

# **Annex to the accreditation certificate: N° 2/004 According to standard ISO/IEC 17025:2017 For a calibration laboratory**

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## Metrology

Objects submitted to calibration	Characteristics or properties measured	Calibration methods	Measuring range	Calibration and Measurement Capability (CMC)
		(e.g. published, adapted, internally validated)		Enlarged uncertainty (k=2)
<b>General Domain: CAL1 – Electricity</b>				
<b>Technical Domain: CAL1.1 – Voltage</b>				
CAL1.1.1 – Voltage measurers – Direct current (DCV)	Voltage	CMC-11 Substitution of divided voltages	100 mV	0,25 µV
		CMC-12 Substitution using a reference voltage	1 V	1,8 µV
			1,018 V	1,8 µV
			10 V	8,0 µV
		CMC-11 Substitution of divided voltages + ratio measurements	$0 \text{ mV} \leq E_x < 200 \text{ mV}$	$2,0 \cdot 10^{-6} E_x + 0,25 \mu\text{V}$
		CMC-13 Substitution of divided voltages + ratio measurements	$200 \text{ mV} \leq E_x < 2 \text{ V}$	$1,2 \cdot 10^{-6} E_x + 0,50 \mu\text{V}$
			$2 \text{ V} \leq E_x < 20 \text{ V}$	$1,0 \cdot 10^{-6} E_x + 2,5 \mu\text{V}$
$20 \text{ V} \leq E_x < 200 \text{ V}$	$1,5 \cdot 10^{-6} E_x + 15 \mu\text{V}$			
$200 \text{ V} \leq E_x \leq 1000 \text{ V}$	$2,0 \cdot 10^{-6} E_x + 250 \mu\text{V}$			
CAL1.1.2 – Voltage measurers – Alternative current (ACV)	Voltage	CMC-31 Direct measurement with a voltmeter and an AC/DC transfer standard	Fixed points 10 Hz to 1 MHz	See <b>Table 1: Matrix CMC-31-fix</b>
			Variable ranges 10 Hz to 1 MHz	See <b>Table 2: Matrix CMC-31-var</b>
CAL1.1.5 – Voltage generators – Direct Current (DCV)	Voltage	CMC-11 Substitution of divided voltages	100mV	0,25µV
		CMC-12 Substitution using a reference voltage	1V	1,8 µV
			1,018V	1,8 µV
			10V	8,0 µV
CMC-11 Substitution of divided voltages + ratio measurements	$0\text{mV} \leq E_x < 200\text{mV}$	$2,0 * 10^{-6} E_x + 0,25\mu\text{V}$		
CMC-13	$200\text{mV} \leq E_x < 2\text{V}$	$1,2 * 10^{-6} E_x + 0,50\mu\text{V}$		
	$2\text{V} \leq E_x < 20\text{V}$	$1,0 * 10^{-6} E_x + 2,5\mu\text{V}$		

