


# Schedule of Accreditation

issued by

## United Kingdom Accreditation Service

2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK

 <p><b>UKAS</b> CALIBRATION <b>0452</b></p> <p>Accredited to <b>ISO/IEC 17025:2005</b></p>	<p><b>Electronic Test and Calibration Ltd</b></p> <p>Issue No: 029    Issue date: 08 August 2017</p>	
	<p><b>Caddsdwn Industrial Estate</b> <b>Clovelly Road</b> <b>Bideford</b> <b>Devon</b> <b>EX39 3DX</b></p>	<p><b>Contact: Steve Campion</b> <b>Tel: +44 (0)1237 423388</b> <b>Fax: +44 (0)1237 423434</b> <b>E-Mail: info@etcal.co.uk</b> <b>Website: www.etcal.co.uk</b></p>
<p><b>Calibration performed at the above address only</b></p>		

### DETAIL OF ACCREDITATION

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty ( $k = 2$ )	Remarks
DC RESISTANCE  Measurement	<p><i>At 10 A:</i> 100 <math>\mu\Omega</math> to 1 m<math>\Omega</math> 1 m<math>\Omega</math> to 10 m<math>\Omega</math></p> <p><i>At 1 A:</i> 10 m<math>\Omega</math> to 100 m<math>\Omega</math> 100 m<math>\Omega</math> to 1 <math>\Omega</math></p> <p><i>From 10 V to 1 kV:</i> 200 M<math>\Omega</math> to 2 G<math>\Omega</math> 2 G<math>\Omega</math> to 20 G<math>\Omega</math> 20 G<math>\Omega</math> to 200 G<math>\Omega</math> 200 G<math>\Omega</math> to 2 T<math>\Omega</math></p> <p><i>From 1 kV to 5 kV:</i> 200 M<math>\Omega</math> to 2 G<math>\Omega</math> 2 G<math>\Omega</math> to 20 G<math>\Omega</math> 20 G<math>\Omega</math> to 200 G<math>\Omega</math> 200 G<math>\Omega</math> to 2 T<math>\Omega</math></p>	<p>130 ppm 42 ppm</p> <p>37 ppm 33 ppm</p> <p>0.031 % 0.037 % 0.042 % 0.12 %</p> <p>0.15 % 0.15 % 0.16 % 0.19 %</p>	<p>Other test currents may be used but with increased uncertainties.</p>
Measurement and generation	<p>0 <math>\Omega</math> to 1 <math>\Omega</math> 1 <math>\Omega</math> to 20 <math>\Omega</math> 20 <math>\Omega</math> to 200 <math>\Omega</math> 200 <math>\Omega</math> to 2 k<math>\Omega</math> 2 k<math>\Omega</math> to 20 k<math>\Omega</math> 20 k<math>\Omega</math> to 200 k<math>\Omega</math> 200 k<math>\Omega</math> to 2 M<math>\Omega</math> 2 M<math>\Omega</math> to 20 M<math>\Omega</math> 20 M<math>\Omega</math> to 200 M<math>\Omega</math></p>	<p>14 <math>\mu\Omega</math> 14 ppm 9.9 ppm 9.9 ppm 10 ppm 14 ppm 17 ppm 20 ppm 180 ppm</p>	



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Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty ( $k = 2$ )	Remarks
DC RESISTANCE (continued)			
Generation	100 $\mu\Omega$ to 2 m $\Omega$ 2 m $\Omega$ to 20 m $\Omega$ 20 m $\Omega$ to 200 m $\Omega$ 200 m $\Omega$ to 1 $\Omega$ 10 $\Omega$ 100 $\Omega$ 1 k $\Omega$ 10 k $\Omega$ 100 k $\Omega$ 1 M $\Omega$ 10 M $\Omega$ 100 M $\Omega$  <i>From 10 V to 1 kV:</i> 200 M $\Omega$ to 2 G $\Omega$ 2 G $\Omega$ to 20 G $\Omega$ 20 G $\Omega$ to 200 G $\Omega$ 200 G $\Omega$ to 2 T $\Omega$  <i>From 1 kV to 5 kV:</i> 200 M $\Omega$ to 2 G $\Omega$ 2 G $\Omega$ to 20 G $\Omega$ 20 G $\Omega$ to 200 G $\Omega$ 200 G $\Omega$ to 2 T $\Omega$	160 ppm 45 ppm 42 ppm 37 ppm 6.7 ppm 6.0 ppm 6.0 ppm 6.1 ppm 6.3 ppm 12 ppm 14 ppm 140 ppm  0.031 % 0.037 % 0.042 % 0.12 %  0.15 % 0.15 % 0.16 % 0.19 %	
DC VOLTAGE			
Generation	0 mV to 200 mV 200 mV to 2 V 2 V to 20 V 20 V to 200 V 200 V to 1000 V 1 kV to 30 kV	14 ppm + 0.12 $\mu$ V 6.6 ppm 6.3 ppm 6.7 ppm 7.2 ppm 0.14 %	
Measurement	0 mV to 200 mV 200 mV to 2 V 2 V to 20 V 20 V to 200 V 200 V to 1000 V 1 kV to 40 kV	18 ppm + 0.16 $\mu$ V 8.6 ppm 8.4 ppm 9.0 ppm 9.7 ppm 0.14 %	



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DC CURRENT			
Generation	10 pA to 200 pA 200 pA to 2 nA 2 nA to 20 nA 20 nA to 200 nA 200 nA to 2 $\mu$ A 2 $\mu$ A to 20 $\mu$ A 20 $\mu$ A to 200 $\mu$ A 200 $\mu$ A to 2 mA 2 mA to 20 mA 20 mA to 200 mA 200 mA to 1 A 1 A to 20 A 20 A to 100 A	0.056 % 0.034 % 0.029 % 0.023 % 0.019 % 0.014 % 11 ppm 11 ppm 12 ppm 14 ppm 22 ppm 46 ppm 0.15 %	
Current clamp calibration	0 A to 20 A 0 A to 1000 A 1000 A to 5000 A	0.25 % + 10 $\mu$ A 0.34 % + 10 $\mu$ A 0.36 %	Single turn 10 or 50 turns
Measurement	10 pA to 200 pA 200 pA to 2 nA 2 nA to 20 nA 20 nA to 200 nA 200 nA to 2 $\mu$ A 2 $\mu$ A to 20 $\mu$ A 20 $\mu$ A to 200 $\mu$ A 200 $\mu$ A to 2 mA 2 mA to 20 mA 20 mA to 200 mA 200 mA to 1 A 1 A to 20 A 20 A to 100 A 100 A to 250 A 250 A to 1000 A	0.056 % 0.038 % 0.034 % 0.027 % 0.023 % 0.019 % 14 ppm 14 ppm 16 ppm 27 ppm 39 ppm 46 ppm 0.15 % 0.17 % 0.31 %	
AC VOLTAGE			
Generation	100 mHz to 10 Hz $V_{rms}$ 2.5 mV to 707 V $V_{pk}$ 1000 V maximum	0.15 % + 5.0 $\mu$ V	
	10 Hz to 30 Hz 200 mV to 2 V 2 V to 20 V 20 V to 200 V	78 ppm 76 ppm 85 ppm	
	30 Hz to 300 Hz 2 mV to 20 mV 20 mV to 200 mV 200 mV to 2 V 2 V to 20 V 20 V to 200 V 200 V to 1000 V	330 ppm 140 ppm 77 ppm 77 ppm 85 ppm 91 ppm	40 Hz minimum



