FLUKE®

Calibration

9500C
Oscilloscope Calibrator
9540C
Active Head™

Product Specifications

10/2024 (English)

Specifications

The performance specifications describe the complete instrumental uncertainty of the Product. The specifications include stability, temperature, and humidity; within specified limits, linearity, line and load regulation, and the reference standard measurement uncertainty. The product specifications are provided at a level of confidence of 99 %, k=2.58, normally distributed.

Specifications are valid after allowing a warm-up period of 20 minutes, or twice the time the Product has been turned off, whichever is shorter.

General Specifications

Mains Power	Line Voltage (automatic selection): 100 V to 240 V Line Frequency: 47 Hz to 63 Hz
Fuse ratings	T 5.0 AH 250 V
Max Power Consumption	250 VA max
Dimensions (HxWxL)	
Base unit	190 mm x 433 mm x 488 mm (7.5 in x 17 in x 19 in)
Active Head™	46 mm x 22 mm x 94 mm (2 in x 1 in x 4 in)
Weight (without options)	
Base unit	13.1 kg (29 lb)
Active Head™	0.215 kg, 0.360 kg (including cables), 0.474 lb, 0.794 lb (including cables)
Environment	
Temperature	
Operating (Base unit)	0 °C to 40 °C (32 ° F to 104 ° F)
Operating (Heads)	0 °C to 50 °C (32 ° F to 122 ° F)
Specified operation	TCal ±5 °C, where Factory TCal = 23 °C
Calibration (tcal)	20 °C to 25 °C (68 °F to 75 °F)
Storage	-20 °C to 70 °C (-4 °F to 158 °F)
Warm up	20 minutes, Complies with MIL-PRF-28800F
Relative Humidity	
Operating	<90 %, 5 °C to 30 °C (41 °F to 86 °F) <75 %, 30 °C to 40 °C (86 °F to 104 °F) <45 %, 40 °C to 50 °C (104 °F to 122 °F)
Storage	<95 %, 0 °C to 70 °C (32 °F to 158 °F)
Altitude	
Operating	<3000 m
Non-operating	12 200 m (40 000 ft) maximum
Vibration and Shock	Complies with MIL-PRF-28800F Class 3

Electromagnetic Compatibility (EMC)	
International	IEC 61326-1: Controlled Electromagnetic Environment CISPR 11: Group 1, Class A *Group 1: Equipment has intentionally generated and/or uses conductively-coupled radio frequency energy that is necessary for the internal function of the equipment itself.* *Class A: Equipment is suitable for use in all establishments other than domestic and those directly connected to a low-voltage power supply network that supplies buildings used for domestic purposes. There may be potential difficulties in ensuring electromagnetic compatibility in other environments due to conducted and radiated disturbances.* *Caution: This equipment is not intended for use in residential environments and may not provide adequate protection to radio reception in such environments.* *Emissions that exceed the levels required by CISPR 11 can occur when the equipment is connected to a test object.*
Korea (KCC)	Class A Equipment (Industrial Broadcasting & Communication Equipment) *Class A: Equipment meets requirements for industrial electromagnetic wave equipment and the seller or user should take notice of it. This equipment is intended for use in business environments and not to be used in homes.*
USA (FCC)	47 CFR 15 subpart B. This product is considered an exempt device per clause 15.103.
Safety	IEC 61010-1: Overvoltage Category II, Pollution Degree 2; IEC 61010-2-030 (Test and Measurement)
Remote Interfaces	IEEE 488.2

Voltage Function - Specifications

Function	DC into 1 MΩ[1]	DC into 50 Ω[1] [2]	Square Wave into 1 MΩ[1]	Square Wave into 50 Ω[1] [2]
Amplitude[3]	±1 mV to ±200 V	±1 mV to ±5 V	40 µV to 200 V_{pk-pk}	40 µV to 5 V_{pk-pk}
Specification (≤10 kHz)[4]	±0.01 % + 10 µV	0.025 % + 10 µV	≥1 mV: ±(0.1 % + 10 µV) <1 mV: ±(1 % + 10 µV)	
Frequency	---	---	10 Hz to 100 kHz[4]	
Frequency Specification [5]	---	---	Internal frequency reference: ±(0.15 µHz/Hz + 10 mHz) External frequency reference: ±(Ext Freq Ref Accuracy + 10 mHz)	
Frequency Ranging	---	---	1, 2, 5; or 1, 2, 2.5, 4, 5; or continuously variable	
Ranging	Volt/Div factors of 1, 2, 5; or 1, 2, 2.5, 4, 5; or continuously variable			
Deviation	±11.2 % (including over and under range)			

[1] Simultaneous multi-channel output is available.
[2] Specification excludes variability of resistance losses in mating BNC connectors.
[3] The Product settles within specifications within 350 ms, however the output will continue to stabilize for a further period depending on the load, the number of channels, and the environmental conditions.
[4] Square Wave output available up to 100 kHz, but specifications are not applicable above 10 kHz
[5] Frequency specification is for 1 year.

