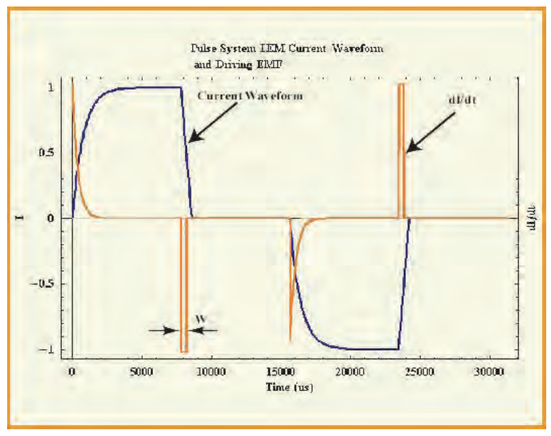
NanoTEM - A System for Fast Multi-Channel TEM Data Acquisition

What is "Fast" TEM?

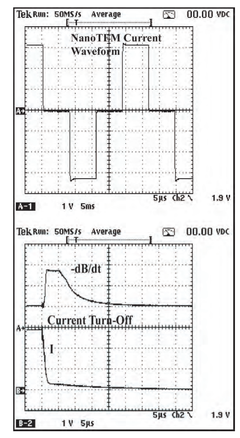
TEM systems measure a voltage related to the time rate of change of the secondary magnetic field at one or more time-gates after the transmitter current has been shut off. The term Fast TEM is a comparative term suggesting that time gates for transient measurements are earlier (hence faster) than those in conventional TEM measurements. The Zonge NanoTEM system can measure transients at times as early as 1 usec after cessation of the transmitter current, much earlier than competing systems. But the capability to measure transients at early times is only part of a fast TEM system. It is also necessary to generate secondary transients containing information at early times.

Fast Transmitter Shut-Off - We illustrate an ideal NanoTEM transmitter waveform in a figure on the right. The top figure on the far right is an oscilloscope trace of the current waveform for one of our NT-32 NanoTEM transmitters driving a 1-m (8T) loop. The current turn-off approximates a linear decay of current with time (blue curve). The time derivative of the magnetic induction field B (primary field) drives electromagnetic induction. The bottom figure shows the current waveform (lower trace) at a greatly expanded time scale (5 us/div). Also shown in the figure is the voltage output from one of the receiver coils (upper trace). The NanoTEM system for this particular antenna set measures the transient starting at approximately 11.8 usec after the initiation of current turn-off.

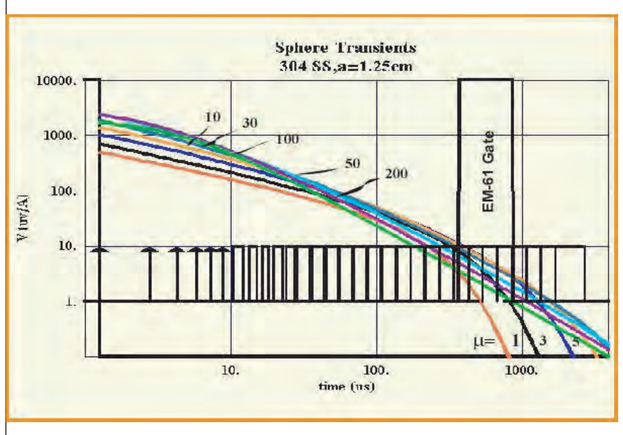
High-Speed Data Acquisition - The TEM receiver requires a bandwidth corresponding to that of the secondary transients generated by the transmitter. The NanoTEM transmitter generates transients with a bandwidth of several hundred KHz. The NanoTEM receiver consists of 3 high-speed digital acquisition channels each with a bandwidth of 400 KHz (800 kSamples/sec).



