TELEDYNE TEST TOOLS
Everywhereyoulook™

T3SP15D Data Sheet

Time Domain Reflectometer (TDR)

Calibrated True-Differential TDR

Rapid and Accurate Single-ended and Differential Impedance Profile Measurements

Two different mainframes available:
T3SP15D, High-Resolution TDR
T3SP15D-XR, High Resolution, Extended range, optimized for cable manufacturing

Affordable Tools for Precision Debugging

• **True Differential TDR and Single-ended TDR** – Best for cables, differential design and twisted pair.	✓ Accurate Impedance measurements, no ground connection required for differential.
• **30 ps typ. Rise Time** – Less than 3 mm impedance measurement spatial resolution.	✓ Precisely locate and detect geometry dimensions and dielectric variation of cables and transmission lines.
• **Instant Cable and Connector Testing** – Verify the quality of your cables and connectors.	✓ Detect even on your premium cables any imperfection that might be the root cause of measurement artifacts.
• **Small Form Factor and Battery Powered** – Measure and analyze in the lab, factory floor or in the field.	✓ Measure and analyze everywhere you go without an AC requirement.
• **Inter-pair and intra-pair skew Measurements** – Automatically calculated from Impedance profile traces.	✓ Inter-Pair skew is calculated when two single-ended or two differential measurements are selected. Intra-Pair skew is calculated when one differential measurement is selected.
• **Up to 50,000 points long memory** – Long TDR response capture with high resolution.	✓ Characterize up to 40 m long cables with more detailed measurement data.

Key Specifications

Model	T3SP15D	T3SP15D-XR
Impedance Profile	Yes, True Differential TDR and Single-Ended TDR	
Rise Time (20 % to 80 %)	35 ps	35 ps
Step Amplitude	150 mV @ 50 Ω	
Pulse Repetition Rate	1 MHz to 10 MHz	500 KHz to 10 MHz
Sampling Interval	10 ps	10 ps, 20 ps, 40 ps @optimized for acquisition time
Max Range Cable Lenth	30 m @1 MHz	50 m @ 500 KHz
Inter-Pair Skew	Yes, for Single-Ended and Differential Transmission Lines	
Intra-Pair Skew	Yes, for Differential Transmission Lines	
Impedance Profile Memory Trace	up to 50,000 points	
Battery Operated (B-models)	Yes	
Dimensions	220 x 210 x 82,5 mm	

ULTRA-PORTABLE AND BATTERY POWERED

The battery option give you the freedom to work where you require

Product Overview

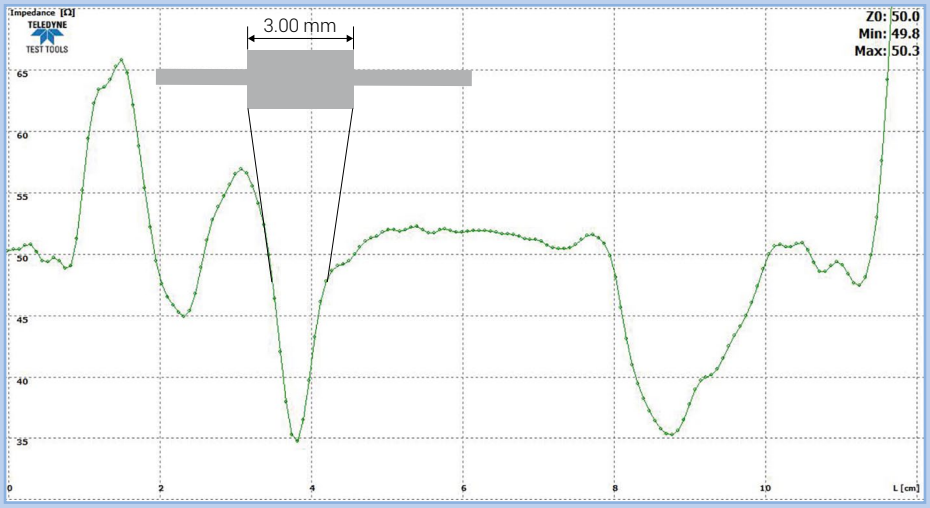
Today's modern fast bus speed designs make debugging signal integrity issues one of the most challenging tasks for engineers to perform efficiently and precisely. For example, take high operating frequencies and mix that with anything that affects your signal's rise time, pulse width, timing, jitter or noise content and you increase the risk of impacting reliability at the system level. If you want to ensure signal integrity you need to understand and control impedance within the transmission environment the signals travel through and the ideal tool to pinpoint those impedance problems are TDR instruments. The Teledyne Test Tools SP-series combines high resolution with a rapid refresh rate, quick data acquisition rate, ultra-portable design including a battery option all for a very attractive price. Use it out in the field and in the lab.

