TFS 2100

Traveling Wave Fault Location System

- The most accurate overhead transmission and distribution line fault locator
- Accuracy: ±150m typical, regardless of 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
- Reduces 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 an 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.

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 the distance to fault by measuring the time for a surge to travel from the fault position to the measurement point.

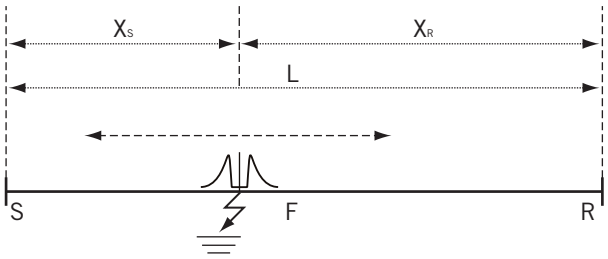
Type D (Double Ended) Method

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.

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

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

TDU 100 - Traveling wave data acquisition unit



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 close to speed of light in overhead lines. L is the total line length.

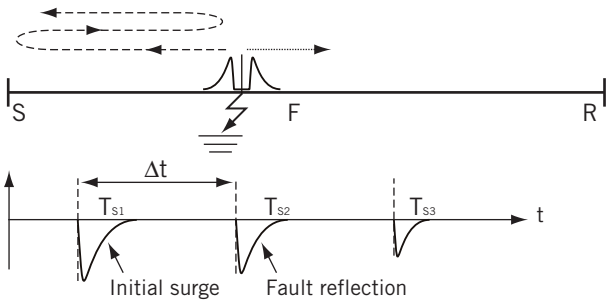
Type A (Single ended) Method

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 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.

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

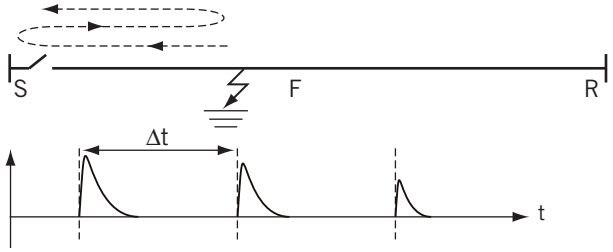
Type E Method

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 complementary fault location means.

Measuring traveling waves

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

AC Power Lines

The conventional current transformer (CT) reproduces current transients faithfully in secondary circuits and 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 is used to measure the transient current of the CT secondary.

The bus of the AC power line has usually more than one line connected besides the faulted one 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 a conventional voltage transformer (VT). In EHV transmission system with capacitive voltage transformer (CTV - which is a tuned circuit and has filtered out transient responses), the transient voltage can be acquired indirectly by measuring transient current through the earth wire of the dividing capacitor, using an external transformer.

