# TFS 2100

## Traveling Wave Fault Location System

- **The most accurate overhead transmission and distribution line fault locator**
- **Accuracy: ±150m typical regardless the line length**
- **Unaffected by fault resistance**
- **Suitable for all kind of power lines AC and DC**
- **Automatic distance to fault calculation**
- **Unlimited number of monitored lines**
- **Reduce overhead lines outage time**
- **Non intrusive installation**
- **Easy to set up**
- **Master Station software for distance to fault calculation and analysis**
- **Ethernet TCP/IP, Modem and Point to Point connections available**

### OVERVIEW

The Traveling Wave Fault Location System TFS 2100 provides accurate fault location solution for transmission and distribution power lines.

The fault distance measurement error is less than ±150m typical regardless of the line length and free from the influence of factors which affect fault location accuracy using traditional impedance methods.
The traveling wave technique can also be used to locate the single phase to ground fault in distribution systems with non-solidly earthed neutral, which can not be accomplished by any other techniques so far.

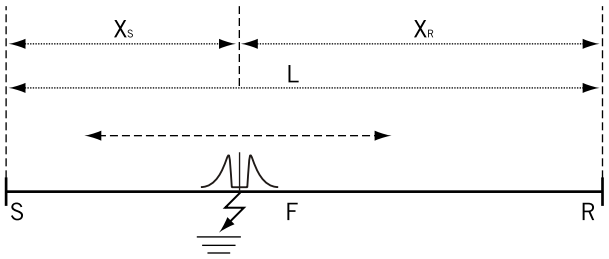
The traveling waves based fault location was first proposed in the 1930s and was made practical for field application in 1990s with the availibility of microelectronic-based ultra-high speed data acquisition and time synchronization using GPS (Global Positioning System) receivers.
While the traveling wave fault locator developed in 1950s measures transient voltages using a specially designed capacitor coupler attached to high voltage bus, the modern system measures the transient signals of existing current transformer (CT) secondaries. This makes the system installation very easy and cost effective.

### Fault Location Principle

Traveling waves are voltage and current surges propagating along the power line, arising from power system disturbances such as fault, switching operations and lightning. The traveling wave fault locator determines distance to fault by measuring the time for a surge to travel from fault position to measurement point. Since the 1950's several practical fault location methods have been proposed.


TDU 100 - Traveling wave data acquisition unit

### Type D (Double Ended) Method




Type D method time tags the arrival of the fault generated surges at two time-synchronized locations, usually the ends of the line. The fault distance is determined in terms of the difference of the arrival times.

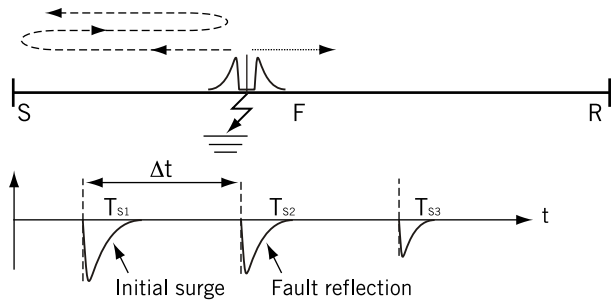
$$X_S = [(T_S - T_R) \cdot n + L]/2$$

$$X_R = [(T_R - T_S) \cdot n + L]/2$$

$T_S$ and $T_R$ are the arrival times of fault generated surges at the two terminals of the line; n is velocity of traveling wave, which is closer to light velocity in overhead line. L is total length of the line.

### Type A (Single ended) Method

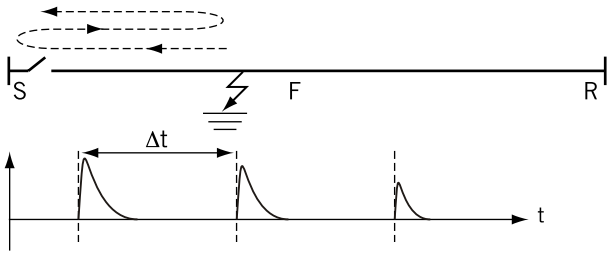
Type A method determines fault distance by analyzing the fault generated traveling wave waveforms recorded at one end of the line. The time difference Dt between the initial fault surge and the corresponding reflected pulse from fault is the time interval for a surge to travel from terminal to fault and back. It can be used to calculate distance to fault XL.




$$X_L = Dt \cdot n/2$$

### Type E Method

Type E method makes use of transients generated when a circuit breaker is closed to a dead line. The time interval between the pulse created by breaker closing and the reflected pulse from a short circuit, open circuit or broken conductor is used to calculate the distance to fault.