Key Benefits

Ultra-Portable and Battery Powered

Current TDR solutions for signal integrity measurements are based on sampling oscilloscopes which are designed to be used in electronics labs. The size and weight of a traditional sampling oscilloscope make it impossible to perform in the field TDR-measurements. The T3SP-series is designed as a portable and lightweight instrument that can easily be used wherever measurements have to be performed. The battery pack option allows up to 3 hours of operation.

HIGH-RESOLUTION CALIBRATED TRUE DIFFERENTIAL TDR



OSLT calibration in time domain avoid aberrations effects in impedance plots and let the user identify impedance anomalies with less than 3 mm resolution

Based on the true differential design, there is no need for a physical ground connection if differential lanes are measured

True differential TDR

Most of the modern high-speed designs are implemented with differential transmission lines. Using a true differential TDR simplifies the setup for signal integrity measurements in such designs. In some scenarios the ground connection could be difficult to connect or not accessible if you want measure unshielded twisted pair cables. Most of the time, when you take measurements using a true differential TDR a ground connection is not required and gives you the flexibility to use TDR-probes without a ground connection.

Fast TDR Repetition Rate

With up to 10 MHz repetition rate the T3SP-series is more than 300 times faster as conventional TDR-instruments which are based on sampling scopes. To achieve the highest possible dynamic range TDR-instruments need to acquire and average out hundreds of waveforms. The faster sampling rate delivers quicker and more accurate measurement results.

Full Calibrated Impedance Plot

Reference impedance in all TDR instruments are relative; they are made by comparing reflected amplitudes to an incident amplitude. Using full OSLT-calibration the T3SP-series is offering best accuracy for impedance measurements in time and frequency domain. Using four calibration standards (open, short, load and Thru) in the time domain instead of using a simple normalization which is common in TDR-instruments offers vastly improved error correction for the setup. Using OSLT-calibration in the time domain avoids irregularities in impedance plots, such as ringing that occurs after the TDR incident step.

Full calibrated S-Parameter

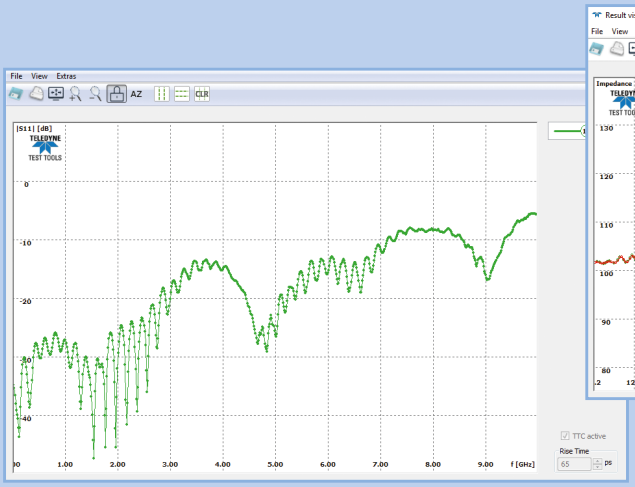
Many of the modern standards like Ethernet or USB require you to measure the impedance matching of the cables and connectors within the frequency domain (S-Parameter S_{11}). These are the measures commonly made with traditional VNA instruments. The T3SP-series offers fully calibrated Differential S_{11} and Full Single-ended (S_{11}, S_{21}, S_{12}, S_{22}) S-parameters measurements up to 15 GHz using the same OSLT-calibration standards used by VNAs.