Objects submitted to calibration	Characteristics or properties measured	Calibration methods	Measuring range	Calibration and Measurement Capability (CMC)
		Substitution of divided voltages + ratio measurements	20V ≤ E <sub>x</sub> < 200V 200V ≤ E <sub>x</sub> < 1000V	1,5 * 10 <sup>-6</sup> E <sub>x</sub> + 15 μV 2,0 * 10 <sup>-6</sup> E <sub>x</sub> + 250 μV
CAL1.1.6 – Voltage generators – Alternative Current (ACV)	Voltage	CMC-31 Direct measurement with a voltmeter and an AC/DC transfer standard	Fixed points 10 Hz to 1 MHz	See <b>Table 1: Matrix CMC-31-fix</b>
			Variable ranges 10 Hz to 1 MHz	See <b>Table 2: Matrix CMC-31-var</b>
			<i>E<sub>x</sub></i> : measured voltage	
<b>Technical Domain: CAL1.2 – Current</b>				
CAL1.2.1 – Current measurers and generators – Direct current (DCI)	Current	CMC-21 Measurement of voltage across a standard shunt in series with UUT	0 μA < I <sub>x</sub> ≤ 1 μA	8,0 · 10 <sup>-6</sup> I <sub>x</sub> + 50 pA
			1 μA < I <sub>x</sub> ≤ 10 μA	12 · 10 <sup>-6</sup> I <sub>x</sub> + 60 pA
			10 μA < I <sub>x</sub> ≤ 100 μA	8,0 · 10 <sup>-6</sup> I <sub>x</sub> + 0,40 nA
			100 μA < I <sub>x</sub> ≤ 1 mA	6,0 · 10 <sup>-6</sup> I <sub>x</sub> + 5,0 nA
			1 mA < I <sub>x</sub> ≤ 10 mA	6,0 · 10 <sup>-6</sup> I <sub>x</sub> + 40 nA
			10 mA < I <sub>x</sub> ≤ 100 mA	6,0 · 10 <sup>-6</sup> I <sub>x</sub> + 0,50 μA
			100 mA < I <sub>x</sub> ≤ 1 A	12 · 10 <sup>-6</sup> I <sub>x</sub> + 20 μA
			1 A < I <sub>x</sub> ≤ 10 A	12 · 10 <sup>-6</sup> I <sub>x</sub> + 40 μA
CAL1.2.2 – Current measurers – Alternative current (ACI)	Current	CMC-41 Measurement of voltage across a standard shunt with a voltmeter and an AC/DC transfer standard	Fixed points 10 Hz to 10 kHz	See <b>Table 3: Matrix CMC-41-fix</b>
			Variable ranges 10 Hz to 10 kHz	See <b>Table 4: Matrix CMC-41-var</b>
CAL1.2.4 – Current generators – Direct current (DCI)	Current	CMC-21 Measurement of voltage across a standard shunt	10 μA < I <sub>x</sub> ≤ 100 μA 100 μA < I <sub>x</sub> ≤ 1 mA 1 mA < I <sub>x</sub> ≤ 10 mA 10 mA < I <sub>x</sub> ≤ 100 mA 100 mA < I <sub>x</sub> ≤ 1 A 1 A < I <sub>x</sub> ≤ 10 A	8,0 · 10 <sup>-6</sup> I <sub>x</sub> + 0,30 nA 6,0 · 10 <sup>-6</sup> I <sub>x</sub> + 15 nA 5,0 · 10 <sup>-6</sup> I <sub>x</sub> + 40 nA 6,0 · 10 <sup>-6</sup> I <sub>x</sub> + 0,40 μA 10 · 10 <sup>-6</sup> I <sub>x</sub> + 5,0 μA 10 · 10 <sup>-6</sup> I <sub>x</sub> + 50 μA
CAL1.2.5 – Current generators – Alternative current (ACI)	Current	CMC-41 Measurement of voltage across a standard shunt with a voltmeter and an AC/DC transfer standard	Fixed points 10 Hz to 10 KHz	See <b>Table 3: Matrix CMC-41-fix</b>
			Variable ranges 10 Hz to 10 KHz	See <b>Table 4: Matrix CMC-41-var</b>
			<i>I<sub>x</sub></i> : measured current	
<b>Technical Domain: CAL1.3 – Resistance</b>				