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Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty ( $k = 2$ )	Remarks
AC VOLTAGE (continued) Generation (continued)	<p><i>300 Hz to 1 kHz</i> 2 mV to 20 mV 20 mV to 200 mV 200 mV to 2 V 2 V to 20 V 20 V to 200 V 200 V to 1000 V</p> <p><i>1 kHz to 10 kHz</i> 2 mV to 20 mV 20 mV to 200 mV 200 mV to 2 V 2 V to 20 V 20 V to 200 V 200 V to 1000 V</p> <p><i>10 kHz to 30 kHz</i> 2 mV to 20 mV 20 mV to 200 mV 200 mV to 2 V 2 V to 20 V 20 V to 200 V 200 V to 1000 V</p> <p><i>30 kHz to 100 kHz</i> 2 mV to 20 mV 20 mV to 200 mV 200 mV to 2 V 2 V to 20 V 20 V to 200 V 200 V to 700 V</p> <p><i>100 kHz to 300 kHz</i> 200 mV to 2 V 2 V to 20 V</p> <p><i>300 kHz to 1 MHz</i> 200 mV to 2 V 2 V to 20 V</p> <p><i>At 50 Hz</i> 1 kV to 7 kV</p>	<p>320 ppm 120 ppm 74 ppm 74 ppm 82 ppm 91 ppm</p> <p>330 ppm 140 ppm 80 ppm 80 ppm 88 ppm 100 ppm</p> <p>390 ppm 220 ppm 130 ppm 130 ppm 130 ppm 140 ppm</p> <p>480 ppm 360 ppm 140 ppm 160 ppm 170 ppm 470 ppm</p> <p>620 ppm 620 ppm</p> <p>0.12 % 0.13 %</p> <p>0.30 %</p>	



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Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty ( $k = 2$ )	Remarks
AC VOLTAGE (continued) Measurement	<p><i>10 Hz to 30 Hz</i> 200 mV to 2 V 2 V to 20 V 20 V to 200 V</p> <p><i>30 Hz to 300 Hz</i> 2 mV to 20 mV 20 mV to 200 mV 200 mV to 2 V 2 V to 20 V 20 V to 200 V 200 V to 1000 V</p> <p><i>300 Hz to 1 kHz</i> 2 mV to 20 mV 20 mV to 200 mV 200 mV to 2 V 2 V to 20 V 20 V to 200 V 200 V to 1000 V</p> <p><i>1 kHz to 10 kHz</i> 2.0 mV to 20 mV 20 mV to 200 mV 200 mV to 2 V 2 V to 20 V 20 V to 200 V 200 V to 1000 V</p> <p><i>10 kHz to 30 kHz</i> 2 mV to 20 mV 20 mV to 200 mV 200 mV to 2 V 2 V to 20 V 20 V to 200 V 200 V to 1000 V</p> <p><i>30 kHz to 100 kHz</i> 2 mV to 20 mV 20 mV to 200 mV 200 mV to 2 V 2 V to 20 V 20 V to 200 V 200 V to 700 V</p> <p><i>100 kHz to 300 kHz</i> 200 mV to 2 V 2 V to 20 V</p> <p><i>300 kHz to 1 MHz</i> 200 mV to 2 V 2 V to 20 V</p>	<p>110 ppm 110 ppm 120 ppm</p> <p>480 ppm 160 ppm 110 ppm 110 ppm 120 ppm 120 ppm</p> <p>480 ppm 140 ppm 100 ppm 100 ppm 120 ppm 120 ppm</p> <p>490 ppm 160 ppm 120 ppm 120 ppm 130 ppm 130 ppm</p> <p>540 ppm 260 ppm 190 ppm 190 ppm 200 ppm 220 ppm</p> <p>620 ppm 410 ppm 240 ppm 250 ppm 260 ppm 510 ppm</p> <p>860 ppm 860 ppm</p> <p>0.14 % 0.15 %</p>	<p>40 Hz minimum</p>



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AC VOLTAGE (continued) Measurement (continued)	40 Hz to 60 Hz 1 kV to 28 kV	0.30 %	
AC CURRENT	60 Hz to 1 kHz 1 kV to 4 kV	1.0 %	
Generation	10 Hz to 300 Hz 10 $\mu$ A to 200 $\mu$ A 200 $\mu$ A to 2 mA 2 mA to 20 mA 20 mA to 200 mA 200 mA to 1 A 1 A to 10 A	190 ppm 170 ppm 170 ppm 170 ppm 220 ppm 290 ppm	
	300 Hz to 1 kHz 10 $\mu$ A to 200 $\mu$ A 200 $\mu$ A to 2 mA 2 mA to 20 mA 20 mA to 200 mA 200 mA to 1 A 1 A to 10 A	170 ppm 150 ppm 150 ppm 150 ppm 180 ppm 260 ppm	
	1 kHz to 5 kHz 10 $\mu$ A to 200 $\mu$ A 200 $\mu$ A to 2 mA 2 mA to 20 mA 20 mA to 200 mA 200 mA to 1 A 1 A to 10 A	240 ppm 210 ppm 190 ppm 190 ppm 350 ppm 500 ppm	
Current clamp calibration	10 Hz to 5 kHz 100 $\mu$ A to 1 A	0.28 %	Single turn
	30 Hz to 5 kHz 1 A to 10 A	0.31 %	Single turn
	30 Hz to 100 Hz 3.2 A to 100 A	0.66 %	10 or 50 turns
	100 Hz to 440 Hz 3.2 A to 100 A	1.8 %	10 or 50 turns
Measurement	10 Hz to 300 Hz 10 $\mu$ A to 200 $\mu$ A 200 $\mu$ A to 2 mA 2 mA to 20 mA 20 mA to 200 mA 200 mA to 1 A 1 A to 10 A	230 ppm 210 ppm 210 ppm 210 ppm 250 ppm 290 ppm	