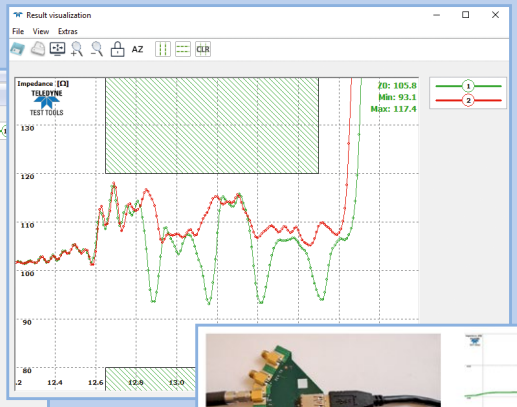
Optimized time bases for cable production (T3SP15D-XR)

The T3SP15D-XR was created to provide a better alternative for production to the use of obsolete TDRs based on the sampling oscilloscope platform.

Four new time bases were added into T3SP15D-XR, achieving two results. First, the extension of measurements to cables up to 50 m, and second, the ability to make very fast acquisitions, which is a key requirement for production. We added a repetition rate of 500 KHz, suitable for longer cables, and sampling rates of 20 ps and 40 ps, suitable for ultrafast acquisition times. Full details can be found in the table on page 8.

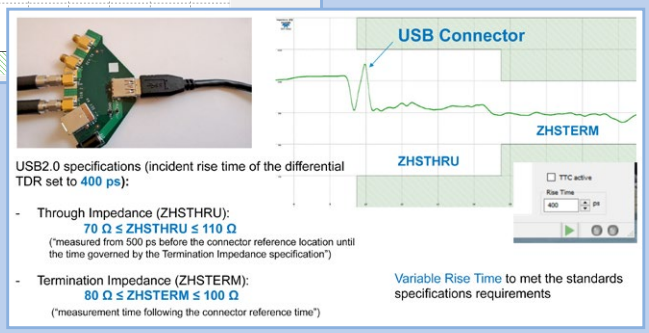
HIGH-RESOLUTION CALIBRATED TRUE DIFFERENTIAL TDR





Less than 3 mm resolution on FR4 can show the effect of blind vias (red) vs. true vias (green)

The T3SP15D series offer S-parameter (S_{dd11} and Full Single-ended, i.e. S_{11}, S_{21}, S_{12}, S_{22}) measurements from DC up to 15 GHz



USB2.0 specifications: Impedance profile @400 ps risetime

ESD-protection

High-frequency measurement devices are extremely sensitive to electrostatic discharge (ESD) and can lead to permanent damage to your measurement device. In addition, many laboratories have a requirement to take special precautions to protect their electronic equipment from any damage caused by ESD. The SP-series mitigates this risk by providing a higher degree of protection from this happening. Every SP-series model comes equipped with an ESD-protection module based on high-performance coaxial RF-switches. The ways this works is the RF input circuitry is protected by isolating the devices RF-signal detector from the input connector when the device is not being used to take measurements.

Measure Impedance, Return Loss and Insertion Loss

The high bit rates used in modern electronics design and future serial data standards extend well into the microwave region. For example, the High-speed Universal Serial Bus (USB3.1) supports transfer rates up to 10 GB/s over twisted-pair cables. These high bit rate transmissions through connectors and cables results in considerable distortion because of channel dispersion.

To keep the distortion to manageable levels, many standards specify the Impedance, return loss and insertion loss for cables and connectors. These measurements are represented by the S-parameter. The T3SP-series offer fully calibrated Differential S_{11} (S_{dd11}) and full single-ended (S_{11}, S_{21}, S_{12}, S_{22}) S-Parameter measurements up to 15 GHz. This gives you the flexibility to store your output files in a variety of formats (CSV, Matlab and Touchstone) which can be easily used in tools like SI-Studio, Matlab or other simulation programs.