Objects submitted to calibration	Characteristics or properties measured	Calibration methods	Measuring range	Calibration and Measurement Capability (CMC)
CAL1.3.1 – Resistance measurers	Resistance	C_RES_M_001 Calibration of DC resistance meters	1 mΩ 10 mΩ 100 mΩ 1 Ω 10 Ω 100 Ω 1 kΩ 10 kΩ 100 kΩ 1 MΩ 100 MΩ 1 GΩ	8,0 * 10 <sup>-6</sup> R <sub>x</sub> 6,0 * 10 <sup>-6</sup> R <sub>x</sub> 3,0 * 10 <sup>-6</sup> R <sub>x</sub> 1,0 * 10 <sup>-6</sup> R <sub>x</sub> 1,0 * 10 <sup>-6</sup> R <sub>x</sub> 1,5 * 10 <sup>-6</sup> R <sub>x</sub> 2,0 * 10 <sup>-6</sup> R <sub>x</sub> 2,0 * 10 <sup>-6</sup> R <sub>x</sub> 6,0 * 10 <sup>-6</sup> R <sub>x</sub> 8,0 * 10 <sup>-6</sup> R <sub>x</sub> 30 * 10 <sup>-6</sup> R <sub>x</sub> 100 * 10 <sup>-6</sup> R <sub>x</sub>
CAL1.3.2 – Resistance generators	Resistance	C_RES_S_001 Calibration of DC resistance standards and sources	100 μΩ < R <sub>x</sub> ≤ 1mΩ	2,5 · 10 <sup>-6</sup> R <sub>x</sub> + 0,3 μΩ
			1 mΩ < R <sub>x</sub> ≤ 100 mΩ	2,0 · 10 <sup>-6</sup> R <sub>x</sub>
			100 mΩ < R <sub>x</sub> ≤ 100 Ω	1,5 · 10 <sup>-6</sup> R <sub>x</sub>
			100 Ω < R <sub>x</sub> ≤ 10 kΩ	1,5 · 10 <sup>-6</sup> R <sub>x</sub>
			10 kΩ < R <sub>x</sub> ≤ 100 kΩ	2,0 · 10 <sup>-6</sup> R <sub>x</sub>
			100 kΩ < R <sub>x</sub> ≤ 1 MΩ	7,0 · 10 <sup>-6</sup> R <sub>x</sub>
CAL1.3.3 – Standard resistors	Resistance	C_RES_S_001 Calibration of DC resistance standards and sources	100 μΩ < R <sub>x</sub> ≤ 1mΩ	2,5 · 10 <sup>-6</sup> R <sub>x</sub> + 0,3 μΩ
			1 mΩ < R <sub>x</sub> ≤ 100 mΩ	2,0 · 10 <sup>-6</sup> R <sub>x</sub>
			100 mΩ < R <sub>x</sub> ≤ 100 Ω	1,5 · 10 <sup>-6</sup> R <sub>x</sub>
			100 Ω < R <sub>x</sub> ≤ 10 kΩ	1,5 · 10 <sup>-6</sup> R <sub>x</sub>
			10 kΩ < R <sub>x</sub> ≤ 100 kΩ	2,0 · 10 <sup>-6</sup> R <sub>x</sub>
			100 kΩ < R <sub>x</sub> ≤ 1 MΩ	7,0 · 10 <sup>-6</sup> R <sub>x</sub>
			R <sub>x</sub> : measured resistance	

Objects submitted to calibration	Characteristics or properties measured	Calibration methods	Measuring range	Calibration and Measurement Capability (CMC)
		(e.g. published, adapted, internally validated)		Enlarged uncertainty (k=2)
<b>General Domain:</b> CAL2 – Time / Frequency				
<b>Technical Domain:</b> CAL2.1 – Frequency counters				
CAL 2.1.3 – Frequency generators – Square wave	Frequency	CMC-50  Measured using a frequency counter with a Caesium frequency standard <sup>1</sup>	1 Hz ≤ $F_x$ < 10 Hz	1000s
			10 Hz ≤ $F_x$ < 100 Hz	$2,3 \cdot 10^{-12}$
			100 Hz ≤ $F_x$ < 1 KHz	$2,3 \cdot 10^{-12}$
			1 KHz ≤ $F_x$ < 10 KHz	$2,3 \cdot 10^{-12}$
			10 KHz ≤ $F_x$ < 100 KHz	$2,3 \cdot 10^{-12}$
			100 KHz ≤ $F_x$ < 1 MHz	$2,3 \cdot 10^{-12}$
			1 Hz ≤ $F_x$ < 10 Hz	100s
			10 Hz ≤ $F_x$ < 100 Hz	$4,2 \cdot 10^{-12}$
			100 Hz ≤ $F_x$ < 1 KHz	$3,8 \cdot 10^{-12}$
			1 KHz ≤ $F_x$ < 10 KHz	$3,8 \cdot 10^{-12}$
			10 KHz ≤ $F_x$ < 100 KHz	$3,8 \cdot 10^{-12}$
			100 KHz ≤ $F_x$ < 1 MHz	$3,8 \cdot 10^{-12}$
			1 Hz ≤ $F_x$ < 10 Hz	10s
			10 Hz ≤ $F_x$ < 100 Hz	$5,8 \cdot 10^{-11}$
			100 Hz ≤ $F_x$ < 1 KHz	$2,1 \cdot 10^{-11}$
			1 KHz ≤ $F_x$ < 10 KHz	$1,2 \cdot 10^{-11}$
			10 KHz ≤ $F_x$ < 100 KHz	$1,1 \cdot 10^{-11}$
			100 KHz ≤ $F_x$ < 1 MHz	$1,1 \cdot 10^{-11}$

