Measurement Uncertainty
rev 1

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MU Basics

- Aim: to calculate margin required to ensure a low probability of 'out of spec' module measurements by third party

- MU accounts for test equipment and test set-up variability as specified by manufacturer, or as measured.

  - MU methodology here was recommended by an established test & measurement equipment maker

  - Calculated MU is always larger than the measured test system repeatability indicates:

    - the calculated MU includes a small element of double counting - test system uncertainties are included individually, plus the system repeatability measurement includes the effect of all components in the test system (see MU pro-forma table)

    - Actual values for 25 G capable test equipment is needed.

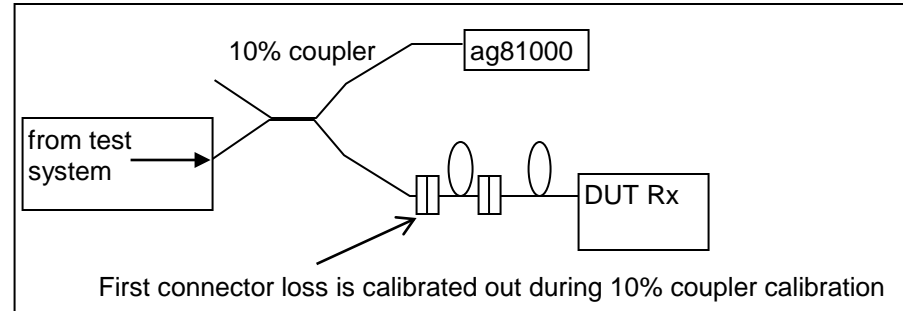   - *MU estimates here are illustrative only.*

Example MU pro-forma table

Source of uncertainty	Value	Probability distribution	Divisor	Sensitivity coefficient	Standard uncertainty	Degrees of freedom
Test equipment	+/-A	(usually rectangular)	2	1	A/2	
Test system component 1	B	Normal	1	1	B	
Test system component 2	C	Normal	1	1	C	
System repeatability	D	Normal	1	1	D	
		Combined uncertainty			rms(A/2,B,C,D)	
		Coverage			2	
		Expanded uncertainty			2.rms(A/2,B,C,D)	

- Test system uncertainties (yellow) can be manufacturers specs (+/-A is taken to be a +/-2 sigma value, usually conservative)

MU Example: MMF average power measurement

- Power meter (spec)
- Optical connection variability (measured)
- System repeatability (measured)

10% coupler → ag81000

from test system →

DUT Rx

First connector loss is calibrated out during 10% coupler calibration

Source of uncertainity	Value	Probability distribution	Divisor	Sensitivity coefficient	Standard uncertainity u_i	Degrees of freedom v_i
Ag 81623B	0.1072	Normal	2	1	0.0536	
Optical connector variability (meas)	0.1064	Normal	1	1	0.1064	
					0	
System repeatability (est., tbc)	0.05	Normal	1	1	0.05	199
				Combined uncertainty u_c	0.129204953	v_{eff}
				Coverage factor k	2	
				Expanded uncertainity U	0.258409907	

