

INSTRUMENT SYSTEMS FOR ELECTRICAL AND ELECTROMAGNETIC EXPLORATION

PHOTO BY NORMAN R. CARLSON



**ZONGE ENGINEERING &
RESEARCH ORGANIZATION, INC.**



INSTRUMENT SYSTEMS FOR ELECTRICAL AND ELECTRO-MAGNETIC EXPLORATION

Since its founding in 1972, Zonge Engineering & Research Organization (ZONGE) has specialized in the development and application of broadband electrical and electromagnetic methods for petroleum and mineral exploration, geothermal prospecting, and engineering site characterization. ZONGE was among the first to recognize the potential of the microprocessor-controlled receiver and, with the introduction of the GDP-12 multifunction receiver in 1977, was the first to commercialize this new technology. The ZONGE GDP-32^{II} receivers are arguably the most versatile electrical and EM receivers available in the world

today. These rugged one-man portable, multi-channel, battery-operated receivers can perform the following measurements with no change in either hardware or software: resistivity-phase IP (RPIP); time domain IP (TDIP); complex resistivity (CR); controlled-source AMT (CSAMT); time domain EM (TEM); and low-frequency and audio frequency magnetotellurics (MT/AMT). ZONGE also manufactures a complete line of supporting instruments and ancillary equipment required in systems used for the acquisition of most electrical resistivity and electromagnetic survey data.

PRODUCT LINE

MULTIFUNCTION RECEIVER: The GDP-32^{II} receiver performs broadband synchronous time- or frequency-domain measurements on both controlled source (i.e., signals generated by transmitting current into grounded dipoles or wire loops) and on natural fields (MT/AMT).

TRANSMITTERS: ZONGE manufactures a complete series of transmitters with power ratings ranging from milliwatts to 10s of kilowatts, and output currents ranging from 1 μ A to 45 A. All transmitters can transmit either frequency domain (100% duty cycle) or time domain (50%

duty cycle) waveforms. These transmitters are suitable for surveys ranging from laboratory-scale (e.g., cores) to deep mining, geothermal, or petroleum exploration.

MAGNETIC SENSORS: The TEM, CSAMT, AMT, and MT methods require the measurement of one or more components of the magnetic field (or its time derivative) as a function of frequency and/or time. ZONGE has designed sensitive permeable-core coils (induction magnetometers) specifically for making the required magnetic field measure-

ments associated with the aforementioned EM methods. These rugged and extremely compact coils represent the state-of-the-art in induction magnetometers for geophysical measurements of controlled and natural magnetic field signals.

ACCESSORY EQUIPMENT: ZONGE manufactures or supplies a variety of accessory equipment including wire reels, switches, multiplexers, and special cables.

DATA PROCESSING AND INTERPRETATION SOFTWARE: To support its instrument customers and its world-wide field operations, ZONGE has developed comprehensive software for the processing, display, modeling, and interpretation of electrical and electromagnetic data.





GDP-32^{II} **MULTIFUNCTION RECEIVER**

The ZONGE GDP-32^{II} multifunction receiver is the fourth generation GDP receiver and it plays a pivotal role in the ZONGE system of instrumentation. The new receiver is downward compatible with its predecessor, the GDP-32, retaining the same package design, analog

circuits, and timing circuits. Its new digital control and front panel assembly features a QWERTY keypad and a high-contrast sun-light readable 1/2 VGA monochrome LCD display both of which are compatible with common operating systems such as MS-DOS and Windows 95.

PERFORMANCE ADVANTAGES

MULTIFUNCTION CAPABILITY: The standard GDP-32^{II} has true multifunction measurement capabilities permitting it to perform as a multi-channel time- or frequency-domain receiver for the measurement of both controlled-source and natural electric and magnetic fields.

SYNCHRONOUS TIMING: An oven-stabilized precision quartz oscillator-driven clock, standard with the GDP-32^{II} receiver, maintains a ultra-stable timing reference with typical drift rates of less than 5 $\mu\text{s/hr}$ (~0.03 $\text{m}\mu\text{s/hr}$ phase drift at 1 Hz). Optionally, the oscillator can be disciplined with the Global Positioning Sys-

tem (GPS) to further reduce timing errors. An identical clock in a separate transmitter controller (XMT-32) can be synchronized with one or more GDP receivers and used to drive a transmitter thereby eliminating the need for hardwire connections to provide phase reference.

MULTI-CHANNEL ACQUISITION: The GDP-32^{II} can acquire data from up to 16 independent analog channels. Each input signal is preconditioned by a precision low-noise gain and filtering circuit after which it is sampled and converted to digital format by a dedicated 16-bit A/D. **Analog signals are not multiplexed**

through a single converter as is commonly done in many receivers.

ON-LINE SOFTWARE FOR DATA QUALITY CONTROL:

The programs controlling the GDP-32^{II} permit the operator to review the data either numerically or graphically while in the field. A standard error of the mean (SEM) is cal-

culated for every measurement. Apparent resistivity is calculated for commonly used antenna arrays for each of the acquisition programs. Time domain transient decay curves and frequency domain spectra may be viewed graphically. Graphic displays of several repeated measurements show error bars.

KEY FEATURES

- Rugged, one-man portable, and environmentally sealed.
- 40 MHz 486DX MPU (Optional 75 MHz and 100 MHz processors available).
- PC-104 expansion buss permits the installation of easily available OEM board-level products.
- Ultra-stable quartz oscillator-based timing reference (aging rate < 5x10-10/24 hr) with optional GPS discipline when better stability is required.
- Broadband TD or FD operation (.001 - f - 8192 Hz).
- Multifunction capability (Resistivity, TD/FD IP, CR, CSAMT, Harmonic Analysis CSAMT, MT/AMT, and TEM/NanoTEM. Other acquisition programs available.)
- High-capacity mass storage (> 1 GB) available as an option for waveform recording.
- Ethernet (10 BaseT) LAN interface facilitates high-speed (0.5 to 1.2 MB/sec) data transfer.
- Remote operation through modem or direct wire serial port.
- Multi-channel operation (16 channels max) with dedicated A/D for each channel.
- Precision internal calibration source with supporting calibration software facilitates data quality checks, and removal of system response.
- Automatic gain ranging, and SP buckout.





