME	0.0001	0.0011	0.0002	0.0012	0.0003	0.0014	0.0002	0.0017	0.0002	0.0012	0.0002	0.0015	0.0003	0.0020		
NMIA	0.00008	0.00046	0.00003	0.00049	0.00009	0.00090	0.00004	0.00055	0.00039	0.00065	0.0000	0.0010	0.0001	0.0017	0.0002	0.0013
SPRING	0.0003	0.0023	0.0003	0.0033	0.0002	0.0036	0.0003	0.0025	0.0007	0.0036	0.0003	0.0028	0.0002	0.0027	0.0005	0.0034
SCL	0.0002	0.0043	0.0003	0.0047	0.0004	0.0047	0.0003	0.0048	0.0001	0.0047	0.0003	0.0047	0.0004	0.0049	0.0001	0.0048
SNIIM	0.0005	0.0014	0.0005	0.0014	0.0005	0.0016	0.0005	0.0017	0.0009	0.0014	0.0005	0.0016	0.0004	0.0018	0.0007	0.0018
NIM	0.00032	0.00059	0.00028	0.00064	0.00025	0.00099	0.0002	0.0011	0.00066	0.00077	0.0003	0.0011	0.0002	0.0011	0.0004	0.0013
NRC	0.00095	0.00053	0.00089	0.00054	0.00084	0.00092	0.0009	0.0012	0.00129	0.00069	0.0009	0.0010	0.0008	0.0016	0.0011	0.0013
NIST	0.0002	0.0014	0.0003	0.0014	0.0003	0.0016	0.0003	0.0014	0.0005	0.0015	0.0002	0.0017	0.0003	0.0017	0.0003	0.0017
CSIR-NML	0.0001	0.0011	0.0002	0.0011	0.0003	0.0014	0.0002	0.0015	0.0003	0.0012	0.0002	0.0014	0.0003	0.0018	0.0001	0.0014
NPLI	0.0010	0.0024	0.0011	0.0024	0.0012	0.0025	0.0011	0.0027	0.0009	0.0027	0.0011	0.0026	0.0012	0.0028	0.0010	0.0027
NMIJ	0.00011	0.00054	0.00016	0.00056	0.00023	0.00093	0.0002	0.0012	0.00024	0.00070	0.0002	0.0010	0.0003	0.0017	0.0001	0.0011
SP	0.0001	0.0010	0.0001	0.0011	0.0002	0.0013	0.0001	0.0011	0.0004	0.0012	0.0001	0.0014	0.0002	0.0015	0.0002	0.0016
LNE	0.0007	0.0015	0.0007	0.0016	0.0007	0.0017	0.0007	0.0016	0.0005	0.0016	0.0007	0.0018	0.0008	0.0019	0.0006	0.0018

Table 22 – Degrees of equivalence for S_{21} measurements of device K5b.CL/2 (20 dB attenuator) at 9 GHz

Lab j ⇒

Lab i ⇓	NMIA		SPRING		SCL		SNIIM		NIM		NRC		NIST		CSIR-NML	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.00003	0.00049	0.0003	0.0033	0.0003	0.0047	0.0005	0.0014	0.00028	0.00064	0.00089	0.00054	0.0003	0.0014	0.0002	0.0011
PTB	0.00009	0.00090	0.0002	0.0036	0.0004	0.0047	0.0005	0.0016	0.00025	0.00099	0.00084	0.00092	0.0003	0.0016	0.0003	0.0014
NMi-VSL	0.00004	0.00055	0.0003	0.0025	0.0003	0.0048	0.0005	0.0017	0.0002	0.0011	0.0009	0.0012	0.0003	0.0014	0.0002	0.0015
INRIM	0.00039	0.00065	0.0007	0.0036	0.0001	0.0047	0.0009	0.0014	0.00066	0.00077	0.00129	0.00069	0.0005	0.0015	0.0003	0.0012
METAS	0.0000	0.0010	0.0003	0.0028	0.0003	0.0047	0.0005	0.0016	0.0003	0.0011	0.0009	0.0010	0.0002	0.0017	0.0002	0.0014
CMI	0.0001	0.0017	0.0002	0.0027	0.0004	0.0049	0.0004	0.0018	0.0002	0.0011	0.0008	0.0016	0.0003	0.0017	0.0003	0.0018
UME	0.0002	0.0013	0.0005	0.0034	0.0001	0.0048	0.0007	0.0018	0.0004	0.0013	0.0011	0.0013	0.0003	0.0017	0.0001	0.0014
NMIA			0.0003	0.0031	0.0003	0.0047	0.0005	0.0014	0.0003	0.00075	0.00090	0.00066	0.0003	0.0015	0.0002	0.0012
SPRING	0.0003	0.0031			0.0006	0.0058	0.0003	0.0019	0.0002	0.0012	0.0007	0.0024	0.0005	0.0021	0.0005	0.0028
SCL	0.0003	0.0047	0.0006	0.0058			0.0008	0.00048	0.0006	0.0047	0.0012	0.0047	0.0004	0.0049	0.0002	0.0048
SNIIM	0.0005	0.0014	0.0003	0.0019	0.0008	0.0048			0.0002	0.0015	0.0005	0.0014	0.0005	0.0020	0.0006	0.0018
NIM	0.0003	0.00075	0.0002	0.0012	0.0006	0.0047	0.0002	0.0015			0.00064	0.00078	0.0003	0.0015	0.0004	0.0013
NRC	0.00090	0.00066	0.0007	0.0024	0.0012	0.0047	0.0005	0.0014	0.00064	0.00078			0.0009	0.0015	0.0011	0.0012
NIST	0.0003	0.0015	0.0005	0.0021	0.0004	0.0049	0.0005	0.0020	0.0003	0.0015	0.0009	0.0015			0.0002	0.0018
CSIR-NML	0.0002	0.0012	0.0005	0.0028	0.0002	0.0048	0.0006	0.0018	0.0004	0.0013	0.0011	0.0012	0.0002	0.0018		
NPLI	0.0011	0.0024	0.0014	0.0039	0.0009	0.0054	0.0014	0.0026	0.0013	0.0024	0.0019	0.0023	0.0010	0.0027	0.0009	0.0027
NMIJ	0.00015	0.00068	0.0004	0.0034	0.0001	0.0047	0.0006	0.0014	0.00042	0.00079	0.00105	0.00071	0.0003	0.0015	0.0001	0.0012
SP	0.0001	0.0012	0.0003	0.0024	0.0003	0.0048	0.0004	0.0017	0.0002	0.0012	0.0009	0.0012	0.0002	0.0018	0.0002	0.0016
LNE	0.0007	0.0016	0.0008	0.0025	0.0006	0.0049	0.0011	0.0021	0.0009	0.0017	0.0015	0.0016	0.0009	0.0021	0.0007	0.0019

Table 22 cont'd – Degrees of equivalence for S_{21} measurements of device K5b.CL/2 (20 dB attenuator) at 9 GHz

Lab j ⇒

Lab i ⇓	NPLI		NMIJ		SP		LNE	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.0011	0.0024	0.00016	0.00056	0.0001	0.0011	0.0007	0.0016
PTB	0.0012	0.0025	0.00023	0.00093	0.0002	0.0013	0.0007	0.0017
NMi-VSL	0.0011	0.0027	0.0002	0.0012	0.0001	0.0011	0.0007	0.0016
INRIM	0.0009	0.0027	0.00024	0.00070	0.0004	0.0012	0.0005	0.0016
METAS	0.0011	0.0026	0.0002	0.0010	0.0001	0.0014	0.0007	0.0018
CMI	0.0012	0.0028	0.0003	0.0017	0.0002	0.0015	0.0008	0.0019
UME	0.0010	0.0027	0.0001	0.0011	0.0002	0.0016	0.0006	0.0018
NMIA	0.0011	0.0024	0.00015	0.00068	0.0001	0.0012	0.0007	0.0016
SPRING	0.0014	0.0039	0.0004	0.0034	0.0003	0.0024	0.0008	0.0025
SCL	0.0009	0.0054	0.0001	0.0047	0.0003	0.0048	0.0006	0.0049
SNIIM	0.0014	0.0026	0.0006	0.0014	0.0004	0.0017	0.0011	0.0021
NIM	0.0013	0.0024	0.00042	0.00079	0.0002	0.0012	0.0009	0.0017
NRC	0.0019	0.0023	0.00105	0.00071	0.0009	0.0012	0.0015	0.0016
NIST	0.0010	0.0027	0.0003	0.0015	0.0002	0.0018	0.0009	0.0021
CSIR-NML	0.0009	0.0027	0.0001	0.0012	0.0002	0.0016	0.0007	0.0019
NPLI			0.0010	0.0025	0.0011	0.0026	0.0014	0.0033
NMIJ	0.0010	0.0025			0.0002	0.0012	0.0006	0.0016
SP	0.0011	0.0026	0.0002	0.0012			0.0008	0.0019
LNE	0.0014	0.0033	0.0006	0.0016	0.0008	0.0019		

Table 22 cont'd – Degrees of equivalence for S_{21} measurements of device K5b.CL/2 (20 dB attenuator) at 9 GHz

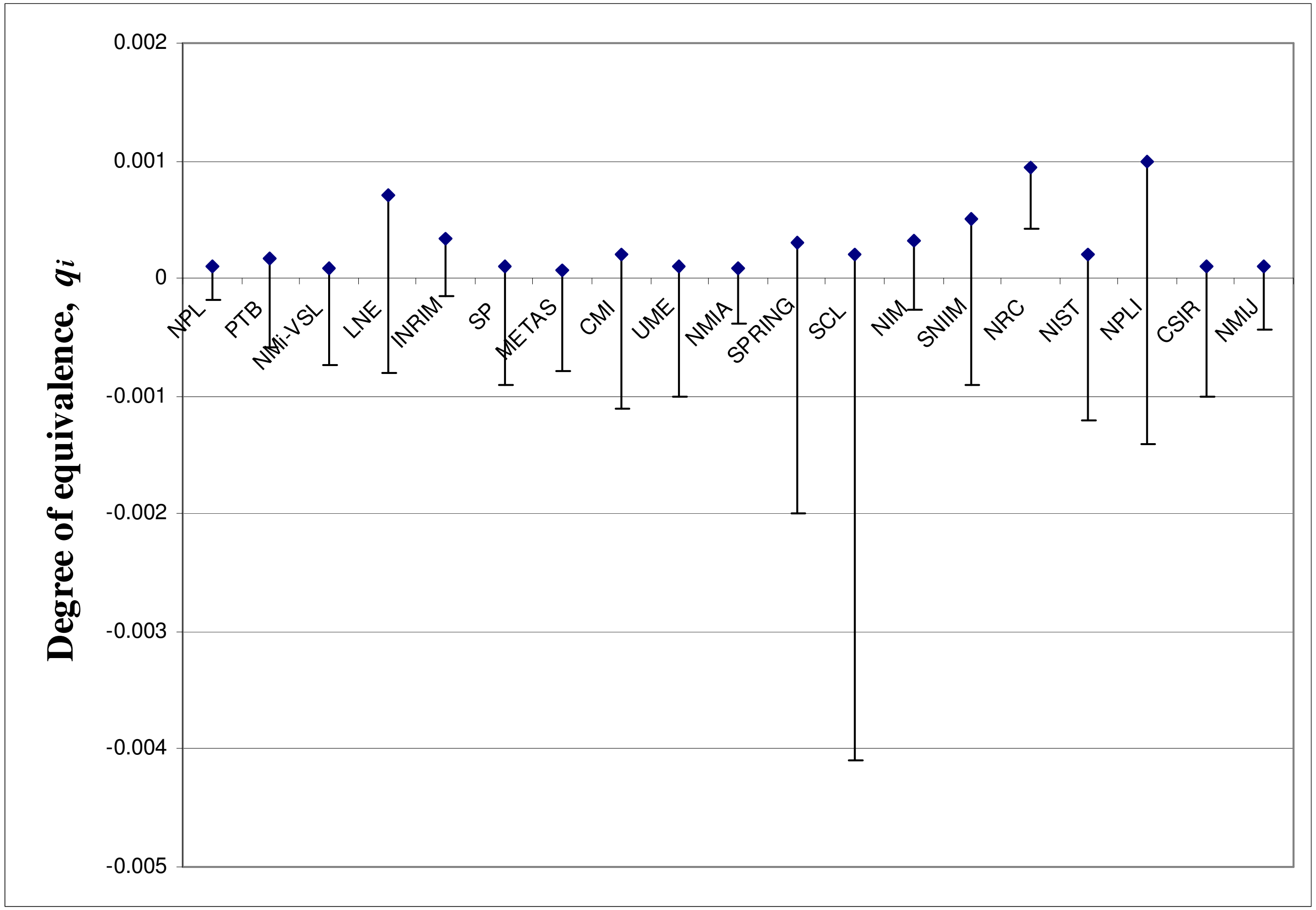

Fig 20 – Reduced dimension degrees of equivalence and their confidence indicators for S_{21} measurements of device K5b.CL/2 (20 dB attenuator) at 9 GHz

Lab j ⇒

Lab i ⇓	KCRV		NPL		PTB		NMi-VSL		INRIM		METAS		CMI		UME	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.00021	0.00043			0.0002	0.0010	0.00019	0.00052	0.00094	0.00071	0.0002	0.0011	0.0004	0.0021	0.0006	0.0030
PTB	0.00008	0.00092	0.0002	0.0010			0.0001	0.0012	0.0007	0.0011	0.0001	0.0014	0.0005	0.0034	0.0004	0.0030
NMi-VSL	0.00005	0.00053	0.00019	0.00052	0.0001	0.0012			0.0009	0.0011	0.0000	0.0011	0.0004	0.0034	0.0005	0.0030
INRIM	0.00082	0.00066	0.00094	0.00071	0.0007	0.0011	0.0009	0.0011			0.0009	0.0012	0.0012	0.0031	0.0004	0.0029
METAS	0.00006	0.00096	0.0002	0.0011	0.0001	0.0014	0.0000	0.0011	0.0009	0.0012			0.0004	0.0035	0.0005	0.0030
CMI	0.0004	0.0028	0.0004	0.0021	0.0005	0.0034	0.0004	0.0034	0.0012	0.0031	0.0004	0.0035			0.0009	0.0044
UME	0.0004	0.0026	0.0006	0.0030	0.0004	0.0030	0.0005	0.0030	0.0004	0.0029	0.0005	0.0030	0.0009	0.0044		
NMIA	0.00017	0.00053	0.00035	0.00066	0.0002	0.0011	0.00016	0.00060	0.00088	0.00082	0.0002	0.0011	0.0004	0.0018	0.0005	0.0026
SPRING	0.0007	0.0033	0.0007	0.0018	0.0008	0.0047	0.0007	0.0039	0.0015	0.0068	0.0007	0.0041	0.0004	0.0022	0.0012	0.0071
SCL	0.0008	0.0080	0.0009	0.0066	0.0007	0.0084	0.0008	0.0089	0.0001	0.0038	0.0008	0.0083	0.0012	0.0089	0.000	0.011
SNIIM	0.0011	0.0016	0.0010	0.0016	0.0012	0.0018	0.0011	0.0020	0.0020	0.0017	0.0011	0.0018	0.0007	0.0032	0.0016	0.0033
NIM	0.00074	0.00066	0.00069	0.00077	0.0006	0.0011	0.00077	0.00070	0.00071	0.00085	0.0007	0.0012	0.0010	0.0020	0.0006	0.0024
NRC	0.0015	0.0013	0.0015	0.0013	0.0016	0.0015	0.0015	0.0017	0.0024	0.0014	0.0015	0.0016	0.0011	0.0035	0.0020	0.0031
NIST	0.0004	0.0037	0.0004	0.0027	0.0003	0.0038	0.0004	0.0038	0.0005	0.0018	0.0004	0.0040	0.0008	0.0051	0.0002	0.0029
CSIR-NML	0.0009	0.0015	0.0010	0.0015	0.0009	0.0017	0.0010	0.0018	0.0002	0.0016	0.0010	0.0018	0.0014	0.0036	0.0005	0.0030
NPLI	0.0008	0.0035	0.0009	0.0043	0.0008	0.0037	0.0009	0.0036	0.0003	0.0031	0.0009	0.0039	0.0012	0.0049	0.0004	0.0037
NMIJ	0.00006	0.00075	0.00022	0.00078	0.0001	0.0012	0.00003	0.00075	0.00087	0.00093	0.0001	0.0012	0.0004	0.0029	0.0005	0.0028
SP	0.0002	0.0016	0.0003	0.0018	0.0003	0.0020	0.0001	0.0018	0.0009	0.0018	0.0002	0.0020	0.0003	0.0029	0.0006	0.0032
LNE	0.0005	0.0011	0.0007	0.0011	0.0005	0.0014	0.0005	0.0013	0.0008	0.0012	0.0005	0.0015	0.0007	0.0018	0.0006	0.0025

Table 23 – Degrees of equivalence for S_{21} measurements of device K5b.CL/2 (20 dB attenuator) at 18 GHz

Lab j ⇒

Lab i ⇓	NMIA		SPRING		SCL		SNIIM		NIM		NRC		NIST		CSIR-NML	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.00035	0.00066	0.0007	0.0018	0.0009	0.0066	0.0010	0.0016	0.00069	0.00077	0.0015	0.0013	0.0004	0.0027	0.0010	0.0015
PTB	0.0002	0.0011	0.0008	0.0047	0.0007	0.0084	0.0012	0.0018	0.0006	0.0011	0.0016	0.0015	0.0003	0.0038	0.0009	0.0017
NMi-VSL	0.00016	0.00060	0.0007	0.0039	0.0008	0.0089	0.0011	0.0020	0.00077	0.00070	0.0015	0.0017	0.0004	0.0038	0.0010	0.0018
INRIM	0.00088	0.00082	0.0015	0.0068	0.0001	0.0038	0.0020	0.0017	0.00071	0.00085	0.0024	0.0014	0.0005	0.0018	0.0002	0.0016
METAS	0.0002	0.0011	0.0007	0.0041	0.0008	0.0083	0.0011	0.0018	0.0007	0.0012	0.0015	0.0016	0.0004	0.0040	0.0010	0.0018
CMI	0.0004	0.0018	0.0004	0.0022	0.0012	0.0089	0.0007	0.0032	0.0010	0.0020	0.0011	0.0035	0.0008	0.0051	0.0014	0.0036
UME	0.0005	0.0026	0.0012	0.0071	0.000	0.011	0.0016	0.0033	0.0006	0.0024	0.0020	0.0031	0.0002	0.0029	0.0005	0.0030
NMIA			0.0007	0.0066	0.001	0.011	0.0011	0.0016	0.00090	0.00086	0.0015	0.0013	0.0005	0.0028	0.0010	0.0016
SPRING	0.0007	0.0066			0.001	0.012	0.0006	0.0022	0.0014	0.0021	0.0009	0.0035	0.0011	0.0058	0.0017	0.0066
SCL	0.001	0.011	0.001	0.012			0.0019	0.0076	0.0006	0.0038	0.0023	0.0083	0.0004	0.0060	0.000	0.011
SNIIM	0.0011	0.0016	0.0006	0.0022	0.0019	0.0076			0.0016	0.0017	0.0005	0.0020	0.0015	0.0035	0.0021	0.0021
NIM	0.00090	0.00086	0.0014	0.0021	0.0006	0.0038	0.0016	0.0017			0.0021	0.0014	0.0004	0.0016	0.0007	0.0016
NRC	0.0015	0.0013	0.0009	0.0035	0.0023	0.0083	0.0005	0.0020	0.0021	0.0014			0.0019	0.0035	0.0025	0.0019
NIST	0.0005	0.0028	0.0011	0.0058	0.0004	0.0060	0.0015	0.0035	0.0004	0.0016	0.0019	0.0035			0.0006	0.0031
CSIR-NML	0.0010	0.0016	0.0017	0.0066	0.000	0.011	0.0021	0.0021	0.0007	0.0016	0.0025	0.0019	0.0006	0.0031		
NPLI	0.0010	0.0033	0.0016	0.0065	0.0002	0.0064	0.0019	0.0050	0.0005	0.0059	0.0024	0.0046	0.0005	0.0058	0.0002	0.0052
NMIJ	0.00013	0.00086	0.0007	0.0047	0.00082	0.00935	0.0011	0.0017	0.00110	0.00172	0.0015	0.0014	0.0004	0.0037	0.0010	0.0016
SP	0.0001	0.0018	0.0006	0.0069	0.001	0.010	0.0010	0.0023	0.0009	0.0019	0.0014	0.0021	0.0006	0.0040	0.0011	0.0023
LNE	0.0003	0.0012	0.0009	0.0031	0.0008	0.0086	0.0014	0.0019	0.0011	0.0012	0.0017	0.0016	0.0007	0.0020	0.0010	0.0018

Table 23 cont'd – Degrees of equivalence for S_{21} measurements of device K5b.CL/2 (20 dB attenuator) at 18 GHz

Lab $j \Rightarrow$

Lab $i \Downarrow$	NPLI		NMIJ		SP		LNE	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.0009	0.0043	0.00022	0.00078	0.0003	0.0018	0.0007	0.0011
PTB	0.0008	0.0037	0.0001	0.0012	0.0003	0.0020	0.0005	0.0014
NMi-VSL	0.0009	0.0036	0.00003	0.00075	0.0001	0.0018	0.0005	0.0013
INRIM	0.0003	0.0031	0.00087	0.00093	0.0009	0.0018	0.0008	0.0012
METAS	0.0009	0.0039	0.0001	0.0012	0.0002	0.0020	0.0005	0.0015
CMI	0.0012	0.0049	0.0004	0.0029	0.0003	0.0029	0.0007	0.0018
UME	0.0004	0.0037	0.0005	0.0028	0.0006	0.0032	0.0006	0.0025
NMIA	0.0010	0.0033	0.00013	0.00086	0.0001	0.0018	0.0003	0.0012
SPRING	0.0016	0.0065	0.0007	0.0047	0.0006	0.0069	0.0009	0.0031
SCL	0.0002	0.0064	0.0008	0.0092	0.001	0.010	0.0008	0.0086
SNIIM	0.0019	0.0050	0.0011	0.0017	0.0010	0.0023	0.0014	0.0019
NIM	0.0005	0.0059	0.00080	0.00095	0.0009	0.0019	0.0011	0.0012
NRC	0.0024	0.0046	0.0015	0.0014	0.0014	0.0021	0.0017	0.0016
NIST	0.0005	0.0058	0.0004	0.0037	0.0006	0.0040	0.0007	0.0020
CSIR-NML	0.0002	0.0052	0.0010	0.0016	0.0011	0.0023	0.0010	0.0018
NPLI			0.0009	0.0036	0.0010	0.0039	0.0010	0.0030
NMIJ	0.0009	0.0036			0.0001	0.0019	0.0004	0.0013
SP	0.0010	0.0039	0.0001	0.0019			0.0004	0.0020
LNE	0.0010	0.0030	0.0004	0.0013	0.0004	0.0020		

Table 23 cont'd – Degrees of equivalence for S_{21} measurements of device K5b.CL/2 (20 dB attenuator) at 18 GHz

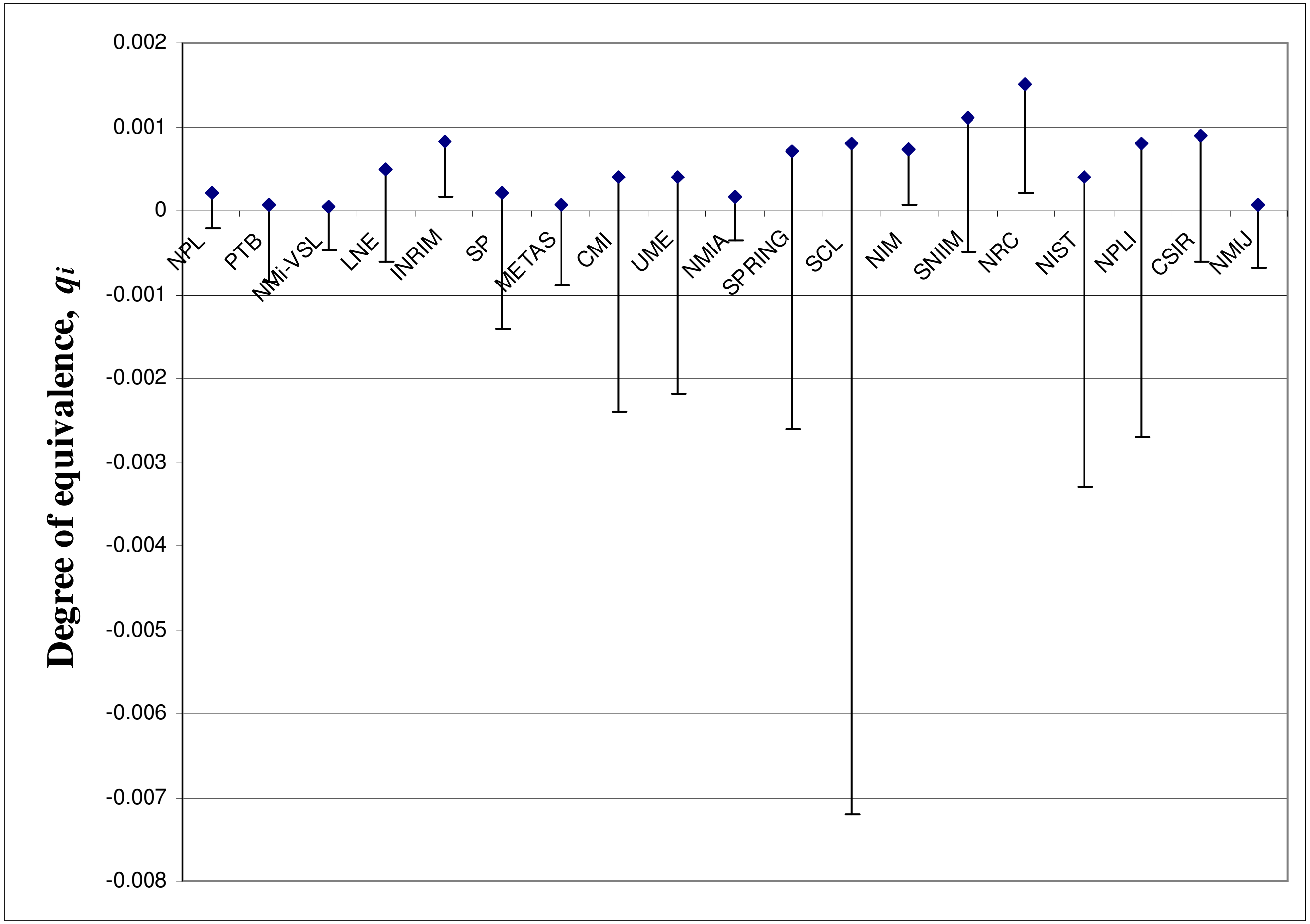

Fig 21 – Reduced dimension degrees of equivalence and their confidence indicators for S_{21} measurements of device K5b.CL/2 (20 dB attenuator) at 18 GHz

Lab j ⇒

Lab i ⇓	KCRV		NPL		PTB		NMi-VSL		INRIM		METAS		CMI		UME	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.000008	0.000023			0.000006	0.000031	0.000010	0.000053	0.000003	0.000052	0.000003	0.000037	0.000009	0.000057	0.000011	0.000093
PTB	0.000005	0.000022	0.000006	0.000031			0.000008	0.000057	0.000004	0.000052	0.000003	0.000037	0.000003	0.000059	0.000008	0.000093
NMi-VSL	0.000004	0.000050	0.000010	0.000053	0.000008	0.000057			0.000008	0.000067	0.000008	0.000057	0.000010	0.000075	0.00000	0.00011
INRIM	0.000005	0.000045	0.000003	0.000052	0.000004	0.000052	0.000008	0.000067			0.000001	0.000056	0.000007	0.000072	0.00001	0.00010
METAS	0.000005	0.000029	0.000003	0.000037	0.000003	0.000037	0.000008	0.000057	0.000001	0.000056			0.000006	0.000062	0.000008	0.000095
CMI	0.000007	0.000049	0.000009	0.000057	0.000003	0.000059	0.000010	0.000075	0.000007	0.000072	0.000006	0.000062			0.00001	0.00010
UME	0.000003	0.000084	0.000011	0.000093	0.000008	0.000093	0.00000	0.00011	0.00001	0.00010	0.000008	0.000095	0.00001	0.00010		
NMIA	0.000010	0.000028	0.000015	0.000036	0.000008	0.000037	0.000012	0.000069	0.000013	0.000055	0.000012	0.000042	0.000006	0.000058	0.000011	0.000098
SPRING	0.000002	0.000056	0.000010	0.000062	0.000007	0.000062	0.000003	0.000080	0.000008	0.000075	0.000007	0.000063	0.000008	0.000075	0.00000	0.00011
SCL	0.000005	0.000076	0.000008	0.000084	0.000009	0.000084	0.000004	0.000098	0.000006	0.000093	0.000007	0.000088	0.000011	0.000097	0.00001	0.00012
SNIIM	0.000003	0.000067	0.000005	0.000069	0.000004	0.000070	0.000006	0.000082	0.000003	0.000081	0.000002	0.000074	0.000006	0.000086	0.00001	0.00011
NIM	0.000011	0.000015	0.000016	0.000026	0.000010	0.000027	0.000013	0.000065	0.000014	0.000050	0.000013	0.000034	0.000008	0.000053	0.000012	0.000095
NRC	0.000019	0.000052	0.000021	0.000056	0.000023	0.000056	0.000016	0.000081	0.000021	0.000070	0.000021	0.000060	0.000026	0.000074	0.00002	0.00011
NIST	0.000003	0.000028	0.000005	0.000035	0.000005	0.000035	0.000006	0.000055	0.000002	0.000055	0.000003	0.000042	0.000007	0.000061	0.000006	0.000094
CSIR-NML	0.000007	0.000019	0.000002	0.000028	0.000007	0.000028	0.000009	0.000051	0.000003	0.000050	0.000004	0.000035	0.000010	0.000057	0.000010	0.000092
NPLI	0.0000	0.0013	0.0000	0.0012	0.0000	0.0014	0.0000	0.0011	0.0000	0.0012	0.000046	0.001000	0.0000	0.0012	0.0000	0.0013
NMIJ	0.000003	0.000049	0.000008	0.000053	0.000003	0.000054	0.000006	0.000074	0.000005	0.000068	0.000004	0.000058	0.000004	0.000071	0.00001	0.00010
SP	0.000020	0.000049	0.000013	0.000056	0.000016	0.000056	0.000023	0.000070	0.000015	0.000070	0.000015	0.000059	0.000017	0.000070	0.00002	0.00010
LNE	0.000003	0.000049	0.000008	0.000053	0.000003	0.000054	0.000006	0.000074	0.000005	0.000068	0.000004	0.000057	0.000004	0.000071	0.00001	0.00011

Table 24 – Degrees of equivalence for S_{21} measurements of device K5b.CL/3 (50 dB attenuator) at 2 GHz

Lab $j \Rightarrow$

Lab $i \Downarrow$	NMIA		SPRING		SCL		SNIIM		NIM		NRC		NIST		CSIR-NML	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.000015	0.000036	0.000010	0.000062	0.000008	0.000084	0.000005	0.000069	0.000016	0.000026	0.000021	0.000056	0.000005	0.000035	0.000002	0.000028
PTB	0.000008	0.000037	0.000007	0.000062	0.000009	0.000084	0.000004	0.000070	0.000010	0.000027	0.000023	0.000056	0.000005	0.000035	0.000007	0.000028
NMi-VSL	0.000012	0.000069	0.000003	0.000080	0.000004	0.000098	0.000006	0.000082	0.000013	0.000065	0.000016	0.000081	0.000006	0.000055	0.000009	0.000051
INRIM	0.000013	0.000055	0.000008	0.000075	0.000006	0.000093	0.000003	0.000081	0.000014	0.000050	0.000021	0.000070	0.000002	0.000055	0.000003	0.000050
METAS	0.000012	0.000042	0.000007	0.000063	0.000007	0.000088	0.000002	0.000074	0.000013	0.000034	0.000021	0.000060	0.000003	0.000042	0.000004	0.000035
CMI	0.000006	0.000058	0.000008	0.000075	0.000011	0.000097	0.000006	0.000086	0.000008	0.000053	0.000026	0.000074	0.000007	0.000061	0.000010	0.000057
UME	0.000011	0.000098	0.00000	0.00011	0.00001	0.00012	0.00001	0.00011	0.000012	0.000095	0.00002	0.00011	0.000006	0.000094	0.000010	0.000092
NMIA			0.000010	0.000058	0.000015	0.000086	0.000011	0.000072	0.000002	0.000033	0.000028	0.000059	0.000012	0.000040	0.000015	0.000034
SPRING	0.000010	0.000058			0.000006	0.000095	0.000005	0.000088	0.000011	0.000052	0.000019	0.000072	0.000006	0.000064	0.000009	0.000059
SCL	0.000015	0.000086	0.000006	0.000095			0.00000	0.00010	0.000016	0.000082	0.000015	0.000096	0.000004	0.000085	0.000006	0.000083
SNIIM	0.000011	0.000072	0.000005	0.000088	0.00000	0.00010			0.000013	0.000068	0.000020	0.000084	0.000001	0.000072	0.000005	0.000068
NIM	0.000002	0.000033	0.000011	0.000052	0.000016	0.000082	0.000013	0.000068			0.000029	0.000054	0.000014	0.000032	0.000017	0.000023
NRC	0.000028	0.000059	0.000019	0.000072	0.000015	0.000096	0.000020	0.000084	0.000029	0.000054			0.000019	0.000058	0.000019	0.000054
NIST	0.000012	0.000040	0.000006	0.000064	0.000004	0.000085	0.000001	0.000072	0.000014	0.000032	0.000019	0.000058			0.000004	0.000033
CSIR-NML	0.000015	0.000034	0.000009	0.000059	0.000006	0.000083	0.000005	0.000068	0.000017	0.000023	0.000019	0.000054	0.000004	0.000033		
NPLI	0.00004	0.00086	0.0000	0.0013	0.00004	0.00095	0.0000	0.0013	0.00004	0.00078	0.00004	0.00041	0.0000	0.0012	0.0000	0.0011
NMIJ	0.000008	0.000057	0.000004	0.000075	0.000007	0.000094	0.000003	0.000082	0.000010	0.000051	0.000022	0.000071	0.000004	0.000056	0.000008	0.000052
SP	0.000022	0.000059	0.000022	0.000079	0.000021	0.000096	0.000017	0.000084	0.000024	0.000054	0.000033	0.000073	0.000017	0.000058	0.000015	0.000054
LNE	0.000008	0.000057	0.000004	0.000075	0.000007	0.000094	0.000003	0.000082	0.000010	0.000051	0.000022	0.000071	0.000004	0.000056	0.000008	0.000052

Table 24 cont'd – Degrees of equivalence for S_{21} measurements of device K5b.CL/3 (50 dB attenuator) at 2 GHz

Lab i ⇓	Lab j ⇒ NPLI		NMIJ		SP		LNE	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.0000	0.0012	0.000008	0.000053	0.000013	0.000056	0.000008	0.000053
PTB	0.0000	0.0014	0.000003	0.000054	0.000016	0.000056	0.000003	0.000054
NMi-VSL	0.0000	0.0011	0.000006	0.000074	0.000023	0.000070	0.000006	0.000074
INRIM	0.0000	0.0012	0.000005	0.000068	0.000015	0.000070	0.000005	0.000068
METAS	0.0000	0.0012	0.000004	0.000058	0.000015	0.000059	0.000004	0.000057
CMI	0.0000	0.0012	0.000004	0.000071	0.000017	0.000070	0.000004	0.000071
UME	0.0000	0.0013	0.00001	0.00010	0.00002	0.00010	0.00001	0.00010
NMIA	0.00004	0.00086	0.000008	0.000057	0.000022	0.000059	0.000008	0.000057
SPRING	0.0000	0.0013	0.000004	0.000075	0.000022	0.000079	0.000004	0.000075
SCL	0.00004	0.00095	0.000007	0.000094	0.000021	0.000096	0.000007	0.000094
SNIIM	0.0000	0.0013	0.000003	0.000082	0.000017	0.000084	0.000003	0.000082
NIM	0.00004	0.00078	0.000010	0.000051	0.000024	0.000054	0.000010	0.000051
NRC	0.00004	0.00041	0.000022	0.000071	0.000033	0.000073	0.000022	0.000071
NIST	0.0000	0.0012	0.000004	0.000056	0.000017	0.000058	0.000004	0.000056
CSIR-NML	0.0000	0.0011	0.000008	0.000052	0.000015	0.000054	0.000008	0.000052
NPLI			0.0000	0.0014	0.0001	0.0014	0.0000	0.0014
NMIJ	0.0000	0.0014			0.000018	0.000071	0.000000	0.000069
SP	0.0001	0.0014	0.000018	0.000071			0.000018	0.000071
LNE	0.0000	0.0014	0.000000	0.000069	0.000018	0.000071		

Table 24 cont'd – Degrees of equivalence for S_{21} measurements of device K5b.CL/3 (50 dB attenuator) at 2 GHz

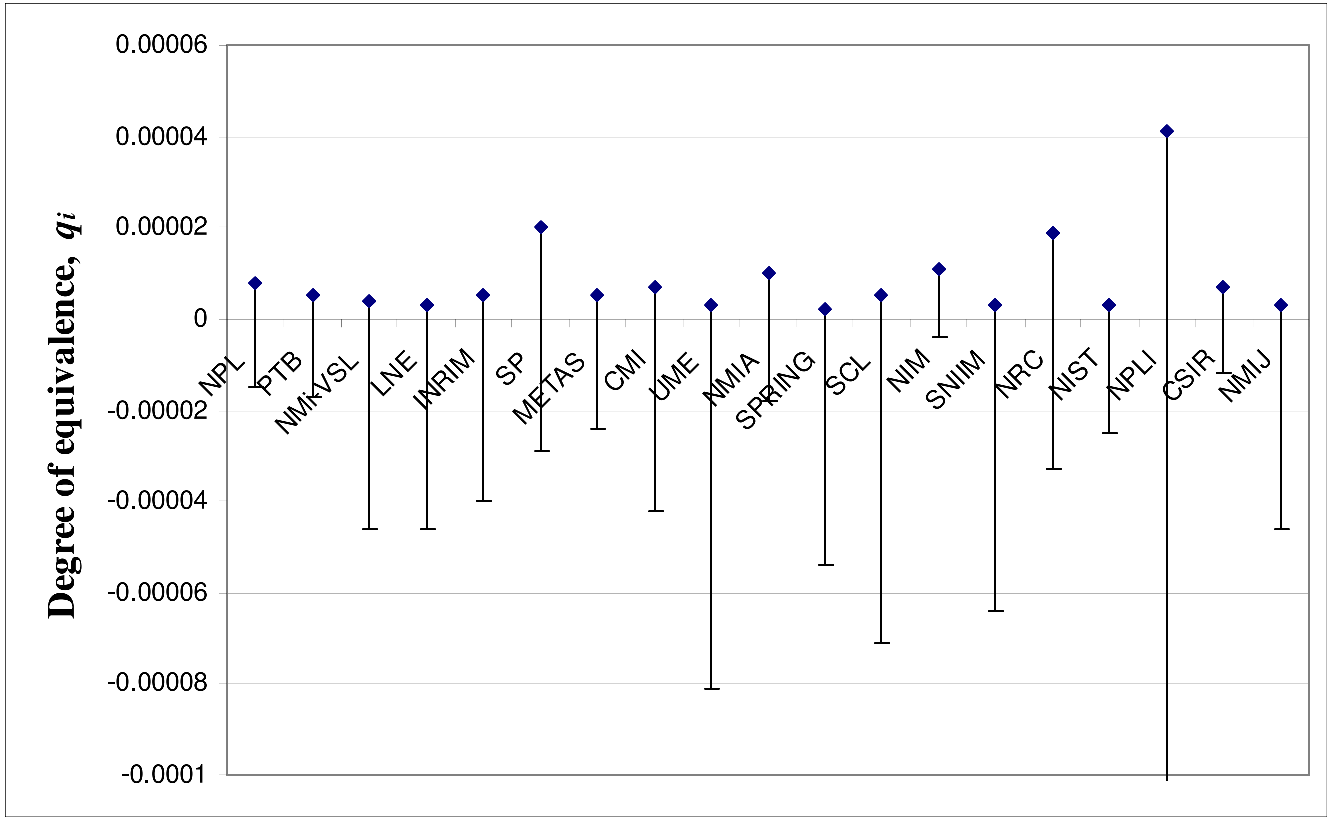

Fig 22 – Reduced dimension degrees of equivalence and their confidence indicators for S_{21} measurements of device K5b.CL/3 (50 dB attenuator) at 2 GHz

Lab j ⇒

Lab i ⇓	KCRV		NPL		PTB		NMi-VSL		INRIM		METAS		CMI		UME	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.000014	0.000039			0.000014	0.000047	0.000011	0.000057	0.000006	0.000062	0.000009	0.000070	0.000016	0.000079	0.00001	0.00037
PTB	0.000011	0.000033	0.000014	0.000047			0.000005	0.000069	0.000019	0.000055	0.000005	0.000065	0.000002	0.000080	0.00001	0.00035
NMi-VSL	0.000007	0.000063	0.000011	0.000057	0.000005	0.000069			0.000015	0.000067	0.000003	0.000076	0.000006	0.000087	0.00000	0.00036
INRIM	0.000016	0.000045	0.000006	0.000062	0.000019	0.000055	0.000015	0.000067			0.000014	0.000076	0.000021	0.000082	0.00001	0.00037
METAS	0.000009	0.000058	0.000009	0.000070	0.000005	0.000065	0.000003	0.000076	0.000014	0.000076			0.000007	0.000090	0.00001	0.00036
CMI	0.000011	0.000062	0.000016	0.000079	0.000002	0.000080	0.000006	0.000087	0.000021	0.000082	0.000007	0.000090			0.00001	0.00036
UME	0.00000	0.00033	0.00001	0.00037	0.00001	0.00035	0.00000	0.00036	0.00001	0.00037	0.00001	0.00036	0.00001	0.00036		
NMIA	0.000013	0.000032	0.000003	0.000050	0.000011	0.000042	0.000009	0.000053	0.000009	0.000058	0.000006	0.000067	0.000013	0.000077	0.00001	0.00037
SPRING	0.00002	0.00011	0.000026	0.000093	0.000012	0.000099	0.00002	0.00011	0.00003	0.00010	0.00002	0.00011	0.00001	0.00013	0.00002	0.00037
SCL	0.00001	0.00015	0.00001	0.00015	0.00001	0.00022	0.00001	0.00022	0.00001	0.00020	0.00001	0.00021	0.00001	0.00023	0.00000	0.00042
SNIIM	0.000030	0.000099	0.00004	0.00011	0.00003	0.00010	0.00003	0.00011	0.00004	0.00011	0.00003	0.00011	0.00002	0.00012	0.00003	0.00038
NIM	0.000018	0.000023	0.000025	0.000042	0.000011	0.000032	0.000015	0.000050	0.000030	0.000052	0.000016	0.000062	0.000010	0.000071	0.00002	0.00036
NRC	0.000031	0.000076	0.000035	0.000083	0.000022	0.000078	0.000026	0.000095	0.000041	0.000088	0.000027	0.000094	0.000021	0.000096	0.00003	0.00036
NIST	0.000008	0.000065	0.000018	0.000063	0.000007	0.000047	0.000007	0.000065	0.000022	0.000074	0.000010	0.000075	0.000006	0.000084	0.00001	0.00037
CSIR-NML	0.000010	0.000035	0.000005	0.000051	0.000013	0.000043	0.000009	0.000060	0.000007	0.000059	0.000008	0.000068	0.000015	0.000073	0.00001	0.00037
NPLI	0.0001	0.0035	0.0001	0.0035	0.0001	0.0035	0.0001	0.0035	0.0001	0.0035	0.0001	0.0035	0.0001	0.0035	0.0001	0.0035
NMIJ	0.000011	0.000052	0.000008	0.000062	0.000006	0.000056	0.000004	0.000069	0.000014	0.000069	0.000001	0.000077	0.000008	0.000086	0.00001	0.00036
SP	0.000015	0.000098	0.00003	0.00011	0.00003	0.00011	0.00002	0.00012	0.00003	0.00011	0.00002	0.00012	0.00003	0.00012	0.00002	0.00037
LNE	0.000011	0.000052	0.000008	0.000062	0.000006	0.000056	0.000004	0.000069	0.000014	0.000069	0.000001	0.000077	0.000008	0.000086	0.00001	0.00036

Table 25 – Degrees of equivalence for S_{21} measurements of device K5b.CL/3 (50 dB attenuator) at 9 GHz

Lab $j \Rightarrow$

Lab $i \Downarrow$	NMIA		SPRING		SCL		SNIIM		NIM		NRC		NIST		CSIR-NML	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.000003	0.000050	0.000026	0.000093	0.00001	0.00015	0.00004	0.00011	0.000025	0.000042	0.000035	0.000083	0.000018	0.000063	0.000005	0.000051
PTB	0.000011	0.000042	0.000012	0.000099	0.00001	0.00022	0.00003	0.00010	0.000011	0.000032	0.000022	0.000078	0.000007	0.000047	0.000013	0.000043
NMi-VSL	0.000009	0.000053	0.00002	0.00011	0.00001	0.00022	0.00003	0.00011	0.000015	0.000050	0.000026	0.000095	0.000007	0.000065	0.000009	0.000060
INRIM	0.000009	0.000058	0.00003	0.00010	0.00001	0.00020	0.00004	0.00011	0.000030	0.000052	0.000041	0.000088	0.000022	0.000074	0.000007	0.000059
METAS	0.000006	0.000067	0.00002	0.00011	0.00001	0.00021	0.00003	0.00011	0.000016	0.000062	0.000027	0.000094	0.000010	0.000075	0.000008	0.000068
CMI	0.000013	0.000077	0.00001	0.00013	0.00001	0.00023	0.00002	0.00012	0.000010	0.000071	0.000021	0.000096	0.000006	0.000084	0.000015	0.000073
UME	0.00001	0.00037	0.00002	0.00037	0.00000	0.00042	0.00003	0.00038	0.00002	0.00036	0.00003	0.00036	0.00001	0.00037	0.00001	0.00037
NMIA			0.000023	0.000088	0.00001	0.00015	0.00004	0.00010	0.000023	0.000037	0.000032	0.000080	0.000016	0.000057	0.000006	0.000047
SPRING	0.000023	0.000088			0.00002	0.00024	0.00002	0.00011	0.000006	0.000073	0.00001	0.00013	0.00001	0.00012	0.00003	0.00010
SCL	0.00001	0.00015	0.00002	0.00024			0.00004	0.00023	0.00002	0.00022	0.00003	0.00023	0.00001	0.00020	0.00000	0.00020
SNIIM	0.00004	0.00010	0.00002	0.00011	0.00004	0.00023			0.00002	0.00010	0.00002	0.00012	0.00002	0.00012	0.00004	0.00010
NIM	0.000023	0.000037	0.000006	0.000073	0.00002	0.00022	0.00002	0.00010			0.000014	0.000076	0.000010	0.000063	0.000024	0.000039
NRC	0.000032	0.000080	0.00001	0.00013	0.00003	0.00023	0.00002	0.00012	0.000014	0.000076			0.000023	0.000094	0.000035	0.000081
NIST	0.000016	0.000057	0.00001	0.00012	0.00001	0.00020	0.00002	0.00012	0.000010	0.000063	0.000023	0.000094			0.000015	0.000066
CSIR-NML	0.000006	0.000047	0.00003	0.00010	0.00000	0.00020	0.00004	0.00010	0.000024	0.000039	0.000035	0.000081	0.000015	0.000066		
NPLI	0.0001	0.0035	0.0001	0.0035	0.0001	0.0035	0.0001	0.0036	0.0001	0.0035	0.0002	0.0035	0.0001	0.0035	0.0001	0.0035
NMIJ	0.000005	0.000058	0.00002	0.00010	0.00001	0.00019	0.00003	0.00011	0.000017	0.000052	0.000027	0.000088	0.000011	0.000066	0.000009	0.000060
SP	0.00003	0.00011	0.00003	0.00015	0.00002	0.00018	0.00004	0.00014	0.00003	0.00010	0.00004	0.00013	0.00002	0.00011	0.00002	0.00011
LNE	0.000005	0.000058	0.00002	0.00010	0.00001	0.00019	0.00003	0.00011	0.000017	0.000052	0.000027	0.000088	0.000011	0.000066	0.000009	0.000060

Table 25 cont’d – Degrees of equivalence for S_{21} measurements of device K5b.CL/3 (50 dB attenuator) at 9 GHz

Lab $j \Rightarrow$

Lab $i \Downarrow$	NPLI		NMIJ		SP		LNE	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.0001	0.0035	0.000008	0.000062	0.00003	0.00011	0.000008	0.000062
PTB	0.0001	0.0035	0.000006	0.000056	0.00003	0.00011	0.000006	0.000056
NMi-VSL	0.0001	0.0035	0.000004	0.000069	0.00002	0.00012	0.000004	0.000069
INRIM	0.0001	0.0035	0.000014	0.000069	0.00003	0.00011	0.000014	0.000069
METAS	0.0001	0.0035	0.000001	0.000077	0.00002	0.00012	0.000001	0.000077
CMI	0.0001	0.0035	0.000008	0.000086	0.00003	0.00012	0.000008	0.000086
UME	0.0001	0.0035	0.00001	0.00036	0.00002	0.00037	0.00001	0.00036
NMIA	0.0001	0.0035	0.000005	0.000058	0.00003	0.00011	0.000005	0.000058
SPRING	0.0001	0.0035	0.00002	0.00010	0.00003	0.00015	0.00002	0.00010
SCL	0.0001	0.0035	0.00001	0.00019	0.00002	0.00018	0.00001	0.00019
SNIIM	0.0001	0.0036	0.00003	0.00011	0.00004	0.00014	0.00003	0.00011
NIM	0.0001	0.0035	0.000017	0.000052	0.00003	0.00010	0.000017	0.000052
NRC	0.0002	0.0035	0.000027	0.000088	0.00004	0.00013	0.000027	0.000088
NIST	0.0001	0.0035	0.000011	0.000066	0.00002	0.00011	0.000011	0.000066
CSIR-NML	0.0001	0.0035	0.000009	0.000060	0.00002	0.00011	0.000009	0.000060
NPLI			0.000135	0.004000	0.0001	0.0035	0.0001	0.0035
NMIJ	0.0001	0.0035			0.00003	0.00011	0.000000	0.000069
SP	0.0001	0.0035	0.00003	0.00011			0.00003	0.00011
LNE	0.0001	0.0035	0.000000	0.000069	0.00003	0.00011		

