OFFICE LUXEMBOURGEOIS D'ACCREDITATION ET DE SURVEILLANCE

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)
General Domain: CAL1 – Electricity					
Technical Domain: CAL1.1 – Voltage					
CAL1.1.1 – Voltage measurers – Direct current (DCV)	Voltage	CMC-11 Substitution of divided voltages	100 mV		0,25 μV
		CMC-12 ratio measurements	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 mV ≤ E_x < 200 mV		$2{,}0 \cdot 10^{-6} E_x$ + 0,25 μV
		CMC-13 Substitution of divided voltages + ratio measurements	200 mV ≤ E_x < 2 V		$1{,}2 \cdot 10^{-6} E_x$ + 0,50 μV
			2 V ≤ E_x < 20 V		$1{,}0 \cdot 10^{-6} E_x$ + 2,5 μV
			20 V ≤ E_x < 200 V		$1{,}5 \cdot 10^{-6} E_x$ + 15 μV
			200 V ≤ E_x ≤ 1000 V		$2{,}0 \cdot 10^{-6} E_x$ + 250 μV
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 **Table 1: Matrix CMC-31-fix**
			Variable ranges	10 Hz to 1 MHz	See **Table 2: Matrix CMC-31-var**
			E_x: measured voltage		
Technical Domain: CAL1.2 – Amperage					
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_x ≤ 1μA		$8{,}0 \cdot 10^{-6} I_x$ + 50 pA
			1 μA < I_x ≤10 μA		$12 \cdot 10^{-6} I_x$ + 60 pA
			10 μA < I_x ≤ 100 μA		$8{,}0 \cdot 10^{-6} I_x$ + 0,4 nA
			100 μA < I_x ≤ 1 mA		$6{,}0 \cdot 10^{-6} I_x$ + 5,0 nA
			1 mA < I_x ≤ 10 mA		$6{,}0 \cdot 10^{-6} I_x$ + 40 nA
			10 mA < I_x ≤100 mA		$6{,}0 \cdot 10^{-6} I_x$ + 0,5μA

Objects submitted to calibration	Characteristics or properties measured	Calibration methods	Measuring range		Calibration and Measurement Capability (CMC)
			100 mA < I_x ≤1 A		$12 \cdot 10^{-6} I_x + 20$ µA
			1 A < I_x ≤10 A		$12 \cdot 10^{-6} I_x + 40$ µA
		CMC-21 Measurement of voltage across a standard shunt	10 µA < I_x ≤ 100 µA		$8{,}0 \cdot 10^{-6} I_x + 0{,}3$ nA
			100 µA < I_x ≤ 1 mA		$6{,}0 \cdot 10^{-6} I_x + 15$ nA
			1 mA < I_x ≤ 10 mA		$5{,}0 \cdot 10^{-6} I_x + 40$ nA
			10 mA < I_x ≤100 mA		$6{,}0 \cdot 10^{-6} I_x + 0{,}4$ µA
			100 mA < I_x ≤1 A		$10 \cdot 10^{-6} I_x + 5{,}0$ µA
			1 A < I_x ≤10 A		$10 \cdot 10^{-6} I_x + 50$ 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 ***Table 3: Matrix CMC-41-fix***
			Variable ranges	10 Hz to 10 kHz	See ***Table 4: Matrix CMC-41-var***
			I_x: measured current		
Technical Domain: CAL1.3 – Resistance					
CAL1.3.1 – Resistance Range Calibration	Resistance	CMC-05 Direct Comparison	100 µΩ < R_x ≤ 1mΩ		$2{,}5 \cdot 10^{-6} R_x + 0{,}3$ µΩ
			1 mΩ < R_x ≤ 100 mΩ		$2{,}0 \cdot 10^{-6} R_x$
			100 mΩ < R_x ≤ 100 Ω		$1{,}5 \cdot 10^{-6} R_x$
			100 Ω < R_x ≤ 10 kΩ		$1{,}5 \cdot 10^{-6} R_x$
			10 kΩ < R_x ≤ 100 kΩ		$2{,}0 \cdot 10^{-6} R_x$
			100 kΩ < R_x ≤ 1 MΩ		$7{,}0 \cdot 10^{-6} R_x$
CAL1.3.3 – Resistance measurers	Resistance	CMC-01 Direct Measurement	1 mΩ		$8{,}0 \cdot 10^{-6} R_x$
			10 mΩ		$6{,}0 \cdot 10^{-6} R_x$
			100 mΩ		$3{,}0 \cdot 10^{-6} R_x$
			1 Ω		$1{,}0 \cdot 10^{-6} R_x$
			10 Ω		$1{,}0 \cdot 10^{-6} R_x$
			100 Ω		$1{,}5 \cdot 10^{-6} R_x$
			1 kΩ		$2{,}0 \cdot 10^{-6} R_x$
			10 kΩ		$2{,}0 \cdot 10^{-6} R_x$
			100 kΩ		$6{,}0 \cdot 10^{-6} R_x$
			1 MΩ		$8{,}0 \cdot 10^{-6} R_x$
			10 MΩ		$8{,}0 \cdot 10^{-6} R_x$