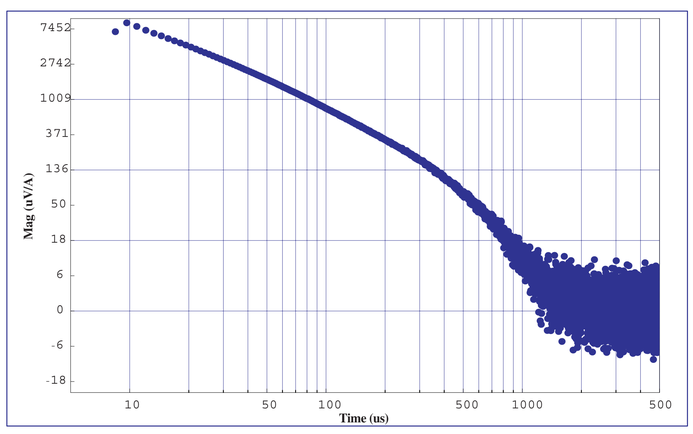
NanoTEM transmitter current waveform (blue) and its time derivative (orange).



Oscilloscope traces of the current waveform for an NT-32 NanoTEM transmitter (A-1) and (B-2, bottom). The (B-2, top) trace is the transient voltage after analog conditioning (i.e., gain and filtering).



NanoTEM time gates



Equal interval NanoTEM from a handgrenade target.

Acquisition Modes

Two NanoTEM acquisition modes are available:

1. Profile Mode - In profile mode, transient data are acquired in 31 logarithmically-spaced time gates as illustrated in the figure (left). The figure also shows theoretical decay transients for a conductive and magnetically permeablility (curve parameter) sphere .

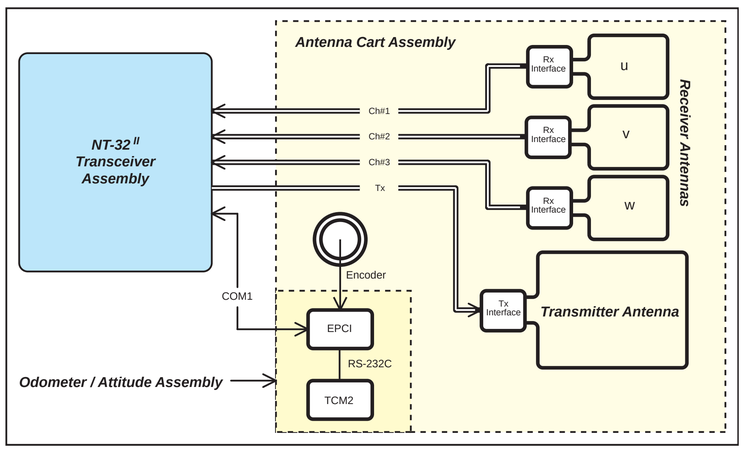
2. Equal Interval Mode: In the equal interval mode, up to 4096 data points are stored for each transient. The equal interval mode is useful for noise studies and for static measurements over a target.

Dynamic NanoTEM (DNT) Hardware

With funding from the ESTCP program, Zonge has assembled a multi-dimensional NanoTEM system for use in characterization and identification of UXO. A block diagram of the system is shown in the figures on the right. As a Fast TEM System, Dynamic NanoTEM has a number of unique capabilities:

* 3-Channel Data Acquisition permits acquisition of 3 orthogonal field components.
* Early Time Data Acquisition - The system is able to acquire data over 3.5 decades of time ranging from microseconds to milliseconds.
* Profile (Gated) and Burst (Equal Interval) Modes of data acquisition.
* Fast Report Rate (32 Hz) with ultra-stable and precise time stamps for each recorded transient permits accurate position recovery when using RTK GPS positioning.

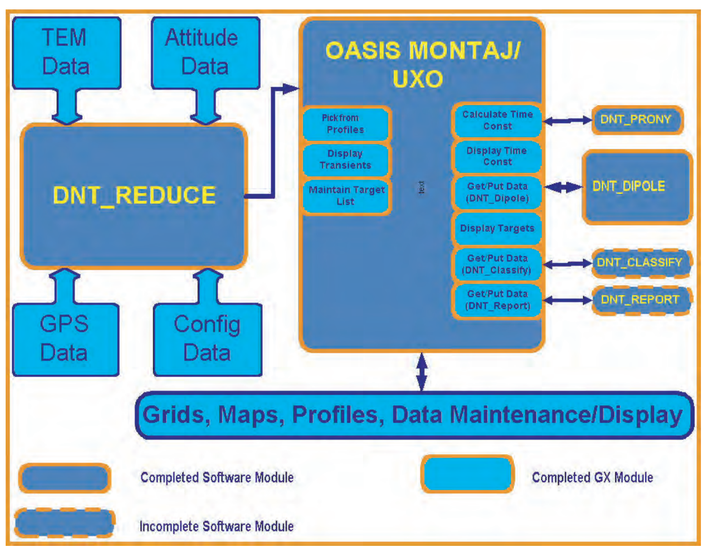
The DNT hardware is mated with an antenna array with characteristics representing a compromise between our desire to measure the TEM transients at early times and the need to maintain sufficient primary field strength for detecting large deep targets.