Table 25 cont'd – Degrees of equivalence for S_{21} measurements of device K5b.CL/3 (50 dB attenuator) at 9 GHz

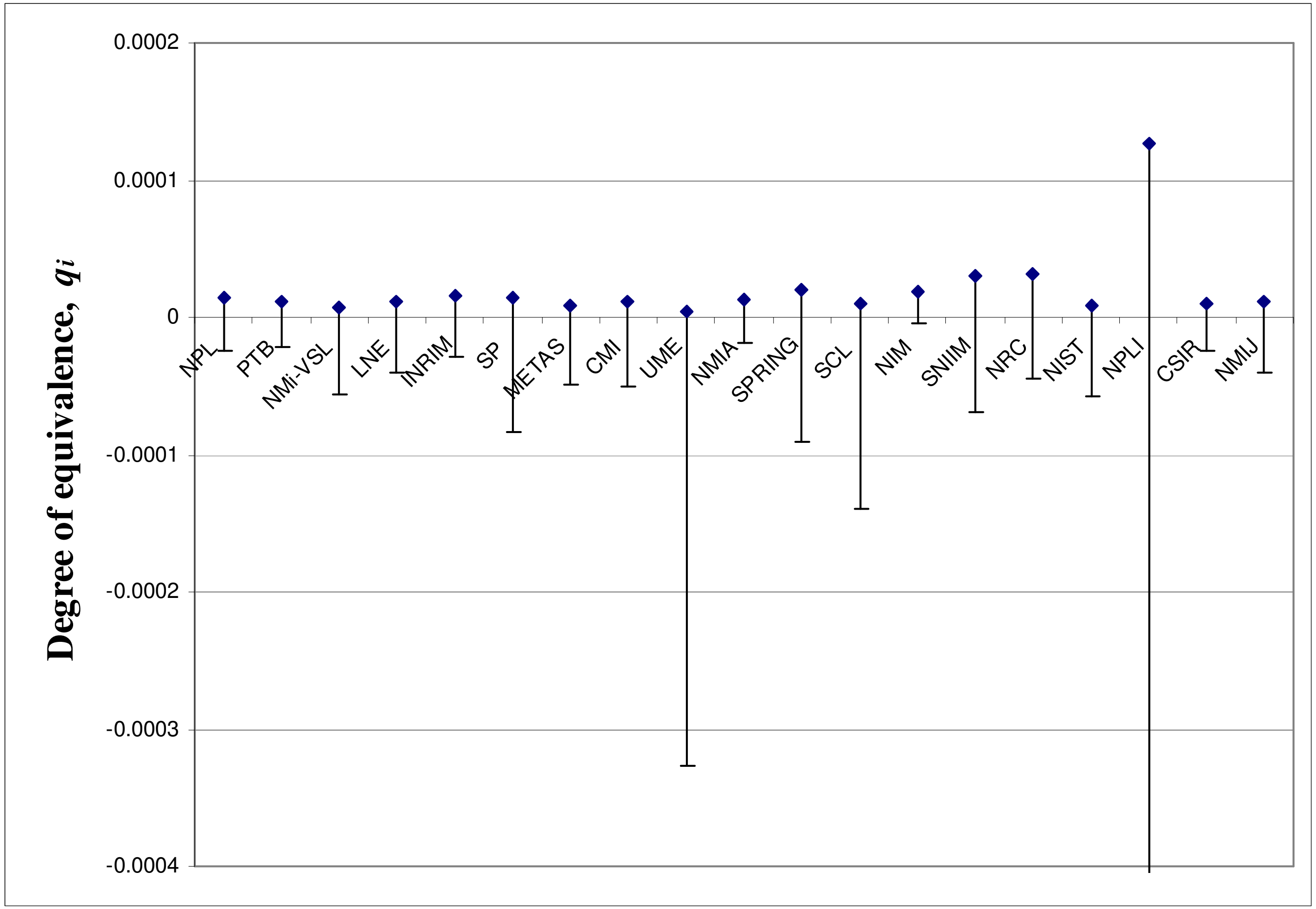

Fig 23 – Reduced dimension degrees of equivalence and their confidence indicators for S_{21} measurements of device K5b.CL/3 (50 dB attenuator) at 9 GHz

Lab $j \Rightarrow$

Lab $i \Downarrow$	KCRV		NPL		PTB		NMi-VSL		INRIM		METAS		CMI		UME	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.000034	0.000093			0.00004	0.00010	0.00005	0.00010	0.00006	0.00011	0.00004	0.00012	0.00005	0.00013	0.00002	0.00060
PTB	0.000009	0.000047	0.00004	0.00010			0.000006	0.000069	0.000029	0.000072	0.000014	0.000084	0.00001	0.00010	0.00003	0.00058
NMi-VSL	0.000013	0.000039	0.00005	0.00010	0.000006	0.000069			0.00003	0.00010	0.000013	0.000095	0.00000	0.00013	0.00003	0.00058
INRIM	0.000028	0.000052	0.00006	0.00011	0.000029	0.000072	0.00003	0.00010			0.000016	0.000087	0.00003	0.00012	0.00003	0.00059
METAS	0.000012	0.000065	0.00004	0.00012	0.000014	0.000084	0.000013	0.000095	0.000016	0.000087			0.00001	0.00012	0.00002	0.00058
CMI	0.000013	0.000086	0.00005	0.00013	0.00001	0.00010	0.00000	0.00013	0.00003	0.00012	0.00001	0.00012			0.00003	0.00059
UME	0.00002	0.00054	0.00002	0.00060	0.00003	0.00058	0.00003	0.00058	0.00003	0.00059	0.00002	0.00058	0.00003	0.00059		
NMIA	0.000033	0.000040	0.00007	0.00010	0.000028	0.000064	0.000022	0.000068	0.000022	0.000069	0.000024	0.000080	0.00002	0.00010	0.00005	0.00058
SPRING	0.00004	0.00018	0.00005	0.00021	0.00003	0.00019	0.00004	0.00019	0.00006	0.00018	0.00005	0.00019	0.00003	0.00020	0.00005	0.00063
SCL	0.00004	0.00027	0.00006	0.00026	0.00004	0.00031	0.00004	0.00033	0.00002	0.00035	0.00003	0.00032	0.00004	0.00034	0.00003	0.00065
SNIIM	0.00002	0.00011	0.00001	0.00015	0.00003	0.00012	0.00003	0.00012	0.00004	0.00012	0.00003	0.00013	0.00003	0.00014	0.00002	0.00062
NIM	0.000019	0.000024	0.000020	0.000095	0.000028	0.000053	0.000032	0.000046	0.000037	0.000058	0.000025	0.000072	0.000032	0.000095	0.00000	0.00060
NRC	0.00004	0.00012	0.00005	0.00015	0.00003	0.00013	0.00004	0.00015	0.00006	0.00013	0.00005	0.00014	0.00003	0.00016	0.00005	0.00061
NIST	0.00000	0.00012	0.00003	0.00013	0.00001	0.00013	0.00002	0.00012	0.00003	0.00010	0.00001	0.00011	0.00002	0.00015	0.00002	0.00059
CSIR-NML	0.000044	0.000052	0.00006	0.00011	0.000049	0.000069	0.000047	0.000089	0.000024	0.000074	0.000035	0.000085	0.00005	0.00012	0.00004	0.00061
NPLI	0.0000	0.0021	0.0001	0.0026	0.0000	0.0021	0.0000	0.0022	0.0001	0.0021	0.0000	0.0021	0.0000	0.0022	0.0000	0.0023
NMIJ	0.000006	0.000050	0.00004	0.00010	0.000006	0.000069	0.000008	0.000064	0.000024	0.000073	0.000008	0.000084	0.00001	0.00011	0.00002	0.00058
SP	0.00004	0.00036	0.00003	0.00040	0.00005	0.00039	0.00006	0.00039	0.00005	0.00039	0.00005	0.00039	0.00006	0.00040	0.00003	0.00070
LNE	0.000006	0.000062	0.00004	0.00011	0.000006	0.000078	0.000008	0.000074	0.000024	0.000082	0.000008	0.000092	0.00001	0.00011	0.00002	0.00058

Table 26 – Degrees of equivalence for S_{21} measurements of device K5b.CL/3 (50 dB attenuator) at 18 GHz

Lab i ⇓	Lab j ⇒ NMIA		SPRING		SCL		SNIIM		NIM		NRC		NIST		CSIR-NML	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.00007	0.00010	0.00005	0.00021	0.00006	0.00026	0.00001	0.00015	0.000020	0.000095	0.00005	0.00015	0.00003	0.00013	0.00006	0.00011
PTB	0.000028	0.000064	0.00003	0.00019	0.00004	0.00031	0.00003	0.00012	0.000028	0.000053	0.00003	0.00013	0.00001	0.00013	0.000049	0.000069
NMi-VSL	0.000022	0.000068	0.00004	0.00019	0.00004	0.00033	0.00003	0.00012	0.000032	0.000046	0.00004	0.00015	0.00002	0.00012	0.000047	0.000089
INRIM	0.000022	0.000069	0.00006	0.00018	0.00002	0.00035	0.00004	0.00012	0.000037	0.000058	0.00006	0.00013	0.00003	0.00010	0.000024	0.000074
METAS	0.000024	0.000080	0.00005	0.00019	0.00003	0.00032	0.00003	0.00013	0.000025	0.000072	0.00005	0.00014	0.00001	0.00011	0.000035	0.000085
CMI	0.00002	0.00010	0.00003	0.00020	0.00004	0.00034	0.00003	0.00014	0.000032	0.000095	0.00003	0.00016	0.00002	0.00015	0.00005	0.00012
UME	0.00005	0.00058	0.00005	0.00063	0.00003	0.00065	0.00002	0.00062	0.00000	0.00060	0.00005	0.00061	0.00002	0.00059	0.00004	0.00061
NMIA			0.00005	0.00015	0.00004	0.00034	0.00005	0.00012	0.000050	0.000047	0.00005	0.00013	0.000033	0.000098	0.000045	0.000065
SPRING	0.00005	0.00015			0.00007	0.00035	0.00004	0.00023	0.00005	0.00020	0.00000	0.00019	0.00004	0.00022	0.00008	0.00019
SCL	0.00004	0.00034	0.00007	0.00035			0.00005	0.00028	0.00004	0.00025	0.00007	0.00033	0.00003	0.00030	0.00001	0.00034
SNIIM	0.00005	0.00012	0.00004	0.00023	0.00005	0.00028			0.00001	0.00011	0.00004	0.00017	0.00002	0.00014	0.00005	0.00012
NIM	0.000050	0.000047	0.00005	0.00020	0.00004	0.00025	0.00001	0.00011			0.00005	0.00012	0.00002	0.00010	0.000042	0.000055
NRC	0.00005	0.00013	0.00000	0.00019	0.00007	0.00033	0.00004	0.00017	0.00005	0.00012			0.00004	0.00017	0.00008	0.00013
NIST	0.000033	0.000098	0.00004	0.00022	0.00003	0.00030	0.00002	0.00014	0.00002	0.00010	0.00004	0.00017			0.00004	0.00011
CSIR-NML	0.000045	0.000065	0.00008	0.00019	0.00001	0.00034	0.00005	0.00012	0.000042	0.000055	0.00008	0.00013	0.00004	0.00011		
NPLI	0.0001	0.0023	0.0000	0.0023	0.0001	0.0021	0.0000	0.0024	0.0000	0.0022	0.0000	0.0023	0.0000	0.0021	0.0001	0.0021
NMIJ	0.000027	0.000064	0.00004	0.00019	0.00004	0.00031	0.00003	0.00012	0.000024	0.000054	0.00004	0.00013	0.00001	0.00012	0.000043	0.000070
SP	0.00007	0.00039	0.00008	0.00043	0.00004	0.00046	0.00003	0.00040	0.00003	0.00038	0.00008	0.00040	0.00004	0.00040	0.00004	0.00039
LNE	0.000027	0.000074	0.00004	0.00019	0.00004	0.00031	0.00003	0.00013	0.000024	0.000065	0.00004	0.00014	0.00001	0.00012	0.000043	0.000079

Table 26 cont'd – Degrees of equivalence for S_{21} measurements of device K5b.CL/3 (50 dB attenuator) at 18 GHz

Lab j ⇒

Lab i ⇓	NPLI		NMIJ		SP		LNE	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.0001	0.0026	0.00004	0.00010	0.00003	0.00040	0.00004	0.00011
PTB	0.0001	0.0021	0.000006	0.000069	0.00005	0.00039	0.000006	0.000078
NMi-VSL	0.0000	0.0022	0.000008	0.000064	0.00006	0.00039	0.000008	0.000074
INRIM	0.0001	0.0021	0.000024	0.000073	0.00005	0.00039	0.000024	0.000082
METAS	0.0000	0.0021	0.000008	0.000084	0.00005	0.00039	0.000008	0.000092
CMI	0.0000	0.0022	0.00001	0.00011	0.00006	0.00040	0.00001	0.00011
UME	0.0000	0.0023	0.00002	0.00058	0.00003	0.00070	0.00002	0.00058
NMIA	0.0001	0.0023	0.000027	0.000064	0.00007	0.00039	0.000027	0.000074
SPRING	0.0000	0.0023	0.00004	0.00019	0.00008	0.00043	0.00004	0.00019
SCL	0.0001	0.0021	0.00004	0.00031	0.00004	0.00046	0.00004	0.00031
SNIIM	0.0000	0.0024	0.00003	0.00012	0.00003	0.00040	0.00003	0.00013
NIM	0.0000	0.0022	0.000024	0.000054	0.00003	0.00038	0.000024	0.000065
NRC	0.0000	0.0023	0.00004	0.00013	0.00008	0.00040	0.00004	0.00014
NIST	0.0000	0.0021	0.00001	0.00012	0.00004	0.00040	0.00001	0.00012
CSIR-NML	0.0000	0.0021	0.000043	0.000070	0.00004	0.00039	0.000043	0.000079
NPLI			0.0000	0.0021	0.0001	0.0023	0.0000	0.0021
NMIJ	0.0000	0.0021			0.00005	0.00039	0.000000	0.000079
SP	0.0000	0.0023	0.00005	0.00039			0.00005	0.00039
LNE	0.0000	0.0021	0.000000	0.000079	0.00005	0.00039		

Table 26 cont'd – Degrees of equivalence for S_{21} measurements of device K5b.CL/3 (50 dB attenuator) at 18 GHz

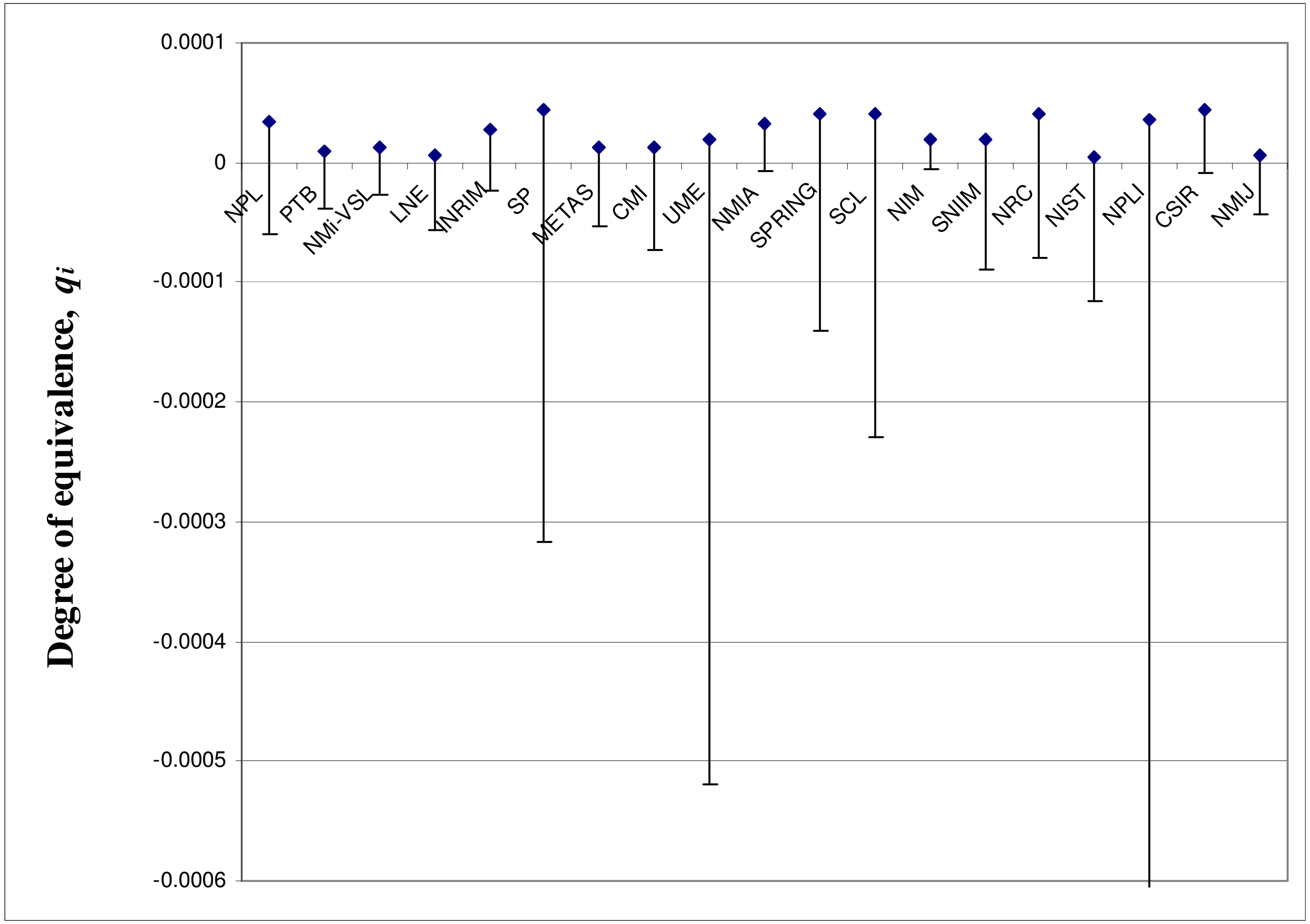

Fig 24 – Reduced dimension degrees of equivalence and their confidence indicators for S_{21} measurements of device K5b.CL/3 (50 dB attenuator) at 18 GHz

Lab $j \Rightarrow$

Lab $i \Downarrow$	KCRV		NPL		PTB		NMi-VSL		INRIM		METAS		CMI		UME	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.0003	0.0028			0.0017	0.0042	0.0025	0.0072	0.002	0.014	0.0003	0.0056	0.001	0.012	0.001	0.013
PTB	0.0014	0.0031	0.0017	0.0042			0.0034	0.0060	0.003	0.014	0.0018	0.0059	0.001	0.012	0.002	0.014
NMi-VSL	0.0024	0.0056	0.0025	0.0072	0.0034	0.0060			0.005	0.017	0.0028	0.0089	0.003	0.013	0.004	0.016
INRIM	0.002	0.013	0.002	0.014	0.003	0.014	0.005	0.017			0.002	0.014	0.002	0.018	0.001	0.019
METAS	0.0005	0.0046	0.0003	0.0056	0.0018	0.0059	0.0028	0.0089	0.002	0.014			0.001	0.012	0.001	0.014
CMI	0.000	0.011	0.001	0.012	0.001	0.012	0.003	0.013	0.002	0.018	0.001	0.012			0.001	0.017
UME	0.001	0.012	0.001	0.013	0.002	0.014	0.004	0.016	0.001	0.019	0.001	0.014	0.001	0.017		
NMIA	0.0007	0.0033	0.0009	0.0044	0.0011	0.0047	0.0032	0.0069	0.002	0.014	0.0008	0.0060	0.000	0.012	0.001	0.014
SPRING	0.001	0.011	0.001	0.012	0.002	0.017	0.004	0.013	0.001	0.021	0.001	0.012	0.001	0.0019	0.000	0.021
SCL	0.0011	0.0076	0.0013	0.0085	0.0018	0.0087	0.0016	0.0097	0.003	0.016	0.0016	0.0095	0.001	0.014	0.003	0.015
SNIIM	0.0018	0.0042	0.0017	0.0050	0.0031	0.0053	0.001	0.012	0.004	0.014	0.0020	0.0064	0.002	0.012	0.003	0.014
NIM	0.0003	0.0016	0.0005	0.0032	0.0014	0.0036	0.0023	0.0059	0.003	0.013	0.0008	0.0052	0.000	0.011	0.002	0.013
NRC	0.002	0.013	0.002	0.013	0.000	0.013	0.004	0.014	0.003	0.018	0.002	0.014	0.001	0.017	0.002	0.018
NIST	0.0006	0.0040	0.0009	0.0051	0.0008	0.0050	0.0027	0.0063	0.003	0.014	0.0010	0.0065	0.000	0.012	0.002	0.013
CSIR-NML	0.0003	0.0062	0.0005	0.0067	0.0015	0.0069	0.0022	0.0089	0.003	0.015	0.0008	0.0079	0.001	0.013	0.002	0.014
NPLI	0.002	0.012	0.002	0.012	0.003	0.014	0.003	0.016	0.002	0.025	0.002	0.014	0.002	0.018	0.002	0.025
NMIJ	0.0004	0.0028	0.0006	0.0038	0.0014	0.0042	0.0022	0.0064	0.003	0.014	0.0008	0.0056	0.001	0.012	0.002	0.013
SP	0.0008	0.0051	0.0010	0.0061	0.0016	0.0063	0.0019	0.0078	0.003	0.014	0.0012	0.0073	0.001	0.013	0.002	0.014
LNE	0.001	0.010	0.001	0.011	0.001	0.011	0.0023	0.0141	0.003	0.017	0.001	0.012	0.001	0.015	0.002	0.017

Table 27 – Degrees of equivalence for S_{11} measurements of device K5b.CL/4 (male matched load) at 2 GHz

Lab j ⇒

Lab i ⇓	NMIA		SPRING		SCL		SNIIM		NIM		NRC		NIST		CSIR-NML	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.0009	0.0044	0.001	0.012	0.0013	0.0085	0.0017	0.0050	0.0005	0.0032	0.002	0.013	0.0009	0.0051	0.0005	0.0067
PTB	0.0011	0.0047	0.002	0.017	0.0018	0.0087	0.0031	0.0053	0.0014	0.0036	0.000	0.013	0.0008	0.0050	0.0015	0.0069
NMi-VSL	0.0032	0.0069	0.004	0.013	0.0016	0.0097	0.001	0.012	0.0023	0.0059	0.004	0.014	0.0027	0.0063	0.0022	0.0089
INRIM	0.002	0.014	0.001	0.021	0.003	0.016	0.004	0.014	0.003	0.013	0.003	0.018	0.003	0.014	0.003	0.015
METAS	0.0008	0.0060	0.001	0.012	0.0016	0.0095	0.0020	0.0064	0.0008	0.0052	0.002	0.014	0.0010	0.0065	0.0008	0.0079
CMI	0.000	0.012	0.001	0.019	0.001	0.014	0.002	0.012	0.000	0.011	0.001	0.017	0.000	0.012	0.001	0.013
UME	0.001	0.014	0.000	0.021	0.003	0.015	0.003	0.014	0.002	0.013	0.002	0.018	0.002	0.013	0.002	0.014
NMIA			0.001	0.016	0.0017	0.0088	0.0026	0.0054	0.0009	0.0038	0.001	0.013	0.0006	0.0043	0.0010	0.0070
SPRING	0.001	0.016			0.003	0.015	0.003	0.011	0.002	0.013	0.002	0.021	0.002	0.015	0.002	0.014
SCL	0.0017	0.0088	0.003	0.015			0.0014	0.0091	0.0008	0.0082	0.002	0.015	0.0012	0.0083	0.001	0.010
SNIIM	0.0026	0.0054	0.003	0.011	0.0014	0.0091			0.0018	0.0045	0.003	0.013	0.0023	0.0051	0.0016	0.0074
NIM	0.0009	0.0038	0.002	0.013	0.0008	0.0082	0.0018	0.0045			0.002	0.013	0.0005	0.0032	0.0001	0.0063
NRC	0.001	0.013	0.002	0.021	0.002	0.015	0.003	0.013	0.002	0.0013			0.001	0.013	0.002	0.014
NIST	0.0006	0.0043	0.002	0.015	0.0012	0.0083	0.0023	0.0051	0.0005	0.0032	0.001	0.013			0.0007	0.0069
CSIR-NML	0.0010	0.0070	0.002	0.014	0.001	0.010	0.0016	0.0074	0.0001	0.0063	0.002	0.014	0.0007	0.0069		
NPLI	0.002	0.015	0.002	0.025	0.003	0.014	0.002	0.012	0.002	0.012	0.004	0.020	0.003	0.014	0.002	0.013
NMIJ	0.0010	0.0044	0.002	0.013	0.0008	0.0085	0.0017	0.0050	0.0001	0.0031	0.002	0.013	0.0006	0.0039	0.0000	0.0067
SP	0.0014	0.0064	0.002	0.014	0.0003	0.0097	0.0015	0.0068	0.0005	0.0056	0.002	0.014	0.0009	0.0059	0.0004	0.0082
LNE	0.001	0.011	0.002	0.018	0.001	0.013	0.002	0.011	0.001	0.011	0.001	0.016	0.001	0.011	0.001	0.012

Table 27 cont'd – Degrees of equivalence for S_{11} measurements of device K5b.CL/4 (male matched load) at 2 GHz

Lab $j \Rightarrow$

Lab $i \Downarrow$	NPLI		NMIJ		SP		LNE	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.002	0.012	0.0006	0.0038	0.0010	0.0061	0.001	0.011
PTB	0.003	0.014	0.0014	0.0042	0.0016	0.0063	0.001	0.011
NMi-VSL	0.003	0.016	0.0022	0.0064	0.0019	0.0078	0.002	0.012
INRIM	0.002	0.025	0.003	0.014	0.003	0.014	0.003	0.017
METAS	0.002	0.014	0.0008	0.0056	0.0012	0.0073	0.001	0.012
CMI	0.002	0.018	0.001	0.012	0.001	0.013	0.001	0.015
UME	0.002	0.025	0.002	0.013	0.002	0.014	0.002	0.017
NMIA	0.002	0.015	0.0010	0.0044	0.0014	0.0064	0.001	0.011
SPRING	0.002	0.025	0.002	0.013	0.002	0.014	0.002	0.018
SCL	0.003	0.014	0.0008	0.0085	0.0003	0.0097	0.001	0.013
SNIIM	0.002	0.012	0.0017	0.0050	0.0015	0.0068	0.002	0.011
NIM	0.002	0.012	0.0001	0.0031	0.0005	0.0056	0.001	0.011
NRC	0.004	0.020	0.002	0.013	0.002	0.014	0.001	0.016
NIST	0.003	0.014	0.0006	0.0039	0.0009	0.0059	0.001	0.011
CSIR-NML	0.002	0.012	0.0000	0.0067	0.0004	0.0082	0.001	0.012
NPLI			0.0023	0.0182	0.003	0.013	0.003	0.016
NMIJ	0.002	0.013			0.0004	0.0060	0.001	0.011
SP	0.003	0.013	0.0004	0.0060			0.001	0.012
LNE	0.003	0.016	0.001	0.011	0.001	0.012		

Table 27 cont'd – Degrees of equivalence for S_{11} measurements of device K5b.CL/4 (male matched load) at 2 GHz

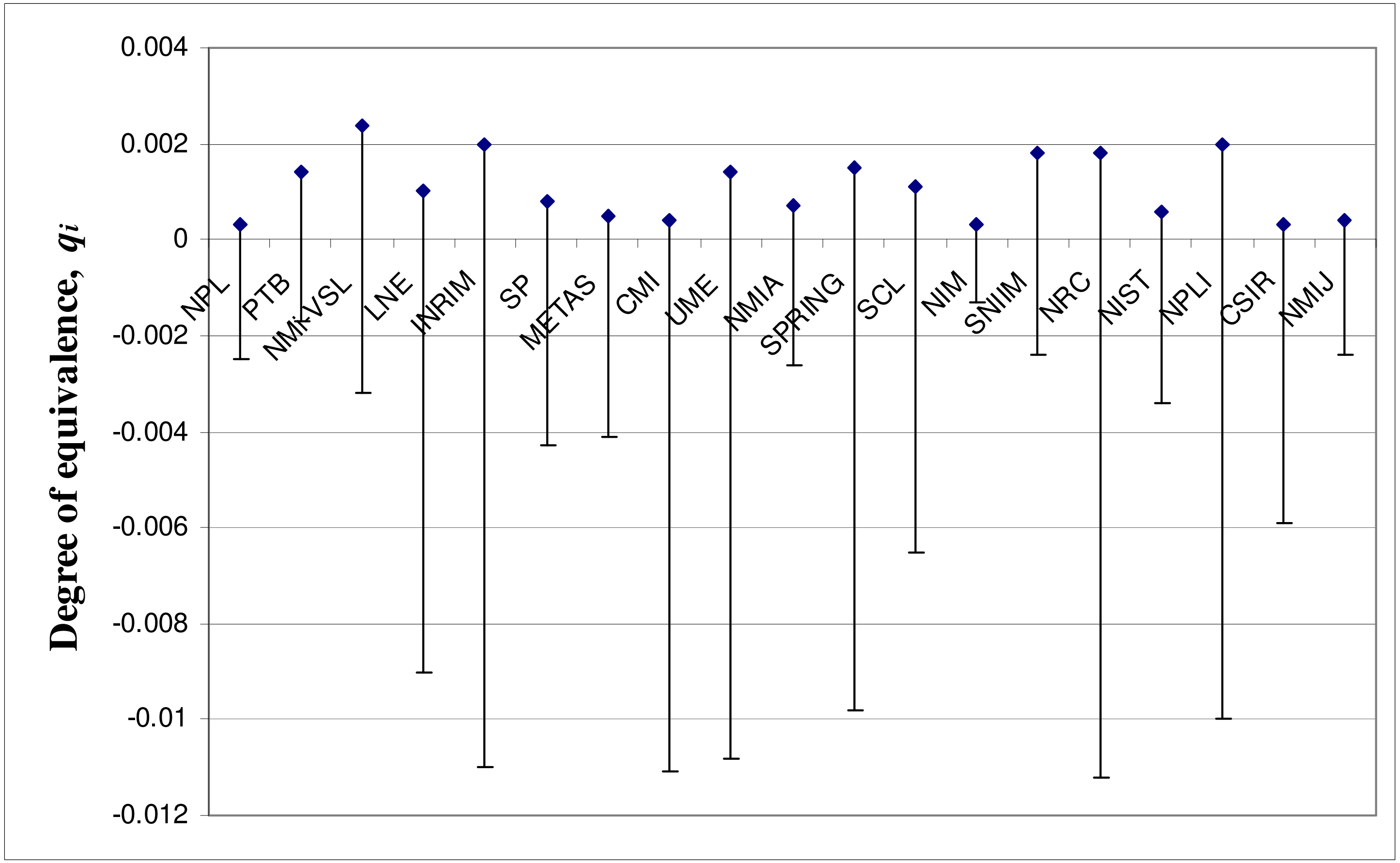

Fig 25 – Reduced dimension degrees of equivalence and their confidence indicators for S_{11} measurements of device K5b.CL/4 (male matched load) at 2 GHz

Lab j ⇒

Lab i ⇓	KCRV		NPL		PTB		NMi-VSL		INRIM		METAS		CMI		UME	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.0011	0.0028			0.0038	0.0042	0.002	0.024	0.004	0.014	0.004	0.010	0.004	0.012	0.003	0.014
PTB	0.0027	0.0032	0.0038	0.0042			0.003	0.018	0.003	0.014	0.003	0.010	0.003	0.012	0.0036	0.0067
NMi-VSL	0.002	0.020	0.002	0.024	0.003	0.018			0.001	0.027	0.002	0.025	0.002	0.026	0.001	0.021
INRIM	0.003	0.012	0.004	0.014	0.003	0.014	0.001	0.027			0.000	0.017	0.000	0.018	0.001	0.016
METAS	0.0033	0.0092	0.004	0.010	0.003	0.010	0.002	0.025	0.000	0.017			0.000	0.015	0.001	0.015
CMI	0.003	0.011	0.004	0.012	0.003	0.012	0.002	0.026	0.000	0.018	0.000	0.015			0.001	0.016
UME	0.0030	0.0080	0.003	0.014	0.0036	0.0067	0.001	0.021	0.001	0.016	0.001	0.015	0.001	0.016		
NMIA	0.0025	0.0052	0.0032	0.0060	0.0025	0.0063	0.001	0.025	0.000	0.014	0.001	0.011	0.001	0.013	0.0011	0.0080
SPRING	0.0019	0.0077	0.002	0.011	0.0035	0.0099	0.001	0.022	0.002	0.022	0.002	0.020	0.002	0.021	0.001	0.021
SCL	0.003	0.023	0.003	0.025	0.004	0.025	0.002	0.031	0.001	0.028	0.001	0.026	0.002	0.027	0.000	0.029
SNIIM	0.0037	0.0049	0.0033	0.0053	0.0055	0.0057	0.005	0.023	0.007	0.014	0.007	0.011	0.007	0.012	0.007	0.013
NIM	0.0053	0.0042	0.0048	0.0049	0.0071	0.0053	0.007	0.023	0.008	0.014	0.009	0.011	0.009	0.012	0.008	0.013
NRC	0.002	0.013	0.002	0.013	0.003	0.014	0.004	0.025	0.005	0.019	0.005	0.016	0.005	0.017	0.005	0.017
NIST	0.0003	0.0045	0.0011	0.0059	0.0028	0.0062	0.002	0.022	0.003	0.014	0.004	0.011	0.004	0.012	0.003	0.011
CSIR-NML	0.0013	0.0063	0.0015	0.0067	0.0033	0.0070	0.001	0.023	0.002	0.015	0.002	0.012	0.002	0.013	0.002	0.015
NPLI	0.003	0.041	0.004	0.039	0.003	0.026	0.004	0.043	0.005	0.035	0.005	0.033	0.005	0.033	0.006	0.039
NMIJ	0.0043	0.0031	0.0036	0.0037	0.0066	0.0042	0.006	0.024	0.007	0.014	0.007	0.010	0.008	0.012	0.007	0.015
SP	0.0049	0.0077	0.0041	0.0085	0.0071	0.0087	0.006	0.025	0.008	0.016	0.008	0.013	0.008	0.014	0.007	0.019
LNE	0.002	0.012	0.002	0.013	0.005	0.013	0.004	0.027	0.005	0.018	0.005	0.016	0.005	0.017	0.005	0.021

Table 28 – Degrees of equivalence for S_{11} measurements of device K5b.CL/4 (male matched load) at 9 GHz

Lab *j* ⇒

Lab *i* ⇓	NMIA		SPRING		SCL		SNIIM		NIM		NRC		NIST		CSIR-NML	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.0032	0.0060	0.002	0.011	0.003	0.025	0.0033	0.0053	0.0048	0.0049	0.002	0.013	0.0011	0.0059	0.0015	0.0067
PTB	0.0025	0.0063	0.0035	0.0099	0.004	0.025	0.0055	0.0057	0.0071	0.0053	0.003	0.014	0.0028	0.0062	0.0033	0.0070
NMi-VSL	0.001	0.025	0.001	0.022	0.002	0.031	0.005	0.023	0.007	0.023	0.004	0.025	0.002	0.022	0.001	0.023
INRIM	0.000	0.014	0.002	0.022	0.001	0.028	0.007	0.014	0.008	0.014	0.005	0.019	0.003	0.014	0.002	0.015
METAS	0.001	0.011	0.002	0.020	0.001	0.026	0.007	0.011	0.009	0.011	0.005	0.016	0.004	0.011	0.002	0.012
CMI	0.001	0.013	0.002	0.021	0.002	0.027	0.007	0.012	0.009	0.012	0.005	0.017	0.004	0.012	0.002	0.013
UME	0.0011	0.0080	0.001	0.021	0.000	0.029	0.007	0.013	0.008	0.013	0.005	0.017	0.003	0.011	0.002	0.015
NMIA			0.002	0.017	0.001	0.025	0.0061	0.0071	0.0077	0.0068	0.004	0.014	0.0027	0.0069	0.0018	0.0082
SPRING	0.002	0.017			0.001	0.028	0.005	0.011	0.007	0.012	0.004	0.016	0.0021	0.0095	0.001	0.013
SCL	0.001	0.025	0.001	0.028			0.006	0.025	0.008	0.025	0.005	0.028	0.003	0.025	0.002	0.025
SNIIM	0.0061	0.0071	0.005	0.011	0.006	0.025			0.0016	0.0062	0.002	0.014	0.0034	0.0063	0.0048	0.0078
NIM	0.0077	0.0068	0.007	0.012	0.008	0.025	0.0016	0.0062			0.004	0.014	0.0050	0.0060	0.0063	0.0075
NRC	0.004	0.014	0.004	0.016	0.005	0.028	0.002	0.014	0.004	0.014			0.002	0.014	0.003	0.015
NIST	0.0027	0.0069	0.0021	0.0095	0.003	0.025	0.0034	0.0063	0.0050	0.0060	0.002	0.014			0.0016	0.0075
CSIR-NML	0.0018	0.0082	0.001	0.011	0.002	0.025	0.0048	0.0078	0.0063	0.0075	0.003	0.015	0.0016	0.0075		
NPLI	0.005	0.033	0.005	0.041	0.006	0.046	0.004	0.024	0.005	0.023	0.002	0.032	0.003	0.041	0.004	0.041
NMIJ	0.0067	0.0060	0.006	0.013	0.007	0.025	0.0015	0.0054	0.0017	0.0049	0.003	0.013	0.0041	0.0054	0.0051	0.0068
SP	0.0072	0.0097	0.006	0.016	0.007	0.026	0.0018	0.0093	0.0015	0.0091	0.004	0.016	0.0046	0.0094	0.006	0.010
LNE	0.005	0.013	0.003	0.019	0.005	0.027	0.002	0.013	0.003	0.013	0.002	0.018	0.002	0.013	0.003	0.014

Table 28 cont'd – Degrees of equivalence for S_{11} measurements of device K5b.CL/4 (male matched load) at 9 GHz

	Lab $j \Rightarrow$							
Lab $i \Downarrow$	NPLI		NMIJ		SP		LNE	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.004	0.039	0.0036	0.0037	0.0041	0.0085	0.002	0.013
PTB	0.003	0.026	0.0066	0.0042	0.0071	0.0087	0.005	0.013
NMi-VSL	0.004	0.043	0.006	0.024	0.006	0.025	0.004	0.027
INRIM	0.005	0.035	0.007	0.014	0.008	0.016	0.005	0.018
METAS	0.005	0.033	0.007	0.010	0.008	0.013	0.005	0.016
CMI	0.005	0.033	0.008	0.012	0.008	0.014	0.005	0.017
UME	0.006	0.039	0.007	0.015	0.007	0.019	0.005	0.021
NMIA	0.005	0.033	0.0067	0.0060	0.0072	0.0097	0.005	0.013
SPRING	0.005	0.041	0.006	0.013	0.006	0.016	0.003	0.019
SCL	0.006	0.046	0.007	0.025	0.007	0.026	0.005	0.027
SNIIM	0.004	0.024	0.0015	0.0054	0.0018	0.0093	0.002	0.013
NIM	0.005	0.023	0.0017	0.0049	0.0015	0.0091	0.003	0.013
NRC	0.002	0.032	0.003	0.013	0.004	0.016	0.002	0.018
NIST	0.003	0.041	0.0041	0.0054	0.0046	0.0094	0.002	0.013
CSIR-NML	0.004	0.041	0.0051	0.0068	0.006	0.010	0.003	0.014
NPLI			0.005	0.025	0.006	0.026	0.004	0.034
NMIJ	0.005	0.025			0.0005	0.0085	0.002	0.013
SP	0.006	0.026	0.0005	0.0085			0.003	0.015
LNE	0.004	0.034	0.002	0.013	0.003	0.015		

Table 28 cont'd – Degrees of equivalence for S_{11} measurements of device K5b.CL/4 (male matched load) at 9 GHz

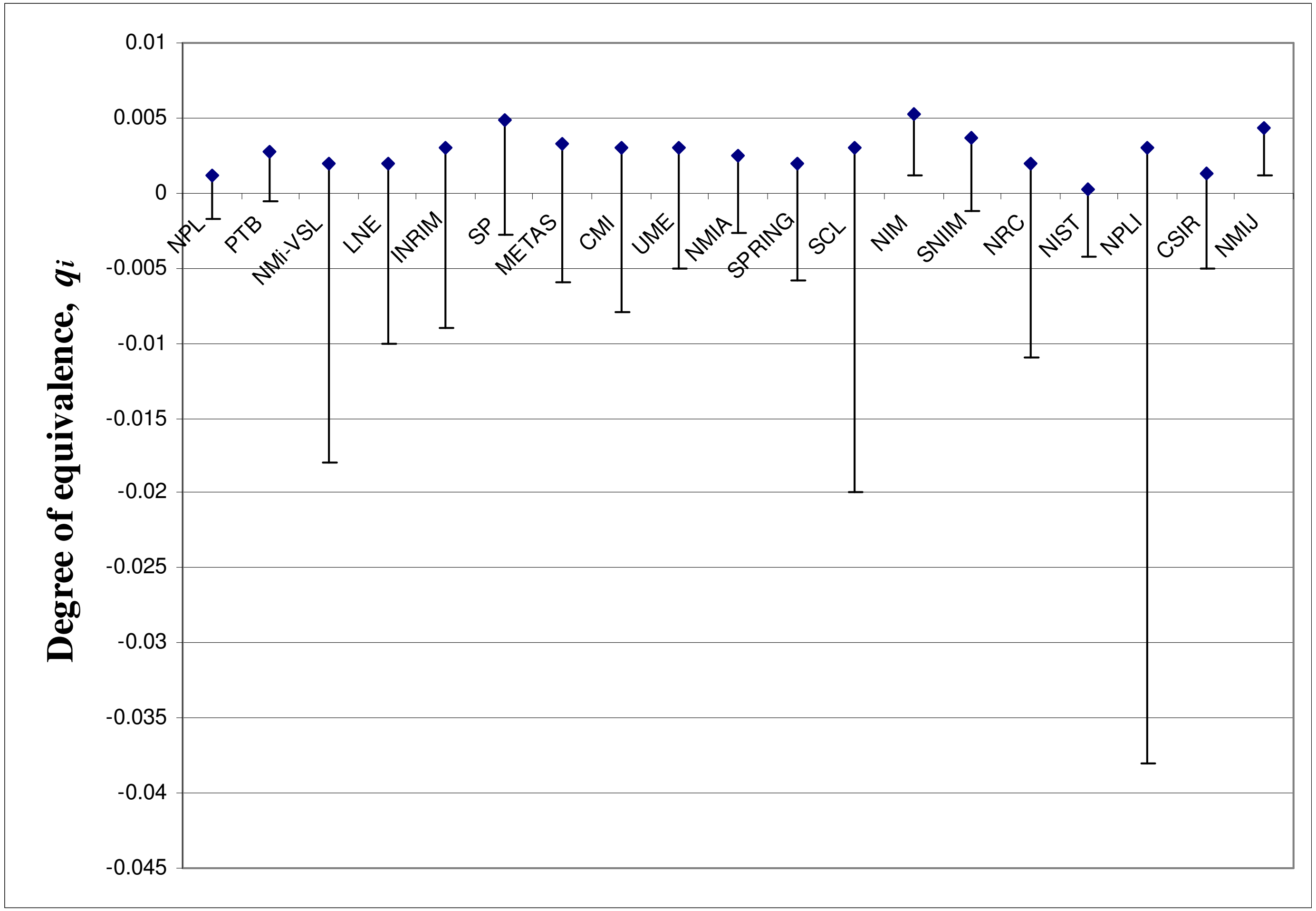

Fig 26 – Reduced dimension degrees of equivalence and their confidence indicators for S_{11} measurements of device K5b.CL/4 (male matched load) at 9 GHz

Lab j ⇒

Lab i ⇓	KCRV		NPL		PTB		NMi-VSL		INRIM		METAS		CMI		UME	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.0023	0.0051			0.0012	0.0057	0.002	0.027	0.004	0.014	0.004	0.011	0.004	0.013	0.004	0.020
PTB	0.0015	0.0040	0.0012	0.0057			0.001	0.010	0.002	0.014	0.003	0.010	0.003	0.012	0.003	0.020
NMi-VSL	0.0029	0.0089	0.002	0.027	0.001	0.010			0.003	0.016	0.004	0.013	0.005	0.015	0.004	0.021
INRIM	0.002	0.013	0.004	0.014	0.002	0.014	0.003	0.016			0.002	0.017	0.003	0.018	0.002	0.023
METAS	0.0017	0.0093	0.004	0.011	0.003	0.010	0.004	0.013	0.002	0.017			0.001	0.015	0.001	0.021
CMI	0.002	0.011	0.004	0.013	0.003	0.012	0.005	0.015	0.003	0.018	0.001	0.015			0.001	0.020
UME	0.002	0.017	0.004	0.020	0.003	0.020	0.004	0.021	0.002	0.023	0.001	0.021	0.001	0.020		
NMIA	0.0024	0.0074	0.0042	0.0089	0.0039	0.0083	0.005	0.013	0.004	0.016	0.002	0.012	0.002	0.014	0.003	0.018
SPRING	0.0024	0.0041	0.0045	0.0062	0.0039	0.0050	0.005	0.014	0.004	0.015	0.002	0.012	0.001	0.015	0.002	0.020
SCL	0.000	0.023	0.002	0.025	0.002	0.025	0.003	0.028	0.002	0.028	0.002	0.026	0.002	0.027	0.002	0.031
SNIIM	0.0049	0.0060	0.0027	0.0072	0.0037	0.0066	0.003	0.011	0.006	0.015	0.006	0.011	0.007	0.013	0.007	0.020
NIM	0.0036	0.0049	0.0023	0.0064	0.0021	0.0057	0.001	0.014	0.003	0.014	0.005	0.011	0.005	0.013	0.005	0.020
NRC	0.005	0.020	0.008	0.020	0.007	0.020	0.008	0.021	0.005	0.024	0.004	0.022	0.003	0.023	0.003	0.027
NIST	0.0034	0.0057	0.0045	0.0065	0.0046	0.0059	0.006	0.016	0.005	0.015	0.004	0.012	0.003	0.014	0.005	0.018
CSIR-NML	0.0067	0.0084	0.0088	0.0093	0.0078	0.0087	0.009	0.011	0.006	0.016	0.005	0.013	0.005	0.014	0.004	0.021
NPLI	0.009	0.022	0.008	0.025	0.008	0.023	0.006	0.026	0.008	0.024	0.010	0.023	0.011	0.024	0.010	0.028
NMIJ	0.0061	0.0037	0.0062	0.0056	0.0069	0.0048	0.008	0.023	0.008	0.014	0.007	0.010	0.007	0.012	0.008	0.017
SP	0.004	0.011	0.005	0.012	0.005	0.012	0.006	0.026	0.007	0.018	0.005	0.015	0.005	0.016	0.006	0.020
LNE	0.006	0.016	0.007	0.016	0.007	0.016	0.008	0.023	0.007	0.021	0.006	0.018	0.005	0.01	0.0061	0.022

Table 29 – Degrees of equivalence for S_{11} measurements of device K5b.CL/4 (male matched load) at 18 GHz

Lab j ⇒

Lab i ⇓	NMIA		SPRING		SCL		SNIIM		NIM		NRC		NIST		CSIR-NML	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.0042	0.0089	0.0045	0.0062	0.002	0.025	0.0027	0.0072	0.0023	0.0064	0.008	0.020	0.0045	0.0065	0.0088	0.0093
PTB	0.0039	0.0083	0.0039	0.0050	0.002	0.025	0.0037	0.0066	0.0021	0.0057	0.007	0.020	0.0046	0.0059	0.0078	0.0087
NMi-VSL	0.005	0.013	0.005	0.014	0.003	0.028	0.003	0.011	0.001	0.014	0.008	0.021	0.006	0.016	0.009	0.011
INRIM	0.004	0.016	0.004	0.015	0.002	0.028	0.006	0.015	0.003	0.014	0.005	0.024	0.005	0.015	0.006	0.016
METAS	0.002	0.012	0.002	0.012	0.002	0.026	0.006	0.011	0.005	0.011	0.004	0.022	0.004	0.012	0.005	0.013
CMI	0.002	0.014	0.001	0.015	0.002	0.027	0.007	0.013	0.005	0.013	0.003	0.023	0.003	0.014	0.005	0.014
UME	0.003	0.018	0.002	0.020	0.002	0.031	0.007	0.020	0.005	0.020	0.003	0.027	0.005	0.018	0.004	0.021
NMIA			0.001	0.019	0.002	0.026	0.0067	0.0094	0.0060	0.0088	0.004	0.021	0.002	0.011	0.006	0.011
SPRING	0.001	0.019			0.002	0.025	0.0070	0.0074	0.0061	0.0057	0.004	0.025	0.002	0.017	0.005	0.017
SCL	0.002	0.026	0.002	0.025			0.005	0.025	0.004	0.025	0.005	0.031	0.003	0.025	0.007	0.026
SNIIM	0.0067	0.0094	0.0070	0.0074	0.005	0.025			0.0030	0.0072	0.010	0.020	0.0066	0.0075	0.0115	0.0098
NIM	0.0060	0.0088	0.0061	0.0057	0.004	0.025	0.0030	0.0072			0.008	0.020	0.0067	0.0066	0.0093	0.0090
NRC	0.004	0.021	0.004	0.025	0.005	0.031	0.010	0.020	0.008	0.020			0.006	0.022	0.002	0.021
NIST	0.002	0.011	0.002	0.017	0.003	0.025	0.0066	0.0075	0.0067	0.0066	0.006	0.022			0.008	0.012
CSIR-NML	0.006	0.011	0.005	0.017	0.007	0.026	0.0115	0.0098	0.0093	0.0090	0.002	0.021	0.008	0.012		
NPLI	0.011	0.023	0.011	0.023	0.009	0.034	0.006	0.029	0.005	0.023	0.013	0.028	0.012	0.024	0.014	0.021
NMIJ	0.0049	0.0083	0.006	0.015	0.006	0.025	0.0073	0.0065	0.0086	0.0056	0.009	0.020	0.0032	0.0091	0.0107	0.0094
SP	0.003	0.014	0.004	0.021	0.004	0.027	0.006	0.013	0.007	0.012	0.007	0.023	0.002	0.015	0.009	0.014
LNE	0.003	0.017	0.004	0.018	0.006	0.029	0.009	0.016	0.009	0.016	0.006	0.025	0.002	0.016	0.008	0.018

