

GEONICS LIMITED

LEADERS IN ELECTROMAGNETICS



GEOPHYSICAL INSTRUMENTATION
FOR EXPLORATION & THE ENVIRONMENT

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EM39 CONDUCTIVITY

The EM39 provides measurement of the electrical conductivity of the soil and rock surrounding a borehole or monitoring well using the inductive electromagnetic technique. The unit employs coaxial coil geometry with an intercoil spacing of 50 cm to provide a substantial radius of exploration into the formation while maintaining excellent vertical resolution. Measurement is unaffected by conductive borehole fluid or the presence of plastic casing. The instrument operates to a depth of 500 metres.

The combination of a large conductivity range, high sensitivity and very low noise and drift, allows accurate measurement of subsurface conditions. Typical applications include groundwater contamination monitoring, groundwater and mineral exploration, and general geotechnical investigations.

The 4-conductor EM39 probe can be used with many commercially available borehole logging systems, or with a dedicated winch and console system from Geonics.

Measurements can either be recorded with the DL720 digital data logger, or viewed in real-time using the EM39RT program with field computer.

Specifications

MEASURED QUANTITIES	Apparent conductivity in millisiemens per metre (mS/m)
PRIMARY FIELD SOURCE	Self-contained dipole transmitter
SENSOR	Self-contained dipole receiver
INTERCOIL SPACING	50 cm
OPERATING FREQUENCY	39.2 kHz
MEASURING RANGES	± 100, 1000, 10,000 mS/m
DEPTH	200 m (500 m cable optional)
MEASUREMENT RESOLUTION	0.1 % of full scale
MEASUREMENT ACCURACY	± 5 % at 30 mS/m
NOISE LEVELS	<0.5 mS/m
POWER SUPPLY	10 disposable "D" cells, or 12 VDC external power source
DIMENSIONS	Probe: 3.6 cm diameter, 163 cm length
WEIGHTS	Probe: 2.2 kg, Console: 7 kg Shipping: 90 kg (2 boxes)

GAMMA39 NATURAL GAMMA

The EM39 Borehole Conductivity Probe has been designed for rapid, accurate measurements of groundwater contamination in the earth and rock surrounding monitoring wells. Since clays also increase the electrical conductivity, Geonics introduced the Gamma39 natural gamma ray probe to resolve this ambiguity. Whereas conductivity highs with coincident gamma ray highs often indicate enhanced clay content, conductivity highs not associated with a gamma ray high can be expected to be due to enhanced TDS in the groundwater.

Like the conductivity probe, the gamma ray probe is unaffected by plastic casing in the well. It requires no special licences, can be used anywhere, is relatively fast to operate and can, of course, also be employed to detect radioactive wastes in the ground.

Specifications

MEASURED QUANTITY	Naturally occurring gamma-radiation, in counts/second
SENSOR	Thallium-activated sodium iodide crystal
COUNTS RANGE	100, 300, 1000 counts/second
DEPTH	200 m (500 m cable optional)
MEASUREMENT PRECISION	one count/second
POWER SUPPLY	10 disposable "D" cells, or 12 VDC external power source
DIMENSIONS	Probe: 3.6 cm diameter, 100 cm length
WEIGHTS	Probe: 1.6 kg Console: uses EM39 console

EM39S MAGNETIC SUSCEPTIBILITY

The EM39S probe provides measurement of the magnetic susceptibility of the formation in the vicinity of a borehole or monitoring well. The EM39S with intercoil spacing of 50 cm provides good vertical resolution while still achieving a reasonable range of investigation into the surrounding medium. Sensitivity and low noise ensure an excellent range of measurement for most geological applications.

The susceptibility response is unaffected by plastic casing, and unlike conventional magnetometers, is unaffected by either variations in remanent magnetization of the surrounding soil or rock, or in the strength of the earth's magnetic field.

