FLUKE®
Calibration

NEW

Introduction

Fluke 9500C
Oscilloscope Calibrator

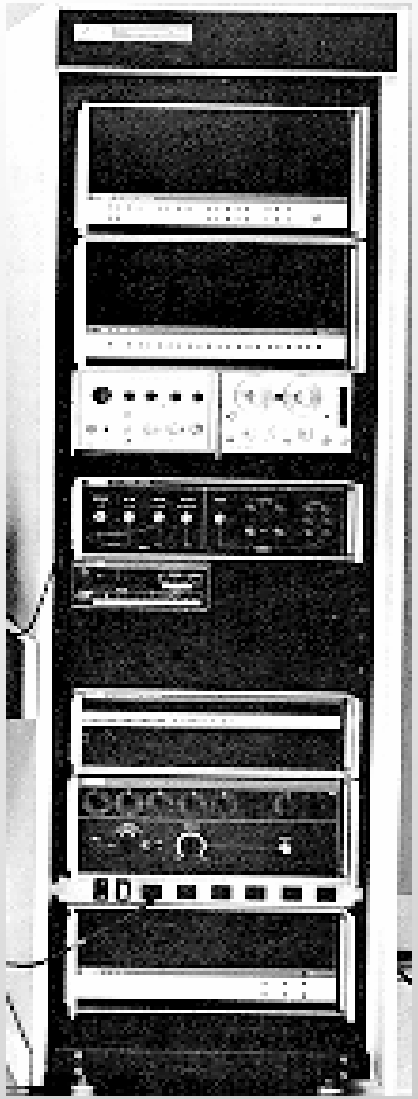
The new Fluke 9500C High-Performance Oscilloscope Calibrator

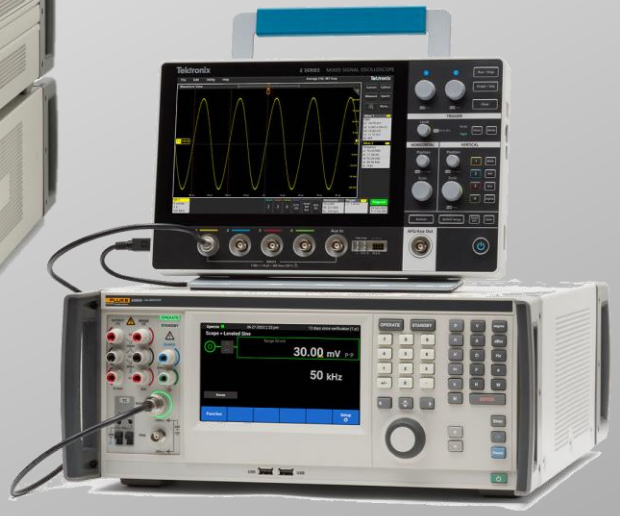
Efficient, effective, productive

The Fluke 9500C High-Performance Oscilloscope Calibrator is a dedicated modern oscilloscope calibrator designed for calibration professionals who need to cover workloads below 4 GHz accurately, reliably, and efficiently

History of Fluke Calibration Oscilloscope Calibration
Dedicated and Multi-Product solutions

FLUKE®
Calibration





Next Gen Electrical Calibrators

January 2014:

Multi-function Calibrator

5730A

March 2019:

Long-scale DMM

8588A/8558A

August 2023:

Multiproduct Calibrator with the Scope Option

August 2015:

AC Measurement Standard

5790B

January 2023:

Multiproduct Calibrator

5540A/5550A/5560A

April 2024:

Next Generation Dedicated Scope Calibrator

Introducing the 9500C

- Features and benefits:
  - Better accuracy
  - High signal purity
  - High bandwidth
  - 4 channels
  - Leveled sine waves up to 4 GHz

- Improvements include:
  - More robust Active Head Technology™
  - Fully automated with MET/CAL Software for hands-free operation
  - *Simultaneous outputs on all channels increase tests speed and efficiency* and eliminates the need for lead changes
  - Color touchscreen with an updated, easy-to-use interface
  - Updated hardware for improved reliability and serviceability

The Fluke 9500C Oscilloscope Calibrator

- Revolutionizing Oscilloscope with Superior Performance and Automation
  - Oscilloscope calibration traditionally demands extensive time, expertise, and equipment, often involving intricate operator interactions and frequent lead switching, especially for multi-channel instruments
  - Many automated systems still require significant manual input, adding to the complexity
    - Additionally, rapid advancements in oscilloscope technology necessitate continuous investment to keep pace with evolving performance standards
  - The Fluke 9500C Oscilloscope Calibration Workstation fundamentally changes this dynamic

Key Advantages of the Fluke 9500C

- Full Automation
  - Achieve completely hands-free calibration for even the most sophisticated, multi-channel oscilloscopes

- Continuous Upgradeability
  - Protect your investment with a system designed to adapt to future technological advancements

- Simultaneous Multi-Channel Output
  - Eliminate the need for lead changing and complex signal multiplexing, enhancing efficiency

Key Advantages of the Fluke 9500C

- High-Performance Calibration
  - Leveled sine waves up to 4 GHz and edges as fast as 125 ps cater to the calibration needs of both current and future high-performance oscilloscopes