Table 29 cont'd – Degrees of equivalence for S_{11} measurements of device K5b.CL/4 (male matched load) at 18 GHz

Lab j ⇒

Lab i ⇓	NPLI		NMIJ		SP		LNE	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.008	0.025	0.0062	0.0056	0.005	0.012	0.007	0.016
PTB	0.008	0.023	0.0069	0.0048	0.005	0.012	0.007	0.016
NMi-VSL	0.006	0.026	0.008	0.023	0.006	0.026	0.008	0.023
INRIM	0.008	0.024	0.008	0.014	0.007	0.018	0.007	0.021
METAS	0.010	0.023	0.007	0.010	0.005	0.015	0.006	0.018
CMI	0.011	0.024	0.007	0.012	0.005	0.016	0.005	0.019
UME	0.010	0.028	0.008	0.017	0.006	0.020	0.006	0.022
NMIA	0.011	0.023	0.0049	0.0083	0.003	0.014	0.003	0.017
SPRING	0.011	0.023	0.006	0.015	0.004	0.021	0.004	0.018
SCL	0.009	0.034	0.006	0.025	0.004	0.027	0.006	0.029
SNIIM	0.006	0.029	0.0073	0.0065	0.006	0.013	0.009	0.016
NIM	0.005	0.023	0.0086	0.0056	0.007	0.012	0.009	0.016
NRC	0.013	0.028	0.009	0.020	0.007	0.023	0.006	0.025
NIST	0.012	0.024	0.0032	0.0091	0.002	0.015	0.002	0.016
CSIR-NML	0.014	0.021	0.0107	0.0091	0.009	0.014	0.008	0.018
NPLI			0.014	0.026	0.012	0.028	0.014	0.029
NMIJ	0.014	0.026			0.002	0.012	0.004	0.016
SP	0.012	0.028	0.002	0.012			0.003	0.019
LNE	0.014	0.029	0.004	0.016	0.003	0.019		

Table 29 cont'd – Degrees of equivalence for S_{11} measurements of device K5b.CL/4 (male matched load) at 18 GHz

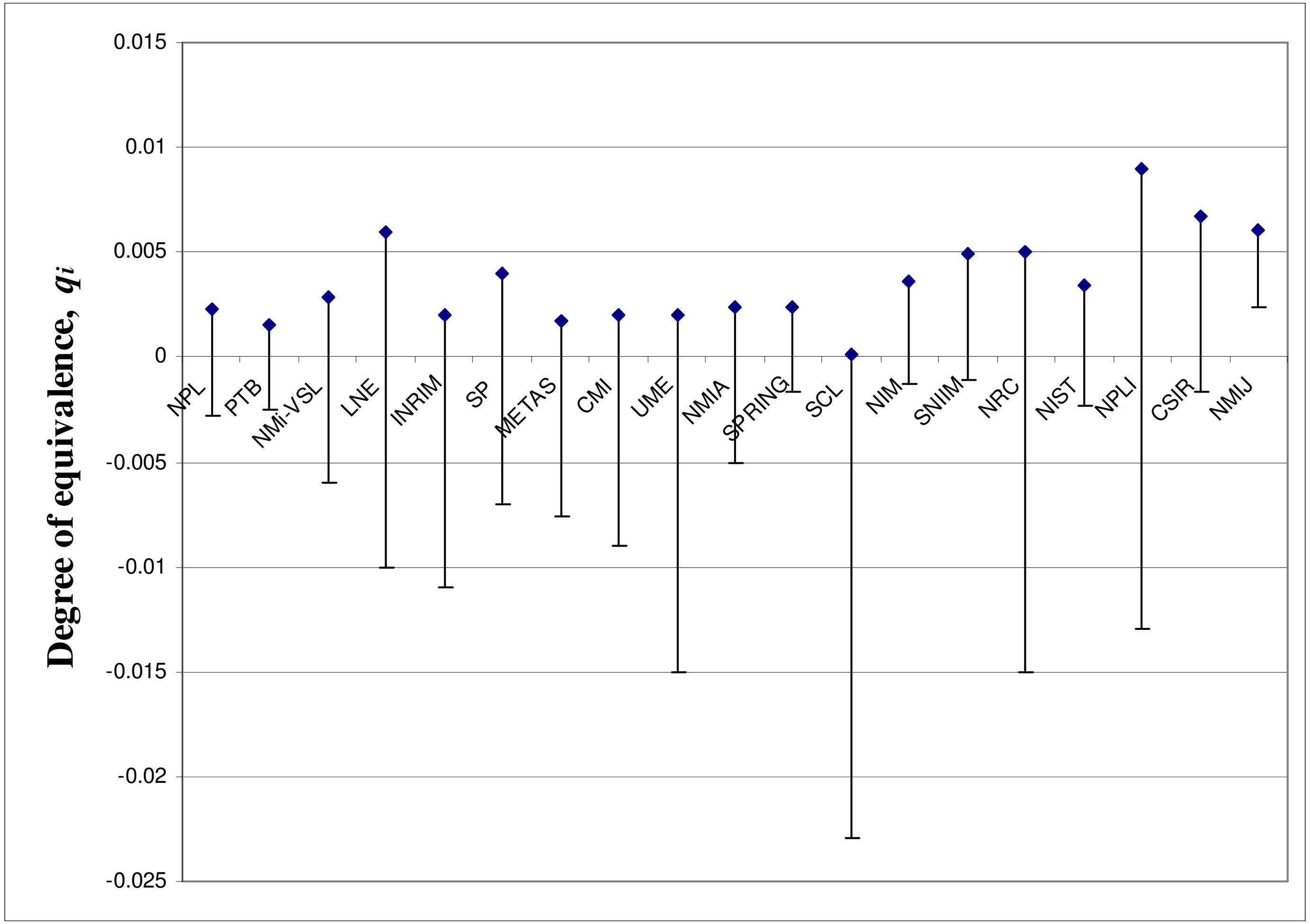

Fig 27 – Reduced dimension degrees of equivalence and their confidence indicators for S_{11} measurements of device K5b.CL/4 (male matched load) at 18 GHz

Lab j ⇒

Lab i ⇓	KCRV		NPL		PTB		NMi-VSL		INRIM		METAS		CMI		UME	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.006	0.015			0.0030	0.0058	0.0019	0.0052	0.09	0.12	0.0002	0.0058	0.001	0.012	0.000	0.011
PTB	0.008	0.011	0.0030	0.0058			0.0044	0.0056	0.09	0.13	0.0030	0.0072	0.002	0.014	0.0029	0.0080
NMi-VSL	0.007	0.020	0.0019	0.0052	0.0044	0.0056			0.09	0.12	0.0018	0.0077	0.003	0.016	0.0018	0.0087
INRIM	0.08	0.12	0.09	0.12	0.09	0.13	0.09	0.12			0.09	0.12	0.09	0.13	0.09	0.13
METAS	0.006	0.016	0.0002	0.0058	0.0030	0.0072	0.0018	0.0077	0.09	0.12			0.002	0.013	0.0001	0.0095
CMI	0.006	0.018	0.001	0.012	0.002	0.014	0.003	0.016	0.09	0.13	0.002	0.013			0.002	0.017
UME	0.007	0.018	0.000	0.011	0.0029	0.0080	0.0018	0.0087	0.09	0.13	0.0001	0.0095	0.002	0.017		
NMIA	0.007	0.010	0.0027	0.0054	0.0007	0.0069	0.0043	0.0055	0.09	0.13	0.0027	0.0069	0.002	0.013	0.0027	0.0081
SPRING	0.006	0.016	0.001	0.020	0.004	0.021	0.001	0.018	0.09	0.12	0.001	0.021	0.003	0.021	0.001	0.021
SCL	0.008	0.014	0.005	0.012	0.008	0.013	0.003	0.012	0.09	0.11	0.005	0.013	0.006	0.017	0.005	0.014
SNIIM	0.005	0.015	0.0013	0.0056	0.0032	0.0071	0.003	0.011	0.09	0.12	0.0015	0.0071	0.001	0.014	0.002	0.016
NIM	0.0067	0.0056	0.0020	0.0032	0.0013	0.0053	0.0037	0.0024	0.09	0.13	0.0020	0.0054	0.001	0.013	0.0020	0.0070
NRC	0.004	0.028	0.003	0.025	0.005	0.025	0.004	0.029	0.09	0.13	0.003	0.025	0.003	0.028	0.003	0.027
NIST	0.006	0.014	0.0010	0.0052	0.0027	0.0067	0.0029	0.0079	0.09	0.13	0.0012	0.0067	0.001	0.013	0.001	0.015
CSIR-NML	0.006	0.024	0.000	0.016	0.003	0.017	0.002	0.018	0.09	0.13	0.000	0.020	0.002	0.018	0.000	0.023
NPLI	0.010	0.016	0.0039	0.0097	0.0056	0.0079	0.002	0.018	0.09	0.12	0.004	0.011	0.005	0.015	0.004	0.015
NMIJ	0.005	0.016	0.0016	0.0070	0.0043	0.0082	0.003	0.017	0.09	0.12	0.0018	0.0082	0.002	0.014	0.002	0.011
SP	0.006	0.014	0.0014	0.0067	0.0026	0.0079	0.003	0.010	0.09	0.13	0.0015	0.0079	0.000	0.014	0.002	0.015
LNE	0.005	0.019	0.001	0.012	0.003	0.013	0.002	0.018	0.09	0.13	0.001	0.013	0.001	0.017	0.001	0.017

Table 30 – Degrees of equivalence for S_{11} measurements of device K5b.CL/7 (female mismatched load) at 2 GHz

Lab j ⇒

Lab i ⇓	NMIA		SPRING		SCL		SNIIM		NIM		NRC		NIST		CSIR-NML	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.0027	0.0054	0.001	0.020	0.005	0.012	0.0013	0.0056	0.0020	0.0032	0.003	0.025	0.0010	0.0052	0.000	0.016
PTB	0.0007	0.0069	0.004	0.021	0.008	0.013	0.0032	0.0071	0.0013	0.0053	0.005	0.025	0.0027	0.0067	0.003	0.017
NMi-VSL	0.0043	0.0055	0.001	0.018	0.003	0.012	0.003	0.011	0.0037	0.0024	0.004	0.029	0.0029	0.0079	0.002	0.018
INRIM	0.09	0.13	0.09	0.12	0.09	0.11	0.09	0.12	0.09	0.13	0.09	0.13	0.09	0.13	0.09	0.13
METAS	0.0027	0.0069	0.001	0.021	0.005	0.013	0.0015	0.0071	0.0020	0.0054	0.003	0.025	0.0012	0.0067	0.000	0.020
CMI	0.002	0.013	0.003	0.021	0.006	0.017	0.001	0.014	0.001	0.013	0.003	0.028	0.001	0.013	0.002	0.018
UME	0.0027	0.0081	0.001	0.021	0.005	0.014	0.002	0.016	0.0020	0.0070	0.003	0.027	0.001	0.015	0.000	0.023
NMIA			0.004	0.020	0.007	0.013	0.0026	0.0068	0.0007	0.0049	0.005	0.025	0.0022	0.0063	0.003	0.016
SPRING	0.004	0.020			0.004	0.019	0.002	0.013	0.003	0.018	0.002	0.026	0.002	0.015	0.001	0.025
SCL	0.007	0.013	0.004	0.019			0.006	0.013	0.007	0.012	0.005	0.027	0.006	0.013	0.005	0.018
SNIIM	0.0026	0.0068	0.002	0.013	0.006	0.013			0.0019	0.0051	0.002	0.025	0.0005	0.0065	0.001	0.016
NIM	0.0007	0.0049	0.003	0.018	0.007	0.012	0.0019	0.0051			0.004	0.025	0.0014	0.0046	0.002	0.015
NRC	0.005	0.025	0.002	0.026	0.005	0.027	0.002	0.025	0.004	0.025			0.003	0.025	0.003	0.031
NIST	0.0022	0.0063	0.002	0.015	0.006	0.013	0.0005	0.0065	0.0014	0.0046	0.003	0.025			0.001	0.015
CSIR-NML	0.003	0.016	0.001	0.025	0.005	0.018	0.001	0.016	0.002	0.015	0.003	0.031	0.001	0.015		
NPLI	0.0057	0.0081	0.004	0.014	0.003	0.013	0.005	0.011	0.0053	0.0067	0.006	0.027	0.005	0.010	0.004	0.018
NMIJ	0.0038	0.0079	0.001	0.011	0.005	0.013	0.0013	0.0080	0.0030	0.0066	0.001	0.025	0.0016	0.0077	0.002	0.021
SP	0.0020	0.0076	0.002	0.016	0.006	0.013	0.0006	0.0078	0.0013	0.0062	0.003	0.025	0.0003	0.0074	0.001	0.015
LNE	0.003	0.012	0.001	0.018	0.005	0.016	0.001	0.012	0.002	0.012	0.002	0.027	0.001	0.012	0.001	0.021

Table 30 cont'd – Degrees of equivalence for S_{11} measurements of device K5b.CL/7 (female mismatched load) at 2 GHz

Lab j ⇒

Lab i ⇓	NPLI		NMIJ		SP		LNE	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.0039	0.0097	0.0016	0.0070	0.0014	0.0067	0.001	0.012
PTB	0.0056	0.0079	0.0043	0.0082	0.0026	0.0079	0.003	0.013
NMi-VSL	0.002	0.018	0.003	0.017	0.003	0.010	0.002	0.018
INRIM	0.09	0.12	0.09	0.12	0.09	0.13	0.09	0.13
METAS	0.004	0.011	0.0018	0.0082	0.0015	0.0079	0.001	0.013
CMI	0.005	0.015	0.002	0.014	0.000	0.014	0.001	0.017
UME	0.004	0.015	0.002	0.011	0.002	0.015	0.001	0.017
NMIA	0.0057	0.0081	0.0038	0.0079	0.0020	0.0076	0.003	0.012
SPRING	0.004	0.014	0.001	0.011	0.002	0.016	0.001	0.018
SCL	0.003	0.013	0.005	0.013	0.006	0.013	0.005	0.016
SNIIM	0.005	0.011	0.0013	0.0080	0.0006	0.0078	0.001	0.012
NIM	0.0053	0.0067	0.0030	0.0066	0.0013	0.0062	0.002	0.012
NRC	0.006	0.027	0.001	0.025	0.003	0.025	0.002	0.027
NIST	0.005	0.010	0.0016	0.0077	0.0003	0.0074	0.001	0.012
CSIR-NML	0.004	0.018	0.002	0.021	0.001	0.015	0.001	0.021
NPLI			0.005	0.012	0.005	0.011	0.005	0.015
NMIJ	0.005	0.012			0.0018	0.0088	0.001	0.013
SP	0.005	0.011	0.0018	0.0088			0.001	0.013
LNE	0.005	0.015	0.001	0.013	0.001	0.013		

Table 30 cont'd – Degrees of equivalence for S_{11} measurements of device K5b.CL/7 (female mismatched load) at 2 GHz

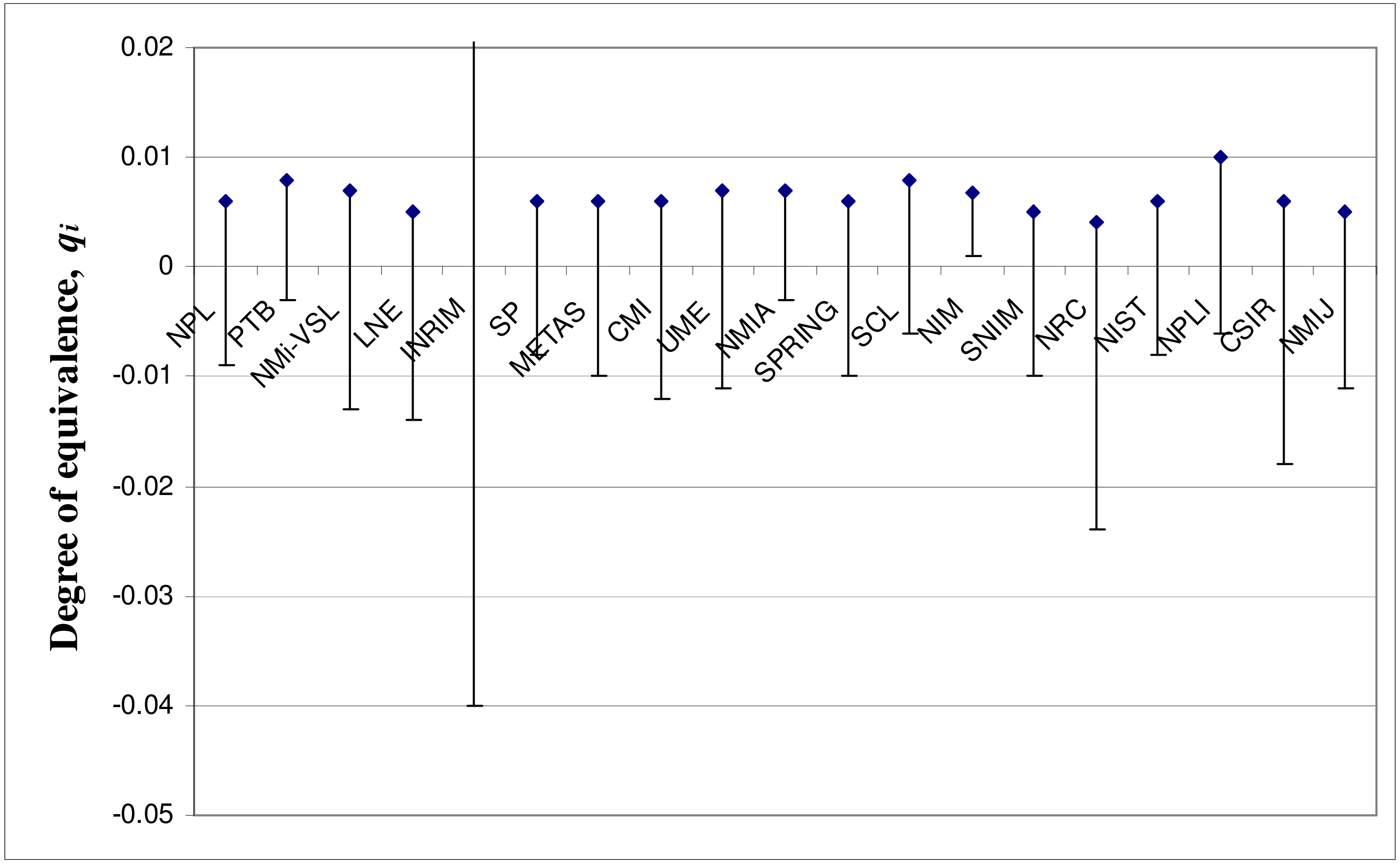

Fig 28 – Reduced dimension degrees of equivalence and their confidence indicators for S_{11} measurements of device K5b.CL/7 (female mismatched load) at 2 GHz

Lab j ⇒

Lab i ⇓	KCRV		NPL		PTB		NMi-VSL		INRIM		METAS		CMI		UME	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.0104	0.0084			0.0008	0.0065	0.004	0.027	0.11	0.17	0.003	0.011	0.004	0.015	0.004	0.029
PTB	0.0111	0.0089	0.0008	0.0065			0.005	0.027	0.11	0.17	0.004	0.012	0.005	0.015	0.005	0.030
NMi-VSL	0.008	0.032	0.004	0.027	0.005	0.027			0.11	0.17	0.001	0.030	0.001	0.034	0.001	0.039
INRIM	0.10	0.15	0.11	0.17	0.11	0.17	0.11	0.17			0.11	0.17	0.11	0.17	0.11	0.17
METAS	0.008	0.019	0.003	0.011	0.004	0.012	0.001	0.030	0.11	0.17			0.002	0.018	0.002	0.024
CMI	0.008	0.023	0.004	0.015	0.005	0.015	0.001	0.034	0.11	0.17	0.002	0.018			0.001	0.033
UME	0.009	0.032	0.004	0.029	0.005	0.030	0.001	0.039	0.11	0.17	0.002	0.024	0.001	0.033		
NMIA	0.009	0.019	0.0043	0.0073	0.0050	0.0080	0.002	0.032	0.11	0.16	0.002	0.012	0.001	0.014	0.001	0.023
SPRING	0.008	0.022	0.008	0.013	0.009	0.014	0.004	0.031	0.11	0.16	0.005	0.016	0.004	0.019	0.004	0.034
SCL	0.011	0.035	0.009	0.034	0.010	0.034	0.006	0.045	0.11	0.16	0.007	0.036	0.005	0.037	0.006	0.044
SNIIM	0.011	0.016	0.0088	0.0067	0.0095	0.0074	0.006	0.031	0.11	0.16	0.007	0.012	0.005	0.015	0.005	0.025
NIM	0.0138	0.0071	0.0148	0.0057	0.0155	0.0066	0.012	0.029	0.11	0.14	0.012	0.011	0.011	0.015	0.011	0.027
NRC	0.016	0.027	0.018	0.025	0.019	0.025	0.015	0.038	0.11	0.14	0.015	0.027	0.014	0.029	0.014	0.038
NIST	0.010	0.013	0.0021	0.0063	0.0029	0.0072	0.002	0.028	0.11	0.17	0.002	0.012	0.002	0.015	0.002	0.031
CSIR-NML	0.009	0.020	0.0035	0.0098	0.004	0.010	0.002	0.032	0.11	0.17	0.002	0.014	0.001	0.016	0.000	0.035
NPLI	0.009	0.023	0.004	0.014	0.004	0.015	0.001	0.035	0.11	0.17	0.001	0.020	0.001	0.019	0.000	0.028
NMIJ	0.009	0.018	0.0040	0.0075	0.0048	0.0082	0.001	0.032	0.11	0.17	0.002	0.012	0.001	0.014	0.000	0.029
SP	0.008	0.019	0.0040	0.0099	0.005	0.010	0.000	0.031	0.11	0.17	0.001	0.014	0.001	0.016	0.001	0.025
LNE	0.007	0.025	0.006	0.014	0.007	0.014	0.002	0.030	0.11	0.16	0.003	0.017	0.002	0.019	0.003	0.036

Table 31 – Degrees of equivalence for S_{11} measurements of device K5b.CL/7 (female mismatched load) at 9 GHz

Lab j ⇒

Lab i ⇓	NMIA		SPRING		SCL		SNIIM		NIM		NRC		NIST		CSIR-NML	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.0043	0.0073	0.008	0.013	0.009	0.034	0.0088	0.0067	0.0148	0.0057	0.018	0.025	0.0021	0.0063	0.0035	0.0098
PTB	0.0050	0.0080	0.009	0.014	0.010	0.034	0.0095	0.0074	0.0155	0.0066	0.019	0.025	0.0029	0.0072	0.004	0.010
NMi-VSL	0.002	0.032	0.004	0.031	0.006	0.045	0.006	0.031	0.012	0.029	0.015	0.038	0.002	0.028	0.002	0.032
INRIM	0.11	0.16	0.11	0.16	0.11	0.16	0.11	0.16	0.11	0.14	0.11	0.14	0.11	0.17	0.11	0.17
METAS	0.002	0.012	0.005	0.016	0.007	0.036	0.007	0.012	0.012	0.011	0.015	0.027	0.002	0.012	0.002	0.014
CMI	0.001	0.014	0.004	0.019	0.005	0.037	0.005	0.015	0.011	0.015	0.014	0.029	0.002	0.015	0.001	0.016
UME	0.001	0.023	0.004	0.034	0.006	0.044	0.005	0.025	0.011	0.027	0.014	0.038	0.002	0.031	0.000	0.035
NMIA			0.004	0.015	0.005	0.035	0.0046	0.0082	0.0105	0.0074	0.014	0.025	0.0021	0.0079	0.001	0.011
SPRING	0.004	0.015			0.002	0.035	0.003	0.017	0.007	0.013	0.011	0.027	0.006	0.014	0.005	0.016
SCL	0.005	0.035	0.002	0.035			0.001	0.030	0.005	0.034	0.009	0.042	0.007	0.035	0.006	0.035
SNIIM	0.0046	0.0082	0.003	0.017	0.001	0.030			0.0061	0.0068	0.010	0.025	0.0067	0.0073	0.005	0.010
NIM	0.0105	0.0074	0.007	0.013	0.005	0.034	0.0061	0.0068			0.004	0.025	0.0126	0.0065	0.0113	0.0099
NRC	0.014	0.025	0.011	0.027	0.009	0.042	0.010	0.025	0.004	0.025			0.016	0.025	0.015	0.026
NIST	0.0021	0.0079	0.006	0.014	0.007	0.035	0.0067	0.0073	0.0126	0.0065	0.016	0.025			0.001	0.010
CSIR-NML	0.001	0.011	0.005	0.016	0.006	0.035	0.005	0.010	0.0113	0.0099	0.015	0.026	0.001	0.010		
NPLI	0.001	0.018	0.004	0.019	0.006	0.037	0.005	0.016	0.011	0.015	0.015	0.028	0.002	0.014	0.000	0.017
NMIJ	0.0009	0.0088	0.004	0.014	0.006	0.035	0.0052	0.0083	0.0109	0.0076	0.014	0.025	0.0019	0.0081	0.001	0.011
SP	0.002	0.011	0.004	0.015	0.006	0.035	0.006	0.011	0.011	0.010	0.015	0.026	0.002	0.011	0.001	0.013
LNE	0.003	0.015	0.002	0.018	0.004	0.036	0.005	0.014	0.009	0.014	0.013	0.028	0.004	0.014	0.003	0.016

Table 31 cont'd – Degrees of equivalence for S_{11} measurements of device K5b.CL/7 (female mismatched load) at 9 GHz

	Lab $j \Rightarrow$							
Lab $i \Downarrow$	NPLI		NMIJ		SP		LNE	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.004	0.014	0.0040	0.0075	0.0040	0.0099	0.006	0.014
PTB	0.004	0.015	0.0048	0.0082	0.005	0.010	0.007	0.014
NMi-VSL	0.001	0.035	0.001	0.032	0.000	0.031	0.002	0.030
INRIM	0.11	0.17	0.11	0.17	0.11	0.17	0.11	0.16
METAS	0.001	0.020	0.002	0.012	0.001	0.014	0.003	0.017
CMI	0.001	0.019	0.001	0.014	0.001	0.016	0.002	0.019
UME	0.000	0.028	0.000	0.029	0.001	0.025	0.003	0.036
NMIA	0.001	0.018	0.0009	0.0088	0.002	0.011	0.003	0.015
SPRING	0.004	0.019	0.004	0.014	0.004	0.015	0.002	0.018
SCL	0.006	0.037	0.006	0.035	0.006	0.035	0.004	0.036
SNIIM	0.005	0.016	0.0052	0.0083	0.006	0.011	0.005	0.014
NIM	0.011	0.015	0.0109	0.0076	0.011	0.010	0.009	0.014
NRC	0.015	0.028	0.014	0.025	0.015	0.026	0.013	0.028
NIST	0.002	0.014	0.0019	0.0081	0.002	0.011	0.004	0.014
CSIR-NML	0.000	0.017	0.001	0.011	0.001	0.013	0.003	0.016
NPLI			0.000	0.015	0.001	0.018	0.003	0.019
NMIJ	0.000	0.015			0.001	0.011	0.003	0.015
SP	0.001	0.018	0.001	0.011			0.002	0.016
LNE	0.003	0.019	0.003	0.015	0.002	0.016		

Table 31 cont'd – Degrees of equivalence for S_{11} measurements of device K5b.CL/7 (female mismatched load) at 9 GHz

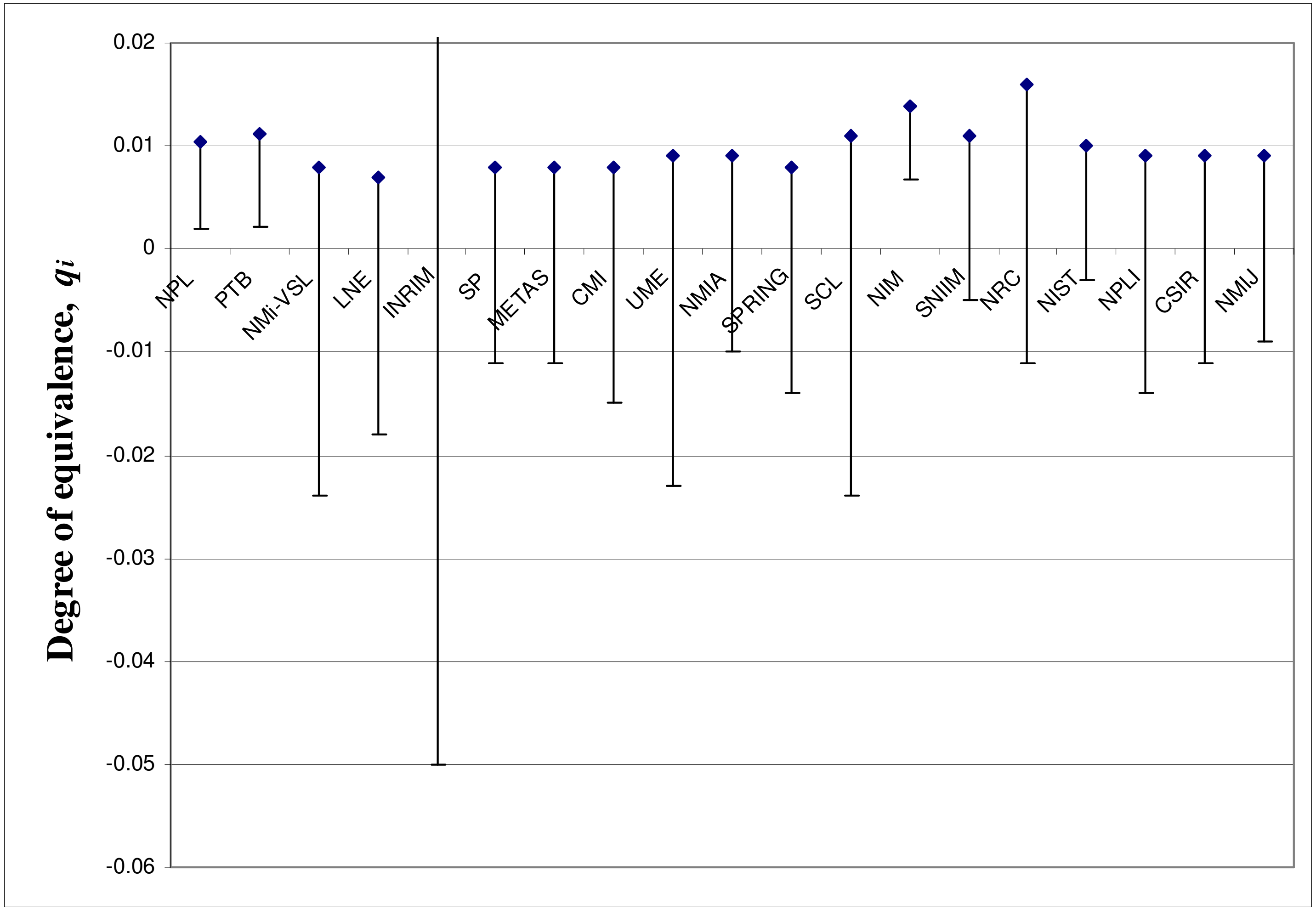

Fig 29 – Reduced dimension degrees of equivalence and their confidence indicators for S_{11} measurements of device K5b.CL/7 (female mismatched load) at 9 GHz

Lab j ⇒

Lab i ⇓	KCRV		NPL		PTB		NMi-VSL		INRIM		METAS		CMI		UME	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.013	0.013			0.005	0.011	0.002	0.020	0.052	0.064	0.006	0.014	0.007	0.018	0.004	0.010
PTB	0.0178	0.0098	0.005	0.011			0.006	0.023	0.057	0.061	0.011	0.012	0.012	0.017	0.0081	0.0075
NMi-VSL	0.012	0.033	0.002	0.020	0.006	0.023			0.051	0.077	0.004	0.034	0.005	0.027	0.002	0.018
INRIM	0.039	0.061	0.052	0.064	0.057	0.061	0.051	0.077			0.046	0.062	0.046	0.062	0.049	0.078
METAS	0.008	0.013	0.006	0.014	0.011	0.012	0.004	0.034	0.046	0.062			0.002	0.017	0.004	0.041
CMI	0.008	0.017	0.007	0.018	0.012	0.017	0.005	0.027	0.046	0.062	0.002	0.017			0.004	0.026
UME	0.011	0.033	0.004	0.010	0.0081	0.0075	0.002	0.018	0.049	0.078	0.004	0.041	0.004	0.026		
NMIA	0.008	0.011	0.005	0.013	0.0099	0.0097	0.005	0.037	0.047	0.066	0.003	0.013	0.005	0.015	0.006	0.015
SPRING	0.005	0.027	0.008	0.028	0.013	0.027	0.007	0.046	0.044	0.073	0.003	0.029	0.004	0.026	0.007	0.050
SCL	0.011	0.033	0.010	0.038	0.013	0.039	0.008	0.041	0.046	0.070	0.007	0.036	0.004	0.037	0.006	0.037
SNIIM	0.006	0.011	0.007	0.012	0.0121	0.0081	0.007	0.039	0.045	0.065	0.003	0.012	0.005	0.015	0.007	0.024
NIM	0.0047	0.0078	0.017	0.011	0.0220	0.0068	0.016	0.030	0.035	0.062	0.012	0.011	0.011	0.019	0.015	0.015
NRC	0.016	0.026	0.028	0.026	0.033	0.025	0.027	0.041	0.024	0.074	0.023	0.027	0.023	0.031	0.026	0.042
NIST	0.0032	0.0089	0.013	0.013	0.0176	0.0095	0.013	0.040	0.040	0.070	0.009	0.014	0.010	0.019	0.013	0.038
CSIR-NML	0.002	0.012	0.012	0.014	0.017	0.011	0.011	0.038	0.041	0.068	0.007	0.014	0.008	0.020	0.011	0.045
NPLI	0.025	0.022	0.038	0.022	0.043	0.020	0.037	0.040	0.019	0.045	0.033	0.023	0.033	0.028	0.037	0.037
NMIJ	0.0032	0.0073	0.012	0.012	0.0169	0.0085	0.012	0.040	0.041	0.070	0.008	0.012	0.009	0.017	0.012	0.034
SP	0.005	0.014	0.009	0.016	0.014	0.014	0.009	0.040	0.044	0.071	0.006	0.017	0.008	0.020	0.009	0.030
LNE	0.002	0.017	0.012	0.019	0.017	0.017	0.012	0.042	0.040	0.071	0.008	0.019	0.009	0.024	0.012	0.046

Table 32 – Degrees of equivalence for S_{11} measurements of device K5b.CL/7 (female mismatched load) at 18 GHz

Lab j ⇒

Lab i ⇓	NMIA		SPRING		SCL		SNIIM		NIM		NRC		NIST		CSIR-NML	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.005	0.013	0.008	0.028	0.010	0.038	0.007	0.012	0.017	0.011	0.028	0.026	0.013	0.013	0.012	0.014
PTB	0.0099	0.0097	0.013	0.027	0.013	0.039	0.0121	0.0081	0.0220	0.0068	0.033	0.025	0.0176	0.0095	0.017	0.011
NMi-VSL	0.005	0.037	0.007	0.046	0.008	0.041	0.007	0.039	0.016	0.030	0.027	0.041	0.013	0.040	0.011	0.038
INRIM	0.047	0.066	0.044	0.073	0.046	0.070	0.045	0.065	0.035	0.062	0.024	0.074	0.040	0.070	0.041	0.068
METAS	0.003	0.013	0.003	0.029	0.007	0.036	0.003	0.012	0.012	0.011	0.023	0.027	0.009	0.014	0.007	0.014
CMI	0.005	0.015	0.004	0.026	0.004	0.037	0.005	0.015	0.011	0.019	0.023	0.031	0.010	0.019	0.008	0.020
UME	0.006	0.015	0.007	0.050	0.006	0.037	0.007	0.024	0.015	0.015	0.026	0.042	0.013	0.038	0.011	0.045
NMIA			0.004	0.024	0.010	0.036	0.002	0.010	0.0125	0.0091	0.024	0.026	0.008	0.011	0.007	0.013
SPRING	0.004	0.024			0.009	0.040	0.001	0.021	0.009	0.025	0.020	0.036	0.005	0.026	0.004	0.029
SCL	0.010	0.036	0.009	0.040			0.009	0.035	0.013	0.037	0.024	0.045	0.014	0.036	0.011	0.036
SNIIM	0.002	0.010	0.001	0.021	0.009	0.035			0.0102	0.0074	0.021	0.025	0.006	0.010	0.004	0.011
NIM	0.0125	0.0091	0.009	0.025	0.013	0.037	0.0102	0.0074			0.011	0.025	0.0070	0.0089	0.006	0.010
NRC	0.024	0.026	0.020	0.036	0.024	0.045	0.021	0.025	0.011	0.025			0.017	0.026	0.017	0.026
NIST	0.008	0.011	0.005	0.026	0.014	0.036	0.006	0.010	0.0070	0.0089	0.017	0.026			0.002	0.013
CSIR-NML	0.007	0.013	0.004	0.029	0.011	0.036	0.004	0.011	0.006	0.010	0.017	0.026	0.002	0.013		
NPLI	0.033	0.021	0.030	0.034	0.035	0.042	0.031	0.020	0.022	0.021	0.012	0.032	0.025	0.020	0.026	0.022
NMIJ	0.007	0.010	0.005	0.025	0.013	0.035	0.0051	0.0090	0.0074	0.0078	0.017	0.025	0.001	0.010	0.002	0.012
SP	0.004	0.016	0.003	0.023	0.012	0.037	0.003	0.015	0.010	0.014	0.021	0.028	0.004	0.015	0.004	0.016
LNE	0.007	0.018	0.005	0.031	0.013	0.038	0.005	0.017	0.006	0.017	0.017	0.029	0.001	0.018	0.001	0.019

Table 32 cont'd – Degrees of equivalence for S_{11} measurements of device K5b.CL/7 (female mismatched load) at 18 GHz

	Lab $j \Rightarrow$							
Lab $i \Downarrow$	NPLI		NMIJ		SP		LNE	
	q_i	dq_i	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}	q_{ij}	dq_{ij}
NPL	0.038	0.022	0.012	0.012	0.009	0.016	0.012	0.019
PTB	0.043	0.020	0.0169	0.0085	0.014	0.014	0.017	0.017
NMi-VSL	0.037	0.040	0.012	0.040	0.009	0.040	0.012	0.042
INRIM	0.019	0.045	0.041	0.070	0.044	0.071	0.040	0.071
METAS	0.033	0.023	0.008	0.012	0.006	0.017	0.008	0.019
CMI	0.033	0.028	0.009	0.017	0.008	0.020	0.009	0.024
UME	0.037	0.037	0.012	0.034	0.009	0.030	0.012	0.046
NMIA	0.033	0.021	0.007	0.010	0.004	0.016	0.007	0.018
SPRING	0.030	0.034	0.005	0.025	0.003	0.023	0.005	0.031
SCL	0.035	0.042	0.013	0.035	0.012	0.037	0.013	0.038
SNIIM	0.031	0.010	0.0051	0.0090	0.003	0.015	0.005	0.017
NIM	0.022	0.021	0.0074	0.0078	0.010	0.014	0.006	0.017
NRC	0.012	0.032	0.017	0.025	0.021	0.028	0.017	0.029
NIST	0.025	0.020	0.001	0.010	0.004	0.015	0.001	0.018
CSIR-NML	0.026	0.022	0.002	0.012	0.004	0.016	0.001	0.019
NPLI			0.026	0.020	0.029	0.023	0.026	0.025
NMIJ	0.026	0.020			0.003	0.015	0.001	0.017
SP	0.029	0.023	0.003	0.015			0.004	0.021
LNE	0.026	0.025	0.001	0.017	0.004	0.021		

Table 32 cont'd – Degrees of equivalence for S_{11} measurements of device K5b.CL/7 (female mismatched load) at 18 GHz

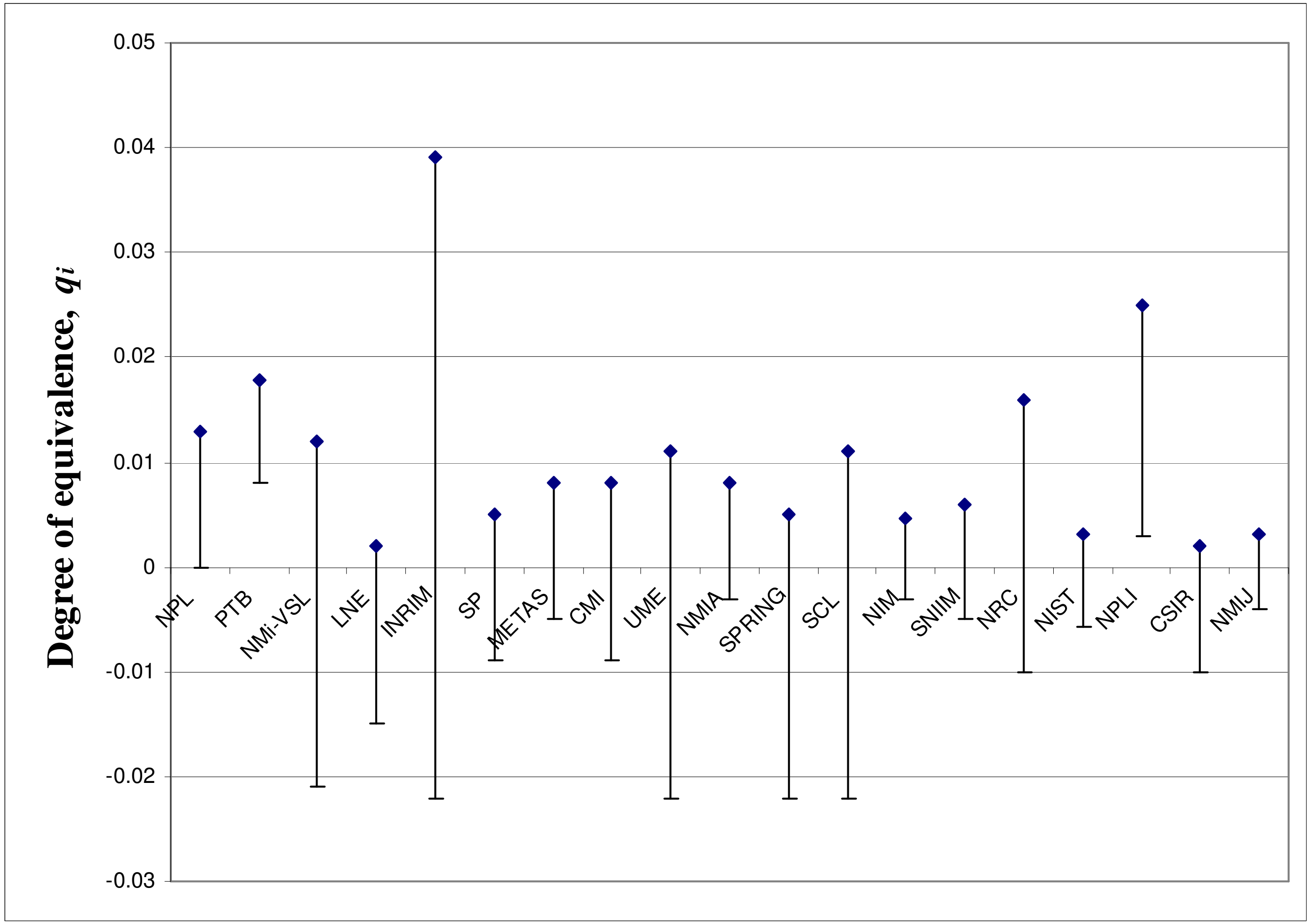

Fig 30 – Reduced dimension degrees of equivalence and their confidence indicators for S_{11} measurements of device K5b.CL/7 (female mismatched load) at 18 GHz

Appendix A: Treatment of Results

$x_i(S_{ab})$	result of measurement of real component of scattering parameter S_{ab} carried out by laboratory *i*.
$u(x_i(S_{ab}))$	combined uncertainty of $x_i(S_{ab})$ reported by laboratory *i*.
$y_i(S_{ab})$	result of measurement of imaginary component of scattering parameter S_{ab} carried out by laboratory *i*.
$u(y_i(S_{ab}))$	combined uncertainty of $y_i(S_{ab})$ reported by laboratory *i*.

Each *S*-parameter, consisting of real and imaginary component, x_i and y_i, can be represented in vector form, $\boldsymbol{z_i}$, and the uncertainties can be represented using a covariance matrix, $\boldsymbol{V_i}$:

$$\boldsymbol{z_i} = \begin{pmatrix} x_i \\ y_i \end{pmatrix}, \qquad (1a)$$

$$\boldsymbol{V_i} = \begin{pmatrix} u^2(x_i) & u(x_i, y_i) \\ u(x_i, y_i) & u^2(y_i) \end{pmatrix}. \qquad (1b)$$

The off-diagonal elements represent the correlation between the real and imaginary components. Where a participant did not provide a value for $u(x_i, y_i)$, this was assumed to be 0.

The KCRV, $\boldsymbol{z_M}$, was determined using an unweighted mean

$$\boldsymbol{z_M} = \frac{1}{N}\sum_{i=1}^{N} \boldsymbol{z_i}, \qquad (2a)$$

and its uncertainty matrix determined using

$$\boldsymbol{V_M} = \begin{pmatrix} u^2(x_M) & u(x_M, y_M) \\ u(y_M, x_M) & u^2(y_M) \end{pmatrix}, \qquad (2b)$$

where

$$u^2(x_M) = \frac{1}{N(N-1)} \sum_{i=1}^{N} (x_i - x_M)^2 \, , \tag{3a}$$

$$u^2(y_M) = \frac{1}{N(N-1)} \sum_{i=1}^{N} (y_i - y_M)^2 \, , \tag{3b}$$

$$u(x_M, y_M) = \frac{1}{N(N-1)} \sum_{i=1}^{N} (x_i - x_M)(y_i - y_M) \tag{3c}$$

and N is the number of participants used to determine the KCRV.

The correlation coefficient for the KCRV is derived using

$$r(x_M, y_M) = \frac{u(x_M, y_M)}{u(x_M)u(y_M)} \, . \tag{4}$$

In calculating the KCRV, inconsistent data was not used. Inconsistent data was highlighted by examining the degrees of equivalence, i.e.,

$$\boldsymbol{\Delta}_i = \boldsymbol{z}_i - \boldsymbol{z}_M \, . \tag{5}$$

The uncertainty matrix associated with $\boldsymbol{\Delta}_i$, $\boldsymbol{V}_{\boldsymbol{\Delta}i}$, is given by [A1]

$$\boldsymbol{V}_{\Delta i} = \boldsymbol{V}_M + \left(1 - \frac{2}{N}\right) \boldsymbol{V}_i \, , \tag{6}$$

where the result from participant i is included in the determination of the KCRV. Equation (8), later in this appendix, describes how the uncertainty matrix is obtained for results not used in the determination of the KCRV.

For one-dimensional data, each element is considered consistent if the magnitude of the degree of equivalence is smaller than its expanded uncertainty (at 95 % confidence level).

With two-dimensional (complex) degree of equivalence data, it is possible that one component (real or imaginary) may be larger than its expanded uncertainty but the other not. Despite this phenomenon, there is a chance that this element may be consistent with the rest of the data.

To confirm its consistency (and also to assist in the graphical representation of degrees of equivalence), the number of dimensions must be reduced [A2]. Let

$$q_i = |\boldsymbol{\Delta}_i| \tag{7a}$$

and

$$dq_i = |\boldsymbol{\Delta}_i| \sqrt{\left(\boldsymbol{\Delta}_i^{\mathrm{T}} \mathbf{V}_{\boldsymbol{\Delta} i}^{-1} \boldsymbol{\Delta}_i\right)^{-1} k^2}\ , \tag{7b}$$

where k is a suitable chosen coverage factor to give a 95 % confidence level. For two-dimensional data, $k^2 = 5.991$ assuming that the degrees of freedom are sufficiently high [A3].

Here, dq_i is not an uncertainty but describes the distance from $\boldsymbol{\Delta}_i$ to its confidence boundary through the origin and, for the purposes of this report, is referred to as a confidence indicator.

If $q_i > dq_i$, the data element is considered inconsistent with the rest of the data. The most discrepant element is removed first, i.e., the element for which $q_i - dq_i$ is most positive, the vector mean is re-calculated and, if still inconsistent, the then most discrepant element is excluded and so on until a set of consistent data is obtained[***].

Note that by using this method, q_i, and hence the bilateral equivalent q_{ij}, will always be positive, due to this quantity representing a magnitude. Therefore, although the bilateral

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[***] CCEM observers were not used to obtain a value for the KCRV, hence they were also not included in this process.

vector degrees of equivalence will negate each other, i.e., $\Delta_{ij} = \Delta_i - \Delta_j = -\Delta_{ji}$, the reduced dimension versions will be equal, i.e., $q_{ij} = q_{ji}$.

