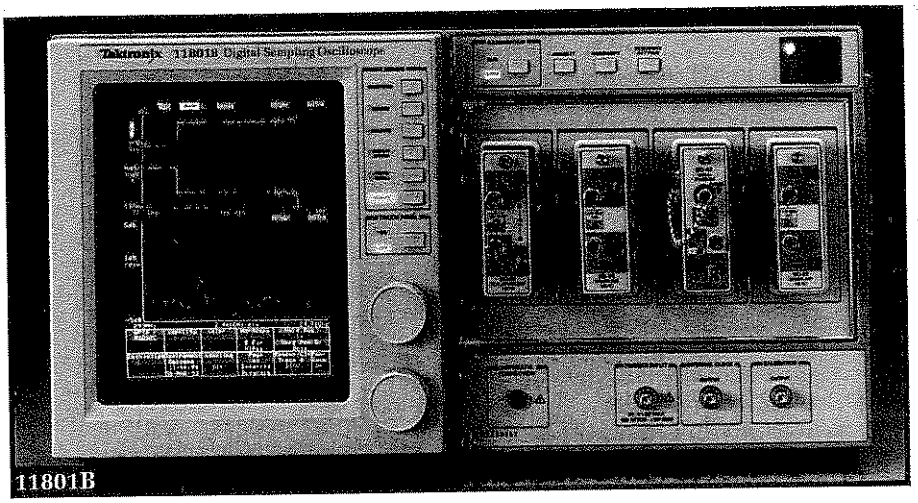
# Digital Sampling Oscilloscope




## 11801B Digital Sampling Oscilloscope

The 11801B Digital Sampling Oscilloscope offers the widest range of on-board measurement and waveform processing capabilities of any multi-gigahertz scope. With excellent measurement repeatability, exceptional vertical resolution and the fastest display update rate, the 11801B is a powerful measurement tool for semiconductor testing, TDR characterization of circuit boards, IC packages and cables, and high-speed digital data communications. An easy-to-use touch screen display gives you instant access to the 11801B's extensive waveform processing and measurement functions.

### MODULARITY MEETS YOUR NEEDS NOW AND IN THE FUTURE

The modular microprocessor-based architecture of the 11801B not only allows you to select the right configuration for your application, but also allows expandability to meet your future measurement needs. The 11801B accepts up to four dual-channel sampling heads and can be expanded through the SM-11 Multi-Channel Units to 136 channels.

There are currently ten sampling heads to choose from:

| | |
|---|---|
| SD-14 | 2.5 GHz high impedance (100 kΩ/0.475 pF) dual-channel probe sampler |
| SD-20 | 20 GHz single-channel loop-through head |
| SD-22 | 12.5 GHz dual-channel low noise head |
| SD-24 | 20 GHz dual-channel TDR/sampling head |
| SD-26 | 20 GHz dual-channel sampling head |
| SD-30 | 40 GHz single-channel sampling head |
| SD-32 | 50 GHz single-channel sampling head |
| SD-42 | 6.4 GHz O/E converter (55 ps optical pulse response FWHM) |
| SD-46 | 20 GHz O/E converter (22 ps optical pulse response FWHM) |
| SD-51 | 20 GHz trigger head |

### 11801B FEATURES

- DC to 50 GHz Bandwidth
- 7 ps Rise Time
- 8 Channels, Expandable to 136 (with SM-11)
- 10 fs Sampling Interval (0.01 ps)
- Modular Architecture
- 200 kS/s Sample Rate
- Dual Time Base
- Non-volatile Waveform and Setting Storage
- FFT
- Predefined Telecom Masks (Opt. 1T)
- TDR
- Automatic Measurements:
  - Jitter/ Noise, Statistical, Histograms, Mask Testing, Pulse with Statistics
- Programmable for ATE Applications
- Color Display

### BENEFITS

- Comprehensive Waveform Processing

*High resolution capable of viewing very fast digital signals.*

Product(s) available through your local Tektronix representative (listed in the back of this catalog) or call 1-800-426-2200.

GPIB IEEE-488 The 11801B Series complies with IEEE Standard 488.1-1987, and with Tektronix Standard Codes and Formats.

ISO 9001 Tektronix Measurement products are manufactured in ISO registered facilities.

