DTDR-65

Differential Time-Domain Reflectometer

The unique combination of bandwidth, time base stability & form factor

Main features:

- **10%-90% rise/fall-time lower than 65ps**
- **Ultra-stable time base (RMS-Jitter < 500fs)**
- **Analog sampling bandwidth ≈ 10GHz**
- **All specifications valid for 0°C ≤ T ≤ 40°C**
- **High stability w/o recurring calibrations**
- **Laboratory & industrial applications**
- **Full metal housing: high immunity to EMI**
- **Hi-Speed USB-interface**
- **Small form factor, low weight**

Step rise/fall-time faster than 65ps

The DTDR-65 is equipped with two ultra fast internal step generators providing step-signals with a 10% - 90% rise/fall-time faster than 65ps (typically < 55ps), corresponds to a 20% - 80% rise-time < 40ps. The voltage step of each channel amounts to 150mV under matched conditions.

Ultra low random Jitter

The DTDR-65 exhibits the best RMS-Jitter performance in its class: lower than 500fs over the full temperature range.

Superior Stability over Temperature

All Sequid products undergo a temperature check from 0°C to 40°C to verify the functionality over the full range. The DTDR-65's excellent jitter performance is minimally influenced by temperature. Amplitude variations are around only 0.5%. Theses parameters are achieved without application of time consuming and recurring error compensations.

Laboratory & Industrial

Due to its time base and temperature stability the DTDR-65 is the ideal choice not only for laboratory but also for outdoor applications. In addition, its fanless full metal housing offers a high level of immunity to EMI and makes it well suited for industrial applications. The instrument can be powered optionally by a battery, enabling operation in basic configuration for more than three hours without recharging. The casing exhibits a small form factor and weighs below 3kg.

Software Applications

A wide range of accessories & applications are implemented or optionally available (see section 0), e.g. probes, the TDR functionality, S_{11}-parameter measurements & permittivity measurements. The DTDR-65 comes along with a user-software (SEUNIS = Sequid Universal Measurement Software), combining all different applications and calibrations. Software libraries (SAIL = Sequid Automation Interface Library) are available for controlling the device in ATE applications from many programming languages (e.g. C/C^{++}, C$^{\#}$, Python, LabVIEW, MATLAB). Modules for exporting the data from the Sequid software are included.

1. Time Base Stability

Sequid TDRs are optimized for time base stability over a wide temperature range from 0°C to 40°C. The typical time bases of the DTDR-65 are based on a fixed equivalent sampling frequency of 100GHz corresponding to a sampling time of 10ps.

In this document the time base is referred to the combination of the repetition frequency f_{rep} and the sampling interval T_s.

Here, f_{rep} determines the maximum measurement range $r_m = \frac{c_0}{4 \cdot f_{rep} \cdot \sqrt{\varepsilon_r}}$, with c_0 being the velocity of light and ε_r the environmental permittivity. Please note that the maximum range is valid for $\varepsilon_r = 1$ and under matched conditions at the far end of the device under test. An overview of the standard time bases is shown in rows 1-4 of Table 1.

For applications requiring faster acquisition times or lower repetition rates, special time bases are available upon request (see e.g. rows 5-6). System parameters (transition times, jitter & noise) of special time bases are not covered by this document.

Table 1: Available & optional time bases

#	T_s [ps]	f_{rep} [MHz]	r_m [m]	Min. Acquisition Time [s]
1	10	10	7.4	0.064
2	10	5	14.8	0.256
3	10	2	37.0	1.600
4	10	1	74.0	6.410
5	50	1	74.0	1.280
6	50	0.5	148.0	5.128

The jitter performance is summarized in Table 2. Due to the unique Sequid time base generation technique, the maximum RMS-Jitter remains for all temperatures below 500fs. The jitter performance shows very little deterioration with temperature, making the DTDR-65 to the device with the best time base stability in its class. This advantage comes along with a high degree of comfort, since it is achieved without the need for any time-consuming and recurring calibration procedures.

