9020 Multifunction Calibrator

HIGHLIGHTS

- **AC/DC voltage/current up to 1050V/30A**
- **Basic uncertainty 9 ppm**
- **AC/DC power, energy, resistance, capacitance, frequency, TC, RTD**
- **Scope options up to 1100 MHz**
- **High voltage resistance option for 1.5 kV insulation testers**
- **Built-in process multimeter**
- **RS232, LAN, USB and GPIB interfaces as standard**

DESCRIPTION

Multifunction calibrator 9020 is designed as universal calibration tool for electrical calibration laboratories, covering most of their workload like multimeters, 6½ digit DMMs, clamp meters, ohm meters, power meters and power analyzers, energy meters, transducers, insulation testers, process meters, scopes and many others. High load capacity of both voltage (up to 50 mA) and current output allows for calibration of high-consumption analogue meters. Installed harmonic and non-harmonic shape signals allow for testing meter sensitivity to distorted signals by a signal with various crest factor.

Compared to its predecessor, 9020 brings wider frequency ranges in both AC voltage and AC current functions, improved accuracy in most functions, 2MHz frequency output with duty cycle and advanced impedance source to match the latest 6½ digit DMM workload.

9020 calibrator can be fully integrated into commonly used calibration automation platforms. Unique camera readout module CamOCR, available in Meatest's SW package Caliber/WinQbase, allows for semi-automated calibrations of multimeters with no remote control interface.

Option	Description
SCO / SC1	Scope extension for calibration of oscilloscopes up to 400 MHz (1.1 GHz with SC1). Comes with N/BNC adapter.
HVR	High voltage resistance extension for calibration of insulation testers and megaohmmeters up to 1.5 kV. Comes with 191-11 5kV cable.
MER	Multimeter extension for calibration of transducers and imulation of strain gauges and other industrial sensors. Comes with 9000-60 cable.

SPECIFICATION

Specifications below describe 1-year absolute uncertainty at a confidence interval of 95%, including long-term stability, linearity, load and line regulation and reference standard measurement uncertainty as well as ambient conditions within specified limits.

GENERAL DATA

Warm-up time	30 minutes
Reference temperature	+21 °C – +25 °C
Operating temperature	+13 °C – +33 °C
Storage temperature	-10 °C – +55 °C
Temperature coefficient	10 % of accuracy / °C outside T_{REF}
Max relative humidity	70 %
Power supply	115/230V - 50/60 Hz, 450 VA max
EMC compliance	Safety class I according to IEC 61010 ed. 2 ESD class I according to EN 61326 Overvoltage CAT II
Dimensions (W x H x D)	434 x 191 x 641 mm
Weight	24 - 25 Kg depending on options installed
Interfaces	RS232, IEEE488, USB, Ethernet

DC/AC Voltage

Voltage range summary	DC: 0 mV – 1050 V AC sine: 1 mV_{RMS} – 1050 V_{RMS} Non-sine: 1 mV_{RMS} – 200 V_{RMS}
Internal ranges	20 mV, 200 mV, 2 V, 20 V, 100V, 280 V, 1050 V
Frequency accuracy and resolution	5 ppm, 5 digit
Non-sine waveform types	saw, triangle, square, truncated sin; 1kHz max; uncertainty: 0.21 % + 0.1 % of range + 70 μV_{PK}
Voltage output modes	passive 50Ω output up to 200 mV_{DC} active output in all DC and AC ranges

Ranges, resolution, 1 year uncertainty [ppm of value]

