

Using the 55XX Series Oscilloscope Calibration Options

Application Note

Modern technology, government regulations, and business trends are driving a demand for increased oscilloscope calibration. Many quality, production and service professionals are looking for the best way to start a calibration program. Others want to reduce the cost and increase the efficiency of calibrating a major part of their workload: low-to-medium-performance equipment.

The Fluke Calibration 55XX Series Multi-Product Calibrators are designed to make calibrating a wide variety of electrical measurement tools fast and easy. Depending on the specific model, these calibrators offer options for calibrating a broad cross section of analog and digital oscilloscopes to 300, 600 or 1100 MHz.

When paired with Fluke Calibration's MET/CAL® software, a 55XX Series calibrator can be the heart of an automated oscilloscope calibration system, providing you with documented procedures and results for the calibrations you perform. This application note discusses the basics of calibrating oscilloscopes with the 55XX Series and the issues, problems and solutions you need to know to do the job properly.

Developing oscilloscopes: A historical perspective

The oscilloscope was a post-World War I invention developed for radio engineers, who needed to make more precise electrical measurements in the time domain.

World War II era laboratories needed oscilloscopes that could record transient events. Howard Vollum, who had developed an early model oscilloscope in 1934, integrated a triggered sweep circuit into his design. The concept wasn't new, but no commercial oscilloscope of the time had it. His design also included a grid (graticule) on the screen. This combination of features transformed the commercial oscilloscope from a qualitative instrument into a quantitative measuring device that would revolutionize electronics.

The oscilloscope became a vital part of the wartime manufacture, calibration, and testing of radar, directional instruments, range finders, and other specialized systems. In the 1950s, the early transistors used in computers lacked uniform characteristics, so computer scientists and engineers found oscilloscopes indispensable.

Oscilloscopes now play central roles in electrical product development, medical instrumentation, physics research, and all facets of electronic communications. They have become the testing and measurement workhorse, second only to the digital multimeter (DMM). Oscilloscopes are vital tools for graphically representing circuit and system behavior, including wave form fidelity and signal distortion, glitches, dropouts, and timing errors.



The 5522A Multi-Product Calibrator at work calibrating an oscilloscope.

Oscilloscope calibration basics

Oscilloscopes in common use today fall into a wide range of categories— analog, digital, hybrids, portable and so on. And they can range from simple, low cost models to very capable and complex laboratory instruments depending on bandwidth, accuracy, features and other characteristics. However the one thing that all oscilloscopes have in common is that they present a visual representation of an electrical signal. While the calibration requirement of any given oscilloscope may range from simple to elaborate, nearly all are based on the need to verify the oscilloscope's performance in amplitude, time and bandwidth.

Calibration is fundamentally a two-step process consisting first of a performance verification, and then an adjustment,

if needed. Because adjustment procedures are a function of the make and model of the oscilloscope being calibrated, this application note will focus on the verification step.

While manufacturers' recommendations may vary, most state that a verification include:

- Vertical deflection (amplitude)
- Pulse response
- Bandwidth
- Horizontal deflection (timing)
- Trigger operation

Verification of vertical deflection (amplitude or voltage)

This step verifies the performance of all the deflection related circuitry for accuracy for each oscilloscope range. Depending on the type, make and model, procedures will vary. However, in general, vertical deflection in analog and many digital storage oscilloscopes (DSOs) is verified using a precise positive 1 kHz square wave referenced to ground. Some DSO manufacturers use a precise dc voltage level to verify vertical deflection; however it is always good practice to perform a check using a precise square wave.

The accuracy of an oscilloscope's vertical deflection or amplitude is stated in $\pm X\%$ and is verified visually by aligning the square wave with the oscilloscope's graticule lines. The 55XX Series' output can be slewed around the reference amplitude to align the signal with the graticule, and the error is automatically calculated and displayed.

A 55XX Series calibrator equipped with an oscilloscope calibration option provides the precision positive (referenced to ground) square wave required by most manufacturer's procedures. It is available at

frequencies of 10 Hz to 10 kHz and amplitudes ranging from 2 mV to 6.6 V p-p (into 50 Ω) or 130 V p-p (into 1 M Ω). The 55XX Series also feature multiply and divide keys that step the amplitude up or down in 1-2-5 steps matching the ranges of most oscilloscopes.

To begin, connect the 55XX Series oscilloscope output to the oscilloscope's input, taking care to properly match impedances. If the oscilloscope being calibrated has selectable input impedance, both modes should be verified.