Objects submitted to calibration	Characteristics or properties measured	Calibration methods	Measuring range	Calibration and Measurement Capability (CMC)
			100 MΩ	$30 \cdot 10^{-6} R_x$
			1 GΩ	$100 \cdot 10^{-6} R_x$
			R_x: 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)			
General Domain: CAL2 – Time / Frequency							
Technical Domain: CAL2.1 – Frequency counters							
CAL 2.1.5 – Multimeters / Calibrators – Square wave	Frequency	CMC-50 Measured using a frequency counter with a Caesium frequency standard[1]	1 mHz ≤ F_x < 10 mHz	$2{,}9 \cdot 10^{-12}$	$5{,}8 \cdot 10^{-11}$	$1{,}9 \cdot 10^{-9}$	$5{,}7 \cdot 10^{-8}$
			10 mHz ≤ F_x < 100 mHz	$2{,}3 \cdot 10^{-12}$	$1{,}9 \cdot 10^{-11}$	$5{,}7 \cdot 10^{-10}$	$1{,}9 \cdot 10^{-8}$
			100 mHz ≤ F_x <1 Hz		$6{,}8 \cdot 10^{-12}$	$1{,}9 \cdot 10^{-10}$	$5{,}7 \cdot 10^{-9}$
			1 Hz ≤ F_x < 10 Hz		$4{,}2 \cdot 10^{-12}$	$5{,}8 \cdot 10^{-11}$	$1{,}9 \cdot 10^{-9}$
			10 Hz ≤ F_x < 100 Hz		$3{,}8 \cdot 10^{-12}$	$2{,}1 \cdot 10^{-11}$	$5{,}7 \cdot 10^{-10}$
			100 Hz ≤ F_x < 1 kHz			$1{,}2 \cdot 10^{-11}$	$1{,}9 \cdot 10^{-10}$
			1 kHz ≤ F_x < 10 kHz			$1{,}1 \cdot 10^{-11}$	$5{,}9 \cdot 10^{-11}$
			10 kHz ≤ F_x < 100 kHz				$2{,}4 \cdot 10^{-11}$
			100 kHz ≤ F_x < 1 MHz				$1{,}7 \cdot 10^{-11}$
			1 MHz ≤ F_x < 12,4 GHz				$1{,}6 \cdot 10^{-11}$
			12,4 GHz ≤ F_x < 26,5 GHz	-	-	-	$2{,}1 \cdot 10^{-10}$

