

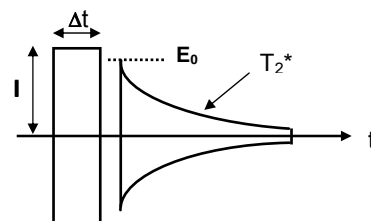
# NUMIS<sup>Plus</sup>

**MAGNETIC RESONANCE SOUNDING SYSTEM FOR *DIRECT DETECTION OF GROUNDWATER* DOWN TO 150 m DEPTH**

water content  
permeability estimate  
depth of water layers

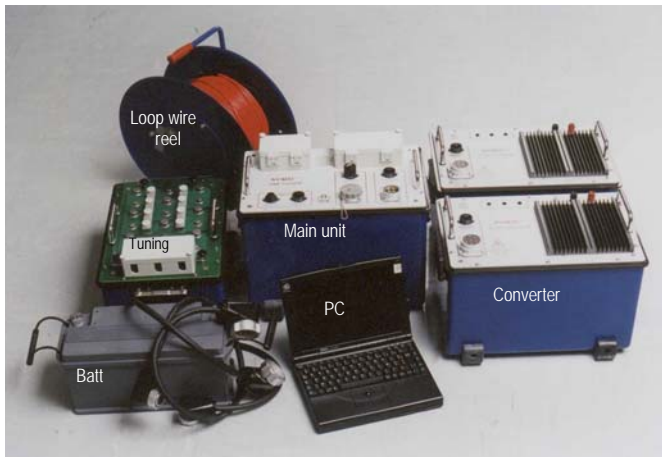
## GROUNDWATER RESOURCES EVALUATION:

Determination of water level and quantity  
Lateral extension of an aquifer layer  
Selection of the best place to drill  
Prediction of yield, after calibration



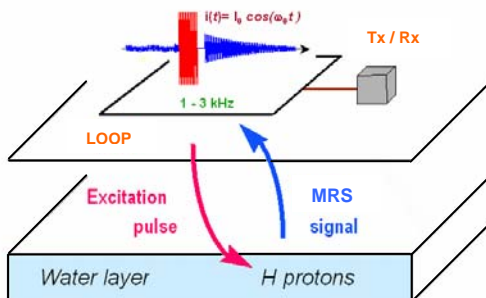
$E_0$ : Initial amplitude of signal (nV)  
Proportional to the **water content** (%)  
 $T_2^*$ : Decay time constant of signal (ms)  
Related to the **mean pore size** (permeability)  
 $I \cdot \Delta t$ : Excitation pulse moment (A.ms)  
Related to the **investigation depth** (m)

# MAGNETIC RESONANCE SOUNDING SYSTEM



NUMIS<sup>PLUS</sup> is a modular MRS equipment consisting of :

- a transmitter-receiver unit for pulse generation and signal measurement,
- a PC computer for the control of the whole system, and for data processing and interpretation,
- two converter units powered by two 12 V batteries,
- two tuning units for optimizing the excitation energy,
- a wire loop used as a transmitting and a receiving coil.



### The Magnetic Resonance Sounding method (MRS):

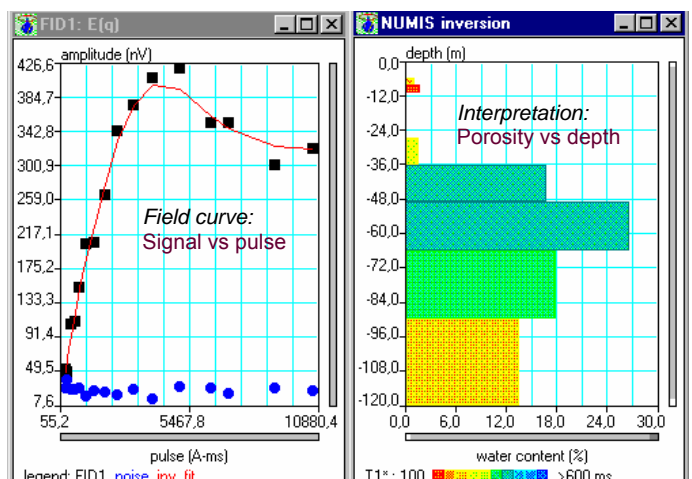
The MRS is the only **non-invasive** method which directly studies groundwater reservoirs from surface measurements:

**A pulse of current**, at a given frequency, is transmitted into a loop.

**The signal produced** in return by the H protons (water molecules) is measured within the same loop.

### How to carry out a Magnetic Resonance Sounding ?

- 1- Measure the Earth magnetic field to know the frequency to apply
- 2- Transmit a pulse of current into a loop, at this frequency
- 3- Measure the amplitude of the water MR signal ( $\approx$  porosity)
- 4- Measure the time constant of the signal ( $\approx$  mean pore size)
- 5- Change the pulse intensity to modify the depth of investigation
- 6- Use the inversion program to get the porosity versus the depth