Note also that if $q_i = 0$, dq_i becomes indeterminable using (7b). Where this occurs, if the diagonal elements of $\boldsymbol{V}_{\Delta i}$ are equal, dq_i is assumed to be this value multiplied by k. Where the elements are not equal, dq_i is assumed to be the largest value multiplied by k.

If a measurement is not used in the calculation of the KCRV, the uncertainty in its degree of equivalence is evaluated using

$$\boldsymbol{V}_{\Delta i} = \boldsymbol{V}_M + \boldsymbol{V}_i . \tag{8}$$

Measurements not used in the calculation of the KCRV are highlighted in the tables in *italic* typeface.

NPL's contribution to the KCRV comes from the first measurement, taken in June 2003. Subsequent measurements were carried out purely to observe the stability of the devices and do not take any further part in this comparison.

The exception to this is the measurement of device K5b.CL/1, the 3 dB attenuator. Observation of the measurements shows a distinct change in value between the measurement period at UME and the third measurement period at NPL (July 2004), therefore two KCRVs have been calculated for this device. As NPL carried out measurements in both periods, NPL contributes to both KCRVs for this device: NPL's first measurement, made in June 2003, contributes to the pre July 2004 KCRV; and NPL's final measurement, made in October 2006, contributes to the post July 2004 KCRV.

The definitive KCRV is provided in real and imaginary format. The equivalent magnitude and phase values, along with uncertainties, are provided for interest only and do not form part of the comparison. The conversion to magnitude, r, and phase, θ, was carried out using

$$r_M = \sqrt{{x_M}^2 + {y_M}^2} , \tag{9a}$$

$$u^2(r_M) = \left(\frac{\partial r_M}{\partial x_M}\right)^2 u^2(x_M) + \left(\frac{\partial r_M}{\partial y_M}\right)^2 u^2(y_M) + 2\left(\frac{\partial r_M}{\partial x_M}\right)\left(\frac{\partial r_M}{\partial y_M}\right) u(x_M, y_M), \tag{9b}$$

$$\theta = \tan^{-1}\left(\frac{y_M}{x_M}\right) \tag{9c}$$

and

$$u^2(\theta_M) = \left(\frac{\partial \theta_M}{\partial x_M}\right)^2 u^2(x_M) + \left(\frac{\partial \theta_M}{\partial y_M}\right)^2 u^2(y_M) + 2\left(\frac{\partial \theta_M}{\partial x_M}\right)\left(\frac{\partial \theta_M}{\partial y_M}\right) u(x_M, y_M). \tag{9d}$$

For ease of reporting, only the reduced dimension version of the degrees of equivalence, q_i and q_{ij}, and their confidence indicators, dq_i and dq_{ij}, have been included in this report and is calculated as described above, using (8) to provide the uncertainty matrix, $\boldsymbol{V}_{\boldsymbol{\Delta}ij}$.

Please note: although the reported uncertainties have been rounded to two significant figures and the associated measured values rounded accordingly in the tables, the analysis was carried out with the results as reported by the participants with no rounding.

References

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[A2] M. Zeier, “On the analysis of multidimensional quantities in measurement comparison”, *CPEM 2006 Conference Digest*, Torino, July 2006, pp 458-459

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Appendix B – Uncertainty Budgets

B.1 NPL Uncertainty Budgets

The tables provided here are of typical budgets for NPL S-parameter measurements and do not include Type A contributions. It is assumed that the real and imaginary uncertainty components are identical.

Table B.1.1: Uncertainties in the S_{21} measurement of device RF-K5b.CL/1 at 2 GHz

Source (i)	**Dist**	u_T**(i)**
Isolation	Rect	0.000007
Linearity	Rect	0.000169
Mismatch	U-shaped	0.000028
Combined uncertainty (k = 1):		0.0002

Table B.1.2: Uncertainties in the S_{21} measurement of device RF-K5b.CL/1 at 9 GHz

Source (i)	**Dist**	u_T**(i)**
Isolation	Rect	0.000013
Linearity	Rect	0.000169
Mismatch	U-shaped	0.000033
Combined uncertainty (k = 1):		0.0002

Table B.1.3: Uncertainties in the S_{21} measurement of device RF-K5b.CL/1 at 18 GHz

Source (i)	**Dist**	u_T**(i)**
Isolation	Rect	0.000202
Linearity	Rect	0.000169
Mismatch	U-shaped	0.000114
Combined uncertainty (k = 1):		0.0003

Table B.1.4: Uncertainties in the S_{21} measurement of device RF-K5b.CL/2 at 2 GHz

Source (i)	**Dist**	u_T**(i)**
Isolation	Rect	0.000007
Linearity	Rect	0.000065
Mismatch	U-shaped	0.000001
Combined uncertainty (k = 1):		0.00007

Table B.1.5: Uncertainties in the S_{21} measurement of device RF-K5b.CL/2 at 9 GHz

Source (i)	**Dist**	u_T**(i)**
Isolation	Rect	0.000013
Linearity	Rect	0.000065
Mismatch	U-shaped	0.000003
Combined uncertainty (k = 1):		0.00007

Table B.1.6: Uncertainties in the S_{21} measurement of device RF-K5b.CL/2 at 18 GHz

Source (i)	**Dist**	u_T**(i)**
Isolation	Rect	0.000028
Linearity	Rect	0.000065
Mismatch	U-shaped	0.000022
Combined uncertainty (k = 1):		0.00007

Table B.1.7: Uncertainties in the S_{21} measurement of device RF-K5b.CL/3 at 2 GHz

Source (i)	**Dist**	u_T**(i)**
Isolation	Rect	0.0000069
Linearity	Rect	0.0000053
Mismatch	U-shaped	0.0000000
Combined uncertainty (k = 1):		0.000009

Table B.1.8: Uncertainties in the S_{21} measurement of device RF-K5b.CL/3 at 9 GHz

Source (i)	**Dist**	u_T**(i)**
Isolation	Rect	0.0000128
Linearity	Rect	0.0000053
Mismatch	U-shaped	0.0000001
Combined uncertainty (k = 1):		0.000014

Table B.1.9: Uncertainties in the S_{21} measurement of device RF-K5b.CL/3 at 18 GHz

Source (i)	**Dist**	u_T**(i)**
Isolation	Rect	0.0000283
Linearity	Rect	0.0000053
Mismatch	U-shaped	0.0000000
Combined uncertainty (k = 1):		0.000029

Table B.1.10: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 2 GHz

Source (i)	**Dist**	**u_{T}(i)**
Resistivity	Rect	0.0003
Conductors’ diameters	Rect	0.0008
Combined uncertainty (k = 1):		0.0011

Table B.1.11: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 9 GHz

Source (i)	**Dist**	**u_{T}(i)**
Resistivity	Rect	0.0002
Conductors’ diameters	Rect	0.0008
Combined uncertainty (k = 1):		0.0010

Table B.1.12: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 18 GHz

Source (i)	**Dist**	**u_{T}(i)**
Resistivity	Rect	0.0002
Conductors’ diameters	Rect	0.0008
Combined uncertainty (k = 1):		0.0010

Table B.1.13: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 2 GHz

Source (i)	**Dist**	**u_{T}(i)**
Resistivity	Rect	0.0004
Conductors’ diameters	Rect	0.0008
Combined uncertainty (k = 1):		0.0012

Table B.1.14: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 9 GHz

Source (i)	**Dist**	**u_{T}(i)**
Resistivity	Rect	0.0003
Conductors’ diameters	Rect	0.0008
Combined uncertainty (k = 1):		0.0011

Table B.1.15: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 18 GHz

Source (i)	**Dist**	**u_{T}(i)**
Resistivity	Rect	0.0002
Conductors’ diameters	Rect	0.0008
Combined uncertainty (k = 1):		0.0010

B.2 PTB Uncertainty Budgets

The real and the imaginary components are considered to have the same uncertainty. PTB performed the measurements with the male connector at Port 1 and the female connector at Port 2; hence the uncertainty budgets presented here are for S_{12}.

Table B.2.1: Uncertainties in the S_{12} measurement of device RF-K5b.CL/1 at 2 GHz

Source (i)	**Dist**	**u_T(i) (dB)**
Transmission tracking	Rect	0.04420
Non-linearity	Rect	0.00035
Mismatch	U-shaped	0.00108
Cross-talk	Rect	0.00002
System and Connector Repeatability	Gaussian	0.00103
Combined uncertainty (k = 2):		0.05110
Combined uncertainty (linear, k = 1):		**0.0021**

Table B.2.2: Uncertainties in the S_{12} measurement of device RF-K5b.CL/1 at 9 GHz

Source (i)	**Type**	**u_T(i) (dB)**
Transmission tracking	Rect	0.04420
Non-linearity	Rect	0.00118
Mismatch	U-shaped	0.00126
Cross-talk	Rect	0.00003
System and Connector Repeatability	Gaussian	0.00435
Combined uncertainty (k = 2):		0.05182
Combined uncertainty (linear, k = 1):		**0.0022**

Table B.2.3: Uncertainties in the S_{12} measurement of device RF-K5b.CL/1 at 18 GHz

Source (i)	**Type**	**u_T(i) (dB)**
Transmission tracking	Rect	0.04420
Non-linearity	Rect	0.00218
Mismatch	U-shaped	0.00284
Cross-talk	Rect	0.00014
System and Connector Repeatability	Gaussian	0.00862
Combined uncertainty (k = 2):		0.05408
Combined uncertainty (linear, k = 1):		**0.0022**

Table B.2.4: Uncertainties in the S_{12} measurement of device RF-K5b.CL/2 at 2 GHz

Source (i)	**Dist**	**u_{T}(i) (dB)**
Transmission tracking	Rect	0.04420
Non-linearity	Rect	0.00028
Mismatch	U-shaped	0.00030
Cross-talk	Rect	0.00015
System and Connector Repeatability	Gaussian	0.00142
Combined uncertainty (*k* = 2):		0.05112
Combined uncertainty (linear, *k* = 1):		**0.00030**

Table B.2.5: Uncertainties in the S_{12} measurement of device RF-K5b.CL/2 at 9 GHz

Source (i)	**Type**	**u_{T}(i) (dB)**
Transmission tracking	Rect	0.04420
Non-linearity	Rect	0.00969
Mismatch	U-shaped	0.00113
Cross-talk	Rect	0.00019
System and Connector Repeatability	Gaussian	0.00991
Combined uncertainty (*k* = 2):		0.05590
Combined uncertainty (linear, *k* = 1):		**0.00032**

Table B.2.6: Uncertainties in the S_{12} measurement of device RF-K5b.CL/2 at 18 GHz

Source (i)	**Type**	**u_{T}(i) (dB)**
Transmission tracking	Rect	0.04420
Non-linearity	Rect	0.02118
Mismatch	U-shaped	0.00236
Cross-talk	Rect	0.00095
System and Connector Repeatability	Gaussian	0.01428
Combined uncertainty (*k* = 2):		0.06349
Combined uncertainty (linear, *k* = 1):		**0.00038**

Table B.2.7: Uncertainties in the S_{12} measurement of device RF-K5b.CL/3 at 2 GHz

Source (i)	**Dist**	**u_T(i) (dB)**
Transmission tracking	Rect	0.04420
Non-linearity	Rect	0.00140
Mismatch	U-shaped	0.00014
Cross-talk	Rect	0.00476
System and Connector Repeatability	Gaussian	0.00239
Combined uncertainty ($k = 2$):		0.05158
Combined uncertainty (linear, $k = 1$):		**0.000009**

Table B.2.8: Uncertainties in the S_{12} measurement of device RF-K5b.CL/3 at 9 GHz

Source (i)	**Type**	**u_T(i) (dB)**
Transmission tracking	Rect	0.04420
Non-linearity	Rect	0.02881
Mismatch	U-shaped	0.00152
Cross-talk	Rect	0.00613
System and Connector Repeatability	Gaussian	0.00560
Combined uncertainty ($k = 2$):		0.06239
Combined uncertainty (linear, $k = 1$):		**0.000011**

Table B.2.9: Uncertainties in the S_{12} measurement of device RF-K5b.CL/3 at 18 GHz

Source (i)	**Type**	**u_T(i) (dB)**
Transmission tracking	Rect	0.04420
Non-linearity	Rect	0.06220
Mismatch	U-shaped	0.00023
Cross-talk	Rect	0.02768
System and Connector Repeatability	Gaussian	0.01041
Combined uncertainty ($k = 2$):		0.09608
Combined uncertainty (linear, $k = 1$):		**0.000020**

Table B.2.10: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 2 GHz

Source (i)	**Dist**	$\boldsymbol{u_T}$**(i)**
Air line reflection	Rect	0.00045
Combined directivity and source match	U-shaped	0.00181
Tracking	Rect	0.00000
Non-linearity	Rect	0.00000
System and Connector Repeatability	Gaussian	0.00012
Combined uncertainty (k = 1):		**0.0013**

Table B.2.11: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 9 GHz

Source (i)	**Type**	$\boldsymbol{u_T}$**(i)**
Air line reflection	Rect	0.00045
Combined directivity and source match	U-shaped	0.00181
Tracking	Rect	0.00002
Non-linearity	Rect	0.00003
System and Connector Repeatability	Gaussian	0.00023
Combined uncertainty (k = 1):		**0.0013**

Table B.2.12: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 18 GHz

Source (i)	**Type**	$\boldsymbol{u_T}$**(i)**
Air line reflection	Rect	0.00045
Combined directivity and source match	U-shaped	0.00182
Tracking	Rect	0.00009
Non-linearity	Rect	0.00019
System and Connector Repeatability	Gaussian	0.00051
Combined uncertainty (k = 1):		**0.0013**

Table B.2.13: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 2 GHz

Source (i)	**Dist**	**u_T(i)**
Air line reflection	Rect	0.00045
Combined directivity and source match	U-shaped	0.00289
Tracking	Rect	0.00056
Non-linearity	Rect	0.00000
System and Connector Repeatability	Gaussian	0.00013
Combined uncertainty (k = 1):		**0.0021**

Table B.2.14: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 9 GHz

Source (i)	**Type**	**u_T(i)**
Air line reflection	Rect	0.00045
Combined directivity and source match	U-shaped	0.00290
Tracking	Rect	0.00056
Non-linearity	Rect	0.00012
System and Connector Repeatability	Gaussian	0.00012
Combined uncertainty (k = 1):		**0.0021**

Table B.2.15: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 18 GHz

Source (i)	**Type**	**u_T(i)**
Air line reflection	Rect	0.00045
Combined directivity and source match	U-shaped	0.00297
Tracking	Rect	0.00060
Non-linearity	Rect	0.00026
System and Connector Repeatability	Gaussian	0.00036
Combined uncertainty (k = 1):		**0.0022**

B.3 NMi-VSL Uncertainty Budgets

The real and the imaginary components are considered to have the same uncertainty. PTB performed the measurements with the male connector at Port 1 and the female connector at Port 2; hence the uncertainty budgets presented here are for S_{12}.

Table B.3.1: Uncertainties in the S_{12} measurement of device RF-K5b.CL/1 at 2 GHz

Source (i)	**Dist**	**u_T(i) (dB)**
Linearity	Rect	0.0030
Mismatch	U-shaped	0.0079
Crosstalk	Rect	0.0000
System Repeatability	Gaussian	0.0100
Noise level	Gaussian	0.0001
Cable flexure	Gaussian	0.0050
Ambient conditions	Gaussian	0.0012
Difference between S_{12} and S_{21}		0.0017
Statistics due to repeat measurement		0.0140
Combined uncertainty (k = 1):		0.0199
Combined uncertainty (linear):		**0.0016**

Table B.3.2: Uncertainties in the S_{12} measurement of device RF-K5b.CL/1 at 9 GHz

Source (i)	**Dist**	**u_T(i) (dB)**
Linearity	Rect	0.0029
Mismatch	U-shaped	0.0076
Crosstalk	Rect	0.0000
System Repeatability	Gaussian	0.0100
Noise level	Gaussian	0.0001
Cable flexure	Gaussian	0.0050
Ambient conditions	Gaussian	0.0012
Difference between S_{12} and S_{21}		0.0018
Statistics due to repeat measurement		0.0130
Combined uncertainty (k = 1):		0.0191
Combined uncertainty (linear):		**0.0016**

Table B.3.3: Uncertainties in the S_{12} measurement of device RF-K5b.CL/1 at 18 GHz

Source (i)	**Dist**	**u_T(i) (dB)**
Linearity	Rect	0.0029
Mismatch	U-shaped	0.0161
Crosstalk	Rect	0.0000
System Repeatability	Gaussian	0.0100
Noise level	Gaussian	0.0001
Cable flexure	Gaussian	0.0050
Ambient conditions	Gaussian	0.0012
Difference between S_{12} and S_{21}		0.0022
Statistics due to repeat measurement		0.0156
Combined uncertainty (k = 1):		0.0254
Combined uncertainty (linear):		**0.0021**

Table B.3.4: Uncertainties in the S_{12} measurement of device RF-K5b.CL/2 at 2 GHz

Source (i)	**Dist**	**u_T(i) (dB)**
Linearity	Rect	0.0200
Mismatch	U-shaped	0.0029
Crosstalk	Rect	0.0003
System Repeatability	Gaussian	0.0100
Noise level	Gaussian	0.0009
Cable flexure	Gaussian	0.0050
Ambient conditions	Gaussian	0.0012
Difference between S_{12} and S_{21}		0.0003
Statistics due to repeat measurement		0.0096
Combined uncertainty (k = 1):		0.0250
Combined uncertainty (linear):		**0.00029**

Table B.3.5: Uncertainties in the S_{12} measurement of device RF-K5b.CL/2 at 9 GHz

Source (i)	**Dist**	**u_T(i) (dB)**
Linearity	Rect	0.0201
Mismatch	U-shaped	0.0072
Crosstalk	Rect	0.0003
System Repeatability	Gaussian	0.0100
Noise level	Gaussian	0.0009
Cable flexure	Gaussian	0.0050
Ambient conditions	Gaussian	0.0012
Difference between S_{12} and S_{21}		0.0004
Statistics due to repeat measurement		0.0200
Combined uncertainty (k = 1):		0.0314
Combined uncertainty (linear):		**0.00036**

Table B.3.6: Uncertainties in the S_{12} measurement of device RF-K5b.CL/2 at 18 GHz

Source (i)	**Dist**	**u_T(i) (dB)**
Linearity	Rect	0.0196
Mismatch	U-shaped	0.0105
Crosstalk	Rect	0.0003
System Repeatability	Gaussian	0.0100
Noise level	Gaussian	0.0008
Cable flexure	Gaussian	0.0050
Ambient conditions	Gaussian	0.0012
Difference between S_{12} and S_{21}		0.0044
Statistics due to repeat measurement		0.0229
Combined uncertainty ($k = 1$):		0.0342
Combined uncertainty (linear):		**0.00039**

Table B.3.7: Uncertainties in the S_{12} measurement of device RF-K5b.CL/3 at 2 GHz

Source (i)	**Dist**	**u_T(i) (dB)**
Linearity	Rect	0.0502
Mismatch	U-shaped	0.0025
Crosstalk	Rect	0.0104
System Repeatability	Gaussian	0.0100
Noise level	Gaussian	0.0282
Cable flexure	Gaussian	0.0050
Ambient conditions	Gaussian	0.0012
Difference between S_{12} and S_{21}		0.0058
Statistics due to repeat measurement		0.0152
Combined uncertainty ($k = 1$):		0.0619
Combined uncertainty (linear):		**0.000023**

Table B.3.8: Uncertainties in the S_{12} measurement of device RF-K5b.CL/3 at 9 GHz

Source (i)	**Dist**	**u_T(i) (dB)**
Linearity	Rect	0.0503
Mismatch	U-shaped	0.0081
Crosstalk	Rect	0.0105
System Repeatability	Gaussian	0.0100
Noise level	Gaussian	0.0284
Cable flexure	Gaussian	0.0050
Ambient conditions	Gaussian	0.0012
Difference between S_{12} and S_{21}		0.0000
Statistics due to repeat measurement		0.0249
Combined uncertainty ($k = 1$):		0.0653
Combined uncertainty (linear):		**0.000024**

Table B.3.9: Uncertainties in the S_{12} measurement of device RF-K5b.CL/3 at 18 GHz

Source (i)	**Dist**	**u_T(i) (dB)**
Linearity	Rect	0.0490
Mismatch	U-shaped	0.0017
Crosstalk	Rect	0.0090
System Repeatability	Gaussian	0.0100
Noise level	Gaussian	0.0244
Cable flexure	Gaussian	0.0050
Ambient conditions	Gaussian	0.0012
Difference between S_{12} and S_{21}		0.0028
Statistics due to repeat measurement		0.0493
Combined uncertainty (k = 1):		0.0751
Combined uncertainty (linear):		**0.000027**

Table B.3.10: Uncertainties in the S_{12} measurement of device RF-K5b.CL/4 at 2 GHz

Source (i)	**Dist**	**u_T(i)**
Directivity		0.0036
Test port		0.0000
Linear sum of directivity and test port match	U-shaped	0.0036
Tracking	Rect	0.0000
Linearity	Rect	0.0000
System Repeatability	Gaussian	0.0010
Cable flexure	Gaussian	0.0004
Ambient conditions	Gaussian	0.0002
Statistics due to repeat measurement		0.0003
Combined uncertainty (k = 1):		**0.0037**

Table B.3.11: Uncertainties in the S_{12} measurement of device RF-K5b.CL/4 at 9 GHz

Source (i)	**Dist**	**u_T(i)**
Directivity		0.0085
Test port		0.0000
Linear sum of directivity and test port match	U-shaped	0.0085
Tracking	Rect	0.0000
Linearity	Rect	0.0000
System Repeatability	Gaussian	0.0010
Cable flexure	Gaussian	0.0004
Ambient conditions	Gaussian	0.0002
Statistics due to repeat measurement		0.0002
Combined uncertainty (k = 1):		**0.0086**

Table B.3.12: Uncertainties in the S_{12} measurement of device RF-K5b.CL/4 at 18 GHz

Source (i)	**Dist**	**u_T(i)**
Directivity		0.0085
Test port		0.0001
Linear sum of directivity and test port match	U-shaped	0.0086
Tracking	Rect	0.0000
Linearity	Rect	0.0002
System Repeatability	Gaussian	0.0010
Cable flexure	Gaussian	0.0004
Ambient conditions	Gaussian	0.0002
Statistics due to repeat measurement		0.0004
Combined uncertainty (k = 1):		**0.0087**

Table B.3.13: Uncertainties in the S_{12} measurement of device RF-K5b.CL/7 at 2 GHz

Source (i)	**Dist**	**u_T(i)**
Directivity		0.0028
Test port		0.0015
Linear sum of directivity and test port match	U-shaped	0.0043
Tracking	Rect	0.0003
Linearity	Rect	0.0004
System Repeatability	Gaussian	0.0010
Cable flexure	Gaussian	0.0004
Ambient conditions	Gaussian	0.0002
Statistics due to repeat measurement		0.0001
Combined uncertainty (k = 1):		**0.0046**

Table B.3.14: Uncertainties in the S_{12} measurement of device RF-K5b.CL/7 at 9 GHz

Source (i)	**Dist**	**u_T(i)**
Directivity		0.0092
Test port		0.0028
Linear sum of directivity and test port match	U-shaped	0.0120
Tracking	Rect	0.0003
Linearity	Rect	0.0004
System Repeatability	Gaussian	0.0010
Cable flexure	Gaussian	0.0004
Ambient conditions	Gaussian	0.0002
Statistics due to repeat measurement		0.0002
Combined uncertainty (k = 1):		**0.0120**

Table B.3.15: Uncertainties in the S_{12} measurement of device RF-K5b.CL/7 at 18 GHz

Source (i)	**Dist**	**u_T(i)**
Directivity		0.0092
Test port		0.0031
Linear sum of directivity and test port match	U-shaped	0.0123
Tracking	Rect	0.0003
Linearity	Rect	0.0004
System Repeatability	Gaussian	0.0010
Cable flexure	Gaussian	0.0004
Ambient conditions	Gaussian	0.0002
Statistics due to repeat measurement		0.0008
Combined uncertainty (k = 1):		**0.0124**

B.4 LNE Uncertainty Budgets

The real and the imaginary components are considered to have the same uncertainty. LNE performed the measurements with the male connector at Port 1 and the female connector at Port 2; hence the uncertainty budgets presented here are for S_{12}.

Table B.4.1: Uncertainties in the S_{12} measurement of device RF-K5b.CL/1 at 2 GHz

Source (i)	**Dist**	**u_T(i) (dB)**
Residual source match	U-shaped	0.00500
Residual load match	U-shaped	0.00015
System Repeatability	Gaussian	0.00289
Connector repeatability	Gaussian	0.00300
Linearity	Gaussian	0.00296
Cable flexure	Gaussian	0.00050
Cross-talk	Rect	0.00002
Combined uncertainty (k = 2):		0.00521
Combined uncertainty (linear, k = 1):		**0.0004**

Table B.4.2: Uncertainties in the S_{12} measurement of device RF-K5b.CL/1 at 9 GHz

Source (i)	**Dist**	**u_T(i) (dB)**
Residual source match	U-shaped	0.00600
Residual load match	U-shaped	0.00032
System Repeatability	Gaussian	0.00707
Connector repeatability	Gaussian	0.00500
Linearity	Gaussian	0.00275
Cable flexure	Gaussian	0.00050
Cross-talk	Rect	0.00002
Combined uncertainty (k = 2):		0.00927
Combined uncertainty (linear, k = 1):		**0.0008**

Table B.4.3: Uncertainties in the S_{12} measurement of device RF-K5b.CL/1 at 18 GHz

Source (i)	**Dist**	**u_T(i) (dB)**
Residual source match	U-shaped	0.00800
Residual load match	U-shaped	0.00067
System Repeatability	Gaussian	0.00385
Connector repeatability	Gaussian	0.00500
Linearity	Gaussian	0.00280
Cable flexure	Gaussian	0.00050
Cross-talk	Rect	0.00002
Combined uncertainty (k = 2):		0.0082
Combined uncertainty (linear, k = 1):		**0.0007**

Table B.4.4: Uncertainties in the S_{12} measurement of device RF-K5b.CL/2 at 2 GHz

Source (i)	**Dist**	**u_T(i) (dB)**
Residual source match	U-shaped	0.00500
Residual load match	U-shaped	0.00015
System Repeatability	Gaussian	0.00673
Connector repeatability	Gaussian	0.00300
Linearity	Gaussian	0.01998
Cable flexure	Gaussian	0.00050
Cross-talk	Rect	0.00016
Combined uncertainty ($k = 2$):		0.0213
Combined uncertainty (linear, $k = 1$):		**0.00025**

Table B.4.5: Uncertainties in the S_{12} measurement of device RF-K5b.CL/2 at 9 GHz

Source (i)	**Dist**	**u_T(i) (dB)**
Residual source match	U-shaped	0.00600
Residual load match	U-shaped	0.00032
System Repeatability	Gaussian	0.05186
Connector repeatability	Gaussian	0.00500
Linearity	Gaussian	0.02012
Cable flexure	Gaussian	0.00050
Cross-talk	Rect	0.00016
Combined uncertainty ($k = 2$):		0.05586
Combined uncertainty (linear, $k = 1$):		**0.00064**

Table B.4.6: Uncertainties in the S_{12} measurement of device RF-K5b.CL/2 at 18 GHz

Source (i)	**Dist**	**u_T(i) (dB)**
Residual source match	U-shaped	0.00800
Residual load match	U-shaped	0.00067
System Repeatability	Gaussian	0.02937
Connector repeatability	Gaussian	0.00500
Linearity	Gaussian	0.01969
Cable flexure	Gaussian	0.00050
Cross-talk	Rect	0.00015
Combined uncertainty ($k = 2$):		0.03597
Combined uncertainty (linear, $k = 1$):		**0.00043**

Table B.4.7: Uncertainties in the S_{12} measurement of device RF-K5b.CL/3 at 2 GHz

Source (i)	**Dist**	**u_T(i) (dB)**
Residual source match	U-shaped	0.00500
Residual load match	U-shaped	0.00015
System Repeatability	Gaussian	0.00369
Connector repeatability	Gaussian	0.00300
Linearity	Gaussian	0.05026
Cable flexure	Gaussian	0.00050
Cross-talk	Rect	0.00517
Combined uncertainty ($k = 2$):		0.05075
Combined uncertainty (linear, $k = 1$):		**0.000020**

Table B.4.8: Uncertainties in the S_{12} measurement of device RF-K5b.CL/3 at 9 GHz

Source (i)	**Dist**	**u_T(i) (dB)**
Residual source match	U-shaped	0.00600
Residual load match	U-shaped	0.00032
System Repeatability	Gaussian	0.01622
Connector repeatability	Gaussian	0.00500
Linearity	Gaussian	0.05032
Cable flexure	Gaussian	0.00050
Cross-talk	Rect	0.00520
Combined uncertainty ($k = 2$):		0.05339
Combined uncertainty (linear, $k = 1$):		**0.000020**

Table B.4.9: Uncertainties in the S_{12} measurement of device RF-K5b.CL/3 at 18 GHz

Source (i)	**Dist**	**u_T(i) (dB)**
Residual source match	U-shaped	0.00800
Residual load match	U-shaped	0.00067
System Repeatability	Gaussian	0.03090
Connector repeatability	Gaussian	0.00500
Linearity	Gaussian	0.04900
Cable flexure	Gaussian	0.00050
Cross-talk	Rect	0.00446
Combined uncertainty ($k = 2$):		0.05832
Combined uncertainty (linear, $k = 1$):		**0.000025**

Table B.4.10: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 2 GHz

Source (i)	**Dist**	**u_T(i)**
Residual directivity	U-shaped	0.0060
Residual source match	U-shaped	0.0050
Tracking	Rect	0.0000
Linearity	Rect	0.0000
Cable flexure	Gaussian	0.0000
System repeatability	Gaussian	0.0001
Connector repeatability	Gaussian	0.0003
Combined uncertainty (k = 1):		**0.0043**

Table B.4.11: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 9 GHz

Source (i)	**Dist**	**u_T(i)**
Residual directivity	U-shaped	0.0070
Residual source match	U-shaped	0.0060
Tracking	Rect	0.0000
Linearity	Rect	0.0000
Cable flexure	Gaussian	0.0000
System repeatability	Gaussian	0.0004
Connector repeatability	Gaussian	0.0005
Combined uncertainty (k = 1):		**0.0050**

Table B.4.12: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 18 GHz

Source (i)	**Dist**	**u_T(i)**
Residual directivity	U-shaped	0.0080
Residual source match	U-shaped	0.0080
Tracking	Rect	0.0000
Linearity	Rect	0.0003
Cable flexure	Gaussian	0.0000
System repeatability	Gaussian	0.0007
Connector repeatability	Gaussian	0.0005
Combined uncertainty (k = 1):		**0.0063**

Table B.4.13: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 2 GHz

Source (i)	**Dist**	**u_T(i)**
Residual directivity	U-shaped	0.0060
Residual source match	U-shaped	0.0050
Tracking	Rect	0.0001
Linearity	Rect	0.0004
Cable flexure	Gaussian	0.0000
System repeatability	Gaussian	0.0003
Connector repeatability	Gaussian	0.0003
Combined uncertainty (k = 1):		**0.0047**

Table B.4.14: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 9 GHz

Source (i)	**Dist**	**u_T(i)**
Residual directivity	U-shaped	0.0070
Residual source match	U-shaped	0.0060
Tracking	Rect	0.0001
Linearity	Rect	0.0004
Cable flexure	Gaussian	0.0000
System repeatability	Gaussian	0.0014
Connector repeatability	Gaussian	0.0005
Combined uncertainty (k = 1):		**0.0055**

Table B.4.15: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 18 GHz

Source (i)	**Dist**	**u_T(i)**
Residual directivity	U-shaped	0.0080
Residual source match	U-shaped	0.0080
Tracking	Rect	0.0001
Linearity	Rect	0.0007
Cable flexure	Gaussian	0.0000
System repeatability	Gaussian	0.0018
Connector repeatability	Gaussian	0.0005
Combined uncertainty (k = 1):		**0.0066**

B.5 INRIM Uncertainty Budgets

The method outlining the determination of the final uncertainty values can be found in Appendix C.5.

Table B.5.1: Uncertainties in the S_{21} measurement of device RF-K5b.CL/1 at 2 GHz

Source (i)	**Dist**	**u_T(i)**
Linearity (L)	Rect	0.0005
Mismatch (M_{TM})	U-shaped	0.0003
Isolation/Cross-talk (I)	Rect	0.0000
Real component Type A uncertainty	Gaussian	0.0001
Imaginary component Type A uncertainty	Gaussian	0.0001
Real component combined uncertainty ($k = 1$):		**0.0003**
Imaginary component combined uncertainty ($k = 1$):		**0.0003**
Magnitude uncertainty ($k = 1$):		0.0003

Table B.5.2: Uncertainties in the S_{21} measurement of device RF-K5b.CL/1 at 9 GHz

Source (i)	**Dist**	**u_T(i)**
Linearity (L)	Rect	0.0005
Mismatch (M_{TM})	U-shaped	0.0004
Isolation/Cross-talk (I)	Rect	0.0000
Real component Type A uncertainty	Gaussian	0.0002
Imaginary component Type A uncertainty	Gaussian	0.0005
Real component combined uncertainty ($k = 1$):		**0.0004**
Imaginary component combined uncertainty ($k = 1$):		**0.0005**
Magnitude uncertainty ($k = 1$):		0.0004

Table B.5.3: Uncertainties in the S_{21} measurement of device RF-K5b.CL/1 at 18 GHz

Source (i)	**Dist**	**u_T(i)**
Linearity (L)	Rect	0.0005
Mismatch (M_{TM})	U-shaped	0.0010
Isolation/Cross-talk (I)	Rect	0.0000
Real component Type A uncertainty	Gaussian	0.0001
Imaginary component Type A uncertainty	Gaussian	0.0011
Real component combined uncertainty ($k = 1$):		**0.0005**
Imaginary component combined uncertainty ($k = 1$):		**0.0012**
Magnitude uncertainty ($k = 1$):		0.0005

Table B.5.4: Uncertainties in the S_{21} measurement of device RF-K5b.CL/2 at 2 GHz

Source (i)	**Dist**	**u_{T}(i)**
Linearity (L)	Rect	0.00046
Mismatch (M_{TM})	U-shaped	0.00002
Isolation/Cross-talk (I)	Rect	0.00003
Real component Type A uncertainty	Gaussian	0.00001
Imaginary component Type A uncertainty	Gaussian	0.00002
Real component combined uncertainty (k = 1):		**0.00019**
Imaginary component combined uncertainty (k = 1):		**0.00019**
Magnitude uncertainty (k = 1):		0.00019

Table B.5.5: Uncertainties in the S_{21} measurement of device RF-K5b.CL/2 at 9 GHz

Source (i)	**Dist**	**u_{T}(i)**
Linearity (L)	Rect	0.00046
Mismatch (M_{TM})	U-shaped	0.00003
Isolation/Cross-talk (I)	Rect	0.00003
Real component Type A uncertainty	Gaussian	0.00004
Imaginary component Type A uncertainty	Gaussian	0.00006
Real component combined uncertainty (k = 1):		**0.00019**
Imaginary component combined uncertainty (k = 1):		**0.00020**
Magnitude uncertainty (k = 1):		0.00020

Table B.5.6: Uncertainties in the S_{21} measurement of device RF-K5b.CL/2 at 18 GHz

Source (i)	**Dist**	**u_{T}(i)**
Linearity (L)	Rect	0.00047
Mismatch (M_{TM})	U-shaped	0.00014
Isolation/Cross-talk (I)	Rect	0.00003
Real component Type A uncertainty	Gaussian	0.00015
Imaginary component Type A uncertainty	Gaussian	0.00006
Real component combined uncertainty (k = 1):		**0.00026**
Imaginary component combined uncertainty (k = 1):		**0.00022**
Magnitude uncertainty (k = 1):		0.00022

Table B.5.7: Uncertainties in the S_{21} measurement of device RF-K5b.CL/3 at 2 GHz

Source (i)	**Dist**	**u_{T}(i)**
Linearity (L)	Rect	0.000036
Mismatch (M_{TM})	U-shaped	0.000000
Isolation/Cross-talk (I)	Rect	0.000031
Real component Type A uncertainty	Gaussian	0.000001
Imaginary component Type A uncertainty	Gaussian	0.000001
Real component combined uncertainty (k = 1):		**0.000019**
Imaginary component combined uncertainty (k = 1):		**0.000019**
Magnitude uncertainty (k = 1):		0.000019

Table B.5.8: Uncertainties in the S_{21} measurement of device RF-K5b.CL/3 at 9 GHz

Source (i)	**Dist**	**u_{T}(i)**
Linearity (L)	Rect	0.000035
Mismatch (M_{TM})	U-shaped	0.000002
Isolation/Cross-talk (I)	Rect	0.000030
Real component Type A uncertainty	Gaussian	0.000005
Imaginary component Type A uncertainty	Gaussian	0.000003
Real component combined uncertainty (k = 1):		**0.000020**
Imaginary component combined uncertainty (k = 1):		**0.000019**
Magnitude uncertainty (k = 1):		0.000019

Table B.5.9: Uncertainties in the S_{21} measurement of device RF-K5b.CL/3 at 18 GHz

Source (i)	**Dist**	**u_{T}(i)**
Linearity (L)	Rect	0.000040
Mismatch (M_{TM})	U-shaped	0.000001
Isolation/Cross-talk (I)	Rect	0.000035
Real component Type A uncertainty	Gaussian	0.000005
Imaginary component Type A uncertainty	Gaussian	0.000003
Real component combined uncertainty (k = 1):		**0.000022**
Imaginary component combined uncertainty (k = 1):		**0.000022**
Magnitude uncertainty (k = 1):		0.000022

Table B.5.10: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 2 GHz

Source (i)	**Dist**	**u_{T}(i)**
Measured effective directivity (D)	U-shaped	0.0109
Measured test port match ($M\Gamma^2$)		0.0000
Tracking & non-linearity ($T\Gamma$)	Rect	0.0000
Real component Type A uncertainty	Gaussian	0.0000
Imaginary component Type A uncertainty	Gaussian	0.0000
Real component combined uncertainty (k = 1):		**0.0055**
Imaginary component combined uncertainty (k = 1):		**0.0055**
Magnitude uncertainty (k = 1):		0.0055

Table B.5.11: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 9 GHz

Source (i)	**Dist**	**u_{T}(i)**
Measured effective directivity (D)	U-shaped	0.0109
Measured test port match ($M\Gamma^2$)		0.0000
Tracking & non-linearity ($T\Gamma$)	Rect	0.0000
Real component Type A uncertainty	Gaussian	0.0001
Imaginary component Type A uncertainty	Gaussian	0.0001
Real component combined uncertainty (k = 1):		**0.0055**
Imaginary component combined uncertainty (k = 1):		**0.0055**
Magnitude uncertainty (k = 1):		0.0055

Table B.5.12: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 18 GHz

Source (i)	**Dist**	**u_{T}(i)**
Measured effective directivity (D)	U-shaped	0.0109
Measured test port match ($M\Gamma^2$)		0.0000
Tracking & non-linearity ($T\Gamma$)	Rect	0.0000
Real component Type A uncertainty	Gaussian	0.0006
Imaginary component Type A uncertainty	Gaussian	0.0003
Real component combined uncertainty (k = 1):		**0.0055**
Imaginary component combined uncertainty (k = 1):		**0.0055**
Magnitude uncertainty (k = 1):		0.0055

Table B.5.13: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 2 GHz

Source (i)	**Dist**	$\boldsymbol{u_T}$**(i)**
Measured effective directivity (D)	U-shaped	0.0109
Measured test port match ($M\Gamma^2$)		0.0008
Tracking & non-linearity ($T\Gamma$)	Rect	0.0002
Real component Type A uncertainty	Gaussian	0.0153
Imaginary component Type A uncertainty	Gaussian	0.0619
Real component combined uncertainty (k = 1):		**0.0164**
Imaginary component combined uncertainty (k = 1):		**0.0622**
Magnitude uncertainty (k = 1):		0.0361

Table B.5.14: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 9 GHz

Source (i)	**Dist**	$\boldsymbol{u_T}$**(i)**
Measured effective directivity (D)	U-shaped	0.0109
Measured test port match ($M\Gamma^2$)		0.0006
Tracking & non-linearity ($T\Gamma$)	Rect	0.0002
Real component Type A uncertainty	Gaussian	0.0215
Imaginary component Type A uncertainty	Gaussian	0.0706
Real component combined uncertainty (k = 1):		**0.0223**
Imaginary component combined uncertainty (k = 1):		**0.0709**
Magnitude uncertainty (k = 1):		0.0709

Table B.5.15: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 18 GHz

Source (i)	**Dist**	$\boldsymbol{u_T}$**(i)**
Measured effective directivity (D)	U-shaped	0.0109
Measured test port match ($M\Gamma^2$)		0.0013
Tracking & non-linearity ($T\Gamma$)	Rect	0.0003
Real component Type A uncertainty	Gaussian	0.0045
Imaginary component Type A uncertainty	Gaussian	0.0281
Real component combined uncertainty (k = 1):		**0.0076**
Imaginary component combined uncertainty (k = 1):		**0.0288**
Magnitude uncertainty (k = 1):		0.0134

B.6 METAS Uncertainty Budgets

METAS did not provide a detailed budget. The overall uncertainties provided are calculated in software, taking into account the following uncertainty contributions:

- Residual directivity, tracking, match and crosstalk
- Trace noise and noise floor
- Cable stability
- Receiver linearity
- Type A contributions

B.7 CMI Uncertainty Budgets

CMI performed the measurements with the male connector at Port 1 and the female connector at Port 2; hence the uncertainty budgets presented here are for S_{12}.

Values have been rounded to an appropriate number of decimal places; rounding errors may occur.

Table B.7.1: Uncertainties in the S_{12} measurement of device RF-K5b.CL/1 at 2 GHz

Source (i)	**Dist**	**Re[u_T(i)]**	**Im[u_T(i)]**
Type A uncertainty		0.0002	0.0004
Mismatch	U-shaped	0.0002	0.0002
Test set linearity	Rect	0.0002	0.0001
System stability	Rect	0.0006	0.0008
Cable flexure	Gaussian	0.0004	0.0005
Combined uncertainty (k = 1):		**0.0008**	**0.0011**

Table B.7.2: Uncertainties in the S_{12} measurement of device RF-K5b.CL/1 at 9 GHz

Source (i)	**Dist**	**Re[u_T(i)]**	**Im[u_T(i)]**
Type A uncertainty		0.0008	0.0023
Mismatch	U-shaped	0.0002	0.0002
Test set linearity	Rect	0.0002	0.0001
System stability	Rect	0.0006	0.0008
Cable flexure	Gaussian	0.0012	0.0023
Combined uncertainty (k = 1):		**0.0016**	**0.0034**

Table B.7.3: Uncertainties in the S_{12} measurement of device RF-K5b.CL/1 at 18 GHz

Source (i)	**Dist**	**Re[u_T(i)]**	**Im[u_T(i)]**
Type A uncertainty		0.0005	0.0052
Mismatch	U-shaped	0.0004	0.0004
Test set linearity	Rect	0.0002	0.0000
System stability	Rect	0.0006	0.0008
Cable flexure	Gaussian	0.0017	0.0048
Combined uncertainty (k = 1):		**0.0020**	**0.0071**

Table B.7.4: Uncertainties in the S_{12} measurement of device RF-K5b.CL/2 at 2 GHz

Source (i)	**Dist**	**Re[u_T(i)]**	**Im[u_T(i)]**
Type A uncertainty		0.00006	0.00010
Mismatch	U-shaped	0.00001	0.00001
Test set linearity	Rect	0.00023	0.00023
System stability	Rect	0.00009	0.00011
Cable flexure	Gaussian	0.00006	0.00007
Combined uncertainty (k = 1):		**0.00026**	**0.00028**

Table B.7.5: Uncertainties in the S_{12} measurement of device RF-K5b.CL/2 at 9 GHz

Source (i)	**Dist**	**Re[u_T(i)]**	**Im[u_T(i)]**
Type A uncertainty		0.00035	0.00035
Mismatch	U-shaped	0.00002	0.00002
Test set linearity	Rect	0.00023	0.00023
System stability	Rect	0.00010	0.00010
Cable flexure	Gaussian	0.00025	0.00025
Combined uncertainty (k = 1):		**0.00050**	**0.00050**

Table B.7.6: Uncertainties in the S_{12} measurement of device RF-K5b.CL/2 at 18 GHz

Source (i)	**Dist**	**Re[u_T(i)]**	**Im[u_T(i)]**
Type A uncertainty		0.00111	0.00029
Mismatch	U-shaped	0.00005	0.00005
Test set linearity	Rect	0.00024	0.00024
System stability	Rect	0.00012	0.00009
Cable flexure	Gaussian	0.00067	0.00030
Combined uncertainty (k = 1):		**0.00133**	**0.00049**

Table B.7.7: Uncertainties in the S_{12} measurement of device RF-K5b.CL/3 at 2 GHz

Source (i)	**Dist**	**Re[u_T(i)]**	**Im[u_T(i)]**
Type A uncertainty		0.000008	0.000008
Mismatch	U-shaped	0.000000	0.000000
Test set linearity	Rect	0.000018	0.000018
Noise and isolation	Rect	0.000005	0.000005
Cable flexure	Gaussian	0.000002	0.000002
Combined uncertainty (k = 1):		**0.000020**	**0.000020**

Table B.7.8: Uncertainties in the S_{12} measurement of device RF-K5b.CL/3 at 9 GHz

Source (i)	**Dist**	**Re[u_T(i)]**	**Im[u_T(i)]**
Type A uncertainty		0.000017	0.000009
Mismatch	U-shaped	0.000001	0.000001
Test set linearity	Rect	0.000018	0.000018
Noise and isolation	Rect	0.000009	0.000009
Cable flexure	Gaussian	0.000009	0.000006
Combined uncertainty (k = 1):		**0.000028**	**0.000022**

Table B.7.9: Uncertainties in the S_{12} measurement of device RF-K5b.CL/3 at 18 GHz

Source (i)	**Dist**	**Re[u_T(i)]**	**Im[u_T(i)]**
Type A uncertainty		0.000030	0.000031
Mismatch	U-shaped	0.000000	0.000000
Test set linearity	Rect	0.000020	0.000020
Noise and isolation	Rect	0.000019	0.000019
Cable flexure	Gaussian	0.000020	0.000015
Combined uncertainty (k = 1):		**0.000045**	**0.000044**

Table B.7.10: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 2 GHz

Source (i)	**Dist**	**Re[u_T(i)]**	**Im[u_T(i)]**
Type A uncertainty		0.0001	0.0000
Residual directivity	U-shaped	0.0046	0.0046
Residual test port match	U-shaped	0.0000	0.0000
Cable flexure	Gaussian	0.0004	0.0004
Combined uncertainty ($k = 1$):		**0.0046**	**0.0046**

Table B.7.11: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 9 GHz

Source (i)	**Dist**	**Re[u_T(i)]**	**Im[u_T(i)]**
Type A uncertainty		0.0002	0.0001
Residual directivity	U-shaped	0.0046	0.0046
Residual test port match	U-shaped	0.0000	0.0000
Cable flexure	Gaussian	0.0007	0.0007
Combined uncertainty ($k = 1$):		**0.0047**	**0.0047**

Table B.7.12: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 18 GHz

Source (i)	**Dist**	**Re[u_T(i)]**	**Im[u_T(i)]**
Type A uncertainty		0.0006	0.0003
Residual directivity	U-shaped	0.0046	0.0046
Residual test port match	U-shaped	0.0000	0.0000
Cable flexure	Gaussian	0.0012	0.0012
Combined uncertainty ($k = 1$):		**0.0048**	**0.0048**

Table B.7.13: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 2 GHz

Source (i)	**Dist**	**Re[u_T(i)]**	**Im[u_T(i)]**
Type A uncertainty		0.0001	0.0001
Residual directivity	U-shaped	0.0046	0.0046
Residual test port match	U-shaped	0.0010	0.0010
Residual reflection tracking	U-shaped	0.0015	0.0016
Cable flexure	Gaussian	0.0005	0.0005
Combined uncertainty (k = 1):		**0.0050**	**0.0050**

Table B.7.14: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 9 GHz

Source (i)	**Dist**	**Re[u_T(i)]**	**Im[u_T(i)]**
Type A uncertainty		0.0005	0.0003
Residual directivity	U-shaped	0.0046	0.0046
Residual test port match	U-shaped	0.0010	0.0010
Residual reflection tracking	U-shaped	0.0033	0.0006
Cable flexure	Gaussian	0.0016	0.0013
Combined uncertainty (k = 1):		**0.0060**	**0.0049**

Table B.7.15: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 18 GHz

Source (i)	**Dist**	**Re[u_T(i)]**	**Im[u_T(i)]**
Type A uncertainty		0.0006	0.0007
Residual directivity	U-shaped	0.0046	0.0046
Residual test port match	U-shaped	0.0011	0.0011
Residual reflection tracking	U-shaped	0.0027	0.0044
Cable flexure	Gaussian	0.0026	0.0031
Combined uncertainty (k = 1):		**0.0061**	**0.0072**

B.8 UME Uncertainty Budgets

UME performed the measurements with the male connector at Port 1 and the female connector at Port 2; hence the uncertainty budgets presented here are for S_{12}. Values have been rounded to an appropriate number of decimal places; rounding errors may occur.