[1] 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)			
CAL 2.1.6 – Multimeters / Calibrators – Sine wave	Frequency	CMC-50 Measured using a frequency counter with a Caesium frequency standard[2]	1 mHz ≤ F_x < 10 mHz	$1{,}4 \cdot 10^{-3}$	-	-	-
			10 mHz ≤ F_x < 100 mHz	$4{,}3 \cdot 10^{-5}$	$1{,}4 \cdot 10^{-3}$	-	-
			100 mHz ≤ F_x < 1 Hz	$1{,}4 \cdot 10^{-6}$	$4{,}3 \cdot 10^{-5}$	$1{,}4 \cdot 10^{-3}$	-
			1 Hz ≤ F_x < 10 Hz	$4{,}3 \cdot 10^{-8}$	$1{,}4 \cdot 10^{-6}$	$4{,}3 \cdot 10^{-5}$	$1{,}4 \cdot 10^{-3}$
			10 Hz ≤ F_x < 100 Hz	$1{,}4 \cdot 10^{-9}$	$4{,}3 \cdot 10^{-8}$	$1{,}4 \cdot 10^{-6}$	$4{,}3 \cdot 10^{-5}$
			100 Hz ≤ F_x < 1 kHz	$4{,}3 \cdot 10^{-11}$	$1{,}4 \cdot 10^{-9}$	$4{,}3 \cdot 10^{-8}$	$1{,}4 \cdot 10^{-6}$
			1 kHz ≤ F_x < 10 kHz	$2{,}7 \cdot 10^{-12}$	$4{,}3 \cdot 10^{-11}$	$1{,}4 \cdot 10^{-9}$	$4{,}3 \cdot 10^{-8}$
			10 kHz ≤ F_x < 100 kHz	$2{,}3 \cdot 10^{-12}$	$4{,}0 \cdot 10^{-12}$	$4{,}4 \cdot 10^{-11}$	$1{,}4 \cdot 10^{-9}$
			100 kHz ≤ F_x < 1 MHz		$3{,}8 \cdot 10^{-12}$	$1{,}1 \cdot 10^{-11}$	$4{,}6 \cdot 10^{-11}$
			1 MHz ≤ F_x < 12,4 GHz				$1{,}7 \cdot 10^{-11}$
			12,4 GHz ≤ F_x < 26,5 GHz	-	-	-	$2{,}1 \cdot 10^{-10}$

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

Table 1: Matrix CMC-31-fix

Input		Expanded Relative Uncertainty of Measurement U in 10^{-6} at Frequencies of:												
Range	**Voltage**	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
22 mV	2 mV	730	690	630	620	650	610	620	660	610	660	780	750	810
	6 mV	290	230	240	230	240	240	240	250	260	310	410	470	600
	10 mV	220	250	190	190	190	190	190	190	210	280	380	510	610
	20 mV	110	77	77	77	81	74	76	76	88	170	270	410	510
220 mV	20 mV	110	76	76	76	72	77	74	74	88	170	270	410	500
	60 mV	54	38	38	39	39	39	39	45	74	160	270	400	520
	100 mV	35	21	21	23	20	21	22	34	52	150	250	390	490
	200 mV	26	17	16	16	15	15	18	28	51	150	250	390	490
700 mV	200 mV	26	17	16	16	14	15	17	28	51	150	250	390	490
	600 mV	22	15	15	15	9	10	14	27	51	150	250	390	490
2.2 V	600 mV	30	15	15	15	9	14	17	28	51	150	250	390	490
	1 V	30	11	6	8	8	14	16	28	51	150	250	390	490
	2 V	33	11	8	8	10	15	16	28	51	150	250	390	490
7 V	2 V	27	12	8	8	8	10	14	27	50	150	250	390	490
	6 V	27	11	8	8	6	10	14	27	51	150	250	390	490
22 V	6 V	28	11	6	8	6	9	12	26	50	150	250	390	490
	10 V	33	14	6	6	6	9	12	26	50	150	250	390	490
	20 V	28	11	9	9	10	11	14	27	50	150	250	390	490
70 V	20 V	26	14	9	9	9	10	14	32	50	150	250	390	490
	60 V	32	14	10	10	11	12	16	32	53	150	-	-	-
220 V	60 V	28	12	11	10	11	11	15	27	52	150	-	-	-
	100 V	28	15	15	15	16	18	22	36	63	-	-	-	-
	200 V	35	17	16	16	17	18	20	35	64	-	-	-	-

