

PROTEM TIME DOMAIN EM SYSTEMS



PROTEM RECEIVER

It is well known that there is a trade-off between depth of exploration and target definition in terms of conductivity, extent and orientation. Greatest depth is obtained with large fixed loop Turam-type systems which generate large half-space responses that, along with current gathering, makes target detection difficult. Better spatial resolution is obtained with a moving transmitter configuration with a short intercoil spacing but is limited to a shallower depth of exploration. These variations in survey requirements make system flexibility an important design consideration.

Time domain systems are also now routinely employed for general geological exploration such as for freshwater aquifers in bedrock fractures, and mapping groundwater contaminant plumes. Mapping to shallow depths, as necessary in these applications, requires a very wide bandwidth and many narrow sampling gates.

Recognition of these diverse requirements led Geonics to develop the extremely flexible PROTEM time domain system. The digital, 3 component receiver is used with any of the three TEM transmitters and choice of receiver coils to cover all applications. With 23 bit resolution, system bandwidth of 270 kHz, microsecond sampling gates and simultaneous XYZ component measurements, the PROTEM receiver provides the ultimate in time domain capability.

The latest addition to the PROTEM receiver enables the selection of either 20 gates per base frequency covering 2 decades of time, or 30 gates for a 3 decade range. If 3 decades of time are required to cover the decay then this selection saves switching frequencies and repeating the measurement; if only 2 decades are required, using the 20 gate range reduces the measurement time by a factor of 10. A further receiver improvement enables automatic measurements during the on-time in addition to the standard off-time measurements.

Specifications

MEASURED QUANTITY	Rate of decay of induced magnetic field along 3 axes, in nV/m ²
EM SENSOR	Air-cored coils
CHANNELS	1 channel used sequentially for 3 components, or 3 channels for 3 component simultaneous operation
TIME GATES	20 gates covering 2 time decades or 30 gates covering 3 time decades
DYNAMIC RANGE	23 bits (132 dB)
BASE FREQUENCY	0.3, 0.75, 3, 7.5, 30, 75 and 285 Hz or 0.25, 0.625, 2.5, 6.25, 25, 62.5 and 237.5 Hz
INTEGRATION TIME	0.5, 2, 4, 8, 15, 30, 60 or 120 s
DISPLAY	240 x 64 dot graphic LCD
DATA HANDLING	Solid-state memory for 3300 data-sets, RS232 output
SYNCHRONIZATION	Reference cable or, optionally, highly stable quartz crystal
POWER SUPPLY	12 V rechargeable battery for 8 h continuous operation
WEIGHT	15 kg
DIMENSIONS	34 x 38 x 27 cm



TEM47 TRANSMITTER

Three interchangeable transmitters - TEM47, TEM57-MK2 and TEM67 - are used with the PROTEM receiver and the appropriate receiver coil to make up different PROTEM systems for various applications such as mineral exploration, structural mapping, resistivity sounding and contaminant plume mapping.

The TEM47 is the smallest, lightest battery operated transmitter with a very fast turn-off time to enable the near-surface response to be measured. The PROTEM 47 (PROTEM receiver and TEM47 transmitter) is most often used for shallow resistivity sounding delineating groundwater contamination plumes, saline intrusion and geologic units. In this mode, single turn transmitter loops from 5 m up to 100 m on a side, with turn-off times as short as half a microsecond, can be used to give maximum near-surface resolution.

The transmitter output current of 3 A into a 100 m x 100 m loop gives good response and resolution to depths of 150 m, making this the ideal instrument for resistivity sounding over a large area. The 30 gate, 3 time decade measurement is usually enough to cover the full decay curve including the early time gates, without changing base frequency.

The TEM47 uses a reference cable to achieve the high synchronization accuracy required for shallow sounding. Regardless of application, the high-frequency receiver coil is used in PROTEM 47 systems. This receiver coil has the bandwidth necessary to capture the earliest portion of the transient decay.

When the TEM47 is used in a PROTEM 47 system for profiling, it supplies 2.5 A to an 8-turn, 5 m x 5 m moving transmitter loop to provide a dipole moment of 500 Am². With base frequency of 75 Hz, and 20 gates from 49 μs to 2.9 ms, this configuration is optimal for Slingram (horizontal loop) surveys for mineral exploration to shallow depths, and for groundwater exploration in bedrock fractures. Electrical sounding is performed simultaneously with the search for fault or dike-like targets.