Table B.8.1: Uncertainties in the S_{12} measurement of device RF-K5b.CL/1 at 2 GHz

Source (i)	**Dist**	**Re[u_T(i)]**	**Im[u_T(i)]**
System repeatability	Gaussian	0.0000	0.0000
Linearity	Rect	-0.0004	-0.0004
Mismatch	U-shaped	0.0001	0.0001
Crosstalk	Rect	0.0000	0.0000
Noise	Gaussian	0.0000	0.0000
Connector repeatability	Gaussian	0.0010	0.0010
Cable Flexure	Gaussian	-0.0008	-0.0008
Ambient Condition	Rect	-0.0002	-0.0002
Combined uncertainty (k = 1):		**0.0014**	**0.0014**

Table B.8.2: Uncertainties in the S_{12} measurement of device RF-K5b.CL/1 at 9 GHz

Source (i)	**Dist**	**Re[u_T(i)]**	**Im[u_T(i)]**
System repeatability	Gaussian	0.0000	0.0000
Linearity	Rect	-0.0004	-0.0004
Mismatch	U-shaped	0.0001	0.0001
Crosstalk	Rect	0.0000	0.0000
Noise	Gaussian	0.0000	0.0000
Connector repeatability	Gaussian	0.0010	0.0010
Cable Flexure	Gaussian	-0.0008	-0.0008
Ambient Condition	Rect	-0.0002	-0.0002
Combined uncertainty (k = 1):		**0.0014**	**0.0014**

Table B.8.3: Uncertainties in the S_{12} measurement of device RF-K5b.CL/1 at 18 GHz

Source (i)	**Dist**	**Re[u_T(i)]**	**Im[u_T(i)]**
System repeatability	Gaussian	0.0000	0.0001
Linearity	Rect	-0.0004	-0.0004
Mismatch	U-shaped	0.0013	0.0013
Crosstalk	Rect	0.0000	0.0000
Noise	Gaussian	0.0000	0.0000
Connector repeatability	Gaussian	0.0010	0.0010
Cable Flexure	Gaussian	-0.0008	-0.0008
Ambient Condition	Rect	-0.0002	-0.0002
Combined uncertainty (k = 1):		**0.0019**	**0.0021**

Table B.8.4: Uncertainties in the S_{12} measurement of device RF-K5b.CL/2 at 2 GHz

Source (i)	**Dist**	**Re[u_T(i)]**	**Im[u_T(i)]**
System repeatability	Gaussian	0.00000	0.00000
Linearity	Rect	-0.00034	-0.00034
Mismatch	U-shaped	0.00004	0.00004
Crosstalk	Rect	0.00003	0.00003
Noise	Gaussian	0.00000	0.00000
Connector repeatability	Gaussian	0.00020	0.00020
Cable Flexure	Gaussian	-0.00012	-0.00012
Ambient Condition	Rect	-0.00002	-0.00002
Combined uncertainty (k = 1):		**0.00042**	**0.00042**

Table B.8.5: Uncertainties in the S_{12} measurement of device RF-K5b.CL/2 at 9 GHz

Source (i)	**Dist**	**Re[u_T(i)]**	**Im[u_T(i)]**
System repeatability	Gaussian	0.00001	0.00002
Linearity	Rect	-0.00034	-0.00034
Mismatch	U-shaped	0.00008	0.00008
Crosstalk	Rect	0.00003	0.00003
Noise	Gaussian	0.00000	0.00000
Connector repeatability	Gaussian	0.00020	0.00020
Cable Flexure	Gaussian	-0.00011	-0.00011
Ambient Condition	Rect	-0.00002	-0.00002
Combined uncertainty (k = 1):		**0.00042**	**0.00042**

Table B.8.6: Uncertainties in the S_{12} measurement of device RF-K5b.CL/2 at 18 GHz

Source (i)	**Dist**	**Re[u_T(i)]**	**Im[u_T(i)]**
System repeatability	Gaussian	0.00003	0.00002
Linearity	Rect	-0.00035	-0.00035
Mismatch	U-shaped	0.00090	0.00090
Crosstalk	Rect	0.00003	0.00003
Noise	Gaussian	0.00000	0.00000
Connector repeatability	Gaussian	0.00020	0.00020
Cable Flexure	Gaussian	-0.00012	-0.00012
Ambient Condition	Rect	-0.00002	-0.00002
Combined uncertainty (k = 1):		**0.00100**	**0.00100**

Table B.8.7: Uncertainties in the S_{12} measurement of device RF-K5b.CL/3 at 2 GHz

Source (i)	**Dist**	**Re[u_T(i)]**	**Im[u_T(i)]**
System repeatability	Gaussian	0.000001	0.000002
Linearity	Rect	-0.000027	-0.000027
Mismatch	U-shaped	0.000018	0.000018
Crosstalk	Rect	0.000027	0.000027
Noise	Gaussian	0.000000	0.000000
Connector repeatability	Gaussian	0.000050	0.000050
Cable Flexure	Gaussian	-0.000004	-0.000004
Ambient Condition	Rect	-0.000001	-0.000001
Combined uncertainty (k = 1):		**0.000065**	**0.000065**

Table B.8.8: Uncertainties in the S_{12} measurement of device RF-K5b.CL/3 at 9 GHz

Source (i)	**Dist**	**Re[u_T(i)]**	**Im[u_T(i)]**
System repeatability	Gaussian	0.000001	0.000004
Linearity	Rect	-0.000026	-0.000026
Mismatch	U-shaped	0.000145	0.000145
Crosstalk	Rect	0.000027	0.000027
Noise	Gaussian	0.000000	0.000000
Connector repeatability	Gaussian	0.000050	0.000050
Cable Flexure	Gaussian	-0.000003	-0.000003
Ambient Condition	Rect	-0.000001	-0.000001
Combined uncertainty (k = 1):		**0.000158**	**0.000158**

Table B.8.9: Uncertainties in the S_{12} measurement of device RF-K5b.CL/3 at 18 GHz

Source (i)	**Dist**	**Re[u_T(i)]**	**Im[u_T(i)]**
System repeatability	Gaussian	0.000002	0.000009
Linearity	Rect	-0.000030	-0.000030
Mismatch	U-shaped	0.000173	0.000173
Crosstalk	Rect	0.000031	0.000031
Noise	Gaussian	0.000000	0.000000
Connector repeatability	Gaussian	0.000050	0.000050
Cable Flexure	Gaussian	-0.000004	-0.000004
Ambient Condition	Rect	-0.000001	-0.000001
Combined uncertainty (k = 1):		**0.000185**	**0.000185**

Table B.8.10: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 2 GHz

Source (i)	**Dist**	**Re[u_{T}(i)]**	**Im[u_{T}(i)]**
System repeatability	Gaussian	0.0000	0.0000
Standard Airline	Rect	0.0050	0.0050
Effective Match	U-shaped	0.0016	0.0016
Tracking	Rect	0.0000	0.0000
Linearity	Rect	0.0000	0.0000
Connector repeatability	Gaussian	0.0010	0.0010
Cable Flexure	Gaussian	0.0000	0.0000
Ambient Condition	Rect	0.0000	0.0000
Combined uncertainty (k = 1):		**0.0054**	**0.0054**

Table B.8.11: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 9 GHz

Source (i)	**Dist**	**Re[u_{T}(i)]**	**Im[u_{T}(i)]**
System repeatability	Gaussian	0.0000	0.0000
Standard Airline	Rect	0.0050	0.0050
Effective Match	U-shaped	0.0030	0.0030
Tracking	Rect	0.0000	0.0000
Linearity	Rect	0.0000	0.0000
Connector repeatability	Gaussian	0.0010	0.0010
Cable Flexure	Gaussian	0.0000	0.0000
Ambient Condition	Rect	0.0000	0.0000
Combined uncertainty (k = 1):		**0.0059**	**0.0059**

Table B.8.12: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 18 GHz

Source (i)	**Dist**	**Re[u_{T}(i)]**	**Im[u_{T}(i)]**
System repeatability	Gaussian	0.0000	0.0000
Standard Airline	Rect	0.0050	0.0050
Effective Match	U-shaped	0.0052	0.0052
Tracking	Rect	0.0000	0.0000
Linearity	Rect	0.0000	0.0001
Connector repeatability	Gaussian	0.0010	0.0010
Cable Flexure	Gaussian	0.0000	0.0002
Ambient Condition	Rect	0.0000	0.0001
Combined uncertainty (k = 1):		**0.0073**	**0.0073**

Table B.8.13: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 2 GHz

Source (i)	**Dist**	**Re[u_{T}(i)]**	**Im[u_{T}(i)]**
System repeatability	Gaussian	0.0000	0.0000
Standard Airline	Rect	0.0040	0.0040
Effective Match	U-shaped	0.0018	0.0018
Tracking	Rect	0.0014	0.0013
Linearity	Rect	0.0003	0.0003
Connector repeatability	Gaussian	0.0010	0.0010
Cable Flexure	Gaussian	0.0010	0.0009
Ambient Condition	Rect	0.0003	0.0003
Combined uncertainty (k = 1):		**0.0048**	**0.0048**

Table B.8.14: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 9 GHz

Source (i)	**Dist**	**Re[u_{T}(i)]**	**Im[u_{T}(i)]**
System repeatability	Gaussian	0.0001	0.0000
Standard Airline	Rect	0.0110	0.0110
Effective Match	U-shaped	0.0030	0.0033
Tracking	Rect	0.0002	-0.0019
Linearity	Rect	0.0001	0.0003
Connector repeatability	Gaussian	0.0010	0.0010
Cable Flexure	Gaussian	0.0001	-0.0013
Ambient Condition	Rect	0.0000	-0.0004
Combined uncertainty (k = 1):		**0.0115**	**0.0118**

Table B.8.15: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 18 GHz

Source (i)	**Dist**	**Re[u_{T}(i)]**	**Im[u_{T}(i)]**
System repeatability	Gaussian	0.0001	0.0001
Standard Airline	Rect	0.0110	0.0110
Effective Match	U-shaped	0.0061	0.0055
Tracking	Rect	0.0017	-0.0011
Linearity	Rect	0.0003	0.0003
Connector repeatability	Gaussian	0.0010	0.0010
Cable Flexure	Gaussian	0.0012	-0.0007
Ambient Condition	Rect	0.0003	-0.0002
Combined uncertainty (k = 1):		**0.0128**	**0.0124**

B.9 NMIA Uncertainty Budgets

Table B.9.1: Uncertainties in the S_{21} measurement of device RF-K5b.CL/1 at 2 GHz

Source (i)	**Dist**	**u_{T}(i)**
Type A		0.0000
Cal standards	Gaussian	0.0008
VNA noise floor	Rect	0.0000
VNA linearity	Rect	0.0001
Mismatch input	U-shaped	0.0000
Mismatch output	U-shaped	0.0000
Mismatch through	U-shaped	0.0000
Mismatch ref	U-shaped	0.0000
Combined uncertainty (k = 1):		**0.0008**

Table B.9.2: Uncertainties in the S_{21} measurement of device RF-K5b.CL/1 at 9 GHz

Source (i)	**Dist**	**u_{T}(i)**
Type A		0.0001
Cal standards	Gaussian	0.0011
VNA noise floor	Rect	0.0000
VNA linearity	Rect	0.0001
Mismatch input	U-shaped	0.0001
Mismatch output	U-shaped	0.0001
Mismatch through	U-shaped	0.0000
Mismatch ref	U-shaped	0.0000
Combined uncertainty (k = 1):		**0.0011**

Table B.9.3: Uncertainties in the S_{21} measurement of device RF-K5b.CL/1 at 18 GHz

Source (i)	**Dist**	**u_{T}(i)**
Type A		0.0004
Cal standards	Gaussian	0.0013
VNA noise floor	Rect	0.0000
VNA linearity	Rect	0.0001
Mismatch input	U-shaped	0.0002
Mismatch output	U-shaped	0.0002
Mismatch through	U-shaped	0.0000
Mismatch ref	U-shaped	0.0000
Combined uncertainty (k = 1):		**0.0014**

Table B.9.4: Uncertainties in the S_{21} measurement of device RF-K5b.CL/2 at 2 GHz

Source (i)	**Dist**	**u_T(i)**
Type A		0.00001
Cal standards	Gaussian	0.00011
VNA noise floor	Rect	0.00001
VNA linearity	Rect	0.00010
Mismatch input	U-shaped	0.00000
Mismatch output	U-shaped	0.00000
Mismatch through	U-shaped	0.00000
Mismatch ref	U-shaped	0.00000
Combined uncertainty (k = 1):		**0.00015**

Table B.9.5: Uncertainties in the S_{21} measurement of device RF-K5b.CL/2 at 9 GHz

Source (i)	**Dist**	**u_T(i)**
Type A		0.00001
Cal standards	Gaussian	0.00015
VNA noise floor	Rect	0.00001
VNA linearity	Rect	0.00010
Mismatch input	U-shaped	0.00001
Mismatch output	U-shaped	0.00001
Mismatch through	U-shaped	0.00000
Mismatch ref	U-shaped	0.00000
Combined uncertainty (k = 1):		**0.00018**

Table B.9.6: Uncertainties in the S_{21} measurement of device RF-K5b.CL/2 at 18 GHz

Source (i)	**Dist**	**u_T(i)**
Type A		0.00002
Cal standards	Gaussian	0.00019
VNA noise floor	Rect	0.00001
VNA linearity	Rect	0.00010
Mismatch input	U-shaped	0.00004
Mismatch output	U-shaped	0.00002
Mismatch through	U-shaped	0.00000
Mismatch ref	U-shaped	0.00000
Combined uncertainty (k = 1):		**0.00022**

Table B.9.7: Uncertainties in the S_{21} measurement of device RF-K5b.CL/3 at 2 GHz

Source (i)	**Dist**	u_T**(i)**
Type A		0.000001
Cal standards	Gaussian	0.000003
VNA noise floor	Rect	0.000008
VNA linearity	Rect	0.000008
Mismatch input	U-shaped	0.000000
Mismatch output	U-shaped	0.000000
Mismatch through	U-shaped	0.000000
Mismatch ref	U-shaped	0.000000
Combined uncertainty (k = 1):		**0.000012**

Table B.9.8: Uncertainties in the S_{21} measurement of device RF-K5b.CL/3 at 9 GHz

Source (i)	**Dist**	u_T**(i)**
Type A		0.000001
Cal standards	Gaussian	0.000005
VNA noise floor	Rect	0.000009
VNA linearity	Rect	0.000008
Mismatch input	U-shaped	0.000000
Mismatch output	U-shaped	0.000000
Mismatch through	U-shaped	0.000000
Mismatch ref	U-shaped	0.000000
Combined uncertainty (k = 1):		**0.000013**

Table B.9.9: Uncertainties in the S_{21} measurement of device RF-K5b.CL/3 at 18 GHz

Source (i)	**Dist**	u_T**(i)**
Type A		0.000003
Cal standards	Gaussian	0.000006
VNA noise floor	Rect	0.000013
VNA linearity	Rect	0.000009
Mismatch input	U-shaped	0.000000
Mismatch output	U-shaped	0.000000
Mismatch through	U-shaped	0.000000
Mismatch ref	U-shaped	0.000000
Combined uncertainty (k = 1):		**0.000017**

Table B.9.10: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 2 GHz

Source (i)	**Dist**	**u_T(i)**
Type A		0.0000
VNA linearity	Rect	0.0000
VNA noise floor	Rect	0.0000
Imperfect connectors	Gaussian	0.0001
Standards	Gaussian	0.0014
Source reflections	U-shaped	0.0000
Combined uncertainty (k = 1):		**0.0014**

Table B.9.11: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 9 GHz

Source (i)	**Dist**	**u_T(i)**
Type A		0.0004
VNA linearity	Rect	0.0001
VNA noise floor	Rect	0.0000
Imperfect connectors	Gaussian	0.0001
Standards	Gaussian	0.0021
Source reflections	U-shaped	0.0000
Combined uncertainty (k = 1):		**0.0022**

Table B.9.12: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 18 GHz

Source (i)	**Dist**	**u_T(i)**
Type A		0.0006
VNA linearity	Rect	0.0003
VNA noise floor	Rect	0.0000
Imperfect connectors	Gaussian	0.0001
Standards	Gaussian	0.0030
Source reflections	U-shaped	0.0002
Combined uncertainty (k = 1):		**0.0031**

Table B.9.13: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 2 GHz

Source (i)	**Dist**	u_T**(i)**
Type A		0.0000
VNA linearity	Rect	0.0007
VNA noise floor	Rect	0.0000
Imperfect connectors	Gaussian	0.0001
Standards	Gaussian	0.0014
Source reflections	U-shaped	0.0010
Combined uncertainty (k = 1):		**0.0019**

Table B.9.14: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 9 GHz

Source (i)	**Dist**	u_T**(i)**
Type A		0.0001
VNA linearity	Rect	0.0007
VNA noise floor	Rect	0.0000
Imperfect connectors	Gaussian	0.0001
Standards	Gaussian	0.0021
Source reflections	U-shaped	0.0010
Combined uncertainty (k = 1):		**0.0025**

Table B.9.15: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 18 GHz

Source (i)	**Dist**	u_T**(i)**
Type A		0.0004
VNA linearity	Rect	0.0007
VNA noise floor	Rect	0.0000
Imperfect connectors	Gaussian	0.0001
Standards	Gaussian	0.0030
Source reflections	U-shaped	0.0011
Combined uncertainty (k = 1):		**0.0033**

B.10 SPRING Uncertainty Budgets

Table B.10.1a: Uncertainties in the real component of the S_{21} measurement of device RF-K5b.CL/1 at 2 GHz

Sources of Uncertainty	**Dist**	**Uncertainty Contribution $u(x_i)$**	**Sensitivity Coefficient c**	**Standard Uncertainty $c . u(x_i) / k$**	**Degree of Freedom**
Type A unc of S_{21X}		***0.000027***	***1***	***0.000027***	***5***
Linearity	Rect	0.000485	-	0.000280	Infinity
Mismatch	U-shaped	0.000497	-	0.000353	Infinity
Isolation	Rect	0.000010	-	0.000006	Infinity
Type A unc of $\lvert S_{21}\rvert$		0.000010	-	0.000010	5
Combined $\lvert S_{21}\rvert$ uncertainty		***0.000451***	***-0.90***	***-0.000407***	***2.0E+07***
Type A unc of θ (rads)		0.000068	-	0.000068	5
θ uncertainty due to $\Delta\lvert S_{21}\rvert$ (rads)		-0.000573	-	-0.000573	Infinity
θ uncertainty due to airline (rads)	Rect	0.000251	-	0.000145	Infinity
θ uncertainty due to cable (rads)	Rect	0.009774	-	0.005650	Infinity
Combined θ uncertainty		***0.005681***	***-0.30***	***-0.001731***	***2.4E+08***
Combined S_{21X} uncertainty		**0.0018**			**Eff DOF** **9.6E+07**

Table B.10.1b: Uncertainties in the imaginary component of the S_{21} measurement of device RF-K5b.CL/1 at 2 GHz

Sources of Uncertainty	**Dist**	**Uncertainty Contribution $u(x_i)$**	**Sensitivity Coefficient c**	**Standard Uncertainty $c . u(x_i) / k$**	**Degree of Freedom**
Type A unc of S_{21Y}		***0.000064***	1	***0.000064***	***5***
Linearity	Rect	0.000485	-	0.000280	Infinity
Mismatch	U-shaped	0.000497	-	0.000353	Infinity
Isolation	Rect	0.000010	-	0.000006	Infinity
Type A unc of $\lvert S_{21}\rvert$		0.000010	-	0.000010	5
Combined $\lvert S_{21}\rvert$ uncertainty		***0.000451***	***-0.43***	***-0.000193***	***2.0E+07***
Type A unc of θ (rads)		0.000068	-	0.000068	5
θ uncertainty due to $\Delta\lvert S_{21}\rvert$ (rads)		-0.000573	-	-0.000573	Infinity
θ uncertainty due to airline (rads)	Rect	0.000251	-	0.000145	Infinity
θ uncertainty due to cable (rads)	Rect	0.009774	-	0.005650	Infinity
Combined θ uncertainty		***0.005681***	***-0.64***	***-0.003651***	***2.4E+08***
Combined S_{21Y} uncertainty		**0.0037**			**Eff DOF** **5.4E+07**

Table B.10.2a: Uncertainties in the real component of the S_{21} measurement of device RF-K5b.CL/1 at 9 GHz

Sources of Uncertainty	**Dist**	**Uncertainty Contribution** $u(x_i)$	**Sensitivity Coefficient** c	**Standard Uncertainty** $c \cdot u(x_i) / k$	**Degree of Freedom**
Type A unc of S_{21X}		***0.000121***	***1***	***0.000121***	***5***
Linearity	Rect	0.000464	-	0.000268	Infinity
Mismatch	U-shaped	0.000683	-	0.000484	Infinity
Isolation	Rect	0.000018	-	0.000010	Infinity
Type A unc of $\|S_{21}\|$		0.000026	-	0.000026	5
Combined $\|S_{21}\|$ uncertainty		***0.000554***	***0.95***	***0.000526***	***1.1E+06***
Type A unc of θ (rads)		0.000333	-	0.000333	5
θ uncertainty due to $\Delta\|S_{21}\|$ (rads)		0.000724	-	0.000724	Infinity
θ uncertainty due to airline (rads)	Rect	0.001131	-	0.000654	Infinity
θ uncertainty due to cable (rads)	Rect	0.025656	-	0.014830	Infinity
Combined θ uncertainty		***0.014866***	***0.23***	***0.003416***	***2.0E+07***
Combined S_{21X} uncertainty		**0.0035**			**Eff DOF** **3.3E+07**

Table B.10.2b: Uncertainties in the imaginary component of the S_{21} measurement of device RF-K5b.CL/1 at 9 GHz

Sources of Uncertainty	**Dist**	**Uncertainty Contribution** $u(x_i)$	**Sensitivity Coefficient** c	**Standard Uncertainty** $c \cdot u(x_i) / k$	**Degree of Freedom**
Type A unc of S_{21Y}		***0.000311***	***1***	***0.000311***	***5***
Linearity	Rect	0.000464	-	0.000268	Infinity
Mismatch	U-shaped	0.000683	-	0.000484	Infinity
Isolation	Rect	0.000018	-	0.000010	Infinity
Type A unc of $\|S_{21}\|$		0.000026	-	0.000026	5
Combined $\|S_{21}\|$ uncertainty		***0.000554***	***0.32***	***0.000175***	***1.1E+06***
Type A unc of θ (rads)		0.000333	-	0.000333	5
θ uncertainty due to $\Delta\|S_{21}\|$ (rads)		0.000724	-	0.000724	Infinity
θ uncertainty due to airline (rads)	Rect	0.001131	-	0.000654	Infinity
θ uncertainty due to cable (rads)	Rect	0.025656	-	0.014830	Infinity
Combined θ uncertainty		***0.014866***	***0.69***	***0.010246***	***2.0E+07***
Combined S_{21Y} uncertainty		**0.0103**			**Eff DOF** **5.9E+06**

Table B.10.3a: Uncertainties in the real component of the S_{21} measurement of device RF-K5b.CL/1 at 18 GHz

Sources of Uncertainty	**Dist**	**Uncertainty Contribution** $u(x_i)$	**Sensitivity Coefficient** c	**Standard Uncertainty** $c\ .\ u(x_i)\ /\ k$	**Degree of Freedom**
Type A unc of S_{21X}		***0.000161***	***1***	***0.000161***	***5***
Linearity	Rect	0.000470	-	0.000272	Infinity
Mismatch	U-shaped	0.001211	-	0.000859	Infinity
Isolation	Rect	0.000018	-	0.000010	Infinity
Type A unc of $\|S_{21}\|$		0.000137	-	0.000137	5
Combined $\|S_{21}\|$ ***uncertainty***		***0.000911***	***1.00***	***0.000910***	***9.7E+03***
Type A unc of θ (rads)		0.000779	-	0.000779	5
θ uncertainty due to $\Delta\|S_{21}\|$ (rads)		0.001259	-	0.001259	Infinity
θ uncertainty due to airline (rads)	Rect	0.002262	-	0.001307	Infinity
θ uncertainty due to cable (rads)	Rect	0.046077	-	0.026634	Infinity
Combined θ ***uncertainty***		***0.026707***	***0.04***	***0.001019***	***6.9E+06***
Combined S_{21X} **uncertainty**		**0.0014**			**Eff DOF**
					2.7E+04

Table B.10.3b: Uncertainties in the imaginary component of the S_{21} measurement of device RF-K5b.CL/1 at 18 GHz

Sources of Uncertainty	**Dist**	**Uncertainty Contribution** $u(x_i)$	**Sensitivity Coefficient** c	**Standard Uncertainty** $c\ .\ u(x_i)\ /\ k$	**Degree of Freedom**
Type A unc of S_{21Y}		***0.000774***	***1***	***0.000774***	***5***
Linearity	Rect	0.000470	-	0.000272	Infinity
Mismatch	U-shaped	0.001211	-	0.000859	Infinity
Isolation	Rect	0.000018	-	0.000010	Infinity
Type A unc of $\|S_{21}\|$		0.000137	-	0.000137	5
Combined $\|S_{21}\|$ ***uncertainty***		***0.000911***	***0.05***	***0.000048***	***9.7E+03***
Type A unc of θ (rads)		0.000779	-	0.000779	5
θ uncertainty due to $\Delta\|S_{21}\|$ (rads)		0.001259	-	0.001259	Infinity
θ uncertainty due to airline (rads)	Rect	0.002262	-	0.001307	Infinity
θ uncertainty due to cable (rads)	Rect	0.046077	-	0.026634	Infinity
Combined θ ***uncertainty***		***0.026707***	***0.72***	***0.019271***	***6.9E+06***
Combined S_{21Y} **uncertainty**		**0.0193**			**Eff DOF**
					1.9E+06

Table B.10.4a: Uncertainties in the real component of the S_{21} measurement of device RF-K5b.CL/2 at 2 GHz

Sources of Uncertainty	**Dist**	**Uncertainty Contribution** ***u*(*x*)**	**Sensitivity Coefficient** ***c***	**Standard Uncertainty** ***c* . *u*(*x*) / *k***	**Degree of Freedom**
Type A unc of S_{21X}		***0.000003***	***1***	***0.000003***	***5***
Linearity	Rect	0.000462	-	0.000267	Infinity
Mismatch	U-shaped	0.000027	-	0.000019	Infinity
Isolation	Rect	0.000010	-	0.000006	Infinity
Type A unc of $\|S_{21}\|$		0.000004	-	0.000004	5
Combined $\|S_{21}\|$ ***uncertainty***		***0.000268***	***-0.86***	***-0.000231***	***1.7E+08***
Type A unc of θ (rads)		0.000063	-	0.000063	5
θ uncertainty due to $\Delta\|S_{21}\|$ (rads)		-0.002304	-	-0.002304	Infinity
θ uncertainty due to airline (rads)	Rect	0.000251	-	0.000145	Infinity
θ uncertainty due to cable (rads)	Rect	0.009774	-	0.005650	Infinity
Combined θ ***uncertainty***		***0.006103***	***-0.05***	***-0.000310***	***4.3E+08***
Combined S_{21X} **uncertainty**		**0.00039**			**Eff DOF** **1.7E+09**

Table B.10.4b: Uncertainties in the imaginary component of the S_{21} measurement of device RF-K5b.CL/2 at 2 GHz

Sources of Uncertainty	**Dist**	**Uncertainty Contribution** ***u*(*x*)**	**Sensitivity Coefficient** ***c***	**Standard Uncertainty** ***c* . *u*(*x*) / *k***	**Degree of Freedom**
Type A unc of S_{21Y}		***0.000009***	***1***	***0.000009***	***5***
Linearity	Rect	0.000462	-	0.000267	Infinity
Mismatch	U-shaped	0.000027	-	0.000019	Infinity
Isolation	Rect	0.000010	-	0.000006	Infinity
Type A unc of $\|S_{21}\|$		0.000004	-	0.000004	5
Combined $\|S_{21}\|$ ***uncertainty***		***0.000268***	***-0.51***	***-0.000136***	***1.7E+08***
Type A unc of θ (rads)		0.000063	-	0.000063	5
θ uncertainty due to $\Delta\|S_{21}\|$ (rads)		-0.002304	-	-0.002304	Infinity
θ uncertainty due to airline (rads)	Rect	0.000251	-	0.000145	Infinity
θ uncertainty due to cable (rads)	Rect	0.009774	-	0.005650	Infinity
Combined θ ***uncertainty***		***0.006103***	***-0.09***	***-0.000527***	***4.3E+08***
Combined S_{21Y} **uncertainty**		**0.00054**			**Eff DOF** **7.0E+07**

Table B.10.5a: Uncertainties in the real component of the S_{21} measurement of device RF-K5b.CL/2 at 9 GHz

Sources of Uncertainty	**Dist**	**Uncertainty Contribution $u(x_i)$**	**Sensitivity Coefficient c**	**Standard Uncertainty $c \cdot u(x_i) / k$**	**Degree of Freedom**
Type A unc of S_{21X}		***0.000018***	***1***	***0.000018***	***5***
Linearity	Rect	0.000459	-	0.000266	Infinity
Mismatch	U-shaped	0.000053	-	0.000038	Infinity
Isolation	Rect	0.000018	-	0.000010	Infinity
Type A unc of $\lvert S_{21} \rvert$		0.000013	-	0.000013	5
Combined $\lvert S_{21} \rvert$ uncertainty		***0.000269***	***0.71***	***0.000191***	***9.5E+05***
Type A unc of θ (rads)		0.000098	-	0.000098	5
θ uncertainty due to $\Delta \lvert S_{21} \rvert$ (rads)		0.001926	-	0.001926	Infinity
θ uncertainty due to airline (rads)	Rect	0.001131	-	0.000654	Infinity
θ uncertainty due to cable (rads)	Rect	0.025656	-	0.014830	Infinity
Combined θ uncertainty		***0.014969***	***0.07***	***0.001044***	***2.8E+09***
Combined S_{21X} uncertainty		**0.00106**			**Eff DOF**
					5.6E+07

Table B.10.5b: Uncertainties in the imaginary component of the S_{21} measurement of device RF-K5b.CL/2 at 9 GHz

Sources of Uncertainty	**Dist**	**Uncertainty Contribution $u(x_i)$**	**Sensitivity Coefficient c**	**Standard Uncertainty $c \cdot u(x_i) / k$**	**Degree of Freedom**
Type A unc of S_{21Y}		***0.000031***	***1***	***0.000031***	***5***
Linearity	Rect	0.000459	-	0.000266	Infinity
Mismatch	U-shaped	0.000053	-	0.000038	Infinity
Isolation	Rect	0.000018	-	0.000010	Infinity
Type A unc of $\lvert S_{21} \rvert$		0.000013	-	0.000013	5
Combined $\lvert S_{21} \rvert$ uncertainty		***0.000269***	***0.7034417***	***0.000189***	***9.5E+05***
Type A unc of θ (rads)		0.000098	-	0.000098	5
θ uncertainty due to $\Delta \lvert S_{21} \rvert$ (rads)		0.001926	-	0.001926	Infinity
θ uncertainty due to airline (rads)	Rect	0.001131	-	0.000654	Infinity
θ uncertainty due to cable (rads)	Rect	0.025656	-	0.014830	Infinity
Combined θ uncertainty		***0.014969***	***0.070481***	***0.001055***	***2.8E+09***
Combined S_{21Y} uncertainty		**0.00107**			**Eff DOF**
					7.1E+06

Table B.10.6a: Uncertainties in the real component of the S_{21} measurement of device RF-K5b.CL/2 at 18 GHz

Sources of Uncertainty	Dist	Uncertainty Contribution $u(x_i)$	Sensitivity Coefficient c	Standard Uncertainty $c\ .\ u(x_i)\ /\ k$	Degree of Freedom
Type A unc of S_{21X}		***0.000086***	***1***	***0.000086***	***5***
Linearity	Rect	0.000472	-	0.000273	Infinity
Mismatch	U-shaped	0.000141	-	0.000100	Infinity
Isolation	Rect	0.000018	-	0.000010	Infinity
Type A unc of $\lvert S_{21}\rvert$		0.000018	-	0.000018	5
Combined $\lvert S_{21}\rvert$ uncertainty		***0.000291***	***0.25***	***0.000073***	***3.3E+05***
Type A unc of θ (rads)		0.000746	-	0.000746	5
θ uncertainty due to $\Delta\lvert S_{21}\rvert$ (rads)		0.000701	-	0.000701	Infinity
θ uncertainty due to airline (rads)	Rect	0.002262	-	0.001307	Infinity
θ uncertainty due to cable (rads)	Rect	0.046077	-	0.026634	Infinity
Combined θ uncertainty		***0.026686***	***0.10***	***0.002686***	***8.2E+06***
Combined S_{21X} uncertainty		**0.00269**			**Eff DOF** **4.8E+06**

Table B.10.6b: Uncertainties in the imaginary component of the S_{21} measurement of device RF-K5b.CL/2 at 18 GHz

Sources of Uncertainty	Dist	Uncertainty Contribution $u(x_i)$	Sensitivity Coefficient c	Standard Uncertainty $c\ .\ u(x_i)\ /\ k$	Degree of Freedom
Type A unc of S_{21Y}		***0.000036***	***1***	***0.000036***	***5***
Linearity	Rect	0.000472	-	0.000273	Infinity
Mismatch	U-shaped	0.000141	-	0.000100	Infinity
Isolation	Rect	0.000018	-	0.000010	Infinity
Type A unc of $\lvert S_{21}\rvert$		0.000018	-	0.000018	5
Combined $\lvert S_{21}\rvert$ uncertainty		***0.000291***	***0.97***	***0.000282***	***3.3E+05***
Type A unc of θ (rads)		0.000746	-	0.000746	5
θ uncertainty due to $\Delta\lvert S_{21}\rvert$ (rads)		0.000701	-	0.000701	Infinity
θ uncertainty due to airline (rads)	Rect	0.002262	-	0.001307	Infinity
θ uncertainty due to cable (rads)	Rect	0.046077	-	0.026634	Infinity
Combined θ uncertainty		***0.026686***	***0.03***	***0.000695***	***8.2E+06***
Combined S_{21Y} uncertainty		**0.00075**			**Eff DOF** **9.1E+05**

Table B.10.7a: Uncertainties in the real component of the S_{21} measurement of device RF-K5b.CL/3 at 2 GHz

Sources of Uncertainty	**Dist**	**Uncertainty Contribution $u(x_i)$**	**Sensitivity Coefficient c**	**Standard Uncertainty $c\ .\ u(x_i)\ /\ k$**	**Degree of Freedom**
Type A unc of S_{21X}		***0.000001***	***1***	***0.000001***	***5***
Linearity	Rect	0.000036	-	0.000021	Infinity
Mismatch	U-shaped	0.000000	-	0.000000	Infinity
Isolation	Rect	0.000010	-	0.000006	Infinity
Type A unc of $\lvert S_{21}\rvert$		0.000001	-	0.000001	5
Combined $\lvert S_{21}\rvert$ uncertainty		***0.000021***	***-0.71***	***-0.000015***	***6.8E+06***
Type A unc of θ (rads)		0.000001	-	0.000001	5
θ uncertainty due to $\Delta\lvert S_{21}\rvert$ (rads)		-0.004943	-	-0.004943	Infinity
θ uncertainty due to airline (rads)	Rect	0.000251	-	0.000145	Infinity
θ uncertainty due to cable (rads)	Rect	0.009774	-	0.005650	Infinity
Combined θ uncertainty		***0.007508***	***-0.0022***	***-0.000016***	***3.9E+16***
Combined S_{21X} uncertainty		**0.000022**			**Eff DOF** **2.0E+07**

Table B.10.7b: Uncertainties in the imaginary component of the S_{21} measurement of device RF-K5b.CL/3 at 2 GHz

Sources of Uncertainty	**Dist**	**Uncertainty Contribution $u(x_i)$**	**Sensitivity Coefficient c**	**Standard Uncertainty $c\ .\ u(x_i)\ /\ k$**	**Degree of Freedom**
Type A unc of S_{21Y}		***0.000001***	***1***	***0.000001***	***5***
Linearity	Rect	0.000036	-	0.000021	Infinity
Mismatch	U-shaped	0.000000	-	0.000000	Infinity
Isolation	Rect	0.000010	-	0.000006	Infinity
Type A unc of $\lvert S_{21}\rvert$		0.000001	-	0.000001	5
Combined $\lvert S_{21}\rvert$ uncertainty		***0.000021***	***-0.71***	***-0.000015***	***6.8E+06***
Type A unc of θ (rads)		0.000001	-	0.000001	5
θ uncertainty due to $\Delta\lvert S_{21}\rvert$ (rads)		-0.004943	-	-0.004943	Infinity
θ uncertainty due to airline (rads)	Rect	0.000251	-	0.000145	Infinity
θ uncertainty due to cable (rads)	Rect	0.009774	-	0.005650	Infinity
Combined θ uncertainty		***0.007508***	***-0.0022***	***-0.000016***	***3.9E+16***
Combined S_{21Y} uncertainty		**0.000022**			**Eff DOF** **7.1E+06**

Table B.10.8a: Uncertainties in the real component of the S_{21} measurement of device RF-K5b.CL/3 at 9 GHz

Sources of Uncertainty	Dist	Uncertainty Contribution $u(x_i)$	Sensitivity Coefficient c	Standard Uncertainty $c\ .\ u(x_i)\ /\ k$	Degree of Freedom
Type A unc of S_{21X}		***0.000001***	***1***	***0.000001***	***5***
Linearity	Rect	0.000036	-	0.000021	Infinity
Mismatch	U-shaped	0.000003	-	0.000002	Infinity
Isolation	Rect	0.000018	-	0.000010	Infinity
Type A unc of $\|S_{21}\|$		0.000002	-	0.000002	5
Combined $\|S_{21}\|$ uncertainty		***0.000023***	***-0.40***	***-0.000009***	***1.2E+05***
Type A unc of θ (rads)		0.000000	-	0.000000	5
θ uncertainty due to $\Delta\|S_{21}\|$ (rads)		-0.002998	-	-0.002998	Infinity
θ uncertainty due to airline (rads)	Rect	0.001131	-	0.000654	Infinity
θ uncertainty due to cable (rads)	Rect	0.025656	-	0.014830	Infinity
Combined θ uncertainty		***0.015144***	***0.0028***	***0.000042***	***4.0E+20***
Combined S_{21X} uncertainty		**0.000043**			**Eff DOF**
					2.3E+07

Table B.10.8b: Uncertainties in the imaginary component of the S_{21} measurement of device RF-K5b.CL/3 at 9 GHz

Sources of Uncertainty	Dist	Uncertainty Contribution $u(x_i)$	Sensitivity Coefficient c	Standard Uncertainty $c\ .\ u(x_i)\ /\ k$	Degree of Freedom
Type A unc of S_{21Y}		***0.000002***	***1***	***0.000002***	***5***
Linearity	Rect	0.000036	-	0.000021	Infinity
Mismatch	U-shaped	0.000003	-	0.000002	Infinity
Isolation	Rect	0.000018	-	0.000010	Infinity
Type A unc of $\|S_{21}\|$		0.000002	-	0.000002	5
Combined $\|S_{21}\|$ uncertainty		***0.000023***	***0.92***	***0.000021***	***1.2E+05***
Type A unc of θ (rads)		0.000000	-	0.000000	5
θ uncertainty due to $\Delta\|S_{21}\|$ (rads)		-0.002998	-	-0.002998	Infinity
θ uncertainty due to airline (rads)	Rect	0.001131	-	0.000654	Infinity
θ uncertainty due to cable (rads)	Rect	0.025656	-	0.014830	Infinity
Combined θ uncertainty		***0.015144***	***-0.0012***	***-0.000018***	***4.0E+20***
Combined S_{21Y} uncertainty		**0.000028**			**Eff DOF**
					1.3E+05

Table B.10.9a: Uncertainties in the real component of the S_{21} measurement of device RF-K5b.CL/3 at 18 GHz

Sources of Uncertainty	**Dist**	**Uncertainty Contribution** ***u*(*x*$_i$)**	**Sensitivity Coefficient** ***c***	**Standard Uncertainty** ***c* . *u*(*x*$_i$) / *k***	**Degree of Freedom**
Type A unc of S_{21X}		***0.000003***	***1***	***0.000003***	***5***
Linearity	Rect	0.000040	-	0.000023	Infinity
Mismatch	U-shaped	0.000001	-	0.000000	Infinity
Isolation	Rect	0.000018	-	0.000010	Infinity
Type A unc of $\|S_{21}\|$		0.000003	-	0.000003	5
Combined $\|S_{21}\|$ uncertainty		***0.000026***	***-0.53***	***-0.000014***	***2.3E+04***
Type A unc of θ (rads)		0.000004	-	0.000004	5
θ uncertainty due to $\Delta\|S_{21}\|$ (rads)		-0.003859	-	-0.003859	Infinity
θ uncertainty due to airline (rads)	Rect	0.002262	-	0.001307	Infinity
θ uncertainty due to cable (rads)	Rect	0.046077	-	0.026634	Infinity
Combined θ uncertainty		***0.026944***	***-0.0030***	***-0.000081***	***1.1E+16***
Combined S_{21X} uncertainty		**0.000082**			**Eff DOF** **3.2E+06**

Table B.10.9b: Uncertainties in the imaginary component of the S_{21} measurement of device RF-K5b.CL/3 at 18 GHz

Sources of Uncertainty	**Dist**	**Uncertainty Contribution** ***u*(*x*$_i$)**	**Sensitivity Coefficient** ***c***	**Standard Uncertainty** ***c* . *u*(*x*$_i$) / *k***	**Degree of Freedom**
Type A unc of S_{21Y}		***0.000003***	***1***	***0.000003***	***5***
Linearity	Rect	0.000040	-	0.000023	Infinity
Mismatch	U-shaped	0.000001	-	0.000000	Infinity
Isolation	Rect	0.000018	-	0.000010	Infinity
Type A unc of $\|S_{21}\|$		0.000003	-	0.000003	5
Combined $\|S_{21}\|$ uncertainty		***0.000026***	***-0.85***	***-0.000022***	***2.3E+04***
Type A unc of θ (rads)		0.000004	-	0.000004	5
θ uncertainty due to $\Delta\|S_{21}\|$ (rads)		-0.003859	-	-0.003859	Infinity
θ uncertainty due to airline (rads)	Rect	0.002262	-	0.001307	Infinity
θ uncertainty due to cable (rads)	Rect	0.046077	-	0.026634	Infinity
Combined θ uncertainty		***0.026944***	***-0.0019***	***-0.000051***	***1.1E+16***
Combined S_{21Y} uncertainty		**0.000056**			**Eff DOF** **3.4E+05**

Table B.10.10a: Uncertainties in the real component of the S_{11} measurement of device RF-K5b.CL/4 at 2 GHz

Sources of Uncertainty	**Type**	**Uncertainty Contribution** $u(x_i)$	**Sensitivity Coefficient** c	**Standard Uncertainty** $c \,.\, u(x_i) \,/\, k$	**Degree of Freedom**
Type A unc of Γ_X		***0.000039***	***1***	***0.000039***	***5***
Directivity	U-shaped	0.01	-	0.007092	Infinity
Reflection Tracking, T	Rect	0.000001	-	0.000001	Infinity
Source Mismatch, $\lvert\Gamma_G\rvert$	U-shaped	0.00000006	-	0.00000004	Infinity
Linearity	Rect	0.000030	-	0.000017	Infinity
Type A unc of $\lvert\Gamma\rvert$		0.000051	-	0.000051	5
Combined $\lvert\Gamma\rvert$ ***uncertainty***		***0.007092***	***0.89***	***0.006339***	***1.9E+09***
Type A unc of φ (rads)		0.000050	-	0.000050	5
φ uncertainty due to $\Delta\lvert\Gamma\rvert$ (rads)		1.57	-	1.57	Infinity
φ uncertainty due to cable (rads)	Rect	0.009774	-	0.005650	Infinity
Combined φ ***uncertainty***		***1.57***	***0.0011***	***0.001769***	***5.0E+18***
					Eff DOF
Combined Γ_X **uncertainty**		**0.0066**			**3.9E+09**

Table B.10.10b: Uncertainties in the imaginary component of the S_{11} measurement of device RF-K5b.CL/4 at 2 GHz

Sources of Uncertainty	**Type**	**Uncertainty Contribution** $u(x_i)$	**Sensitivity Coefficient** c	**Standard Uncertainty** $c \,.\, u(x_i) \,/\, k$	**Degree of Freedom**
Type A unc of Γ_X		***0.000059***	***1***	***0.000059***	***5***
Directivity	U-shaped	0.01	-	0.007092	Infinity
Reflection Tracking, T	Rect	0.000001	-	0.000001	Infinity
Source Mismatch, $\lvert\Gamma_G\rvert$	U-shaped	0.000000	-	0.000000	Infinity
Linearity	Rect	0.000030	-	0.000017	Infinity
Type A unc of $\lvert\Gamma\rvert$		0.000051	-	0.000051	5
Combined $\lvert\Gamma\rvert$ ***uncertainty***		***0.007092***	***-0.45***	***-0.003181***	***1.9E+09***
Type A unc of φ (rads)		0.000050	-	0.000050	5
φ uncertainty due to $\Delta\lvert\Gamma\rvert$ (rads)		1.57	-	1.57	Infinity
φ uncertainty due to cable (rads)	Rect	0.009774	-	0.005650	Infinity
Combined φ ***uncertainty***		***1.57***	***0.0022***	***0.003526***	***5.0E+18***
					Eff DOF
Combined Γ_X **uncertainty**		**0.0047**			**2.1E+08**

Table B.10.11a: Uncertainties in the real component of the S_{11} measurement of device RF-K5b.CL/4 at 9 GHz

Sources of Uncertainty	Type	Uncertainty Contribution $u(x_i)$	Sensitivity Coefficient c	Standard Uncertainty $c \cdot u(x_i) / k$	Degree of Freedom
Type A unc of Γ_X		***0.000233***	***1***	***0.000233***	***5***
Directivity	U-shaped	0.01	-	0.007092	Infinity
Reflection Tracking, T	Rect	0.000003	-	0.000002	Infinity
Source Mismatch, $\lvert\Gamma_G\rvert$	U-shaped	0.000001	-	0.000000	Infinity
Linearity	Rect	0.000076	-	0.000044	Infinity
Type A unc of $\lvert\Gamma\rvert$		0.000234	-	0.000234	5
Combined $\lvert\Gamma\rvert$ uncertainty		***0.007096***	***-0.50***	***-0.003540***	***4.2E+06***
Type A unc of φ (rads)		0.000164	-	0.000164	5
φ uncertainty due to $\Delta\lvert\Gamma\rvert$ (rads)		-0.475833	-	-0.475833	Infinity
φ uncertainty due to cable (rads)	Rect	0.025656	-	0.014830	Infinity
Combined φ uncertainty		***0.476064***	***-0.0066978***	***-0.003189***	***3.6E+14***
					Eff DOF
Combined Γ_X uncertainty		**0.0048**			**8.7E+05**

Table B.10.11b: Uncertainties in the imaginary component of the S_{11} measurement of device RF-K5b.CL/4 at 9 GHz

Sources of Uncertainty	Type	Uncertainty Contribution $u(x_i)$	Sensitivity Coefficient c	Standard Uncertainty $c \cdot u(x_i) / k$	Degree of Freedom
Type A unc of Γ_X		***0.000165***	***1***	***0.000165***	***5***
Directivity	U-shaped	0.01	-	0.007092	Infinity
Reflection Tracking, T	Rect	0.000003	-	0.000002	Infinity
Source Mismatch, $\lvert\Gamma_G\rvert$	U-shaped	0.000001	-	0.000000	Infinity
Linearity	Rect	0.000076	-	0.000044	Infinity
Type A unc of $\lvert\Gamma\rvert$		0.000234	-	0.000234	5
Combined $\lvert\Gamma\rvert$ uncertainty		***0.007096***	***0.87***	***0.006150***	***4.2E+06***
Type A unc of φ (rads)		0.000164	-	0.000164	-1
φ uncertainty due to $\Delta\lvert\Gamma\rvert$ (rads)		-0.475833	-	-0.475833	Infinity
φ uncertainty due to cable (rads)	Rect	0.025656	-	0.014830	Infinity
Combined φ uncertainty		***0.476064***	***-0.0039***	***-0.001835***	***-7.2E+13***
					Eff DOF
Combined Γ_X uncertainty		**0.0064**			**1.2E+07**

Table B.10.12a: Uncertainties in the real component of the S_{11} measurement of device RF-K5b.CL/4 at 18 GHz

Sources of Uncertainty	**Type**	**Uncertainty Contribution** $u(x_i)$	**Sensitivity Coefficient** c	**Standard Uncertainty** $c \, . \, u(x_i) / k$	**Degree of Freedom**
Type A unc of Γ_X		***0.000413***	***1***	***0.000413***	***5***
Directivity	U-shaped	0.01	-	0.007092	Infinity
Reflection Tracking, T	Rect	0.000020	-	0.000011	Infinity
Source Mismatch, $\|\Gamma_G\|$	U-shaped	0.000033	-	0.000023	Infinity
Linearity	Rect	0.000330	-	0.000190	Infinity
Type A unc of $\|\Gamma\|$		0.000630	-	0.000630	5
Combined $\|\Gamma\|$ ***uncertainty***		***0.007123***	***0.040***	***0.000285***	***8.2E+04***
Type A unc of φ (rads)		0.000426	-	0.000426	5
φ uncertainty due to $\Delta\|\Gamma\|$ (rads)		0.004945	-	0.004945	Infinity
φ uncertainty due to cable (rads)	Rect	0.046077	-	0.026634	Infinity
Combined φ ***uncertainty***		***0.027092***	***-0.057***	***-0.001558***	***8.2E+07***
					Eff DOF
Combined Γ_X **uncertainty**		**0.0016**			**1.2E+03**

Table B.10.12b: Uncertainties in the imaginary component of the S_{11} measurement of device RF-K5b.CL/4 at 18 GHz