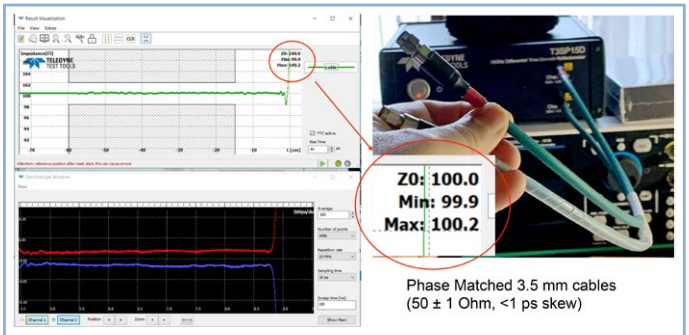
Controlled Impedance Traces on Printed Circuit Boards (PCB)

Due to increasing clock rates in high speed digital systems the necessity of controlled impedance PCBs is growing rapidly. Additionally, cables and connectors must meet high frequency design specifications and controlled impedance specifications. The T3SP-series helps you to measure wave impedances of PCBs, cables, and connectors very accurate and comfortably. In contrast to other systems on the market, the T3SP-series is designed for measuring specific traces on a PCB and for on-board tests, the TDR-Probes ensure accurate measurement for qualification testing and debugging assembled PCBs.

INSTANT CABLES AND CONNECTORS TESTING

Key Benefits

Quality of cables and connectors instantly revealed



Impedance profile measurement (100 Ohm) of the 3.5 mm phase matched cables provided with the T3SP15D or T3SP15D-XR

Assuming cables and connectors are perfect is a common mistake. You make a measurement that involves a fast edge or high bandwidth signal and something doesn't look quite right. In those situations, you add a bad cable or connector to your list of "usual suspects". Unless you have verified the quality of your cables and connectors, there is always the possibility that even your premium cables and connectors may have some imperfections that can cause measurement artifacts. The T3SP-series TDR reveals immediately the quality of your cables and connectors, identifying parts that are out of spec, due to damage or defects. This drammatically improves your productivity and increases the confidence in your design and results.

T3SP15D + WAVEPULSER 40iX

The Teledyne LeCroy WavePulser 40iX and the Teledyne Test Tools T3SP15D are a perfect combination of complementary products to serve the requirements for testing, validating and troubleshooting cables, backplanes, connectors, and transmission lines on printed-circuit boards.

Model	WavePulser40iX	T3SP15D and T3SP15D-XR
Time		
Impedance Profile	Differential, Single-ended and Common-Mode	Differential and Single-ended
Rise Time	8.5 ps	35 ps
Frequency		
S-Parameters	Full 4 port Single-ended, Full Differential and Mixed-mode	Full 2 port Single-ended and Differential S_{11}
Frequency	40 GHz	15 GHz
ToolBox		
De-embedding and Emulation	Yes	No
Eye Diagram and Jitter	Yes	No
Platform		
Number of ports	4	2
USB-connected	Yes	Yes
Battery powered	No	Yes

MODEL SPECIFIC SPECIFICATIONS

Model	T3SP15D and T3SP15D-XR
Operating Frequency	15 GHz
S-parameter Measurements	Full Single-ended S_{11}, S_{21}, S_{12}, S_{22} and Differential S_{dd11}
Calibration Method	OSL and OSLT
Connector Type	2.92 mm

Standard Measurement Capability

Measurement Modes	TDR, DTDR
Frequency Domain Displays	S_{xy} (Magnitude, Phase), VSWR, Smith Chart
Insertion Loss Accuracy (max typ. @10 dB)	DC ≤f <5 GHz: ±0.5 dB 5 GHz ≤f <10 GHz: ±0.75 dB 10 GHz ≤f <15 GHz: ±1 dB
Time Domain Displays	Oscilloscope Mode, Z – normalized to specified rise time, Step response
File Outputs	CSV, Matlab, Touchstone 1.0, PDF-Report