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AC CURRENT (continued) Measurement (continued)	<p>300 Hz to 1 kHz 10 µA to 200 µA 200 µA to 2 mA 2 mA to 20 mA 20 mA to 200 mA 200 mA to 1 A 1 A to 10 A</p> <p>1 kHz to 5 kHz 10 µA to 200 µA 200 µA to 2 mA 2 mA to 20 mA 20 mA to 200 mA 200 mA to 1 A 1 A to 10 A</p>	<p>210 ppm 200 ppm 190 ppm 190 ppm 220 ppm 260 ppm</p> <p>270 ppm 240 ppm 220 ppm 230 ppm 370 ppm 400 ppm</p>	
AC HARMONICS AND DISTORTION			

NOTE

The total harmonic distortion of a repetitive waveform (THD) is often defined as the ratio of the RMS values of the harmonics with reference to that of the fundamental. This is referred to herein as  $THD_F$ :

$$THD_F = \frac{\sqrt{\sum_{n=2}^{\infty} V_n^2}}{V_1}, \text{ where } V_1 \text{ is the RMS value of the fundamental and } V_n \text{ is the RMS value of the } n\text{th harmonic.}$$

Certain types of distortion analyser use a broad band voltmeter in conjunction with a notch filter. The total signal (including harmonics) is used as a "100 % reference"; the notch filter is then used to remove the fundamental and the residue is displayed as the "THD". This is referred to herein as  $THD_R$ , the subscript  $R$  referring to the RMS value of the reference voltage.  $THD_R$  is defined as:

$$THD_R = \sqrt{\frac{\sum_{n=2}^{\infty} V_n^2}{\sum_{n=1}^{\infty} V_n^2}}, \text{ where } V \text{ is the RMS value of each spectral component.}$$

It should be noted that  $THD_R$  cannot exceed 100 % as the total signal is used as the reference, whereas  $THD_F$  can have any value. At relatively low values, the two converge, e.g. if  $THD_F = 10 \%$  then  $THD_R = 9.5 \%$ . At higher values of THD the differences between the two can be very significant indeed.

For this reason the capabilities described overleaf distinguish clearly between the two definitions.



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Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty ( $k = 2$ )	Remarks
Generation of Harmonic Distortion, $THD_R$ and $THD_F$	$THD_R$ 0.006 % to 100 % $THD_F$ 0.006 % to 1000 %  30 Hz to 20 kHz 20 kHz to 50 kHz 50 kHz to 100 kHz	0.62 % to 5.7 % 0.85 % to 5.8 % 1.7 % to 6.4 %	Fundamental: 3 mV to 300 V, 30 Hz to 20 kHz. Harmonic(s): 3 $\mu$ V to 300 V. Not all combinations of voltage and frequency may be available.
Measurement of Harmonic Distortion, $THD_R$ and $THD_F$	$THD_R$ 0.00032 % to 100 % $THD_F$ 0.00032 % to 1000 %  30 Hz to 100 kHz	0.73 % to 1.8 %	Fundamental: 3 mV to 300 V, 30 Hz to 20 kHz. Harmonic(s): 3 $\mu$ V to 300 V.
Harmonic Amplitude Measurement and Generation	3 $\mu$ V to 300 V 30 Hz to 100 kHz	0.90 % to 1.7 %	
Flicker Measurement and Generation	In accordance with EN61000-4-15	0.37 %	
CAPACITANCE Measurement and generation	<i>At 100 Hz:</i> 100 pF to 190 pF 190 pF to 350 pF 350 pF to 1 nF 1 nF to 1 $\mu$ F 1 $\mu$ F to 100 $\mu$ F  <i>At 1 kHz:</i> 10 pF to 15 pF 15 pF to 25 pF 25 pF to 100 pF 100 pF to 1 $\mu$ F 1 $\mu$ F to 100 $\mu$ F  <i>At 10 kHz:</i> 10 pF to 25 pF 25 pF to 70 pF 70 pF to 100 nF 100 nF to 1 $\mu$ F	0.60 % 0.26 % 0.17 % 0.080 % 0.10 %  0.62 % 0.32 % 0.24 % 0.080 % 0.10 %  0.32 % 0.24 % 0.080 % 0.085 %	





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INDUCTANCE Measurement and Generation	<i>At 100 Hz:</i> 100 $\mu$ H to 250 $\mu$ H 250 $\mu$ H to 600 $\mu$ H 600 $\mu$ H to 1 mH 1 mH to 100 mH 100 mH to 1 H  <i>At 1 kHz:</i> 10 $\mu$ H to 25 $\mu$ H 25 $\mu$ H to 60 $\mu$ H 60 $\mu$ H to 100 $\mu$ H 100 $\mu$ H to 150 $\mu$ H 150 $\mu$ H to 1 H  <i>At 10 kHz:</i> 10 $\mu$ H to 20 $\mu$ H 20 $\mu$ H to 1 mH 1 mH to 10 mH 10 mH to 100 mH	0.59 % 0.25 % 0.15 % 0.11 % 0.27 %  0.59 % 0.25 % 0.14 % 0.14 % 0.092 %  0.14 % 0.099 % 0.092 % 0.13 %	
FREQUENCY MEASUREMENT Specific Values	10 MHz	1 in $10^{10}$	Can be expressed as average periodic time (1/f) for repetitive waveforms.
Other Values	1 Hz to 1 GHz 1 GHz to 26.5 GHz	12 in $10^9$ 1.3 in $10^9$	
TIME INTERVAL	11 ps to 1 ns 1 ns to 10 ns 10 ns to 100 ns 100 ns to 1 $\mu$ s 1 $\mu$ s to 100 $\mu$ s 100 $\mu$ s to $10^5$ s	2.2 % 220 ppm 22 ppm 12 ppm 12 ppm 14 in $10^9$	Single Event
ELECTRICAL SIMULATION OF TEMPERATURE Measurement and Generation			
Thermocouple Simulation			Excluding cold junction compensation
Type K	-270 °C to +1372 °C	0.12 °C to 0.30 °C	
Type J	-210 °C to +1200 °C	0.12 °C to 0.23 °C	
Type E	-270 °C to +1000 °C	0.12 °C to 0.22 °C	
Type N	-270 °C to +1300 °C	0.12 °C to 0.27 °C	
Type T	-270 °C to +400 °C	0.12 °C to 0.22 °C	
Type S	0 °C to 1768 °C	0.18 °C to 0.29 °C	
Type R	0 °C to 1768 °C	0.17 °C to 0.28 °C	
Type B	0 °C to 1820 °C	0.19 °C to 0.34 °C	
Thermocouple CJC	Ambient (23 °C)	0.13 °C	
PRT Simulation	-200 °C to 0 °C 0 °C to 400 °C 400 °C to 850 °C	0.027 °C to 0.049 °C 0.049 °C to 0.12 °C 0.12 °C to 0.21 °C	



