TEMPO® COMMUNICATIONS

Locate network cable faults quickly and safely
Simple and reliable, the TDR CS90 from Tempo Communications

An electromagnetic wave will propagate undisturbed along a cable until an Impedance irregularity is encountered. This change in the conductor's characteristic gives rise to a phenomenon whereby, part or all of the wave energy is reflected back to the source. The remaining energy carries on in the original direction.

This can be observed in everyday life when shouting in front of a distant object, e.g. a mountain, a house wall, a forest edge, part of the (sound) wave, returns as an "echo" towards the source, i.e. the caller (radar operates on the exact same principle). The time between the transmission of an electromagnetic wave (pulse) and the time when its echo is received can be used to calculate the distance to the event.

Such reflections are undesirable with respect to fidelity of transmission; however, they form the basis for Time Domain Reflectometry (TDR) & "seeing" a graphical representation of the cable pair under test.

Reflections in the cable.

Coaxial cables, consisting of an inner, an outer and a dielectric, are used in cable networks. If you launch a short pulse into a Fault Free cable section, where the output impedance of the pulse generator matches the input impedance of the cable (typically 75Ω) and listen for an echo, you can experience one of three different phenomena.

1. Although the cable is Fault Free, the TDR will see the end of the cable (disconnection) as one of the two extremes of impedance mismatch (i.e. High Impedance).
An echo/reflected pulse of the same polarity occurs here.

2. Provided that the cable is correctly terminated (i.e. in its Characteristic Impedance), no returning pulse can be observed. The reason: The Transmitted pulse is completely absorbed by the terminating impedance.
This means that there is no energy to be reflected to the line input (and consequently TDR display.)

3. The other extreme case of impedance mismatch is the short circuit. The reflected pulse with reverse polarity to the input pulse is reflected.

The elapsed time between the transmission of the Incident pulse (Start or Sent pulse) and the arrival of the Reflected pulse (echo) can be converted into Length if the speed of the cable is known. The amplitude of the reflected pulse (echo) is an indication of the level of propagation loss (Attenuation) in the cable.

$$T_L = \frac{2 \cdot L}{c_0 \cdot v} \quad \textit{Runtime}$$

with c_0: Light Speed and v: Propagation Factor
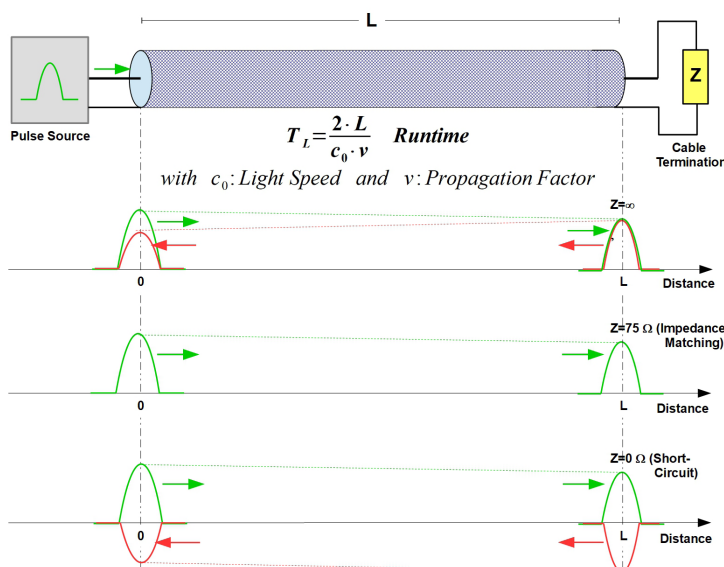
Calculating Distance from Transit Time.

Firstly, let us distinguish the difference between: Velocity and Velocity of Propagation Factor (Vp). Velocity is the speed that an electromagnetic wave travels (could be along a cable or could be in free space) and is usually measured in m/ms or m/µs or any other variation of distance per time. Velocity of Propagation Factor (Vp) is expressed as a ratio of the speed of the pulse in a material to the speed of light in a vacuum.

Velocity of Propagation (Vp), plays an important role in determining the transit time from the sending of the test (incident) pulse to the arrival of its reflection.

The Velocity of Propagation (Vp) of an electromagnetic wave in any material is always lower than in a vacuum ($C \approx 300 \times 10^6$ m/s, Vp = 1). This is also the case in coaxial cables:

$$Vp = \frac{V}{C} \quad \begin{array}{l} \text{velocity of pulse in cable (m/µs)} \\ \text{velocity in free space (300m/µs)} \end{array}$$

Vp changes from cable to cable depending on cable geometry & dielectric material used, it is usually specified by the cable manufacturer in the data sheet. To determine or check Vp, measure the time it takes the test pulse to travel through a cable route of known length and compare it to the transit time in a vacuum.