To source a reference amplitude, press the  key to put the calibrator into oscilloscope calibration mode. The amplitude (volt) mode is the first function available. This is indicated by the [VOLT] displayed above the right-most softkey. The 55XX Series defaults to 20 mV at 1 kHz. To activate the signal, press the  key. To set impedance of the calibrator to match the oscilloscope under test, press the  softkey to toggle between 50 Ω and 1 M Ω while in amplitude mode.

For a verification at this level, set the oscilloscope for 5 mV per division, dc coupled, and align the base of the square wave with the graticule. The square waves should be displayed over four divisions, with the tops aligned with the sixth graticule. See Figure 1. If not, vary the calibrator's output using the edit knob until the trace is aligned. The 55XX Series will calculate the error.

Digital oscilloscopes generally offer higher measurement accuracy, so cursors can be used to determine amplitude more precisely than is possible with a visual check. Also, the manufacturer's procedure may call out a dc voltage rather than a square wave. Nevertheless, the approach is the same, and often,

it is good practice to follow an amplitude verification using dc voltage with a check using a square wave.

In addition to verifying the amplitude, look for distortion in the shape of the square waves. They should be straight and square without noticeable aberrations or tilt. Distorted wave forms indicate other problems with the instrument.

Other comments

In their lower amplitude ranges, noise contributed by the amplifiers in the input circuitry of most oscilloscopes constitutes a higher percentage of amplitude error than in higher ranges. Extra care must be taken to center the trace on the graticule line.

Both analog and digital oscilloscopes exhibit different degrees of dc offset in all ranges. Take care that the base line is properly aligned with the 0V graticule line before checking amplitude in each range. If the oscilloscope exhibits a tilt, align the midpoints of the top and bottom traces.

Verification of pulse response (rise time or edge)

This test verifies the vertical amplifiers, attenuators, analog-to-digital converters (in DSOs) and all other vertical deflection circuitry for dynamic performance.

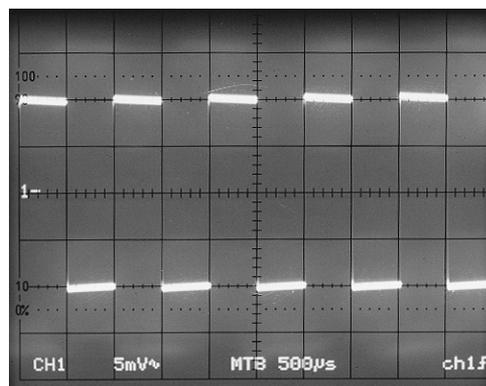


Figure 1. Vertical deflection (amplitude) verification.

Pulse response for most oscilloscopes is specified in rise time between the 10 % and 90 % amplitude points. Also specified are aberrations—undershoot, overshoot, ringing—as $\pm X\%$ at certain times.

The 55XX Series' oscilloscope cal options feature a < 300 ps rise time pulse with amplitudes ranging from 5 mV to 2.5 V p-p into 50 Ω .

To perform the verification, connect the calibrator's SCOPE output to the oscilloscope input, taking care to match impedances. In edge mode, the 55XX Series defaults to 25 mV p-p at 1 MHz into 50 Ω . If the oscilloscope being tested does not have a selectable 50 Ω input, a high quality, feed-through 50 Ω terminator must be connected at the oscilloscope input. Do not use a tee connection.

To set up the verification, place the calibrator in oscilloscope calibration mode by pressing the  key, and press the right-most softkey (mode) until [EDGE] is displayed. Connect the TRIGGER output of the calibrator to the trigger input of the oscilloscope and toggle the  to [1]. Then press . Set your oscilloscope to use this trigger signal. This will make it easy to synchronize the calibrator and the oscilloscope.

Set the range of the oscilloscope and adjust the 55XX Series so that the edge amplitude is displayed over the 0 % to 100 % markings on the oscilloscope display. For analog scopes, the verification is made visually by observing the time it takes the trace to travel between the 10 % and 90 % points on the scope display. With digital oscilloscopes, cursors can be used to display the rise time directly. See Figure 2.

To calculate the actual worst-case oscilloscope rise time, use this formula:

$$Tr = \sqrt{\text{Measured Rise Time}^2 - \text{Calibrator Rise Time}^2}$$

In addition to rise time, it is important to observe the aberrations, which should be less than a specified percentage of the peak-to-peak amplitude at set points during the pulse event, often called *epochs*.