		Expanded Relative Uncertainty of Measurement U in 10^{-6} at Frequencies of:												
1000 V	200 V	34	16	16	16	15	16	18	29	62	-	-	-	-
	600 V	-	-	16	16	16	17	18	30	71	-	-	-	-
	1000 V	-	-	22	17	16	17	18	-	-	-	-	-	-

Table 2: Matrix CMC-31-var

Input		Expanded Relative Uncertainty of Measurement U in 10^{-6} at Frequencies of:											
Range	**Voltage**	10 -20 Hz	20 -40 Hz	40-120 Hz	120 Hz - 1 kHz	1 - 10 kHz	10 -20 kHz	20 -50 kHz	50 -100 kHz	100 - 300 kHz	300 - 500 kHz	500 - 800 kHz	800 kHz - 1 MHz
22 mV	2 - 6 mV	730	690	630	650	650	620	660	660	660	780	780	810
	6 - 10 mV	290	260	250	250	250	250	250	260	310	410	510	610
	10 - 20 mV	260	260	190	190	190	190	200	210	280	380	510	610
220 mV	20 - 60 mV	110	90	90	90	90	90	80	100	170	280	410	520
	60 - 100 mV	62	47	48	48	48	48	53	80	170	270	400	520
	100 - 200 mV	46	35	36	36	35	36	45	59	160	250	390	490
700 mV	200 - 600 mV	39	34	33	33	33	34	40	58	150	250	390	490
2.2 V	600 mV - 1 V	42	33	33	33	32	34	40	58	150	250	390	490
	1 - 2 V	44	30	29	30	33	33	40	58	150	250	390	490
7 V	2 - 6 V	39	32	29	29	30	32	39	58	150	250	390	490
22 V	6 - 10 V	44	32	29	29	30	32	39	58	150	250	390	490
	10 - 20 V	44	32	30	30	30	32	39	58	150	250	390	490
70 V	20 - 60 V	42	32	30	30	32	33	42	60	160	-	-	-
220 V	60 - 100 V	40	33	33	33	34	36	46	69	-	-	-	-
	100 - 200 V	46	34	33	34	34	36	46	70	-	-	-	-
1000 V	200 - 600 V	-	-	33	33	34	34	42	77	-	-	-	-
	600 - 1000 V	-	-	36	34	34	34	-	-	-	-	-	-

Table 3: Matrix CMC-41-fix

	Expanded Relative Uncertainty of Measurement I in 10^{-6} at Frequencies of:										
Input Current	10 Hz	20 Hz	30 Hz	40 Hz	55 Hz	400 Hz	500 Hz	1 kHz	2 kHz	5 kHz	10 kHz
10 mA	69	51	68	49	50	48	50	49	69	51	53
30 mA	73	70	74	70	71	74	74	69	74	71	74
100 mA	59	58	58	54	55	53	59	52	56	57	51
300 mA	110	110	100	100	100	93	89	91	120	92	92
1 A	71	64	64	61	59	64	65	59	68	63	71
3 A	120	130	96	110	90	91	94	95	99	110	92
10 A	74	73	73	69	69	67	77	68	74	76	72

Table 4: Matrix CMC-41-var

	Expanded Relative Uncertainty of Measurement I in 10^{-6} at Frequencies of:									
Input Range	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
5 mA - 10 mA	73	72	72	56	56	55	55	73	73	58
10 mA - 30 mA	77	78	78	75	77	77	77	78	78	78
30 mA - 100 mA	64	32	32	30	30	32	32	31	31	31
100 mA - 300 mA	110	110	110	110	110	96	94	120	120	95
0.3 A - 1 A	75	68	68	66	69	70	70	73	73	75
1 A - 3 A	140	140	110	110	95	97	98	110	110	110
3 A - 10 A	78	77	77	73	73	81	81	78	80	80