Table 2: Jitter performance vs. temperature

Temperature [°C]	RMS-Jitter [fs]	
	Typ.	Max.
0	285	500
10	290	
20	300	
30	310	
40	320	

Additional drifts originating from changes in the signal path's permittivity are reduced by the consequent usage of temperature stable materials to a minimum of 500fs over the entire temperature range.

2. Signal Generator

The DTDR-65 is equipped with two synchronized (skew < 2ps) high performance single ended step generators featuring 10% - 90% rise/fall-times below 65ps (typically < 55ps). The differential output voltage amounts under matched conditions to 300mV. The generators exhibit a duty cycles of 50% with variations of less than 0.05%. The preset repetition rate is 10MHz.

2.1 Rise/fall-Time

The rise/fall-time is the key feature not only for a high spatial resolution in cable fault detection but also for high bandwidth measurements when using TDR e.g. as a Time-Domain-Network-Analyzer (TDNA).

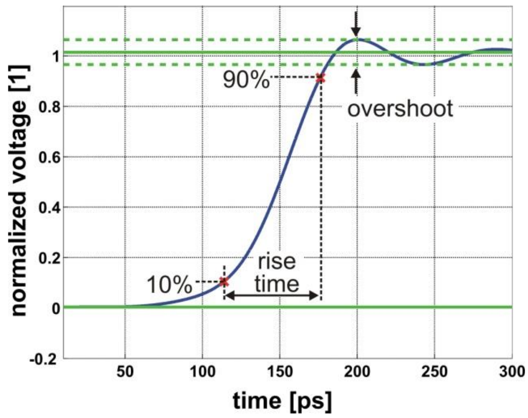

Figure 1: Rise-time and overshoot.

The rise-time is the duration the signal requires for the transition from 10% to 90% of its steady state value (Fig. 1). The minimum, typical, and maximum values are given in Table 3 for the entire temperature range.

Table 3: 10%-90% rise/fall-time vs. temperature

Temperature [°C]	rise/fall-time [ps]		
	Min.	Typ.	Max.
0	42.0	49.0	61.0
10	43.0	50.0	62.0
20	44.0	51.0	63.0
30	45.0	52.0	64.0
40	46.0	53.0	65.0

The rise/fall-time slightly increases with temperature, but never exceeds 65ps (typ. 55ps).

Less usual but also found in literature is the 20%-80% rise/fall-time. For better comparability with this specification the 20% - 80% rise/fall-time is given in Table 4. It is about 35% shorter than the 10% - 90% rise/fall-time and shows in general the equivalent increase with temperature.

Table 4: 20%-80% rise/fall-time vs. temperature

Temperature [°C]	rise/fall-time [ps]		
	Min.	Typ.	Max.
0	30.0	35.0	40.0
10	30.5	35.5	40.5
20	31.0	36.0	41.0
30	31.5	36.5	41.5
40	32.0	37.0	42.0

2.2 Overshoot

The overshoot is defined as the percentage by which the maximum exceeds the steady state value (see Fig. 1).
The overshoot vs. temperature of the DTDR-65 is correlated linearly with rise/fall-time, levels typically between 11% and 15%, and does not exceed 20%. For details see Table 5.
If a calibration is active – which is the normal case – the overshot reduces to the ideal value of 0.

Table 5: Overshoot vs. temperature

Temperature [°C]	overshoot [%]		
	Min.	Typ.	Max.
0	13.0	15.0	20.0
10	12.5	14.5	20.0
20	12.0	14.0	20.0
30	11.5	13.5	20.0
40	11.0	13.0	20.0

3. Acquisition Unit

Analog Bandwidth

The acquisition units consist of a high bandwidth (> 10GHz) sampling modules followed by 12-bit Analog-Digital-Converters.

Noise

The characteristic single channel RMS-noise amounts typically to <250µV and does not exceed 450µV. This holds for stable temperature conditions within the range of 0°C ≤ T ≤ 40°C. The temperature induced drift in this range is below 0.5%.

Memory Depth

The maximum number of acquisition points amounts to 50.000 per channel. This ensures that even in case of the most memory demanding 10ps/1MHz time base, a complete half period of 500ns can be sampled with an interval of 10ps.