TRANSMITTERS

ZONGE manufactures a complete line of transmitters for applications ranging from the laboratory to mining and geothermal exploration

MOTOR-GENERATOR DRIVEN TRANSMITTERS (GGT SERIES)

The GGT series transmitters provide a broad range of rated output power. Primary power for these transmitters is 208 3-phase 400 Hz Vac. Both the transmitter and the required motor-generator are significantly smaller and more portable than they would otherwise be if powered by 50/60Hz 3-phase AC power. The higher primary frequency (400 Hz) also results in current waveforms that are free of AC noise ripple below 2400 Hz. GGT series transmitters include features important for operational safety including automatic shutdown when load circuit is broken and a two-step RESET-TRANSMIT switch to prevent accidental transmission. A multifunction digital panel meter measures output power, output current, internal temperature, and current shut-off time. Three GGT Transmitters with different output power ratings are manufactured: GGT-3 (3 KVA); GGT-

10 (10 KVA); and GGT-30 (30 KVA). Motor-generators with appropriate output power levels are available for each of the GGT transmitters.

KEY-FEATURES:

- Dual-function resistivity or EM transmitter (i.e., grounded dipole or loop antennas)
- Broadband frequency range (DC to 10 kHz)
- Constant-current supply with regulation to $\pm 0.2\%$ at a maximum output voltage of 1000 Vdc
- Frequency or time domain operation
- Fast shutoff times ($\sim 10 \mu\text{s}$ into resistive load; $125 \mu\text{s}$ into 300m x 300m loop)
- Automatic fault detection and shutdown circuits
- Current shutoff time measurement (Important for TEM)

1) A version of the ZT-30 with primary DC power voltages as high as 400 Vdc is under development.

2) A 400 watt DC-DC power converter (DCPS400) with current-regulated output (400 VA output power) is available. When used as the source of primary power for the ZT-30, the two units together constitute a 400 watt battery-powered current-regulated resistivity/IP transmitter suitable for small-scale precision resistivity/IP measurements. Where AC is available, the DCPS400 can be configured so that it will operate from a universal AC source (i.e., 85-264 VAC, 47-440 Hz)

BATTERY-POWERED TRANSMITTERS

ZONGE manufactures three transmitters that use DC power (e.g., storage batteries) as the primary power source. Two of the transmitters (NT-20; ZT-30) were developed specifically as TEM transmitters. A third transmitter, the LDT-10, is designed for small-scale resistivity/IP measurements in drill holes and on core samples.

ZT-30 ZeroTEM TRANSMITTER: Operating from a DC power source (24-120 Vdc),¹ the ZT-30 can switch currents as high as 30 A into inductive or resistive loads. Two or more 12 Vdc automotive batteries connected in series provide DC power when the ZT-30 is used as a TEM transmitter. The ZT-30 is also being used as a low-power resistivity/IP transmitters for applications where precision current regulation is not required (e.g., time domain IP) or when the current waveform can be directly measured (e.g., reference IP, CR, ERT, etc).² The ZT-30 transmitter is small and easily transportable by one person. It is most appropriate for use in TEM surveys where the targets of interest are less than 500 m.

NT-20 NanoTEM TRANSMITTER: When equipped with optional NanoTEM analog acquisition cards, the GDP-32^{II} can measure TEM transients at time delays as short as $\sim 1 \mu\text{s}$ after current shutoff. When used together with a fast shutoff TEM transmitter, these early time TEM measurements provide information about the subsurface for depths less than 100 m. The NT-20 supplies up to 3 A into small loops (5-100 m) while achieving the rapid current turnoff (e.g., $1.5 \mu\text{s}$ into a 20 m loop) required for NanoTEM measurements. The NT-20 is a dual mode TEM transmitter. When operating in its slow turnoff mode (ZeroTEM mode), it can supply up to 20 A into larger loops.

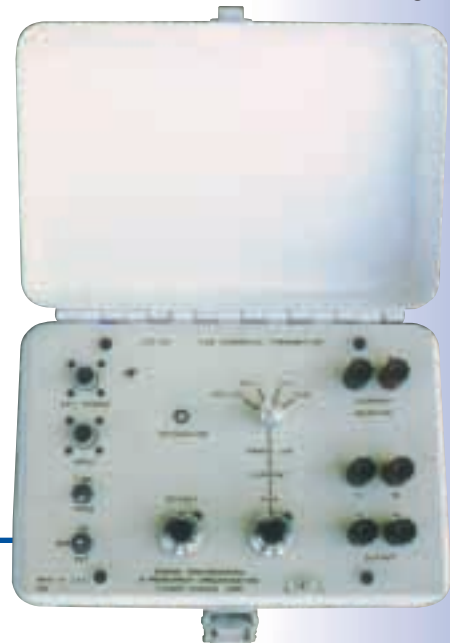


NT-20

LDT-10 LABORATORY TRANSMITTER:

The LDT-10 operates with 12 Vdc power and, depending on the load resistance, can provide precision current-regulated frequency domain or time domain waveforms with amplitudes ranging from $1 \mu\text{A}$ to 10 mA. The transmitter is ideal for resistivity/IP measurements on drill core and for use in connection with drill hole logging.