<sup>1</sup> The accuracy of the Caesium frequency standard, traceable up to national standards, is  $2 \cdot 10^{12}$  (k=2).

Objects submitted to calibration	Characteristics or properties measured	Calibration methods	Measuring range	Calibration and Measurement Capability (CMC)
			$1 \text{ Hz} \leq F_x < 10 \text{ Hz}$ $10 \text{ Hz} \leq F_x < 100 \text{ Hz}$ $100 \text{ Hz} \leq F_x < 1 \text{ KHz}$ $1 \text{ KHz} \leq F_x < 10 \text{ KHz}$ $10 \text{ KHz} \leq F_x < 100 \text{ KHz}$ $100 \text{ KHz} \leq F_x < 1 \text{ MHz}$	1s $1,9 * 10^{-9}$ $5,7 * 10^{-10}$ $1,9 * 10^{-10}$ $5,9 * 10^{-11}$ $2,4 * 10^{-11}$ $1,7 * 10^{-11}$
CAL2.1.4 – Frequency generators – Sine vawe	Frequency	CMC-50  Measured using a frequency counter with a Caesium frequency standard <sup>2</sup>	$1 \text{ Hz} \leq F_x < 10 \text{ Hz}$ $10 \text{ Hz} \leq F_x < 100 \text{ Hz}$ $100 \text{ Hz} \leq F_x < 1 \text{ KHz}$ $1 \text{ KHz} \leq F_x < 10 \text{ KHz}$ $10 \text{ KHz} \leq F_x < 100 \text{ KHz}$ $100 \text{ KHz} \leq F_x < 1 \text{ MHz}$ $1 \text{ MHz} \leq F_x < 12,4 \text{ GHz}$ $12,4 \text{ GHz} \leq F_x < 26,5 \text{ GHz}$	1000s $4,3 * 10^{-8}$ $1,4 * 10^{-9}$ $4,3 * 10^{-11}$ $2,7 * 10^{-12}$ $2,3 * 10^{-12}$ $2,3 * 10^{-12}$ $2,3 * 10^{-12}$ -
			$1 \text{ Hz} \leq F_x < 10 \text{ Hz}$ $10 \text{ Hz} \leq F_x < 100 \text{ Hz}$ $100 \text{ Hz} \leq F_x < 1 \text{ KHz}$ $1 \text{ KHz} \leq F_x < 10 \text{ KHz}$ $10 \text{ KHz} \leq F_x < 100 \text{ KHz}$ $100 \text{ KHz} \leq F_x < 1 \text{ MHz}$ $1 \text{ MHz} \leq F_x < 12,4 \text{ GHz}$ $12,4 \text{ GHz} \leq F_x < 26,5 \text{ GHz}$	100s $1,4 * 10^{-6}$ $4,3 * 10^{-8}$ $1,4 * 10^{-9}$ $4,3 * 10^{-11}$ $4,0 * 10^{-12}$ $3,8 * 10^{-12}$ $3,8 * 10^{-12}$ -
			$1 \text{ Hz} \leq F_x < 10 \text{ Hz}$ $10 \text{ Hz} \leq F_x < 100 \text{ Hz}$	10s $4,3 * 10^{-5}$ $1,4 * 10^{-6}$

<sup>2</sup> The accuracy of the Caesium frequency standard, traceable up to national standards, is  $2 \cdot 10^{12}$  (k=2).