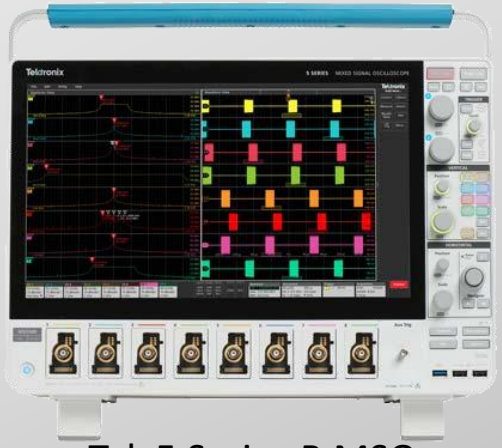
- Active Head Technology™
  - Generate calibration signals directly at the oscilloscope input, ensuring waveform accuracy and eliminating doubts about lead-induced aberrations

FLUKE®
Calibration

Oscilloscope Calibration

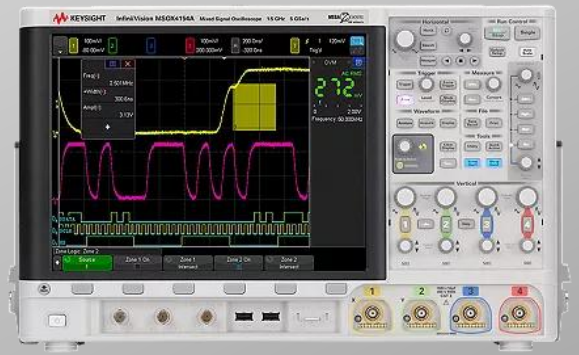
What is tested?

- Vertical Accuracy
  - DC Voltage Accuracy
  - AC Voltage Accuracy
- Horizontal Accuracy
  - Frequency Accuracy
  - AC-coupled Lower Frequency
  - Time Base
- Voltage Accuracy (HF) and Bandwidth
- Miscellaneous
  - Peak Measurement
  - Phase
  - Trigger sensitivity
  - Input Impedance
  - Input overload
  - Random noise



Tek 5 Series B MSO

350 MHz to 2 GHz



Keysight InfiniiVision 4000

200 MHz to 1.5 GHz

Scope Function Menu

- Vertical Accuracy
  - Tested with DCV or ACV
- Horizontal Accuracy
  - Marker
  - Waveform Generator
  - Pulse
- Voltage Accuracy (HF) and Bandwidth
  - Leveled Sine
  - Edge
- Miscellaneous
  - Video
  - Pulse
  - Measure Resistance
  - Measure Capacitance
  - Overload AC and DC
  - Phase on 9500C with dual output

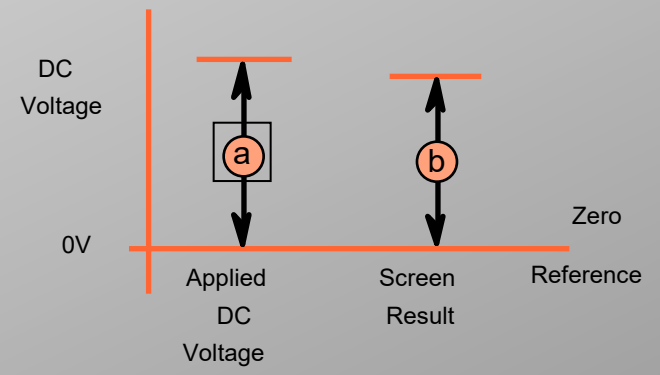
Scope DCV

- Test vertical accuracy – predominately used with Digital Scopes

- Variable output impedance
  - 1 MΩ or 50 Ω
  - 1 MΩ provides better accuracy

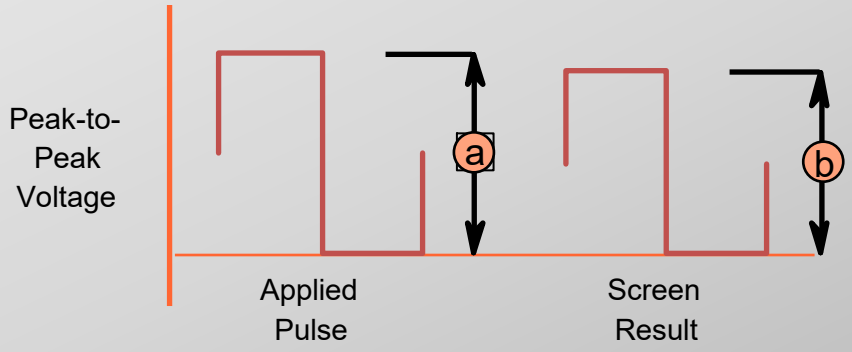
- 0 V to 210 V amplitude
  - 1-2-4 or 1-2-5 divisions sequence to quickly align to display graticules

- Tests done for each input range (V/div) of the Scope



Scope ACV

- Test vertical accuracy – predominately used with older Analog Scopes
  - 50% duty cycle square wave
  - Positive or negative zero referenced



- Variable output impedance
  - 1 MΩ or 50 Ω
  - 1 MΩ provides better accuracy
- 0 V to 210 V amplitude
  - 1-2-4 or 1-2-5 divisions sequence to quickly align to display graticules
- 10 Hz to 10 kHz

- If using measured values on Scope, may need to switch between $V_{p\text{-}p}$ and V_{rms} on the Scope to match output