Pulser / Sampler and Time base

Step Amplitude	150 mV Single-ended / 300 mV differential (nominal top-base, 50 Ω termination)
Rise Time	35 ps
	(20 – 80 % typical — as measured by sampler) Rise Time could be limited by software (up to 1 ns)
Input Voltage Range	+/-325 mV (+/-2 V nondestructive)
Noise	< 500 μV_{RMS} typical
Repetition Rate	1, 2, 5 and 10 MHz (T3SP15D), 0.5, 1, 2, 5, 10 MHz (T3SP15D-XR)
Acquisition Duration	50,000 Points
Max DUT length	30 meters @1 Mhz (T3SP15D), 50 meters @500 KHz (T3SP15D-XR)
Equivalent Time Sample Rate	100 GS/s
Jitter	< 500 fs RMS typical

Internal ESD Protection Relays

Frequency Rating	>15 GHz
Rated Life	2 million actuations per contact

Model	T3SP15D and T3SP15D-XR

Battery (Option)

Type	Internal Li-Ion-Battery, 2.2 Ah
Operational Time	> 3 hours * (in ESD-protection mode)
Recharging Time	3 hours

Physical Dimensions

Dimensions	Without connectors: 220 × 210 × 82.5 mm With connectors: 242 × 210 × 82.5 mm Coax connector spacing: 28 mm
Shipping Dimensions	500 mm x 400 mm x 200 mm
Weight	2600 g (2800 g with battery)
Shipping Weight	7300 g (including travel case and accessories)

Power Requirements

Voltage	100 – 240 VAC, 50 – 60 Hz, 1.7 A with distributed external power adapter
Max. Power Consumption	17 watt (42 watt with battery)

Temperature Range

Operation	0 °C – 40 °C
Store	-20 °C – 80 °C (0 °C – 40 °C with Battery)

Recommended PC Configuration

Operating System	Windows 7, Windows 8, Windows 10
Processor	Dual core or better recommended
Memory	Minimal 2 Gbyte
Hard Drive	Minimal 25 Mbyte
Display Resolution	1024 x 768 or larger
Connectivity	USB 2.0

T3SP-DPROBE

The high precision differential TDR Probe T3SP-DPROBE provides an 18 GHz, high performance solution for TDR circuit board impedance characterization and high-speed electrical signal analysis applications. The ergonomic and robust case design providing best ratio of thickness and width. The robust measuring tips guarantee a long life and high repeatability of the measurements.

Parameter	Value / Unit	Comments
Impedance	100 Ω	VSWR < 1.05
Electrical Length	690 ps	
Probe Tips	Fixed Blades	Copper beryllium (3 pairs of replacement tips included)
Pitch	0.1 – 5 mm	adjustable
Pin Configuration	Signal – Signal	
Connectors	SMA female	compatible with 2.92 mm and 3.5 mm connectors
Frequency Range	DC – 18 GHz	valid for probe without tips
Dimensions	130 × 34 × 14 mm	casing only
	157.5 × 34 × 14 mm	with connectors and tips
Material	Aluminum	
Specials		direct in-circuit TDR testing

T3SP-DPROBE-F

The economic differential TDR Probe T3SP-DPROBE-F provides an ideal solution for TDR circuit board impedance characterization on a very attractive price. It is the ideal probe for fast and accurate PCB impedance measurements up to 5 GHz.

Parameter	Value / Unit	Comments
Impedance	100 Ω	VSWR < 1.05
Electrical Length	830 ps	
Probe Tips	Spring-loaded pin	
Pitch	2.54 mm	fixed
Pin Configuration	Signal – Signal	
Connectors	SMA female	compatible with 2.92 mm and 3.5 mm connectors
Frequency Range	DC – 5 GHz	valid for probe without tips
Dimensions	131 × 32 × 13.2 mm	casing only
	131 × 32 × 15.6 mm	with connectors and tips
Material	Polystyrene	

T3SP-SEPROBE-F

The T3SP-SEPROBE-F Single-ended TDR probe provides an ideal solution for TDR circuit board impedance characterization at a very attractive price. It is the ideal single-ended probe for fast, accurate and repeatable accurate PCB impedance measurements up to 5 GHz.