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RF POWER			50 Ω systems only
Specific value	1 mW 50 MHz	0.79 %	
Other values (measurement and generation)	-60 dBm to -50 dBm 9 kHz to 20 kHz 20 kHz to 1 MHz 1 MHz to 10 MHz	3.9 % 3.8 % 3.9 %	
	-50 dBm to +20 dBm 9 kHz to 20 kHz 20 kHz to 1 MHz 1 MHz to 10 MHz	1.7 % 1.5 % 1.7 %	
	-62 dBm to -20 dBm 10 MHz to 50 MHz 50 MHz to 1 GHz 1 GHz to 5 GHz 5 GHz to 10 GHz 10 GHz to 15 GHz 15 GHz to 18 GHz	2.1 % 1.7 % 2.1 % 2.8 % 3.1 % 3.1 %	
	-20 dBm to +20 dBm 10 MHz to 50 MHz 50 MHz to 1 GHz 1 GHz to 5 GHz 5 GHz to 10 GHz 10 GHz to 15 GHz 15 GHz to 18 GHz	1.7 % 1.5 % 1.7 % 2.0 % 2.1 % 2.2 %	
Other values (measurement only)	+20 dBm to +55 dBm 9 kHz to 20 kHz 20 kHz to 1 MHz 1 MHz to 10 MHz	2.1 % 1.9 % 2.1 %	
	+20 dBm to +44 dBm 10 MHz to 50 MHz 50 MHz to 1 GHz 1 GHz to 5 GHz 5 GHz to 10 GHz 10 GHz to 15 GHz 15 GHz to 18 GHz	2.1 % 1.9 % 2.2 % 2.7 % 3.3 % 3.6 %	
	+44 dBm to +55 dBm 10 MHz to 300 MHz 300 MHz to 1.5 GHz 1.5 GHz to 4 GHz 4 GHz to 7 GHz 7 GHz to 10 GHz 10 GHz to 12.5 GHz	2.8 % 2.5 % 3.6 % 5.4 % 5.6 % 6.9 %	



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RF POWER (continued)			
Other values (generation only)	+20 dBm to +50 dBm 10 kHz to 20 kHz 20 kHz to 1 MHz 1 MHz to 20 MHz	2.1 % 1.9 % 2.1 %	
	+20 dBm to +53 dBm 20 MHz to 100 MHz 100 MHz to 1 GHz	2.1 % 2.8 %	
	+20 dBm to +40 dBm 1 GHz to 3 GHz	1.8 %	
RF Calibration Factor (Power Sensor Calibration)	100 kHz to 0.5 MHz 0.5 MHz to 1 MHz 1 MHz to 5 MHz 5 MHz to 10 MHz	0.60 % 0.70 % 0.70 % 0.70 %	50 $\Omega$ systems only. Nominal level +10 dBm.
	10 MHz to 50 MHz 50 MHz to 1 GHz 1 GHz to 5 GHz 5 GHz to 10 GHz 10 GHz to 15 GHz 15 GHz to 18 GHz	1.5 % 0.80 % 1.0 % 1.6 % 1.6 % 1.8 %	50 $\Omega$ systems only. Nominal level 0 dBm.
	10 MHz to 50 MHz 50 MHz to 1.0 GHz 1 GHz to 5 GHz 5 GHz to 10 GHz 10 GHz to 15 GHz 15 GHz to 18 GHz	1.4 % 0.90 % 1.1 % 1.8 % 2.0 % 2.2 %	50 $\Omega$ systems only. Nominal level -30 dBm.
RF VOLTAGE	200 $\mu$ V to 1 mV 9 kHz to 20 kHz 20 kHz to 1 MHz 1 MHz to 100 MHz 100 MHz to 1 GHz 1 GHz to 1.5 GHz	1.0 % 0.92 % 1.0 % 1.6 % 2.4 %	50 $\Omega$ systems only
	1 mV to 10 mV 9 kHz to 20 kHz 20 kHz to 1 MHz 1 MHz to 100 MHz 100 MHz to 1 GHz 1 GHz to 1.5 GHz	0.95 % 0.82 % 0.93 % 1.6 % 2.4 %	
	10 mV to 1 V 9 kHz to 20 kHz 20 kHz to 1 MHz 1 MHz to 100 MHz 100 MHz to 1 GHz 1 GHz to 1.5 GHz	0.85 % 0.71 % 0.82 % 1.5 % 2.4 %	



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RF VOLTAGE (continued)	1 V to 10 V 9 kHz to 20 kHz 20 kHz to 1 MHz 1 MHz to 100 MHz 100 MHz to 1 GHz 1 GHz to 1.5 GHz	0.85 % 0.71 % 0.82 % 1.5 % 2.4 %	50 $\Omega$ systems only
VOLTAGE REFLECTION COEFFICIENT	5 MHz to 1 GHz 0.00 to 0.05 0.05 to 0.1 0.1 to 0.2 0.2 to 0.7 0.7 to 1.0	0.016 0.019 0.030 0.090 0.16	
	1 GHz to 2 GHz 0.00 to 0.05 0.05 to 0.1 0.1 to 0.2 0.2 to 0.7 0.7 to 1.0	0.022 0.023 0.029 0.077 0.11	
	2 GHz to 5 GHz 0.00 to 0.05 0.05 to 0.1 0.1 to 0.2 0.2 to 0.7 0.7 to 1.0	0.021 0.034 0.065 0.22 0.32	
	5 GHz to 10 GHz 0.00 to 0.05 0.05 to 0.1 0.1 to 0.2 0.2 to 0.7 0.7 to 1.0	0.026 0.028 0.038 0.11 0.14	
	10 GHz to 15 GHz 0.00 to 0.05 0.05 to 0.1 0.1 to 0.2 0.2 to 0.7 0.7 to 1.0	0.033 0.035 0.042 0.093 0.13	
	15 GHz to 18 GHz 0.00 to 0.05 0.05 to 0.1 0.1 to 0.2 0.2 to 0.7 0.7 to 1.0	0.035 0.038 0.050 0.13 0.18	



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AUTOMATIC NETWORK ANALYSER SYSTEM

VOLTAGE TRANSMISSION COEFFICIENT MAGNITUDE AND PHASE

The CMCs are for 50Ω coaxial systems fitted with Type N, 3.5 mm, 2.92 mm or 2.4 mm connectors over the frequency ranges as specified below. The CMCs are presented in dB terms for magnitude and in [degrees for phase](#).

