SkyTEM312HP – Optimized for depth of investigation

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SUMMARY

The development of the SkyTEM312HP system focuses on optimizing the depth of investigation of the AEM system through improvement of the signal to noise ratio. The developments has been twofold focusing on both increasing the signal strength through a new generation high power airborne TEM transmitters and reducing the noise level of the receiver coil system.

The high power TEM transmitters is capable of delivering a maximum current of 250 A in all transmitter turns of the system. For the SkyTEM312HP system this leads to a magnetic dipole moment of 1,000,000 NIA.

The reduction of the noise level of the receiver coil system is through enhancements of both instrument noise and motion-induced noise. The high area receiver coil increases the TEM signal over the instrument noise. The suspension system for this coil is optimized to the reduction of the motion-induced noise at the low repetition frequencies.

The developments on both the transmitter and receiver side results in an improved signal to noise ratio of the SkyTEM312HP system. Which in turn leads to an optimized depth of investigation.

Key words: SkyTEM312HP, Depth of Investigation, Signal to Noise Ratio.

INTRODUCTION

The SkyTEM312HP system is developed to optimize the depth of investigation (DOI). The DOI attainable by the transient electromagnetic method (TEM) is constrained by the signal-to-noise ratio (SNR) at the late off-times (Spies 1989).

There are two ways to improve the SNR. Either the signal strength is increased or the noise level is reduced. The increase of the signal strength relates to the transmitter technology while the reduction of noise relates to the receiver technology.

The SkyTEM312HP system is the result of developments on both transmitter and receiver technology. A new generation of high power airborne TEM transmitters delivering twice the magnetic dipole moment of the standard transmitters has been developed. In addition a high area receiver coil with an optimized damping of movement noise is developed for lowering the receiver system noise level at late times.

INCREASING THE MAGNETIC DIPOLE MOMENT

The magnetic dipole moment, which is the product of the current, I, and the total area, A, of the TEM transmitter loop, determines the magnitude of the signal employed to generate the TEM response.

The new high power TEM transmitters deliver a maximum current of 250 Ampere in each transmitter turn. The 12 turns mounted on the SkyTEM300 series compact frames with an area of 342 m^2 delivers a high moment magnetic dipole moment of approximately 1,000,000 Am2. This magnetic dipole moment facilitates the deep penetration required for deep-seated exploration targets.

The waveform of the high power TEM transmitter is a near square waveform with a ramp down time of 1,000 µs (Figure 1). The transmitter operates at various repetition frequencies. When optimized for depth of investigation the low repetition frequency of 12.5 Hz is chosen. This has an on-time of 8 ms and an off-time of 32 ms with the last gate centre time around 29 ms. The low repetition frequencies and late gate times is an important factor in optimizing the DOI and detecting superconductive bodies.

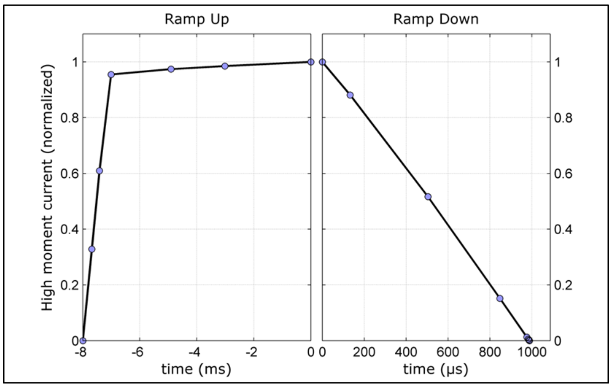

Figure 1. Normalised current waveform for the SkyTEM312HP transmitter operated at a 12.5 Hz repetition frequency. Left panel show the ramp up normalised current versus time in ms and right panel show the ramp down normalised current versus time in µs.

REDUCING THE NOISE LEVEL

There are two main noise sources in TEM: instrument noise and motion-induced noise.

Instrument noise

Nyboe and Sørensen (2012) demonstrate that the raw TEM signal generated by the induction coil is contaminated with instrument noise along the transmission path of the receiver system. Because the instrument noise is independent of the TEM signal the TEM signal to instrument noise ratio (TNR) can be enhanced by increasing the size of the TEM signal. The raw TEM signal is enhanced simply by increasing the area of the induction coil.

Principally, the TNR can be increased to any desired level in that the area can be manipulated changing the area of each induction coil turn and the total number of turns. But increasing the total area comes at the expense of lowering the induction coil's cutoff frequency. In the practical design, a balance between the cutoff frequency and the noise reduction, therefore, has to be struck. Lowering the cutoff frequency too much will render useful near-surface resolution impossible to obtain.