Parameter	Value / Unit	Comments
Impedance	50 Ω ±1 Ω	
Electrical Length	850 ps	
Probe Tips	spring-loaded	
Pitch	2.54 mm	fixed
Pin Configuration	S-G	
Connectors	SMA female	compatible with 2.92 mm and 3.5 mm connectors
Frequency Range	DC – 5 GHz	valid for probe with tips
Dimensions	131 x 32 x 13.2 mm	casing only
	131 x 32 x 15.6 mm	with connectors and tips
Material	Polystyrene	

T3SP-SEP

The high precision Single-ended T3SP-SEP TDR probe provides a 10 GHz, high performance and repeatable solution for TDR circuit board impedance characterization for all the high-speed single-ended electrical signal analysis applications. The variable pitch combined with the compact dimension make this probe an ideal solution for high repeatable TDR single-ended measurements.

Parameter	Value / Unit	Comments
Impedance	50 Ω ±1 Ω	
Electrical Length	100 ps	
Probe Tips	spring loaded	
Pitch	1.0, 1.27, 1.65, 2.0 & 2.5 mm	variable
Pin Configuration	S-G	
Connectors	2.92 mm female	compatible with SMA and 3.5 mm connectors
Frequency Range	DC – 10 GHz	
Dimensions	29.8 x 9.0 mm	(length x diameter)
Material	Brass	
Specials		direct in-circuit TDR testing

T3SP-CASE included with the T3SP15D-BUNDLE, T3SP15D-B-BUNDLE, T3SP15D-XR-BUNDLE and T3SP15D-B-XR-BUNDLE models

The T3SP-CASE aluminum case is an ideal choice to safely store and transport your T3SP15D instrument and additional accessories.

Platform selection guide

Product Code	Max Cables Length	Mainframe and Phase Matched Cables	Calibration Kit and Torque wrench	Internal Battery	PCBs line impedance	MDI Automotive Ethernet	Inter-pair and intra-pair Skew	S-par (Sdd11 and S11, S21, S12 and S22)
T3SP15D-BUNDLE	30 m	Yes, 3.5 mm cables	Yes, 3.5 mm OSLT	No	Yes	Yes	Yes	Yes
T3SP15D-B-BUNDLE	30 m	Yes, 3.5 mm cables	Yes, 3.5 mm OSLT	Yes	Yes	Yes	Yes	Yes
T3SP15D-XR-BUNDLE	50 m	Yes, 3.5 mm cables	Yes, 3.5 mm OSLT	No	Yes	Yes	Yes	Yes
T3SP15D-B-XR-BUNDLE	50 m	Yes, 3.5 mm cables	Yes, 3.5 mm OSLT	Yes	Yes	Yes	Yes	Yes

T3SP15D-XR includes new time bases optimized for cable manufacturing

Pulse Repetition Rate	Sampling Interval	Acquisition Time (s)	Comments	T3SP15D	T3SP15D-XR
10 MHz	10 ps			Yes	Yes
5 MHz	10 ps			Yes	Yes
2 MHz	10 ps			Yes	Yes
1 MHz	10 ps	6.4 s		Yes	Yes
1 MHz	20 ps	0.8 s	@optimized for manufacturing	No	Yes
1 MHz	40 ps	0.4 s	@optimized for manufacturing	No	Yes
500 KHz	20 ps	3.2 s	@extended range (50 m) @optimized for manufacturing	No	Yes
500 KHz	40 ps	1.6 s	@extended range (50 m) @optimized for manufacturing	No	Yes