Type N systems	0 dB	to	40 dB	40 dB	to	50 dB	50 dB	to	60 dB	60 dB	to	70 dB
10 MHz to 100 MHz Magnitude Phase	0.085 0.36	to	0.11 0.48	0.090 0.41	to	0.22 1.4	0.092 0.43	to	0.64 4.2	0.11 0.57	to	2.0 13
100 MHz to 1 GHz Magnitude Phase	0.085 0.36	to	0.11 0.48	0.090 0.41	to	0.22 0.48	0.090 0.42	to	0.11 0.57	0.090 0.45	to	0.21 1.3
1 GHz to 12 GHz Magnitude Phase	0.085 0.45	to	0.090 1.5	0.090 0.48	to	0.090 1.5	0.090 0.48	to	0.090 1.5	0.090 0.48	to	0.091 1.5
12 GHz to 18 GHz Magnitude Phase	0.085 1.5	to	0.11 2.0	0.090 1.5	to	0.090 2.0	0.090 1.5	to	0.090 2.0	0.090 1.5	to	0.090 2.0
3.5 mm systems	0 dB	to	40 dB (50 dB)	40 dB (50 dB)	to	60 dB	60 dB	to	70 dB			
50 MHz to 1 GHz Magnitude Phase	0.085 0.36	to	0.091 0.55	0.090 0.42	to	0.20 1.2	0.090 0.45	to	0.56 3.7			
1 GHz to 12 GHz Magnitude Phase	0.085 0.45	to	0.090 1.5	0.090 0.48	to	0.090 1.5	0.090 0.49	to	0.091 1.5			
12 GHz to 26.5 GHz Magnitude Phase	0.085 1.5	to	0.090 2.8	0.090 1.5	to	0.090 2.8	0.090 1.5	to	0.090 2.8			
2.92 mm systems	0 dB	to	40 dB (50 dB)	40 dB (50 dB)	to	60 dB	60 dB	to	70 dB			
50 MHz to 100 MHz Magnitude Phase	0.057 0.36	to	0.066 0.42	0.063 0.41	to	0.19 1.2	0.064 0.57	to	0.56 3.7			
100 MHz to 26.5 GHz Magnitude Phase	0.057 0.36	to	0.063 1.9	0.063 0.41	to	0.064 1.9	0.063 0.44	to	0.066 1.9			
26.5 GHz to 40 GHz Magnitude Phase	0.057 1.9	to	0.063 2.6	0.063 1.9	to	0.064 2.6	0.063 1.9	to	0.071 2.6			
2.4 mm systems	0 dB	to	40 dB (50 dB)	40 dB (50 dB)	to	60 dB	60 dB	to	70 dB			
50 MHz to 1 GHz Magnitude Phase	0.057 0.36	to	0.066 0.55	0.063 0.42	to	0.19 1.2	0.064 0.44	to	0.56 3.7			
1 GHz to 5 GHz Magnitude Phase	0.057 0.41	to	0.063 0.66	0.063 0.45	to	0.064 0.67	0.064 0.45	to	0.066 0.67			
5 GHz to 26.5 GHz Magnitude Phase	0.057 0.64	to	0.063 1.9	0.063 0.66	to	0.064 1.9	0.063 0.67	to	0.070 1.9			
26.5 GHz to 40 GHz Magnitude Phase	0.057 1.9	to	0.063 2.6	0.063 1.9	to	0.064 2.6	0.063 1.9	to	0.071 2.6			



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**Electronic Test and Calibration Ltd**  
Issue No: 029 Issue date: 08 August 2017

Calibration performed at main address only

Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (k = 2)	Remarks
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AUTOMATIC NETWORK ANALYSER SYSTEM

VOLTAGE REFLECTION COEFFICIENT MAGNITUDE

The CMCs are for 50Ω coaxial systems fitted with Type N, 3.5 mm, 2.92 mm or 2.4 mm connectors over the frequency ranges as specified below. The CMCs are presented in VRC terms.

Connector type	Frequency	VRC range 0.0 to 0.2		VRC range 0.2 to 1.0	
Type N	10 MHz to 1 GHz	0.0061	to 0.0062	0.0062	to 0.012
	1 GHz to 12 GHz	0.0061	to 0.0078	0.0062	to 0.017
	12 GHz to 18 GHz	0.0077	to 0.0078	0.0077	to 0.018
3.5 mm	50 MHz to 1 GHz	0.00050	to 0.0010	0.00080	to 0.0015
	1 GHz to 12 GHz	0.00080	to 0.0020	0.0010	to 0.0028
	12 GHz to 26.5 GHz	0.0019	to 0.0024	0.0019	to 0.0037
2.92 mm	50 MHz to 1 GHz	0.0072	to 0.0073	0.0075	to 0.019
	1 GHz to 26.5 GHz	0.0072	to 0.018	0.0075	to 0.029
	26.5 GHz to 40 GHz	0.012	to 0.015	0.011	to 0.029
2.4 mm	50 MHz to 1 GHz	0.0019	to 0.0023	0.0020	to 0.0045
	1 GHz to 26.5 GHz	0.0023	to 0.0031	0.0023	to 0.0069
	26.5 GHz to 40 GHz	0.0031	to 0.0037	0.0031	to 0.0084

VOLTAGE REFLECTION COEFFICIENT PHASE, 0° to ±180°		
Type N systems		
VRC 0.0000 to 0.0003	10 MHz to 1 GHz 1 GHz to 12 GHz 12 GHz to 18 GHz	175° to 180° 175° to 180° 180°
VRC 0.0003 to 0.0005	10 MHz to 1 GHz 1 GHz to 12 GHz 12 GHz to 18 GHz	87° to 175° 87° to 180° 109° to 180°
VRC 0.0005 to 0.001	10 MHz to 1 GHz 1 GHz to 12 GHz 12 GHz to 18 GHz	70° to 87° 70° to 110° 87° to 110°
VRC 0.001 to 0.01	10 MHz to 1 GHz 1 GHz to 12 GHz 12 GHz to 18 GHz	35° to 70° 35° to 88° 44° to 88°
VRC 0.01 to 0.1	10 MHz to 1 GHz 1 GHz to 12 GHz 12 GHz to 18 GHz	3.5° to 70° 3.4° to 44° 4.4° to 44°