## Application of different methods

The Type D method is simpler and proven to be excellent in accuracy and reliability by field operation results. The Type E method is very efficient to locate broken conductor faults. The Type A method is more cost effective, but its reliability is compromised by the difficulty in discriminating fault reflections from pulses introduced by reflections from other line terminals and nonlinearity of fault arc.

TFS 2100 uses the Type D method as its major fault location principle, while the Type A and Type E methods are employed as complimentary fault location means.

## Measuring traveling waves

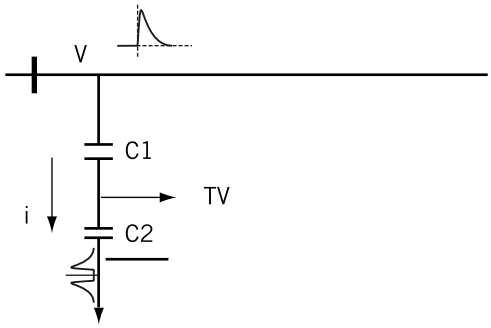
The traveling waves can be detected by monitoring the fault generated transient voltage or current signals at the bus.

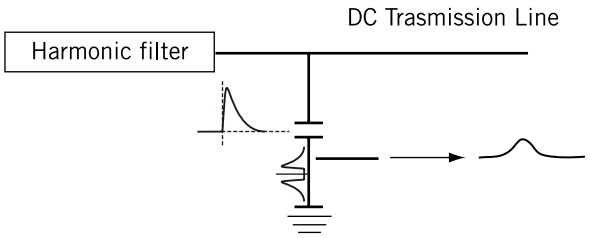
## For AC Power Line

The conventional current transformer (CT) which can reproduce current transients faithfully in secondary qualities provides a simple and cost-effective means to detect traveling waves for AC power lines. For maximum ease of installation an auxiliary clip on CT could be used to measure the transient current of existing CT secondary.

The bus of the AC power line has usually more than one line connected besides the faulted line and therefore produces very significant current transient when the incident surge arrives, which ensures the detection sensitivity of the traveling wave.

If there are no other lines other than the faulted line connected to the bus the magnitude of transient current is limited and the voltage transient should be measured using conventional voltage transformer (VT). In EHV transmission system with capacitive voltage transformer (CTV - which is a tuned circuit and has filtered out transient responses) installed, the transient voltage can be acquired indirectly by measuring transient current through the earth wire of the coupling capacitor using a clip-on transformer.