### APPLICATIONS

- **Semiconductor Testing**
- **TDR Characterization of Circuit Boards, IC Packages and Cables**

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## STATE-OF-THE-ART WAVEFORM ACQUISITION

The state-of-the-art timebase provides equivalent-time sweep rates from 1 ps/div to 5 ms/div, with record lengths from 512 points to 5120 points, and a sample interval of 10 femtoseconds (0.01 ps). The 11801B also offers true windowing, whereby sections of a main trace are re-acquired at higher resolution for close examination of details. The windows are not just a digital zoom as in some competitive instruments. Only Tektronix sampling scopes offer such high resolution viewing of the main acquisition. The acquisition system provides 8-Bit vertical resolution at all deflection factors (78 µV/LSB at 2 mV/div). Powerful on-board waveform processing allows usable deflection factors down to 100 µV/div, giving resolution well beyond the basic 2 mV/div sensitivity of the sampling system itself. The 11801B boasts the fastest sample rate among sampling scopes. The 200 kHz sampling rate gives "real-time" feel for waveform manipulation and increases throughput on data capture for histograms and measurements.

## A POWERFUL MEASUREMENT TOOL ON YOUR BENCH

The 11801B offers a comprehensive, accurate and automatic measurement system. A total of 28 on-board measurements can be conveniently selected through the touch screen measurement menu. Results of up to six measurements may be simultaneously displayed on the screen, continuously updated to follow changing signal conditions. However, any number of measurements may be made over GPIB or RS-232-C interfaces. There are three different modes of measurements: hardware, software and statistics. Hardware mode allows high throughput on timing measurements and simultaneous measurements on up to 68 channels at once. Statistics mode uses the statistical database to make all the measurements based on the statistical distribution of the data over multiple acquisitions. It provides very stable and accurate measurements even in the presence of jitter or noise. With the statistical measurement mode, direct automatic jitter and noise measurements are possible (see Figure 1). This eliminates the human judgment and error that comes with manual measurements from histograms. As in all the other 11000 Series instruments, software measurement mode uses IEEE algorithms to make measurements based on digitized waveforms. An alternate Tektronix proprietary algorithm that is optimized for pulses with ringing and other anomalies is also selectable.

## FFT

The 11801B offers FFT display and measurements as a useful tool for the design engineer and scientist. FFT magnitude or phase displays can be created of the acquired waveform and the automatic Spectral Frequency, Spectral Magnitude, and THD (Total Harmonic Distortion) measurements can be used for a complete analysis (see Figure 2).

## COLOR GRADING AND MASK/TEMPLATE TESTING

The power of the measurement capabilities of the 11801B can be extended even further with color graded display, histogramming capabilities and mask testing. Both vertical and horizontal histograms, with periodically updated measurements such as mean, RMS and peak-to-peak allow statistical distributions to be analyzed at any point on the signal. The statistical database, available in the color graded display, not only adds a third dimension to your waveforms (by showing a point density of the samples), but also avoids time consuming re-acquisitions or repeated histogram analysis and statistical measurements. The mask testing capability of the 11801B provides an easy, yet powerful and quantitative way to characterize metastability in your device or system. In addition to custom mask editing, the 11801B offers AutoMask – 38 standards-defined masks in memory for instant recall (Option 1T, Predefined Telecom Masks). This option, together with automatic waveform scaling, gives a rapid verification of a digital bit stream's conformance to pulse templates or eye pattern masks (see Figure 3, on following page).

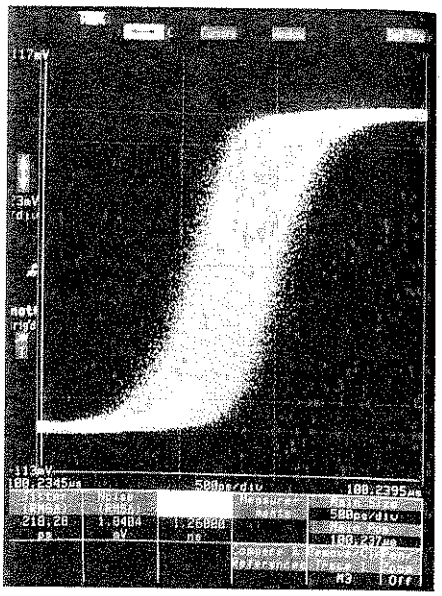

*Figure 1. Direct and automatic jitter, noise and rise time measurement using the statistical measurement mode.*