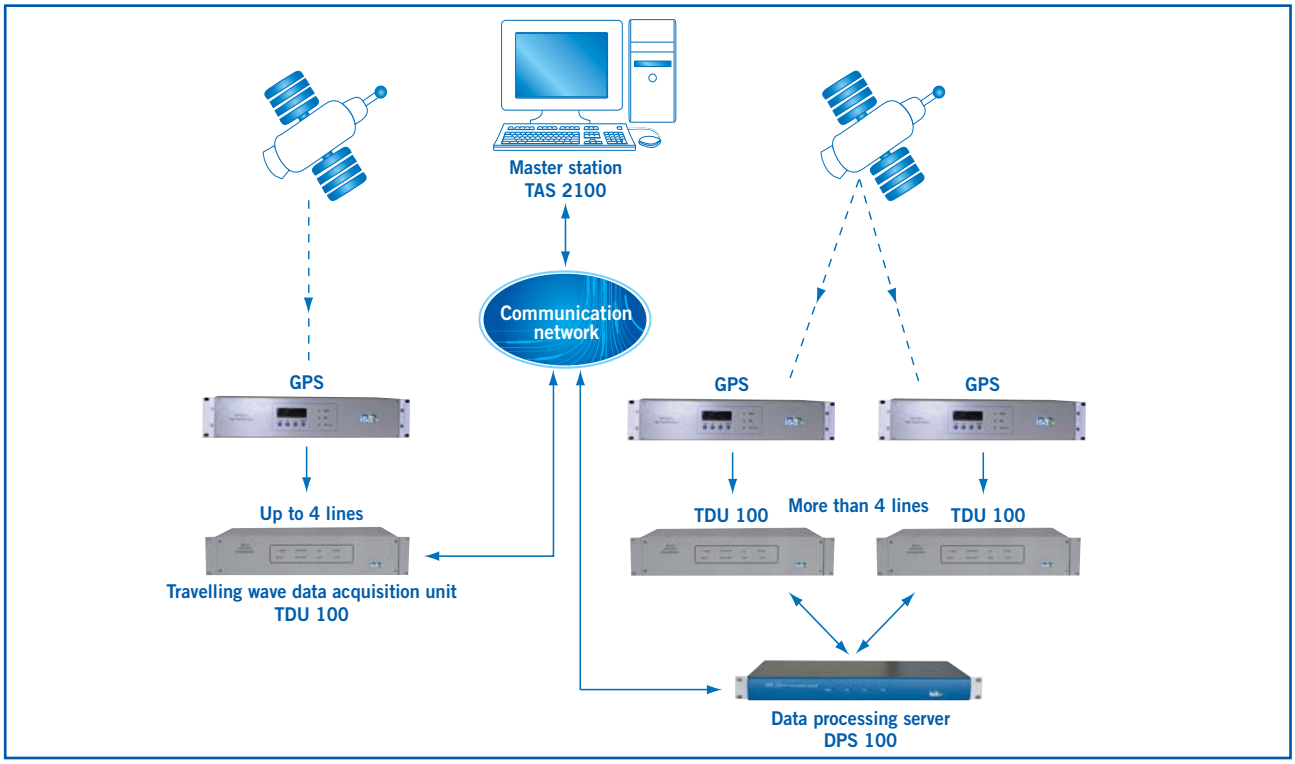
HVDC Transmission Line

The CT's and VT's of HVDC system are usually installed behind an 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 the transient current through the earth wire of the surge suppression or carrier coupling capacitor using an external 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 a 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 is 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 and to communicate 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 transferred to a non-volatile memory when the unit is triggered, i.e. when any input signals exceeds a pre-set threshold level. The acquired transient data are then sent to the Master Station via the communication network for further processing.

TDU 100 - Traveling wave data acquisition unit

TDU 100 features:

. Software controlled analog gain and trigger thresholds.
. Synchronized to 1 µs accuracy by an external GPS clock (available at site or from T GPS 2000).
. Successive transient recording with less than 100 µs reset time.
. Contacts input and output are provided for external triggering, remote alarm and indication of internal failure.
. Supports local setting and transient records interrogation through Ethernet port.

T GPS 2000 - Syncronization clock

. Flexible communication, including point-to-point, dial-up or TCP/IP communication to the Master Station and 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/7 environments).

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.
. Versatile waveform analysis utilities to allow the users to review the fault waveforms in detail and to measure the distance to fault by identifying fault reflections.
. Transient records management allows the user to manipulate, search, copy in and copy out the fault waveforms.
. Supports remote configuration and setting of the TDU 100.
. Remote diagnosis to allow the service engineer to maintain the system or to verify the fault location results.
. Supports 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 to communicate 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 2 Gbyte of collected transient records.