## For HVDC Transmission Line

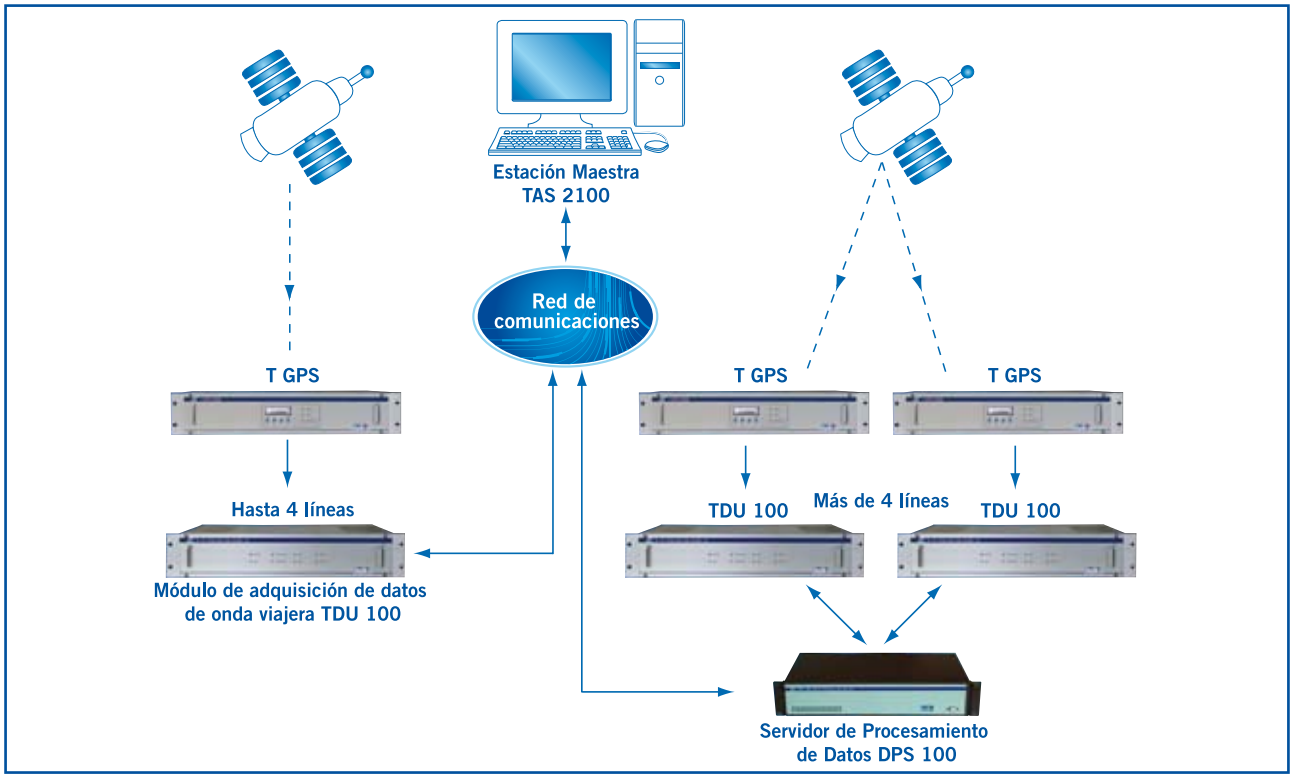
The CT's and VT's of HVDC system are usually installed behind

harmonic filtering circuit and their outputs can not be used to detect traveling waves from the line. The transient voltage can be acquired by measuring transient current through the earth wire of the surge suppression or carrier coupling capacitor using a clip-on transformer.

## SYSTEM DESCRIPTION

The TFS 2100 consists of Traveling Wave Data Acquisition Unit TDU 100 installed at substations, a Master Station Software deployed in the control center and communication network. Each TDU 100 can monitor up to 4 lines, and therefore two or more TDU 100 units are needed to monitor more than 4 lines in a substation.

In bay level application a TDU 100 is dedicated for one line monitoring and installed near the circuit breaker. When more than one TDU 100 is installed in a substation, a Data Processing Server DPS 100 is used to collect traveling wave data acquisition units and communicates with the Master Station.




System Configuration

## TRAVELING WAVE DATA ACQUISITION UNIT TDU 100 AND T GPS 2000

TDU 100 records traveling wave transients and it is synchronized by an external GPS clock (T GPS 2000). It continuously samples the secondary outputs of CT's or VT's and stores the sampled data in a circular memory buffer. The buffered data is then transferred to a non-volatile memory when the unit is triggered, i.e. the deviation of any input signals exceeds a pre-set threshold level. The acquired transient data are then sent to the Master Station via communication network for further processing.

TDU 100 - Traveling wave data acquisition unit

The TDU 100 features:

. Number of inputs: 3-12 input channels configurable for 1-4 lines, 1-10ms length of record time and 100 kHz - 4 MHz sampling frequency, user programmable.
. Software controlled analog gain and trigger threshold.
. Direct CT secondary input or via an external clip-on CT.
. Synchronized to 1 µs accuracy by external GPS clock (GPS MC 100).