Range	DC	3 Hz – 10 Hz	10 Hz – 20 kHz	20 kHz – 50 kHz	50 kHz – 100 kHz	100 – 300 kHz
1.00000 – 20.00000 mV	30 + 1.5 µV *1	2 500 + 25 µV	1 400 + 15 µV	1 500 + 30 µV	2 500 + 35 µV	4 500 + 100 µV
20.0000 – 200.0000 mV	15 + 1.5 µV *1	2 150 + 20 µV	250 + 10 µV	350 + 15 µV	1 000 + 50 µV	4 500 + 100 µV
0.200000 – 2.000000 V	11 + 4 µV	2 150 + 100 µV	165 + 90 µV	300 + 100 µV	700 + 200 µV	2 000 + 800 µV
2.00000 – 20.00000 V*2	8 + 25 µV	2 150 + 1 mV	160 + 700 µV	300 + 1.2 mV	600 + 2 mV	2 000 + 5 mV
20.0001 – 100.0000 V	13 + 150 µV	2 150 + 6 mV	180 + 5 mV	300 + 14 mV	1 000 + 14 mV	N/A
100.0001 – 280.0000 V *3	15 + 300 µV	2 150 + 13 mV	180 + 10 mV	300 + 40 mV	N/A	N/A
280.000 – 1050.000 V *4	20 + 3.5 mV	N/A	250 + 30 mV	N/A	N/A	N/A

*1 Uncertainty in passive mode. Active mode uncertainty is 100 ppm + 10 µV and 15 ppm + 10 µV respectively.
*2 Frequency is limited to 100 kHz above 12 V.
*3 Frequency is limited to 3 Hz – 10 kHz above 210 V.
*4 Frequency is limited to 20 Hz – 10 kHz.

Distortion and Load Characteristics

Parameter	Range	20mV	200mV	2V	20V	100 V	280V	1050V
THD + noise *5	3 – 10 Hz	0.25 % + 200 µV	0.25 % + 300 µV	0.25 %	0.25 %	0.25 %	0.25 %	N/A
	10 – 45 Hz	0.05 % + 200 µV	0.05 % + 300 µV	0.15 %	0.15 %	0.15 %	0.15 %	0.25 %
	45 – 20000 Hz	0.05 % + 200 µV	0.05 % + 300 µV	0.05 %	0.05 %	0.05 %	0.05 %	0.20 %
	20 – 50 kHz	0.25 % + 200 µV	0.25 % + 300 µV	0.12 %	0.15 %	0.3 %	0.7 %	N/A
	50 – 100 kHz	0.35 % + 230 µV	0.35 % + 300 µV	0.22 %	0.3 %	0.5 %	N/A	N/A
	100 – 300 kHz	1.5 % + 500 µV	1 % + 700 µV	0.7 %	2.5 %	N/A	N/A	N/A
Burden current	DC active	1 mA	5 mA	30 mA	50 mA	50 mA	50 mA	5 mA
	3 – 20000 Hz	0.5 mA_{RMS}	4 mA_{RMS}	30 mA_{RMS}	50 mA_{RMS}	50 mA_{RMS}	40 mA_{RMS}	4 mA_{RMS}
	20 – 50 kHz	0.5 mA_{RMS}	4 mA_{RMS}	10 mA_{RMS}	10 mA_{RMS}	10 mA_{RMS}	10 mA_{RMS}	N/A
	50 – 100 kHz	0.5 mA_{RMS}	2 mA_{RMS}	5 mA_{RMS}	5 mA_{RMS}	N/A	N/A	N/A
	100 – 300 kHz	100 Ω min. load	100 Ω min. load	1 mA_{RMS}	5 mA_{RMS}	N/A	N/A	N/A

*5 THD in bandwidth up to 500 kHz or 10 lowest harmonics.

DC/AC Current

Current range summary	DC: 0.0000 µA – 30.00000 A AC Sine: 10.0000 μA_{RMS} – 30.00000 A_{RMS} Non-sine: 100.0000 μA_{RMS} – 2.000000 A_{RMS}
Internal ranges	200 µA, 2 mA, 20 mA, 200 mA, 2 A, 20.5 A, 30 A
Frequency accuracy and resolution	5 ppm, 5 digit
Non-sine waveform types	saw, triangle, square, truncated sin; 1kHz max.
Non-sine amplitude uncertainty	0.21 % of value + 0.1 % of range + 0.7 μA_{pk}

Ranges, resolution, 1 year uncertainty [ppm of value]