Voltage Function - Operating Characteristics

Function	DC into 1 MΩ[1]	DC into 50 Ω[1] [2]	Square Wave into 1 MΩ[1]	Square Wave into 50 Ω[1] [2]
Rise/Fall Time	---	---	<100 V_{pk-pk} <150 ns; ≥100 V_{pk-pk} <200 ns[3]	
Aberrations	---	---	<2 % peak for first 500 ns; < 0.1 % after 500 ns; <0.01 % after 100 µs	
Output Current	>± 50 mA max.	>±120 mA max.	>± 50 mA max.	>±120 mA max.
Waveform settling time	<100 ms to 0.01 %		<100 ms to 0.1 %	

[1] Simultaneous multi-channel output is available.
[2] Specification excludes variability of resistance losses in mating BNC connectors.
[3] Rise/fall times increase with the number of active channels and voltage. ≥100 V_{pk-pk} <300 ns with 5 active channels.

Leveled Sine Function - Specifications

Function	Leveled Sine [1]	
Frequency Range [2]	0.1 Hz to 4.2 GHz	
Frequency Specification [3]	Internal frequency reference: ±(0.15 µHz/Hz + 1 µHz) External frequency reference: ±(Ext Freq Ref Accuracy + 1 µHz)	
Amplitude (pk-pk) (into 50 Ω)	0.1 Hz to 2.02 GHz: >2.02 GHz to 3.2 GHz: >3.2 GHz to 4.2 GHz:	5 mV to 5 V 5 mV to 3 V 5 mV to 2 V
Amplitude Specification	±1.5 % at 50 kHz Ref Frequency	
Flatness relative to Ref Freq (into 50 Ω)	0.1 Hz to 550 MHz: >550 MHz to 1.1 GHz: >1.1 GHz to 2.02 GHz: >2.02 GHz to 4.2 GHz:	± 1.5 % ± 2 % ± 3 % ± 4 %
Source VSWR	>49 kHz to 100 MHz: >100 MHz to 3.2 GHz: >3.2 GHz to 4.2 GHz:	≤1.12 : 1 ≤1.2 + 0.02 x f (GHz) : 1 ≤1.45:1
Amplitude Ranging	Volts/div ranging 1, 2, 5 or 1, 2, 2.5, 4, 5 or continuously variable	
Deviation	±11.2 % (Including over and under-range)	
Harmonic Purity	< -50 dBc	

[1] Simultaneous multi-channel output is available.
[2] Frequencies above 500 MHz are not recommended for 1 MΩ input applications.
[3] Frequency accuracy specification is for 1 year.

Leveled Sine Function - Operating Characteristics

Function	Leveled Sine [1]						
SSB Phase Noise (dBc/Hz)	Offset	100 MHz	250 MHz	500 MHz	1 GHz	2 GHz	4 GHz
At max output, internal ref frequency	100 Hz	-104	-98	-92	-86	-80	-74
	1 kHz	-116	-108	-102	-96	-90	-84
	10 kHz	-120	-112	-106	-100	-94	-88
	100 kHz	-132	-124	-118	-112	-106	-100
	1 MHz	-153	-150	-144	-138	-132	-126

[1] Simultaneous multi-channel output is available.