Scope Edge

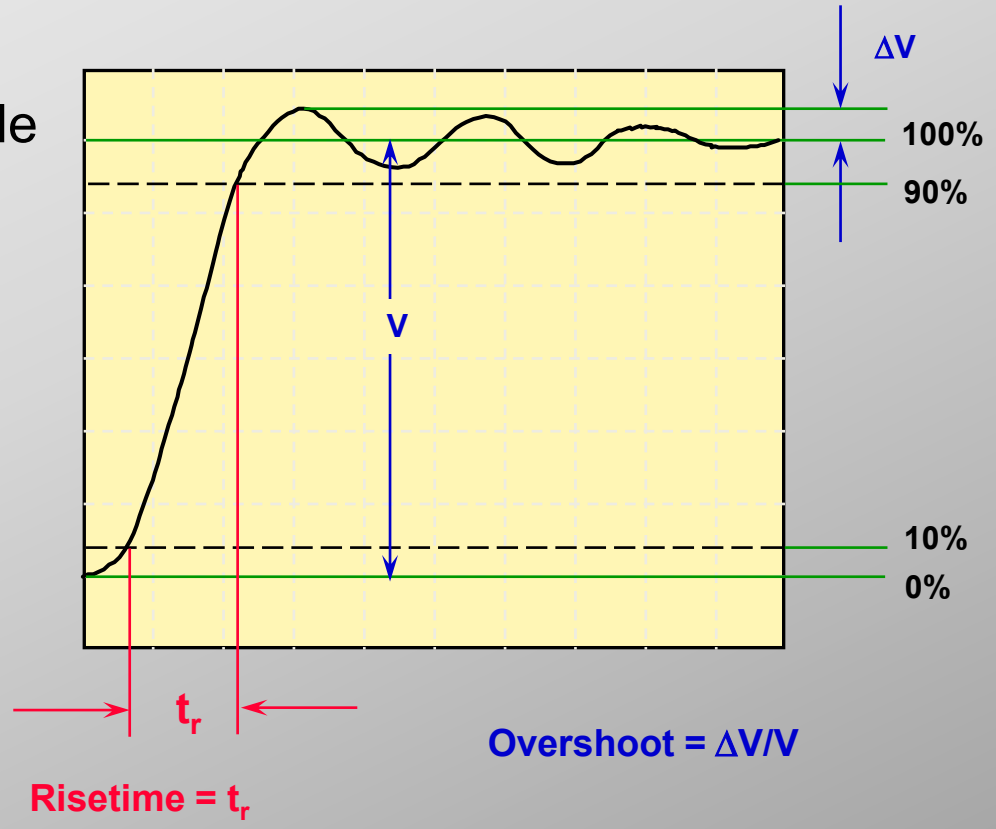
- Measures Scope Risetime limitations
  - Sometime for Bandwidth
    - BW = $^{k}/_{risetime}$
    - k can be between 0.35 and 0.45 depending on Scope Model

- Variable output 5 mV to 2.5 V to match a wide range of scopes
- Low jitter provides stable signal making measurement easier

- Risetime of scope is measured 10% to 90% time plus Calibrator Edge time
  - 9500C has <125 ps edge rise time

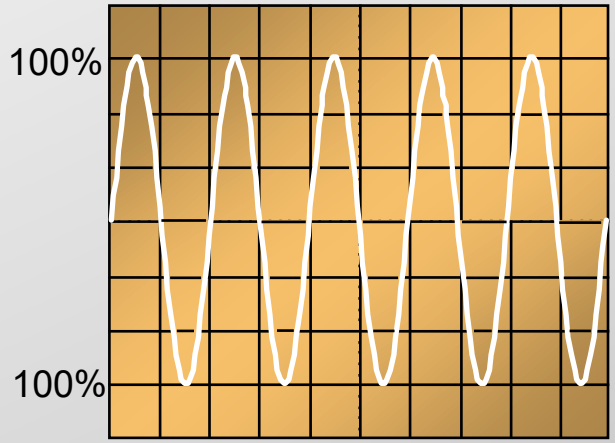
Risetime and pulse response

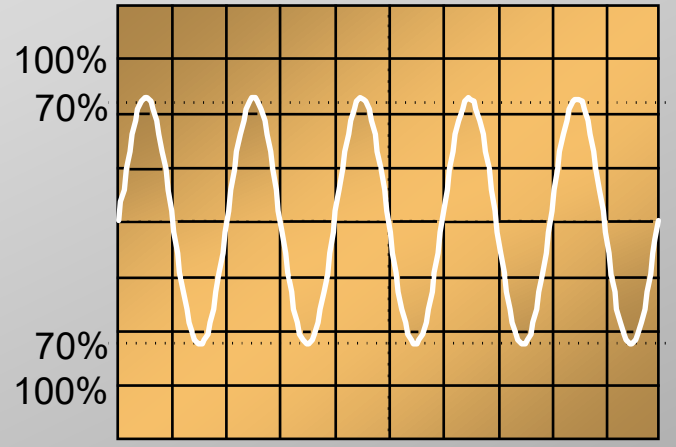
- Risetime = transition time between 10% and 90% points
- Pulse/edge response aberrations (impairments) include overshoot ($^{\Delta V}/_{V}$ in diagram)
  - Pre-shoot
  - Dribble-up
- Risetime is related to Bandwidth:
  - Bandwidth = $^{k}/_{risetime}$
  - k = 0.35 for Scopes < 1 GHz
  - k = 0.4 to 0.45 for Scopes > 1 GHz