Rise time and aberrations verifications should be repeated for all ranges as recommended by the manufacturer.

Other comments

Due to the limited tools available in the past, many oscilloscope calibration procedures called for a 1 V p-p edge signal for rise time verification. With some oscilloscopes, this results in a compromise, because these instruments actually need to be verified at higher amplitudes to assess any slew rate related dynamic limitations. The 55XX Series calibrator provides edge amplitudes to 2.5 V p-p allowing you to verify rise time at a higher amplitude.

When making rise time measurements with analog oscilloscopes, it is tempting to expand the oscilloscope's vertical display in order to better see the aberrations. This could produce misleading results due to circuitry overdrive. In addition, making this range change invalidates the verification because you are trying to verify one range by looking at the results displayed in another. For best results, the vertical range should be locked and the peak-to-peak wave form displayed on the screen.

Similar problems will result if you attempt to offset the displayed wave form beyond its visual range. In verifying rise time, it is always important that you see the full peak-to-peak amplitude of the wave form.

Bandwidth verification (leveled sine)

Bandwidth verification checks the dynamic response of the oscilloscope and can uncover

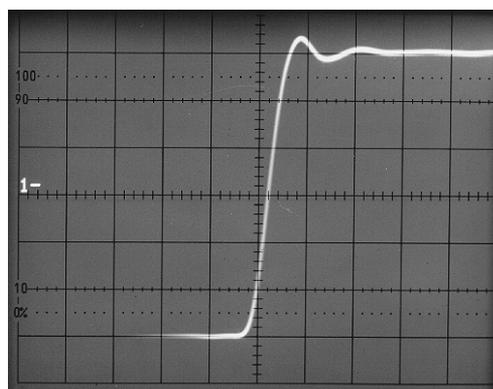


Figure 2. Rise time verification.

other anomalies such as dropouts.

Oscilloscopes bandwidth is specified at the frequency where the amplitude displayed is reduced by 3 dB.

To verify bandwidth, the oscilloscope cal option features a 50 kHz to 600 MHz leveled sine wave generator with flatness as low as $\pm 1.5\%$.

To perform the verification, connect the calibrator's SCOPE output to the oscilloscope input, taking care to match impedances. In leveled sine wave mode, the 55XX Series calibrator defaults to 30 mV p-p at 50 kHz into 50 Ω . If the oscilloscope being tested has something other than a 50 Ω input, a high quality, feed-through 50 Ω terminator must be connected at the oscilloscope input. Do not use a tee connection.

To set up the verification, place the calibrator in oscilloscope calibration mode by pressing the  key, and press the right-most softkey (mode) until [LEVSINE] is displayed. Then press .

Set up the oscilloscope so that it displays the sine wave over six divisions. See Figure 3. Using the  key, increase the calibrator's frequency until the amplitude of the wave form decreases to 4.2 divisions. See Figure 4. Along the way, look for any discontinuities that might indicate other problems with the oscilloscope. Repeat for all

amplitude ranges as recommended by the manufacturer.

The 55XX Series calibrator provides a number of options for checking the 3 dB roll-off point. In addition to the **[MULT]** key mentioned above, the calibrator's frequency can be slewed with the edit knob or set to jump or sweep to a desired frequency. The sweep and jump features are selected by pressing the **[MORE OPTIONS]** softkey while in **[LEVSINE]** mode. Press **[FREQ CHG]** to select between **[JUMP]** and **[SWEEP]**. Press **[RATE]** to select between **[FAST]** and **[SLOW]**. For example, to use sweep mode, set **[MORE OPTIONS]** **[FREQ CHG]** to **[SWEEP]** and **[RATE]** to **[FAST]**. Then, for a 100 MHz oscilloscope, enter **[1]** **[0]** **[0]** **[M]** **[Hz]** **[ENTER]** from the numeric key pad. The calibrator will begin to increment the frequency from the 50 kHz reference to 100 MHz. For a 100 MHz oscilloscope, the amplitude should be greater than or equal to 4.2 divisions throughout the sweep. At anytime you can stop the sweep, by pressing the **[HALT SWEEP]** softkey. The **[JUMP]** mode lets you go directly to the higher frequency, but prevents you for looking for discontinuities.