Range	DC	10 Hz – 1 kHz	1 kHz – 5 kHz	5 kHz – 10 kHz	10 kHz – 30 kHz
10.0000 – 200.0000 µA	200 + 12 nA	400 + 20 nA *6	450 + 25 nA*6	3 000 + 100 nA *6	5 500 + 900 nA *6
0.200000 – 2.000000 mA	150 + 30 nA	400 + 150 nA	450 + 200 nA	2 500 + 600 nA	4 000 + 5 µA
2.00000 – 20.00000 mA	100 + 600 nA	300 + 1 µA	400 + 2 µA	2 000 + 6 µA	4 000 + 10 µA
20.0000 – 200.0000 mA	100 + 2 µA	300 + 20 µA	400 + 25 µA	2 000 + 60 µA	4 000 + 100 µA
0.200000 – 2.00000 A *7	160 + 50 µA	300 + 100 µA	450 + 250 µA	2 500 + 500 µA	12 000+ 800 µA
2.00000 – 20.50000 A	250 + 500 µA	650 + 3 mA	N/A	N/A	N/A
20.50000 – 30.00000 A *8	450 + 750 µA	1 200 + 5 mA	N/A	N/A	N/A

*6 Accuracy not specified below 10 µA.
*7 Frequency is limited to 10 kHz above 500 mA.
*8 Continuous operation in case of good air flow and in reference temperature range. Built-in overheat sensor.

Distortion and Load Characteristics

Parameter	Range	200µA	2mA	20mA	200mA	2A	30A
Max. inductive load	10 Hz – 30 kHz	1 H	100 mH	100 mH	10 mH	1 mH	500 µH
THD + noise *9	10 Hz – 1 kHz	0.2 %	0.2 %	0.2 %	0.2 %	0.2 %	0.3 %
	1 kHz – 5 kHz	0.2 %	0.2 %	0.2 %	0.2 %	0.2 %	N/A
	5 kHz – 10 kHz	0.5 %	0.4 %	0.4 %	0.4 %	1.5 %	N/A
	10 kHz – 30 kHz	0.8 %	0.8 %	0.8 %	0.8 %	N/A	N/A
Compliance voltage	DC	5 V	5 V	10 V	10 V	5 V	5 V
	10 Hz – 1 kHz	4 V_{rms}	4 V_{rms}	5 V_{rms}	5 V_{rms}	3.5 V_{rms}	3 V_{rms}
	1 kHz – 5 kHz	4 V_{rms}	4 V_{rms}	5 V_{rms}	5 V_{rms}	3.5 V_{rms}	N/A
	5 kHz – 10 kHz	2 V_{rms}	2 V_{rms}	2 V_{rms}	2 V_{rms}	1.5 V_{rms}	N/A
	10 kHz – 30 kHz	1 V_{rms}	1 V_{rms}	1 V_{rms}	1 V_{rms}	N/A	N/A
Load adder *10	DC	50 nA/V	50 nA/V	200 nA/V	2 µA /V	100 µA/V	500 µA/V
	10 Hz – 1 kHz	70 nA/V	100 nA/V	200 nA/V	2 µA /V	100 µA/V	500 µA/V
	1 kHz – 5 kHz	1.5 µA/V	1.5 µA/V	1.5 µA/V	2 µA/V	200 µA/V	N/A
	5 kHz – 10 kHz	2 µA/V	2 µA/V	2 µA/V	3 µA/V	3 000 µA/V	N/A
	10 kHz – 30 kHz	4 µA/V	5 µA/V	10 µA/V	10 µA/V	N/A	N/A

*9 THD in bandwidth up to 100 kHz
*10 Additional uncertainty for compliance voltage above 0.5 VRMS

Voltage from current

Voltage range	2.5000 mV – 5.00000 V
Waveform	DC, 10.000 Hz – 400.00 Hz sine
Amplitude uncertainty	0.05 % + [0.02 – 0.04] % of range
Distortion	< 0.1 % in 100 kHz bandwidth
Source impedance	2.2, 22 or 220 Ω

Current coil (option 0950)

Applicable multiplier	2 – 200
Max. simulated current	multiplier × 30 A (1500 A with 0950 Current Coil)
Frequency range	45 – 65 Hz
Additional uncertainty	0.3 % with 0950 Current Coil

Frequency

Frequency range	0.10000 Hz – 2.00000 MHz
Frequency accuracy	5 ppm
Waveform type	positive 100 mVpk, 1 Vpk, 3 Vpk
Amplitude accuracy	20 %