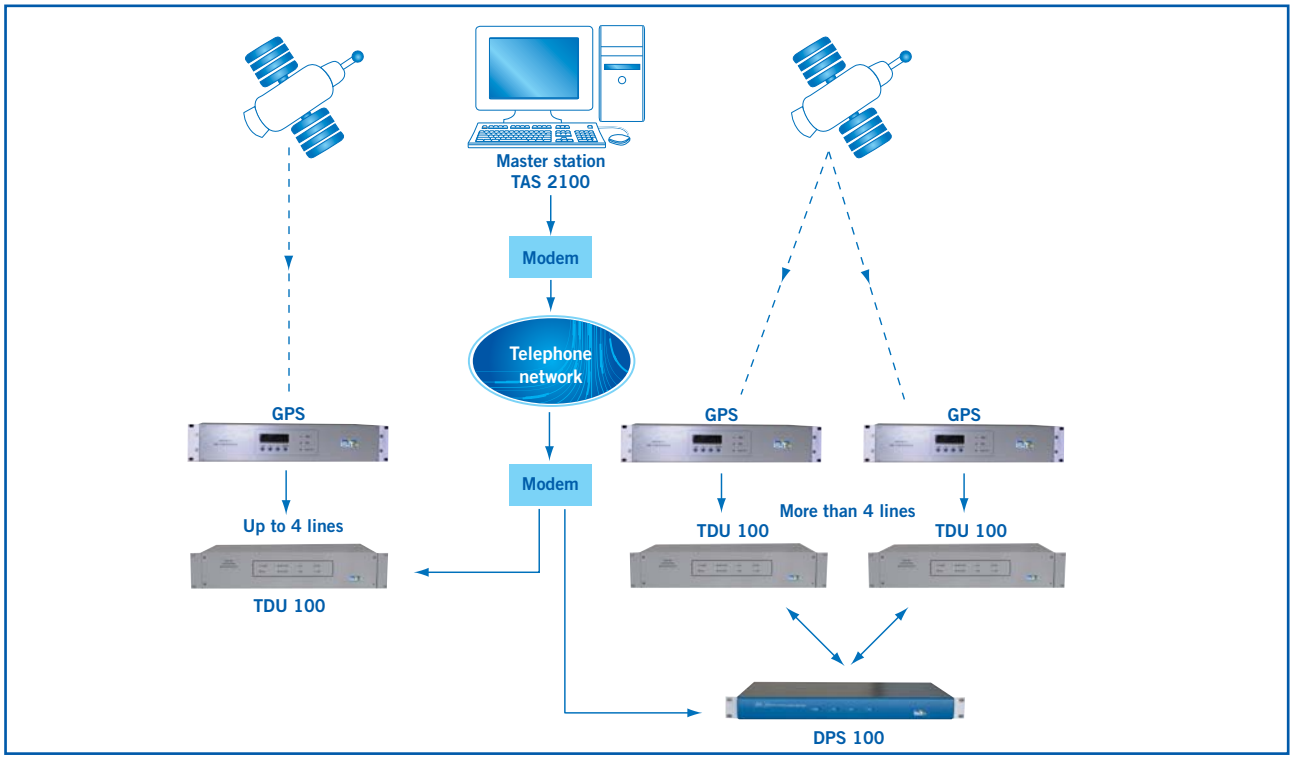
DPS 100 - Data processing server

COMMUNICATION

Dial up modem

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

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.