Ordering information

Product Description	Product Code
Mainframes (T3SP15D)	
Differential High-Resolution TDR, 35 ps Rise Time, ESD protection, 2 phase matched 3.5 mm cables, 3.5 mm Cal. Kit, Aluminum Case, Sdd11 and S11, S21, S12 and S22	**T3SP15D-BUNDLE**
Differential High-Resolution TDR, 35 ps Rise Time, ESD protection, Internal Battery, 2 phase matched 3.5 mm cables, 3.5 mm Cal. Kit, Aluminum Case, Sdd11 and S11, S21, S12 and S22	**T3SP15D-B-BUNDLE**
Mainframes (T3SP15D-XR)	
Differential Extended Range, High-Resolution TDR, 35 ps Rise Time, ESD protection, 2 phase matched 3.5 mm cables, 3.5 mm Cal. Kit, Aluminum Case, Sdd11 and S11, S21, S12 and S22	**T3SP15D-XR-BUNDLE**
Differential Extended Range, High-Resolution TDR, 35 ps Rise Time, ESD protection, Internal Battery, 2 phase matched 3.5 mm cables, 3.5 mm Cal. Kit, Aluminum Case, Sdd11 and S11, S21, S12 and S22	**T3SP15D-B-XR-BUNDLE**
TDR probes (all mainframes)	
Differential TDR-Probe (high precision, 18 GHz, 0.5 – 5.0 mm variable pitch)	**T3SP-DPROBE**
Differential TDR-Probe (economic, 5 GHz, 2.5 or 5 mm fixed pitch)	**T3SP-DPROBE-F**
Single-ended TDR-Probe (fixed pitch 2.54 mm)	**T3SP-SEPROBE-F**
Single-ended TDR-Probe (high precision, 10 GHz, variable pitch)	**T3SP-SEP**
Accessories	
OSLT Calibration Kit 3.5MM with torque wrench, female*	**T3SP-CALKIT-3.5MM**
Phase Matched 3.5 mm cables (50 ± 1 Ohm, <1 ps skew)*	**T3SP-CABLE-3.5MM**
Storage and Travel Case (aluminum suitcase for TDRs and accessories)**	**T3SP-CASE**
Demo and Verification Board	**T3SP-BOARD**

* included with T3SP15D and T3SP15D-XR BUNDLE configurations
** included with all BUNDLE configurations

Standard warranty is one year (for warranty extension please contact Teledyne LeCroy Service)

Included with T3SP15D-BUNDLE, T3SP15D-B-BUNDLE, T3SP15D-XR-BUNDLE and T3SP15D-B-XR-BUNDLE

T3SP15D or T3SP15D-B (internal battery) time-domain mainframe, 1 x pair of phase matched cables (± 2 ps), OSLT calibration Kit (@26.5 GHz, 2.92 mm with certificate), torque wrench, USB Hasp (to enable TDR application to run off-line), USB2.0 cable, Mini USB to USB-A, External Power Supply, Aluminum case (T3SP-CASE), Calibration and Performance Certificate, 1 year warranty.

ABOUT TELEDYNE TEST TOOLS

TELEDYNE TEST TOOLS
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Company Profile

Teledyne LeCroy is a leading provider of oscilloscopes, protocol analyzers and related test and measurement solutions that enable companies across a wide range of industries to design and test electronic devices of all types. Since our founding in 1964, we have focused on creating products that improve productivity by helping engineers resolve design issues faster and more effectively. Oscilloscopes are tools used by designers and engineers to measure and analyze complex electronic signals in order to develop high-performance systems and to validate electronic designs in order to improve time to market.

The Teledyne Test Tools brand extends the Teledyne LeCroy product portfolio with a comprehensive range of test equipment solutions. This new range of products delivers a broad range of quality test solutions that enable engineers to rapidly validate product and design and reduce time-to-market. Designers, engineers and educators rely on Teledyne Test Tools solutions to meet their most challenging needs for testing, education and electronics validation.

Location and Facilities

Headquartered in Chestnut Ridge, New York, Teledyne Test Tools and Teledyne LeCroy has sales, service and development subsidiaries in the US and throughout Europe and Asia. Teledyne Test Tools and Teledyne LeCroy products are employed across a wide variety of industries, including semiconductor, computer, consumer electronics, education, military/aerospace, automotive/industrial, and telecommunications.

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T3 stands for Teledyne Test Tools.

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