Scope Leveled Sine

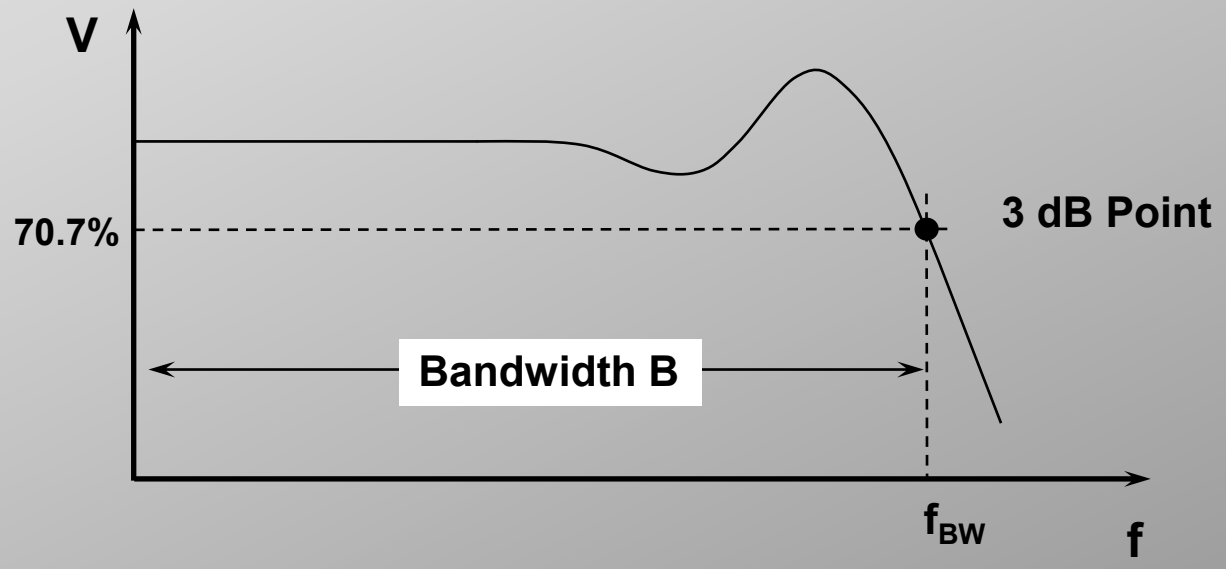
- Preferred method to test Scope Bandwidth performance
  - This is a relative measurement done against low frequency reference
  - Flatness is most critical specification
  - VSWR needed for complete measurement
    - Allows amplitude uncertainty to be calculated





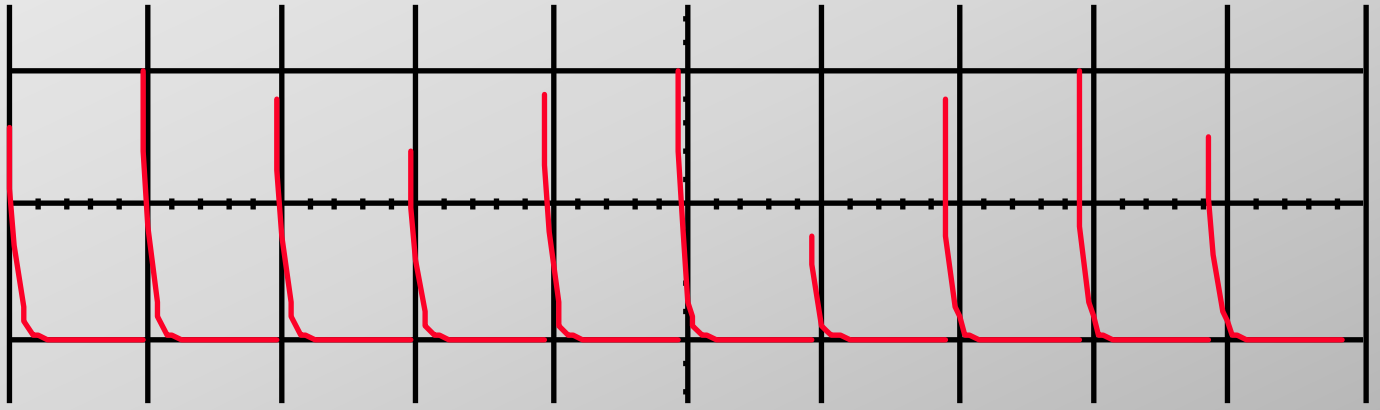
Frequency Response and bandwidth

- Scopes often classified by bandwidth
  - e.g. 500 MHz, 1 GHz, 2 GHz, 4 GHz
  - 3db roll-off point
- Frequency response generally not a classic single pole gain/phase response
  - Response may contain peaks below 3dB frequency
  - -3dB point is always specified and tested
  - Flatness often not tested or specified



Scope Marker

- Used for horizontal and time base tests
  - Spike, Square of Pulse waveforms
  - Low jitter for more reliable measurement
  - 1-2-4 or 1-2-5 for horizontal graticule alignment



Resistance and Capacitance Measure

- Used for impedance verification
  - This is a measurement not an output!

- When measuring capacitance ensure that you zero the cable capacitance before connecting to Scope input

Scope Overload

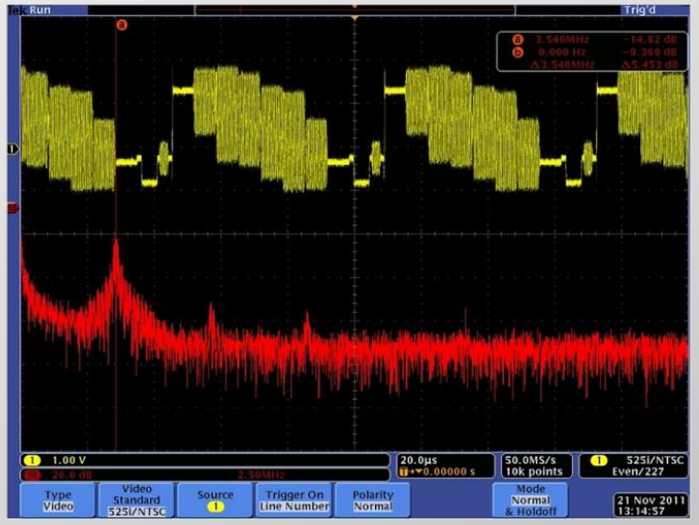
- Verifies Scopes overload protection mechanism
- DC and AC overload tests provided
  - Both measure the time for the Scope to trip to a safe state
  - Time limit prevents accidental damage to Scope

