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# *Time-Domain Reflectometry*

## *for Measurement of Rock-Mass Deformation*

Time-Domain Reflectometry (TDR) is used to detect deformation within a rock mass. A length of coaxial cable, grouted into a borehole, serves as the system's sensor. Electronic pulses are sent down the cable; reflected pulses are related to deformation of the cable or to pre-established reference points (crimps). Areas of offset in the resulting trace depict zones of extension or shear along the cable.

### *Features*

- Supports long-term, in situ measurements
- Multiplexes up to 512 grouted cables
- Environmental enclosure provides protection against atmospheric temperature and humidity extremes
- Power supplied only during measurement
- Automated operation - system can be programmed to scan and record at defined intervals or can be reprogrammed from a remote location

### *System Description*

TDR was originally developed as a system to locate breaks in coaxial transmission cables (Moffitt, 1964). An electronic pulse emitted by a cable tester is transmitted through an attached coaxial cable. Discontinuities along the cable result in partial or total reflection of the signal. Elapsed travel time and reflected signal strength are measured -- travel time is indicative of distance to the discontinuity ( $\pm 2\%$ ); reflected signal strength is related to the severity of cable deformation (O'Connor and Dowding, 1984).

TDR was applied to measurement of rock-mass deformation by Panek and Tesch (1981) and O'Connor and Dowding (1984). A coaxial cable is emplaced in a borehole and grouted into place. Crimps, at measured intervals along the cable, partially reflect the transmitted signal and provide a more accurate scale for correlation of deformational zones to depth (Dowding, Su and O'Connor, 1989). Crimps appear as small negative polarity events along the trace of the waveform. Events that offset the waveform indicate deformational zones; the polarity of the offset indicates whether a zone is experiencing tensile or shear deformation.

The Campbell Scientific TDR system is optimized for remote use. A CR10X, 21X, or CR10 datalogger is housed in a weather-resistant enclosure along with the Tektronix<sup>®</sup> 1502CS cable tester. The datalogger controls operation of the cable tester; power is supplied only during measurement. This significantly reduces power demands. The datalogger digitally stores waveform data from a sequence of cable tests, thus allowing the system to operate in an unattended mode. Data are retrieved via telecommunications. It is also possible to reprogram the datalogger through telecommunications allowing zones of interest to be thoroughly examined.

Multiplexers, controlled by the datalogger, allow the system to test as many as 512 cables. A block diagram depicting a generalized system is on the reverse side of this sheet.

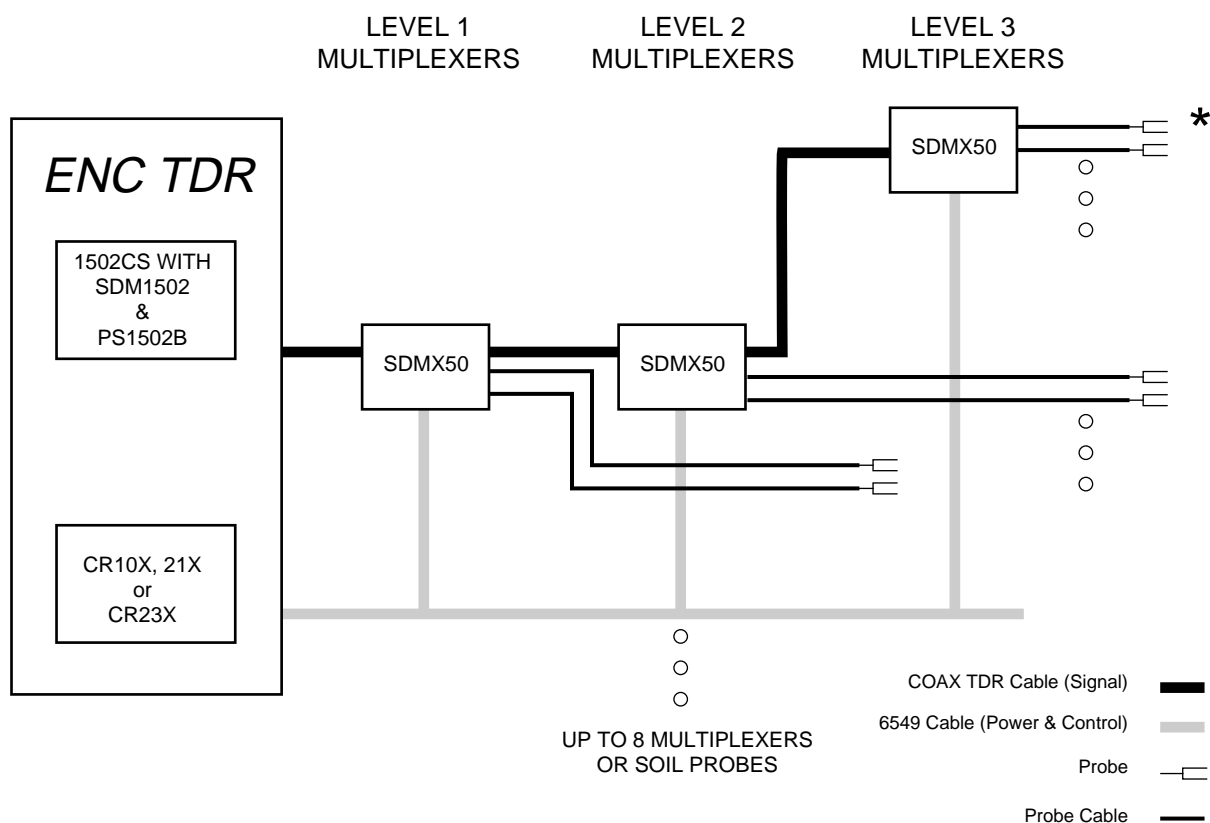
### *Literature Cited*

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- Panek, L. A., Tesch, W. J. (1981): Monitoring Ground Movements Near Caving Slopes - Methods and Measurements, RI 8585, U.S. Bureau of Mines, Denver, Colorado, 108 p.



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- \* For rock-mass deformation applications, the soil probe sensors are replaced with user-supplied coaxial cables.

## System Components

**1502CS** - The 1502CS is a 1502C modified by Tektronix to accept the PS1502B Power Control Module. It is the source of the electromagnetic pulse applied to the TDR cable.

**SDM1502** - Communication Interface; this module plugs into the cable tester and provides a Synchronous Device for Measurement (SDM) interface to a CR10(X) or 21X datalogger.

**PS1502B** - Power Control Module; plugs into the battery receptacle of the cable tester; provides for connection to an external 12 VDC source and allows the datalogger to control power to the cable tester.

**CR10(X) or 21X** - The datalogger communicates with the cable tester and multiplexers with the SDM interface using control ports 1-3 (and single-ended channel 1 on the 21X). An additional control port is used to switch power to the 1502B.

**Datalogger Software** - Special PROMs for the CR10 or 21X datalogger include Instruction 100 for controlling the cable tester and multiplexers. Standard in the CR10X.

**ENC TDR** - Enclosure to hold cable tester and datalogger. The ENC TDR includes a transient suppressor and cabling for connecting the power supply and datalogger. The cable tester mount allows it to swing out to view screen.

**6590** - Transient suppressor attaches to cable from cable tester and is required if ENC TDR is *not* purchased.

**SDMX50** - 50 Ohm Coax Multiplexer - 8 to 1, BNC connectors, enclosure included. The multiplexer is used to connect additional multiplexers or probes. Balanced probes attached to this multiplexer require a balun for each probe.

**COAX TDR** - 50 ohm RG8 coax cable with BNC connectors for connecting multiplexers.



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Printed October 1997