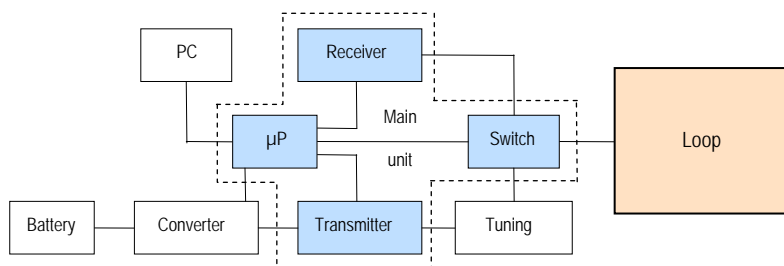


# NUMIS<sup>PLUS</sup> MRS equipment

## NUMIS<sup>PLUS</sup> MAIN FEATURES

- NUMIS<sup>PLUS</sup> is a modular MRS equipment designed to allow measurements at remote locations, as each component of the system weighs 25 kg or less, making it one man portable.
- **The Tx / Rx unit** is the core of the system. It ensures the production of the energizing pulses at the Larmor frequency, also the measurement of the MRS response with filtering, amplification and analog to digital conversion.
- **The PC computer** receives raw data, then processes, displays and stores them for further interpretation.
- **The two DC / DC converter units** are required for a maximum investigation depth of 150 m), to energize the 150 m side square loop (600 m total length). However, if an investigation of 100 m is sufficient, one converter unit only is required with a 100 m side square loop (400 m total length).  
With one only converter, just the *transverse time constant* ( $T_2^*$ ) is measured, while with two converters, the transverse and the *longitudinal* ( $T_1$ ) *time constants* are measured;  $T_1$  offers a better estimation of the permeability than  $T_2^*$
- **The two tuning units** must be used at lower magnetic latitudes (for an Earth's field lower than 31 000 nT with the 150 m side square loop, or 37 000 nT with the 100 m side square loop), while one tuning unit only is needed at medium and higher latitudes.

### NUMIS Plus SCHEMATIC DIAGRAM



### NUMIS Plus CONFIGURATIONS

Investigation depth	Number of DC/DC converters	Loop dimensions
100 m	one	100x100 m
150 m	two	150x150 m



## NUMIS<sup>PLUS</sup>

### TECHNICAL SPECIFICATIONS

#### DC/DC CONVERTER UNIT

- Power supply: two 12 V batteries (65 Ah each)
- 6 to 8 hours reading autonomy
- Capacitance: 0.07F
- Outputs:  $\pm 430$  V DC; 0.5 A
- Two converters may be used in parallel.
- Dimensions: 43 x 30 x 43 cm; weight: 24 kg

#### Tx / Rx MAIN UNIT

- Dimensions: 43 x 30 x 43 cm; weight: 24 kg

#### TRANSMITTER SPECIFICATIONS

- Supplied by one or two DC/DC converters
- Frequency range: 0.8 to 3 kHz
- Maximum outputs: 4000 V, 450 A
- Pulse amplitude and duration: programmable
- Pulse moment: 100 to 18000 A.ms (loop and frequency dependant) for 40 ms standard pulse duration

#### RECEIVER SPECIFICATIONS

- Band pass filter width: 100 Hz
- Programmable gain:  $10^4$  to  $10^6$
- Noise: less than 10 nV / sqrt(Hz)
- A/D converter: 14 bits
- Sampling frequency: four times the Larmor frequency
- Calibration procedure for phase reference
- Measurement of  $T_2^*$  (with one converter) and of  $T_2^*$  and  $T_1$  (with two converters)

#### TUNING UNIT

- Tuning of the loop to the Larmor precession frequency by capacitors
- Capacitance of 6 to 30  $\mu$ F with one tuning unit and up to 60  $\mu$ F with two tuning units.
- Dimensions: 43 x 30 x 34 cm; weight: 20 kg

#### TRANSMITTING / RECEIVING LOOP

- Reels of 100 m wire, 10 mm<sup>2</sup> section
- Six reels for 150 m investigation: impedance 1.0 ohm, 1.2 mH
- Four reels for 100 m investigation: impedance 0.7 ohm, 0.8 mH
- Other loop configuration on request

#### PC COMPUTER

- Control of the whole system: converter, transmitter, receiver
- Data processing: DFT and weighted stacking
- Data interpretation: 1D inversion

### SQUARE (standard) and EIGHT (noise reduction) loop shapes for MRS soundings