Sources of Uncertainty	**Type**	**Uncertainty Contribution** $u(x_i)$	**Sensitivity Coefficient** c	**Standard Uncertainty** $c \, . \, u(x_i) / k$	**Degree of Freedom**
Type A unc of Γ_X		***0.000638***	***1***	***0.000638***	***5***
Directivity	U-shaped	0.01	-	0.007092	Infinity
Reflection Tracking, T	Rect	0.000020	-	0.000011	Infinity
Source Mismatch, $\|\Gamma_G\|$	U-shaped	0.000033	-	0.000023	Infinity
Linearity	Rect	0.000330	-	0.000190	Infinity
Type A unc of $\|\Gamma\|$		0.000630	-	0.000630	5
Combined $\|\Gamma\|$ ***uncertainty***		***0.007123***	***1.00***	***0.007117***	***8.2E+04***
Type A unc of φ (rads)		0.000426	-	0.000426	5
φ uncertainty due to $\Delta\|\Gamma\|$ (rads)		0.004945	-	0.004945	Infinity
φ uncertainty due to cable (rads)	Rect	0.046077	-	0.026634	Infinity
Combined φ ***uncertainty***		***0.027092***	***0.0023***	***0.000062***	***8.2E+07***
					Eff DOF
Combined Γ_X **uncertainty**		**0.0071**			**7.9E+04**

Table B.10.13a: Uncertainties in the real component of the S_{11} measurement of device RF-K5b.CL/7 at 2 GHz

Sources of Uncertainty	Type	Uncertainty Contribution $u(x_i)$	Sensitivity Coefficient c	Standard Uncertainty $c \, . \, u(x_i) \, / \, k$	Degree of Freedom
Type A unc of Γ_X		***0.000036***	***1***	***0.000036***	***5***
Directivity	U-shaped	0.01	-	0.007092	Infinity
Reflection Tracking, T	Rect	0.000116	-	0.000067	Infinity
Source Mismatch, $\lvert\Gamma_G\rvert$	U-shaped	0.001126	-	0.000798	Infinity
Linearity	Rect	0.000734	-	0.000424	Infinity
Type A unc of $\lvert\Gamma\rvert$		0.000027	-	0.000027	5
Combined $\lvert\Gamma\rvert$ ***uncertainty***		***0.007150***	***0.74***	***0.005270***	***2.6E+10***
Type A unc of φ (rads)		0.000058	-	0.000058	5
φ uncertainty due to $\Delta\lvert\Gamma\rvert$ (rads)		0.015709	-	0.015709	Infinity
φ uncertainty due to cable (rads)	Rect	0.009774	-	0.005650	Infinity
Combined φ ***uncertainty***		***0.016694***	***-0.23***	***-0.003785***	***3.3E+10***
					Eff DOF
Combined Γ_X uncertainty		**0.0065**			**5.1E+09**

Table B.10.13b: Uncertainties in the imaginary component of the S_{11} measurement of device RF-K5b.CL/7 at 2 GHz

Sources of Uncertainty	Type	Uncertainty Contribution $u(x_i)$	Sensitivity Coefficient c	Standard Uncertainty $c \, . \, u(x_i) \, / \, k$	Degree of Freedom
Type A unc of Γ_X		***0.000053***	***1***	***0.000053***	***5***
Directivity	U-shaped	0.01	-	0.007092	Infinity
Reflection Tracking, T	Rect	0.000116	-	0.000067	Infinity
Source Mismatch, $\lvert\Gamma_G\rvert$	U-shaped	0.001126	-	0.000798	Infinity
Linearity	Rect	0.000734	-	0.000424	Infinity
Type A unc of $\lvert\Gamma\rvert$		0.000027	-	0.000027	5
Combined $\lvert\Gamma\rvert$ ***uncertainty***		***0.007150***	***0.68***	***0.004832***	***2.6E+10***
Type A unc of φ (rads)		0.000058	-	0.000058	5
φ uncertainty due to $\Delta\lvert\Gamma\rvert$ (rads)		0.015709	-	0.015709	Infinity
φ uncertainty due to cable (rads)	Rect	0.009774	-	0.005650	Infinity
Combined φ ***uncertainty***		***0.016694***	***0.25***	***0.004129***	***3.3E+10***
					Eff DOF
Combined Γ_X uncertainty		**0.0064**			**1.0E+09**

Table B.10.14a: Uncertainties in the real component of the S_{11} measurement of device RF-K5b.CL/7 at 9 GHz

Sources of Uncertainty	**Type**	**Uncertainty Contribution** $u(x_i)$	**Sensitivity Coefficient** c	**Standard Uncertainty** $c \cdot u(x_i) / k$	**Degree of Freedom**
Type A unc of Γ_X		***0.000176***	***1***	***0.000176***	***5***
Directivity	U-shaped	0.01	-	0.007092	Infinity
Reflection Tracking, T	Rect	0.000115	-	0.000067	Infinity
Source Mismatch, $\|\Gamma_G\|$	U-shaped	0.001111	-	0.000788	Infinity
Linearity	Rect	0.000733	-	0.000424	Infinity
Type A unc of $\|\Gamma\|$		0.000301	-	0.000301	5
Combined $\|\Gamma\|$ ***uncertainty***		***0.007155***	***0.11***	***0.000778***	***1.6E+06***
Type A unc of φ (rads)		0.000177	-	0.000177	5
φ uncertainty due to $\Delta\|\Gamma\|$ (rads)		0.002333	-	0.002333	Infinity
φ uncertainty due to cable (rads)	Rect	0.025656	-	0.014830	Infinity
Combined φ ***uncertainty***		***0.015014***	***0.33***	***0.004975***	***2.6E+08***
					Eff DOF
Combined Γ_X uncertainty		**0.0050**			**3.4E+06**

Table B.10.14b: Uncertainties in the imaginary component of the S_{11} measurement of device RF-K5b.CL/7 at 9 GHz

Sources of Uncertainty	**Type**	**Uncertainty Contribution** $u(x_i)$	**Sensitivity Coefficient** c	**Standard Uncertainty** $c \cdot u(x_i) / k$	**Degree of Freedom**
Type A unc of Γ_X		***0.000302***	***1***	***0.000302***	***5***
Directivity	U-shaped	0.01	-	0.007092	Infinity
Reflection Tracking, T	Rect	0.000115	-	0.000067	Infinity
Source Mismatch, $\|\Gamma_G\|$	U-shaped	0.001111	-	0.000788	Infinity
Linearity	Rect	0.000733	-	0.000424	Infinity
Type A unc of $\|\Gamma\|$		0.000301	-	0.000301	5
Combined $\|\Gamma\|$ ***uncertainty***		***0.007155***	***-0.99***	***-0.007113***	***1.6E+06***
Type A unc of φ (rads)		0.000177	-	0.000177	5
φ uncertainty due to $\Delta\|\Gamma\|$ (rads)		0.002333	-	0.002333	Infinity
φ uncertainty due to cable (rads)	Rect	0.025656	-	0.014830	Infinity
Combined φ ***uncertainty***		***0.015014***	***0.036***	***0.000544***	***2.6E+08***
					Eff DOF
Combined Γ_X uncertainty		**0.0071**			**1.6E+06**

Table B.10.15a: Uncertainties in the real component of the S_{11} measurement of device RF-K5b.CL/7 at 18 GHz

Sources of Uncertainty	Type	Uncertainty Contribution $u(x_i)$	Sensitivity Coefficient c	Standard Uncertainty $c \cdot u(x_i) / k$	Degree of Freedom
Type A unc of Γ_X		***0.001178***	***1***	***0.001178***	***5***
Directivity	U-shaped	0.01	-	0.007092	Infinity
Reflection Tracking, T	Rect	0.000122	-	0.000071	Infinity
Source Mismatch, $\lvert\Gamma_G\rvert$	U-shaped	0.001248	-	0.000885	Infinity
Linearity	Rect	0.000736	-	0.000425	Infinity
Type A unc of $\lvert\Gamma\rvert$		0.000981	-	0.000981	5
Combined $\lvert\Gamma\rvert$ uncertainty		***0.007227***	***0.86***	***0.006234***	***1.5E+04***
Type A unc of φ (rads)		0.000689	-	0.000689	5
φ uncertainty due to $\Delta\lvert\Gamma\rvert$ (rads)		0.017646	-	0.017646	Infinity
φ uncertainty due to cable (rads)	Rect	0.046077	-	0.026634	Infinity
Combined φ uncertainty		***0.031956***	***0.18***	***0.005712***	***2.3E+07***
					Eff DOF
Combined Γ_X uncertainty		**0.0085**			**1.4E+04**

Table B.10.15b: Uncertainties in the imaginary component of the S_{11} measurement of device RF-K5b.CL/7 at 18 GHz

Sources of Uncertainty	Type	Uncertainty Contribution $u(x_i)$	Sensitivity Coefficient c	Standard Uncertainty $c \cdot u(x_i) / k$	Degree of Freedom
Type A unc of Γ_X		***0.000227***	***1***	***0.000227***	***5***
Directivity	U-shaped	0.01	-	0.007092	Infinity
Reflection Tracking, T	Rect	0.000122	-	0.000071	Infinity
Source Mismatch, $\lvert\Gamma_G\rvert$	U-shaped	0.001248	-	0.000885	Infinity
Linearity	Rect	0.000736	-	0.000425	Infinity
Type A unc of $\lvert\Gamma\rvert$		0.000981	-	0.000981	5
Combined $\lvert\Gamma\rvert$ uncertainty		***0.007227***	***-0.51***	***-0.003656***	***1.5E+04***
Type A unc of φ (rads)		0.000689	-	0.000689	5
φ uncertainty due to $\Delta\lvert\Gamma\rvert$ (rads)		0.017646	-	0.017646	Infinity
φ uncertainty due to cable (rads)	Rect	0.046077	-	0.026634	Infinity
Combined φ uncertainty		***0.031956***	***0.30***	***0.009739***	***2.3E+07***
					Eff DOF
Combined Γ_X uncertainty		**0.0104**			**2.2E+07**

B.11 SCL Uncertainty Budgets

Table B.11.1: Uncertainties in the S_{21} measurement of device RF-K5b.CL/1 at 2 GHz

Source (i)	**Dist**	**Re[u_T(i)]**	**Im[u_T(i)]**
Repeatability		0.0000	0.0001
Linearity, Isolation and Mismatch	U-shaped	0.0028	0.0028
Reference air line standard	Gaussian	0.0004	0.0008
Verification	Rect	0.0009	0.0019
Cable flexure	Gaussian	0.0033	0.0070
Combined uncertainty (k = 1):		**0.0044**	**0.0078**

Table B.11.2: Uncertainties in the S_{21} measurement of device RF-K5b.CL/1 at 9 GHz

Source (i)	**Dist**	**Re[u_T(i)]**	**Im[u_T(i)]**
Repeatability		0.0000	0.0004
Linearity, Isolation and Mismatch	U-shaped	0.0051	0.0051
Reference air line standard	Gaussian	0.0012	0.0037
Verification	Rect	0.0015	0.0046
Cable flexure	Gaussian	0.0054	0.0164
Combined uncertainty (k = 1):		**0.0077**	**0.0182**

Table B.11.3: Uncertainties in the S_{21} measurement of device RF-K5b.CL/1 at 18 GHz

Source (i)	**Dist**	**Re[u_T(i)]**	**Im[u_T(i)]**
Repeatability		0.0001	0.0008
Linearity, Isolation and Mismatch	U-shaped	0.0058	0.0058
Reference air line standard	Gaussian	0.0004	0.0078
Verification	Rect	0.0004	0.0084
Cable flexure	Gaussian	0.0013	0.0292
Combined uncertainty (k = 1):		**0.0059**	**0.0319**

Table B.11.4: Uncertainties in the S_{21} measurement of device RF-K5b.CL/2 at 2 GHz

Source (i)	**Dist**	**Re[u_{T}(i)]**	**Im[u_{T}(i)]**
Repeatability		0.0000	0.0001
Linearity, Isolation and Mismatch	U-shaped	0.0003	0.0003
Reference air line standard	Gaussian	0.0001	0.0001
Verification	Rect	0.0002	0.0003
Cable flexure	Gaussian	0.0006	0.0009
Combined uncertainty (k = 1):		**0.0007**	**0.0011**

Table B.11.5: Uncertainties in the S_{21} measurement of device RF-K5b.CL/2 at 9 GHz

Source (i)	**Dist**	**Re[u_{T}(i)]**	**Im[u_{T}(i)]**
Repeatability		0.0000	0.0000
Linearity, Isolation and Mismatch	U-shaped	0.0007	0.0007
Reference air line standard	Gaussian	0.0004	0.0004
Verification	Rect	0.0006	0.0006
Cable flexure	Gaussian	0.0017	0.0017
Combined uncertainty (k = 1):		**0.0019**	**0.0019**

Table B.11.6: Uncertainties in the S_{21} measurement of device RF-K5b.CL/2 at 18 GHz

Source (i)	**Dist**	**Re[u_{T}(i)]**	**Im[u_{T}(i)]**
Repeatability		0.0001	0.0000
Linearity, Isolation and Mismatch	U-shaped	0.0008	0.0008
Reference air line standard	Gaussian	0.0011	0.0003
Verification	Rect	0.0014	0.0004
Cable flexure	Gaussian	0.0041	0.0011
Combined uncertainty (k = 1):		**0.0045**	**0.0015**

Table B.11.7: Uncertainties in the S_{21} measurement of device RF-K5b.CL/3 at 2 GHz

Source (i)	**Dist**	**Re[u_{T}(i)]**	**Im[u_{T}(i)]**
Repeatability		0.00000	0.00000
Linearity, Isolation and Mismatch	U-shaped	0.00002	0.00002
Reference air line standard	Gaussian	0.00000	0.00000
Verification	Rect	0.00001	0.00001
Cable flexure	Gaussian	0.00002	0.00002
Combined uncertainty (k = 1):		**0.00003**	**0.00003**

Table B.11.8: Uncertainties in the S_{21} measurement of device RF-K5b.CL/3 at 9 GHz

Source (i)	**Dist**	**Re[u_{T}(i)]**	**Im[u_{T}(i)]**
Repeatability		0.00000	0.00000
Linearity, Isolation and Mismatch	U-shaped	0.00005	0.00005
Reference air line standard	Gaussian	0.00002	0.00001
Verification	Rect	0.00003	0.00001
Cable flexure	Gaussian	0.00007	0.00003
Combined uncertainty (k = 1):		**0.00009**	**0.00006**

Table B.11.9: Uncertainties in the S_{21} measurement of device RF-K5b.CL/3 at 18 GHz

Source (i)	**Dist**	**Re[u_{T}(i)]**	**Im[u_{T}(i)]**
Repeatability		0.00000	0.00000
Linearity, Isolation and Mismatch	U-shaped	0.00005	0.00005
Reference air line standard	Gaussian	0.00003	0.00002
Verification	Rect	0.00006	0.00004
Cable flexure	Gaussian	0.00012	0.00008
Combined uncertainty (k = 1):		**0.00014**	**0.00010**

Table B.11.10: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 2 GHz

Source (i)	**Dist**	**Re[u_T(i)]**	**Im[u_T(i)]**
Repeatability		0.0000	0.0001
Linearity, Isolation and Mismatch	U-shaped	0.0033	0.0033
Reference air line standard	Gaussian	0.0000	0.0000
Cable flexure	Gaussian	0.0000	0.0000
Combined uncertainty (k = 1):		**0.0033**	**0.0033**

Table B.11.11: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 9 GHz

Source (i)	**Dist**	**Re[u_T(i)]**	**Im[u_T(i)]**
Repeatability		0.0000	0.0001
Linearity, Isolation and Mismatch	U-shaped	0.0100	0.0100
Reference air line standard	Gaussian	0.0001	0.0001
Cable flexure	Gaussian	0.0001	0.0001
Combined uncertainty (k = 1):		**0.0100**	**0.0100**

Table B.11.12: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 18 GHz

Source (i)	**Dist**	**Re[u_T(i)]**	**Im[u_T(i)]**
Repeatability		0.0003	0.0004
Linearity, Isolation and Mismatch	U-shaped	0.0102	0.0102
Reference air line standard	Gaussian	0.0012	0.0000
Cable flexure	Gaussian	0.0016	0.0000
Combined uncertainty (k = 1):		**0.0104**	**0.0102**

Table B.11.13: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 2 GHz

Source (i)	**Dist**	**Re[u_T(i)]**	**Im[u_T(i)]**
Repeatability		0.0001	0.0003
Linearity, Isolation and Mismatch	U-shaped	0.0045	0.0045
Reference air line standard	Gaussian	0.0005	0.0006
Cable flexure	Gaussian	0.0017	0.0019
Combined uncertainty ($k = 1$):		**0.0048**	**0.0049**

Table B.11.14: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 9 GHz

Source (i)	**Dist**	**Re[u_T(i)]**	**Im[u_T(i)]**
Repeatability		0.0007	0.0004
Linearity, Isolation and Mismatch	U-shaped	0.0124	0.0124
Reference air line standard	Gaussian	0.0036	0.0004
Cable flexure	Gaussian	0.0056	0.0006
Combined uncertainty ($k = 1$):		**0.0141**	**0.0124**

Table B.11.15: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 18 GHz

Source (i)	**Dist**	**Re[u_T(i)]**	**Im[u_T(i)]**
Repeatability		0.0008	0.0011
Linearity, Isolation and Mismatch	U-shaped	0.0125	0.0125
Reference air line standard	Gaussian	0.0039	0.0064
Cable flexure	Gaussian	0.0051	0.0085
Combined uncertainty ($k = 1$):		**0.0141**	**0.0165**

B.12 NIM Uncertainty Budgets

The budgets reported by NIM did not include an overall combined value. The real and the imaginary components are considered to have the same uncertainty. NIM performed the measurements with the male connector at Port 1 and the female connector at Port 2; hence the uncertainty budgets presented here are for S_{12}.

Table B.12.1: Uncertainties in the S_{12} measurement of device RF-K5b.CL/1 at 2 GHz

Source (i)	**Dist**	u_T**(i)**
Residual Source Match		0.00045
Residual Load Match		0.00047
Test Set Linearity		0.0015
Test Set Isolation		0.000003

Table B.12.2: Uncertainties in the S_{12} measurement of device RF-K5b.CL/1 at 9 GHz

Source (i)	**Dist**	u_T**(i)**
Residual Source Match		0.0013
Residual Load Match		0.0013
Test Set Linearity		0.0015
Test Set Isolation		0.000003

Table B.12.3: Uncertainties in the S_{12} measurement of device RF-K5b.CL/1 at 18 GHz

Source (i)	**Dist**	u_T**(i)**
Residual Source Match		0.0017
Residual Load Match		0.0017
Test Set Linearity		0.0015
Test Set Isolation		0.000003

Table B.12.4: Uncertainties in the S_{12} measurement of device RF-K5b.CL/2 at 2 GHz

Source (i)	**Dist**	u_T**(i)**
Residual Source Match		0.00045
Residual Load Match		0.00047
Test Set Linearity		0.0015
Test Set Isolation		0.000003

Table B.12.5: Uncertainties in the S_{12} measurement of device RF-K5b.CL/2 at 9 GHz

Source (i)	**Dist**	u_T**(i)**
Residual Source Match		0.0013
Residual Load Match		0.0013
Test Set Linearity		0.0015
Test Set Isolation		0.000003

Table B.12.6: Uncertainties in the S_{12} measurement of device RF-K5b.CL/2 at 18 GHz

Source (i)	**Dist**	u_T**(i)**
Residual Source Match		0.0017
Residual Load Match		0.0017
Test Set Linearity		0.0015
Test Set Isolation		0.000003

Table B.12.7: Uncertainties in the S_{12} measurement of device RF-K5b.CL/3 at 2 GHz

Source (i)	**Dist**	u_T**(i)**
Residual Source Match		0.00045
Residual Load Match		0.00047
Test Set Linearity		0.0015
Test Set Isolation		0.000003

Table B.12.8: Uncertainties in the S_{12} measurement of device RF-K5b.CL/3 at 9 GHz

Source (i)	**Dist**	u_T**(i)**
Residual Source Match		0.0013
Residual Load Match		0.0013
Test Set Linearity		0.0015
Test Set Isolation		0.000003

Table B.12.9: Uncertainties in the S_{12} measurement of device RF-K5b.CL/3 at 18 GHz

Source (i)	**Dist**	u_T**(i)**
Residual Source Match		0.0017
Residual Load Match		0.0017
Test Set Linearity		0.0015
Test Set Isolation		0.000003

Table B.12.10: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 2 GHz

Source (i)	**Dist**	$\mathbf{u_T}$**(i)**
Residual Directivity		0.00056
Residual Load Match		0.00045
Test Set Linearity		0.0015

Table B.12.11: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 9 GHz

Source (i)	**Dist**	$\mathbf{u_T}$**(i)**
Residual Directivity		0.0012
Residual Load Match		0.0013
Test Set Linearity		0.0015

Table B.12.12: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 18 GHz

Source (i)	**Dist**	$\mathbf{u_T}$**(i)**
Residual Directivity		0.0016
Residual Load Match		0.0017
Test Set Linearity		0.0015

Table B.12.13: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 2 GHz

Source (i)	**Dist**	$\mathbf{u_T}$**(i)**
Residual Directivity		0.00056
Residual Load Match		0.00045
Test Set Linearity		0.0015

Table B.12.14: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 9 GHz

Source (i)	**Dist**	$\mathbf{u_T}$**(i)**
Residual Directivity		0.0012
Residual Load Match		0.0013
Test Set Linearity		0.0015

Table B.12.15: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 18 GHz

Source (i)	**Dist**	$\mathbf{u_T}$**(i)**
Residual Directivity		0.0016
Residual Load Match		0.0017
Test Set Linearity		0.0015

B.13 SP Uncertainty Budgets

Table B.13.1: Uncertainties in the S_{21} measurement of device RF-K5b.CL/1 at 2 GHz

Source (i)	**Dist**	u_T**(i)**
Cable flexure	Gaussian	0.0000354
Drift	Rect	0.0017185
Frequency	Rect	0.0000026
Isolation	Rect	0.0000070
Linearity	Rect	0.0001423
Repeatability	Gaussian	0.0001529
Residual match port 1	U-shaped	0.0000459
Residual match port 2	U-shaped	0.0000448
Residual tracking	Rect	0.0003135
Residual match port interaction	U-shaped	0.0000018
Trace noise	Gaussian	0.0003722
Combined uncertainty (k = 1):		**0.0018**

Table B.13.2: Uncertainties in the S_{21} measurement of device RF-K5b.CL/1 at 9 GHz

Source (i)	**Dist**	u_T**(i)**
Cable flexure	Gaussian	0.0000738
Drift	Rect	0.0028203
Frequency	Rect	0.0000122
Isolation	Rect	0.0000136
Linearity	Rect	0.0003646
Repeatability	Gaussian	0.0003038
Residual match port 1	U-shaped	0.0000897
Residual match port 2	U-shaped	0.0001064
Residual tracking	Rect	0.0011526
Residual match port interaction	U-shaped	0.0000042
Trace noise	Gaussian	0.0006955
Combined uncertainty (k = 1):		**0.0032**

Table B.13.3: Uncertainties in the S_{21} measurement of device RF-K5b.CL/1 at 18 GHz

Source (i)	**Dist**	**u_T(i)**
Cable flexure	Gaussian	0.0001214
Drift	Rect	0.0041557
Frequency	Rect	0.0000242
Isolation	Rect	0.0000500
Linearity	Rect	0.0014490
Repeatability	Gaussian	0.0005319
Residual match port 1	U-shaped	0.0002925
Residual match port 2	U-shaped	0.0002817
Residual tracking	Rect	0.0011452
Residual match port interaction	U-shaped	0.0000084
Trace noise	Gaussian	0.0015939
Combined uncertainty (k = 1):		**0.0049**

Table B.13.4: Uncertainties in the S_{21} measurement of device RF-K5b.CL/2 at 2 GHz

Source (i)	**Dist**	**u_T(i)**
Cable flexure	Gaussian	0.0000050
Drift	Rect	0.0002422
Frequency	Rect	0.0000004
Isolation	Rect	0.0000070
Linearity	Rect	0.0000201
Repeatability	Gaussian	0.0000136
Residual match port 1	U-shaped	0.0000015
Residual match port 2	U-shaped	0.0000020
Residual tracking	Rect	0.0000442
Residual match port interaction	U-shaped	0.0000000
Trace noise	Gaussian	0.0000525
Combined uncertainty (k = 1):		**0.00025**

Table B.13.5: Uncertainties in the S_{21} measurement of device RF-K5b.CL/2 at 9 GHz

Source (i)	**Dist**	**u_T(i)**
Cable flexure	Gaussian	0.0000101
Drift	Rect	0.0003842
Frequency	Rect	0.0000017
Isolation	Rect	0.0000136
Linearity	Rect	0.0000497
Repeatability	Gaussian	0.0000302
Residual match port 1	U-shaped	0.0000097
Residual match port 2	U-shaped	0.0000053
Residual tracking	Rect	0.0001570
Residual match port interaction	U-shaped	0.0000000
Trace noise	Gaussian	0.0000947
Combined uncertainty (k = 1):		**0.00043**

Table B.13.6: Uncertainties in the S_{21} measurement of device RF-K5b.CL/2 at 18 GHz

Source (i)	**Dist**	**u_T(i)**
Cable flexure	Gaussian	0.0000174
Drift	Rect	0.0005963
Frequency	Rect	0.0000035
Isolation	Rect	0.0000500
Linearity	Rect	0.0002079
Repeatability	Gaussian	0.0000491
Residual match port 1	U-shaped	0.0000210
Residual match port 2	U-shaped	0.0000421
Residual tracking	Rect	0.0001643
Residual match port interaction	U-shaped	0.0000000
Trace noise	Gaussian	0.0002287
Combined uncertainty (k = 1):		**0.00070**

Table B.13.7: Uncertainties in the S_{21} measurement of device RF-K5b.CL/3 at 2 GHz

Source (i)	**Dist**	**u_{T}(i)**
Cable flexure	Gaussian	0.0000002
Drift	Rect	0.0000074
Frequency	Rect	0.0000000
Isolation	Rect	0.0000070
Linearity	Rect	0.0000006
Repeatability	Gaussian	0.0000011
Residual match port 1	U-shaped	0.0000000
Residual match port 2	U-shaped	0.0000000
Residual tracking	Rect	0.0000013
Residual match port interaction	U-shaped	0.0000000
Trace noise	Gaussian	0.0000080
Combined uncertainty (k = 1):		**0.000013**

Table B.13.8: Uncertainties in the S_{21} measurement of device RF-K5b.CL/3 at 9 GHz

Source (i)	**Dist**	**u_{T}(i)**
Cable flexure	Gaussian	0.0000003
Drift	Rect	0.0000118
Frequency	Rect	0.0000001
Isolation	Rect	0.0000136
Linearity	Rect	0.0000015
Repeatability	Gaussian	0.0000035
Residual match port 1	U-shaped	0.0000003
Residual match port 2	U-shaped	0.0000004
Residual tracking	Rect	0.0000048
Residual match port interaction	U-shaped	0.0000000
Trace noise	Gaussian	0.0000146
Combined uncertainty (k = 1):		**0.000024**

Table B.13.9: Uncertainties in the S_{21} measurement of device RF-K5b.CL/3 at 18 GHz

Source (i)	**Dist**	**u_T(i)**
Cable flexure	Gaussian	0.0000006
Drift	Rect	0.0000206
Frequency	Rect	0.0000001
Isolation	Rect	0.0000500
Linearity	Rect	0.0000072
Repeatability	Gaussian	0.0000050
Residual match port 1	U-shaped	0.0000000
Residual match port 2	U-shaped	0.0000002
Residual tracking	Rect	0.0000057
Residual match port interaction	U-shaped	0.0000000
Trace noise	Gaussian	0.0000395
Combined uncertainty (k = 1):		**0.000068**

Table B.13.10: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 2 GHz

Source (i)	**Dist**	**u_T(i)**
Cable flexure	Gaussian	0.000000
Drift	Rect	0.000001
Frequency	Rect	0.000000
Linearity	Rect	0.000000
Repeatability	Gaussian	0.000041
Residual directivity	U-shaped	0.002213
Residual match	U-shaped	0.000000
Residual tracking	Rect	0.000001
Combined uncertainty (k = 1):		**0.0022**

Table B.13.11: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 9 GHz

Source (i)	**Dist**	**u_T(i)**
Cable flexure	Gaussian	0.000000
Drift	Rect	0.000003
Frequency	Rect	0.000000
Linearity	Rect	0.000002
Repeatability	Gaussian	0.000226
Residual directivity	U-shaped	0.003302
Residual match	U-shaped	0.000000
Residual tracking	Rect	0.000007
Combined uncertainty (k = 1):		**0.0033**

Table B.13.12: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 18 GHz

Source (i)	**Dist**	u_T**(i)**
Cable flexure	Gaussian	0.000000
Drift	Rect	0.000043
Frequency	Rect	0.000000
Linearity	Rect	0.000107
Repeatability	Gaussian	0.000379
Residual directivity	U-shaped	0.004703
Residual match	U-shaped	0.000014
Residual tracking	Rect	0.000085
Combined uncertainty (k = 1):		**0.0047**

Table B.13.13: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 2 GHz

Source (i)	**Dist**	u_T**(i)**
Cable flexure	Gaussian	0.000000
Drift	Rect	0.000149
Frequency	Rect	0.000000
Linearity	Rect	0.000067
Repeatability	Gaussian	0.000058
Residual directivity	U-shaped	0.002213
Residual match	U-shaped	0.000247
Residual tracking	Rect	0.000147
Combined uncertainty (k = 1):		**0.0025**

Table B.13.14: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 9 GHz

Source (i)	**Dist**	u_T**(i)**
Cable flexure	Gaussian	0.000000
Drift	Rect	0.000201
Frequency	Rect	0.000001
Linearity	Rect	0.000167
Repeatability	Gaussian	0.000242
Residual directivity	U-shaped	0.003302
Residual match	U-shaped	0.000368
Residual tracking	Rect	0.000527
Combined uncertainty (k = 1):		**0.0037**

Table B.13.15: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 18 GHz

Source (i)	**Dist**	**u_T(i)**
Cable flexure	Gaussian	0.000000
Drift	Rect	0.000288
Frequency	Rect	0.000001
Linearity	Rect	0.000713
Repeatability	Gaussian	0.000554
Residual directivity	U-shaped	0.004703
Residual match	U-shaped	0.000598
Residual tracking	Rect	0.000564
Combined uncertainty (k = 1):		**0.0054**

B.14 SNIIM Uncertainty Budgets

The real and the imaginary components are considered to have the same uncertainty. SNIIM performed the measurements with the male connector at Port 1 and the female connector at Port 2; hence the uncertainty budgets presented here are for S_{12}. Values have been rounded to an appropriate number of decimal places; rounding errors may occur.

Table B.14.1: Uncertainties in the S_{12} measurement of device RF-K5b.CL/1 at 2 GHz

Source (i)	**Dist**	**u_T(i)**
Residual load match	U-shaped	0.0012
Residual source match	U-shaped	0.0012
Test set linearity	Rect	0.0018
Test set isolation	Rect	0.0000
Connector repeatability	Gaussian	0.0035
Combined uncertainty (k = 1):		**0.0043**

Table B.14.2: Uncertainties in the S_{12} measurement of device RF-K5b.CL/1 at 9 GHz

Source (i)	**Dist**	**u_T(i)**
Residual load match	U-shaped	0.0012
Residual source match	U-shaped	0.0012
Test set linearity	Rect	0.0018
Test set isolation	Rect	0.0000
Connector repeatability	Gaussian	0.0040
Combined uncertainty (k = 1):		**0.0047**

Table B.14.3: Uncertainties in the S_{12} measurement of device RF-K5b.CL/1 at 18 GHz

Source (i)	**Dist**	**u_T(i)**
Residual load match	U-shaped	0.0012
Residual source match	U-shaped	0.0012
Test set linearity	Rect	0.0018
Test set isolation	Rect	0.0000
Connector repeatability	Gaussian	0.0045
Combined uncertainty (k = 1):		**0.0051**

Table B.14.4: Uncertainties in the S_{12} measurement of device RF-K5b.CL/2 at 2 GHz

Source (i)	**Dist**	**u_T(i)**
Residual load match	U-shaped	0.00014
Residual source match	U-shaped	0.00014
Test set linearity	Rect	0.00032
Test set isolation	Rect	0.00001
Connector repeatability	Gaussian	0.00030
Combined uncertainty (k = 1):		**0.00048**

Table B.14.5: Uncertainties in the S_{12} measurement of device RF-K5b.CL/2 at 9 GHz

Source (i)	**Dist**	**u_T(i)**
Residual load match	U-shaped	0.00014
Residual source match	U-shaped	0.00014
Test set linearity	Rect	0.00032
Test set isolation	Rect	0.00002
Connector repeatability	Gaussian	0.00040
Combined uncertainty (k = 1):		**0.00055**

Table B.14.6: Uncertainties in the S_{12} measurement of device RF-K5b.CL/2 at 18 GHz

Source (i)	**Dist**	**u_T(i)**
Residual load match	U-shaped	0.00014
Residual source match	U-shaped	0.00014
Test set linearity	Rect	0.00032
Test set isolation	Rect	0.00004
Connector repeatability	Gaussian	0.00050
Combined uncertainty (k = 1):		**0.00063**

Table B.14.7: Uncertainties in the S_{12} measurement of device RF-K5b.CL/3 at 2 GHz

Source (i)	**Dist**	**u_{T}(i)**
Residual load match	U-shaped	0.000004
Residual source match	U-shaped	0.000004
Test set linearity	Rect	0.000010
Test set isolation	Rect	0.000013
Connector repeatability	Gaussian	0.000020
Combined uncertainty ($k = 1$):		**0.000027**

Table B.14.8: Uncertainties in the S_{12} measurement of device RF-K5b.CL/3 at 9 GHz

Source (i)	**Dist**	**u_{T}(i)**
Residual load match	U-shaped	0.000004
Residual source match	U-shaped	0.000004
Test set linearity	Rect	0.000010
Test set isolation	Rect	0.000023
Connector repeatability	Gaussian	0.000030
Combined uncertainty ($k = 1$):		**0.000040**

Table B.14.9: Uncertainties in the S_{12} measurement of device RF-K5b.CL/3 at 18 GHz

Source (i)	**Dist**	**u_{T}(i)**
Residual load match	U-shaped	0.000004
Residual source match	U-shaped	0.000004
Test set linearity	Rect	0.000010
Test set isolation	Rect	0.000040
Connector repeatability	Gaussian	0.000020
Combined uncertainty ($k = 1$):		**0.000046**

Table B.14.10: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 2 GHz

Source (i)	**Dist**	**u_T(i)**
Residual directivity	U-shaped	0.0010
Residual source match	U-shaped	0.0000
Residual reflection tracking	Rect	0.0001
Test set linearity	Rect	0.0002
Connector repeatability	Gaussian	0.0014
Combined uncertainty (k = 1):		**0.0017**

Table B.14.11: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 9 GHz

Source (i)	**Dist**	**u_T(i)**
Residual directivity	U-shaped	0.0012
Residual source match	U-shaped	0.0000
Residual reflection tracking	Rect	0.0001
Test set linearity	Rect	0.0002
Connector repeatability	Gaussian	0.0015
Combined uncertainty (k = 1):		**0.0019**

Table B.14.12: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 18 GHz

Source (i)	**Dist**	**u_T(i)**
Residual directivity	U-shaped	0.0014
Residual source match	U-shaped	0.0000
Residual reflection tracking	Rect	0.0001
Test set linearity	Rect	0.0002
Connector repeatability	Gaussian	0.0018
Combined uncertainty (k = 1):		**0.0023**

Table B.14.13: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 2 GHz

Source (i)	**Dist**	**u_T(i)**
Residual directivity	U-shaped	0.0010
Residual source match	U-shaped	0.0005
Residual reflection tracking	Rect	0.0007
Test set linearity	Rect	0.0009
Connector repeatability	Gaussian	0.0012
Combined uncertainty (k = 1):		**0.0020**

Table B.14.14: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 9 GHz

Source (i)	**Dist**	**u_T(i)**
Residual directivity	U-shaped	0.0012
Residual source match	U-shaped	0.0006
Residual reflection tracking	Rect	0.0007
Test set linearity	Rect	0.0009
Connector repeatability	Gaussian	0.0014
Combined uncertainty (k = 1):		**0.0022**

Table B.14.15: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 18 GHz

Source (i)	**Dist**	**u_T(i)**
Residual directivity	U-shaped	0.0014
Residual source match	U-shaped	0.0008
Residual reflection tracking	Rect	0.0007
Test set linearity	Rect	0.0009
Connector repeatability	Gaussian	0.0016
Combined uncertainty (k = 1):		**0.0025**

B.15 NRC Uncertainty Budgets

The real and the imaginary components are considered to have the same uncertainty. NRC performed the measurements with the male connector at Port 1 and the female connector at Port 2; hence the uncertainty budgets presented here are for S_{12}.

Table B.15.1: Uncertainties in the S_{12} measurement of device RF-K5b.CL/1 at 2 GHz

Source (i)	**Dist**	**u_T(i)**
Linearity/noise	Rect	0.0000
Crosstalk	Gaussian	0.0000
System repeatability	Gaussian	0.0001
Connector repeatability	Gaussian	0.0010
Combined uncertainty (k = 1):		**0.0010**

Table B.15.2: Uncertainties in the S_{12} measurement of device RF-K5b.CL/1 at 9 GHz

Source (i)	**Dist**	**u_T(i)**
Linearity/noise	Rect	0.0000
Crosstalk	Gaussian	0.0000
System repeatability	Gaussian	0.0001
Connector repeatability	Gaussian	0.0010
Combined uncertainty (k = 1):		**0.0010**

Table B.15.3: Uncertainties in the S_{12} measurement of device RF-K5b.CL/1 at 18 GHz

Source (i)	**Dist**	**u_T(i)**
Linearity/noise	Rect	0.0000
Crosstalk	Gaussian	0.0000
System repeatability	Gaussian	0.0001
Connector repeatability	Gaussian	0.0010
Combined uncertainty (k = 1):		**0.0010**

Table B.15.4: Uncertainties in the S_{12} measurement of device RF-K5b.CL/2 at 2 GHz

Source (i)	**Dist**	**u_T(i)**
Linearity/noise	Rect	0.00000
Crosstalk	Gaussian	0.00000
System repeatability	Gaussian	0.00002
Connector repeatability	Gaussian	0.00020
Combined uncertainty ($k = 1$):		**0.00020**

Table B.15.5: Uncertainties in the S_{12} measurement of device RF-K5b.CL/2 at 9 GHz

Source (i)	**Dist**	**u_T(i)**
Linearity/noise	Rect	0.00000
Crosstalk	Gaussian	0.00000
System repeatability	Gaussian	0.00002
Connector repeatability	Gaussian	0.00020
Combined uncertainty ($k = 1$):		**0.00020**

Table B.15.6: Uncertainties in the S_{12} measurement of device RF-K5b.CL/2 at 18 GHz

Source (i)	**Dist**	**u_T(i)**
Linearity/noise	Rect	0.00000
Crosstalk	Gaussian	0.00000
System repeatability	Gaussian	0.00005
Connector repeatability	Gaussian	0.00050
Combined uncertainty ($k = 1$):		**0.00050**

Table B.15.7: Uncertainties in the S_{12} measurement of device RF-K5b.CL/3 at 2 GHz

Source (i)	**Dist**	$\boldsymbol{u_T}$**(i)**
Linearity/noise	Rect	0.000004
Crosstalk	Gaussian	0.000004
System repeatability	Gaussian	0.000002
Connector repeatability	Gaussian	0.000020
Combined uncertainty (*k* = 1):		**0.000021**

Table B.15.8: Uncertainties in the S_{12} measurement of device RF-K5b.CL/3 at 9 GHz

Source (i)	**Dist**	$\boldsymbol{u_T}$**(i)**
Linearity/noise	Rect	0.000004
Crosstalk	Gaussian	0.000004
System repeatability	Gaussian	0.000003
Connector repeatability	Gaussian	0.000030
Combined uncertainty (*k* = 1):		**0.000030**

Table B.15.9: Uncertainties in the S_{12} measurement of device RF-K5b.CL/3 at 18 GHz

Source (i)	**Dist**	$\boldsymbol{u_T}$**(i)**
Linearity/noise	Rect	0.000004
Crosstalk	Gaussian	0.000004
System repeatability	Gaussian	0.000005
Connector repeatability	Gaussian	0.000050
Combined uncertainty (*k* = 1):		**0.000050**

Table B.15.10: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 2 GHz

Source (i)	**Dist**	u_{T}**(i)**
Effective Directivity	Rect	0.0049
Linearity/Noise	Rect	0.0001
System repeatability	Gaussian	0.0010
Cable flexure	Gaussian	0.0010
Ambient conditions	Rect	0.0008
Connector repeatability	Gaussian	0.0010
Reference load/line	Rect	0.0008
Combined uncertainty (k = 1):		**0.0052**

Table B.15.11: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 9 GHz

Source (i)	**Dist**	u_{T}**(i)**
Effective Directivity	Rect	0.0049
Linearity/Noise	Rect	0.0001
System repeatability	Gaussian	0.0010
Cable flexure	Gaussian	0.0015
Ambient conditions	Rect	0.0008
Connector repeatability	Gaussian	0.0010
Reference load/line	Rect	0.0008
Combined uncertainty (k = 1):		**0.0054**

Table B.15.12: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 18 GHz

Source (i)	**Dist**	u_{T}**(i)**
Effective Directivity	Rect	0.0049
Linearity/Noise	Rect	0.0001
System repeatability	Gaussian	0.0020
Cable flexure	Gaussian	0.0020
Ambient conditions	Rect	0.0008
Connector repeatability	Gaussian	0.0020
Reference load/line	Rect	0.0008
Combined uncertainty (k = 1):		**0.0080**

Table B.15.13: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 2 GHz

Source (i)	**Dist**	**u_{T}(i)**
Effective Directivity	Rect	0.0049
Tracking	Rect	0.0087
Linearity/Noise	Rect	0.0001
System repeatability	Gaussian	0.0010
Cable flexure	Gaussian	0.0010
Ambient conditions	Rect	0.0008
Connector repeatability	Gaussian	0.0010
Reference load/line	Rect	0.0008
Combined uncertainty (k = 1):		**0.0102**

Table B.15.14: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 9 GHz

Source (i)	**Dist**	**u_{T}(i)**
Effective Directivity	Rect	0.0049
Tracking	Rect	0.0087
Linearity/Noise	Rect	0.0001
System repeatability	Gaussian	0.0010
Cable flexure	Gaussian	0.0010
Ambient conditions	Rect	0.0008
Connector repeatability	Gaussian	0.0010
Reference load/line	Rect	0.0008
Combined uncertainty (k = 1):		**0.0102**

Table B.15.15: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 18 GHz

Source (i)	**Dist**	**u_{T}(i)**
Effective Directivity	Rect	0.0049
Tracking	Rect	0.0087
Linearity/Noise	Rect	0.0001
System repeatability	Gaussian	0.0020
Cable flexure	Gaussian	0.0020
Ambient conditions	Rect	0.0008
Connector repeatability	Gaussian	0.0020
Reference load/line	Rect	0.0008
Combined uncertainty (k = 1):		**0.0108**

B.16 NIST Uncertainty Budgets

Table B.16.1: Uncertainties in the S_{21} measurement of device RF-K5b.CL/1 at 2 GHz

Source (i)	**Dist**	**Mag[u_T(i)] (dB)**	**Phase[u_T(i)] (°)**
Airline standards and test ports		0.002	0.12
System repeatability	Gaussian	0.008	0.08
Repeat measurements	Gaussian	0.000	0.01
Combined uncertainty (k = 1):		0.008	0.15
		Re[u_T(i)]	**Im[u_T(i)]**
Combined uncertainty (k = 1):		**0.00031**	**0.0017**

Table B.16.2: Uncertainties in the S_{21} measurement of device RF-K5b.CL/1 at 9 GHz

Source (i)	**Dist**	**Mag[u_T(i)] (dB)**	**Phase[u_T(i)] (°)**
Airline standards and test ports		0.004	0.44
System repeatability	Gaussian	0.011	0.14
Repeat measurements	Gaussian	0.000	0.02
Combined uncertainty (k = 1):		0.012	0.47
		Re[u_T(i)]	**Im[u_T(i)]**
Combined uncertainty (k = 1):		**0.0020**	**0.0056**

Table B.16.3: Uncertainties in the S_{21} measurement of device RF-K5b.CL/1 at 18 GHz

Source (i)	**Dist**	**Mag[u_T(i)] (dB)**	**Phase[u_T(i)] (°)**
Airline standards and test ports		0.006	0.87
System repeatability	Gaussian	0.018	0.27
Repeat measurements	Gaussian	0.001	0.03
Combined uncertainty (k = 1):		0.020	0.91
		Re[u_T(i)]	**Im[u_T(i)]**
Combined uncertainty (k = 1):		**0.0016**	**0.0115**

Table B.16.4: Uncertainties in the S_{21} measurement of device RF-K5b.CL/2 at 2 GHz

Source (i)	**Dist**	**Mag[u_T(i)] (dB)**	**Phase[u_T(i)]** (°)
Airline standards and test ports		0.002	0.12
System repeatability	Gaussian	0.008	0.08
Repeat measurements	Gaussian	0.000	0.01
Combined uncertainty (k = 1):		0.008	0.15
		Re[u_T(i)]	**Im[u_T(i)]**
Combined uncertainty (k = 1):		**0.00016**	**0.00023**

Table B.16.5: Uncertainties in the S_{21} measurement of device RF-K5b.CL/2 at 9 GHz

Source (i)	**Dist**	**Mag[u_T(i)] (dB)**	**Phase[u_T(i)]** (°)
Airline standards and test ports		0.004	0.44
System repeatability	Gaussian	0.011	0.14
Repeat measurements	Gaussian	0.000	0.02
Combined uncertainty (k = 1):		0.012	0.47
		Re[u_T(i)]	**Im[u_T(i)]**
Combined uncertainty (k = 1):		**0.00058**	**0.00059**

Table B.16.6: Uncertainties in the S_{21} measurement of device RF-K5b.CL/2 at 18 GHz

Source (i)	**Dist**	**Mag[u_T(i)] (dB)**	**Phase[u_T(i)]** (°)
Airline standards and test ports		0.006	0.87
System repeatability	Gaussian	0.018	0.27
Repeat measurements	Gaussian	0.001	0.03
Combined uncertainty (k = 1):		0.020	0.91
		Re[u_T(i)]	**Im[u_T(i)]**
Combined uncertainty (k = 1):		**0.00160**	**0.00049**

Table B.16.7: Uncertainties in the S_{21} measurement of device RF-K5b.CL/3 at 2 GHz

Source (i)	**Dist**	**Mag[u_{T}(i)] (dB)**	**Phase[u_{T}(i)] (°)**
Airline standards and test ports		0.002	0.12
System repeatability	Gaussian	0.036	0.13
Repeat measurements	Gaussian	0.007	0.04
Combined uncertainty ($k = 1$):		0.036	0.18
		Re[u_{T}(i)]	**Im[u_{T}(i)]**
Combined uncertainty ($k = 1$):		**0.000023**	**0.000023**

Table B.16.8: Uncertainties in the S_{21} measurement of device RF-K5b.CL/3 at 9 GHz

Source (i)	**Dist**	**Mag[u_{T}(i)] (dB)**	**Phase[u_{T}(i)] (°)**
Airline standards and test ports		0.004	0.44
System repeatability	Gaussian	0.036	0.25
Repeat measurements	Gaussian	0.003	0.05
Combined uncertainty ($k = 1$):		0.036	0.51
		Re[u_{T}(i)]	**Im[u_{T}(i)]**
Combined uncertainty ($k = 1$):		**0.000051**	**0.000032**

Table B.16.9: Uncertainties in the S_{21} measurement of device RF-K5b.CL/3 at 18 GHz

Source (i)	**Dist**	**Mag[u_{T}(i)] (dB)**	**Phase[u_{T}(i)] (°)**
Airline standards and test ports		0.006	0.87
System repeatability	Gaussian	0.032	0.41
Repeat measurements	Gaussian	0.011	0.04
Combined uncertainty ($k = 1$):		0.033	0.96
		Re[u_{T}(i)]	**Im[u_{T}(i)]**
Combined uncertainty ($k = 1$):		**0.000101**	**0.000069**

Table B.16.10: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 2 GHz

Source (i)	**Dist**	**Mag[u_T(i)]**	**Phase[u_T(i)]** (°)
Airline standards and test ports		0.0017	39.00
System repeatability	Gaussian	0.0006	0.03
Repeat measurements	Gaussian	0.0000	2.41
Combined uncertainty (k = 1):		0.0018	39.01
		Re[u_T(i)]	**Im[u_T(i)]**
Combined uncertainty (k = 1):		**0.0018**	**0.0008**

Table B.16.11: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 9 GHz

Source (i)	**Dist**	**Mag[u_T(i)]**	**Phase[u_T(i)]** (°)
Airline standards and test ports		0.0018	12.83
System repeatability	Gaussian	0.0012	0.07
Repeat measurements	Gaussian	0.0005	0.52
Combined uncertainty (k = 1):		0.0022	12.83
		Re[u_T(i)]	**Im[u_T(i)]**
Combined uncertainty (k = 1):		**0.0017**	**0.0022**

Table B.16.12: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 18 GHz

Source (i)	**Dist**	**Mag[u_T(i)]**	**Phase[u_T(i)]** (°)
Airline standards and test ports		0.0019	1.89
System repeatability	Gaussian	0.0032	0.18
Repeat measurements	Gaussian	0.0014	1.23
Combined uncertainty (k = 1):		0.0038	1.96
		Re[u_T(i)]	**Im[u_T(i)]**
Combined uncertainty (k = 1):		**0.0019**	**0.0037**

Table B.16.13: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 2 GHz

Source (i)	**Dist**	**Mag[u_T(i)]**	**Phase[u_T(i)] (°)**
Airline standards and test ports		0.0017	0.29
System repeatability	Gaussian	0.0006	0.03
Repeat measurements	Gaussian	0.0001	0.02
Combined uncertainty (k = 1):		0.0018	0.30
		Re[u_T(i)]	**Im[u_T(i)]**
Combined uncertainty (k = 1):		**0.0018**	**0.0018**

Table B.16.14: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 9 GHz

Source (i)	**Dist**	**Mag[u_T(i)]**	**Phase[u_T(i)] (°)**
Airline standards and test ports		0.0018	0.34
System repeatability	Gaussian	0.0012	0.07
Repeat measurements	Gaussian	0.0003	0.03
Combined uncertainty (k = 1):		0.0022	0.35
		Re[u_T(i)]	**Im[u_T(i)]**
Combined uncertainty (k = 1):		**0.0020**	**0.0022**

Table B.16.15: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 18 GHz

Source (i)	**Dist**	**Mag[u_T(i)]**	**Phase[u_T(i)] (°)**
Airline standards and test ports		0.0019	0.43
System repeatability	Gaussian	0.0032	0.18
Repeat measurements	Gaussian	0.0010	0.13
Combined uncertainty (k = 1):		0.0038	0.47
		Re[u_T(i)]	**Im[u_T(i)]**
Combined uncertainty (k = 1):		**0.0036**	**0.0031**

B.17 NPLI Uncertainty Budgets

The real and the imaginary components are considered to have the same uncertainty. NPLI performed the measurements with the male connector at Port 1 and the female connector at Port 2; hence the uncertainty budgets presented here are for S_{12}.