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VOLTAGE REFLECTION COEFFICIENT PHASE, 0° to ±180° (continued)			
Type N systems (continued)			
VRC 0.1 to 1	10 MHz to 1 GHz 1 GHz to 12 GHz 12 GHz to 18 GHz	0.69° to 3.5° 0.69° to 4.4° 1.0° to 4.4°	
3.5 mm systems			
VRC 0.0000 to 0.0001	50 MHz to 1 GHz 1 GHz to 12 GHz 12 GHz to 26.5 GHz	103° to 180° 138° to 180° 180°	
VRC 0.0001 to 0.0005	50 MHz to 1 GHz 1 GHz to 12 GHz 12 GHz to 26.5 GHz	32° to 139° 49° to 180° 105° to 180°	
VRC 0.0005 to 0.001	50 MHz to 1 GHz 1 GHz to 12 GHz 12 GHz to 26.5 GHz	32° to 49° 49° to 180° 105° to 106°	
VRC 0.001 to 0.01	50 MHz to 1 GHz 1 GHz to 12 GHz 12 GHz to 26.5 GHz	2.7° to 49° 4.6° to 105° 10° to 131°	
VRC 0.01 to 0.1	50 MHz to 1 GHz 1 GHz to 12 GHz 12 GHz to 26.5 GHz	0.30° to 4.6° 0.48° to 10° 1.0° to 10°	
VRC 0.1 to 1	50 MHz to 1 GHz 1 GHz to 12 GHz 12 GHz to 26.5 GHz	0.083° to 0.28° 0.083° to 0.53° 0.16° to 0.66°	
2.92 mm systems			
VRC 0.000 to 0.003	50 MHz to 1 GHz 1 GHz to 5 GHz 5 GHz to 26.5 GHz 26.5 GHz to 40 GHz	137° to 180° 136° to 180° 180° 180°	
VRC 0.003 to 0.004	50 MHz to 1 GHz 1 GHz to 5 GHz 5 GHz to 26.5 GHz 26.5 GHz to 40 GHz	103° to 137° 103° to 193° 145° to 180° 175° to 180°	
VRC 0.004 to 0.005	50 MHz to 1 GHz 1 GHz to 5 GHz 5 GHz to 26.5 GHz 26.5 GHz to 40 GHz	82° to 103° 82° to 145° 116° to 177° 140° to 177°	
VRC 0.005 to 0.01	50 MHz to 1 GHz 1 GHz to 5 GHz 5 GHz to 26.5 GHz 26.5 GHz to 40 GHz	41° to 82° 41° to 116° 58° to 142° 70° to 142°	



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VOLTAGE REFLECTION COEFFICIENT PHASE, 0° to ±180° (continued)			
2.92 mm systems (continued)			
VRC 0.01 to 0.1	50 MHz to 1 GHz 1 GHz to 5 GHz 5 GHz to 26.5 GHz 26.5 GHz to 40 GHz	4.1° to 41° 4.1° to 58° 5.8° to 71° 7.0° to 71°	
VRC 0.1 to 1	50 MHz to 1 GHz 1 GHz to 5 GHz 5 GHz to 26.5 GHz 26.5 GHz to 40 GHz	1.1° to 4.1° 1.1° to 5.8° 1.2° to 7.0° 1.6° to 7.0°	
2.4 mm systems			
VRC 0.000 to 0.001	50 MHz to 1 GHz 1 GHz to 5 GHz 5 GHz to 26.5 GHz 26.5 GHz to 40 GHz	107° to 180° 130° to 180° 170° to 180° 176° to 180°	
VRC 0.001 to 0.002	50 MHz to 1 GHz 1 GHz to 5 GHz 5 GHz to 26.5 GHz 26.5 GHz to 40 GHz	52° to 130° 64° to 177° 84° to 176° 87° to 180°	
VRC 0.002 to 0.003	50 MHz to 1 GHz 1 GHz to 5 GHz 5 GHz to 26.5 GHz 26.5 GHz to 40 GHz	35° to 64° 43° to 88° 56° to 86° 58° to 107°	
VRC 0.003 to 0.004	50 MHz to 1 GHz 1 GHz to 5 GHz 5 GHz to 26.5 GHz 26.5 GHz to 40 GHz	27° to 43° 32° to 58° 42° to 58° 44° to 71°	
VRC 0.004 to 0.005	50 MHz to 1 GHz 1 GHz to 5 GHz 5 GHz to 26.5 GHz 26.5 GHz to 40 GHz	21° to 32° 25° to 44° 33° to 44° 35° to 53°	
VRC 0.005 to 0.01	50 MHz to 1 GHz 1 GHz to 5 GHz 5 GHz to 26.5 GHz 26.5 GHz to 40 GHz	10° to 25° 13° to 35° 17° to 35° 17° to 43°	
VRC 0.01 to 0.1	50 MHz to 1 GHz 1 GHz to 5 GHz 5 GHz to 26.5 GHz 26.5 GHz to 40 GHz	1.0° to 13° 1.3° to 17° 1.7° to 17° 2.1° to 21°	
VRC 0.1 to 1	50 MHz to 1 GHz 1 GHz to 5 GHz 5 GHz to 26.5 GHz 26.5 GHz to 40 GHz	0.25° to 1.3° 0.25° to 1.8° 0.36° to 1.7° 0.38° to 2.1°	





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Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty ( $k = 2$ )	Remarks
RF ATTENUATION Tuned receiver method	0 dB to 30 dB 9 kHz to 100 kHz 100 kHz to 10 MHz 10 MHz to 50 MHz 50 MHz to 1 GHz 1 GHz to 5 GHz 5 GHz to 10 GHz 10 GHz to 15 GHz 15 GHz to 18 GHz	0.032 dB 0.032 dB 0.032 dB 0.051 dB 0.055 dB 0.087 dB 0.12 dB 0.13 dB	50 $\Omega$ systems only
	30 dB to 60 dB 9 kHz to 100 kHz 100 kHz to 10 MHz 10 MHz to 50 MHz 50 MHz to 1 GHz 1 GHz to 5 GHz 5 GHz to 10 GHz 10 GHz to 15 GHz 15 GHz to 18 GHz	0.045 dB 0.045 dB 0.045 dB 0.072 dB 0.079 dB 0.12 dB 0.16 dB 0.18 dB	
	60 dB to 70 dB 9 kHz to 100 kHz 100 kHz to 10 MHz 10 MHz to 50 MHz 50 MHz to 1 GHz 1 GHz to 5 GHz 5 GHz to 10 GHz 10 GHz to 15 GHz 15 GHz to 18 GHz	0.055 dB 0.055 dB 0.055 dB 0.088 dB 0.097 dB 0.14 dB 0.20 dB 0.22 dB	
	70 dB to 80 dB 9 kHz to 100 kHz 100 kHz to 10 MHz 10 MHz to 50 MHz 50 MHz to 1 GHz 1 GHz to 5 GHz 5 GHz to 10 GHz 10 GHz to 15 GHz 15 GHz to 18 GHz	0.080 dB 0.056 dB 0.056 dB 0.088 dB 0.097 dB 0.15 dB 0.20 dB 0.22 dB	
	80 dB to 90 dB 9 kHz to 100 kHz 100 kHz to 10 MHz 10 MHz to 50 MHz 50 MHz to 1 GHz 1 GHz to 5 GHz 5 GHz to 10 GHz 10 GHz to 15 GHz 15 GHz to 18 GHz	0.13 dB 0.067 dB 0.063 dB 0.093 dB 0.10 dB 0.15 dB 0.23 dB 0.24 dB	