LDT-10



ZT-30



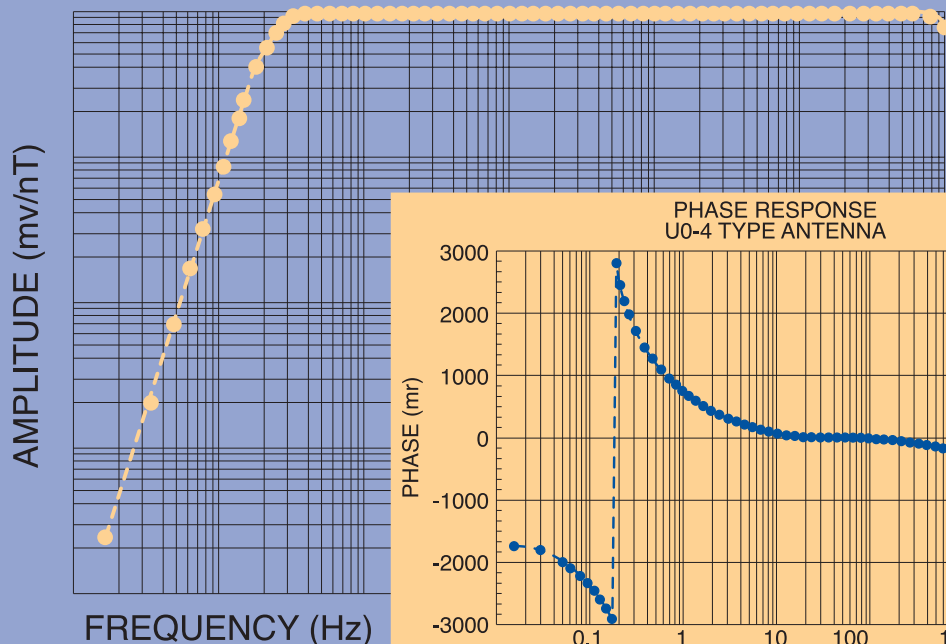
ACCESSORIES

Regardless of the particular method employed, electrical and EM surveys require considerable accessory equipment to facilitate efficient data production. ZONGE manufactures a broad line of the accessories necessary to properly equip a field operation. Many of these accessories have been developed as the result of 25 years of accumulated field experience in applying electrical and EM methods to mining, petroleum, geothermal, groundwater, and engineering problems, and they are simply not available from any other source. Accessories include:

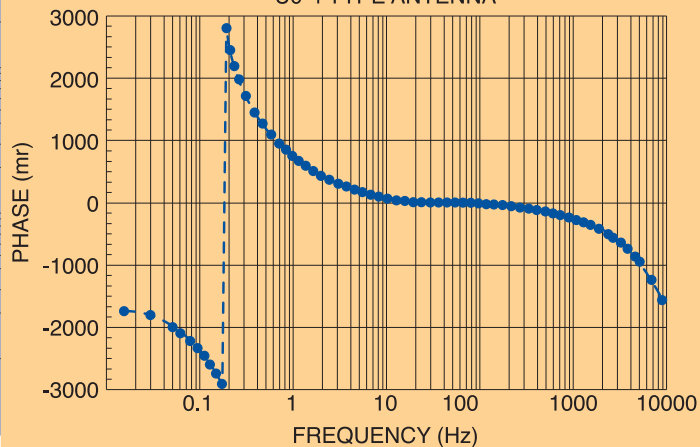
WIRE REELS: Light-weight breast reels (manual) and heavy-duty power reels for transmitter and receiver wire.

ANCILLARY EQUIPMENT: Resistor load banks, isolation amplifiers, electrode switch boxes and multiplexers (manual & computer controlled), active electrode amplifiers.