Horizontal timing verification (time marks)

Time marks are used to verify the horizontal deflection of the oscilloscope by checking frequency accuracy and linearity. Oscilloscope timing is typically specified at $\pm X$ % or $\pm Y$ ppm (parts per million).

To verify horizontal timing, the 55XX Series with the oscilloscope cal option outputs sawtooth time marks ranging from 5 seconds to 2 ns (sine wave between 10 ns and 2 ns) at a pre-set amplitude.

To perform the verification, connect the calibrator's SCOPE output to the oscilloscope input. In time mark mode, the

55XX defaults to 1 ms. If the oscilloscope being tested has something other than a 50 Ω input, a 50 Ω terminator must be connected at the oscilloscope input. Then connect the TRIGGER output of the calibrator to the trigger input of the oscilloscope.

To set up the verification, place the 55XX Series calibrator in oscilloscope calibration mode by pressing the **[CALIB]** key, and press the right-most softkey (mode) until **[MARKER]** is displayed. Then press **[CAL]** and toggle the **[TRIG OUT]** softkey to **[/1]**. This will make it easy to synchronize the calibrator and the oscilloscope.

Adjust the oscilloscope's time base until there is a marker displayed for every graticule line. Then, align the first and ninth markers, using the edit knob as necessary. See Figure 5. The error will be calculated and displayed. Finally, verify the alignment of the other time marks. Alignment problems here indicate problems with the time base, horizontal deflection circuitry or linearity.

Other comments

We recommend using external trigger in the time marks mode because at higher frequencies, the bandwidth of the calibrator signal generator may exceed the bandwidth of the oscilloscope, preventing it from triggering on its own. The trigger frequency from the 55XX Series calibrator can be divided by 1, 10 or 100 to eliminate the problem.

The oscilloscope cal options use the traditional and proven comb pattern with a fast rise/slow fall time (sawtooth) markers for horizontal timing verifications because they are much easier to align precisely with the graticule line. The comb pattern works equally well with analog and digital oscilloscopes.

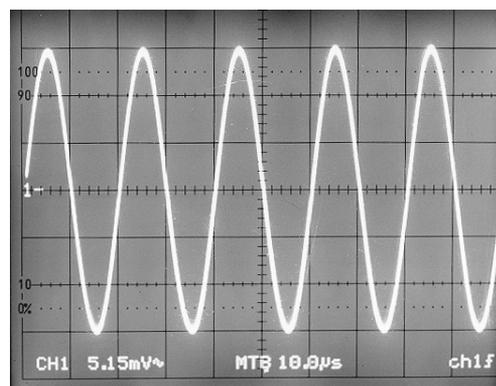


Figure 3. Setting the reference frequency for bandwidth verification.

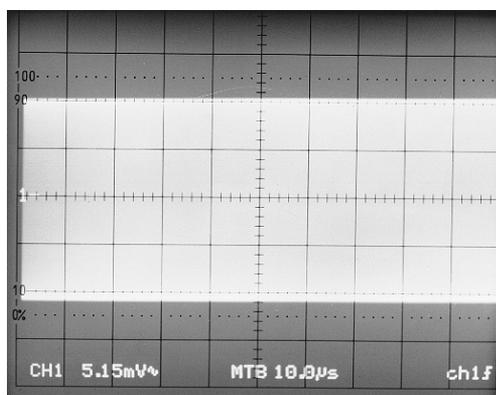


Figure 4. The 3 dB roll-off point for bandwidth verification.

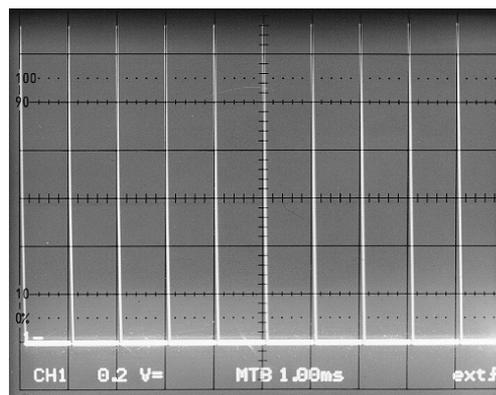


Figure 5. Horizontal timing verification using time marks.

Trigger operation

Oscilloscopes in common use today, both analog and DSOs, offer a wide range of triggering functions. While not pure measurement functions, virtually all verification procedures call for a check of the trigger operations. Verification frequencies can vary from 50-60 Hz, for line triggering, to beyond the

bandwidth of the oscilloscope. And there can be a wide range of coupling modes—ac, dc, low frequency, high frequency or noise reject and so on. DSOs offer still more triggering capabilities.