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Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty ( $k = 2$ )	Remarks
RF ATTENUATION (continued)  Tuned receiver method (continued)	90 dB to 100 dB 9 kHz to 100 kHz 100 kHz to 10 MHz 10 MHz to 50 MHz 50 MHz to 1 GHz 1 GHz to 5 GHz 5 GHz to 10 GHz 10 GHz to 15 GHz 15 GHz to 18 GHz	0.29 dB 0.14 dB 0.12 dB 0.15 dB 0.16 dB 0.22 dB 0.35 dB 0.37 dB	50 $\Omega$ systems only
	100 dB to 110 dB 9 kHz to 100 kHz 100 kHz to 10 MHz 10 MHz to 50 MHz 50 MHz to 1 GHz 1 GHz to 5 GHz 5 GHz to 10 GHz 10 GHz to 15 GHz 15 GHz to 18 GHz	0.67 dB 0.48 dB 0.33 dB 0.34 dB 0.36 dB 0.39 dB 0.76 dB 1.3 dB	
Power meter method	0 dB to 25 dB 9 kHz to 20 kHz 20 kHz to 1 MHz 1 MHz to 10 MHz 10 MHz to 50 MHz 50 MHz to 1 GHz 1 GHz to 5 GHz 5 GHz to 10 GHz 10 GHz to 15 GHz 15 GHz to 18 GHz	0.050 dB 0.029 dB 0.025 dB 0.032 dB 0.030 dB 0.033 dB 0.046 dB 0.060 dB 0.061 dB	
	25 dB to 60 dB 9 kHz to 20 kHz 20 kHz to 1 MHz 1 MHz to 10 MHz 10 MHz to 50 MHz 50 MHz to 1 GHz 1 GHz to 5 GHz 5 GHz to 10 GHz 10 GHz to 15 GHz 15 GHz to 18 GHz	0.053 dB 0.035 dB 0.032 dB 0.032 dB 0.031 dB 0.035 dB 0.054 dB 0.078 dB 0.078 dB	



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Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty ( $k = 2$ )	Remarks
RF ATTENUATION (continued)  Power meter method (continued)	60 dB To 70 dB 9 kHz to 20 kHz 20 kHz to 1 MHz 1 MHz to 10 MHz 10 MHz to 50 MHz 50 MHz to 1 GHz 1 GHz to 5 GHz 5 GHz to 10 GHz 10 GHz to 15 GHz 15 GHz to 18 GHz	0.24 dB 0.23 dB 0.23 dB 0.12 dB 0.12 dB 0.12 dB 0.13 dB 0.14 dB 0.14 dB	50 $\Omega$ systems only
FREQUENCY MODULATION	0 Hz to 40 kHz	2.6 % + 2.0 Hz	Carrier frequency range 250 kHz to 10 MHz; modulation frequency range 20 Hz to 10 kHz
	0 Hz to 400 kHz	1.6 % + 16 Hz	Carrier frequency range 10 MHz to 1.3 GHz; modulation frequency range 20 Hz to 200 kHz
AMPLITUDE MODULATION	0 to 0.05 0.05 to 0.3 0.3 to 0.5 0.5 to 0.9	4.3 % + 0.00020 3.1 % + 0.00020 2.8 % + 0.0020 2.6 % + 0.0020	Ranges and uncertainties are shown in terms of modulation index  Carrier frequency range 150 kHz to 10 MHz; modulation frequency range 20 Hz to 10 kHz.
	0 to 0.05 0.05 to 0.3 0.3 to 0.5 0.5 to 0.9	3.7 % + 0.00020 3.7 % + 0.00020 1.8 % + 0.0020 1.6 % + 0.0020	Carrier frequency range 10 MHz to 1.3 GHz; modulation frequency range 20 Hz to 100 kHz.
PHASE MODULATION	0 radian to 400 radian	3.7 % + 0.0020 radian	Carrier frequency range 10 MHz to 1.3 GHz; modulation frequency range 20 Hz to 20 kHz
RF INTERMODULATION PRODUCTS	0 dB to -80 dB 10 kHz to 110 MHz 110 MHz to 18 GHz	0.94 dB 1.9 dB	



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Measured Quantity Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty ( $k = 2$ )	Remarks
PULSE TRANSITION TIME	1 ns to 1 s	2.9 %	For the calibration of Waveform Generators
PULSE WIDTH	1 ns to 1 s	1.2 %	
VOLTAGE AMPLITUDE	0.1 kV to 6.6 kV	3.0 %	
ELECTROSTATIC VOLTAGE	0.1 kV to 30 kV	1.0 %	Fieldmeters for measuring charged surfaces
HIGH IMPEDANCE CONTACT VOLTAGE	0.1 kV to 30 kV	0.70 %	Electrostatic voltmeter and other high resistance voltmeters for measuring charged surfaces
<b>ELECTROSTATIC DISCHARGE GENERATORS</b>			
Air discharge voltage	0.5 kV to 30 kV	0.73 %	EN61000-4-2:2009 EN61000-4-2:1995 ISO10605:2008 EN61340-3-1:2007 MIL-STD-331C:2005 Corr 1:2009 (Personnel) EIA/JES22-A114-B June 2000 EIA/JES22-A115-A October 1997 The measurement bandwidth is the lowest specified by the associated standard.
Pulse transition time	500 ps to 50 ns	2.2 %	
Peak current	0.1 A to 30 A	3.7 %	
Decay current	0.1 A to 30 A	5.0 %	
<b>BURST TRANSIENT GENERATOR CHARACTERISTICS</b>			
Transition time	3.5 ns to 50 s	0.91 %	For the calibration of Electrical Fast Transient generators and CDNs to 61000-4-4
Pulse width	10 ns to 100 ns	0.91 %	
Burst duration	100 $\mu$ s to 100 ms	0.91 %	
Burst period	1 ms to 1 s	0.14 %	
Frequency	1 kHz to 1 MHz	0.91 %	
Peak voltage	0.1 kV to 5 kV	2.6 %	
<b>SURGE PULSE CHARACTERISTICS</b>			
Risetime and falltime	0.1 $\mu$ s to 1.0 s	2.3 %	For the calibration of Surge generators to 61000-4-5
Pulse width	0.6 $\mu$ s to 1.0 ms	1.5 %	
Repetition rate	1.0 s to 100 s	0.030 %	
Phase angle	0° to 360°	1.3°	
Voltage amplitude	0.25 kV to 6.6 kV	2.6 %	
Current amplitude	0.2 kA to 3.3 kA	2.9 %	
RF IMPEDANCE	5 $\Omega$ to 60 $\Omega$ 9.0 kHz to 30 MHz	4.6 %	For impedance calibration of line impedance stabilisation networks (LISNs)