AMPLITUDE RESPONSE
U0-4 TYPE ANTENNA



PHASE RESPONSE
U0-4 TYPE ANTENNA



MAGNETIC SENSORS

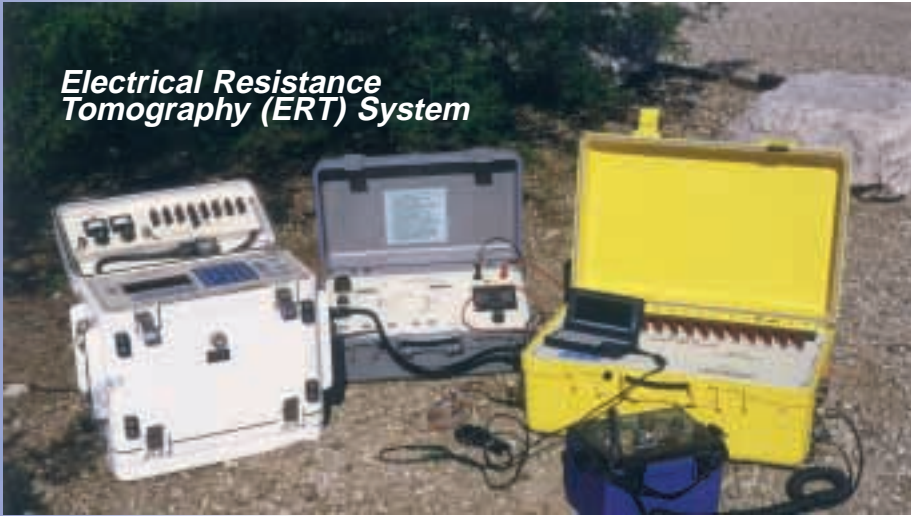
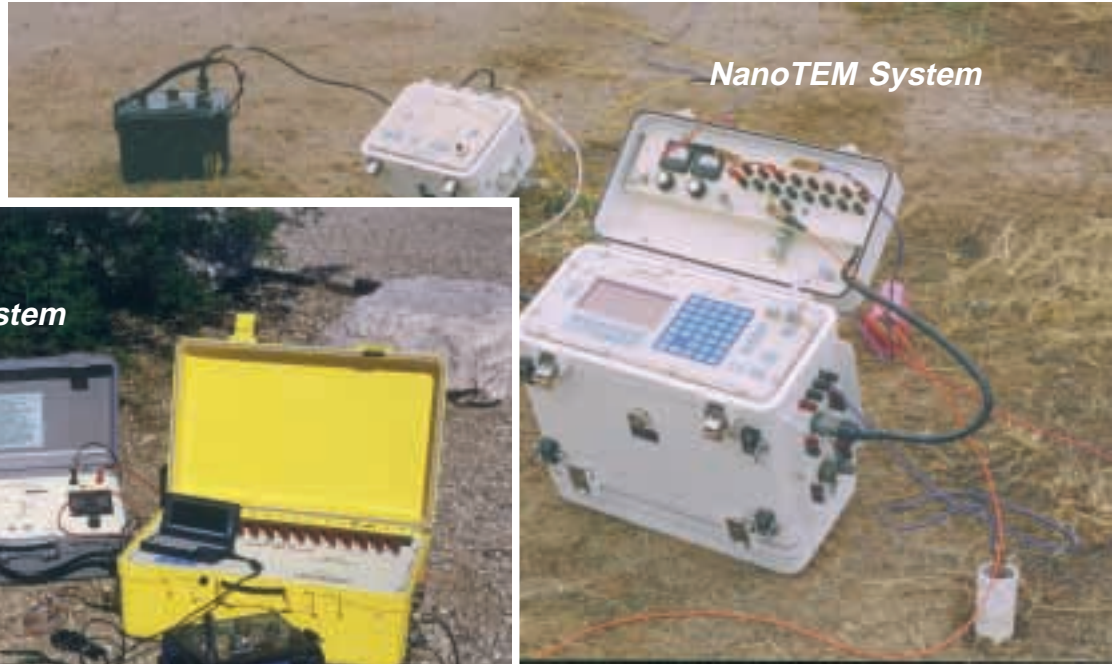
With the advent of high dynamic range receivers, such as the GDP-32^{II}, the importance of high quality magnetic field sensors has increased. ZONGE manufactures a complete range of induction coil based magnetic field detectors, each tailored to the requirements of a particular application. Low-noise, low-power,

and thermal stability are important design objectives in magnetic sensors for geophysical exploration. The ZONGE sensors meet these objectives. The magnetic sensors we manufacture and their corresponding application are listed in the table:

MAGNETIC SENSORS

SENSOR	APPLICATION	FREQUENCY RANGE	REMARKS
ANT-3	CSAMT/AMT	$0.1 \leq f \leq 20$ kHz	H-field response; 100 mv/nT
ANT-4	MT	$0.0005 \leq f \leq 1.5$ kHz	H-field response; 100 mv/nT
U0-4	CSAMT	$1 \leq f \leq 20$ kHz	H-field response; 100 mv/nT
TEM-3	TEM	$f_0 > 20$ kHz	dB/dt response $A_e = 10,000$ m ²