Edge Function - Specifications

Function	500 ps Edge [1] Into 50 Ω	HV Edge Into 50 Ω	HV Edge Into 1 MΩ
Rise Time[2] (10 % to 90 %)	450 ps to 550 ps	---	---
Rise/Fall Time[2] (10 % to 90 %)	---	<100 ns	<100 V_{pk-pk} <150 ns, ≥ 100 V_{pk-pk} <200 ns [5]
Displayed Rise Time Specification	±40 ps	---	---
Polarity	Rising Return to Ground	Rising or Falling	
Amplitude	5 mV to 3 V_{pk-pk}	1 V to 5 V_{pk-pk}	1 V to 200 V_{pk-pk}
Amplitude Specification	±3 %		
Ranging	Volt/div factors of 1, 2, 5 or 1, 2, 2.5, 4, 5; or continuously variable		
Deviation	±11.2 % (Including over and under-range)		
Duty Cycle	10 %	50 %	
Aberrations[3]	<±2 % pk in first 10 ns (into 50 Ω, <4 GHz)	<±2 % pk (first 500 ns)	
Extended Aberrations[3]	<±0.5 % pk 10 ns to 1 µs	<±0.1 % pk 500 ns to 100 µs	
	<0.2 % pk beyond 1 µs	<0.01 % pk beyond 100 µs	
Frequency	10 Hz to 2 MHz 100 kHz to 2 MHz for amplitudes >2.5 V_{pk-pk}	10 Hz to 100 kHz	
Frequency Specification[4]	Internal frequency reference: ±(0.15 µHz/Hz + 1 µHz) External frequency reference: ±(Ext Freq Ref Accuracy + 1 µHz)	Internal frequency reference: ±(0.15 µHz/Hz + 10 mHz) External frequency reference: ±(Ext Freq Ref Accuracy + 10 mHz)	

[1] Edge speeds faster than 500 ps are not recommended for 1 MΩ input applications.
[2] Accuracy of displayed rise time with respect to measured rise time.
[3] Waveform aberrations are referenced to a Gaussian waveform.
[4] Frequency accuracy specification is for 1 year.
[5] Rise/fall times increase with number of active channels and voltage. ≥100 V_{pk-pk} <300 ns with 5 active channels

Edge Function - Operating Characteristics

Function	500 ps Edge [1] Into 50 Ω	HV Edge Into 50 Ω	HV Edge Into 1 MΩ
Trigger to Edge delay	50 ±5 ns	---	---
Trigger to Edge jitter	<15 ps $_{pk-pk}$	---	---

[1] Edge speeds faster than 500 ps are not recommended for 1 MΩ input applications.

Fast Edge Function - Specifications

Function	125 ps Fast Edge [1] into 50 Ω
Rise Time (10 % to 90 %)	100 ps to 140 ps
Displayed Rise Time Specification [2]	±15 ps
Polarity	Rising Return to Ground
Amplitude	5 mV to 3 V_{pk-pk}
Amplitude Specification	±3 %
Ranging	Volt/div factors of 1, 2, 5 or 1, 2, 2.5, 4, 5; or continuously variable
Deviation	±11.2 % (Including over and under-range)
Duty Cycle	10 %
Aberrations	<±4 % pk in first 1 ns (<4 GHz)
Extended Aberrations	<± 1 % pk 1 ns to 10 ns <± 0.5 % pk beyond 10 ns
Frequency Specification [3]	Internal frequency reference: ±(0.15 µHz/Hz + 1 µHz) External frequency reference: ±(Ext Freq Ref Accuracy + 1 µHz)

[1] Fast edge speeds are not recommended for 1 MΩ input applications.
[2] Accuracy of displayed rise-time with respect to measured rise time.
[3] Frequency accuracy specification is for 1 year.

Fast Edge Function - Operating Characteristics

Function	125 ps Fast Edge [1] into 50 Ω
Frequency	10 Hz to 2 MHz 100 kHz to 2 MHz for amplitudes >2.5 V_{pk-pk}
Trigger to Edge delay	50 ±5 ns
Trigger to Edge jitter	<15 ps_{pk-pk}

[1] Fast edge speeds are not recommended for 1 MΩ input applications.

Timing Marker Function - Specifications

Function	Square [2]	Pulse	Spike	Sine (Extension of Square) [1]
Period	9.0091 ns to 55 s	900.91 ns to 55 s	900.91 ns to 55 s	240 ps to 9.009 ns
Ranging	Time/div ranging 1, 2, 5 or 1, 2, 2.5, 4, 5 or continuously variable			
Period Deviation Range	±45 %			
Timing Specification [3]	Internal frequency reference: ±(0.15 µs/s) External frequency reference: ±(Ext Freq Ref Accuracy + 1 ns/s)			
Duty Cycle	50 %	5 %	5 %	---
Amplitude	100 mV, 250 mV, 500 mV and 1 $V_{pk\text{-}pk}$ symmetrical about ground			
Subdivision	Every 10th marker can be set to higher amplitude.			---

[1] Frequencies >500 MHz (periods <2 ns) are not recommended for 1 MΩ input applications.
[2] Line frequency timing markers are available in the Square Wave function. Jitter relative to Line zero crossing: <±20 $\mu s_{pk\text{-}pk}$.
[3] Timing accuracy specification is for 1 year.