4. General Specifications

4.1 Wave Impedance

The system's wave impedance is 50Ω ± 1Ω.

4.2 Dimensions

Without connectors: 220 × 210 × 82.5mm³
With connectors: 242 × 210 × 82.5mm³
SMA-connector spacing: 28mm

4.3 Weight

The device weighs 2.8kg with battery and 2.6kg without.

4.4 Temperature

The temperature range is mainly limited by the integrated Lithium-Ion-Battery.

	with Battery	without Battery
Operation	0°C – 40°C	0°C – 40°C
Storage	0°C – 40°C	-20°C – 80°C

4.5 Power

AC-Power

100-240 VAC, 50-60Hz, 1.5A via external power adapter.

DC-Power

24 V, 350mA typ., 1100mA max. (during charging), low power jack 6.3/2.1mm

Battery-Power (optional):

Internal Li-Ion-Battery, 2.2Ah, endurance > 3hours, recharging time: 3hours

Power Indicator

During operation, the red LED (incorporated in the ON/OFF button) is on, otherwise off.

In case the optional battery pack is installed, slowly and fast blinking of the red LED indicates charging of the battery and low battery status, respectively. Charging of the battery in off-state is indicated by a slowly blinking green LED.

5. Accessories

5.1 Standard (delivered with device)

- SEUNIS software featuring:
  - Typical TDR functionality
  - Calibration wizard (OSLT)
  - De-embedding
  - Saving, reloading & exporting data
- Software module for single-ended impedance measurement (*SMM-Ωplus*)
- Software module for differential impedance measurement (*SMM-DΩplus*)
- Power supply (for indoor use only)
- Operator's manual & quick start guide
- 2m USB-cable for connection with PC
- 24-months standard limited warranty
- Test certificate

5.2 Optional (*order code*)

- Integrated ESD-Protection Module (*SESD-PCS-D*)
- Motion Sensor (*SESD-PMS*): keeps ESD-Protection disabled during motion
- Battery pack for 3 hours of operation in basic configuration (*SAP*)
- Metallic Storage and Travel suitcase for safe transport and storage (*SSTC*)
- Software module for Single-ended Time-Domain-Network-Analyzer functionality (*SMM-S11*)
- Software module for Differential Time-Domain-Network-Analyzer functionality (*SMM-DS11* with *SMM-S11* included)
- Software module for Software-Measurement Module F2P "full 2-port" single-ended S-Parameters (*SMM-F2P-S*)
- Software module for determining the dielectric constant of PCBs (*SMM-EpsBase*)
- Software module for determining the frequency dependent dielectric constant of PCBS (*SMM-EpsPlus*)
- Coaxial line sensor for permittivity measurements (*SDM-10G*)
- Software module for Permittivity Measurement Software Module (*SMM-Perm-Coax*)
- RPC-3.5mm calibration kit OSL (S03K30R-OSL3), OSLT (S03K30R-OSLT)
- SMA economy calibration kit OSL (*SCKE-SF-R*), OSLT (SCKE-SF-RT)
- Phase matched pair of SMA cables (75cm, 50Ω, skew < 1ps) with SMA (*SPMC-P*)
- Phase matched pair of RPC-3.5 cables (50cm, 50Ω, skew < 1ps) with (*SPMC-P-3.5mm*)
- Precision 50Ω single-ended SMA cable with rotational adapter (*SCC-P*)
- Precision 50Ω single-ended SMA cable (*SCC-P-S*)
- Economy single-ended probe with fixed 2.5 or 5.mm pitch (*SSTP-E*)
- Precision single-ended probe with variable pitch from 0.5 to 1.5mm (*SSTP-P*)
- Economy differential probe with fixed 1.0 or 2.5mm pitch (*SDTP-E*)
- Precision differential probe with variable pitch from 0.5 to 5.0mm (*SDTP-P*)
- USB foot switch (*SUSB-FS2*)
- Connector for Pt100 (*SPT100*)

6. Sales Contact

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