While there is great variation between oscilloscopes, the basic principle for verifying trigger operation is the same. Most trigger functions are specified as the minimum number of divisions where a stable signal is displayed at a given frequency.

To make this test, the 55XX Series calibrator with the oscilloscope cal option features a function generator mode that can generate square, sine and triangle waves over 10 Hz to 100 kHz.

To verify trigger operation, connect the scope output of the calibrator to the input of the oscilloscope being tested, making sure the impedances match. Press the  softkey until [WAVEGEN] appears. Then toggle the [WAVE] softkey until [SINE] is shown. Press the  key to activate the generator. Select the frequency output as required for your oscilloscope. Then press the  key again to select the amplitude display, and press  (or use the edit knob) to reduce the amplitude until the displayed wave form becomes unstable.

Other comments

For frequencies above 100 kHz, the calibrator's leveled sinewave mode can be used. In this mode, a 55XX Series calibrator can generate a leveled sine wave up to 1100 MHz. Though leveling is necessary for bandwidth verification, it is unnecessary for trigger operations tests.

Advantages of using a Multi-Product Calibrator

55XX Series Multi-Product Calibrators are each eleven calibrators in one. This automatically presents an advantage over using standalone oscilloscope calibrators and signal

generators: it basically occupies the space of one calibrator.

With a 55XX Series calibrator, you have only one instrument to calibrate periodically, rather than several. If you perform calibrations in multiple locations, their rugged portable design makes them easy to take to the job site.

In addition, the 55XX series features an optional shock-mounted carrying case accessory with built-in handles and wheels. The case's front and rear access doors are removable, so you can calibrate while its top, bottom and side panels remain protected—and avoid having to completely unpack and then re-pack the calibrator.

Workload segregation

The problem most calibration laboratories face today is the high volume of complex low-to-medium accuracy test tools. The goal of a Fluke Calibration multi-product calibrator with the scope option is to minimize the amount of equipment needed to calibrate the bulk of the workload. It calibrates a wider cross-section of the calibration workload than any other calibrator. And it does it at an economical price, little over the cost of a conventional DMM calibrator.

Some examples include:

- The Fluke ScopeMeter® test tool, which is a digitizing oscilloscope and multimeter, requires four signal generators and a five function DMM calibrator. A Fluke Calibration 55XX Series calibrator does it all.
- The Fluke 39, 41B and 43B Power Meters require

concurrent voltage or voltage plus current references with phase control and harmonics. The 55XX Series meets the requirement with one instrument.

- The Fluke 700 Series documenting process calibrators source and measure thermocouples and rtds, and require calibration of voltage, current, temperature and resistance measurement ranges. A 55XX Series calibrator can meet the requirement with one instrument.

Automation

Calibration with 55XX Series calibrators can be fully automated with Fluke Calibration's MET/CAL Plus Calibration Management Software calibration software packages. MET/CAL software permits control of the instrument under test, via the IEEE-488 bus. This permits semi-automated to fully hands-off calibration under computer control.

Automation has two important benefits. The first is consistency. With the procedures documented in software, you are assured they are executed completely and consistently every time, and that all test results are recorded accurately and archived. The second is productivity. MET/CAL helps technicians do more work faster, and can simplify more complex work that might otherwise have to be performed by more experienced personnel.

Sample procedures are included with the software. Thousands of additional



A rugged carrying case for the 55XX Series calibrators makes it easy to do on-site calibration.

warranted procedures are available for purchase. These procedures are also available at no charge to subscribers to the MET/SUPPORT Gold software support program. More information about the MET/SUPPORT program is available on the flukecal.com website.

Convenience

When you have a 55XX Series calibrator equipped with oscilloscope calibration option, you have one instrument, one interface to learn, and it's easy to use. All connections are located on the front panel, and the controls are intuitive.

Portability

55XX Series calibrators are compact and portable, with handles. Combined with a laptop computer and automation software, it allows you to have a calibration laboratory in one instrument.

Availability and support

The 55XX Series with oscilloscope calibration options is widely used and is supported world-wide.

Comparison with other signal generators

Prior to the introduction of the 55XX Series, most oscilloscope calibration was done with a range of discrete signal sources, which typically included a pulse generator, time mark generator, leveled sine wave generator, function generator and a meter calibrator. Each has its own "operator interface". Most were manual, making automation impossible. And each had its own calibration support requirements.