Timing Marker Function - Operating Characteristics

Function	Square [2]	Pulse	Spike	Sine (Extension of Square) [1]
Rise/Fall Times	< 1 ns	< 1 ns	---	---
Timing Jitter	<10 ps RMS for periods ≤10 ms <10 ns RMS for periods ≤1 s <1 µs RMS for periods >1 s			

[1] Frequencies >500 MHz (periods <2 ns) are not recommended for 1 MΩ input applications.
[2] Line frequency timing markers are available in the Square Wave function. Jitter relative to Line zero crossing: <±20 $\mu s_{pk\text{-}pk}$.

Input Impedance Function - Specifications

Resistance Measurement	10 Ω to 40 Ω	>40 Ω to 90 Ω	>90 Ω to 800 kΩ	>800 kΩ to 1.2 MΩ	>1.2 MΩ to 12 MΩ
Specification	±0.5 %	±0.1 %	±0.5 %	±0.1 %	±0.5 %

Capacitance Measurement (100 kHz)	1 pF to 35 pF	>35 pF to 95 pF
Specification	±2 % ± 0.25 pF	±3 % ± 0.25 pF

Pulse Width Function - Specifications

Function	Pulse Width
Pulse Width	1 ns to 100 ns
Specification	<±5 % ±200 ps
Adjustment Resolution	1 ns to 4 ns: <50 ps 4 ns to 20 ns: <250 ps 20 ns to 100 ns: <1 ns
Frequency	1 kHz to 1 MHz
Amplitude	1 $V_{pk\text{-}pk}$ into 50 Ω

Pulse Width Function - Operating Characteristics

Function	Pulse Width
Rise and Fall Time	700 ps
Aberrations into 50 Ω	<±5 % pk
Width Stability	<± (0.5 % of width setting + 50 ps)

Trigger Output - Operating Characteristics

	Amplitude	1 $V_{pk\text{-}pk}$ into 50 Ω
	Rise and Fall Time into 50 Ω	<350 ps from cable output
		<1 ns from head output
	Aberrations into 50 Ω	<±10 %

Function	Signal	Trigger Waveform	Trigger Frequency[1]	Trigger Alignment	Trigger Leads by
Voltage	DC	Square	100 Hz	---	---
	Square	Square	Signal	Depart from ground	1/64 Period
Leveled Sine	<68.75 MHz	Square	Signal	---	---
	68.75 MHz to 137.5 MHz	Square	Signal / 2	---	---
	137.5 MHz to 275 MHz	Square	Signal / 4	---	---
	275 MHz to 550 MHz	Square	Signal / 8	---	---
	550 MHz to 1100 MHz	Square	Signal / 16	---	---
	1100 MHz to 2200 MHz	Square	Signal / 32	---	---
	2200 MHz to 4200 MHz	Square	Signal / 64	---	---
Edge	500 ps	1:9 Pulse	Signal	Return to Ground	25 ns
	HV	Square	Signal	Depart from ground	1/64 Period
	150 ps	1:9 Pulse	Signal	Return to Ground	50 ns
Timing Markers (>10 ns)	Normal	Square	Signal	Rising Edge or Spike Peak	---
	Highlighted	Square	Signal	Rising Edge or Spike Peak	---
Current	DC	Square	100 Hz	---	---
	Square	Square	Signal	Depart from ground	1/64 Period
Composite Video	Line	Composite Sync	Line Freq	Sync leading edge	---
	Field	Pulse	Frame Freq	Frame start	---
Linear Ramp	---	1:2 Pulse	Signal	Start of rise or fall	---
Overload Pulse	---	Step or Square	Single or 100 Hz	Leading edge	---
Input leakage Auxiliary Input Input Impedance	These functions have no related trigger output. Free running 100 Hz trigger signal provided.				
Pulse Width	No trigger signal is provided.				

[1] For repetitive signals, the trigger frequency can be further divided by 1/10/100.

Current Function - Specifications

Requires BNC Current adapter.

Function	Current
Amplitude	DC current: ±100 µA to ±100 mA Square wave current: 100 $\mu A_{pk\text{-}pk}$ to 100 $mA_{pk\text{-}pk}$
Ranging	Amps/div ranging 1, 2, 5 or 1, 2, 2.5, 4, 5 or continuously variable
DC Specifications	± (0.25 % + 0.5 µA)
Square wave Specification	± (0.25 % + 0.5 µA) @ 1 kHz
Square wave Frequency	10 Hz to 100 kHz
Square wave Duty Cycle and Symmetry	50 %, symmetrical about ground

Current Function - Operating Characteristics

Requires BNC Current adapter.