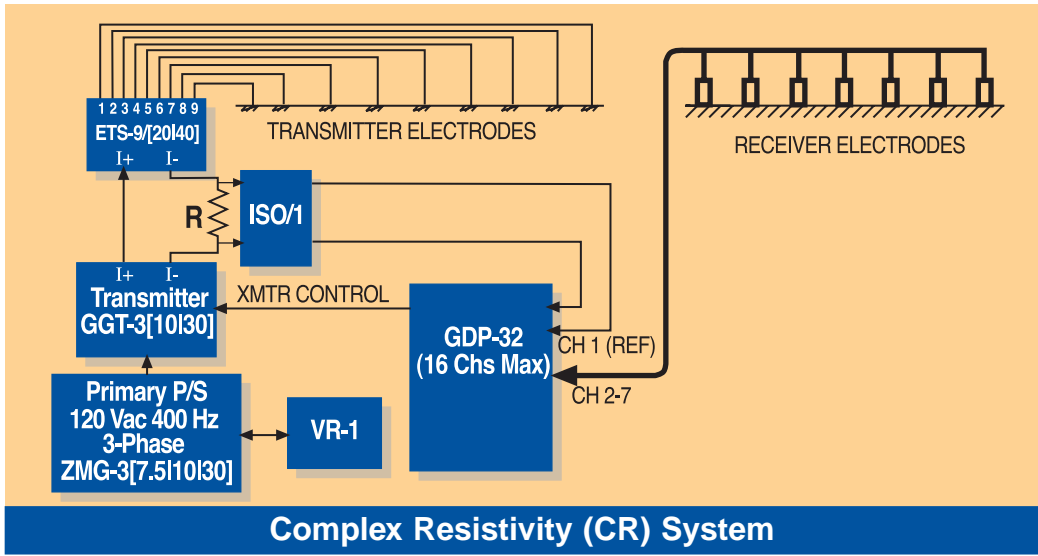




A SINGLE RECEIVER HANDLES ROUTINE AND SPECIAL SURVEYS

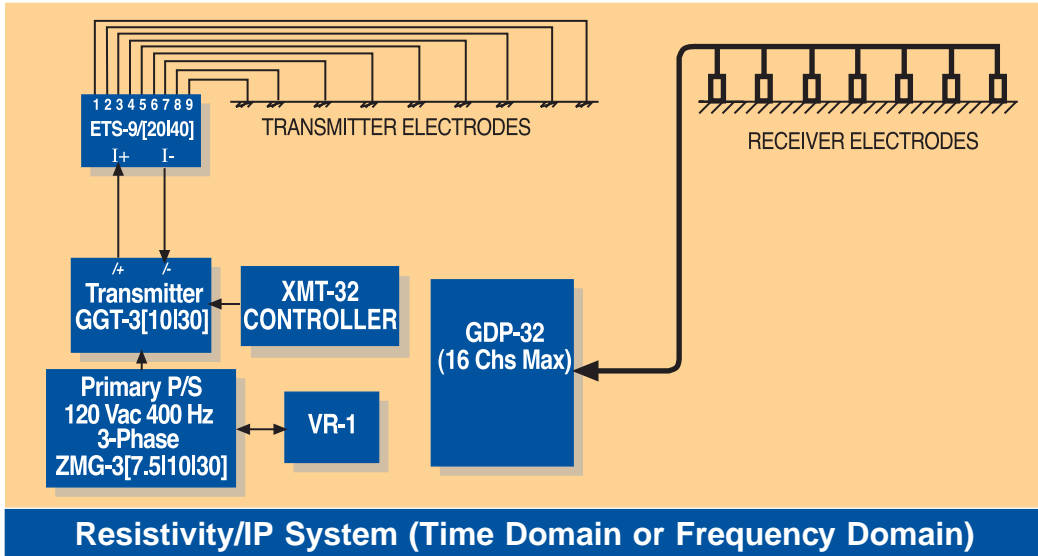
ZONGE has adapted its instrument systems to conduct electrical and EM surveys for a wide range of engineering, environmental, and research applications. A hallmark of the ZONGE GDP receiver, indeed perhaps its most significant feature, is its multi-function capability. When paired with an appropriate transmitter, the

receiver is applicable to a variety of survey methods. Moreover, the functionality of the GDP receiver is constantly being expanded with special purpose measuring software. Illustrated on succeeding pages are block diagrams showing GDP-32^{II} instrument systems configured for different types of electrical or EM surveys.



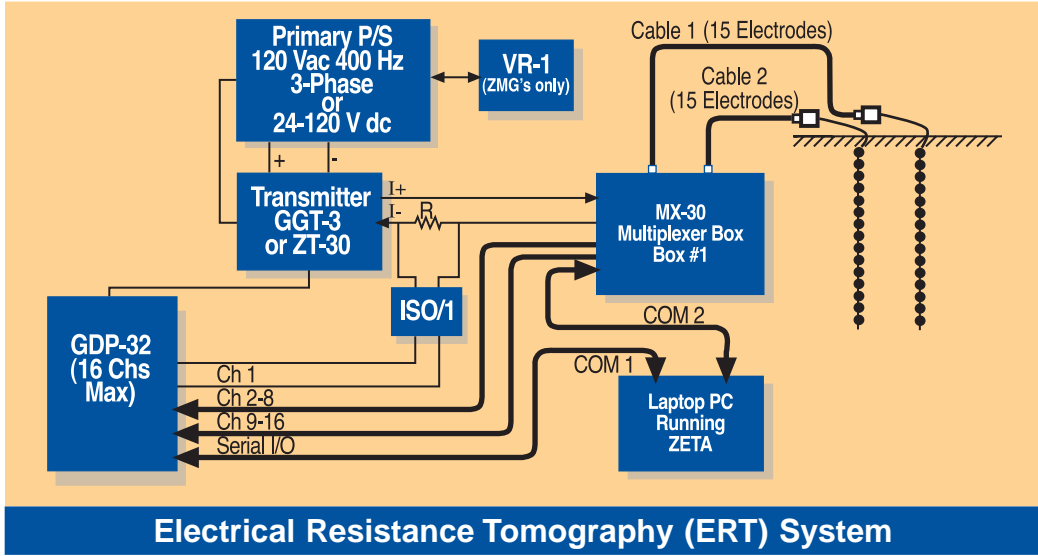
CR APPLICATIONS

- Mining Exploration
- Petroleum Exploration
- IP Source Determination



RP/IP/TDIP APPLICATIONS

- Mining Exploration
- Engineering Site Investigation
- Hazardous Waste Site Characterization
- Groundwater Exploration
- Petroleum Exploration

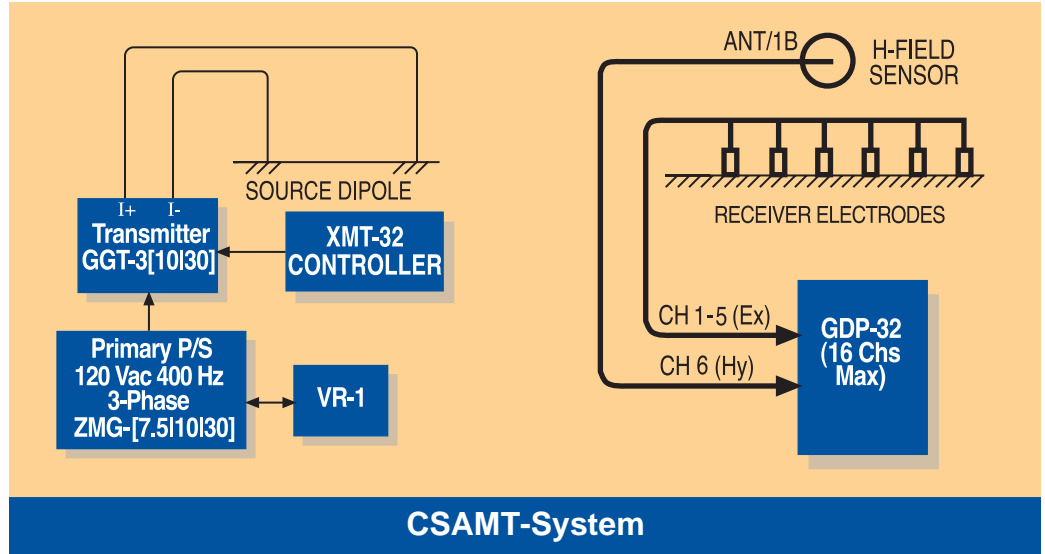


ERT APPLICATIONS

- Plume Migration
- In Situ Leaching
- Heap Leach Monitoring
- Secondary Recovery (petroleum)
- Site Remediation
- Tank Monitoring