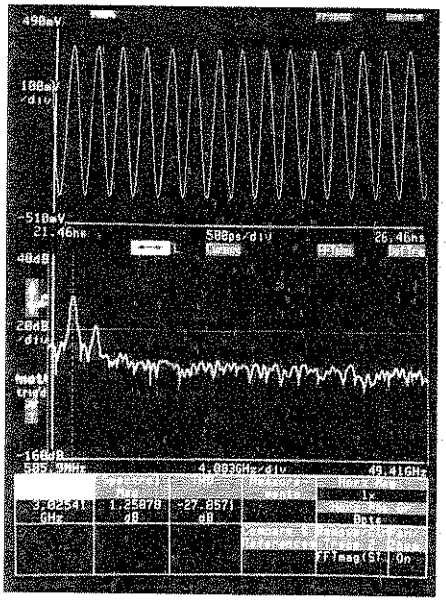

*Figure 2. FFT display and measurements in the 11801B offer additional analysis power to the engineer or scientist.*

# Digital Sampling Oscilloscope





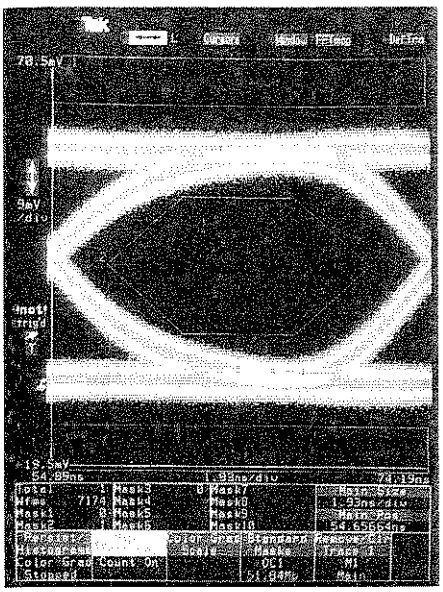

*Figure 3. Predefined Telecom masks make verifying digital stream conformance simple.*

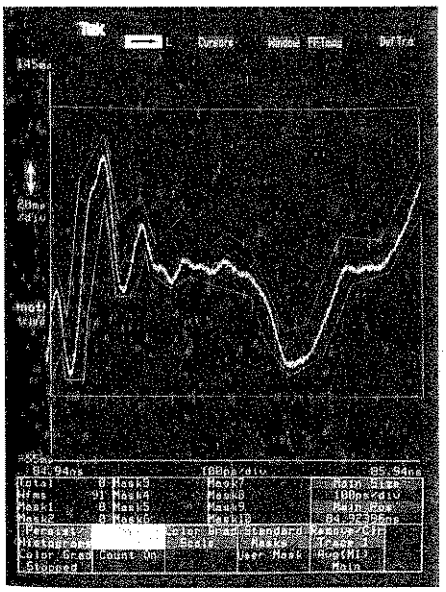

*Figure 4. TDR go/no-go impedance measurement using masks.*

### UNMATCHED TDR CAPABILITIES

With the SD-24 Dual-Channel TDR/Sampling Head, the 11801B offers full 20 GHz acquisition and unmatched TDR performance on up to 136 channels. Each channel has an independent polarity-selectable (positive-going or negative-going) TDR step generator. The TDR outputs can also be precisely matched at a reference plane, providing the only true integrated differential TDR system available today. Differential TDR offers an accurate picture of the performance of balanced or unbalanced differential systems such as twisted pair cables, coupled microstrips, or differential inputs in active devices. Tektronix' differential TDR system is the only system available today that offers true differential TDR with live waveform updates and simple direct readout of impedance. Other systems require complex and error-prone computations and do not provide direct readout in ohms.

The step generator of the SD-24 also represents state-of-the-art technology, offering unmatched 35 ps reflected rise time*[1], with the flattest step in the industry. TDR is also simple to use, with one-touch preset functions for both single-ended and differential TDR. There is direct readout of impedance in rho and ohms, as well as readout of one-way or round trip distance in meters, feet, or inches. Using the mask testing capability of the 11801B, you can perform go/no-go testing of impedances in circuit board runs, IC packages and cables (see Figure 4).

Single-ended and differential TDT (Time Domain Transmission) is also possible with the 11801B and SD-24. This type of testing may involve transmission testing (an end-to-end measurement through a cable or conductor), or crosstalk testing (signals induced on one or more adjacent cables or conductors). The ability to apply a step on any channel of the 11801B means that both forward and reverse testing is possible without switching test channels or relay multiplexing, which can be prone to errors. Also, as with differential TDR, Tektronix' system is the only system offering true differential TDT. Any of the above measurements may be performed single-ended or true differential.