Specifications

CURRENT WAVEFORM	Bipolar rectangular current with 50 % duty cycle
BASE FREQUENCY	30, 75, or 285 Hz where powerline frequency is 60 Hz 25, 62.5 or 237.5 Hz where powerline frequency is 50 Hz
TURN-OFF TIME	2.5 μs at 3 A into 40 x 40 m loop. Faster into smaller loop
TRANSMITTER LOOP	5 x 5 to 100 x 100 m single turn loop, or 5 x 5 m 8-turn loop
OUTPUT VOLTAGE	0 to 9 V, continuously variable
POWER SUPPLY	Internal 12 V rechargeable battery
BATTERY LIFE	5 h continuous operation at 2 A output
WEIGHT	5.3 kg
DIMENSIONS	10.5 x 24 x 32 cm

PROTEM TIME DOMAIN EM SYSTEMS



TEM57-MK2 TRANSMITTER

The TEM57-MK2 transmitter is the upgraded version of the TEM57 and combined with the PROTEM digital receiver are the principal components of the PROTEM 57-MK2 system. The design and performance of the TEM57-MK2, with its increased power of 1,500 W from an internal power supply makes it a highly portable powerful mid-range time domain transmitter. The internal power supply has variable voltage range from 18 to 60 volts so that it can be perfectly matched to the transmitter loop for optimum performance. An external battery supply increases this capability to 3,800 W and 160 V.

The TEM57-MK2 is the perfect mid-range power transmitter for sounding depth, thickness and conductivity of layers down to 500 m for a wide variety of applications such as mapping of aquifers and aquitards, water quality and stratigraphy. In coastal areas the PROTEM 57-MK2 system has defined depth to saline intrusion as accurately as chemical well samples.

The PROTEM 57-MK2, with a short reference cable, portable transmitter and 3-D receiver coil, can delineate complex ore bodies within 200 m of surface. Deeper conductors can be characterized by profiling with a crystal-synchronized receiver and a large, fixed transmitter loop. Modelling provides conductivity, thickness, dip and extent of the ore body.

Specifications

CURRENT WAVEFORM	Bipolar rectangular current with 50 % duty cycle
BASE FREQUENCY	3, 7.5, or 30 Hz (powerline frequency 60 Hz) 2.5, 6.25, or 25 Hz (powerline frequency 50 Hz) Rates below 1 Hz available from PROTEM receiver through reference cable
TURN-OFF TIME	20 to 115 μ s, depending on size, current and number of turns in transmitter loop
TRANSMITTER LOOP	Single turn: Any dimension; minimum resistance is 0.7 ohms, up to 300 x 600 m. 8-turn; 5 x 5 or 10 x 10 m
OUTPUT CURRENT	25 A maximum
OUTPUT VOLTAGE	18 V to 60 V continuous control with motor generator; up to 160 V (3,800 W) with external power supply
SYNCHRONIZATION	Reference cable or, optionally, quartz crystal
POWER SUPPLY	1,800 W, 110/220 V, 50/60 Hz single-phase motor-generator or, optionally multiple 12 V batteries
TRANSMITTER PROTECTION	Electronic and electromechanical protection
TRANSMITTER SIZE	43 x 25 x 25 cm
TRANSMITTER WEIGHT	15 kg



TEM67 TRANSMITTER

The TEM67 transmitter is the most powerful PROTEM transmitter, replacing the TEM37. Not only is the TEM67 more powerful than the TEM37 (3,800 W as compared to 2,800 W for the TEM37), but the TEM67 offers a degree of flexibility not previously available in time domain transmitters. The TEM67 uses the TEM57-MK2 transmitter with a separate power module and larger generator (4,500 W); this means that one can upgrade from the TEM57-MK2 with the addition of a TEM67 power module and generator. Conversely, if the full power of the TEM67 is not required for a particular survey, much of the weight can be eliminated by using only the TEM57-MK2 portion.

The PROTEM 67 system with the 3D receiver coil is the ideal time domain system for profiling deeply buried conductive ore bodies, such as massive sulphides, to depths in excess of 500 metres, and with the 3-axis BH43-3 borehole probe for time domain logging to 2 kilometres.

The PROTEM 67 is also ideal for deep soundings in ground water exploration, saline intrusion mapping, geothermal exploration, and regional geological research where structures and layer information is required to depths of 1,000 m or more.

Specifications

CURRENT WAVEFORM	Bipolar rectangular current with 50 % duty cycle
BASE FREQUENCY	0.3, 0.75, 3, 7.5 or 30 Hz (powerline frequency 60 Hz) 0.25, 0.625, 2.5 or 25 Hz (powerline frequency 50 Hz) Rates below 1 Hz available from PROTEM receiver through reference cable
TURN-OFF TIME	20 to 750 μ s, depending on transmitter loop size, current and number of turns
TRANSMITTER LOOP	up to 2,000 x 2,000 m maximum
OUTPUT CURRENT	25 A maximum
OUTPUT VOLTAGE	18 to 150 V continuously adjustable
SYNCHRONIZATION	Quartz crystal or reference cable
POWER SUPPLY	4,500 W, 110/220 V, 50/60 Hz, single phase with 8 h continuous operation motor generator
TRANSMITTER PROTECTION	Electronic and electromechanical protection
TRANSMITTER SIZE	43 x 25 x 25 cm (TEM57-MK2); 42 x 20 x 31 cm (TEM67 Power Module)
TRANSMITTER WEIGHT	15 kg (TEM57-MK2); 12 kg (TEM67 Power Module)
MOTOR GENERATOR SIZE	60 x 50 x 49 cm
MOTOR GENERATOR WEIGHT	62 kg

BOREHOLE TDEM PROBE



BH43-3

The BH43-3 provides 3-dimensional time domain EM exploration from boreholes, in conjunction with a PROTEM system. Boreholes as deep as 2 km can be surveyed using a PROTEM system with a 500 x 500 m transmitter loop. (At developed mines, the transmitter loop can be laid out in underground workings.)