Specifications

MEASURED QUANTITY	Magnetic susceptibility in parts per thousand (ppt)
PRIMARY FIELD SOURCE	Self-contained dipole transmitter
SENSOR	Self-contained dipole receiver
INTERCOIL SPACING	50 cm
OPERATING FREQUENCY	39.2 kHz
MEASURING RANGES	± 30, 300 ppt
DEPTH	200 m (500 m cable optional)
MEASUREMENT RESOLUTION	0.1 % of full scale
MEASUREMENT ACCURACY	± 5 % at 30 ppt
NOISE LEVELS	0.02 ppt
POWER SUPPLY	10 disposable "D" cells, or 12 VDC external power source
DIMENSIONS	Probe: 3.6 cm diameter, 163 cm length
WEIGHTS	Probe: 2.2 kg Shipping: 90 kg (2 boxes)

GROUND CONDUCTIVITY METERS



EM31-MK2

The EM31-MK2 maps geological variations, groundwater contaminants or any subsurface feature associated with changes in ground conductivity, using a patented electromagnetic inductive technique that allows measurement without electrodes or ground contact. With this inductive method, surveys can be carried out under most geologic conditions including those of high surface resistivity such as sand, gravel and asphalt.

Ground conductivity (quad-phase) and magnetic susceptibility (in-phase) measurements are read directly from an integrated data logger (which can be easily removed from the console for data transfer). Real-time (RT) data collection is available by connecting a computer directly to the RS232 output port on the front panel with an optional RS232 interconnect cable.

The effective depth of exploration is about six metres, making it ideal for geotechnical and environmental site characterization. Important advantages of the EM31-MK2 over conventional resistivity methods are the speed with which surveys can be performed, the precision with which small changes in conductivity can be measured and the continuous readout and data collection while traversing the survey area. Additionally, the in-phase component is particularly useful for the detection of buried metallic structure and waste material.

EM31-SH

The EM31-SH is a "short" version of the EM31-MK2 offering an effective depth of exploration of about four metres. With a smaller coil separation (2 m) and lighter weight, the EM31-SH offers improvements in sensitivity to smaller near-surface targets, lateral resolution and portability, while maintaining the high levels of accuracy and stability provided by the standard EM31-MK2. A "trailer-mount" (inset) is available for either instrument, offering greater convenience in field operation.

Specifications

MEASURED QUANTITIES	1: Apparent conductivity in millisiemens per metre (mS/m) 2: In-phase ratio of the secondary to primary magnetic field in parts per thousand (ppt)
INTERCOIL SPACING	3.66 metres
OPERATING FREQUENCY	9.8 kHz
POWER SUPPLY	8 disposable alkaline "C" cells (approx. 20 h continuous)
MEASURING RANGES	Conductivity: 10, 100, 1000 mS/m; In-phase: ± 20 ppt
MEASUREMENT RESOLUTION	± 0.1 % of full scale
MEASUREMENT ACCURACY	± 5 % at 20 mS/m
NOISE LEVELS	Conductivity: 0.1 mS/m; In-phase: 0.03 ppt
DATA STORAGE	10,000 records (2 components); 16,500 records (1 component) (ext. memory available)
DIMENSIONS	Boom: 4.0 m extended, 1.4 m stored Shipping Case: 145 x 38 x 23 cm
WEIGHTS	Instrument: 12.4 kg; Shipping: 28 kg



EM34-3

The EM34-3 is a simple-to-operate, cost-effective instrument for the geologist and hydrogeologist alike; applications have been particularly successful for the mapping of deeper groundwater contaminant plumes and for the exploration of potable groundwater resources.

Using the same inductive method as the EM31-MK2, the EM34-3 uses three intercoil spacings - 10, 20 and 40 m - to provide variable depths of exploration down to 60 metres. With three spacings and two dipole modes (horizontal as shown, and vertical), vertical electrical soundings can be obtained. In the vertical dipole (horizontal coplanar) mode, the EM34-3 is very sensitive to vertical geologic anomalies, and is widely used for groundwater exploration in 30 metres of fractured and faulted bedrock.

The EM34-3 includes connectors for an analog signal output, as well as an input which can be used with a rechargeable battery option. Digital signal output, required for data collection with the DL600 system, is available as an option for all modes of the EM34-3.

In regions of particularly high cultural and for atmospheric noise, the EM34-3XL - including increased transmitter power and a larger transmitter coil - improves the signal-to-noise ratio by a factor of 10 at the 40 m spacing, and by a factor of 4 at the 10 m and 20 m spacings.