Table B.17.1: Uncertainties in the S_{12} measurement of device RF-K5b.CL/1 at 2 GHz

Source (i)	**Dist**	**u_{T}(i)**
Linearity	Rect	0.0006
Mismatch	U-shaped	0.0008
Crosstalk	Gaussian	0.0000
System repeatability	Gaussian	0.0001
Noise	Gaussian	0.0000
Cable fixture	Gaussian	0.0002
Ambient condition	Rect	0.0001
Connector repeatability	Gaussian	0.0001
Combined uncertainty (k = 1):		**0.0011**

Table B.17.2: Uncertainties in the S_{12} measurement of device RF-K5b.CL/1 at 9 GHz

Source (i)	**Dist**	**u_{T}(i)**
Linearity	Rect	0.0008
Mismatch	U-shaped	0.0014
Crosstalk	Gaussian	0.0000
System repeatability	Gaussian	0.0008
Noise	Gaussian	0.0000
Cable fixture	Gaussian	0.0002
Ambient condition	Rect	0.0001
Connector repeatability	Gaussian	0.0006
Combined uncertainty (k = 1):		**0.0019**

Table B.17.3: Uncertainties in the S_{12} measurement of device RF-K5b.CL/1 at 18 GHz

Source (i)	**Dist**	**u_{T}(i)**
Linearity	Rect	0.0010
Mismatch	U-shaped	0.0039
Crosstalk	Gaussian	0.0000
System repeatability	Gaussian	0.0005
Noise	Gaussian	0.0000
Cable fixture	Gaussian	0.0002
Ambient condition	Rect	0.0001
Connector repeatability	Gaussian	0.0003
Combined uncertainty (k = 1):		**0.0041**

Table B.17.4: Uncertainties in the S_{12} measurement of device RF-K5b.CL/2 at 2 GHz

Source (i)	**Dist**	$\boldsymbol{u_T}$**(i)**
Linearity	Rect	0.00014
Mismatch	U-shaped	0.00027
Crosstalk	Gaussian	0.00001
System repeatability	Gaussian	0.00009
Noise	Gaussian	0.00002
Cable fixture	Gaussian	0.00015
Ambient condition	Rect	0.00001
Connector repeatability	Gaussian	0.00007
Combined uncertainty (k = 1):		**0.00036**

Table B.17.5: Uncertainties in the S_{12} measurement of device RF-K5b.CL/2 at 9 GHz

Source (i)	**Dist**	$\boldsymbol{u_T}$**(i)**
Linearity	Rect	0.00020
Mismatch	U-shaped	0.00076
Crosstalk	Gaussian	0.00002
System repeatability	Gaussian	0.00078
Noise	Gaussian	0.00002
Cable fixture	Gaussian	0.00015
Ambient condition	Rect	0.00001
Connector repeatability	Gaussian	0.00061
Combined uncertainty (k = 1):		**0.00127**

Table B.17.6: Uncertainties in the S_{12} measurement of device RF-K5b.CL/2 at 18 GHz

Source (i)	**Dist**	$\boldsymbol{u_T}$**(i)**
Linearity	Rect	0.00023
Mismatch	U-shaped	0.00195
Crosstalk	Gaussian	0.00002
System repeatability	Gaussian	0.00055
Noise	Gaussian	0.00002
Cable fixture	Gaussian	0.00015
Ambient condition	Rect	0.00001
Connector repeatability	Gaussian	0.00034
Combined uncertainty (k = 1):		**0.00207**

Table B.17.7: Uncertainties in the S_{12} measurement of device RF-K5b.CL/3 at 2 GHz

Source (i)	**Dist**	**u_{T}(i)**
Linearity	Rect	0.000007
Mismatch	U-shaped	0.000049
Crosstalk	Gaussian	0.000325
System repeatability	Gaussian	0.000088
Noise	Gaussian	0.000005
Cable fixture	Gaussian	0.000150
Ambient condition	Rect	0.000000
Connector repeatability	Gaussian	0.000071
Combined uncertainty (k = 1):		**0.000378**

Table B.17.8: Uncertainties in the S_{12} measurement of device RF-K5b.CL/3 at 9 GHz

Source (i)	**Dist**	**u_{T}(i)**
Linearity	Rect	0.000010
Mismatch	U-shaped	0.001153
Crosstalk	Gaussian	0.000459
System repeatability	Gaussian	0.000779
Noise	Gaussian	0.000005
Cable fixture	Gaussian	0.000150
Ambient condition	Rect	0.000000
Connector repeatability	Gaussian	0.000609
Combined uncertainty (k = 1):		**0.001594**

Table B.17.9: Uncertainties in the S_{12} measurement of device RF-K5b.CL/3 at 18 GHz

Source (i)	**Dist**	**u_{T}(i)**
Linearity	Rect	0.000011
Mismatch	U-shaped	0.000411
Crosstalk	Gaussian	0.000577
System repeatability	Gaussian	0.000548
Noise	Gaussian	0.000005
Cable fixture	Gaussian	0.000150
Ambient condition	Rect	0.000000
Connector repeatability	Gaussian	0.000339
Combined uncertainty (k = 1):		**0.000970**

Table B.17.10: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 2 GHz

Source (i)	**Dist**	**u_T(i)**
Effective directivity/test port match	U-shaped	0.0072
Tracking	Rect	0.0000
Linearity	Rect	0.0000
System repeatability	Gaussian	0.0000
Cable fixture	Gaussian	0.0000
Ambient condition	Rect	0.0000
Connector repeatability	Gaussian	0.0005
Combined uncertainty (k = 1):		**0.0072**

Table B.17.11: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 9 GHz

Source (i)	**Dist**	**u_T(i)**
Effective directivity/test port match	U-shaped	0.0106
Tracking	Rect	0.0000
Linearity	Rect	0.0000
System repeatability	Gaussian	0.0000
Cable fixture	Gaussian	0.0000
Ambient condition	Rect	0.0000
Connector repeatability	Gaussian	0.0083
Combined uncertainty (k = 1):		**0.0135**

Table B.17.12: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 18 GHz

Source (i)	**Dist**	**u_T(i)**
Effective directivity/test port match	U-shaped	0.0102
Tracking	Rect	0.0000
Linearity	Rect	0.0000
System repeatability	Gaussian	0.0000
Cable fixture	Gaussian	0.0000
Ambient condition	Rect	0.0000
Connector repeatability	Gaussian	0.0015
Combined uncertainty (k = 1):		**0.0103**

Table B.17.13: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 2 GHz

Source (i)	**Dist**	**u_{T}(i)**
Effective directivity/test port match	U-shaped	0.0031
Tracking	Rect	0.0004
Linearity	Rect	0.0003
System repeatability	Gaussian	0.0001
Cable fixture	Gaussian	0.0001
Ambient condition	Rect	0.0004
Connector repeatability	Gaussian	0.0005
Combined uncertainty (k = 1):		**0.0032**

Table B.17.14: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 9 GHz

Source (i)	**Dist**	**u_{T}(i)**
Effective directivity/test port match	U-shaped	0.0061
Tracking	Rect	0.0004
Linearity	Rect	0.0001
System repeatability	Gaussian	0.0000
Cable fixture	Gaussian	0.0001
Ambient condition	Rect	0.0004
Connector repeatability	Gaussian	0.0004
Combined uncertainty (k = 1):		**0.0062**

Table B.17.15: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 18 GHz

Source (i)	**Dist**	**u_{T}(i)**
Effective directivity/test port match	U-shaped	0.0068
Tracking	Rect	0.0006
Linearity	Rect	0.0008
System repeatability	Gaussian	0.0003
Cable fixture	Gaussian	0.0002
Ambient condition	Rect	0.0004
Connector repeatability	Gaussian	0.0005
Combined uncertainty (k = 1):		**0.0069**

B.18 CSIR-NML Uncertainty Budgets

CSIR-NML have provided typical uncertainty budgets and do not include Type A uncertainties and differences between measurement sets.

Table B.18.1: Uncertainties in the S_{21} measurement of device RF-K5b.CL/1 at 2 GHz

Source (i)	**Dist**	**u_T(i) (dB)**
Linearity	Rect	0.0012
Isolation	Rect	0.0000
Mismatch	U-shaped	0.0067
System Repeatability	Gaussian	0.0020
Cables	Gaussian	0.0020
Connector Repeatability	Gaussian	< 0.0050
Combined uncertainty (k = 1):		0.0089
Combined uncertainty (linear):		**0.0007**

Table B.18.2: Uncertainties in the S_{21} measurement of device RF-K5b.CL/1 at 9 GHz

Source (i)	**Dist**	**u_T(i) (dB)**
Linearity	Rect	0.0012
Isolation	Rect	0.0001
Mismatch	U-shaped	0.0206
System Repeatability	Gaussian	0.0020
Cables	Gaussian	0.0020
Connector Repeatability	Gaussian	< 0.0050
Combined uncertainty (k = 1):		0.0215
Combined uncertainty (linear):		**0.0018**

Table B.18.3: Uncertainties in the S_{21} measurement of device RF-K5b.CL/1 at 18 GHz

Source (i)	**Dist**	**u_T(i) (dB)**
Linearity	Rect	0.0012
Isolation	Rect	0.0001
Mismatch	U-shaped	0.0226
System Repeatability	Gaussian	0.0020
Cables	Gaussian	0.0020
Connector Repeatability	Gaussian	< 0.0100
Combined uncertainty (k = 1):		0.0249
Combined uncertainty (linear):		**0.0020**

Table B.18.4: Uncertainties in the S_{21} measurement of device RF-K5b.CL/2 at 2 GHz

Source (i)	**Dist**	**u_T(i) (dB)**
Linearity	Rect	0.0080
Isolation	Rect	0.0003
Mismatch	U-shaped	0.0066
System Repeatability	Gaussian	0.0020
Cables	Gaussian	0.0020
Connector Repeatability	Gaussian	< 0.0030
Combined uncertainty (k = 1):		0.0111
Combined uncertainty (linear):		**0.00013**

Table B.18.5: Uncertainties in the S_{21} measurement of device RF-K5b.CL/2 at 9 GHz

Source (i)	**Dist**	**u_T(i) (dB)**
Linearity	Rect	0.0080
Isolation	Rect	0.0005
Mismatch	U-shaped	0.0203
System Repeatability	Gaussian	0.0020
Cables	Gaussian	0.0020
Connector Repeatability	Gaussian	< 0.0030
Combined uncertainty (k = 1):		0.0222
Combined uncertainty (linear):		**0.00026**

Table B.18.6: Uncertainties in the S_{21} measurement of device RF-K5b.CL/2 at 18 GHz

Source (i)	**Dist**	**u_T(i) (dB)**
Linearity	Rect	0.0080
Isolation	Rect	0.0005
Mismatch	U-shaped	0.0216
System Repeatability	Gaussian	0.0025
Cables	Gaussian	0.0025
Connector Repeatability	Gaussian	< 0.0100
Combined uncertainty (k = 1):		0.0254
Combined uncertainty (linear):		**0.00029**

Table B.18.7: Uncertainties in the S_{21} measurement of device RF-K5b.CL/3 at 2 GHz

Source (i)	**Dist**	**u_{T}(i) (dB)**
Linearity	Rect	0.0200
Isolation	Rect	0.0087
Mismatch	U-shaped	0.0066
System Repeatability	Gaussian	0.0020
Cables	Gaussian	0.0020
Connector Repeatability	Gaussian	< 0.0030
Combined uncertainty (k = 1):		0.0231
Combined uncertainty (linear):		**0.000008**

Table B.18.8: Uncertainties in the S_{21} measurement of device RF-K5b.CL/3 at 9 GHz

Source (i)	**Dist**	**u_{T}(i) (dB)**
Linearity	Rect	0.0200
Isolation	Rect	0.0154
Mismatch	U-shaped	0.0203
System Repeatability	Gaussian	0.0020
Cables	Gaussian	0.0020
Connector Repeatability	Gaussian	< 0.0030
Combined uncertainty (k = 1):		0.0327
Combined uncertainty (linear):		**0.000012**

Table B.18.9: Uncertainties in the S_{21} measurement of device RF-K5b.CL/3 at 18 GHz

Source (i)	**Dist**	**u_{T}(i) (dB)**
Linearity	Rect	0.0200
Isolation	Rect	0.0154
Mismatch	U-shaped	0.0216
System Repeatability	Gaussian	0.0020
Cables	Gaussian	0.0020
Connector Repeatability	Gaussian	< 0.0030
Combined uncertainty (k = 1):		0.0335
Combined uncertainty (linear):		**0.000012**

Table B.18.10: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 2 GHz

Source (i)	**Dist**	u_T**(i)**
Residual directivity	U-shaped	0.0017
Residual port match	U-shaped	0.0000
Linearity	Rect	0.0000
System Repeatability	Gaussian	0.0005
Connector Repeatability	Gaussian	0.0017
Combined uncertainty (k = 1):		0.0025

Table B.18.11: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 9 GHz

Source (i)	**Dist**	u_T**(i)**
Residual directivity	U-shaped	0.0017
Residual port match	U-shaped	0.0000
Linearity	Rect	0.0000
System Repeatability	Gaussian	0.0005
Connector Repeatability	Gaussian	0.0017
Combined uncertainty (k = 1):		0.0025

Table B.18.12: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 18 GHz

Source (i)	**Dist**	u_T**(i)**
Residual directivity	U-shaped	0.0017
Residual port match	U-shaped	0.0001
Linearity	Rect	0.0002
System Repeatability	Gaussian	0.0005
Connector Repeatability	Gaussian	0.0024
Combined uncertainty (k = 1):		0.0030

Table B.18.13: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 2 GHz

Source (i)	**Dist**	u_T**(i)**
Residual directivity	U-shaped	0.0017
Residual port match	U-shaped	0.0001
Linearity	Rect	0.0009
System Repeatability	Gaussian	0.0005
Connector Repeatability	Gaussian	0.0054
Combined uncertainty (k = 1):		0.0058

Table B.18.14: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 9 GHz

Source (i)	**Dist**	u_T**(i)**
Residual directivity	U-shaped	0.0017
Residual port match	U-shaped	0.0015
Linearity	Rect	0.0009
System Repeatability	Gaussian	0.0005
Connector Repeatability	Gaussian	0.0017
Combined uncertainty (k = 1):		0.0037

Table B.18.15: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 18 GHz

Source (i)	**Dist**	u_T**(i)**
Residual directivity	U-shaped	0.0017
Residual port match	U-shaped	0.0016
Linearity	Rect	0.0010
System Repeatability	Gaussian	0.0005
Connector Repeatability	Gaussian	0.0007
Combined uncertainty (k = 1):		0.0036

B.19 NMIJ Uncertainty Budgets

See Appendix C.19 for the derivation of the final uncertainty estimate.

Table B.19.1: Uncertainties in the S_{21} measurement of device RF-K5b.CL/1 at 2 GHz

Source (i)	**Dist**	**u_T(i)**
Residual Load Match	U-shaped	0.0016
Residual tracking	Rect	0.0025
Noise Floor	Gaussian	0.0000
High Level Noise	Gaussian	0.0001
Test set linearity	Rect	0.0002
Resolution	Rect	0.0000
Cable repeatability	Gaussian	0.0003
Cable stability	Gaussian	0.0003
Connector repeatability	Gaussian	0.0005
Test set isolation	Gaussian	0.0000
Combined uncertainty (k = 1):		**0.0018**

Table B.19.2: Uncertainties in the S_{21} measurement of device RF-K5b.CL/1 at 9 GHz

Source (i)	**Dist**	**u_T(i)**
Residual Load Match	U-shaped	0.0016
Residual tracking	Rect	0.0020
Noise Floor	Gaussian	0.0000
High Level Noise	Gaussian	0.0001
Test set linearity	Rect	0.0002
Resolution	Rect	0.0000
Cable repeatability	Gaussian	0.0003
Cable stability	Gaussian	0.0003
Connector repeatability	Gaussian	0.0007
Test set isolation	Gaussian	0.0000
Combined uncertainty (k = 1):		**0.0015**

Table B.19.3: Uncertainties in the S_{21} measurement of device RF-K5b.CL/1 at 18 GHz

Source (i)	**Dist**	**u_T(i)**
Residual Load Match	U-shaped	0.0031
Residual tracking	Rect	0.0029
Noise Floor	Gaussian	0.0000
High Level Noise	Gaussian	0.0001
Test set linearity	Rect	0.0002
Resolution	Rect	0.0000
Cable repeatability	Gaussian	0.0003
Cable stability	Gaussian	0.0003
Connector repeatability	Gaussian	0.0010
Test set isolation	Gaussian	0.0000
Combined uncertainty (k = 1):		**0.0019**

Table B.19.4: Uncertainties in the S_{21} measurement of device RF-K5b.CL/2 at 2 GHz

Source (i)	**Dist**	**u_T(i)**
Residual Load Match	U-shaped	0.0016
Residual tracking	Rect	0.0025
Noise Floor	Gaussian	0.0000
High Level Noise	Gaussian	0.0001
Test set linearity	Rect	0.0002
Resolution	Rect	0.0000
Cable repeatability	Gaussian	0.0003
Cable stability	Gaussian	0.0003
Connector repeatability	Gaussian	0.0005
Test set isolation	Gaussian	0.0000
Combined uncertainty (k = 1):		**0.00026**

Table B.19.5: Uncertainties in the S_{21} measurement of device RF-K5b.CL/2 at 9 GHz

Source (i)	**Dist**	**u_T(i)**
Residual Load Match	U-shaped	0.0016
Residual tracking	Rect	0.0020
Noise Floor	Gaussian	0.0000
High Level Noise	Gaussian	0.0001
Test set linearity	Rect	0.0002
Resolution	Rect	0.0000
Cable repeatability	Gaussian	0.0003
Cable stability	Gaussian	0.0003
Connector repeatability	Gaussian	0.0007
Test set isolation	Gaussian	0.0000
Combined uncertainty (k = 1):		**0.00021**

Table B.19.6: Uncertainties in the S_{21} measurement of device RF-K5b.CL/2 at 18 GHz

Source (i)	**Dist**	u_T**(i)**
Residual Load Match	U-shaped	0.0031
Residual tracking	Rect	0.0029
Noise Floor	Gaussian	0.0000
High Level Noise	Gaussian	0.0001
Test set linearity	Rect	0.0002
Resolution	Rect	0.0000
Cable repeatability	Gaussian	0.0003
Cable stability	Gaussian	0.0003
Connector repeatability	Gaussian	0.0010
Test set isolation	Gaussian	0.0000
Combined uncertainty (k = 1):		**0.00026**

Table B.19.7: Uncertainties in the S_{21} measurement of device RF-K5b.CL/3 at 2 GHz

Source (i)	**Dist**	u_T**(i)**
Residual Load Match	U-shaped	0.0016
Residual tracking	Rect	0.0025
Noise Floor	Gaussian	0.0000
High Level Noise	Gaussian	0.0001
Test set linearity	Rect	0.0002
Resolution	Rect	0.0000
Cable repeatability	Gaussian	0.0003
Cable stability	Gaussian	0.0003
Connector repeatability	Gaussian	0.0005
Test set isolation	Gaussian	0.0000
Combined uncertainty (k = 1):		**0.000020**

Table B.19.8: Uncertainties in the S_{21} measurement of device RF-K5b.CL/3 at 9 GHz

Source (i)	**Dist**	u_T**(i)**
Residual Load Match	U-shaped	0.0016
Residual tracking	Rect	0.0020
Noise Floor	Gaussian	0.0000
High Level Noise	Gaussian	0.0001
Test set linearity	Rect	0.0002
Resolution	Rect	0.0000
Cable repeatability	Gaussian	0.0003
Cable stability	Gaussian	0.0003
Connector repeatability	Gaussian	0.0007
Test set isolation	Gaussian	0.0000
Combined uncertainty (k = 1):		**0.000020**

Table B.19.9: Uncertainties in the S_{21} measurement of device RF-K5b.CL/3 at 18 GHz

Source (i)	**Dist**	$\boldsymbol{u_T}$**(i)**
Residual Load Match	U-shaped	0.0031
Residual tracking	Rect	0.0029
Noise Floor	Gaussian	0.0000
High Level Noise	Gaussian	0.0001
Test set linearity	Rect	0.0002
Resolution	Rect	0.0000
Cable repeatability	Gaussian	0.0003
Cable stability	Gaussian	0.0003
Connector repeatability	Gaussian	0.0010
Test set isolation	Gaussian	0.0000
Combined uncertainty (k = 1):		**0.000020**

Table B.19.10: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 2 GHz

Source (i)	**Dist**	$\boldsymbol{u_T}$**(i)**
Residual tracking	Rect	0.0008
Noise Floor	Gaussian	0.0000
High Level Noise	Gaussian	0.0000
Test set linearity	Rect	0.0002
Resolution	Rect	0.0000
Approximation error	Gaussian	0.0001
S_{11} and S_{22} uncertainty of air line	Gaussian	0.0006
S_{21} and S_{12} uncertainty of air line	Gaussian	0.0004
Connector repeatability	Gaussian	0.0005
Combined uncertainty (k = 1):		**0.0011**

Table B.19.11: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 9 GHz

Source (i)	**Dist**	$\boldsymbol{u_T}$**(i)**
Residual tracking	Rect	0.0008
Noise Floor	Gaussian	0.0000
High Level Noise	Gaussian	0.0000
Test set linearity	Rect	0.0002
Resolution	Rect	0.0000
Approximation error	Gaussian	0.0001
S_{11} and S_{22} uncertainty of air line	Gaussian	0.0005
S_{21} and S_{12} uncertainty of air line	Gaussian	0.0003
Connector repeatability	Gaussian	0.0007
Combined uncertainty (k = 1):		**0.0011**

Table B.19.12: Uncertainties in the S_{11} measurement of device RF-K5b.CL/4 at 18 GHz

Source (i)	**Dist**	**u_T(i)**
Residual tracking	Rect	0.0008
Noise Floor	Gaussian	0.0000
High Level Noise	Gaussian	0.0000
Test set linearity	Rect	0.0002
Resolution	Rect	0.0000
Approximation error	Gaussian	0.0001
S_{11} and S_{22} uncertainty of air line	Gaussian	0.0005
S_{21} and S_{12} uncertainty of air line	Gaussian	0.0008
Connector repeatability	Gaussian	0.0010
Combined uncertainty (k = 1):		**0.0013**

Table B.19.13: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 2 GHz

Source (i)	**Dist**	**u_T(i)**
Residual tracking	Rect	0.0024
Noise Floor	Gaussian	0.0000
High Level Noise	Gaussian	0.0000
Test set linearity	Rect	0.0002
Resolution	Rect	0.0000
Approximation error	Gaussian	0.0005
S_{11} and S_{22} uncertainty of air line	Gaussian	0.0006
S_{21} and S_{12} uncertainty of air line	Gaussian	0.0004
Connector repeatability	Gaussian	0.0005
Combined uncertainty (k = 1):		**0.0026**

Table B.19.14: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 9 GHz

Source (i)	**Dist**	**u_T(i)**
Residual tracking	Rect	0.0024
Noise Floor	Gaussian	0.0000
High Level Noise	Gaussian	0.0000
Test set linearity	Rect	0.0002
Resolution	Rect	0.0000
Approximation error	Gaussian	0.0005
S_{11} and S_{22} uncertainty of air line	Gaussian	0.0003
S_{21} and S_{12} uncertainty of air line	Gaussian	0.0012
Connector repeatability	Gaussian	0.0007
Combined uncertainty (k = 1):		**0.0026**

Table B.19.15: Uncertainties in the S_{11} measurement of device RF-K5b.CL/7 at 18 GHz

Source (i)	**Dist**	**u_T(i)**
Residual tracking	Rect	0.0024
Noise Floor	Gaussian	0.0000
High Level Noise	Gaussian	0.0000
Test set linearity	Rect	0.0002
Resolution	Rect	0.0000
Approximation error	Gaussian	0.0005
S_{11} and S_{22} uncertainty of air line	Gaussian	0.0005
S_{21} and S_{12} uncertainty of air line	Gaussian	0.0008
Connector repeatability	Gaussian	0.0010
Combined uncertainty (k = 1):		**0.0026**

Appendix C – Participants reports

C.1 NPL (UK) Measurements

The items were measured using an HP8510C network analyser configured with an external LRL (Line-Reflect-Line) type calibration algorithm, implemented by NPL, and calibration items traceable to UK national standards via their mechanical properties following the procedures given in NPL procedure document QPCETM/B/042.

The ambient laboratory temperature during the measurements was (23 ± 2) °C.

The uncertainty in the frequency is negligible.

The results supplied are the values of the real and imaginary components of the complex voltage reflection coefficients and transmission coefficients (where applicable) of the items, at each given frequency, referred to 50 Ω. The expanded uncertainty, associated with each coefficient at each frequency, is based on a standard uncertainty multiplied by a coverage factor chosen, on the basis of six replicate measurements, to provide a level of confidence of approximately 95%.

All measurements were taken with the female end of the items attached to port 1 of the network analyser. Thus S_{11} refers to the voltage reflection coefficient of the female end of the items with the other scattering parameters designated accordingly.

The single port devices with male connectors were connected to port 2 of the network analyser and an S_{22} measurement carried out. This is equivalent to measuring S_{11}.

C.2 PTB (Germany) Measurements

The items were measured using an HP 8510B network analyser with an 8515A 3.5 mm test port and an Agilent 85054B calibration kit. The calibration items are traceable to PTB national standards via their mechanical properties.

For the set of four one-port devices, K5b.CL/4 to K5b.CL/7, three one-port MSO calibrations, using the sliding load for M, were performed on either test port 1 (S_{11} for devices with male connector) or test port 2 (S_{22} for devices with female connector). For these measurements, the test port adaptors were fixed in a rigid clamp.

For the set of three two-port devices, K5b.CL/1 to K5b.CL/3, three full two-port TMSO calibrations, using the sliding load for M, were performed.

After each of the three calibrations, each device was measured six times. Between the single measurements, the device was disconnected, rotated by about 60° and connected again. For the calculation of the mean value, all 18 single measurements were considered. The uncertainty contribution “System and connector repeatability” was evaluated from the three groups of six measurements.

After the full two-port calibration, a set of four working RF attenuation standards of (nominal) attenuation values A = 10 dB, 30 dB, 40 dB and 50 dB, which are traced to PTB attenuation standards, were measured on the VNA for all frequencies from 2 GHz to 18 GHz. From the plots of the differences, d, between the VNA results of the four working standards and their accordant standard values vs. frequency, f, a mathematical expression was obtained where d is expressed as a function of A and f.

The ambient temperature of the laboratory during the measurements was (23 ± 0.5) °C and the relative air humidity was (50 ± 15) %.

C.3 NMi-VSL (Netherlands) Measurements

The measurements were performed using a Vector Network Analyser (VNA) set-up suitable for different connector types with a maximum frequency of 50 GHz. The VNA system owned by NMi-VSL is an Agilent system containing the 8510C basic unit, an HP synthesiser 83651B as signal source and a model 8517B for the frequency range 45 MHz up to 50 GHz. Switching between the test sets is done by changing the cable between the signal source and the relevant test set and by choosing the appropriate GPIB address on the 8510C menu.

The VNA is calibrated using an Agilent 85054B calibration kit and the internal software of the VNA. The calibration method is the well-known SOLT method (short-open-load-through). As load, a lowband 50 Ω load is used up to 2 GHz and a sliding load for the higher frequencies. An Agilent 85132 cable is attached to each port of the test set with a suitable adaptor (PC7-N) from the calibration kit 85054B, which results in an effective test port 1 having a slotless female connector and an effective test port 2 having a male connector. A verification kit model 85055A is used to evaluate the uncertainty of the measurements using the ripple technique.

The characteristic impedance standard of 50 Ω is based upon the mechanical dimensions of the beadless airline, which is part of the verification kit. These are measured by the Department of Length at NMi-VSL. The linearity of the system has been checked using a step attenuator equipped with type-N 50 Ω connectors and calibrated by NPL, UK, at 1 GHz.

The ambient temperature of the laboratory during the measurements was (23.0 ± 0.5) °C and the relative air humidity was (41 ± 5) %.

C.4 LNE (France) Measurements

The measurements have been carried out on an Agilent 8510XF network analyser coupled with an 8517B test set. The calibration method is SOLT (with sliding load) and firmware based, using an Agilent 85054B calibration kit. Impedance traceability is based on the verification measurement of the air lines of an Agilent 85055A verification kit, air lines of which dimensions have been calibrated by METAS, giving traceability to the SI unit of length (m). The measurement results are based on 3 different connector orientations with approximately 120° of rotation. At each orientation, the component is measured twice: before and after disconnect-reconnect operation. The final result is then the average of 6 values, each value obtained from an average of 4096 individual measurements.

C.5 INRIM (Italy) Measurements

The S-parameter measurements on travelling standards K5b.CL/1, K5b.CL/2, K5b.CL/3, K5b.CL/4, K5b.CL/5, K5b.CL/6 and K5b.CL/7 have been performed by means of the Vector Network Analyzers (VNA) type HP8510C that is the INRIM primary system for such measurements.

The INRIM HP8510C is traced to a set of impedance standards, which are defined and maintained through mechanical and electrical measurements. Basically, for each transmission line or connector type, INRIM has a precision calibration kit and a verification kit both qualified for realizing together a primary impedance standard set. Actually, the calibration kit components are only submitted for functional check, so to verify the validity of the theoretical models associated them. Conversely, the verification kit components are dimensionally and electrically calibrated through independent sources and methods. In this manner traceability is assumed of the HP8510C to the primary standards of length and direct current, that is, to the SI fundamental quantities.

INRIM Official Data come from 12 sets of repeated measurements, which have been performed under well-controlled environment parameters, (23 ± 0.3) ˚C and (50 ± 5) % RH. The HP8510C calibration process has been repeated four times in different days and by different operators, always using a high number of averages (1024). Furthermore, maintaining the same calibration data set, the travelling standards have been measured three times rotating their connector positions of 120°. In this manner the 12 data sets should realistically include all the random error sources of the system that are: system repeatability, connector repeatability, cable stability and ambient conditions.

Accuracy assessment of the measurements has been performed according to the request of the pilot laboratory and the main suggestions reported Guide Document EA-10/12, “EA Guidelines on the Evaluation of Vector Network Analysers (VNA)”, even though some point has had an INRIM interpretation.

Basically, Type B uncertainty U_{VRC} on reflection coefficients for two port devices have been calculated using the formula:

$$U_{VRC}=\sqrt{\frac{(D+M\Gamma^2)^2}{2}+\frac{(T\Gamma)^2}{3}+\frac{(S_{21}^2\Gamma_L)^2}{2}+\frac{(2\Gamma MS_{21}^2\Gamma_L)^2}{2}} \tag{1}$$

where:

Γ is the measured Voltage Reflection Coefficient,

D is the measured VNA Effective Directivity,

T is the estimated overall effect of Tracking and Non-Linearity (of VNA),

M is the measured effective VNA Test Port Match,

Γ_L is the measured effective VNA Load Match

and S_{21} is the measured Transmission Coefficient of the device under test.

Formula (1) reduces for one port device to the following:

$$U_{VRC}=\sqrt{\frac{(D+M\Gamma^2)^2}{2}+\frac{(T\Gamma)^2}{3}} \tag{2}$$

All the quantities of (1), (2) are expressed in modulus and linear scale.

The Directivity and Test Port Match terms combine linearly before entering in the square sum because are considered highly correlated terms. Even though, all the other terms are correlated to some extent, it has been decided to combine them in square sum.

For transmission measurement uncertainty U_{TM} the following formula has been used:

$$U_{TM}=\sqrt{\frac{L^2}{3}+\frac{M_{TM}}{2}^{2}+\frac{I}{3}^{2}} \tag{3}$$

where:

L is the measured System Deviation from linearity,

M_{TM} is the Calculated Mismatch term

and I is the estimated/measured Cross-Talk.

Furthermore M_{TM} is given by:

$$M_{TM}=20\,log_{10}\frac{1+MS_{11}+\Gamma_L S_{22}+M\Gamma_L S_{11}S_{22}+M\Gamma_L S_{21}S_{12}}{1-M\Gamma_L} \tag{4}$$

where $S_{11}, S_{22}, S_{21}, S_{12}$ are the scattering parameters (in modulus) of the device under test. All the terms in equation (3) and (4) are expressed in modulus and linear scale.

The terminology here used has correspondence to that of the EA-10/12 document.

Eq. (1), (2) and (3) refers to the type B uncertainty on the modulus of the scattering parameter. To evaluate the type B uncertainty on the real and the imaginary part (x and y) of the parameter, we suppose that x and y are affected by the same type B uncertainty, so

$$U_B(x) = U_B(y) = \frac{U_B}{\sqrt{2}} \tag{5}$$

where U_B is eq. (1) or (2) or (3).

The combined uncertainties on the real and the imaginary parts have been calculated as square sum between a Type-B term (5) and a Type-A term coming from the dispersion of the experimental data:

$$U_C(x) = \sqrt{U_B(x)^2 + U_A(x)^2} \qquad U_C(y) = \sqrt{U_B(y)^2 + U_A(y)^2} \tag{6}$$

Finally the combined total uncertainty on the modulus supplied to the Pilot Laboratory has been evaluated supposing that the Gaussian propagation holds:

$$U = \sqrt{\frac{x^2}{x^2 + y^2} U_C(x)^2 + \frac{y^2}{x^2 + y^2} U_C(y)^2} \,. \tag{7}$$

C.6 METAS (Switzerland) Measurements

C.6.1 Measurement method

A special cable support and fixture (developed at METAS) were used during the calibration and measurement process. The calibration of the VNA was done with an OSLT method using calibration standards, which were characterised prior by means of an LRL and/or a cross-ratio method [C.6.1], [C.6.2], [C.6.6], [C.6.8].

The METAS results are obtained as the mean of at least six measurement series. For each series, a new calibration of the VNA was performed. For additional information see section C.6.3.

C.6.2 Traceability

- Air lines are measured dimensionally, traceable to the SI base unit of length (m) at METAS.
- Air line modelling (S-parameter) capability [C.6.3], [C.6.4], [C.6.5], [C.6.7], [C.6.9].

C.6.3 Measurements

The measurements were performed using a VNA system and configuration as summarised in the following tables.

Type of VNA:	8510C
Type of test set:	8515A
Type of calibration kit	85054B and 85054B K42
Method of VNA calibration	- Open/Short/Load/Sliding load and - LRL
VNA error correction	External, using METAS written software “VNA TOOLS”
Sweep type	Frequency list
VNA number of averages: (One and two port measurements)	Calibration and measurements: 512 Isolation calibration (two port setup): 2048 50 dB attenuator measurement: 2048
Power flatness correction	no
Source power:	10 dBm

Table 1 – METAS VNA measurement system

One port measurement setup (male devices)	A test port adapter NMD 3.5 mm to Type-N (female) is connected to port 1 of the test set.
Measured female test port pin-depth (µm)	slotless: -4.3 µm
One port measurement setup (female devices)	A test port adapter NMD 3.5 mm to Type-N (male) is connected to port 1 of the test set.
Measured male test port pin-depth (µm)	-7.6 µm
Two port measurements setup: - Port 1: Test port connector Type-N (male) - Port 2: Test port connector Type-N (female) **DUT orientation: Port 1 Type-N(female)** **Port 2 Type-N(male)**	A single male cable is connected to port 1 and the cable end is fixed with a special clamp. A flexible female cable is connected to port 2. The VNA is first calibrated with this configuration. The VNA setup is then reversed: port 1 (male) with flexible cable and port 2 (female) always fixed. The VNA is then calibrated for that configuration. During the OSL reflection calibration the flexible port is always kept stable with a clamp. At least three measurements are made with each calibration. The final results are the average of these measurements. Precision adapters and a special fixture are used for the test ports.
Measured male test port pin-depth (µm) Measured female test port pin-depth (µm)	-6.4 µm slotless: -3.1 µm

Table 2 – METAS VNA measurement setup

Laboratory temperature	23 °C ± 0.5 °C
Laboratory relative humidity	45 % ± 5 %

Table 3 – METAS ambient conditions

C.6.4 Measurement Uncertainties

Type B uncertainties are represented by a single vector in the complex plane. Currently, METAS are not able to determine Type B correlations.

Type A uncertainties with correlations are calculated from a set of repeated measurements. Depending on the device the size of the sample varies from 19 to 52 measurements. Included are measurements at different connector orientations.

It turns out that the Type A uncertainties are negligible compared to the Type B uncertainties and Type A correlations become diluted such that they are in agreement with zero. For the combined uncertainty, a single vector is therefore given in the complex plane.

C.6.5 References

[C.6.1] M. Wollensack. *VNA Tools calculations.* Document based on the free metrology measurement software from METAS. Version 0.75, March 2004

[C.6.2] M. Kossel. *One-port calibration procedure based on air line impedance standards*. Post-diploma thesis. Swiss Federal Institute of Technology Zürich, May 2001.

[C.6.3] P. Leuchtmann and J. Ruefenacht. *On the calculations of air lines*. Kleinheubacher Berichte, Band 45, pp. 1-5, Copernicus Gesellschaft e.V. October 2001.

[C.6.4] P. Leuchtmann and J. Ruefenacht. *Remarks on the accurate calculation of air lines*. METAS, Report 2002-250-483, June 2002.

[C.6.5] P. Leuchtmann and J. Ruefenacht. *Air lines make impedance traceable to SI base units*. METAS, metINFO, Vol. 9, No. 2/2002.

[C.6.6] B. Szentkuti, M. Wollensack and J. Ruefenacht. *Zur Implementierung der Doppelverhältnis-Korrekturmethode bei METAS*. METAS, Report 2003-250-507, December 2003.

[C.6.7] P. Leuchtmann and J. Ruefenacht. *On the calculation of the Electrical Properties of Precision Coaxial Lines*. IEEE Trans, IM-53 (2), pp 392-397, April 2004.

[C.6.8] M. Kossel, P. Leuchtmann and J. Ruefenacht. Traceable Correction Method for Complex Reflection Coefficient, using Calculable Air Line Impedance Standards. IEEE Trans, IM-53 (2), pp 398-405, April 2004.

[C.6.9] M. Zeier, M. Wollensack and J. Ruefenacht. *Air Line Characterisation Formalism*. METAS, Report 2003-250-508, April 2003.

C.7 CMI (Czech Republic) Measurements

The *S*-parameters were measured with an HP 8510C VNA calibrated using a Open/Short/Sliding Load/Thru calibration scheme. The measured items were connected to the test ports of VNA through flexible cables several times with various positions of the connectors. The male connector was connected to Port 1 of the VNA and the female connector connected to Port 2 of the VNA.

The list of equipment used can be found in Table 4.

Type of VNA:	HP 8510C ser. no. 3312A00583
Type of calibration kit	HP 85054B ser. no. 3106A01997
Method of VNA calibration	- Open/Short/Load/Sliding load/Thru
Airline	N-type 12.5 cm HP ser no. 00943
Other	Flexible cable 85132-60004 ser no. 02738 Flexible cable 85132-60004 ser no. 02739

Table 4 – List of equipment used in CMI measurements

The calibration devices used to perform the measurement are traceable to Czech National Standards.

C.8 UME (Turkey) Measurements

The *S*-parameters were measured with an HP 8510C network analyser with an HP 8515A test set. The network analyser was calibrated using the Short-Open-Sliding Load-Through method and verified using an HP 85055A verification kit, calibrated by NMi-VSL.

HP 85132F cable pairs were used at ports 1 and 2 of the network analyser, with port 1 used to measure devices with male connectors and port 2 to measure devices with female connectors.

The measurements were carried out in a laboratory held at temperature (23 ± 1) °C and relative humidity (45 ± 10) %.

C.9 NMIA (Australia) Measurements

The test items were measured using an HP 8510C VNA, calibrated using an HP 85054B calibration kit. The sliding loads of the kit were calibrated using air gauging. The air gauge setting rings and rods were calibrated by a NAMAS accredited laboratory.

12 sets of measurements were made, with the VNA being re-calibrated between sets.

C.10 SPRING (Singapore) Measurements

The complex-valued S-parameters of the artefacts were measured from 2 to 18 GHz using a vector network analyser (VNA), HP model 8510C with HP model 8515A S-parameter test set. Initialisation of the system was done using an HP model 85054B Type N calibration kit, and an HP model 85055A Type N verification kit was used to verify the system's performance.

Immediately before the measurement, the system was verified through a full two-port calibration. The calibration was made in the frequency range of 45 MHz to 18 GHz using Open-Short-Load-Thru method with sliding loads. The VNA system has been verified with impedance standards whose dimensions in turn have been calibrated with traceability to the SI metre.

In the Type B evaluation of measurement uncertainties, the corrected system performance, such as directivity, test port match, load match, isolation and linearity of the system, were measured. Other factors, such as reflection and transmission tracking, were estimated based on the specifications of the VNA.

A two-port calibration, with an averaging factor of 1024, was performed on the VNA from 2 to 18 GHz at an interval of 1 GHz. Each artefact was then measured at the measurement port of the VNA. S_{11}, S_{21}, S_{12} and S_{22} were measured on artefacts K5b.CL/1, K5b.CL/2 and K5b.CL/3. For the other artefacts, only S_{11} was measured. In the measurement of artefacts K5b.CL/1, K5b.CL/2 and K5b.CL/3, Port 1 refers to the female connector, while Port 2 refers to the male connector.

The results for each artefact were obtained from six measurement runs. Before each run, the artefact was disconnected, rotated and reconnected to the measurement port of the VNA.

C.11 SCL (Hong Kong) Measurements

The travelling standards were stabilised in a laboratory environment at an ambient temperature of 23 °C for over twelve hours before the commencement of the tests.

The measurements were made using the laboratory vector network analyser HP8510B (VNA) with the full *S*-parameter test set (HP8515A) and a pair of test port cables (HP85132F). The VNA was calibrated with the laboratory Type-N Calibration Kit HP85045B using a Sliding Load calibration method from 2 to 18 GHz in 1 GHz steps. The output power of the VNA was set to 10 dBm and its averaging factor to 1024.

The *S*-parameter measurement was repeated for a total of 4 sets of measurement data at each test frequency for each travelling standard. The standard was disconnected, rotated by about 90° and reconnected for each measurement.

The uncertainty evaluation has been carried out in accordance with principles described in the ISO Guide to the Expression of Uncertainty in Measurement

The voltage reflection coefficient measurement is traceable to the calibrated dimensions of the laboratory reference airlines. The transmission coefficient measurement is traceable to the Waveguide Below Cut Off (WBCO) piston attenuator and calibrated dimensions of the laboratory reference airlines.

C.12 NIM (China) Measurements

C.12.1 Measurement system

An HP8722ES VNA and a Maury 8860 LRL calibration kit are used to measure the comparison travelling standards.

A special designed fixture with rail, two Agilent 85133E flexible cables, and precision adaptors are used to provide good repeatability.

The NIST StatistiCal software is used to process measurement data and get final results.

C.12.2 Measurement techniques

A special frequency list is used in the VNA to minimize trace noise and noise level. Alternative sweep mode is used to improve isolation. A calibrated step attenuator is used to calibrate the VNA's linearity. With these techniques, the measurement system specification is as follows:

- Trace Noise < 0.001 dB
- Noise Level < -120 dB
- Isolation > 105 dB
- Linearity < 0.030 dB

A multi-line calibration method and orthogonal distance regression (ODRPACK) algorithm is used in StatistiCal software. This allows StatistiCAL to consider errors in both the measurements and the standard definitions when finding optimal solutions and estimating their uncertainties.

Since repeat measurement data of calibration kit and travelling standards are used by StatistiCAL to determine uncertainties in the solution, the estimate of cable and connector repeatability is not listed in the report.

C.12.3 Traceability routes

As mentioned above, NIM's coaxial attenuation standard is used to provide linearity traceability for the measurement system. A mechanical method is used to provide impedance traceability of the airlines.

The deviation of mechanical length of the 3.12 cm and 3.82 cm airlines is < 50 μm. The measurement uncertainty is 5 μm.

The diameter deviation of airline inner conductor (Δd) is within 0.6 μm. The measurement uncertainty is 0.2 μm.

The diameter deviation of airline outer conductor (ΔD) is within 5 μm. The measurement uncertainty is 1 μm.

For the 50 ohm airline, $\frac{\Delta Zc}{Zc} = 1.2(\frac{\Delta D}{D} + \frac{\Delta d}{d}) \approx 1.2 \times 10^{-3}$ and $\Delta\Gamma = 6 \times 10^{-4}$.

C.13 SP (Sweden) Measurements

Measurement technique

The DUTs were measured using a Vector Network Analyser (VNA) Agilent 8510 with an Agilent 8515 test set. The measurements were performed according to the standard procedure for S-parameter measurements at SP [SP1-SP3]. The VNA was calibrated using the unknown thru technique with a female connector on port 1 and male connector on port 2 of the VNA. The one-port standards used were characterised with a TRL calibration. The complex S-parameters were measured. The uncertainty analysis is based on the EA10/12 guidelines [SP4].

The SOLT standards and DUTs were connected 6 times each in order to estimate connector repeatability.

Results are reported on the complex S-parameters of each device. The results can be found in the appended excel document.

Instrumentation

The instrumentation used is found in Table 1.

Inspection on arrival and before dispatch

The connectors of the DUTs were inspected, cleaned and the pin depth was measured both on arrival and before dispatch to the next lab. The pin-depth was found to be ok both on arrival and before dispatch to the next lab.

On arrival the shoulder of the male pin on devices K5b.CL/2 and K5b.CL/3 had some scratches but this should not affect measurements since this surface is not a contacting surface.

Table 1 Instrumentation used for the measurements

Item	Identification number
Agilent 8515A testset	SP602333
Agilent 8510C Network analyzer	SP602331
Agilent 83651B Synthesized sweeper	SP602343
Agilent 11713A attenuator switch	SP602726
Type N calibration kit HP 85054B	SP503388
Flexcable port 1 Maury	SP602814
Flexcable port 2 Agilent	SP602610
Adapter NMD 3.5mm->Type N female	SP602776
Adapter NMD 3.5mm->Type N male	SP602776
Type N adapter Male-Male	S/N 63713
Type N adapter Female-Female	S/N 59205

Uncertainty

Traceability

VNA impedance is traced to calibrated airline impedance standards. VNA linearity is evaluated with calibrated step attenuators. See Table 2 for details on devices used.

Table 2 Traceability table

Device	Identification number	Traceability
Agilent 125mm airline	SP503389	NPL
Maury 150mm airline	SP602571	NPL
Maury 300mm airline	SP602852	NPL
Agilent 84904L step attenuator	SP602845	NPL
Agilent 84906L step attenuator	SP602844	NPL

Environmental conditions

The temperature and humidity was measured at the VNA. The temperature was (22.9 ± 1) ºC. And the relative humidity was (35 ± 10) %.

References

[SP1] J. Stenarson and K. Yhland, "One and two-port measurement with vector network analyser," SP-Metod 2925, 2004.

[SP2] J. Stenarson, "SOL/SOLT Vector Network Analyzer calibration," SP Sveriges Provnings- och Forsknings Institut, Borås SP-AR 2002:24, 2002.

[SP3] J. Stenarson and K. Yhland, "Uncertainty in VNA measurements," SP Sveriges Provnings- och Forsknings Institut, Borås SP-AR 2003:04, 2003.

[SP4] EA, "Guidelines on the Evaluation of Vector Network Analysers (VNA)," European co-operation for Accreditation EA-10/12 (rev.00), 2000.

C.14 SNIIM (Russia) Measurements

The measurements were performed using a measurement test set incorporating a directional coupler and two-channel vector voltmeter. The vector voltmeter is a two-channel receiver with double frequency conversion to an IF signal of 55 kHz. LF substitution was performed by the use of stepped and variable standard attenuators and phase shifters.

The calibration of the measurement system was performed using a set of seven quarter-wavelength precision air lines, two offset short circuits and a small reflected termination (the calibration elements chosen were dependent upon the frequency band).

Impedance measurements are traceable, via the calibrated dimensions of the reference coaxial air lines, to the SI metre.

The laboratory temperature was (21 ± 1) °C and (20 ± 10) % relative humidity.

C.15 NRC (Canada) Measurements

Our measurement system is a commercial Agilent 8510C system. The only differences from the manufacturer procedures are described below:

1 - The flexible cables were replaced by home made semi-rigid cables. We took care to avoid any cable movement. One cable is attached to the table and therefore does not move at all.

2 - The "TRL 2 PORT" procedure from the analyser firmware was used to calibrate the VNA. The airline standards are as follows:

-- The THRU is a 4.28 cm (m-f) air line
-- The LINE is a 5 cm (m-f) air line
-- The REFLECT are a pair (one male and one female) of 7.35 mm offset short-circuits.

All standards are from Maury Microwave.