CSAMT APPLICATIONS

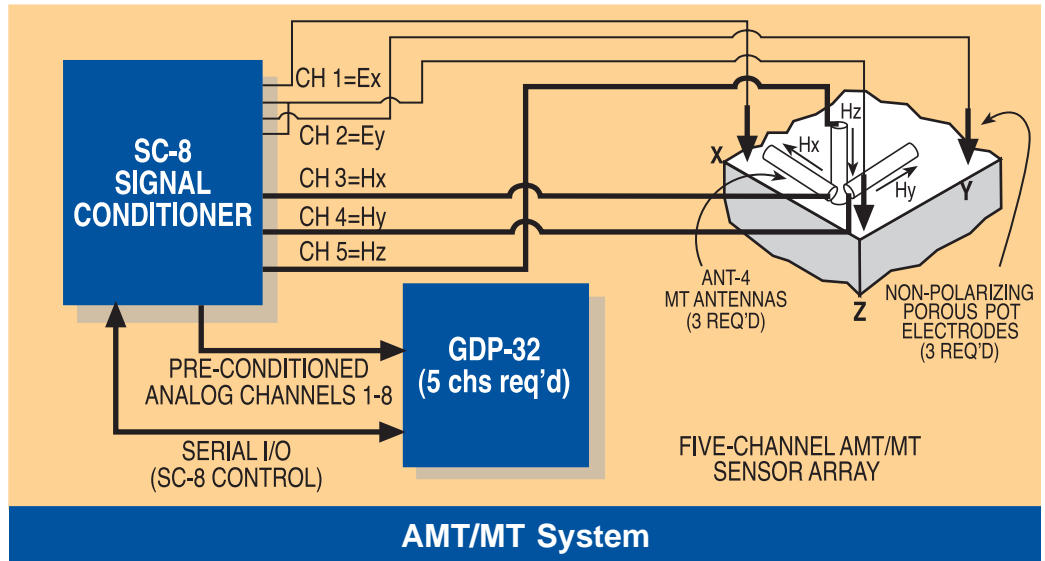
- Mining Exploration
- Petroleum Exploration
- In Situ Leaching
- Heap Leach Monitoring
- Geothermal Exploration
- Groundwater Exploration



CSAMT-System

AMT/MT APPLICATIONS

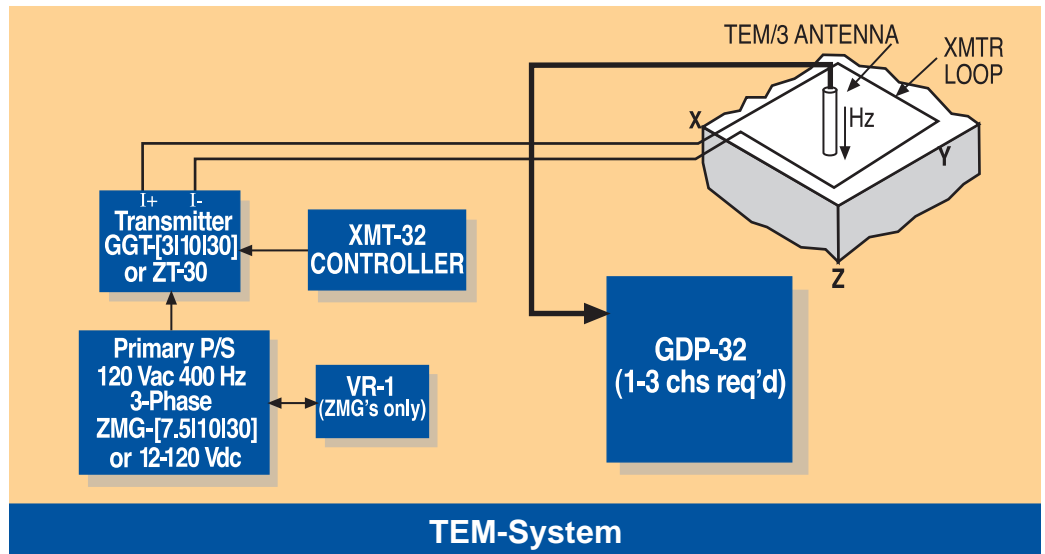
- Mining Exploration
- Petroleum Exploration
- Geothermal Exploration