Objects submitted to calibration	Characteristics or properties measured	Calibration methods	Measuring range	Calibration and Measurement Capability (CMC)
			$100 \text{ Hz} \leq F_x < 1 \text{ KHz}$ $1 \text{ KHz} \leq F_x < 10 \text{ KHz}$ $10 \text{ KHz} \leq F_x < 100 \text{ KHz}$ $100 \text{ KHz} \leq F_x < 1 \text{ MHz}$ $1 \text{ MHz} \leq F_x < 12,4 \text{ GHz}$ $12,4 \text{ GHz} \leq F_x < 26,5 \text{ GHz}$	$4,3 * 10^{-8}$ $1,4 * 10^{-9}$ $4,4 * 10^{-11}$ $1,1 * 10^{-11}$ $1,1 * 10^{-11}$ -
			$1 \text{ Hz} \leq F_x < 10 \text{ Hz}$ $10 \text{ Hz} \leq F_x < 100 \text{ Hz}$ $100 \text{ Hz} \leq F_x < 1 \text{ KHz}$ $1 \text{ KHz} \leq F_x < 10 \text{ KHz}$ $10 \text{ KHz} \leq F_x < 100 \text{ KHz}$ $100 \text{ KHz} \leq F_x < 1 \text{ MHz}$ $1 \text{ MHz} \leq F_x < 12,4 \text{ GHz}$ $12,4 \text{ GHz} \leq F_x < 26,5 \text{ GHz}$	1s $1,4 * 10^{-3}$ $4,3 * 10^{-5}$ $1,4 * 10^{-6}$ $4,3 * 10^{-8}$ $1,4 * 10^{-9}$ $4,6 * 10^{-11}$ $1,7 * 10^{-11}$ $2,1 * 10^{-10}$

**Table 1: Matrix CMC-31-fix**

Input		Expanded Relative Uncertainty of Measurement U in 10 <sup>-6</sup> at Frequencies of:												
		10 Hz	20 Hz	40 Hz	120 Hz	1 kHz	10 kHz	20 kHz	50 kHz	100 kHz	300 kHz	500 kHz	800 kHz	1 MHz
Range	Voltage													
22 mV	2 mV	840	920	860	920	890	800	980	800	920	890	850	910	1100
	6 mV	310	280	280	280	280	280	280	290	300	320	400	470	560
	10 mV	220	190	190	190	180	180	180	180	200	230	340	410	490
	20 mV	150	110	110	110	110	110	110	97	110	180	270	380	460
220 mV	20 mV	150	110	110	120	110	110	110	98	110	170	280	380	460
	60 mV	77	56	56	57	56	57	57	60	110	160	260	360	440
	100 mV	40	29	29	29	23	23	25	30	46	130	210	340	420
	200 mV	33	26	24	24	17	18	19	26	44	130	210	340	420
700 mV	200 mV	28	24	25	25	20	18	19	27	45	130	210	340	420
	600 mV	23	23	23	24	10	21	15	24	44	130	210	340	420
2.2 V	600 mV	23	23	23	23	13	19	21	28	45	130	210	340	420
	1 V	23	9	7	10	10	20	19	26	45	130	210	330	410
	2 V	15	9	8	8	13	19	20	26	45	130	210	330	410
7 V	2 V	15	10	10	10	8	12	13	23	43	130	210	330	410
	6 V	20	7	6	7	7	15	13	22	43	130	210	330	410
22 V	6 V	22	8	5	6	9	16	10	21	42	130	210	330	410
	10 V	21	10	7	7	7	9	11	22	42	130	210	330	410
	20 V	22	14	13	13	13	13	15	24	43	130	210	330	410
70 V	20 V	22	13	13	13	13	14	15	24	43				
	60 V	25	20	17	17	16	20	18	26	48				
220 V	60 V	25	18	18	17	16	22	18	26	48				
	100 V	27	23	23	23	23	24	25	31	73				
	200 V	29	25	25	25	23	24	24	31	73				