C.16 NIST (USA) Measurements

All measurements were performed on a commercial Vector Network Analyser (VNA). The VNA used for this set of measurements was a Hewlett-Packard 8510C. The VNA was calibrated using the NIST Multical software with a set of five airline standards. For the measurements, there were six separate connections of the Device Under Test (DUT). Three were in the forward direction, port 1 of the device connected to port 1 of the VNA, and three with the device in the reverse direction, port 2 of the device connected to port 1 of the VNA. The final values reported are the mean of all six connections corrected for orientation.

The system produces the results in magnitude and phase format so the results and the uncertainties were converted to real and imaginary using the method outlined below.

First form the covariance matrix ($\mathbf{S}_p$):

$$S_p = \begin{pmatrix} S_{rr} & S_{r\theta} \\ S_{r\theta} & S_{\theta\theta} \end{pmatrix}$$

S_{rr} is the uncertainty in Magnitude

$S_{\theta\theta}$ is the uncertainty in Phase

$S_{r\theta}$ for this discussion is set to 0.

The transformations of form that are used are:

$$X = r\cos\theta$$
$$Y = r\sin\theta$$
$$for\ S_{11}\ and\ S_{22}\ and$$
$$X = 10^{\left(\frac{r}{20}\right)}\cos\theta,\quad Y = 10^{\left(\frac{r}{20}\right)}\sin\theta \quad for\ S_{12}\ and\ S_{21}.$$

The Jacobian matrix is formed:

$$J = \begin{pmatrix} \frac{\partial X}{\partial r} & \frac{\partial X}{\partial \theta} \\ \frac{\partial Y}{\partial r} & \frac{\partial Y}{\partial \theta} \end{pmatrix} = \begin{pmatrix} \cos\theta & -r\sin\theta \\ \sin\theta & r\cos\theta \end{pmatrix} \quad for\ S_{11,22}\ etc.$$

The transformed covariance matrix (S_c) is obtained from:

$$S_c = J\,S_p\,J^T$$

where

$S_{c1,1}$ is the real uncertainty and

$S_{c2,2}$ is the imaginary uncertainty.

C.17 NPLI (India) Measurements

Environmental conditions:

Temperature: (23 ± 1) °C
Relative Humidity: (50 ± 10) % RH

Measurement description:

The Scattering coefficients of the artefacts of this comparison have been measured using a Vector Network Analyser System. The VNA (WILTRON VNA 37247B) has been calibrated using a Type N Calibration kit, Model no.3653 and the precision coaxial airline for full 12-term, 1601 data points. The calibration technique used was the open-short-load in Type-N connector for the broadband frequency range 2-18 GHz.

The respective S-parameters of one port and two port components have been recorded in the real and imaginary form as required by the key comparison, $S = x + jy$. The S-parameters of each artefact have been measured six times by connect-disconnect at 17 frequencies points. The mean value of the real and imaginary components of S-parameter has been reported for each artefact as desired.

The combined standard uncertainty of the real and imaginary components i.e. $u(x)$ and $u(y)$ and the correlation coefficient $r(x, y)$ for each artefact have been calculated and reported accordingly [C.17.1], [C.17.2].

Traceability route:

The attenuation measurement using vector network analyser is traceable to the 30 MHz WBCO attenuator of NPL India through transfer standards coaxial attenuators.

The impedance measurement using vector network analyser is traceable to the Dimension metrology at NPL India through transfer standards coaxial airlines and calibration kit components.

References:

[C.17.1] "EA Guidelines on the Evaluation of Vector Network Analyzers (VNA)", publication Reference EA-10/12, European Co-operation for Accreditation, May 2000.

[C.17.2] N.M.Ridler and M.J.Salter, "An approach to the treatment of uncertainty in complex S-parameter measurements", *Metrologia*, 2002, **39**, pp 295-302.

C.18 CSIR-NML (South Africa) Measurements

The measurements were performed using a Hewlett-Packard 8510C vector network analyser (VNA) with a Hewlett-Packard 8515A *S*-parameter test set. The VNA was calibrated using a Hewlett-Packard 85054B calibration kit.

One-port measurements were performed using rigid test port adapters connected to the 3.5 mm test ports of the VNA. Two-port measurements were performed using phase stable cables connected to the test ports of the VNA.

The linearity traceability for the VNA comes from a Techtest WBCO 310 piston attenuator. Other uncertainty components were identified using reference airlines and terminations in accordance with the EA document on the estimation of uncertainties of vector network analysers.

C.19 NMIJ (Japan) Measurements

Laboratory temperature: 23 ± 1ºC

Laboratory relative humidity: 50 ± 20%

Measurement system:

- One port devices: The adapter of special 2.4 to GPC-7 is attached to port 1 of E8364B PNA. And then, the test port adapter of GPC-7 to N50 female (for male devices) or GPC-7 to N50 male (for female devices) is connected to GPC-7 port.

- Two port devices: The adapter of special 2.4 to GPC-7 is attached to port 1of E8364B PNA. And then, the test port adapter of GPC-7 to N50 male is connected to GPC-7 port. The flexible cable is connected to port 2 of PNA, and the test port adapter of GPC-7 to N50 male, is attached on other side of cable. The test ports are protected from temperature drift by the thermal insulations made of plastic.

- The pin depths of N50 female and male connector of test ports are -5.3 µm and -1.3 µm, respectively.
- The bodies of devices are covered by plastic caps as the thermal isolation for preventing the thermal effect of drift of device characteristics.
- The measurement condition about E8364B PNA is as follows;

Firmware version: A04.86
Sweep type: Segment (List)
lF band-width: 100 Hz
Number of average: 10
Power direct on the test port at 18 GHz: -14dBm.

Measurement methods :

- One port devices: NMlJ employ the "Quarter wave method", for one port devices. The VNA calibrated by OSLT calibration kit (85054B), and then, the devices are measured. After that, several lengths (30mm, 42mm, 49mm, and 125mm) beadless airlines are inserted between test port and devices, and then, S11 are obtained. The reflection coefficients of one port devices are calculated using the measured S11data of devices and that with several lengths of airline.

- Tow port devices: NMIJ employ the multiline TRL and LRL methods using beadless airline with 30 mm, 42 mm and 49 mm length and phase matched shorts. VNA error corrections are based on firmware with original definition parameters. After devices are measured, the residual errors in measured data are corrected. The residuals are calculated using airline with several lengths in advance.

Traceability route:

- Airline standards are measured dimensionally, traceable to the SI base unit of length (m), NMIJ.

Uncertainty calculations :

- Uncertainty of Sii for one port devices is calculated as followed equations;

$$Unc(S_{ii}) \approx \sqrt{Unc_{Noise}(S_{ii})^2 + Unc_{std}(S_{ii})^2 + Unc_{Rpt}(S_{ii})^2 + Unc_{sys}(S_{ii})^2 + Unc_{approx}(S_{ii})^2}$$

$$Unc_{Noise}(S_{ii}) \approx N_F + N_T S_{ii}$$

$$Unc_{std}(S_{ii}) \approx \delta S_{ii-airline} + K(f) S_{ji-airline}$$

$$Unc_{Rpt}(S_{ii}) \approx R_{Ri}$$

$$Unc_{sys}(S_{ii}) \approx 2 S_{ii} E_{RF} + A S_{ii}$$

$$Unc_{approx}(S_{ii}) \approx |S_{ii}||E_{RF}| + \frac{1}{2}|S_{ii}|^2 |S_{22-airline}|$$

Where parameters in mentioned above are as follows:

$S_{ii,ij}$: S-parameters of device under tests

$S_{ii,ij\text{-airline}}$: S-parameters of airline standards

A: Linearity

N_F: Noise floor

N_T: High-level noise

R_{R1}: Reflection repeatability of connection

E_{RF}: Residual tracking

K(f): Sensitivity coefficient (depends on frequency)for standard uncertainty of Sij

-Uncertainties of Sii and Sij for two port devices are calculated as followed equations;

For Uncertainty of Sii:

$$Unc(S_{ii}) \approx \sqrt{Unc_{Noise}(S_{ii})^2 + Unc_{Cable}(S_{ii})^2 + Unc_{Rpt}(S_{ii})^2 + Unc_{sys}(S_{ii})^2}$$

$$Unc_{Noise}(S_{ii}) \approx N_F + N_T S_{ii}$$

$$Unc_{Cable}(S_{ii}) \approx C_{Ri} + 2C_{Ti}S_{ii} + C_{Ri}S_{ii}{}^2 + S_{ij}S_{ji}C_{Rj}$$

$$Unc_{Rpt}(S_{ii}) \approx R_{Ri} + R_{Ri}S_{ii}{}^2 + 2R_{Ti}S_{ii} + S_{ij}S_{ji}R_{Rj}$$

$$Unc_{sys}(S_{ii}) \approx E_{DF} + E_{RF}S_{ii} + E_{SF}S_{ii}{}^2 + S_{ij}S_{ji}E_{LF} + AS_{ii}$$

For Uncertainty of Sji:

$$Unc(S_{ji}) \approx \sqrt{Unc_{Noise}(S_{ji})^2 + Unc_{Cable}(S_{ji})^2 + Unc_{Rpt}(S_{ji})^2 + Unc_{sys}(S_{ji})^2}$$

$$Unc_{Noise}(S_{ji}) \approx N_F + S_{ij}N_T$$

$$Unc_{Cable}(S_{ii}) \approx S_{ji}(C_{Ti} + C_{Tj} + S_{ii}C_{Ri} + S_{jj}C_{Rj} + S_{ij}S_{ji}C_{Ri}C_{Rj})$$

$$Unc_{Rpt}(S_{ji}) \approx S_{ji}(R_{Ti} + R_{Tj} + S_{ii}R_{Ri} + S_{jj}R_{Rj} + S_{ij}S_{ji}R_{Ri}R_{Rj})$$

$$Unc_{sys}(S_{ji}) \approx S_{ji}(E_{TF} + S_{ii}E_{SF} + S_{jj}E_{LF} + S_{ij}S_{ji}E_{SF}E_{LF} + A) + E_{XTF}$$

Where parameters in mentioned above are as follows:

$S_{ii,ij}$: S-parameters of device under tests
E_{XTF}: Cross talk
A: Linearity
N_F: Noise floor
N_T: High-level noise
$C_{R1,2}$: Reflection repeatability of cable
$C_{T1,2}$: Transmission repeatability of cable
$R_{R1,2}$: Reflection repeatability of connection
$R_{T1,2}$: Transmission repeatability of connection
$E_{DF,DR}$: Residual directivity of forward and reverse
$E_{RF,TF}$: Residual tracking of forward and reverse
$E_{SF,LF}$: Residual source and load matching of forward and reverse

Appendix D: Reported Pin Depth Measurements

The participants were asked to report the pin depths of the devices upon arrival at their premises. The following tables show the reported values (depths in micrometres, µm)[†††]. The participants are listed in the order they performed the measurements.

Not all of the labs reported pin depth measurements.

[†††] The measurements were requested in µm; however, as most dial gauge readings are in inches, many of these results are converted from inches.

Lab	**K5b.CL/1**		**K5b.CL/2**		**K5b.CL/3**	
	Female	Male	Female	Male	Female	Male
NPL (1)	30	30	48	30	36	25
PTB	27	28	40	37	33	29
NMi-VSL	28.5	36.8	44	44.4	36.5	31.8
INRIM	30	33	46	43	36	28
NPL (2)	30	28	46	30	36	20
METAS	27.8	30.9	41.1	41.7	32.3	29.4
CMI	22.1	18.8	30	36.1	25.4	18.8
UME	36.6	22.9	49.3	38.1	39.9	23.6
NPL (3)	36	25	46	30	36	25
NMIA	38	30	51	41	41	30
SPRING	30	30	45	36	40	27
SCL	54	12	71	26	61	14
NPL (4)	28	20	48	36	43	25
SNIIM	27	38	47	53	32	43
NIM	15.24	26.67	29.21	41.91	13.97	35.56
NRC	25	25	50	44	25	31.25
NIST	-	-	-	-	-	-
NPL (5)	36	20	41	28	38	18
CSIR-NML	-	-	-	-	-	-
NPLI	13	25	25	25	12	38
NMIJ	36.7	25.7	53.1	37.0	42.6	28.1
NPL (6)	28	18	48	30	46	20
SP	37.3	26.2	50.0	48.3	44.9	35.6
LNE	-	-	-	-	-	-
NPL (7)	30	18	38	30	41	15

Table D.1 – Pin depth measurements of the two-port devices

Lab	**K5b.CL/4**	**K5b.CL/5**	**K5b.CL/6**	**K5b.CL/7**
NPL (1)	18	33	25	13
PTB	26	26	40	23
NMi-VSL	32.2	28	45.5	24.5
INRIM	28	32	43	28
NPL (2)	15	25	33	25
METAS	26.3	25.8	44.6	23.8
CMI	18.5	22.4	43.9	19.6
UME	23.9	36.6	43.2	28.7
NPL (3)	20	25	25	30
NMIA	30	33	46	28
SPRING	25	34	44	30
SCL	13	55	29	54
NPL (4)	20	33	38	28
SNIIM	68	27	58	27
NIM	40.6	22.9	38.1	22.9
NRC	44	25	38	25
NIST	-	-	-	-
NPL (5)	38	23	36	20
CSIR-NML	-	-	-	-
NPLI	25	13	25	13
NMIJ	59.3	37.2	51.7	33.4
NPL (6)	48	38	41	38
SP	66	41.5	59.3	34.7
LNE	-	-	-	-
NPL (7)	48	25	41	20

Table D.2 – Pin depth measurements of the one-port devices

Appendix E: Device monitoring

During the course of the comparison, the devices were returned periodically to the pilot laboratory for inspection purposes.

Figs E.1 to E.5 show the measurements of each device made by the pilot laboratory, along with the expanded uncertainty associated with the measurement, normalised to the mean value of the measurements at the respective frequencies. Each measurement is offset slightly in the graphs for ease of viewing.

It is clear from Fig E.1 that there is a change in the characteristics of the 3 dB pad between NPL's second and third measurement and this can also be highlighted by looking at the other measurands and frequencies other than those within the scope of this comparison. Fig E.6 shows the value of S_{11} for this device at 2, 9 and 18 GHz and Fig E.7 shows the value of S_{21} for this device at 4, 12 and 15 GHz.

It was decided to continue the comparison with this device but treat it as two separate devices.

Measurements of the other devices agree well with each other. There is no obvious drift in the other devices. The male matched load shows a small oscillation in the measured values but, despite this, the measurements are still in agreement within the uncertainties.

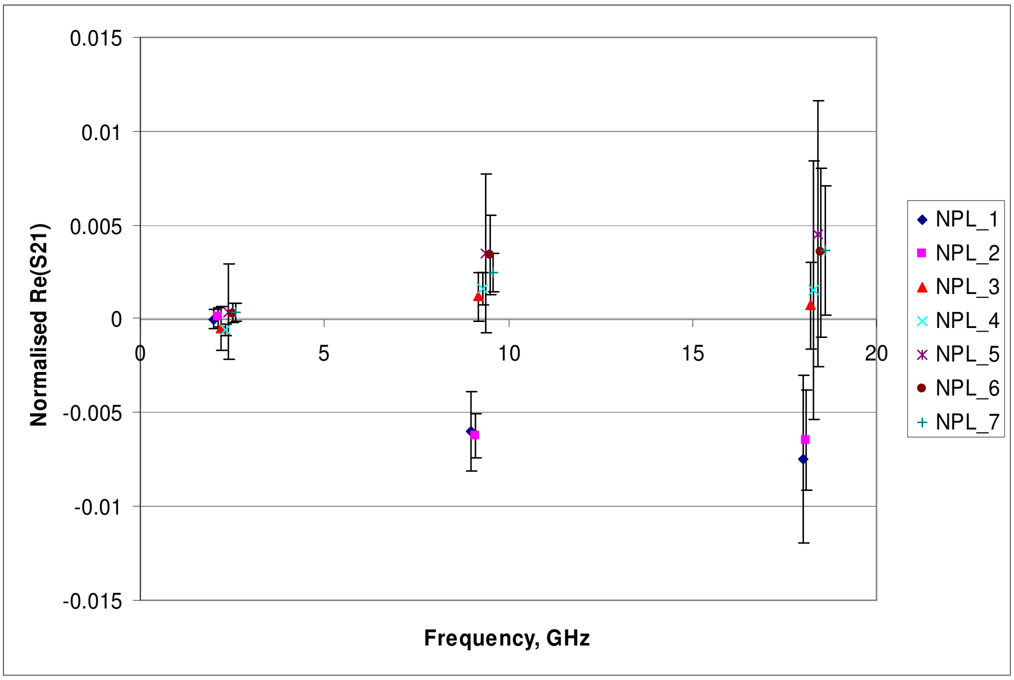

Fig E.1a – Real part of NPL's measurements of S_{21} for device K5b.CL/1 (3 dB attenuator)

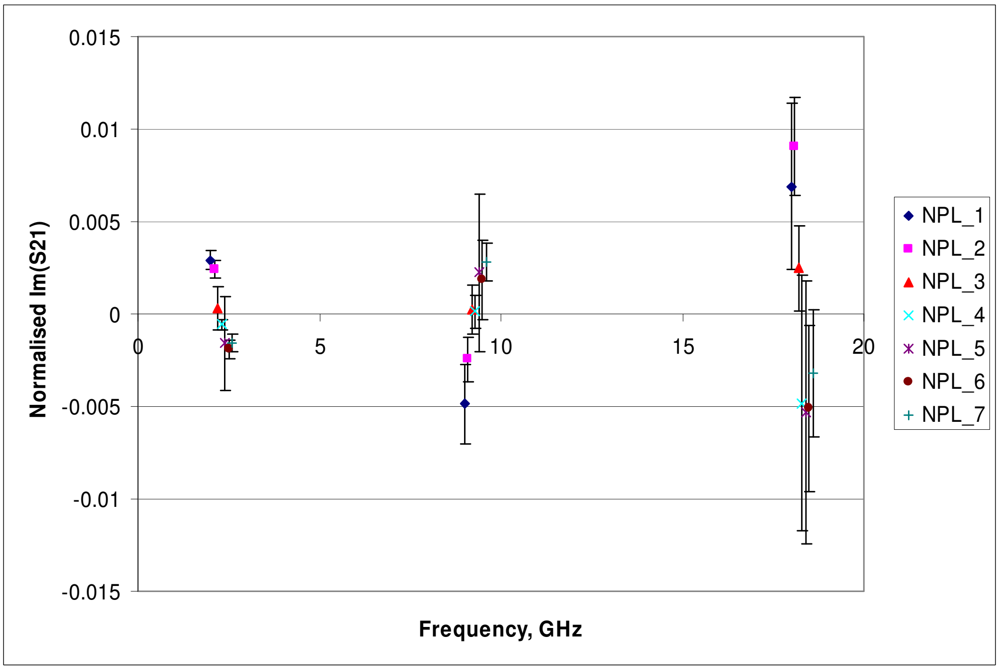

Fig E.1b – Imaginary part of NPL's measurements of S_{21} for device K5b.CL/1 (3 dB attenuator)

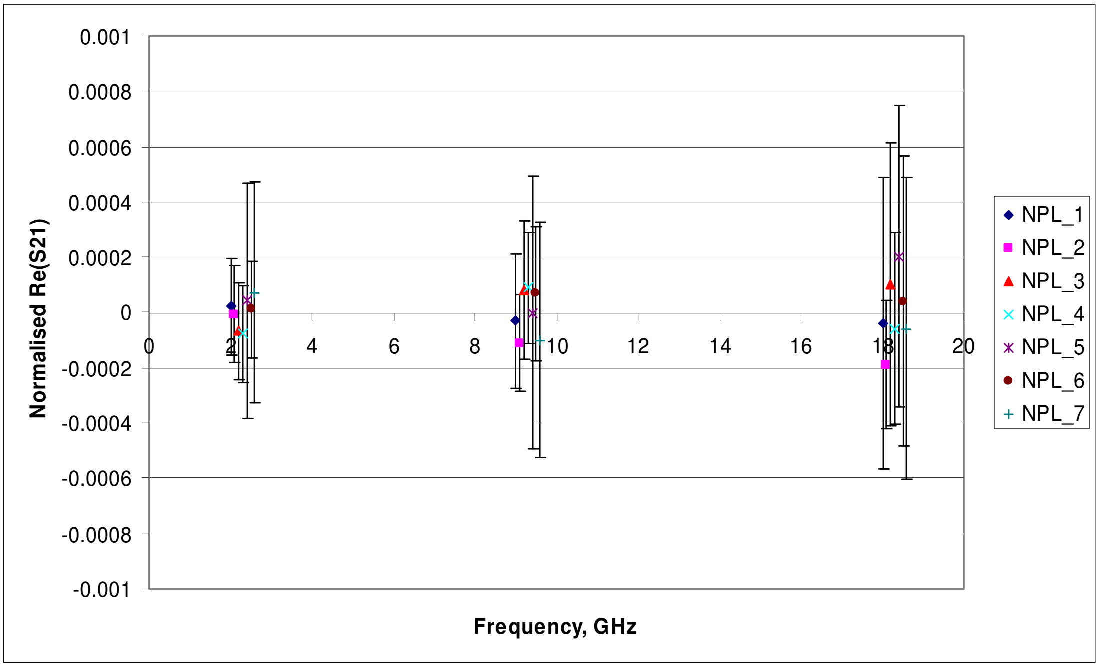

Fig E.2a – Real part of NPL's measurements of S_{21} for device K5b.CL/2 (20 dB attenuator)

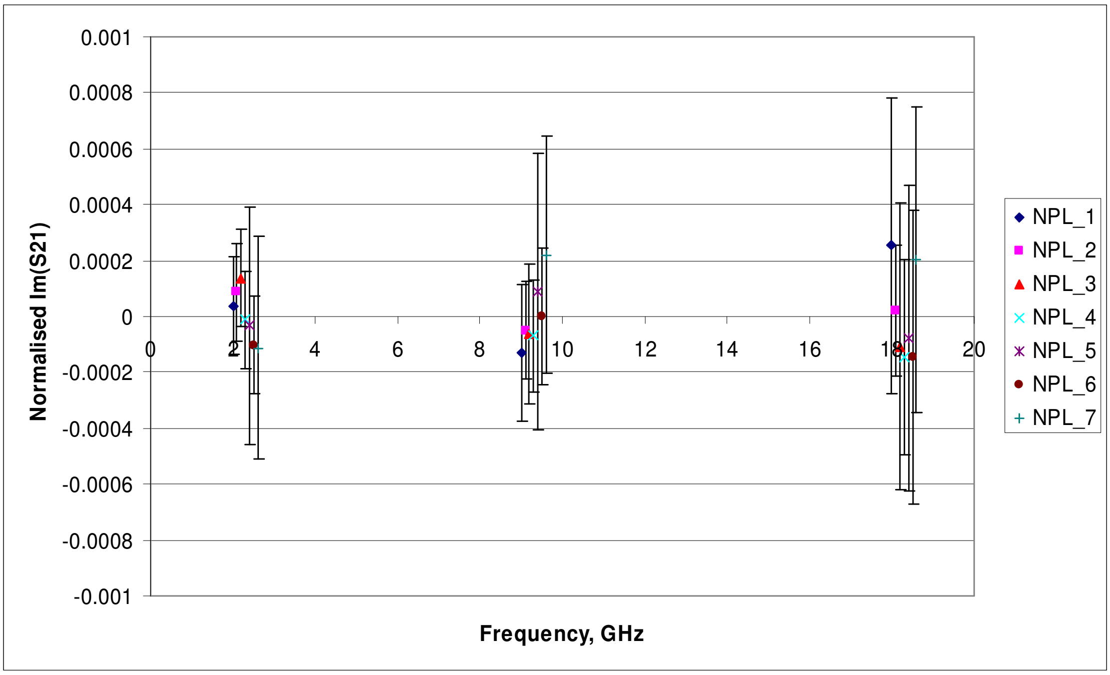

Fig E.2b – Imaginary part of NPL's measurements of S_{21} for device K5b.CL/2 (20 dB attenuator)

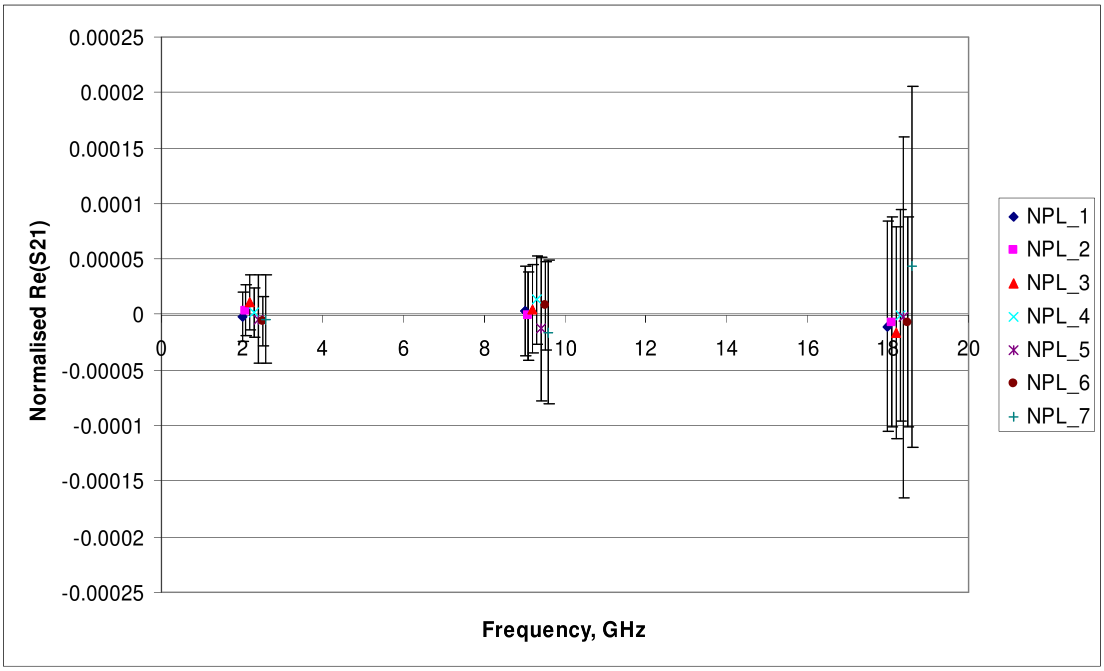

Fig E.3a – Real part of NPL's measurements of S_{21} for device K5b.CL/3 (50 dB attenuator)

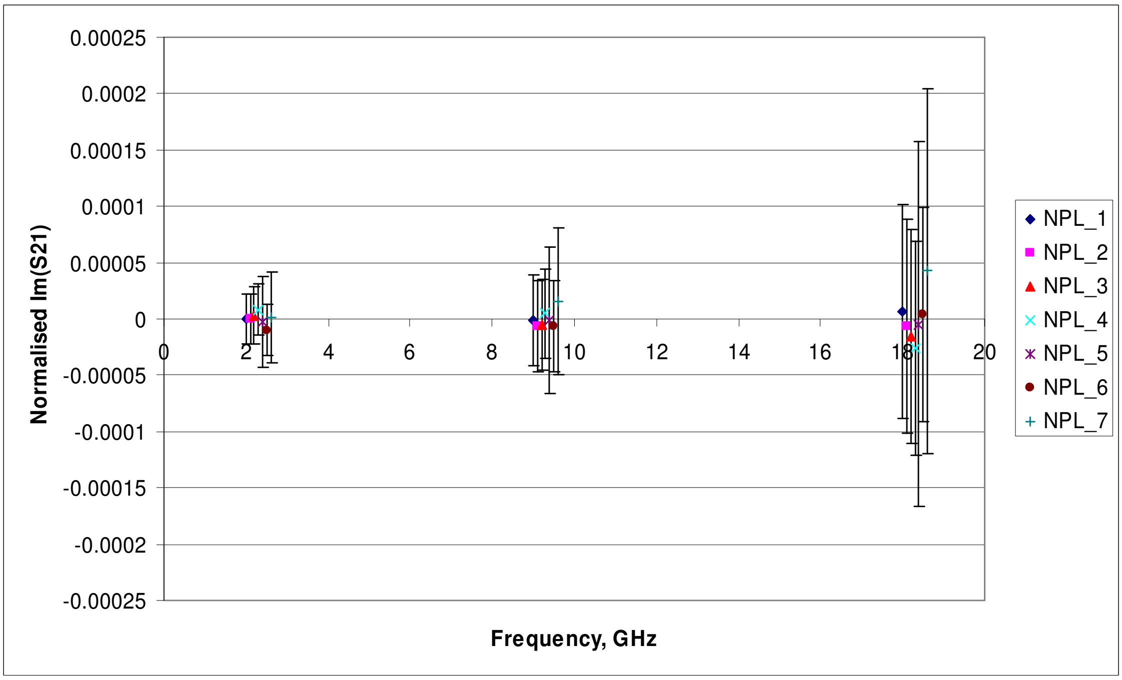

Fig E.3b – Imaginary part of NPL's measurements of S_{21} for device K5b.CL/3 (50 dB attenuator)

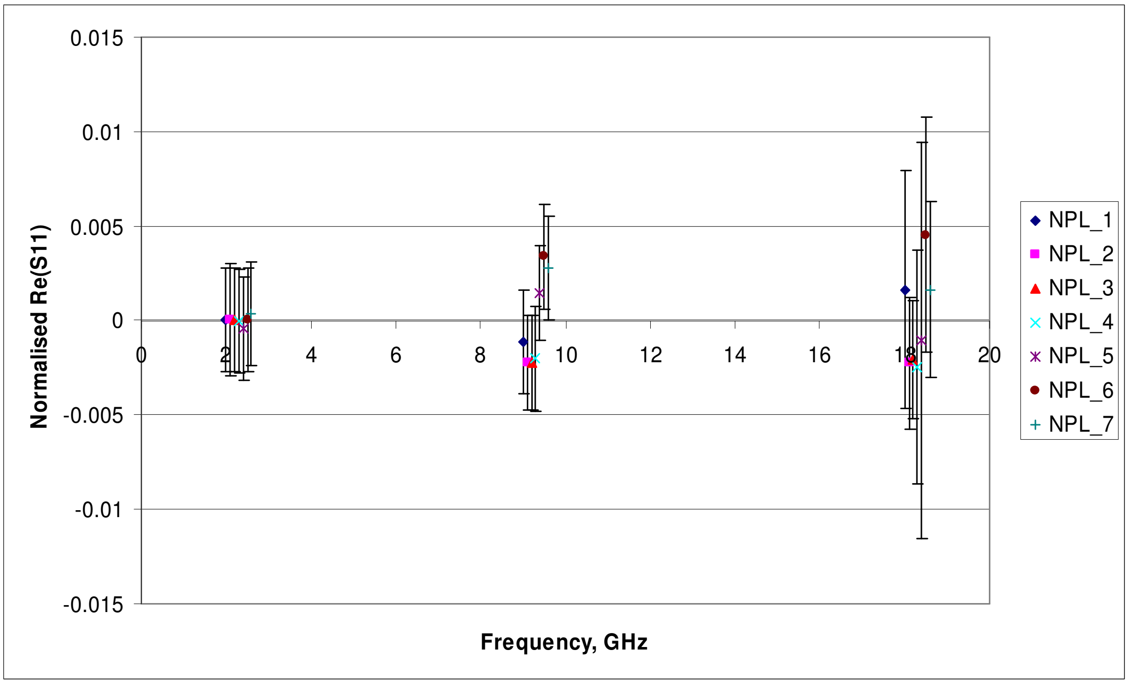

Fig E.4a – Real part of NPL's measurements of S_{21} for device K5b.CL/4 (male matched load)

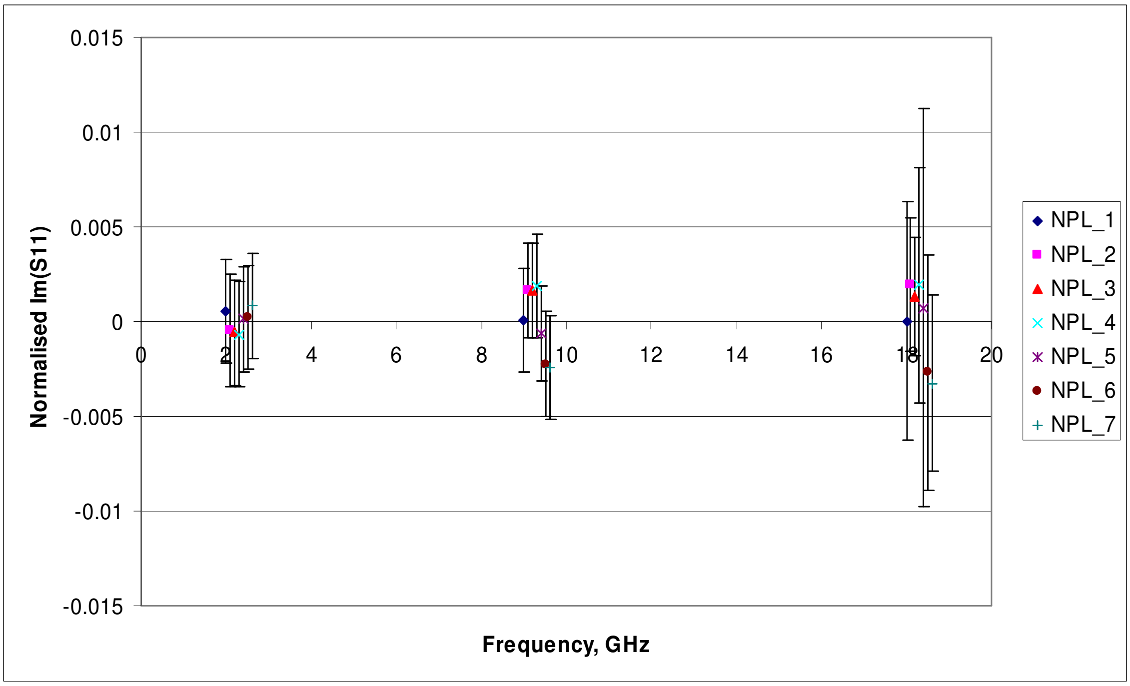

Fig E.4b – Imaginary part of NPL's measurements of S_{21} for device K5b.CL/4 (male matched load)

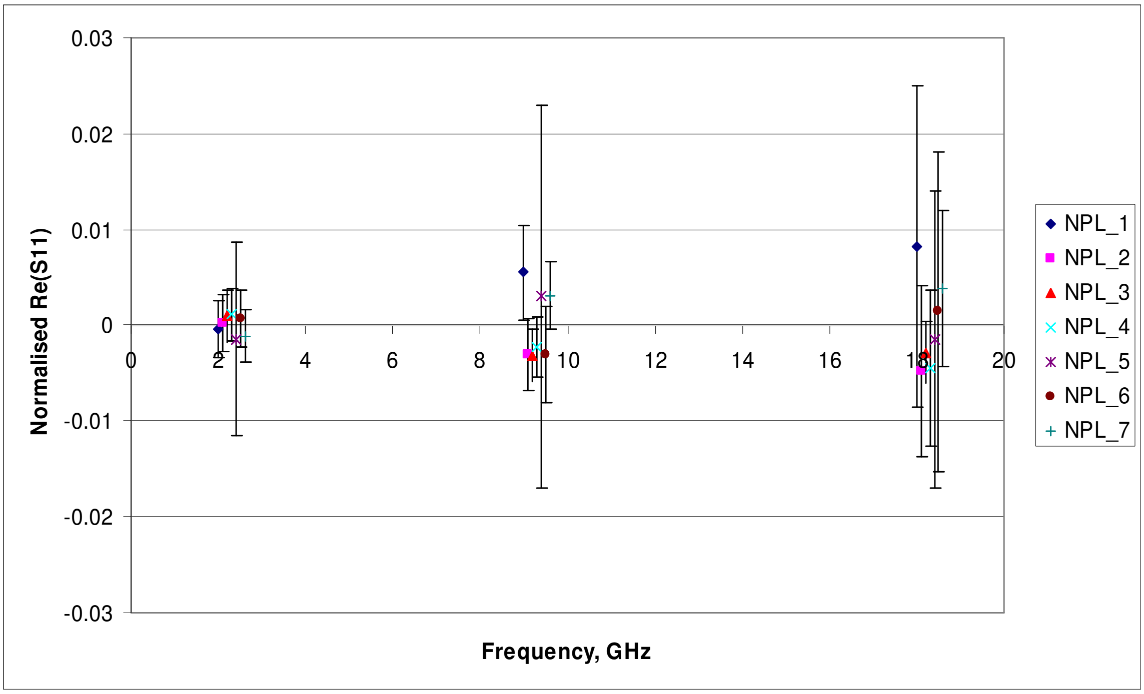

Fig E.5a – Real part of NPL's measurements of S_{21} for device K5b.CL/7 (female mismatched load)

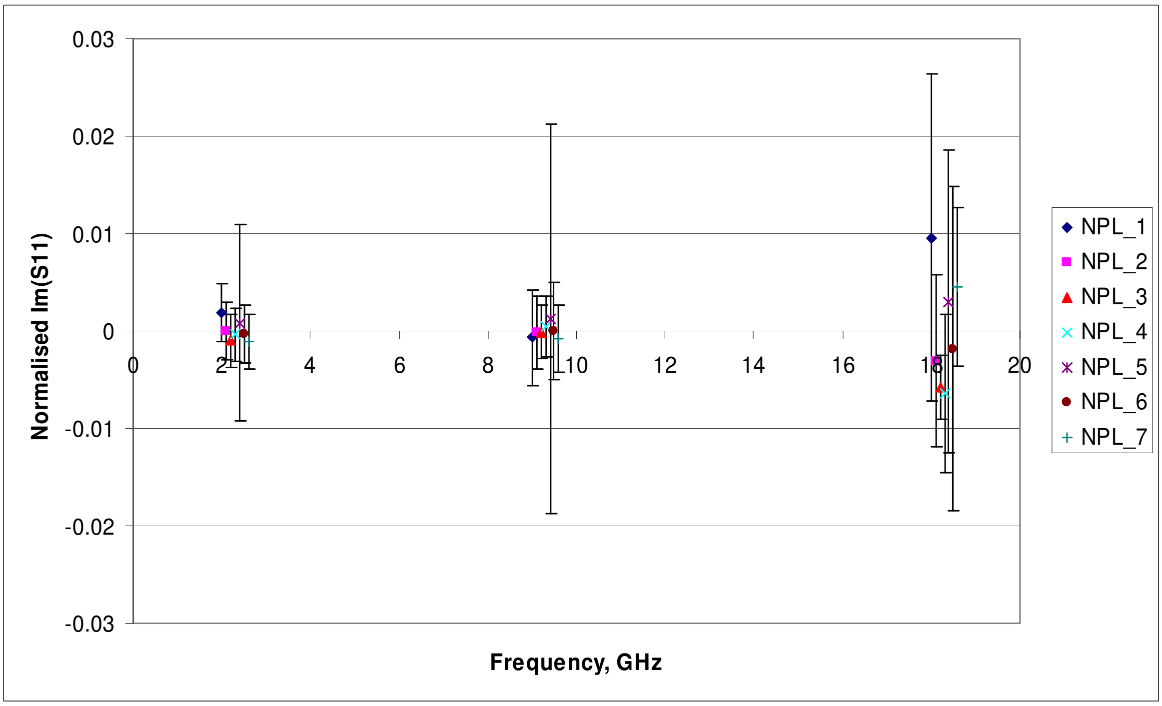

Fig E.5b – Imaginary part of NPL's measurements of S_{21} for device K5b.CL/7 (female mismatched load)

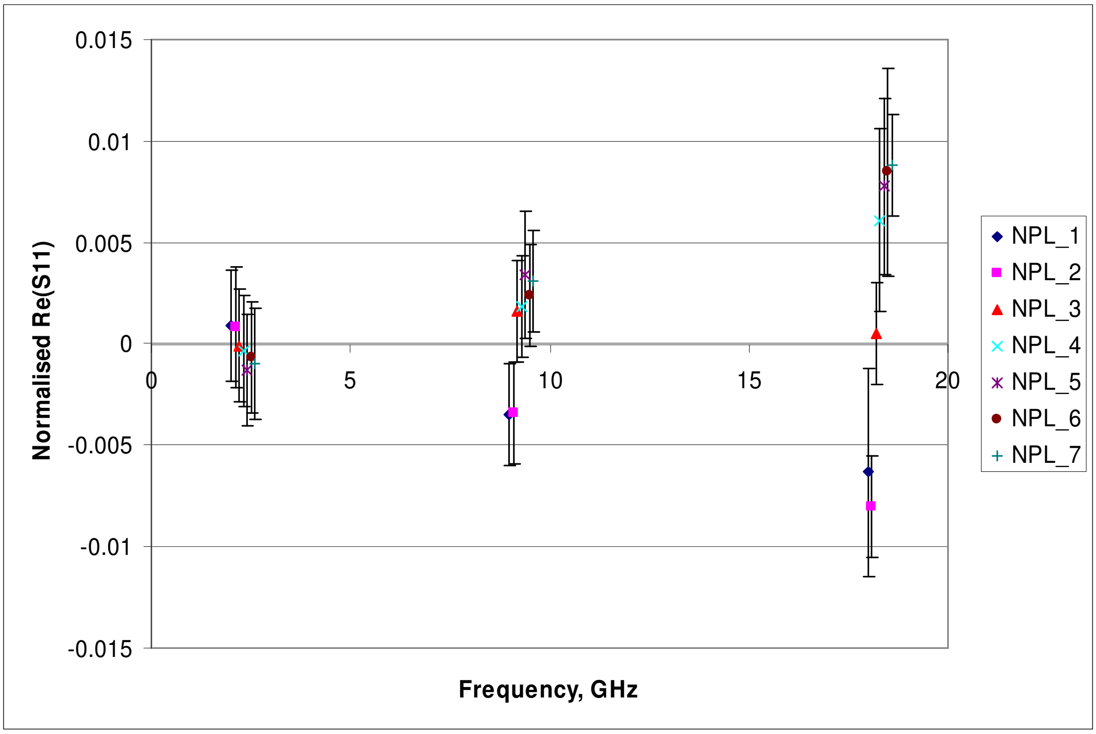

Fig E.6a – Real part of NPL's measurements of S_{11} for device K5b.CL/1 (3 dB attenuator)

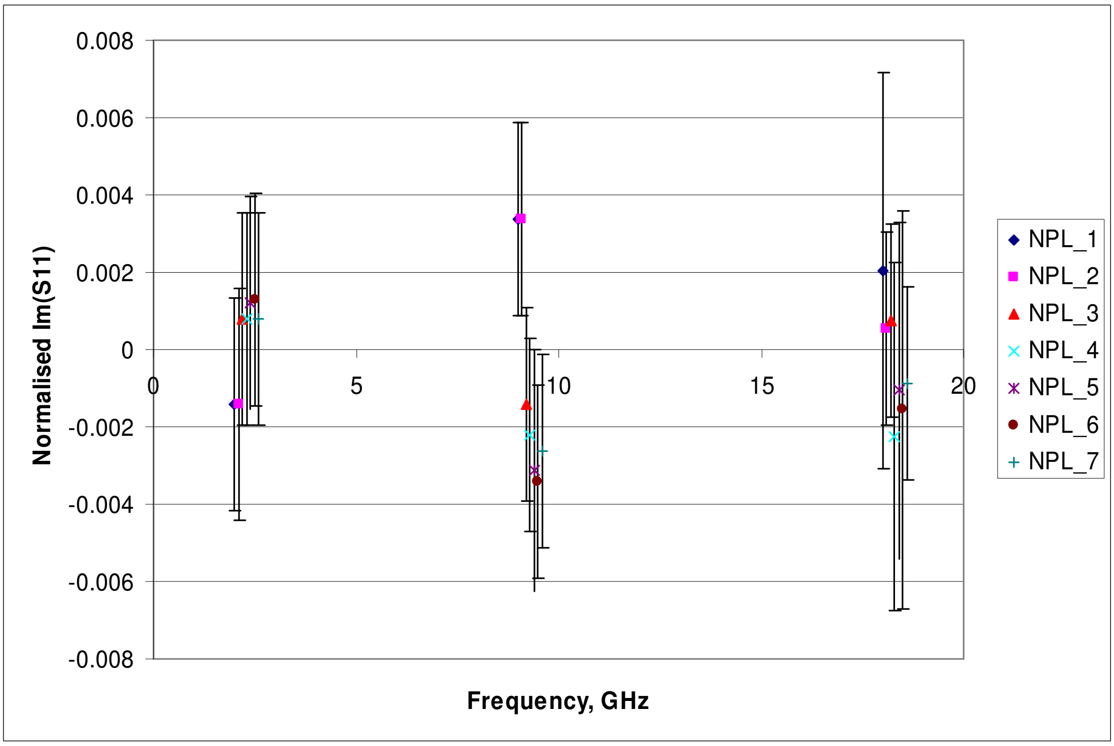

Fig E.6b – Imaginary part of NPL's measurements of S_{11} for device K5b.CL/1 (3 dB attenuator)

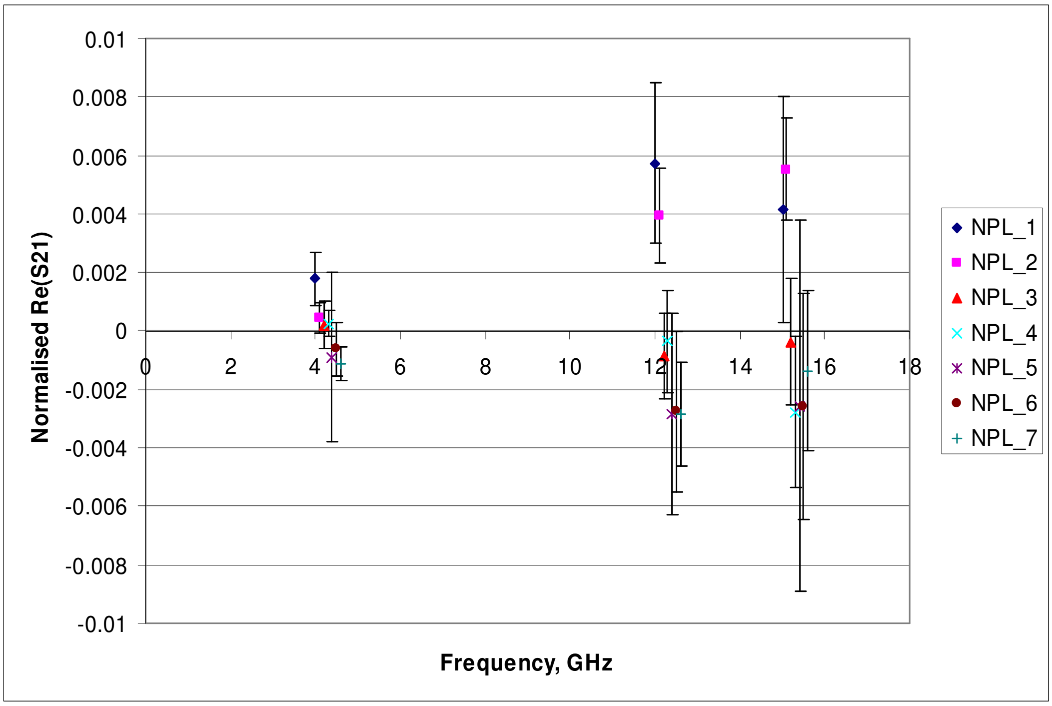

Fig E.7a – Real part of NPL's measurements of S_{21} for device K5b.CL/1 (3 dB attenuator) at 4, 12 and 15 GHz

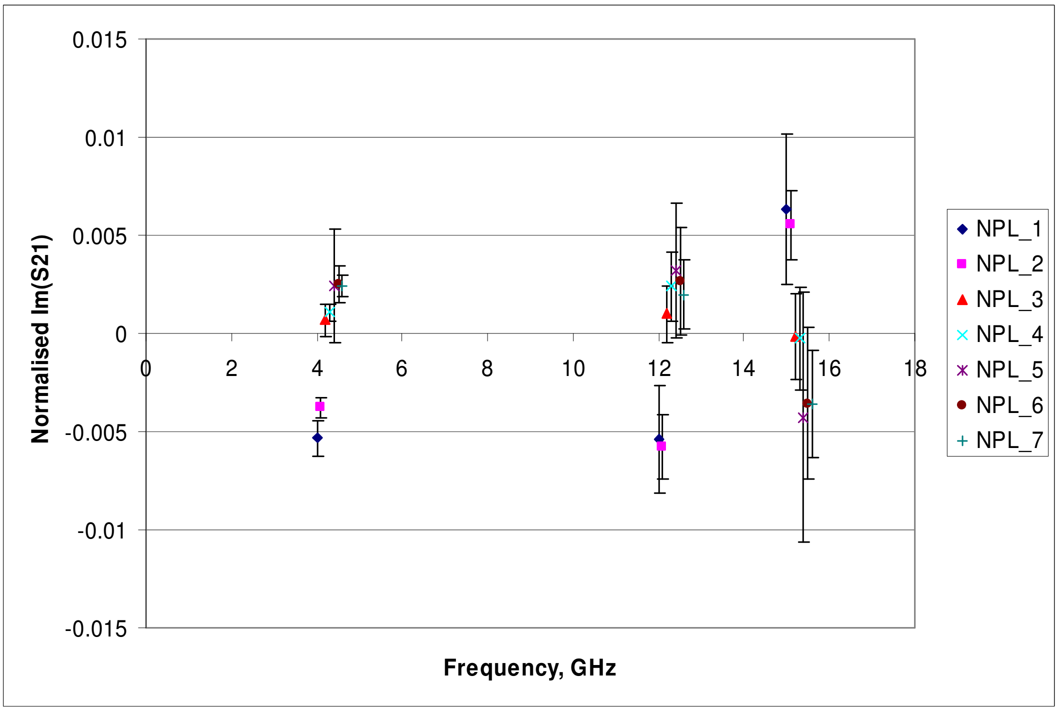

Fig E.7a – Imaginary part of NPL's measurements of S_{21} for device K5b.CL/1 (3 dB attenuator) at 4, 12 and 15 GHz