Using Multi-turn Receiver Coils with terraTEM System

Brief Description

Multi-turn receiver coils for use on the **surface**, if they measure one component, are usually either a square shape of around 50 cm on a side, or a cylinder of around 10-15 cm in diameter. If they measure three components, they will have a thicker 3rd dimension to accommodate the extra sets of windings. For **drill-hole** use they have to be thin enough to fit in the hole and are usually 25-30 mm in diameter and 1-2 m long. The **core** of the coils can be just open space, or as usually the case with thin cylinders, windings on a ferrite core. They usually weigh around 5-10 kg and have a pre-amplifier which can be powered by a battery or by voltage from the separate receiver console. Each can be made to have an equivalent reception to that of a large open, single turn receiver loop by compensating for their much reduced area with many hundreds of turns of wire plus electronic pre-amplification. This **"equivalent (or "effective") area"** is the product of the number of turns, the actual area and the gain of the amplification. In the case of a drill-hole probe, the extra small actual area is also compensated for by extra length of the probe. Other specifications of the coil include its **sensitivity** and its **bandwidth** or response time. The latter can be customised to suit particular requirements and improve their performance in early and late times, as required.

Advantages and Disadvantages

- The compact size makes multi-turn coils **convenient** to use. They are essential as down-hole probes to give sufficient signal with such a small actual area.
- Any receiver loop measures only the **component of the total field** that is perpendicular to the plane of the loop. A big advantage of compact receivers is that they can be easily oriented to any direction to measure components of the field **other than the vertical field** which is all that can be conveniently measured by a loop laid flat on the ground. One less common use of this is to actually note the varying orientation to obtain maximum signal over a conductor and use the intersection of the radials perpendicular the plane of the coils to define the position of the conductor spatially and in depth.
- Coils that measure **3 components** simultaneously have the particular advantage over measuring 3 directions separately with a single component coil, that they are all measured in the same background noise field.
- Being easy to move a receiver coil around in the area of a fixed transmitter coil can be used to define **small closed targets**. Such circumstances include dump sites that contain multiple discarded objects. (If such a target may be the object of a police search then the application is one of **"forensic geophysics"**).
- Receiver coils have the advantage that they can avoid, or substantially diminish a spurious signal due to **superparamagnetism** ("SPM") related to the transmitter loop.
- One **disadvantage** of small coils is that they average less of the near-surface response than a large loop and are therefore more subject to **local heterogeneities**. This would be noticed if a different response is obtained by a small movement in the position of the coil while the transmitter loop remains fixed.

Field Deployment

Coils can be used in place of open receiver loops with the measurement point being at their location. When they are placed at the centre of the transmitter loop in a configuration known as **"In-loop",** they should give a similar result to a Coincident receiver-transmitter geometry, at least in the shape of the decay if not in amplitude. The amplitude will not be the same if the transmitter loop area is not the same as the effective area of the coil. To make it match in amplitude, the result from the coil can be scaled up or down by the ratio of the difference in area. For example, if the Coincident transmitter area is 10,000 sq. metres and the effective coil area is 2,500 sq. metres, then the coil results would need to be multiplied by 4.

The shape may still not be similar, especially at early and late times for various reasons, some of which may be the avoidance of late time noise by the coils as explained above. Early time differences may be due to differing bandwidths or response times of the particular coil.

Compact coils are especially convenient for the configuration of a **large fixed transmitter** and a moving receiver. For **down-hole** use, a compact receiver coil is essential as a receiver of the necessary small diameter and only one turn would give insufficient signal.

Tips on using coils with best effect

(In this section the coil is a terraTEM coil, "TRC".)

a) Keep the TRC and the terraTEM **separated** by the maximum length of the connecting cable. In strong fields, especially if large currents and large Tx loops, the terraTEM and the battery pack can be mild conductors and give a response.
b) If the TRC is close to a transmitter loop cable place the terraTEM and battery pack as far as possible from the loop.
c) Place the TRC on firm ground so that there is **no movement** of it during the acquisition as this will affect the measurement. Tall grass is not a satisfactory location, for example. Clear the space for the TRC if necessary. If you use props to make the coil **level**, make sure they will not move.
d) If it is **windy,** so as to shake the TRC, **shield** it in some way. Only use non-conducting materials for this purpose – wood sheets, stakes, etc. Dig a hole to place the TRC in if necessary and possible. Also at this time, avoid placing the TRC near large **trees** as their roots can shake the ground underneath the TRC. When measuring **horizontal components** this is particularly important as the signals from horizontal fields are weaker than the vertical field and any effects of movement are more noticeable.
e) If you use a **compass** to align the direction of the TRC, do not leave it nearby during acquisition. The magnetic needle of the compass can be influenced by the Tx field and detected by the TRC. The needle can be seen to oscillate back and forward in synchronism with the Tx pulses.
f) Do not leave a **reel of connecting cable** near the Tx loop as it can act as an inductor and be detected by the TRC (This is more of a problem with the use of an open loop as the receiver).
g) Do not use **portable radio transmitters** near the TRC during acquisition.

Trouble Shooting

First, try to isolate whether the problem is in the TRC alone, or the terraTEM alone, or only when the two are connected.

Check if the problem is with the **TRC** by either reversing the sense of the Tx loop or reverse the orientation of the TRC 180 degrees and compare the results from the two positions. If the two results are NOT the same except only that now they are of opposite polarity, there is a problem with the TRC or the connections to it. Another check is to make a measurement without the TRC, say on single loop, but keeping the position and size of Tx loop the same. If this result is normal, the fault is with the TRC or the connection to it.

Check the **connecting cable** for loss of continuity using a multimeter and observing the required voltages at the various pin combinations.

Be sure that the problem is not just due to the **position of the TRC** in relation to the geological situation. Coils are much more sensitive to local heterogeneities in the near surface. To test for this take a measurement some few metres away from the original position and see if the results improve.

To check if the problem is with the **terraTEM only**, carry out the trouble shooting suggestions in the terraTEM Manual. In particular, check that the terraTEM fuses are good. terraTEM supplies voltage to the TRC pre-amplifier. Especially check that the receiver pins are supplying +/- 12 V (Correct pin voltages are given in the terraTEM Manual).

If the terraTEM or the TRC continues to exhibit problems, they may need to be returned to the distributor for repair.

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Ref: TEM Multi-turn Receiver Coil v.1.docx