Scope Waveform Generator

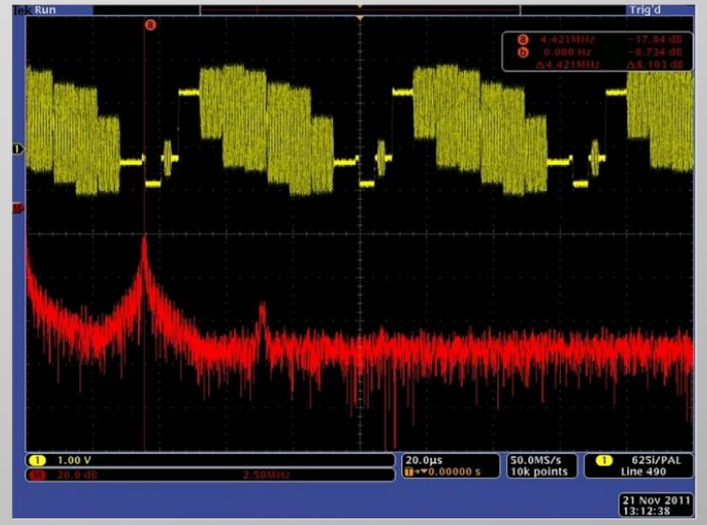
- Used for miscellaneous tests
- Square, Sine and Triangle waveforms available
- Amplitude range depends on Z_0
  - 4.44 mV to 210 V_{p-p}; 1 MΩ
  - 4.44 mV to 5.6 V_{p-p}; 50 Ω
- 10 Hz to 100 kHz

Scope Video Trigger

- Test Scope Video Triggering Circuits
  - Primarily in legacy hardware designs that had dedicated Video triggering hardware
    - Modern designs do this in software
  - Supports NTSC, PAL, PAL-M and SECAM formats



NTSC – Spectrum Analysis, peak at 3.546 MHz



PAL – Spectrum Analysis, peak at 4.421 MHz

FLUKE®
Calibration

How can the Fluke 9500C help with this,

more efficient,
more effective and
more productive

Complete Functionality of the Fluke 9500C Oscilloscope Calibrator

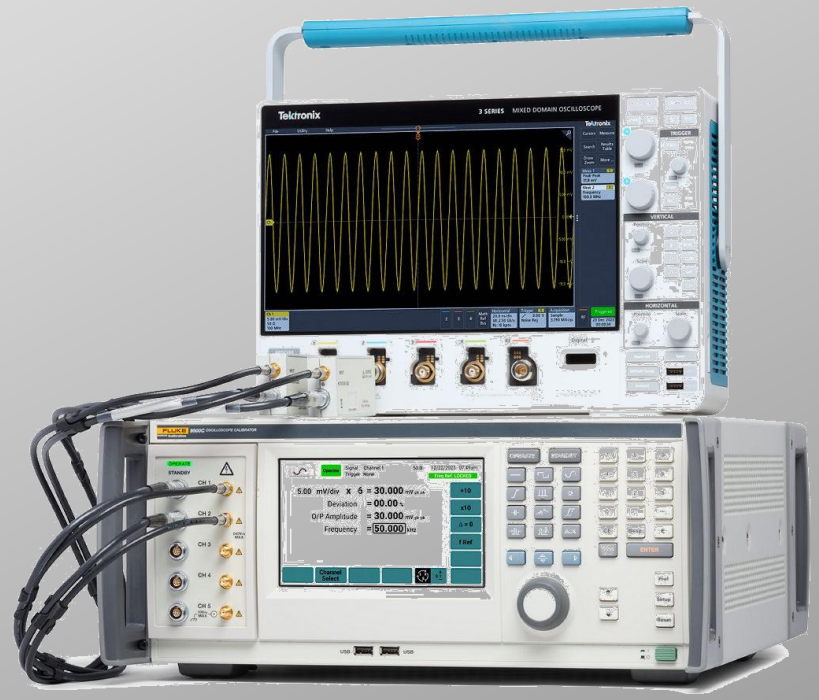
- Vertical and Horizontal Deflection Bandwidth:
  - The Fluke 9500C checks the pulse response and bandwidth of an oscilloscope's vertical deflection/acquisition amplifiers with fast return-to-ground edges, offering amplitudes between 4.44 mV and 3.1 V and rise/fall times of 125 ps, or 500 ps
  - High-level edges up to 210 $V_{pk\text{-}pk}$ evaluate the dynamic performance of input attenuators
  - Leveled sine waves up to 4 GHz, with an amplitude range of 4.44 mV to 5.56 $V_{pk\text{-}pk}$ into 50 Ω, enable direct calibration of oscilloscope bandwidth, including Z-axis and horizontal deflection bandwidth
  - Dual sine outputs facilitate the calibration of the oscilloscope's trigger sensitivity and other functions that typically require a splitter in the connecting