T GPS 2000 - Syncronization clock

. 1Mb standard or optional 12 Mb nonvolatile memory for local transients data storage.
. Successive transient recording with less than 100 µs reset time.
. Contacts inputs and outputs are provided for external triggering, remote alarm and indication of internal failure, such as lost of synchronization.
. Support local setting and transient records interrogation through Ethernet port.
. 1 RS 232/422 port, 2 RS 232 port and 1 Ethernet port enable flexible communication, including point-to-point, dial-up or TCP/IP communication to the Master Station using selectable protocol and point-to-point or TCP/IP communication to the Data Processing Server (DPS 100).

## MASTER STATION SOFTWARE TAS 2100

The Master Station is a PC and runs Traveling Wave Analysis Software TAS 2100 (Windows NT/2000/XP/Vista environment). It collects and processes the transient data acquired by each traveling wave data acquisition unit and calculates the distance to fault automatically by the double-ended (Type D) method.
The Master Station with TAS 2100 software features:

. Automatic distance to fault calculation based on Type D Method.
. Versatile waveform analysis utilities to allow the users to analyze the fault waveforms in detail and measure the distance to fault by identifying fault reflections.
. Transient records management to allow the user manipulate, search, copy in and copy out the fault waveforms.
. Support remote configuration and setting to the field TDU 100.
. Remote diagnosis to allow the service engineer of system provider to maintain the system or verify the fault location results.
. Support point-to-point, dial-up or TCP/IP communication to the TDU 100 or DPS 100 units. A serial communication server connected to the Master Station through a Ethernet port is used to extend multiple point to point ports.

## DATA PROCESSING SERVER DPS 100

DPS 100 is used to collect the data of TDU 100 units and communicates to the master station when two or more TDU 100 units are installed in a substation. Its 8 RS 232/485 ports and 4 Ethernet ports support point-to point, dial-up or TCP/IP communication to the Master Station and serial point to point or Ethernet connection to the TDU 100. With a built in Flash-disk the DPS 100 can store a large amount of collected transient records.