Duty cycle

Duty cycle range	0.1 % – 99.9 %
Accuracy	0.05 %
Frequency range	0.1 Hz – 1 kHz
Voltage range	1 mV_{pk} – 28.2 V_{pk}
Amplitude accuracy	0.5 % + 100 µV

Resistance

Resistance range summary	0.0000 Ω – 100.0000 kΩ in 4W 0.0000 Ω – 1.100000 GΩ in 2W
Modes	2W, 2W COMP and 4W

Resistance modes, 1 year uncertainty [ppm of value + absolute]

Variable range *11	Uncertainty *12
0.0000 – 10.0000 Ω	35 + 2 mΩ
10.0001 – 33.0000 Ω	30 + 2 mΩ
33.0001 – 100.0000 Ω	30 + 3 mΩ
100.0001 – 200.0000 Ω	30 + 3 mΩ
200.001 – 1000.000 Ω	30 + 3 mΩ
1000.001 – 2000.000 Ω	30 + 30 mΩ
2.00001 – 10.00000 kΩ	30 + 30 mΩ
10.00001 – 20.00000 kΩ	30 + 300 mΩ
20.0001 – 100.0000 kΩ	30 + 300 mΩ
100.0001 – 200.0000 kΩ	30 + 3 Ω
200.001 – 330.000 kΩ	30 + 3 Ω
330.001 – 1000.000 kΩ	50 + 3 Ω
1000.001 – 2000.000 kΩ	50 + 30 Ω
2.00001 – 3.30000 MΩ	50 + 30 Ω
3.30001 – 10.00000 MΩ	100 + 30 Ω
10.00001 – 20.00000 MΩ	2000 + 300 Ω
20.0001 – 100.0000 MΩ	2000 + 300 Ω
100.0001 – 200.0000 MΩ	3000 + 3 kΩ
200.001 – 330.000 MΩ	3000 + 3 kΩ
330.001 – 1100.000 MΩ	10000 + 10 kΩ

Fixed nominal value	Uncertainty *13
0.0000 Ω	< 0.5 mΩ
0.1000 Ω	0.5 mΩ
1.0000 Ω	0.5 mΩ
10.0000 Ω	1 mΩ
33.0000 Ω	2 mΩ
100.0000 Ω	3 mΩ
330.0000 Ω	25 ppm
1 000.000 Ω	15 ppm
3 300.000 Ω	15 ppm
10.00000 kΩ	15 ppm
33.00000 kΩ	15 ppm
100.0000 kΩ	15 ppm
330.0000 kΩ	20 ppm
1 000.000 kΩ	20 ppm
3 300.000 kΩ	80 ppm
10.00000 MΩ	130 ppm
33.00000 MΩ	250 ppm
100.0000 MΩ	1000 ppm
330.0000 MΩ	1500 ppm
1 000.000 MΩ	2500 ppm

*11 Range boundaries are based on calibration values of fixed resistance mode standards and as such may deviate from nominal values by up to 5%.

*12 Uncertainty in 4W and 2W COMP modes. Add 30 mΩ in 2W mode. Uncertainty is specified for test voltages above 0.1 V

*13 Uncertainty in 4W mode. Add 30 + (0.015 / test current) milliohms in 2W mode.

Capacitance

Capacitance range summary	0.600000 nF – 120.0000 mF in 2W
Modes	2W continuous range 2W fixed standards

Capacitance modes, 1 year uncertainty and frequency limits

Variable range *14	Uncertainty
0.600000 – 2.000000 nF	0.15 % + 10 pF
2.00001 – 3.30000 nF	0.15 % + 10 pF
3.30001 – 20.00000 nF	0.15 %
20.0001 – 33.0000 nF	0.15 %
33.0001 – 100.0000 nF	0.15 %
100.0001 – 200.0000 nF	0.15 %
0.200001 – 2.000000 µF	0.15 %
2.00001 – 3.30000 µF	0.15 %
3.30001 – 10.00000 µF	0.15 %
10.00001 – 20.00000 µF	0.15 %
20.0001 – 33.0000 µF	0.15 %
33.0001 – 100.0000 µF	0.15 %
100.0001 – 200.0000 µF	0.25 %
0.200001 – 1.100000 mF	0.25 %
1.100001 – 2.000000 mF	0.25 %
2.00001 – 11.00000 mF	0.25 %
11.00001 – 20.00000 mF	0.25 %
20.0001 – 120.0000 mF	0.45 %

*14 Range boundaries up to 1.1 mF are based on calibration values of fixed capacitance mode standards and as such may deviate from nominal values by up to 10 %.