		Expanded Relative Uncertainty of Measurement U in 10 <sup>-6</sup> at Frequencies of:												
1000 V	200 V	-	-	26	25	23	24	25	31	74				
	600 V	-	-	26	24	24	24	25	31	82				
	1000 V	-	-	25	23	23	23	24	-	-				

**Table 2: Matrix CMC-31-var**

Input		Expanded Relative Uncertainty of Measurement U in 10 <sup>-6</sup> at Frequencies of:											
		10 -20 Hz	20 -40 Hz	40-120 Hz	120 Hz - 1 kHz	1 kHz - 10 kHz	10 kHz - 20 kHz	20 kHz - 50 kHz	50 kHz - 100 kHz	100 kHz - 300 kHz	300 kHz - 500 kHz	500 kHz- 800 kHz	800 kHz - 1 MHz
Range	Voltage												
22 mV	2 - 6 mV	970	970	990	990	910	1000	1070	1020	990	980	990	1120
	6 - 10 mV	440	410	300	330	330	310	340	350	370	430	500	570
	10 - 20 mV	340	320	200	190	190	180	190	210	240	340	430	510
220 mV	20 - 60 mV	190	160	120	120	110	110	110	110	180	290	430	500
	60 - 100 mV	140	130	66	59	60	60	61	110	170	290	450	570
	100 - 200 mV	110	110	38	32	30	31	32	48	150	250	420	550
700 mV	200 - 600 mV	200	140	38	27	32	32	30	47	140	230	390	500
2.2 V	600 mV - 1 V	55	55	26	25	22	23	29	46	130	220	340	420
	1 - 2 V	130	120	35	20	22	22	27	46	130	210	330	410
7 V	2 - 6 V	220	130	39	18	21	21	24	44	130	210	330	420
22 V	6 - 10 V	55	52	14	11	22	22	24	43	130	210	330	410
	10 - 20 V	130	130	41	20	15	16	25	44	130	210	330	410
70 V	20 - 60 V	220	130	43	22	25	25	28	51				
220 V	60 - 100 V	58	56	26	24	27	28	33	74				
	100 - 200 V	130	130	47	28	25	26	32	74				
1000 V	200 - 600 V			31	27	26	26	32	83				
	600 - 1000 V			46	29	26	26						

**Table 3: Matrix CMC-41-fix**

Input Current	Expanded Relative Uncertainty of Measurement I in 10 <sup>-6</sup> at Frequencies of:										
	10 Hz	20 Hz	30 Hz	40 Hz	55 Hz	400 Hz	500 Hz	1 kHz	2 kHz	5 kHz	10 kHz
10 mA	80	30	30	40	30	30	30	30	30	40	40
30 mA	70	70	70	70	70	70	70	70	70	80	80
100 mA	50	30	30	30	30	30	30	40	30	30	40
300 mA	90	90	90	90	90	90	90	90	90	90	90
1 A	40	40	40	40	40	40	40	40	40	40	60
3 A	70	70	70	70	70	70	70	70	70	70	80
10 A	50	40	40	50	50	50	50	50	50	60	60

**Table 4: Matrix CMC-41-var**

Input Range	Expanded Relative Uncertainty of Measurement I in 10 <sup>-6</sup> at Frequencies of:										
	10 -20 Hz	20 - 30 Hz	30 - 40 Hz	40 - 55 Hz	55 - 400 Hz	400 - 500 Hz	0.5 - 1 kHz	1 - 2 kHz	2 - 5 kHz	5 - 10 kHz	
10 mA - 30 mA	80	80	80	80	80	80	80	80	80	90	
30 mA - 100 mA	80	80	80	80	80	80	80	80	80	80	
100 mA - 300 mA	100	100	90	90	90	90	90	90	90	90	
0.3 A - 1 A	90	90	90	90	90	90	90	90	90	90	
1 A - 3 A	80	80	80	80	80	80	80	80	80	80	
3 A - 10 A	70	70	70	70	70	70	70	70	70	70	