With commercially available coaxial cables in all levels of the distribution network,

Vp is typically between 0.7 and 0.9.

$$L = \frac{T_t}{2} \times Vp_x C$$

Tt: Transit Time between sent & received pulse (m/s)
C: Speed of light (C = 300·10⁶m/s)
Vp: Velocity of Propagation Factor (always less than 1)

In summary: The Transit time (Tt) between the sending of the test pulse and the arrival of its echo at the TDR, can be used to calculate the length of the cable by converting that time into distance, using the correct Vp. The length of the cable must be considered twice: once for the sent pulse and once for the reflected pulse. Once the Transit Time is known, the cable length L can be calculated.

$$L = \frac{T_L}{2} \cdot v \cdot c_0 \quad \textbf{\textit{Cable Length}}$$

T_L: Delay between outgoing test− pulse and incoming echo− pulse

c_0: Light Speed $\left(c_0 = 300 \cdot 10^6 \frac{m}{s}\right)$,

v: Propagation Factor

Pulse duration.

The pulse duration should be selected depending on the cable length (L).

Short (low energy) pulses only travel short distances but exhibit greater resolution.

Longer pulses are required for longer cables, but the resolution decreases.

Because of this relationship, the pulse width can be automatically selected depending on the distance range of the TDR.

Typical pulse widths in the CATV range are between 1... 25 ns. A dead zone is associated with the selected pulse width. Dead zones therefore correspond to the transmission pulse width (equation).

$$L_{Tot} = T_{Impuls} \cdot v \cdot c_0 \quad \textbf{\textit{Totzone}}$$

The pulse width can affect how close events can be whilst still being distinguishable from each other. For example, when using the 25 ns pulse width, this equates to approximately 6 metres for a typical cable type with Vp of 0.8.
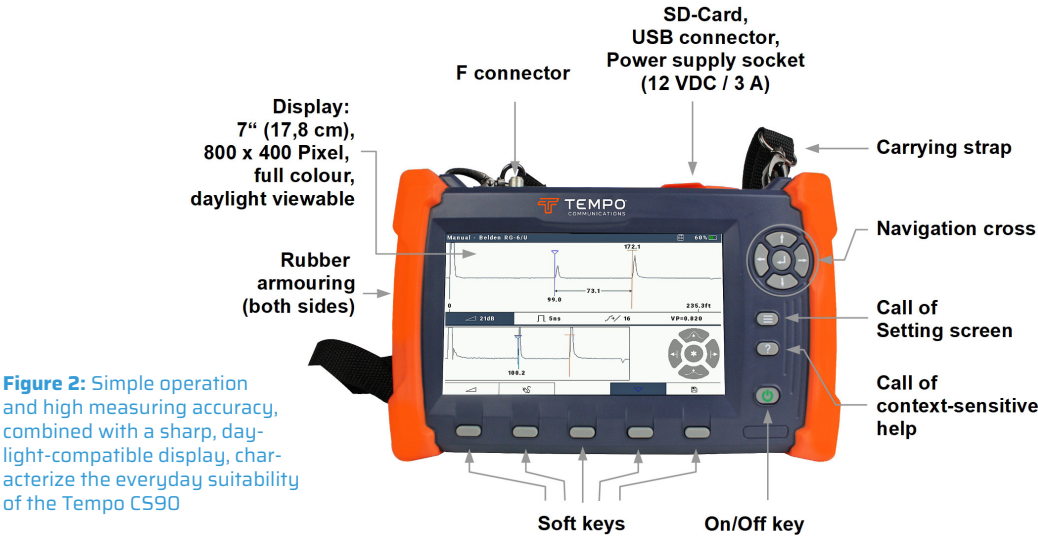
But if you can use the 1 ns pulse width at that range, then this equates to 0.24 m at 0.8. Therefore, always use the narrowest pulse practical for the range being tested so that close together events can be distinguished. If you use Auto mode, the CS90 will automatically adjust the gain and pulse width as needed based upon the cable's Vp and loss per metre, so you can always see the maximum detail.

CableScout® 90.

Tempo Communications has designed CableScout 90 (CS90), as a practical TDR for CATV technicians, which impresses in everyday use due to its ease of use and precise measurement results.

Due to the small dimensions: 26 x 16 x 5 cm, the CS90 with its padded protective bag, (which also offers space for the charger and other small items), fits in any tool case. The weight at 974 g makes it comfortably portable. The built-in, fully charged lithium-ion battery lasts a good 8 hours and thus a full working day. It is fully charged in less than 4 hours.

The power button is slightly recessed to avoid unintentional operation. If the device is switched off whilst connected to the charger, the current charge status is shown on the display.