Specifications

MEASURED QUANTITIES	Apparent conductivity in millisiemens per metre (mS/m)
PRIMARY FIELD SOURCE	Self-contained dipole transmitter
SENSOR	Self-contained dipole receiver
REFERENCE CABLE	Lightweight, 2 wire shielded cable
INTERCOIL SPACINGS	10 m at 6.4 kHz
OPERATING FREQUENCY	20 m at 1.6 kHz 40 m at 0.4 kHz
POWER SUPPLY	Transmitter: 8 disposable or rechargeable "D" cells Receiver: 8 disposable or rechargeable "C" cells
CONDUCTIVITY RANGES	10, 100, 1000 mS/m
MEASUREMENT RESOLUTION	± 0.1 % of full scale
MEASUREMENT ACCURACY	± 5 % at 20 mS/m
NOISE LEVELS	0.2 mS/m (can be greater in regions of high power line interference)
DIMENSIONS	Receiver Console: 19 x 13.5 x 26 cm Transmitter Console: 155 x 8 x 26 cm Receiver & Transmitter Coil: 63 cm diameter EM34-3XL Transmitter Coil: 100 cm Shipping Case: 27.5 x 75 x 75 cm
WEIGHTS	Instrument: 20.5 kg; XL: 26.5 kg Shipping: 43 kg; XL: 51 kg

GROUND CONDUCTIVITY METERS



EM38

Designed for relatively shallow applications - specifically within the agricultural root zone - the EM38 provides measurement of ground conductivity (quad-phase) and magnetic susceptibility (in-phase) within two effective depth ranges: 1.5 m in the vertical dipole mode (shown above); and 0.75 m in the horizontal dipole mode. Based on the same induction principle as the EM31-MK2, the EM38 can survey large areas quickly, without any requirement for ground-to-instrument contact.

For agricultural applications, measurement of ground conductivity is particularly useful in the mapping of variations in important soil properties such as salt and soil moisture content.

The EM38 has proven to be useful for many near-surface applications, including archaeology, wherein use can also be made of the information available in the measurement of soil magnetic susceptibility.

Very lightweight and only one metre long, the EM38 provides rapid surveys with excellent lateral resolution. Measurement is generally made by placing the instrument on the ground and recording the indicated reading; digital meters are located on the top and side of the EM38 for the horizontal and vertical dipole measurements. Continuous, or discreet measurements can be obtained from a standing position using the optional extender arm (shown above) with cable connection to a DL600 data logger. In this mode of operation, 3000 data points can be easily obtained in one hour.

For larger-area surveys, the EM38 can be easily mounted on a platform and towed behind a vehicle. Real-time (RT) data acquisition, with direct connection to computer-based acquisition systems, is available with an optional modification.

Specifications

MEASURED QUANTITIES	1: Apparent conductivity in millisiemens per metre (mS/m) 2: In-phase ratio of the secondary to primary magnetic field in parts per thousand (ppt)
PRIMARY FIELD SOURCE	Self-contained dipole transmitter
SENSOR	Self-contained dipole receiver
INTERCOIL SPACING	1 metre
OPERATING FREQUENCY	14.6 kHz
POWER SUPPLY	9 V battery
MEASURING RANGES	Conductivity: 100, 1000 mS/m In-phase: ± 29 ppt
MEASUREMENT RESOLUTION	± 0.1 % of full scale
MEASUREMENT ACCURACY	± 5 % at 30 mS/m
NOISE LEVELS	Conductivity: 0.5 mS/m; In-phase: 0.02 ppt
BATTERY LIFE	30 hours continuous
DIMENSIONS	Instrument: 106 x 15 x 3.6 cm Shipping Case: 117 x 19 x 13 cm
WEIGHTS	Instrument: 3 kg Shipping: 10 kg

EM38B



For any one measurement, the standard EM38 provides measurements of either quad-phase (conductivity) or in-phase (magnetic susceptibility) component data, as selected by the operator. Comparatively, the EM38B provides simultaneous measurement of both phase components, at all times. For surveys which include measurement of both components - common for archaeological investigations - the EM38B significantly reduces the amount of time required.

EM38-DD



The standard EM38 is operated in either the vertical or horizontal dipole mode at any given time. The EM38-DD provides simultaneous measurement of both dipoles at all times. The time required to complete any survey which includes the measurement of both dipole modes, therefore, is significantly reduced.