- 0.26 dB

MU Example: ER measurement

- Oscilloscope (spec)
- Photodiode linearity
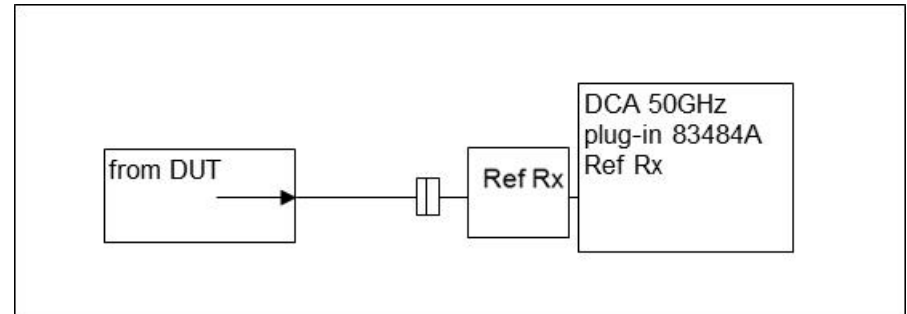- System repeatability (measured)
- (for ER>8dB part)
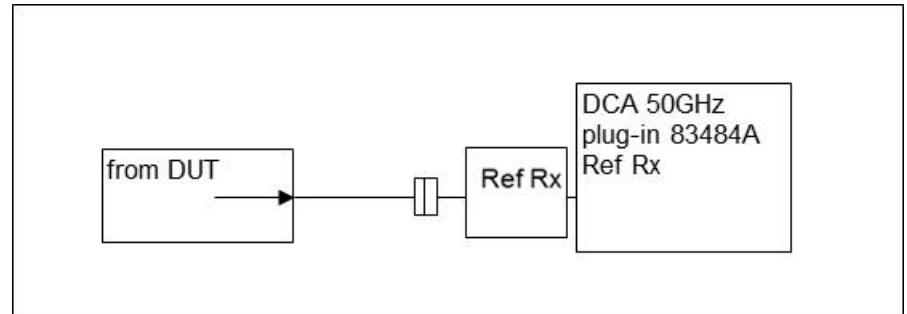
Source of uncertainty	Value	Probability distribution	Divisor	Sensitivity coefficient	Standard uncertainity ui	Degrees of freedom vi
Oscilloscope plug-in to plug-in variability	0.4	Normal	1	1	0.4	
O:E linearity (1%)	0.05		1	1	0.05	
					0	
System repeatability (meas)	0.0244	normal	1	1	0.0244	
				Combined uncertainty uc	0.403850665	veff
				Coverage factor k	2	
				Expanded uncertainity U	**0.807701331**	

- ~0.8 dB was calculated for a nominal ER of 8.2 dB
  - *Perhaps half this for lower ER ? TBD*

MU estimate: OMA measurement

- Oscilloscope (spec)

- Photodiode linearity (measured)

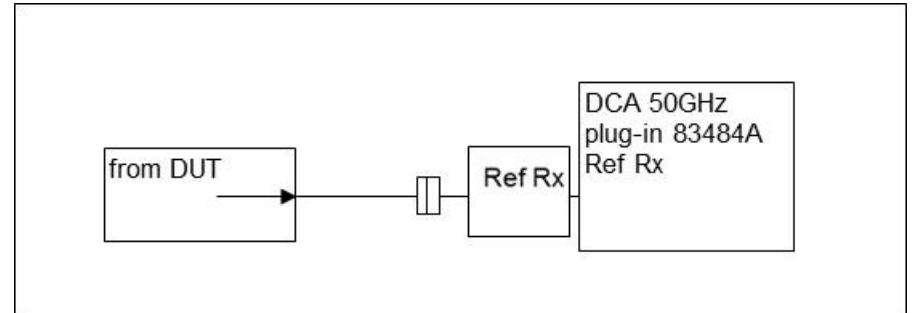- Optical connection repeatability (measured)

- System repeatability (measured)

Source of uncertainty	Value	Probability distribution	Divisor	Sensitivity coefficient	Standard uncertainity ui	Degrees of freedom vi
Oscilloscope plug-in to plug-in variation (tbc)	0.2	Normal	1	1	0.2	
O:E linearity (1%)	0.05		1	1	0.05	
Optical connector variability	0.1064		1	1	0.1064	199
System repeatability (meas)	0.0244	normal	1	1	0.0244	
				Combined uncertainty uc	0.233273059	veff
				Coverage factor k	2	
				Expanded uncertainty U	**0.466546118**	

- *~0.5 dB ?*

MU estimate: VEC measurement

- Oscilloscope (spec)
- O:E linearity (spec)
- Optical connection repeatability
  - (VEC is a ratio, so doesn't impact result)
- System repeatability (small tbc)

Source of uncertainty	Value	Probability distribution	Divisor	Sensitivity coefficient	Standard uncertainity ui	Degrees of freedom vi
Oscilloscope plug-in to plug-in variation (tbc)	0.3	Normal	1	1	0.3	
O:E linearity (1%)	0.05		1	1	0.05	
			1	1	0	
System repeatability (meas)	0.0244	normal	1	1	0.0244	
				Combined uncertainty uc	0.305115322	veff
				Coverage factor k	2	
				Expanded uncertainty U	**0.610230645**	

- *~0.6 dB ?*

MU Estimate: TDP

- ## RMS of
  - VEC variability (test source)
  - Reference sensitivity (OMA) measurement
  - DUT sensitivity (OMA) measurement
  - Ref Rx bandwidth variability

  - ~ 0.9 dB

Next:

- Re-calculate with real 26Gb/s test equipment values