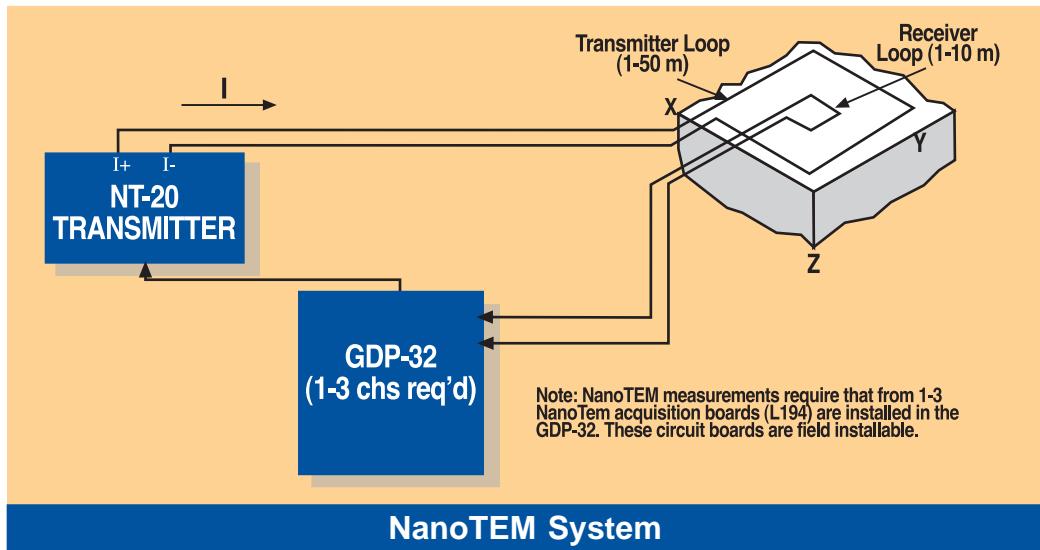
AMT/MT System

TEM APPLICATIONS

- Mining Exploration
- Geothermal Exploration
- Static Corrections for MT/AMT

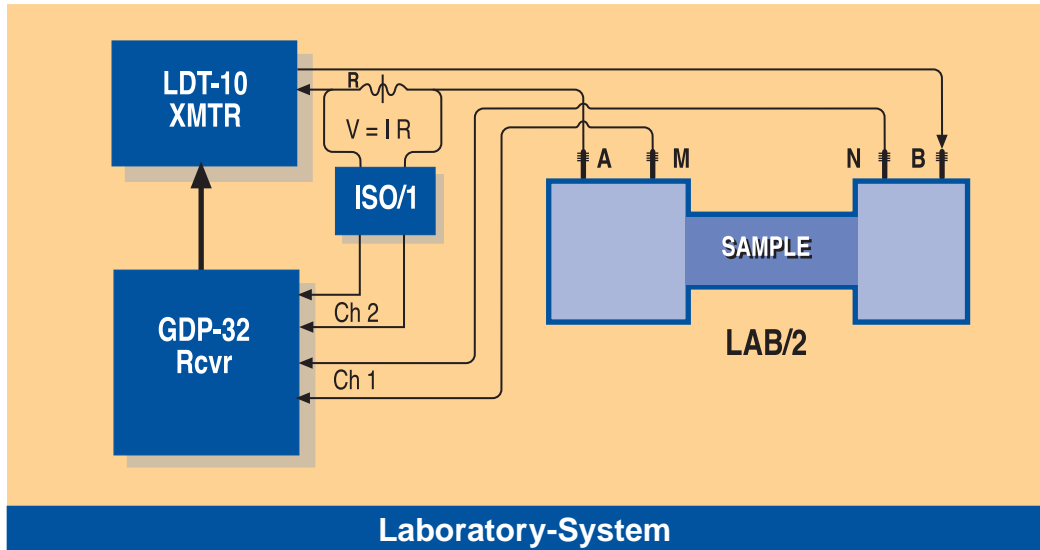


TEM-System



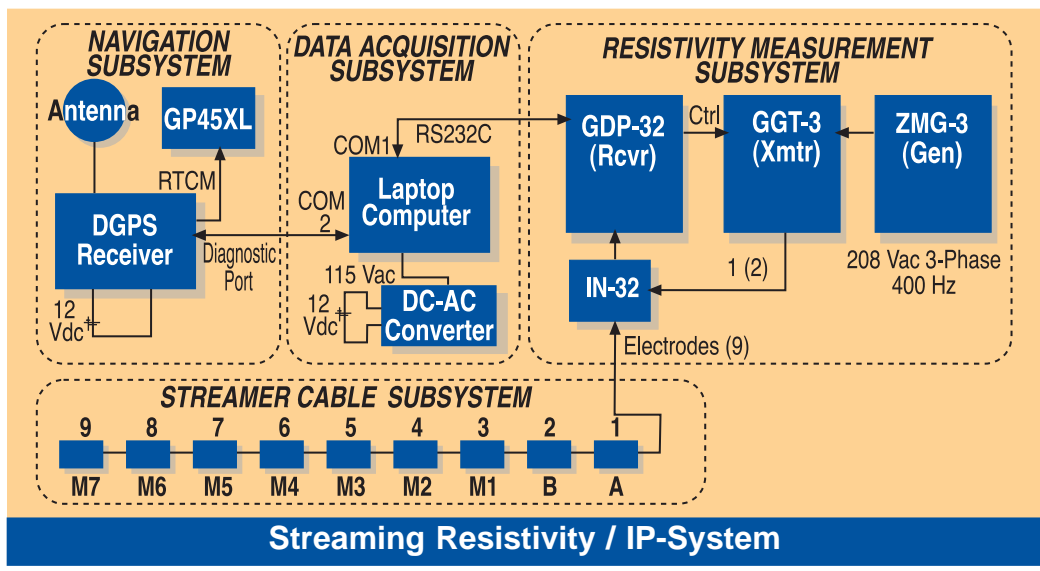
NanoTEM APPLICATIONS

- Waste Site Characterization
- Shallow Groundwater Exploration
- UXO-Detection
- Engineering Site Investigation
- Acid Mine Drainage
- Void Detection
- Metal Detection
- Underground Tank Detection