Fixed nominal value	Uncertainty*15
1.000000 nF	0.30 %
3.300000 nF	0.25 %
10.00000 nF	0.12 %
33.00000 nF	0.12 %
100.0000 nF	0.12 %
330.0000 nF	0.12 %
1.000000 µF	0.12 %
3.300000 µF	0.12 %
10.00000 µF	0.12 %
33.00000 µF	0.15 %
100.0000 µF	0.15 %

*15 Specification applies to Relative mode of capacitance, for Absolute mode add additional floor 15 pF.

Temperature (RTD, TC)

RTD temperature standards	Pt3850, Pt3851, Pt3916, Pt3926, Ni120, custom
RTD R_0 range	20 Ω – 2 kΩ
Thermocouple types	B,C,D,E,G_2,J,K,M,N,R,S,T
TC cold junction compensation	Manual or automatic with adapter 91
Uncertainty	0.02 °C – 0.08 °C in RTD 0.18 °C – 0.96 °C in TC

AC/DC Power & Energy

Range summary	power:	40 µW – 31.5 kW
	voltage:	0.2 V – 1050 V
	current:	0.2 mA – 30 A
	frequency:	DC, 15 – 1000 Hz
	time period:	2 s – 1 hour
Total uncertainty	based on voltage, current, phase shift and energy period specifications.	
Phase shift uncertainty	0.15° up to 200 Hz 0.25° above 200 Hz 0.5° in 1050V range, 20 – 500 Hz	
Energy period uncertainty	0.01% + 0.3 s	
Additional features	Harmonic distortion, voltage from current, current coil multiplication	

Total 1 year power accuracy in common applications [% of value]

Set current	EU grid power (230 V, 50 Hz)	US grid power (115 V, 60 Hz)	Aircraft onboard power (115 V, 400 Hz)	Ship onboard power (440 V, 60 Hz)
100 mA	0.071 %	0.071 %	0.071 %	0.074 %
1 A	0.069 %	0.069 %	0.069 %	0.073 %
10 A	0.111 %	0.111 %	0.111 %	0.114 %
30 A	0.142 %	0.142 %	0.142 %	0.144 %

Harmonic distortion (all AC functions)

Number of products	50	
Fundamental harmonic uncertainty	amplitude:	≥ 0.2% of range
	frequency:	25 ppm
	phase shift:	0.2 – 0.5 °
Frequency range	1st product:	15 – 1000 Hz
	2nd – 50th product:	30 – 5000 Hz
Harmonic product amplitude range	0 – 30 % of fundamental	
Harmonic product phase shift unc.	5 µs (typical)	

MER Multimeter option

Measurement function	Range	Uncertainty
DC voltage	12 mV 120 mV, 1.2 V, 12 V	50 ppm + 3 µV 50 ppm + [5 – 500] µV
DC current	100 µA, 1 mA 2.4 mA, 24 mA	200 ppm + [20 – 100] nA 150 ppm + 800 nA
Frequency	0.1 Hz – 100 kHz	50 ppm
Resistance *16	2 kΩ, 20 kΩ	200 ppm + [10 – 50] mΩ
RTD temperature *16	Pt3850, Pt3851, Pt3916, Pt3926, Ni120, custom	0.08 – 0.42 °C
TC temperature	BCDEG$_2$JKMNRST	0.22 – 1 °C

*16 Using 9000-60 4W measurement adapter (comes as standard with MER option)

HVR High Voltage Resistance option

Resistance range	Maximum test voltage	Resistance uncertainty	Test voltage uncertainty
100 – 200 kΩ	800 V_{DC}	0.2 %	0.3 % + 2 V
200 kΩ - 1 MΩ	1100 V_{DC}	0.2 %	0.3 % + 2 V
1 – 10 MΩ	1150 V_{DC}	0.3 %	0.5 % + 5 V
10 MΩ – 1 GΩ	1500 V_{DC}	0.5 %	0.5 % + 5 V
1 – 10 GΩ	1500 V_{DC}	1.0 %	1 % + 5 V
100 GΩ (fixed standard)	1500 V_{DC}	3.0 %	1.5 % + 5 V