While these are perfectly adequate for the job, the 55XX provides a more modern, self-contained approach, which is easier to use and to support, and which can be automated.

Convenience

The 55XX Series oscilloscope calibration options add the functionality (Leveled Sinewave Generator, Time Mark Generator, and Pulse Generator) of the discontinued Tektronix™ 500 series calibrators to the 55XX calibrators in one compact, portable instrument that can be controlled by a computer.

Adequacy

The 55XX Series oscilloscope calibration performance is comparable with the best single-function calibrators, and is designed to calibrate most widely used analog and digital oscilloscopes.

Traceability

All oscilloscope calibration outputs are traceable to standards, including aberrations on the fast edge pulse.

Ease of use

Using a 55XX Series calibrator is easier than a collection of signal generators because it is a single instrument with common output terminals, a single control panel, and a common user interface. Operators work with and learn one instrument. They don't have to master the operation of several single function calibrators.

Acquisition and ownership costs

A Fluke Calibration multi-product calibrator costs little more than a traditional set of oscilloscope calibration generators, yet it does much more.

Modern design and manufacturing techniques assure a high degree of reliability and greatly simplify periodic calibration and verification. The largest cost of owning a calibrator is not the purchase price. The cost of calibration, maintenance, repair and training over the instrument's overall lifetime can be several orders of magnitude greater. Fluke Calibration

multi-product calibrators are designed to reduce those costs.

Complexity

The 55XX Series created a new class of calibrator that covers a broader workload with a single instrument than ever before. It offers more functionality than previous calibrators, in areas such as wave form selection, square wave dc offset and amplitude level controls, broader frequency coverage, coverage at low signal levels, and better frequency uncertainty. Yet the connections and controls are more intuitive and convenient.

Standards, traceability, and specifications

Why calibrate?

Measurement quality is becoming a core concern throughout industry. Modern quality programs and standards stress controlling and managing processes. A central method for doing that is to make meaningful measurements of those processes. Calibration makes measurements meaningful.

Meaningful measurements

For any measurement to be meaningful, it must be traceable to a recognized standard, in most cases, a national or legal standard for the quantity being measured. This traceability is accomplished through a documented series of comparisons from one level of standards to increasingly accurate standards. Parameters of interest in establishing traceability for oscilloscopes include:

- Time interval
- Frequency
- Voltage amplitude
- RF power
- Pulse characteristics

Trends

Because of its central role in process control, measurement quality has gained a more widely recognized place in today's quality standards.

Examples include the ISO 9000 series, the U.S. auto manufacturer's QS9000, U.S. Food and Drug Commission's GMPs, and the Nuclear Regulatory Commission's 10CFRs. The one thing these standards have in common is the requirement that measurements affecting quality be adequate and documented traceable to recognized standards.

Technology advances have put greater measurement and troubleshooting power in the hands of more people. The 55XX Series calibrators were designed with that in mind—making simple and efficient-to-perform traceable calibrations of the kinds of electronic test tools commonly in use today.

Truth in specifications

Many specifications are hard to understand. Some list several independent factors, so that when you combine them, you get surprises. Sometimes, it is almost impossible to compare specifications of one instrument to another due to the differences. Good calibrator specifications are complete, are easy to use and interpret, and adequately define environmental and load effects. Reputable manufacturers will describe calibrator performance as accurately and simply as possible without hiding areas of poor performance.

To make the 55XX Series calibrators' specifications easier to use and interpret, Fluke Calibration combines all the sources of measurement uncertainty into a single, 99 %-confidence-level uncertainty specification. You could say that Fluke Calibration wrote the book on instrument specifications. In fact, two of our technical publications, *Calibration: Philosophy and Practice* and "Understanding and Comparing Instrument Specifications," provide industry-standard guidelines for understanding and using instrument specifications.

Automating the calibration process

Making the measurements is only part of the calibration process. The calibration manager also must assure that his process is:

- Performing consistently
- Has documented, controlled and understandable procedures
- Has traceability to accepted standards
- Can report information quickly

The power, flexibility, and easy customization of the optional MET/CAL Plus Calibration Management Software helps you meet these requirements with a minimum of effort and administration. The convenience that Fluke Calibration software provides is especially valuable in ISO 9000 documentation programs, where keeping calibration records and assessing test results validity are important program functions.