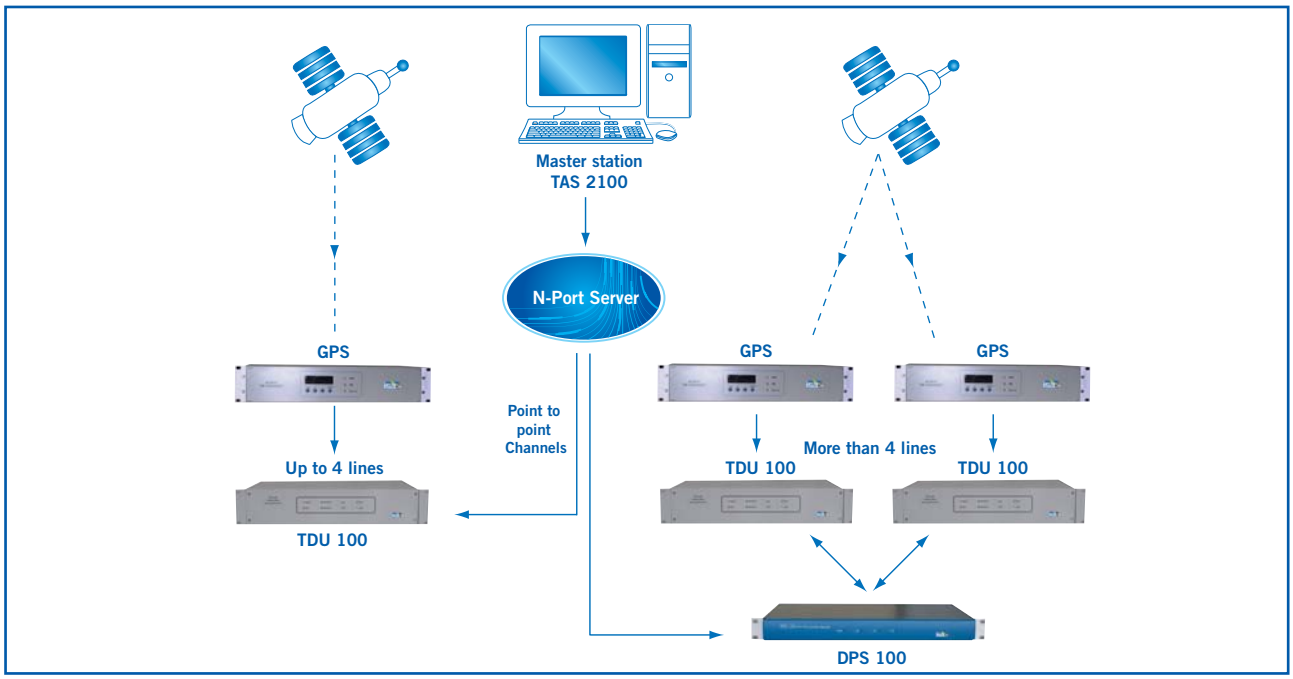


Modem communication configuration

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.

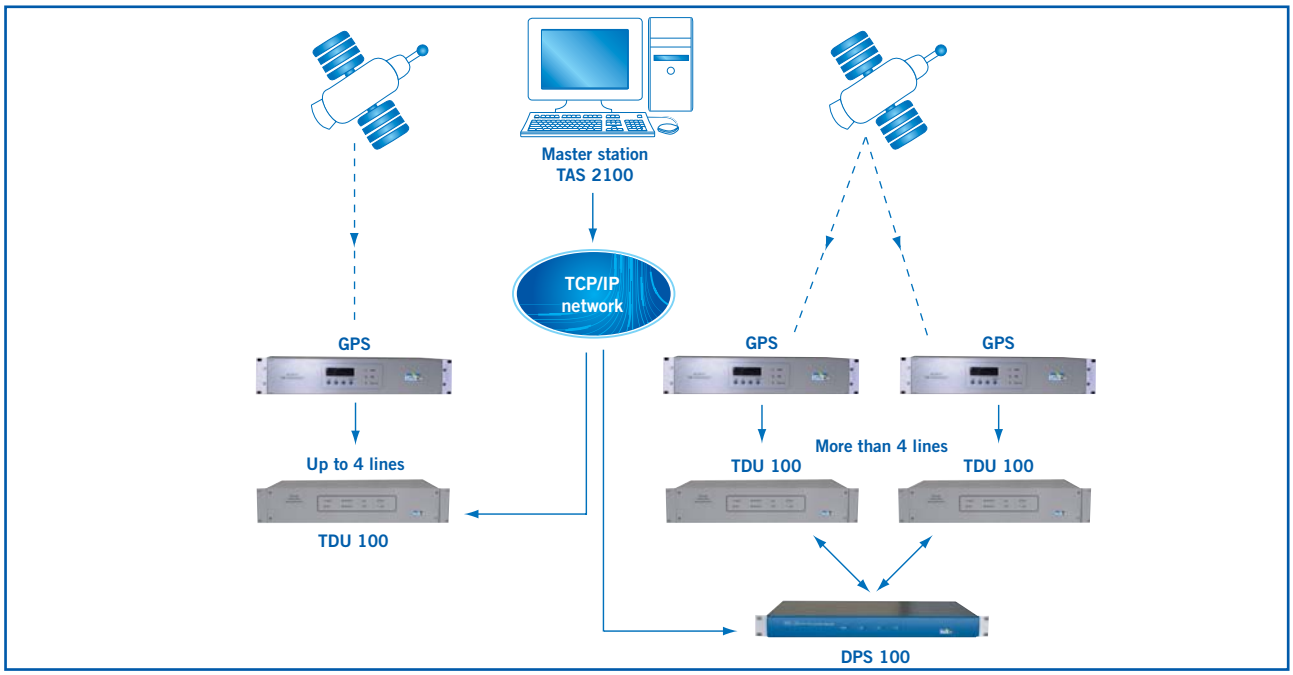
The baud rate is 1,200-56k bps, selectable depending on channel conditions. A serial communication server is used to extend multiple point-to-point connections of Master Station to traveling wave data acquisition units.



