Using the GEM-2 and what to expect

Once the basic operation of the GEM-2 is understood, the user needs to choose frequencies and data acquisition methods to suit his needs. In choosing frequencies, a few basic ground rules should be kept in mind. Although the instrument can function with up to ten frequencies at once in combined frequency mode, the signal strength gets diluted as frequencies are added, and for most objectives little new information is gained from having more than three or four frequencies. The signal/noise diminishes below about 5 kHz because the induction coil sensors generate a voltage that is proportional to frequency in that range, so the lowest frequency chosen should not be lower than needed. Although the depth of exploration is related to the skin depth and thus frequency, it is not the only factor; since the sensor consists of small coils, the response to a target falls with distance due to the dipole geometric factor, and reducing the frequency to arbitrarily low values will not always see deeper. In most geologic environments, going below 2 kHz will not see deeper; in very conductive geology such as wetlands and areas with briny soil moisture it may pay to go lower. Very high (> 40 kHz) are useful for mapping the shallow soil conductivity variations, which will show up in the quadrature component.

Mapping geology will be reflected in the quadrature components; the response increases with frequency and thus the signal/noise will diminish somewhat at low frequencies; mapping features below a conductive overburden is challenging, as variations in the overburden will generate response variations at all frequencies (low frequencies do respond to shallow targets, but they extend deeper than high frequencies). The GEM-2 has three filtering features that are helpful for smoothing noise and improving geologic maps, particularly in high ambient noise environments associated with power lines (always a factor in urban areas). The first feature is the base period averaging available in the frequency setting menu; this is a simple averaging of the base 30 Hz (25 Hz in 50 Hz power regions) samples. The output sample rate decreases as the base period averaging increases – with no averaging (set to 1), the GEM-2 output rate is 30 Hz (or 25 Hz), and at the value the GEM-2 is shipped with (set to 3) the output sample rate is 10 Hz (or 8.3 Hz). When surveying over large areas for geology or large scaled features, this smoothing method reduces the data set size with little loss of information. The other two features are found in the filtering/configuration selection and consist of moving window mean (averaging) and median filters selected as a number if base period samples (not output samples). The mean filter is a basic smoothing filter and reduces noise (both ambient electromagnetic noise and small scale shallow geologic noise), and the median filter eliminates spikes in the data. Neither of these filters effects output sample rate and allow smoothing without reducing spatial sampling and thus better spatial resolution retained than that of the base period averaging. These filters are particularly useful when mapping man-made shallow targets in engineering and environmental applications, where high spatial resolution is desired, and typically the setting is in or near urban and ambient power line noise is high.

Metallic targets in engineering and environmental applications such as drums, tanks and rebar typically respond strongest in the inphase component at mid-frequency (5 kHz – 25 kHz) in which the inductive limit of the response is achieved. Small shallow (< 1 ft) metal targets sometimes appear as negative quadrature anomalies. Very small isolated metal objects can be difficult to map; if they are shallow you must traverse directly over them, and if they are more than a meter deep they may not produce enough signal. Non-metallic man-made targets (e.g.

concrete without rebar, landfills, backfills etc.) will often produce the best response in the quadrature component at mid to high frequencies (> 10 kHz) depending on depth and soil conductivity.

Mapping soil magnetic susceptibility is possible with a GEM-2. The response to ground with magnetic minerals is negative inphase at low frequencies; in resistive terrain the frequency range is higher and may provide better signal/noise for magnetic geology.