Calibration automation software

MET/CAL software uses hundreds of procedures to automate the 55XX and other calibrators. It provides the user with an environment for developing, testing and executing calibration procedures, collecting and reporting results and managing the calibration system.

MET/CAL provides:

- Flexibility and a growth path to accommodate changing needs
- The ability to configure calibration programs for future performance requirements
- Testing consistency: Instruments tested will be calibrated the same way, every time
- Reliable documentation: The software generates complete, readable calibration procedures
- Documented calibration results: The software

automatically records the measurements, calculates and records the error, and reports the results

- Comprehensive reporting: Report formats include calibration certificates, summaries, detailed results, as-found/as-left and test uncertainty ratio reports, traceability, and the calibration environment. The procedures, data collection functions and reports meet all ISO 9000, ISO 17025 and other requirements
- Improved productivity: Fluke calibration software uses the familiar Microsoft Windows® user interface to make learning and running the software easy. The software takes control of the 55XX Series calibrator and speeds it through its paces. It steps the technician through connections, visual verifications, and UUT control steps. And the technician doesn't need to record data
- Flexible workload management: The procedures that come with Fluke calibration software will probably cover most of your oscilloscope calibration workload. Use Fluke Calibration procedures as is, change them to reflect local laboratory protocols, or use them to write new procedures
- Easy procedure development: If you prefer, you can write your own procedures. You don't have to be a programmer to write them. The calibration software uses a modular approach to create readable procedures. You can also use the Autopro utility to fill out a spreadsheet with specifications from a data sheet. And if you need help developing your procedures, Fluke training is available

Metrology workload management

Calibration laboratory managers must maintain equipment asset information and manage their staff's workload. MET/TEAM™ Test Equipment Asset Management Software can help meet modern calibration laboratory requirements. MET/TEAM™ software is a powerful, flexible, and scalable solution for managing your calibration assets. Designed by metrologists for metrology, it is ideal for calibration professionals who need to manage workflow through the calibration laboratory. MET/TEAM software enables you to:

- Manage all aspects of your calibration operation with one paperless solution
- Improve productivity and reduce operating costs
- Maintain compliance with regulatory standards
- Configure and customize for your business rules
- Report to meet a wide range of requirements
- Schedule maintenance events
- Perform batch receiving
- Create, track and close work orders
- Track assets as they move through the lab

- Create and print calibration reports
- Maintain an audit trail
- Manage shipping information
- Track customer and vendor information
- View business statuses
- Create data templates and store procedures
- Choose from optional modules for onsite calibration, customer web portal, and billing/quoting/contract pricing.

Training and technical support

A good instrument is not the total product. Training and support services can help you achieve maximum efficiency and satisfaction from Fluke Calibration products.

Details about training and support services are available on the Fluke Calibration website at www.flukecal.com.

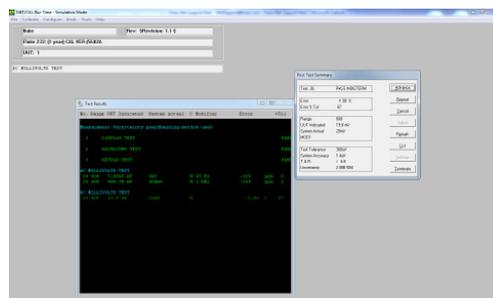


Figure 6. Calibration with the 55XX Series calibrators can be fully automated with MET/CAL Plus Calibration Management Software.



Figure 7. MET/TEAM is a powerful, browser-based application for managing calibration assets and workflow.

Fluke Calibration. Precision, performance, confidence.™

Electrical	RF	Temperature	Pressure	Flow	Software
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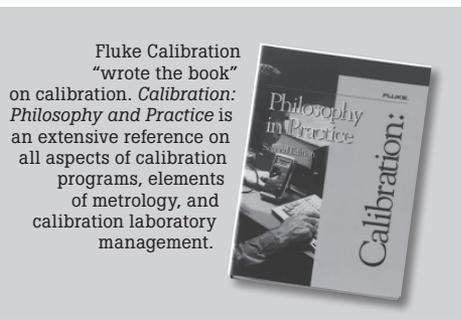
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Fluke Calibration "wrote the book" on calibration. *Calibration: Philosophy and Practice* is an extensive reference on all aspects of calibration programs, elements of metrology, and calibration laboratory management.