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

HARDWARE SPECIFICATIONS

Traveling Wave Data Acquisition Unit TDU 100

Modular construction

Input:
. Channels: 3-12, configurable for 1-4 lines application.
. Type of input: direct connection clip-on CT's (base model), external CT's or PT's, depending on field application (additional modules).

A/D conversion:
. Sampling rate: 500 kHz-4MHz, programmable.
. Resolution: 12 Bits

Length of each transient record:
. 1-10ms, programmable.

Nonvolatile memory:
. 1Mbytes

Event input:
. 1 dry contact.

Alarms:
. 2 dry contacts: normally open.
. Contact rating: 28V DC/2A, 250V AC/0.5A

Communication port:
. 2 RS 232 ports.
. 1 Ethernet port.

Time synchronization (alternative choices):
. 1PPS GPS synchronization signal, RS 232/422 for date and time; electrical and optical.
. 1 IRIG-B, electrical (base model) or optical.

Power:
. Voltage 85...264V, 50/60Hz AC or 90...260V DC (base model); option 48 V DC.
. Power consumption: <10W.

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/ 7.

Communication ports:
. 2 RS 232 ports (or USB converters).
. 1 Ethernet port.

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.

Power:
. Voltage: 85...264V, 50/60 Hz AC or 90...260V DC (base model); option 48 V DC.
. Power consumption: <10W.

T GPS 2000 syncronization clock

Modular construction

Led indications:
. Power ON
.1PPS sync.
. Sync. Lost
Performance acquisition time:
. 90 seconds max (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.
Contact outputs:
. 4 dry contact outputs.
Output modules (maximum 3 per type; additional modules):
. IRIG-B DC (2 outputs, base model; optional 4).
. IRIG-B AC (2 outputs; optional 4).
. IRIG-B optical: 2 outputs (maximum 1 additional module).
. 1 PPS TTL (2 outputs; optional 4).
. 1 PPS optical and serial message (2+2).
. Serial: 2 RS 232 and 2 RS 485.
Power:
. Voltage 85...264 V, 50/60Hz AC or 90...260V DC; option 48 V DC.
Power consumption: <40 W

FOR ALL MODULES

Environmental:
. Operating temperature: 0° / +55°C
. Storage temperature: -40° / +85°C
. Humidity: 0% - 90% (non-condensing)
Applicable standard: IEC 255-22-1(1988); 2004/108/EC
Electromagnetic Compatibility: EN61326:2006.
Low Voltage Directive: EN60950-1: 2006/95/EC.
Standard: EN61010
Physical dimension: 19", 2U