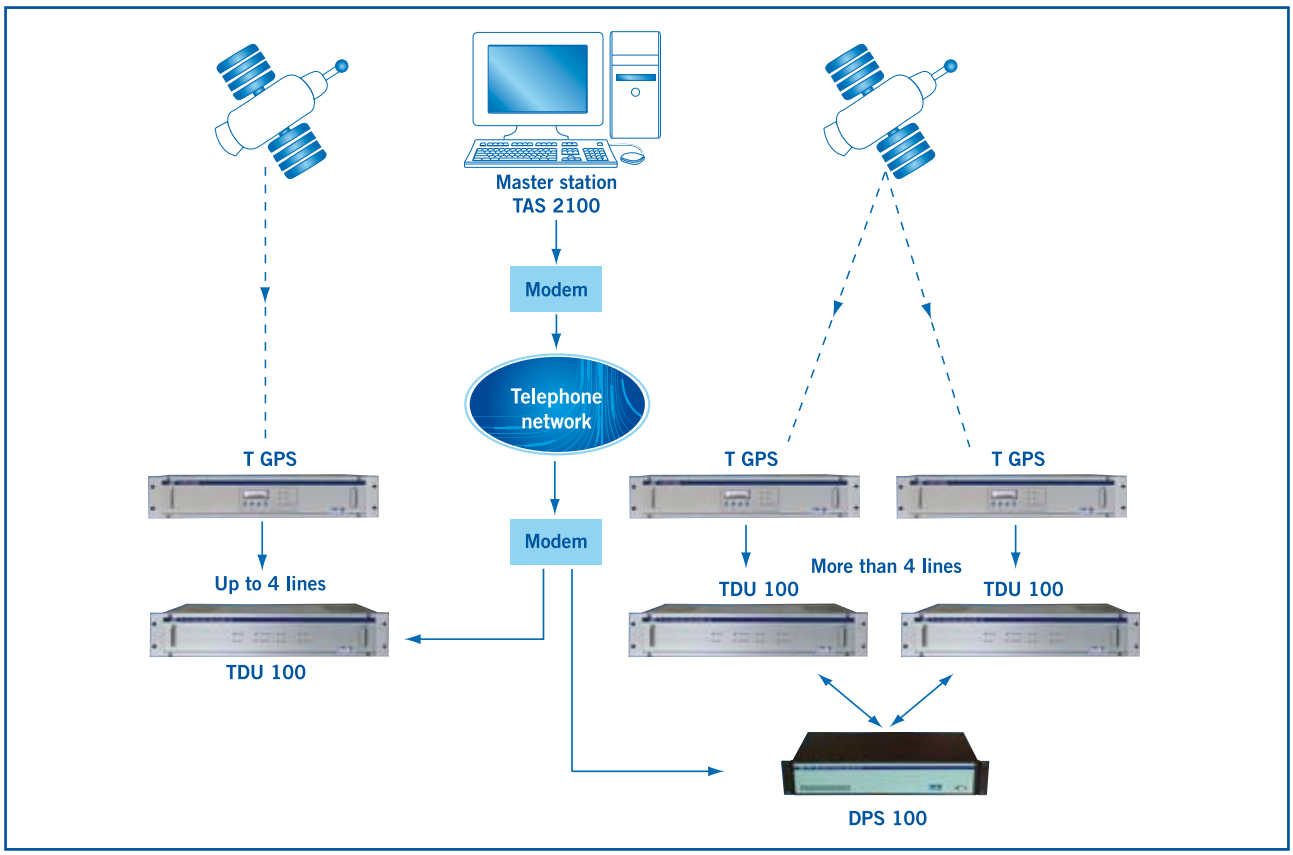
DPS 100 - Data processing server

## COMMUNICATION

### Dial up modem

The TDU 100/DPS 100 and the Master Station are connected to the utility or public telephone network using modems connected to their RS 232 port.

The transient data acquired by each TDU 100 are sent to the Master Station by dialing up modem communication automatically from the TDU to Master Station.