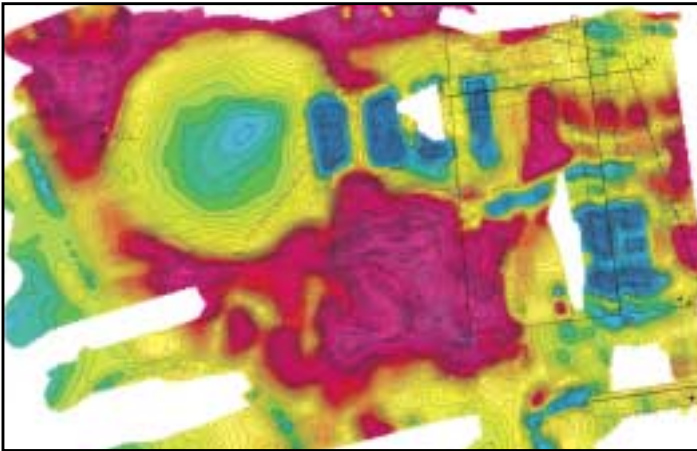
DL600 DIGITAL DATA LOGGER

The DL600 Data Acquisition Systems includes a rugged and weatherproof data logger, designed to support all Ground Conductivity Meters. (The DL600 system is only appropriate for those instruments with a real-time (RT) modification for digital signal output; the DL720 system remains available for instruments with analog signal output). A complete system includes a Polycorder data logger, interfacing cables, and DAT (for Windows) software for data transfer and reduction.

Data can be collected either discreetly, or "continuously" at a time interval selected by the operator. Recorded data is downloaded from the data logger directly to the DAT program which allows the user to edit, plot and print profiles of both the quad-phase (conductivity) and in-phase (susceptibility) responses. The data logger has a time-stamp option that makes the DAT data compatible with many common GPS file formats; GPS files can be merged with DAT files within the DAT program.

Specifications

DATA STORAGE	16,500 records (1-component); 10,000 records (2-components) (ext. memory available)
A/D RESOLUTION	16 bits
DIMENSIONS	20 x 10 x 5.3 cm
WEIGHTS	1.5 kg



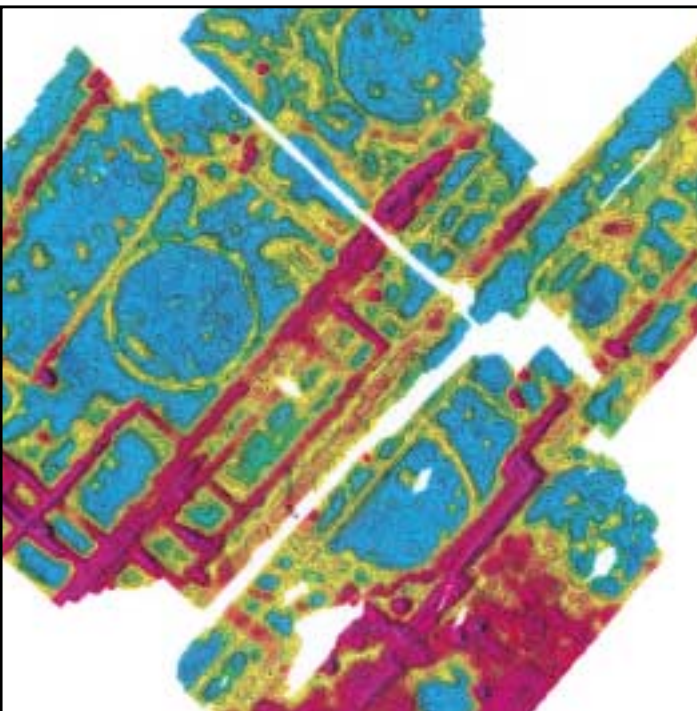
Geonics recommends any contour program which can generate both color image and shaded relief maps in addition to the standard isoline contour maps. The gridding algorithms should be best suited to line-based data of high density and high dynamic range. The following are two programs recommended by Geonics.