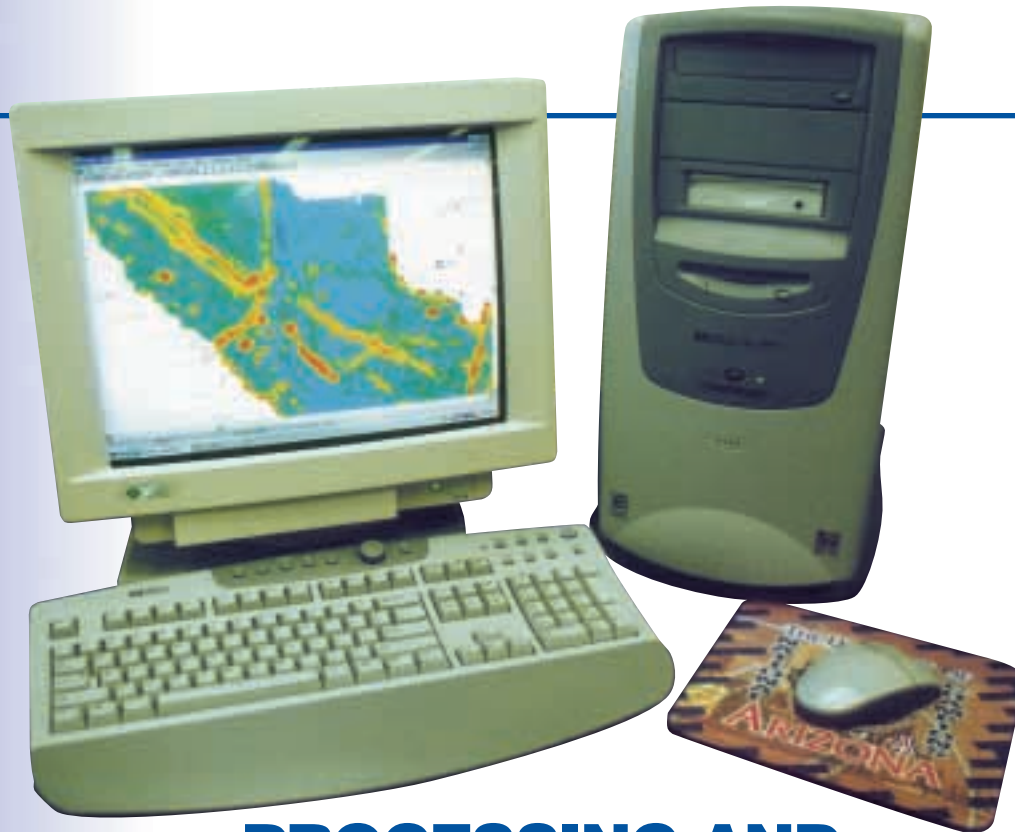
LABORATORY APPLICATIONS

- Electrical Properties
- Scale Modeling



STREAMING RESISTIVITY/ IP APPLICATIONS

- River/Lake Bottom Surveys
- Petroleum Exploration



PROCESSING AND INTERPRETATION SOFTWARE

During the course of processing real-world electrical and EM field data over a 25-year period, ZONGE has developed a comprehensive set of programs for the processing, display, and interpretation of field data for the many survey methods that ZONGE instrument systems routinely perform. Key features of ZONGE software are:

- **data processing and display software** for all survey types and options that allow you to generate the results you want.
- **DatProWin**, a Windows 95/NT based program that integrates the editing, processing, and display functions that heretofore were accomplished with

text-based editors and a series of DOS based programs.

- **modeling and interpretation programs** that use robust smooth-model inversion.

The following basic software is furnished at no charge with purchase of a GDP-32^{II} receiver:

- QC, averaging, and display programs for CSAMT, Harmonic CSAMT, RPIP, TDIP, CR, and TEM
- **DatProWin**
- Utilities

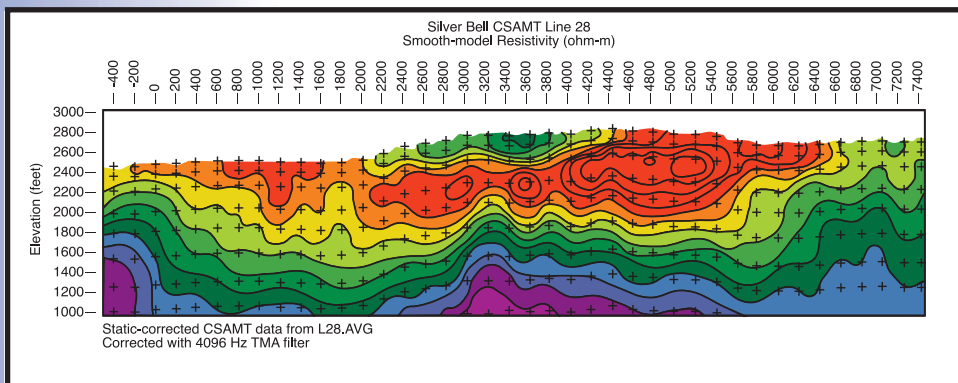
The following software is available for purchase:

- Modeling and interpretation programs

Upgrades from *DatPro3* to *DatProWin*.

Additional licenses for *DatPro*, *DatProWin*, and modeling programs.

3) *DatPro* is the name of a series of MS-DOS based data processing programs that has been replaced by the Windows 95/NT based program *DatPro Win*





SERVICES

ZONGE provides a broad range of services beyond the manufacture of instruments. These include:

FIELD SERVICES: The company was founded as a geophysical service company specializing in electrical and electromagnetic surveys for the mining industry. Field services and data interpretation remain an essential part of the company's business.

TRAINING: Training courses in all aspects of field data acquisition, data processing, and interpretation are available at our Tucson office or at the customer's site.

CONSULTING: With 26-years of experience in providing field services and data

interpretation of electrical and EM data for mining, petroleum, and engineering applications, ZONGE can provide consulting services relating to development and conduct of exploration or site characterization programs.

PETROPHYSICS LABORATORY: ZONGE maintains a small petrophysics laboratory for measuring electrical and magnetic properties of cores and grab samples. Physical properties routinely measured in our laboratory include: bulk resistivity/IP (frequency domain or time domain), complex resistivity, magnetic susceptibility, remnant magnetism, wet/dry bulk density and porosity.



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