ORDERING INFORMATION

TDU 100 CONFIGURATION

CODE	MODEL
10171	TDU 1 LINE - Basic unit: . Non volatile memory: 1Mbyte . Communication: Internal MODEM; 2 RS232; 1 Ethernet . Digital I/O module . Analog input for 1 line, with split core CT's (3) included (max three additions) . TAS 2100 Master Station - Software License for Travelling Wave Analysis. . Time Synchronization: IRIG-B, 5V level TTL (BNC) (See alternatives 1) . Power Supply: 85 to 264 V AC or 90 to 260 V DC (See alternative 2)
11171	TDU 2 LINES - Basic unit: . Non volatile memory: 1Mbyte . Communication: Internal MODEM; 2 RS232; 1 Ethernet . Digital I/O module . Analog input for 2 lines, with split core CT's (6) included (max two additions) . TAS 2100 Master Station - Software License for Travelling Wave Analysis. . Time Synchronization: IRIG-B, 5V level TTL (BNC) (See alternatives 1) . Power Supply: 85 to 264 V AC or 90 to 260 V DC (See alternative 2)
12171	TDU 3 LINES - Basic unit: . Non volatile memory: 1Mbyte . Communication: Internal MODEM; 2 RS232; 1 Ethernet . Digital I/O module . Analog input for 3 lines, with split core CT's (9) included (max one addition) . TAS 2100 Master Station - Software License for Travelling Wave Analysis. . Time Synchronization: IRIG-B, 5V level TTL (BNC) (See alternatives 1) . Power Supply: 85 to 264 V AC or 90 to 260 V DC (See alternative 2)

CODE	MODEL
13171	TDU 4 LINES - Basic unit: . Non volatile memory: 1Mbyte . Communication: Internal MODEM; 2 RS232; 1 Ethernet . Digital I/O module . Analog input for 4 lines, with split core CT's (12) included . TAS 2100 Master Station - Software License for Travelling Wave Analysis. . Time Synchronization: IRIG-B, 5V level TTL (BNC) (See alternatives 1) . Power Supply: 85 to 264 V AC or 90 to 260 V DC (See alternative 2)

TDU 100 OPTIONS

CODE	MODEL
Additional analog inputs (maximum 4, including the base):	
50171	Additional analog input type AD, for 1 line
51171	Additional analog input type AI, for 1 line, with external CT's (3) and IP box
52171	Additional analog input type AV, for 1 line, for CVT connection
Alternative 1 to the time synchronization (choose one):	
53171	1PPS input, 5V level TTL (BNC) + Serial time message input from GPS clock: RS 485
54171	Optical IRIG-B (ST)
55171	Optical 1 PPS input (ST) + optical serial time message from GPS clock (ST)
Alternative 2 to the power supply:	
56171	Optional Power supply: 35 to 65 V DC

DPS 100 CONFIGURATION

CODE	MODEL
20171	DPS 100 - Basic unit: . Data storage memory size: 2 Gbyte . Power supply: 90 to 264 V AC or 90 to 260 V DC (see alternative)

DPS 100 OPTIONS

CODE	MODEL
60171	Alternative power supply: 35 to 65 V DC

T GPS 2000 CONFIGURATION

CODE	MODEL
30171	T GPS 2000 - Basic unit: . Synchronization: always present . Alarms output module . IRIG-B DC, Outputs: 2 (see additional modules) . Antenna and cable (cable lenght 30m; see alternative lenghts) . Power supply: 85 to 264 V AC or 90 to 260 V DC (see alternative)

T GPS 2000 OPTIONS

CODE	MODEL
Additional synchronization output modules:	
70171	IRIG-B DC: Outputs: 2 - Max 2 modules
71171	IRIG-B DC: Outputs: 4 -Max 2 modules
72171	1 PPs TTL: Outputs: 2 - Max 3 modules
73171	1 PPs TTL: Outputs: 4 - Max 3 modules
74171	Optical IRIG-B: Outputs: 4 - Max 3 modules
75171	Optical 1 PPs: Outputs: 2 - Max 3 modules
76171	IRIG-B AC: Outputs: 2
77171	IRIG-B AC: Outputs: 4
78171	Serial: Outputs: 2 + 2 - Max 2 modules
Alternative antenna cable lenght:	
80171	Cable lenght 40 m
81171	Cable lenght 50 m
82171	Cable lenght 60 m
83171	Cable lenght 100 m
Alternative power supply:	
84171	Optional Power supply: 35 to 65 V DC

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