Block diagram of DNT System.

DNT System at Zonge / University of Arizona UXO Test Site

Dynamic NanoTEM Data Processing



The DNT data processing system.

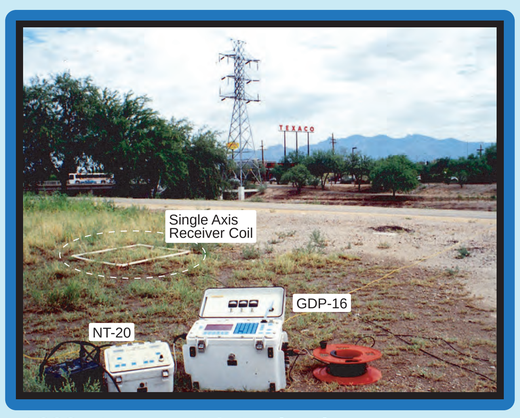
Overview

The DNT system acquires an unprecedented amount of data during the course of even a short survey. To handle these data, we have implemented a software system for processing and display of the data. The figure to the left shows the major functional elements of the DNT data processing system. The processing capability is built around Oasis Montaj to which we have added a number of custom GX's, DLL's, and loosely coupled proprietary programs. Two of the programs deserve special mention.

DNT_Reduce (Pre-Processing)

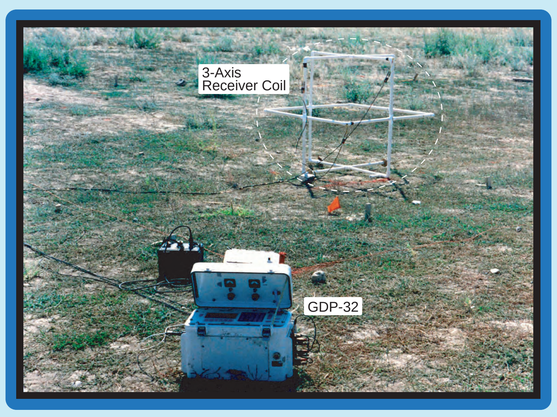
DNT_Reduce provides the interface between raw data as it is collected in the field and the utilities within Oasis Montaj. As suggested in the figure to the left, DNT_Reduce accepts up to 4 input data streams including raw receiver data, GPS data, antenna attitude data (when measured), and configuration data. These data streams are merged and generate text and/or binary metafiles that are easily read into Oasis Montaj and can also be used as deliverables. Zonge performs basic QC within Oasis several custom GX's along with standard utilities supplied by Geosoft.

The Evolution of NanoTEM™



1992 NanoTEM Introduction

The NanoTEM system was introduced by Zonge Engineering in 1992. The system consisted of a fast battery-powered TEM transmitter, the NT-20 and the Zonge GDP-16 Multi-Function Receiver equipped with a high-speed 14-bit data acquisition channel. The new system was designed for static TEM soundings in the shallow subsurface. Since its introduction, the system has been employed worldwide for shallow environmental, engineering, hydrology, and mining applications.



1996 3-Axis NanoTEM

In 1996, Zonge developed a modified NanoTEM acquisition program for its GDP-32 receiver that permitted the receiver to simultaneously acquire data from three high-speed acquisition channels. The upgraded system (3-ch GDP-32 receiver & NT-20 Transmitter) was demonstrated at the Idaho National Engineering Laboratory. The demonstration was part of a DOE-funded project directed toward development of Very Early Time Electromagnetics (VETEM).

1998 NT-32 Transmitter Introduced

In 1998, Zonge introduced the NT-32 “Imbedded NanoTEM Transmitter”. This transmitter is a circuit-board level NanoTEM transmitter that can be installed within the latest generation Zonge receiver, the GDP-32II, thus making the receiver a single-unit transceiver.