The 11801B allows quick real-time viewing of the TDR response to a user-selected rise time with the filter function. Simply enter the filter rise time, and the 11801B displays a live trace that shows the response at the filtered rise time. Waveform math can also be used to subtract a reference trace acquired with a 50 Ω terminator for removal of unwanted aberrations due to cabling and fixturing.

### WAVEFORM MEMORY AND NON-VOLATILE STORAGE

The 11801B is equipped with 512 KB of volatile waveform acquisition and display memory, and 256 KB of non-volatile memory for storage of waveforms and settings. These memories are independent; that is, the number of waveforms being acquired has no impact on the memory available for stored waveforms and settings.

### MULTI-CHANNEL CAPABILITIES

The SM-11 Multi-channel Unit provides the means of expanding the 11801B's measurement system to 136 channels. Each SM-11 accepts up to 16 SD-Series sampling heads for 32 channels (with dual-channel heads). An 11801B mainframe with Option 1M is capable of driving up to four SM-11s. The entire system can then be driven through a single GPIB address. The 11801B acquisition system is designed to simultaneously acquire half of all active channels in a single acquisition cycle. Thus, in two acquisition cycles, all 136 channels can be acquired, and measurements performed on them. All channels, whether in the 11801B or SM-11 mainframes, offer the full specified performance. There is no loss of performance throughput or reliability as is the case in relay-multiplexed systems.

### EASY-TO-USE HUMAN INTERFACE

The power of the 11801B is accessed through a simple menu structure with pop-up menus and two control knobs. In addition, common functions such as time/div and volts/div, are accessed through on-screen icons which are always accessible. For ATE applications, the 11801B is completely programmable through its IEEE 488 and RS-232-C interfaces.

### DOCUMENTATION

The 11801B provides extensive hardcopy support. Documenting your results, complete with labels and time and date stamp, is as easy as pressing the HARDCOPY button. A variety of printers and plotters, including Tektronix color printers, are supported. TIFF (Tagged Image File Format) output is also supported for exporting hardcopy to word processors.

*[1] The observed rise time of a reflection from a short circuit.*

## Accessory

### AK02

- Provides adaptability to most signal sources for 50 Ω termination
- Includes 50 Ω attenuators, 50 Ω cables, gender adapters

*For complete information on all Accessory products, see page 446.*

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## Characteristics

**VERTICAL SYSTEM*[1]**

**Rise Time/Bandwidth** – Determined by the sampling head used.

**Vertical Resolution** – 8-Bits full screen (78 µV/LSB at 2 mV/div deflection factor).

**Amplifier Gain Accuracy** – ±1% of all settings.

**Deflection Factors** – 2 to 255 mV/div in 1 mV/div increments.

**Offset Range** – ±2 V.

**HORIZONTAL SYSTEM**

**Main and Window Time Base** – 1 ps/div to 5 ms/div, settable to 1-2-5 sequence or in 1 ps increments.

**Record Length** – 512, 1024, 2048, 4096, and 5120 samples.

**Windows** – Any number of window records may be placed on any number of main records, up to a maximum of eight displayed traces. All window records have the same duration, but may be independently positioned on any main record. Windows may be set to automatically track a moving edge on the main record.

**Maximum Sample Rate** – 200 kS/s.

**TRIGGER SYSTEM*[4]**

**Trigger Bandwidth** – 3 GHz.

**Trigger Sensitivity** –
DC, 1X ≤3 GHz: 100 mV;
AC, 1X 300 kHz to 3 GHz: 100 mV;
DC, 10X ≤3 GHz: 1 V;
AC, 10X 300 kHz to 3 GHz: 1 V.

**Delay Jitter** – 1.3 ps +4 ppm of a position typical. 2.0 ps +5 ppm of position maximum (RMS).

**Internal Clock** – 100 kHz (drives TDR, Internal Clock Output, and Calibrator).

**Trigger Level Range** – ±1.0 V (±10 V with 10X trigger attenuator activated).

**Trigger Input Range** – ±1.5 V (+15 V, 5 V RMS maximum with 10X).

**Trigger Holdoff** – 5 µs to 2.5 s.

**MEASUREMENT SYSTEM**

**Waveform Processing Functions** – Add, subtract, multiply, divide, absolute, average, differentiate, envelope, exponent, integrate, natural log, log, signum, square root, smoothing, and filter.