Complete Functionality of the Fluke 9500C Oscilloscope Calibrator

- Vertical Deflection Gain:
  - DC levels and square waves from 10 Hz to 100 kHz are adjustable up to 210 V, with 5-digit amplitude resolution at 0.025% accuracy for DC and 0.05% for square waves, sufficient for calibrating vertical deflection ranges of 12-bit digitizing and 14-bit interpolating oscilloscopes
  - The 9500C checks the oscilloscope's input impedance before applying high voltages to protect 50 Ω input terminations
  - Automatic switching to 50 Ω output impedance allows the same waveforms at amplitudes up to 5.56 V

Complete Functionality of the Fluke 9500C Oscilloscope Calibrator

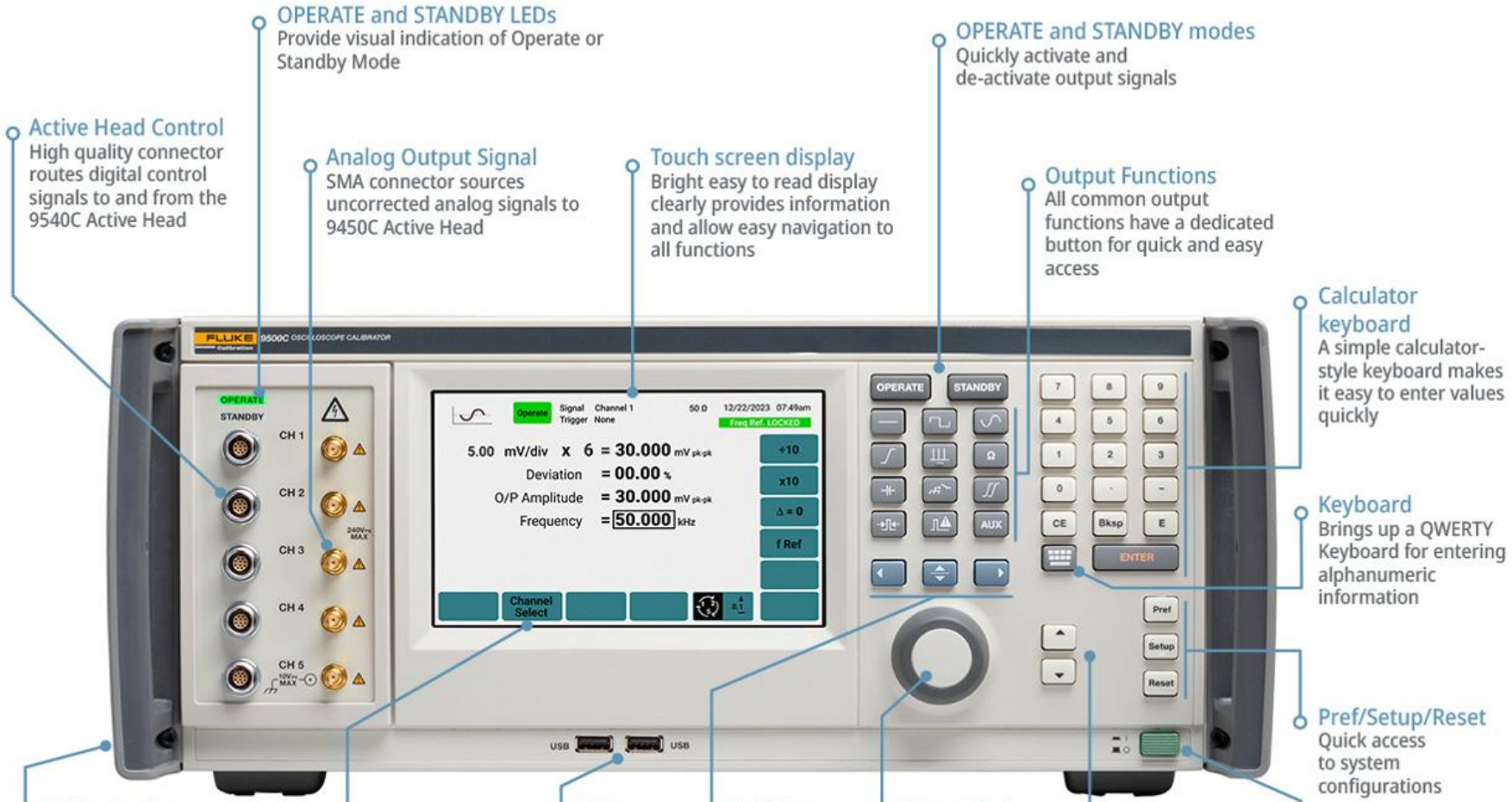
- Time base accuracy:
  - Timing markers cover calibration of time base ranges from 0.2 ns to 50 s per division, with a choice of four styles and the option to highlight every tenth marker for enhanced visibility on both analog and digital storage oscilloscopes
  - The square and pulse markers are used for calibrating time base jitter, supported by a high-stability crystal reference, providing timing accuracy of ± 0.25 ppm



Complete Functionality of the Fluke 9500C Oscilloscope Calibrator

- Auxiliary Calibration Functions:
  - DC and square wave currents up to 100 mA for calibrating current probes
  - Composite video signals for testing TV sync separator functions
  - Linear ramps for calibrating trigger level markers and checking DSOs for missing bits
  - High current pulses (5 V to 20 V) for testing 50 Ω terminator protection
  - Zero skew for accurate alignment of pulse edges, evaluating channel delays in multi-channel scopes
  - AUX IN to route external calibration waveforms to an Active Head's BNC/SMA connector
  - Resistance and capacitance functions for directly measuring oscilloscope input impedance
  - Short/open circuit outputs for testing oscilloscope input leakage current