Function	Current
Square wave Rise Time and Aberrations	<150 ns and <±2 % pk

Composite Video Output Function - Operating Characteristics

Function	Amplitude
Amplitude	1.0 $V_{pk\text{-}pk}$
Pattern (Full Raster)	White, Grey, or Black
Sync Polarity	Positive or Negative
Standards	625-line 50 Hz /525-line 60 Hz
Trigger Output	Composite Sync or Odd Field start

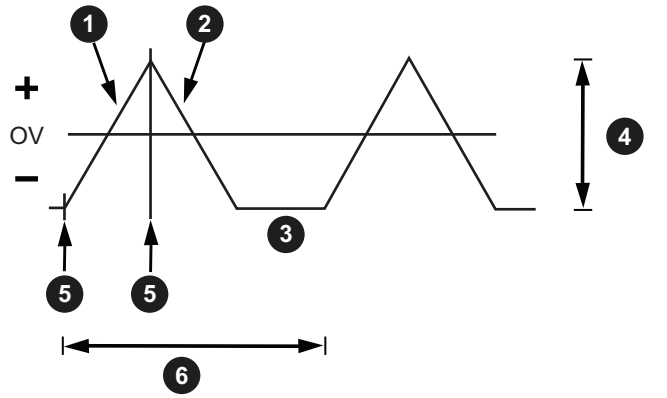
LF Linear Ramp Function - Specifications

Function	Linear Ramp
Waveforms	1 V_{pk-pk} triangle symmetrical about ground
Linearity[1]	<±0.1 % deviation over 10 % to 90 %, symmetrical about 0 V
[1] Spec does not apply between -10 % and +10 % or above 90 %	

LF Linear Ramp Function - Operating Characteristics

Function	Linear Ramp
Ramp Time	1 ms, 10 ms, 100 ms or 1 s

Table 1. LF Linear Ramp - Waveshape



Item	Description	Item	Description
1	Rising Ramp	4	1 V_{pk-pk}
2	Falling Ramp	5	Alternative Triggers
3	Flat	6	Period

Overload Pulse Function - Specification

Function	Overload Pulse
Amplitude	5 V to 20 V into 50 Ω
Polarity	Positive/Negative
Duration	0.2 s to 100 s (subject to pulse energy limits)
Energy	0.1 J to 800 J
Power in 50 Ω	0.5 W to 8 W
Trigger	Manual, Max Rep Rate 0.3 Hz (internally limited)

Zero Skew Function - Specifications

Function	Zero Skew
Unadjusted Skew	<±50 ps ch to ch
Adjusted Skew	<±5 ps ch to ch
Skew Temperature Coefficient	<0.2 ps/°C

Zero Skew Function - Operating Characteristics

Function	Zero Skew
Rise and Fall Time into 50 Ω	<350 ps from cable output <1 ns from Active Head output
Relative Jitter	<7 $ps_{pk\text{-}pk}$

Input Leakage Function - Operating Characteristics

Open or short output conditions are applied to all Active Heads simultaneously.

Function	Input Leakage
Open Circuit Output	Leakage <±50 pA
Short Circuit Output	Offset <±10 µV

Auxiliary Input Function - Operating Characteristics

Function	Auxiliary Input
Signal Routing	Rear BNC input, passive and switched 50 Ω path to any Active Head
Maximum Input	±40 $V_{pk\text{-}pk}$, ±400 $mA_{pk\text{-}pk}$
Switching Break and Make Capacity	±5 $V_{pk\text{-}pk}$, ±100 $mA_{pk\text{-}pk}$
Insertion Loss into 50 Ω	<3 dB to 350 MHz

Reference Frequency Function - Operating Characteristics

Function	Reference Frequency	
Input / Output	**Input (BNC)**	**Output (BNC)**
Frequency Range	1 MHz to 20 MHz in 1 MHz steps	1 MHz or 10 MHz
Level	90 mV to 1 $V_{pk\text{-}pk}$	Into 50 Ω: 1.5 $V_{pk\text{-}pk}$ Into 1 MΩ: 3 $V_{pk\text{-}pk}$
Lock Range	±0.5 µHz/Hz	---