**Measurement Set** – Max, min, mid, p-p, mean, RMS, amplitude, extinction ratio, overshoot, undershoot, noise*[5], rise, fall, spectral magnitude, spectral frequency, THD, SNR, frequency, period, prop delay, cross, width, phase, duty cycle, jitter*[5], area +, area –, and energy. Measurements are constantly updated; mean and standard deviation available on all measurements.

**Measurement Parameters** – (Proximal, mesial, distal, and start/stop levels): May be set to absolute levels.

**Cursors** – Paired or split dots, vertical bars, and horizontal bars.

**TDR SYSTEM (SD-24 ONLY)**

**Combined TDR/Acquisition Reflected Rise Time** – 35 ps or less.

**TDR Step Amplitude** – Adjustable to ±250 mV (polarity of either step may be inverted).

**Time Coincidence Between TDR Steps** – Adjustable to less than 1 ps.

**Source Resistance** – 50 ±0.5 Ω.

**Typical Aberrations** – (at ±250 mV Amplitude) 10 ns to 20 ps before step: ±3% or less; Less than 300 ps after step: +10%, –5% or less; 300 ps to 5 ns after step: ±3% or less; Elsewhere: ±1% or less.

**CRT AND DISPLAY FEATURES**

**CRT** – 9 inch diagonal, magnetic deflection, vertical raster scan orientation. Color.

**Colors** – Eight-color default color set included; or colors are user-selectable from palette of 262,144 colors.

**Video Resolution** – 552 horizontal by 704 vertical displayed pixels.

**POWER REQUIREMENTS**

**Line-voltage Ranges** – 90 to 132 V RMS, 180 to 250 V RMS.

**Line Frequency** – 48 to 440 Hz.

**Maximum Power Consumption** – 214 W.

**ENVIRONMENTAL AND SAFETY**

**Temperature** – Operating: 0°C to +50°C; Nonoperating: –40°C to +75°C.

**Humidity** – Operating and Nonoperating: up to 95% relative humidity, up to 50°C. Per MIL-T-28800E, Type III, Class 5.

**Altitude, Vibration, Shock Nonoperating, Bench Handling** – Meets MIL-T-28800E, Type III, Class 5.

**Electromagnetic Compatibility** – (with sampling heads or optional blank panels installed in all sampling head compartments) Meets the Requirements of: MIL-STD-461B; FCC Part 15, subpart J, Class A; VDE 0871/6.78 Class B.

**Safety** – Listed UL 1244, CSA Bulletin 556B September 1973.

## PHYSICAL CHARACTERISTICS

| | Cabinet | | Rackmount | |
|---|---|---|---|---|
| **Dimensions** | **mm** | **in.** | **mm** | **in.** |
| **11801B** | | | | |
| Width | 448 | 17.6 | 483 | 19.0 |
| Height | 238 | 9.4 | 222 | 8.8 |
| Depth | 599 | 23.6 | 550 | 21.6 |
| **SM-11** | | | | |
| Width | 448 | 17.6 | 483 | 19.0 |
| Height | 238 | 9.4 | 222 | 8.8 |
| Depth | 558 | 22.0 | 550 | 21.6 |
| **Weight** | **kg** | **lb.** | **kg** | **lb.** |
| **11801B** | | | | |
| Net | 22.3 | 49 | 23.2 | 51 |
| Shipping | 25.9 | 57 | 26.8 | 59 |
| **SM-11** | | | | |
| Net | 20.0 | 44 | 20.9 | 46 |
| Shipping | 23.6 | 52 | 24.5 | 54 |

## TIME BASE ACCURACY – TYPICAL SPECIFICATIONS

| Range*[2, *3] | Base | + | Interval Specification | + | Position Specification |
|---|---|---|---|---|---|
| Interval ≥1 ns | 4 ps | | 0.004%* Interval | | 0.0004%* Position |
| Interval =100 ps | 2.5 ps | | – | | 0.0004%* Position |
| Interval ≤10 ps | 1 ps | | – | | 0.0004%* Position |

*[1] *Vertical system specifications of 11801B with SD-14 non-applicable. See 11800 Series Sampling Head specifications.*

*[2] *For intervals <100 ps, the above holds for time/div ≤20 ps/div.*

*[3] *For other intervals not listed above, linearly interpolate the cardinal points.*

*[4] *11801B external trigger requires 23 ns pre-trigger or DL 11 Delay Lines to view trigger point (45.5 ns with Option 1M).*

*[5] *Available only in statistical measurement mode.*