Surfer

Surfer is a grid-based contouring and three dimensional surface plotting graphics program produced by Golden Software, Inc that runs under Microsoft Windows, Windows 95/98 and Windows NT. Surfer interpolates your irregularly or regularly spaced XYZ data onto a regularly spaced grid, and places this data in a grid file. Surfer combines sophisticated gridding and data interpretation with a variety of presentation capabilities that allow the user to produce quick and customized maps.

OASIS montaj

OASIS montaj is a comprehensive PC-based earth science data processing software package for Windows 95/98 and NT platforms produced by Geosoft Inc. This program is ideally suited for line-based data of high density and dynamic range. Presentation formats include standard contour maps, color image maps and shaded relief maps. Any combination of formats can be merged into a single plot file for customized presentation. Plot files can be easily converted to AutoCad.DXF format for transfer to AutoCad facilities.



EM61-MK2

The EM61-MK2, an enhanced version of the patented EM61, is a time domain metal detector which detects both ferrous and non-ferrous objects with excellent spatial resolution. Target response is a single, sharply defined peak, facilitating quick and accurate location. A single 200 litre (55 gal.) drum can be detected at depths greater than three metres; modification for increased power, to increase both the sensitivity to smaller targets and depth of exploration is available.

Data from multiple time gates - three or four, user-selectable - are recorded to provide a more complete measurement of the response decay rate for improved target characterization (and discrimination). Early time gates improve the detection of smaller, as well as deeper targets; a mid-range time gate, at the same position as the original EM61, offers comparison with, and continuation of original EM61 data sets.

Data acquisition is supported by the PRO4000 field computer. Important features include real-time graphic display of data for review and quality control; high capacity data storage (min. 330,000 data sets) for extended survey time; increased rate of data collection; and additional input connections for simultaneous collection of EM and GPS data.

The system is immediately GPS compatible; a fully integrated Trimble AG114 - with no requirement for a separate GPS receiver console - is available as an option.

The system can be pulled as a trailer, in single or multiple unit configurations, or carried by an operator with a belt harness.

For applications in marine environments, the **EM61S** (Submersible) is capable of data collection to depths of 60 metres below the surface of water.

Specifications

MEASURED QUANTITIES	Four time gates of secondary response in mV
EM SOURCE	Air-cored coil, 1 x 0.5 m size
CURRENT WAVEFORM	Unipolar rectangular current with 25 % duty cycle
EM SENSORS	a) Main: Air-cored coil, 1 x 0.5 m in size, coincident with EM source b) Focusing: Air-cored coil, 1 x 0.5 m in size 30 cm above main coil
MEASURING RANGES	10,000 mV
DYNAMIC RANGE	18 bits
OUTPUT MONITORS	16-line graphic LCD with 24 characters per line, and audio tone
DATA STORAGE	330,000 data sets
POWER SUPPLY	12 V rechargeable battery for 4 h continuous operation
OPERATING WEIGHT & DIMENSIONS	Backpack: 60 x 30 x 20 cm; 8 kg Coil Assembly: 100 x 50 x 5 (bottom), 100 x 50 x 2 (top); 14 kg (23 kg in trailer mode)
SHIPPING WEIGHTS & DIMENSIONS	106 x 61 x 33 cm (box 1) 54 x 45 x 56 cm (box 2) with trailer option only 48 kg (74 kg with trailer)



EM61HH-MK2

EM61HH-MK2 is a "hand-held" complement to the EM61-MK2, providing greater sensitivity to smaller targets at shallow depths. A single 20 mm projectile can be detected to a depth greater than 0.5 metres. Comparatively, a single 200 litre (55 gal.) drum can be detected to depths of greater than two metres.

Data is collected from a single receiver at four time gates after transmitter turn-off. Information from four gates provides for the discrimination of targets based on the response decay rate; the early time data will detect both small and large targets with short and long decay rates respectively, while the late time data will detect only larger targets with relatively long response decay.

Calculation of the decay apparent time constant, proportional to the ratio between early and late time signal response, allows for the identification of targets with similar physical characteristics such as material, size and shape; inherently, information is provided for improved target discrimination.

An optional second receiver coil provides for the determination of "differential" data - to remove or reduce the effect of near-surface, non-target response - and an estimated depth to the target. GPS integration is available for either coil configuration.