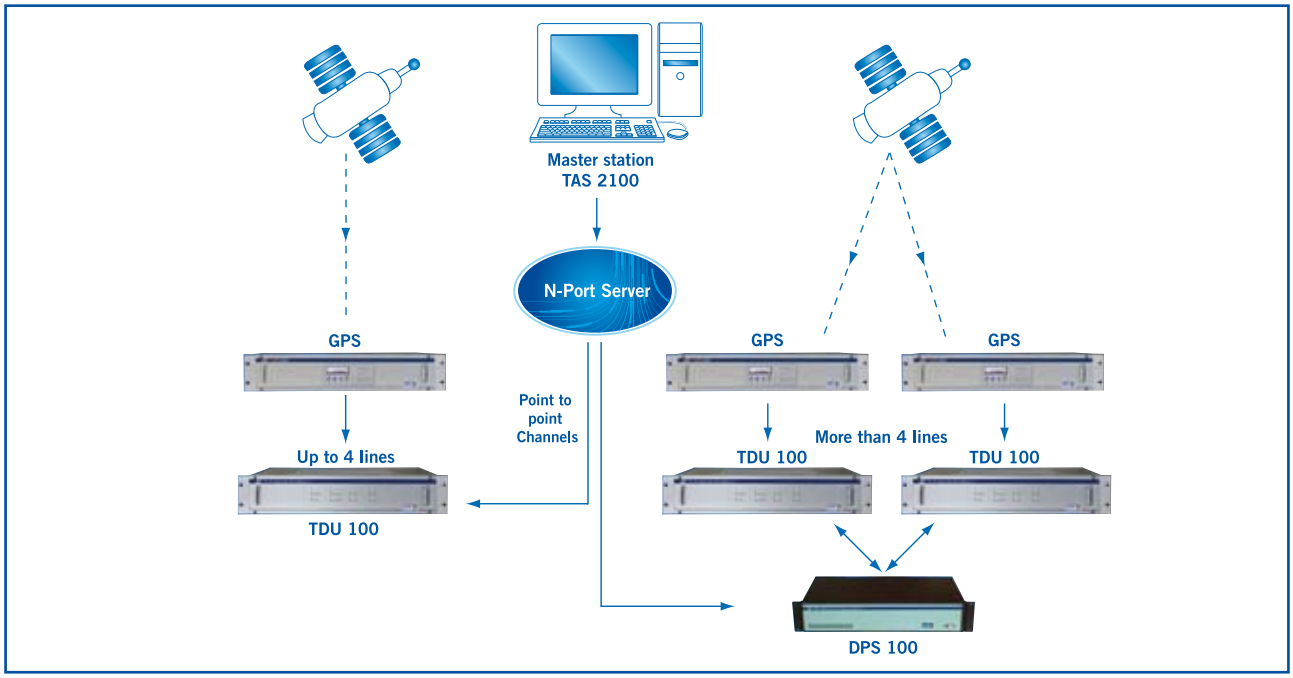



Modem communication configuration

## POINT TO POINT CONNECTION

The TDU 100/DPS 100 and the Master Station are linked together through a dedicated point to point data transmission channel provided by optical fiber or microwave communication network. Communication is via RS 232 port.

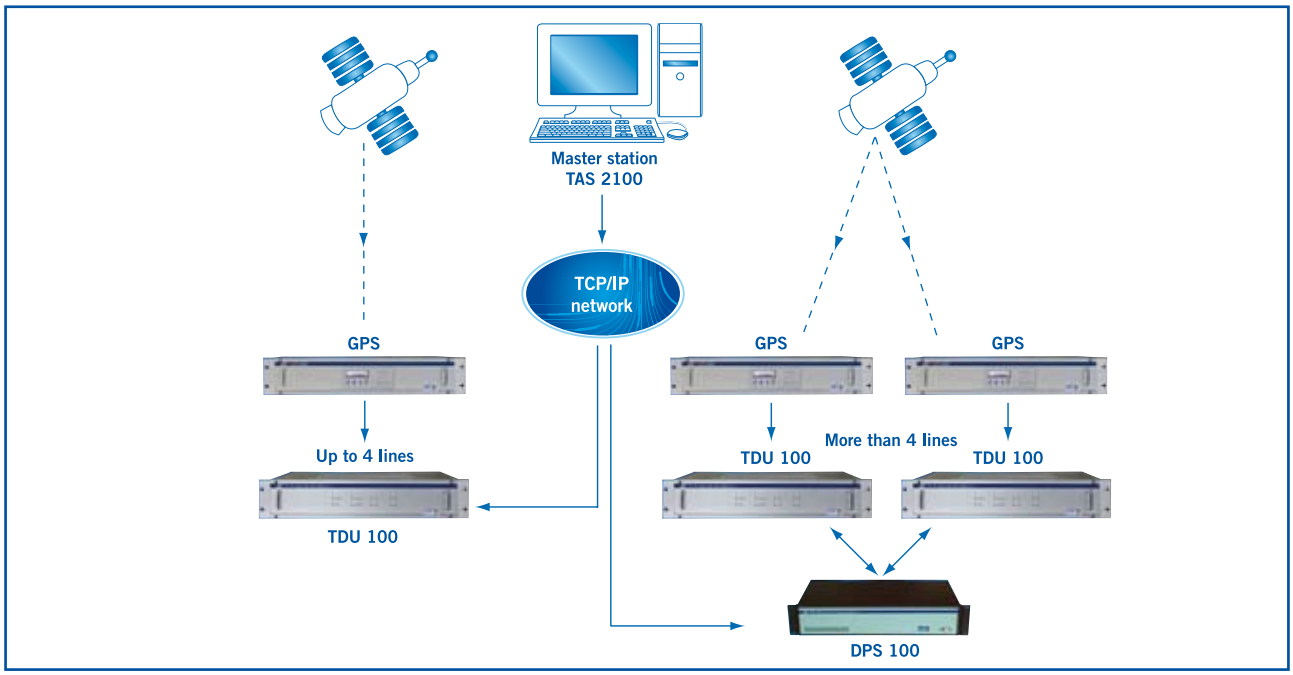
The baud rate is 1,200-56k bps selectable depending on channel conditions. A serial communication server is used to extend multiple point-to-point connections of Master Station to field traveling wave data acquisition units.