Front Panel


OPERATE and STANDBY LEDs
Provide visual indication of Operate or Standby Mode
OPERATE and STANDBY modes
Quickly activate and de-activate output signals
Active Head Control
High quality connector routes digital control signals to and from the 9540C Active Head
Analog Output Signal
SMA connector sources uncorrected analog signals to 9450C Active Head
Touch screen display
Bright easy to read display clearly provides information and allow easy navigation to all functions
Output Functions
All common output functions have a dedicated button for quick and easy access
Calculator keyboard
A simple calculator-style keyboard makes it easy to enter values quickly
Keyboard
Brings up a QWERTY Keyboard for entering alphanumeric information
Pref/Setup/Reset
Quick access to system configurations
Power On/ Off
UP/DOWN Keys
These keys provide small incremental changes to the output value selected
Output dial
To adjust the reading, simply rotate the output dial. This allows output skewing while focusing on the Scope screen
Field Keys
Provide button press navigation of the editable fields on the screen
USB
Provides easy firmware updates
Soft-Buttons
Offer contextual access to appropriate options for each output function
Rubberized Handles
Provide easy, comfortable carrying points
FLUKE 9500C OSCILLOSCOPE CALIBRATOR
OPERATE
STANDBY
CH 1
CH 2
CH 3
CH 4
CH 5
Operate
Signal
Trigger
Channel 1
None
50 Ω
12/22/2023 07:49am
Freq Ref. LOCKED
5.00 mV/div x 6 = 30.000 mV pk-pk
Deviation = 00.00 %
O/P Amplitude = 30.000 mV pk-pk
Frequency = 50.000 kHz
÷10
x10
Δ = 0
f Ref
Channel Select
OPERATE
STANDBY
AUX
CE
Bksp
E
ENTER
Pref
Setup
Reset
USB
USB

Back Panel

FLUKE® Calibration

Universal Power Input
Power input adapts to Global mains power

Chassis Ground
Provides ground point in systems that require it

Auxiliary Input
Provides a pass through signal port

Remote Interfaces
GPIB and LAN for remote control

Rear Panel USB
Duplicates USB access on front panel for convenience

Ref Frequency
Allows precise synchronization with external clock or to synchronize other devices

9500C vs 9500B

Feature	9500C	9500B
Mainframe Models	9500C 4 GHz	9500B 600 MHz – 3.2 GHz
Active Heads	9540C - 4 GHz 125 ps	9510 - 1.1 GHz 500 ps 9530 - 3.2 GHz 150 ps/500 ps
Simultaneous Output	All sourcing functions except Edge, Marker	Two channel levelled sine only
Signal Accuracy & Fidelity	0.01% +10 µV DCV 4% levelled sine 2 GHz to 4 GHz Sub-Harmonic Purity -55 dBc SSB Phase Noise Specified	0.025% + 25 µV DCV 5% leveled sine 1 GHz to 3 GHz Sub-Harmonic Purity -40 dBc SSB Phase Noise **Unspecified**
Serviceability	User replaceable head connectors and cables	Return to Fluke Service Only
User Interface	Bright 7” (17.8 cm) Color with touch	5” backlit LCD

Specifications

Oscilloscope Function	Range	9500B w/ 9530 Head Performance	9500C w/ 9540 Head Performance
DCV	1 mV to 200 V into 1 MΩ 1 mV to 5 V into 50 Ω	± (0.025 % + 25 µV)	**± (0.01% + 10 µV)**
Square Wave	40 µV to 200 Vp-p into 1 MΩ 40 µV to 5 Vp-p into 50 Ω 10 Hz to 100 kHz	≥ 1 mV ± (0.1 % + 10 µV) < 1 mV ± (1 % + 10 µV)	**≥ 1 mV: ± (0.1 % + 10 µV)** **< 1 mV: ± (1 % + 10 µV)**
Edge Function	5 mV to 3 Vp-p into 50 Ω 5 mV to 3 Vp-p into 50 Ω or 1 MΩ	175 ps, 350 ps to 550 ps	**125 ps** **500 ps**
Leveled Sine Frequency	0.1 Hz to 4.2 GHz	≥ 15 kHz ± (0.25 ppm + 12 mHz) up to 3.2 GHz < 15 kHz ± 3 ppm	**± (0.15 µHz/Hz + 1 µHz)**
Leveled Sine Amplitude	0.1 Hz to 2.1 GHz 2.1 GHz to 3.2 GHz 3.2 GHz to 4.2 GHz	5 mV to 3 Vp-p 5 mV to 2 Vp-p -	**5 mV to 5 Vp-p** **5 mV to 3 Vp-p** **5 mV to 2 Vp-p**
Leveled Sine Flatness	0.1 Hz to 550 MHz 550 MHz to 1.1 GHz 1.1 GHz to 2.1 GHz 2.1 GHz to 4.2 GHz	0.1 Hz to 300 MHz: ± 2 % 300 MHz to 550 MHz ± 2.5 % 550 MHz to 1.1 GHz ± 3.5 % 1.1 GHz to 3.2 GHz: (± 4 %)	**± 1.5 %** **± 2 %** **± 3 %** **± 4 %**
Pulse Width	1 ns to 100 ns	< ± (5 % ± 200 ps)	**< ± (5% + 500 ps)**