With a narrower spatial focus than the standard EM61-MK2, the EM61HH-MK2 is relatively less sensitive to sources of potential interference. As a result, data can be collected in closer proximity to cultural features such as fences and buildings. Additionally, the narrower focus provides enhanced target resolution, and consequently improves discrimination of multiple targets.

The EM61HH-MK2 can be operated either with or without wheels. In either configuration, the smaller, more portable design offers improved access to areas of difficult terrain and dense vegetation.

Specifications

MEASURED QUANTITIES	Four time gates of secondary response in mV
EM SOURCE	Air-cored coil, 17 cm diameter
CURRENT WAVEFORM	Unipolar rectangular current with 25 % duty cycle
EM SENSOR	Air-cored coil, 17 cm diameter
MEASURING RANGES	10,000 mV
DYNAMIC RANGE	18 bits
OUTPUT MONITORS	16-line graphic LCD with 24 characters per line, and audio tone
DATA STORAGE	330,000 data sets
DATA OUTPUT	RS232 serial port
POWER SUPPLY	12 V rechargeable battery for 4 h continuous operation
OPERATING WEIGHT & DIMENSIONS	Backpack: 60 x 30 x 20 cm; 8 kg Sensor Assembly: 33 x 20 cm; 2.8 kg (7.5 kg with wheels)
SHIPPING WEIGHTS & DIMENSIONS	50 kg 117 x 50 x 54 cm



EM63

The EM63 Metal Detector advances the application of time domain electromagnetics (TDEM) methods to the detection of unexploded ordnance. Measurement of the full transient electromagnetic response offers improved detection capability and information on target characteristics.

Comparable to the EM61-MK2, the EM63 generates a pulsed primary magnetic field which induces eddy currents in nearby metallic objects. The decay of these eddy currents with time generates a secondary magnetic field with a specific rate of decay that is determined uniquely by the character - the size, shape, orientation and metal composition - of the object itself.

Measurement of the secondary magnetic field decay (the transient response), therefore, will provide important information toward: a more complete characterization and classification of the target; identification and rejection of the characteristic response from certain geologic materials (e.g. magnetite); and consequently, a reduction in target selection error (the "false positive rate").

The EM63 accurately measures the complete transient response over a wide dynamic range of time: measurements are recorded at 26 geometrically spaced gates, covering a time range from 180µs to 25ms. Data acquisition is supported by the PRO4000 field computer, with expanded 16 MB data storage capacity, which is able to simultaneously receive GPS data for location control.

Specifications

MEASURED QUANTITIES	26 time gates of secondary response in mV covering range from 180µs to 25 ms
EM SOURCE	Air-cored coil, 1 x 1 m size
CURRENT WAVEFORM	Bipolar rectangular current
EM SENSORS	a) Main: Air-cored coil, 0.5 x 0.5 m in size, coincident with EM source b) Focusing: Air-cored coil, 0.5 x 0.5 m in size 60 cm above main coil
MEASURING RANGES	10,000 mV
DYNAMIC RANGE	18 bits
OUTPUT MONITORS	16-line graphic LCD with 24 characters per line
DATA STORAGE	Solid state memory with capacity of 31,000 data sets
DATA OUTPUT	RS232 serial port
POWER SUPPLY	12 V rechargeable battery for 8 h continuous operation
OPERATING WEIGHT & DIMENSIONS	Sensor: 100 x 100 x 60 cm; 32 kg Console: 38 x 19 x 6 cm; 4.5 kg Battery: 23 x 21 x 14 cm; 10 kg
SHIPPING WEIGHTS & DIMENSIONS	104 x 104 x 22 cm (box 1); 60 kg 58 x 48 x 47 cm (box 2); 46 kg

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 3A 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 ampere square metres. With base frequency of 75 Hz, and 20 gates from 49µs 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



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 3,800W and 160V.

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 is 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 watts as compared to 2,800 watts 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 watts) 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 metres 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 is 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, 115 or 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

VLF RECEIVER / TRANSMITTER



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 ± 1° to ± 80° (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



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 MΩ in parallel with 0.5 pf
OPERATING FREQUENCY	15 to 30 kHz, depending on VLF broadcasting station
MEASUREMENT RANGES	EM16: In-phase: ±150 %; Quadrature: ±40 % EM16R: 300, 3000, 30000 Ω-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



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