Point to point connection configuration

## TCP / IP NETWORK

The TDU 100, DPS 100 and the Master Station are connected to a TCP/IP network via their Ethernet ports.




TCP/IP network configuration

## SPECIFICATIONS

### Traveling Wave Data Acquisition Unit TDU 100

Input:
. Channels: 3-12 configurable for 1-4 lines application.
. Type of input: clip on CT's, secondaries CT's or PT's depending on field application.
A/D conversion:
. Sampling rate: 100 kHz-4MHz programmable, standard 1MHz.
. Resolution: 12 Bits
Length of each transient record:
. 1-10ms programmable, standard 4ms.
Nonvolatile memory:
. 1Mbytes
Event inputs:
. 2 dry contacts.
Alarm:
. 2 dry contacts: normally open.
. Contact rating: 28V DC/2A, 250V AC/0.5A
. 1 for power failure alarm, 1 for GPS synchronization lost
Communication port:
. 2 RS 232 port
. 1 Ethernet port
Time synchronization:
. 1PPS GPS synchronization signal, RS 232/422 for date information input
. 1 IRIG-B
Power:
. Voltage 90...240V, 50/60Hz AC or 90...240V DC
. Power consumption: <10W
Environment:
. Operating temperature: 0° / +55°C
. Storage temperature: -40° / +85°C
. Humidity: 5% - 95% (non-condensing)
Applicable standard: IEC 255-22-1(1988); EC 255-5(1977)
Electromagnetic Compatibility: EN61326
Low Voltage Directive: EN61010
Physical dimension: 19", 2U

### Traveling Wave Analysis Software TAS 2100

Minimum hardware requirements:
. X86 series Pentium II 366 above desktops or laptops
Software environment:
. Windows 95/98 / NT 4.0 / 2000 Professional / XP / Vista
Communication port:
. 2 RS 232 port
. 1 Ethernet port
. RS 232 port Extension for multiple point to point communication to TDU's, Serial port server

### Data Processing Server DPS 100

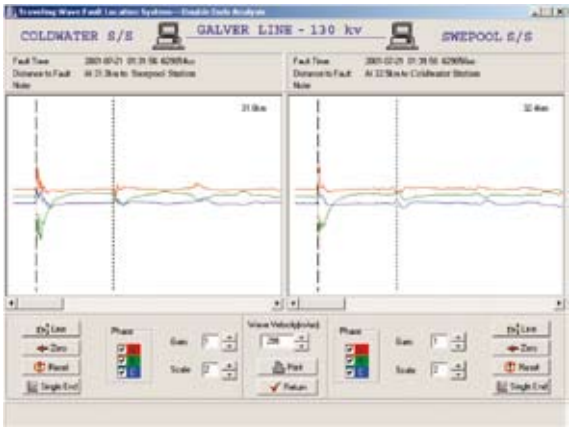
. 8 RS 232 ports: 4 for TDU and 1 to Master Station; 3 spares.
. 4 Ethernet ports.
Mass storage memory 2 Gbytes standard- optional 4 or 8 Gbytes.
Power:
. Voltage: 90...240V, 50/60 Hz AC or 90...240V DC
. Power consumption: <10W
Environment:
. Operating temperature: 0° / +55°C
. Storage temperature: -40° / +85°C
. Humidity: 5% - 95% (non-condensing)
Applicable standard: IEC 255-22-1(1988); IEC 255-5(1977)
Electromagnetic Compatibility: EN61326
Low Voltage Directive: EN61010
Physical dimension: 19", 2U