After pressing the power button, a welcome screen with device name, serial and version number is displayed during the boot process, which lasts a few seconds. The main screen then appears, from which all settings and measurements can be made.

Display:
7" (17,8 cm),
800 x 400 Pixel,
full colour,
daylight viewable

F connector

**SD-Card,
USB connector,
Power supply socket
(12 VDC / 3 A)**

Carrying strap

Navigation cross

**Rubber
armouring
(both sides)**

**Call of
Setting screen**

**Call of
context-sensitive
help**

Soft keys

On/Off key

Figure 2: Simple operation and high measuring accuracy, combined with a sharp, daylight-compatible display, characterize the everyday suitability of the Tempo CS90

Before each measurement, the cable under test, or at least one that is closest to it, must be selected from a list of common cables. If the desired cable cannot be found in the list, you can create it yourself: Enter manufacturer and type designation, attenuation per 100 m @ 500 MHz in dB and PVF and save.

For "Televes SK2000plus" cable with 14 dB @ 500 MHz and a VP = 0.84 (Velocity of Propagation) this was no problem

After these short Setup steps, you can start measuring on the voltage-free cable.

For initial tests, a 100 m drum of the Televes SK2000plus, entered and selected in the cable library, was connected to the F socket on the top of the device. Then three measurements were made with the cable end open, adjusted and short-circuited. The measurement results were as expected.

Kabel Name	Verlust(dB / 100m @ 500 MHz)	VP
Televes SK2000plus	14.0	0.840
Belden RG-59/6/11/U; Trilogy 59/6/7/11	15.0	0.820
Comm/Scope 59/6/7/11	15.0	0.850
Times Fiber T10 59/6/611/11	15.0	0.850
Belden RG-6/U	15.4	0.820
Comm/Scope(QR) 540 Series	4.89	0.880
Comm/Scope(QR) 715 Series	3.90	0.880
Comm/Scope 6 Series	15.0	0.850
Comm/Scope Quantum Reach (QR)	15.0	0.880

Figure 3: If the cable to be measured by the user is not listed, the user can easily add it themselves.

An extensive "setup" screen is available for configuring the CS90. Here you can make the display lighter or darker and switch between day and night mode, activate the manual or automatic operating mode, specify automatic switch-off times (off, 1, 2, 5, 10 min)), switch between the units feet, meters or nanoseconds and set the units of the PVF (0.xxx, xx.x%, m / μs, ft / μs).

The test pulse has the shape of a half sine wave resulting in a lower-noise trace. TDRs using a square wave pulse, with its broad harmonic spectrum, experience noisier traces making interpretation of the trace, sometimes impossible.

The 1ns pulse width enables the detection of events at a sub-metre distance. With the longest pulse of 25 ns, event distances of up to approximately 3 km can be detected.
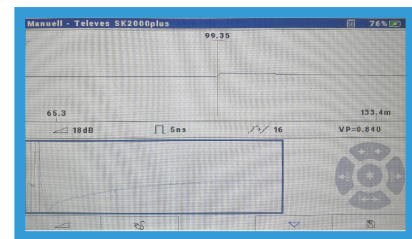

Figure 4: An important application of the CS90 is the preliminary testing of a cable drum for correct length and homogeneous impedance curve
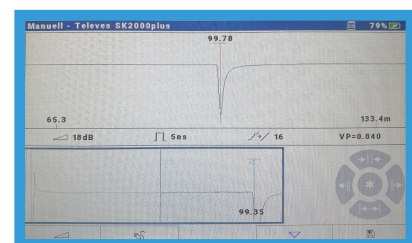
Figure 5: Short circuit and open circuit (mismatch) lead to the classic reflection pictures that are missing in the absence of impedance joints (matching)
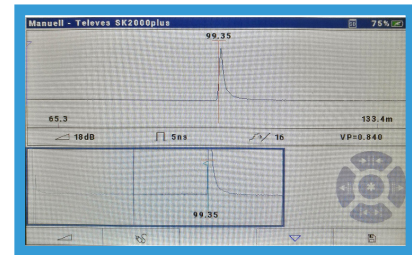
Cable end open-circuited

Cable end impedance-matched

Cable end short-circuited

Conclusion

CS90 TDR from Tempo Communications (after a few basic settings have been made), is extremely easy to use.

Simultaneously showing the "overview" of the cable in the lower trace, plus the detail around the cursor in the upper trace on the high resolution,

Figure 6: All important device parameters are to be adapted to the needs of the user on the basis of a clear setting screen

sunlight viewable screen, ensures that the user has always got a good understanding of what's happening on the cable. A dead zone need not be taken into account (zero dead zone).

Screenshots for documentation and reference traces are easy to create and save. No More is needed in the everyday life of the cable technician.