The receiver induction coil specification made for the SkyTEM312HP system has an area of 100 m^2 and a cut-off frequency of 31.5 kHz. These specifications are found to provide the best enhancement of the TEM signal and keeping an acceptable cutoff frequency. At the same time this coil design provides an optimal design for reducing the motion-induced noise described in the next section.

Motion-induced noise

Motion-induced noise is caused by the signal generated in the induction coil when it is moved in the Earth magnetic field (Munkholm 1997). As opposed to ground-based geophysics this noise component is substantial in airborne TEM due to erratic movements of the combined transmitter-receiver system during the flight.

The receiver induction coil suspension system used for the SkyTEM312 HP reduces the motion-induced noise by a factor of 100 over the earliest SkyTEM receiver coils and a factor of 5 to 10 over the previous version (Figure 2). It is important to note that this reduction occurs at the low frequencies from 12.5 to 30 Hz where the system operates for maximum depth of investigation.

CONCLUSIONS

The development of the SkyTEM312HP system optimized for DOI through improvement of the SNR is in agreement with the principles established. The combination of the new high power TEM transmitters for increasing the signal strength and the high area receiver coil with a reduction in motion-induced noise results in overall improvement of the SNR. The improved SNR leads to the final goal of optimizing the DOI.

ACKNOWLEDGMENTS

This work was supported by Innovation Fund Denmark as part of the Airtech4Water project.

All employees at Airborne Instruments and SkyTEM Surveys involved in the development of the new technology are highly acknowledged for their continued efforts and dedicated work..

REFERENCES

Munkholm, M. S., 1997. Motion-induced noise from vibration of a moving TEM detector coil: characterization and suppression. Journal of Applied Geophysics, 37, 21-29.

Nyboe, N. S., & Sørensen, K., 2012. Noise reduction in TEM: Presenting a bandwidth-and sensitivity-optimized parallel recording setup and methods for adaptive synchronous detection. Geophysics, 77, 203-212.

Spies, B. R., 1989. Depth of investigation in electromagnetic sounding methods. Geophysics, 54, 872-888.

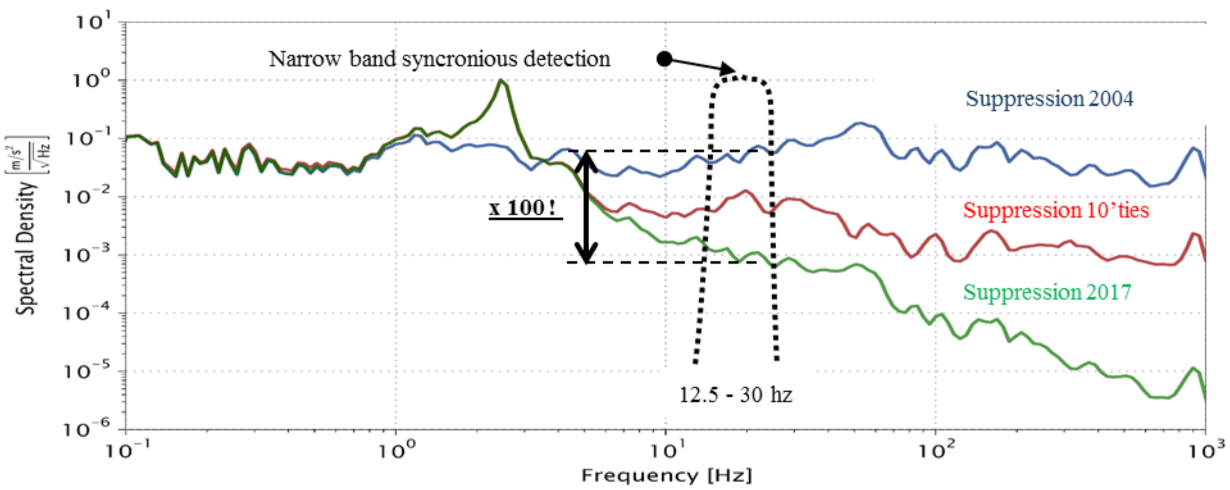

Figure 2. Spectral density of the noise versus frequency for the different generations of SkyTEM receiver coils. The reduction in spectral density within the narrow band synchronous detection band used for measuring at low repetition rates and corresponding late off times are important for the DOI.