SCO Frequency / Scope option

HF mode (levelled sine)

Amplitude range: 1.400 m V_{PK} – 1.5000 V_{PK}

Freq. range	15 Hz – 100 kHz	100 – 500 kHz	0.5 – 10 MHz	10 – 100 MHz	100 – 400 MHz
Harmonic distortion	-55 dB	-38 dB (< 10 dBm)	-38 dB (< 10 dBm)	-38 dB (< 10 dBm)	-30 dB (< 10 dBm)
Flatness	< 0.2 % + 100 μV_{PK}	< 0.7 % + 100 μV_{PK}	< 1.2 % + 100 μV_{PK}	< 2.0 % + 200 μV_{PK}	< 2.5 % + 200 μV_{PK}
Amplitude uncertainty	0.5 % + 350 μV_{PK}	2.0 % + 250 μV_{PK}	2.5 % + 250 μV_{PK}	3.3 % + 250 μV_{PK}	3.7 % + 250 μV_{PK}

LF mode (DC, square wave)

High voltage range	0 – 200 V_{PK} at 1 kHz max, 0.3 % amplitude uncertainty
Low voltage range	0 – 10.5 V_{PK} at 100 kHz max, 0.1 – 0.2 % amp. uncertainty

PULSE WIDTH and TIME MARKER modes

Frequency range	0.1 Hz – 400 MHz
Frequency uncertainty	2.5 ppm
Amplitude ranges	50 mV_{PK}, 100 mV_{PK}, 500 mV_{PK}, 1 V_{PK}
Duty cycle ratios	1 – 50 %
TM waveforms	PWM up to 25 MHz, 2 ns spike otherwise
Jitter	< 2 ns
Rise time	< 1 ns

TRIGGER mode

Amplitude	> 1 V_{PK}
Division ratio	off, /1, /10, /100
Frequency range	15 Hz – 400 MHz
Rise time	< 1 ns

Input impedance measurement

Ranges	100 Ω, 2 MΩ
Measurement accuracy	0.1 % in 10 – 100 % of range

SC1 Frequency / Scope option

HF mode (levelled sine)

Amplitude range: 1.400 mV_{PK} – 1.5000 V_{PK} up to 1 GHz

1.400 mV_{PK} – 1.0000 V_{PK} above 1 GHz

Freq. range	15 Hz – 100 kHz	100 – 500 kHz	0.5 – 10 MHz	10 – 100 MHz	100 – 600 MHz	600 – 1100 MHz
Harmonic distortion	-55 dB	-33 dB (< 10 dBm)	-33 dB (< 10 dBm)	-33 dB (< 10 dBm)	-30 dB (< 10 dBm)	-30 dB (< 10 dBm)
Flatness	< 0.2 % + 100 μV_{PK}	< 0.7 % + 100 μV_{PK}	< 1.2 % + 100 μV_{PK}	< 2.0 % + 100 μV_{PK}	< 2.5 % + 200 μV_{PK}	< 4.5 % + 200 μV_{PK}
Amplitude uncertainty	0.5 % + 350 μV_{PK}	2.0 % + 250 μV_{PK}	2.5 % + 250 μV_{PK}	3.3 % + 250 μV_{PK}	3.7 % + 250 μV_{PK}	6.5 % + 300 μV_{PK}

PULSE WIDTH and TIME MARKER modes

Frequency range	0.1 Hz – 400 MHz square wave
	400 – 1100 MHz sine
Frequency uncertainty	0.1 ppm
Amplitude ranges	50 mV_{PK}, 100 mV_{PK}, 500 mV_{PK}, 1 V_{PK}
Duty cycle ratios	1 – 50 %
TM waveforms	PWM up to 25 MHz, 2 ns spike otherwise
Jitter	< 2 ns
Rise time	< 1 ns

LF mode, TRIGGER mode and Input impedance measurement function specifications are the same as in SCO option.