Fluke 9500C vs. Fluke 5540A/5550A/5560A




	Fluke Multiproduct Calibrators				Fluke Oscilloscope Calibrators	
		5560A	5550A	5540A		9500C with 9540C Head
Oscilloscope Functions	**Range**	**2 GHz, 1 GHz or 600 MHz**	**1 GHz or 600 MHz**	**600 MHz**	**Range**	**4 GHz**
Square Wave	1 mV to 120 V into 1 MΩ 1 mV to 6.6 V into 50Ω 10 Hz to 10 kHz		0.25% 50 Ω 0.1% 1 MΩ		40 µV to 200 Vp-p into 1 MΩ; 40 µV to 5 Vp-p into 50 Ω; 10 Hz to 100 kHz	≥ 1 mV: ± (0.1 % + 10 µV) < 1 mV: ± (1 % + 10 µV)
DCV	0V to 120V into 1 M load 0 to 6.6V Into 50 Ω load		0.05% 1 MΩ 0.25% 50 Ω		1 mV to 200 V into 1 MΩ; 1 mV to 5 V into 50 Ω	± (0.01% + 10 µV)
Edge	5 mV to 2.5V into 50Ω		< 175 ps		5 mV to 3 Vp-p into 50 Ω; 5 mV to 3 Vp-p into 50 Ω or 1 MΩ	125 ps 500 ps
Leveled Sine Flatness	5 mV to 5.5V; 50 Ω	5% 1.1GHz to 2.1 GHz 4% 600 MHz to 1.1 GHz 3% 50 kHz to 600 MHz	4% 600 MHz to 1.1 GHz 3% 50 kHz to 600 MHz	3% 50 kHz to 600 MHz	5 mV to 5 V; 50 Ω	0.1 Hz to 550 MHz - 1.5% 550 MHz to 1.1 GHz - 2% 1.1 GHz to 2.1 GHz - 3% 2.1 GHz to 4.2 GHz - 4%
Marker	500 ps to 5s		±2.5 µs/s		250 ps to 50 s	± 0.15 µs/s
Pulse	4 to 500 nS		±2 ns		1 ns to 100 ns	< ± (5% + 500 ps)
Resistance & Capacitance Measure	40 Ω to 60 Ω or 500 kΩ to 1.5 MΩ 5 to 50 pF		±0.1% ± 5% + 0.5 pF		10 Ω to 12 MΩ 1 pF to 95 pF	± 0.1 % ± (2 % + 0.25 pF)
Input Overload	1 to 60 Sec		5 V to 9 V		0.2 s to 100 s	5 V to 20 V into 50 Ω

Features to Benefits

Features	Advantages	Benefits
MET/CAL software integration	Enables hands-free operation	Increases throughput and efficiency in calibration processes
Active Head Technology ™	Enhanced functionality and precise signals	Provides precise signals without additional cables, supporting automation and maintain accuracy
Full capabilities to completely calibrate a scope	Addressed often-overlooked calibration needs	Offers versatile solutions for current probes, TV sync separators, trigger level markers, etc.
MET/SUPPORT ™ Gold Membership	Provides premium support and services	Ensures maximum productivity

Fluke 9500C Oscilloscope Calibrator

FLUKE® Calibration

OVERVIEW

The most efficient, effective, and productive scope calibrator on the market.

Your key to exceptional signal performance

- Simultaneous output
- Easily switch between 1 MΩ and 50 Ω
- Timing accuracy of ±0.25 ppm
- Increased auxiliary function capabilities
- Fully automate with MET/CAL

Fluke 9500C Oscilloscope Calibrator

9540C Active Head Technology™

OVERVIEW

The ability to completely automate your scope calibration

New Active Heads with improved performance

Control trigger and up to 4 channels simultaneously

- Precision DC up to ± 220 V
- Calibrated square waves up to 210 $V_{pk\text{-}pk}$ from 10 Hz to 100 kHz
- Leveled sinewaves from 0.1 Hz to 4 GHz

Fluke 9500C Oscilloscope Calibrator

Service and Reliability

OVERVIEW

Higher uptime, improved performance

New Active Heads, Resilient Design

Field Replaceable Components:

- BNC Adapter
- Analog Signal Cable
- Digital Control and Power Cable

Improved internal components

Fluke 9500C Oscilloscope Calibrator

Bandwidth Testing and Error Analysis

OVERVIEW

True bandwidth testing up to 4 GHz and a guide to oscilloscope calibration

The Calibrator | Active Heads | Reliability | Use Cases

Make the best use of your machine

Improved Bandwidth and signal purity make testing more precise.

Automated switching between 50 Ω and 1 MΩ at the Active Head

Close to perfect VSWR outputs

MET/CAL™ Compatibility

- 9500C FSC available as of version 11.1.0

- Current Fluke 9500B based procedures ***are compatible (!)*** with the new Fluke 9500C
  - As if it was a 9500B
  - Does not make advantage of the simultaneous output and better uncertainties
  - Only up to the frequency of the heads which are used in the procedure

- New procedures for the Fluke 9500C will be available later as part of MET/SUPPORT™ Gold

H/W Compatibility with 9500B

- Fluke 9500B Mainframes
  - The Fluke 9500B mainframes have been made obsolete since March 15, 2024
- Active Heads for the 9500B and 9500C
  - The Fluke 9540C Active head is the only active head available for the Fluke 9500C mainframe
  - Fluke 9500B heads do NOT work on the Fluke 9500C
  - The Fluke 9540C Active Head is NOT compatible with the Fluke 9500B mainframe
  - The Fluke 9500B heads are available until to the end of 2026 for extension of existing systems

30-40% Faster

More Reliable

Supports Up to 4 GHz

Simultaneous Output

Fully Automated

Backwards Compatible

Faster Edge

Efficient

Effective

Productive

FLUKE®
Calibration

Questions?

FLUKE®
Calibration

Fluke Calibration.

Precision, Performance, Confidence.™