The probe has 3 sensors which measure orthogonal components of decay. Along the hole, spatial resolution as fine as 1 m can be obtained; the actual measurement interval depends on the desired resolution of the response.

The wide bandwidth of the probe, coupled with the excellent temporal resolution and large dynamic range of the PROTEM system, provides maximum diagnostic information and a high degree of rejection of powerline and other noise sources.

Computer programs for editing, displaying and interpreting BH43-3 responses are supplied with the probe, including a program for calculating all field components in a conductive earth. The BH43-3 probe is available separately, or as a complete borehole system with cable, main winch, dummy probe, test cable and winch, and retrieval tools.

Specifications

SENSOR	Three orthogonal coils (one axial and two radial)
SENSOR AREA-TURNS PRODUCT	5000 m ² for axial and 1250 m ² for radial sensors (with amplification)
SENSOR-PREAMPLIFIER RESONANT FREQUENCY	10 kHz for all sensors
PROBE ROTATION CORRECTION	Two orthogonal tilt meters with range from $\pm 1^\circ$ to $\pm 80^\circ$ (from vertical)
OPERATING TEMPERATURE	-30° C to +80° C
POWER SUPPLY	Rechargeable nickel cadmium battery sealed pack for 40 h continuous operation
CONTROL BOX	Channel selection, impedance and gain matching network between probe and PROTEM receiver (normalizes sensor effective area to 100 m ² for all three sensors); comes with VLF filter
CABLE	Two-conductor shielded; polyurethane jacket; Kevlar strength membrane, 5.6 mm diameter with weight 40 kg/km and breaking strength 500 kg
WEIGHT	Probe: 9.5 kg Control Box: 1.5 kg
DIMENSIONS	Probe: 3.8 cm diameter, 234 cm length Control Box: 22 x 13.5 x 8 cm

VLF RECEIVER / TRANSMITTER



EM16 / EM16R / TX27

The EM16 is the most widely used EM geophysical instrument of all time. It measures the local tilt and ellipticity of VLF broadcasts and resolves these values into in-phase and quadrature components of VLF response. The EM16 has discovered several base and precious-metal orebodies and many water-bearing faults.

The EM16R attaches to the EM16 and, using a pair of electrodes, measures the apparent resistivity of the earth. The combined EM16/16R instrument can detect a second earth-layer if the layer occurs within the VLF skin-depth. In addition, the EM16/16R can map resistive alteration for gold exploration.

The TX27 is a portable VLF transmitter supplying a VLF field for surveying with the EM16/16R if remote broadcasts are weak, intermittent or poorly coupled with the target. For EM16 surveys, the TX27 antenna consists of a long (typically 1 km) grounded wire.

Specifications (EM16 / EM16R)

MEASURED QUANTITY	EM16: In-phase and Quadrature components of the secondary VLF field, as percentages of the primary field EM16R: Apparent resistivity in ohm-metres, and phase angle between E_x and H_y
PRIMARY FIELD SOURCE	VLF broadcast stations
SENSOR	EM16: Ferrite-core coil EM16R: Stainless-steel electrodes, separated by 10 m: impedance of sensor is 100 M Ω in parallel with 0.5 pf
OPERATING FREQUENCY	15 to 30 kHz, depending on VLF broadcasting station
MEASUREMENT RANGES	EM16: In-phase: $\pm 150\%$; Quadrature: $\pm 40\%$ EM16R: 300, 3000, 30000 T-m, Phase: 0-90°
POWER SUPPLY	EM16/EM16R: 6 alkaline "AA" cells
DIMENSIONS	EM16 and/or EM16R: 53 x 30 x 22 cm
WEIGHTS	EM16: Operational: 1.8 kg; Shipping: 6.2 kg EM16R: Operational: 1.5 kg; Shipping: 6 kg

Specifications (TX27)

PRIMARY FIELD SOURCE	Grounded wire or 500 x 500 m loop, current adjustable, 0 to 2 A
OPERATING FREQUENCY	18.6 kHz
POWER SUPPLY	120/220 V, 350 W motor generator
DIMENSIONS	Transmitter and loop; Shipping: 89 x 29 x 39 cm Generator; Shipping: 50 x 27 x 36 cm
WEIGHTS	Transmitter and loop; Shipping: 32.5 kg Generator; Shipping: 17 kg