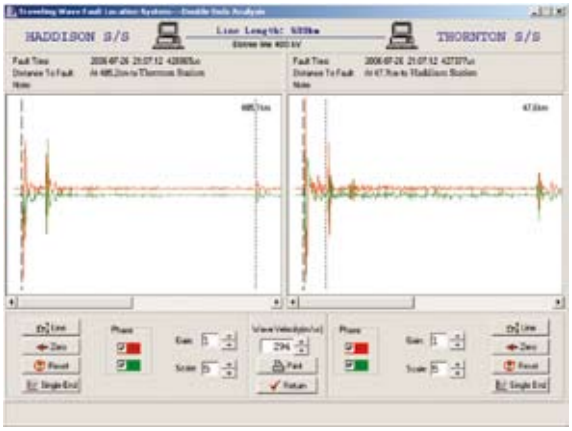
### T GPS 2000 syncronization clock

Led indications:
. Power ON
.1PPS sync.
. Sync. Lost
Performance acquisition time:
. 90 seconds max typical (new installation).
. 90 seconds max with location changes.
. 45 seconds max without location changes.
. 20 seconds max with power instant shut up.
Time accuracy:
.1 µs for PPS
Output port features:
. Voltage between dry contact C and E VCE<300V.
. Current between dry contact C and E ICE< 50mA.
Serial Port Outputs with selectable baud rate:
. 2 RS 232 outputs.
. 2 RS 422/485 outputs.
. 1 IRIG-B
Programmable Pulse Output:
. PPS, PPM and PPH output, standard 200 ms pulse width.
. 7 dry contact outputs.
. 1 TTL wet contact output.

Power:
. Voltage 90...240V, 50/60Hz AC or 90...240V DC.
Power consumption: <40 W
Environment:
. Operating temperature: 0°/ + 40°C
. Storage temperature: -40°/ + 50°C
. Humidity: 5% - 95% (non-condensing)
Applicable standard: IEC 255-22-1(1988), IEC 255-5(1977)
Electromagnetic Compatibility: EN61326
Low voltage directive: EN61010
Physical dimension: 19", 2U
Weight: <3 kg

## EXAMPLE OF FAULT LOCATION RESULTS




## ORDERING INFORMATION:

| CODE | MODULE |
|---|---|
| 10171 | Traveling Wave Fault Location System TFS 2100, including: - No. 1 TDU 100 data acquisition unit (for 1 power line), 2 RS 232, 1 Ethernet port, 1 IRIG-B, 1 Mb non volatile Memory; - Master Station Software license TAS 2100 (code ZSW90171) |
| 11171 | Traveling Wave Fault Location System TFS 2100, including: - No. 1 TDU 100 data acquisition unit (for 2 power lines), 2 RS 232, 1 Ethernet port, 1 IRIG-B, 1 Mb non volatile Memory; - Master Station Software license TAS 2100 (code ZSW90171) |
| 12171 | Traveling Wave Fault Location System TFS 2100, including: - No. 1 TDU 100 data acquisition unit (for 3 power lines), 2 RS 232, 1 Ethernet port, 1 IRIG-B, 1 Mb non volatile Memory; - Master Station Software license TAS 2100 (code ZSW90171) |
| 13171 | Traveling Wave Fault Location System TFS 2100, including: - No. 1 TDU 100 data acquisition unit (for 4 power lines), 2 RS 232, 1 Ethernet port, 1 IRIG-B, 1 Mb non volatile Memory; - Master Station Software license TAS 2100 (code ZSW90171) |
| 11150 | Additional 1 Power Line (up to 3 additional lines) |
| 20171 | DPS 100 - Data processing server: Mass Storage memory 4 Gbytes, 4 RS 232 ports, 1 Ethernet port. |
| 14150 | Clip-on CT (1 Power Line) - q.ty 3 CT's |
| 30171 | T GPS 4000 receiver - 2 RS 232, 1 IRIG-B, 2 RS 422/485 for centralized installation |
| 31171 | T GPS 2000 receiver - 1 RS 232, 1 RS 422/485, 1 IRIG-B for distributed installation |
| 17150 | GPS antenna with 30 m cable |
| 18150 | GPS antenna with 40 m cable |
| 19150 | GPS antenna with 50 m cable |



ISA Srl
Via Prati Bassi, 22
21020 Taino VA - Italia
Tel +39 0331 956081
Fax +39 0331 957091
Web site: www.isatest.com
E-Mail: isa@isatest.com

GB -TFS 2100 -07-09