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IMPULSE GENERATOR MEASUREMENTS	50 dB $\mu$ V to 110 dB $\mu$ V 9 kHz to 30 MHz 30 MHz to 300 MHz 300 MHz to 1 GHz	0.55 dB 0.53 dB 0.55 dB	
IMPULSE GENERATION			
Absolute and relative amplitude	50 dB $\mu$ V to 110 dB $\mu$ V 9 kHz to 150 kHz	0.25 dB	
Absolute amplitude	50 dB $\mu$ V to 110 dB $\mu$ V 150 kHz to 30 MHz 30 MHz to 300 MHz 300 MHz to 1 GHz	0.80 dB 1.1 dB 1.6 dB	
Relative amplitude	50 dB $\mu$ V to 110 dB $\mu$ V 150 kHz to 30 MHz 30 MHz to 300 MHz 300 MHz to 1 GHz	0.50 dB 0.60 dB 0.90 dB	
VOLTAGE DIPS, SHORT INTERRUPTIONS VOLTAGE VARIATIONS GENERATORS			
Dip RMS Voltage	1 V to 400 V	2.3 %	
Voltage Variations	1 V to 400 V	3.5 %	
Interruptions Overshoot Voltage	25 % to 100 %	3.5 %	
Transition rise and fall time	1 $\mu$ s to 1 s	3.0 %	
Phase Angle	0° to 360°	11°	
Damped Oscillatory Generators			
Voltage	100 V to 6.6 kV Frequency $\leq$ 1 MHz Frequency 1 MHz to 50 MHz	2.1 % 2.9 %	
Ringwave Current	1 A to 400 A	2.8 %	
Oscillatory Wave Current	1 A to 150 A	3.6 %	
Impedance	5 $\Omega$ to 500 $\Omega$	4.6 %	
Transition time	1 ns to 10 $\mu$ s	0.91 %	
Frequency	10 kHz to 100 MHz	0.91 %	
Repetition Rate	100 $\mu$ s to 1 s	0.91 %	
Burst Duration	1 ms to 5 s	0.91 %	
Burst Period	1 ms to 1 s	0.14 %	
Phase	0° to 360°	3.3°	



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ANTENNA MEASUREMENTS			
Monopole Antenna Antenna Factor	20 Hz to 30 MHz 30 MHz to 100 MHz	1.4 dB/m 1.6 dB/m	Equivalent capacitance method.
Antenna Factor and Apparent Gain			Best capability using the three antenna method or by comparison with similar antennas using the standard antenna method.
Biconical and Broad Band Dipoles	20 MHz to 300 MHz 300 MHz to 1.0 GHz	1.5 dB (1.8 dB at 1 m) 1.5 dB (1.8 dB at 1 m)	Measurement distance 10 m, 3.0 m and 1.0 m.
Log Periodic	80 MHz to 18.0 GHz	1.5 dB (1.6 dB at 1 m)	Measurement distances 3.0 m and 1.0 m; calculated results for 10 m and for Free Space.
Bilog and hybrid antennas	20 MHz to 18.0 GHz	1.5 dB (1.8 dB at 1 m)	Measurement distances 3.0 m and 1.0 m; calculated results for 10 m and for Free Space.
Horn Antennas	200 MHz to 1.0 GHz 1.0 GHz to 18.0 GHz 18.0 to 26.5 GHz	1.5 dB 1.5 dB 1.5 dB	Horn measurement at 3.0 m and 1.0 m.
Voltage Reflection Coefficient	30 MHz to 1.0 GHz 1.0 GHz to 18.0 GHz	0.090 0.129	
END			



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Appendix - Calibration and Measurement Capabilities

**Introduction**

The definitive statement of the accreditation status of a calibration laboratory is the Accreditation Certificate and the associated Schedule of Accreditation. This Schedule of Accreditation is a critical document, as it defines the measurement capabilities, ranges and boundaries of the calibration activities for which the organisation holds accreditation.

**Calibration and Measurement Capabilities (CMCs)**

The capabilities provided by accredited calibration laboratories are described by the Calibration and Measurement Capability (CMC), which expresses the lowest uncertainty of measurement that can be achieved during a calibration. If a particular device under calibration itself contributes significantly to the uncertainty (for example, if it has limited resolution or exhibits significant non-repeatability) then the uncertainty quoted on a calibration certificate will be increased to account for such factors. The CIPM-ILAC definition of the CMC is as follows:

*A CMC is a calibration and measurement capability available to customers under normal conditions:  
(a) as published in the BIPM key comparison database (KCDB) of the CIPM MRA; or  
(b) as described in the laboratory's scope of accreditation granted by a signatory to the ILAC Arrangement.*

The CMC is normally used to describe the uncertainty that appears in an accredited calibration laboratory's schedule of accreditation and is the uncertainty for which the laboratory has been accredited using the procedure that was the subject of assessment. The CMC is calculated according to the procedures given in M3003 and is normally stated as an expanded uncertainty at a coverage probability of 95 %, which usually requires the use of a coverage factor of  $k = 2$ . An accredited laboratory is not permitted to quote an uncertainty that is smaller than the published CMC in certificates issued under its accreditation.

The CMC may be described using various methods in the Schedule of Accreditation:

- As a single value that is valid throughout the range.
- As an explicit function of the measurand or of a parameter (see below).
- As a range of values. The range is stated such that the customer can make a reasonable estimate of the likely uncertainty at any point within the range.
- As a matrix or table where the CMCs depend on the values of the measurand and a further quantity.
- In graphical form, providing there is sufficient resolution on each axis to obtain at least two significant figures for the CMC.

**Expression of CMCs - symbols and units**

In general, only units of the SI and those units recognised for use with the SI are used to express the values of quantities and of the associated CMCs. Nevertheless, other commonly used units may be used where considered appropriate for the intended audience. For example, the term "ppm" (part per million) is frequently used by manufacturers of test and measurement equipment to specify the performance of their products. Terms like this may be used in Schedules of Accreditation where they are in common use and understood by the users of such equipment, providing their use does not introduce any ambiguity in the capability that is being described.

When the CMC is expressed as an explicit function of the measurand or of a parameter, this often comprises a relative term (e.g., percentage) and an absolute term, i.e. one expressed in the same units as those of the measurand. This form of expression is used to describe the capability that can be achieved over a range of values. Some examples, and an indication of how they are to be interpreted, are shown below.

DC voltage, 100 mV to 1 V: 0.0025 % + 5.0  $\mu$ V:

Over the range 100 mV to 1 V, the CMC is 0.0025 %  $\cdot$  V + 5.0  $\mu$ V, where V is the measured voltage.

Hydraulic pressure, 0.5 MPa to 140 MPa: 0.0036 % + 0.12 ppm/MPa + 4.0 Pa

Over the range 0.5 MPa to 140 MPa, the CMC is 0.0036 %  $\cdot$  p + (0.12  $\cdot$  10<sup>-6</sup>  $\cdot$  p  $\cdot$  10<sup>-6</sup>) + 4.0 Pa, where p is the measured pressure in Pa.

It should be noted that the percentage symbol (%) simply represents the number 0.01. In cases where the CMC is stated only as a percentage, this is to be interpreted as meaning percentage of the measured value or indication.

Thus, for example, a CMC of 1.5 % means 1.5  $\cdot$  0.01  $\cdot$  i, where i is the instrument indication.