Introduction to TEM

Overview

The transient electromagnetic (TEM) method is a commonly-used, surface-based geophysical technique that provides information on the electrical resistivity of the subsurface.

A transmitter, typically a loop of wire laid on the ground, is driven by a time-varying current. The change in current and the resulting EM field establish an image current within the earth equal in magnitude, but opposite in polarity, to that of the transmitter. This image current then interacts with conductive materials in the earth below creating secondary magnetic fields that are measured at the receiver site.

The depth of exploration attained can vary from 10s of meters to over 1000 meters, depending upon transmitter loop size, available power from the transmitter, and ambient noise levels.

TEM is frequently used in exploration for groundwater and geothermal sources, for mapping lithology and contaminant migration, and for several engineering applications including depth to bedrock. TEM is also the preferred method for locating buried metal objects such as abandoned wells, pipelines, UST (underground storage tanks) and UXO.

The transient electromagnetic (TEM) method is alternately known as time-domain EM (TDEM). It can be used for vertical depth sounding at depths greater than 10 km as well as metal detection less than 5 meters from the surface.
**Field Logistics**

TEM equipment consists of a transmitter and receiver, which may be in separate enclosure boxes with an external power source for the transmitter or contained in a single box.

Field logistics vary depending upon the target, but all configurations are non-intrusive and low-impact. For large scale (deep sounding) TEM surveys a typical field crew consists of three or four people, with one pick-up truck at the transmitter site and one at the receiver site. At the receiver site, the equipment can be carried by backpack, and no off-road driving is needed. Shallow surveys using a fast-turn-off system require one to three people and all of the equipment is backpack portable.

Depending upon the target, the set-up of the equipment system varies greatly from large loops on the ground, to cart-mounted systems or boat-towed arrays. When not self-contained in a cart-mount or towed system, the transmitter consists of a thin, insulated surface wire laid out along the ground. Vehicle access along the length of the transmitter is not needed.

Four basic TEM configurations:

a) vertical sounding mode, in this image an in-loop configuration;

b) moving-loop or slingram profiling configuration;

c) profiling mode using a fixed-loop configuration;

d) down-hole measurements using a surface transmitter loop and a drill-hole receiver probe.

*Cart-mounted dynamic NanoTEM® (continuous, fast turn-off) survey*
Measured Fields

The TEM method is based on transmitting a time-domain, square-wave signal into a large, ungrounded wire loop and then interrupting the current as fast as possible causing a rapid change in the magnetic field. This induces eddy currents in nearby conducting materials, producing small secondary magnetic fields that are measured by observing the induced voltages in receiver loops. Induced currents decay quickly in poor conductors (moderate resistivity) and will decay slowly in good conductors (very low resistivity). Very poor conductors (high resistivity) will not sustain any measurable induced currents.

The response from the transmitted signal after turn off time can be represented as current filaments propagating outward and downward with time.

Inversion Models

Smooth-model inversion is a method of converting TEM measurements to profiles of resistivity versus depth. The resulting estimated resistivity values are depicted as varying smoothly with depth. Lateral variation is determined by inverting successive stations along a survey line. Results for a complete line are presented in cross section form by contouring the modeled resistivities.
Final Product

The results of processing and modeling TEM data may be presented as: modeled cross sections, plan-view plots of the survey area at a given time window or windows (time along the decay curve) in the data, and fence diagrams. Interpretation is given to help in identifying the mapped changes within the subsurface.

Reference


For more information, see [www.zonge.com/geophysical-methods/](http://www.zonge.com/geophysical-methods/)