地球物理学报 » 2011, Vol. 54 » Issue (9) :2397-2406
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WANG Shi-Long, WANG Yan-Zhang, SUI Yang-Yi, WANG Qi, LIN Jun.A bird calibration device of Helicopter-borne TEM with concentric bucking loop.Chinese J.Geophys. (in Chinese),2011,V54(9): 2397-2406,DOI: 10.3969/j.issn.0001-5733.2011.09.023

同心补偿式直升机时间域航空电磁法吊舱校准装置研究

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A bird calibration device of Helicopter-borne TEM with concentric bucking loop

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摘要 直升机时间域航空电磁法(Helicopter-borne time-domain electromagnetic method,HTEM)的多次空中仪器校准可消除飞行过程中仪器系统受外界环境的时变影响.吊舱校准装置可解决地面环线方式无法实现的空中飞行过程中仪器校准问题.本文从研究同心补偿吊舱装置模型出发,提出了吊舱装置空间模型和线圈电路模型,分析了发射磁场的空间分布、补偿环作用及其与接收线圈的关系、校准装置的空间信息和信号的检测方法,得到结论如下:(1)以损失发射面积0.89%的补偿环可提高信号44.5 dB的动态范围;(2)校准装置水平安置在补偿环与发射线圈之间,其匝数越多、半径越大、离补偿环越近,信号响应越强;(3)校准线圈电感越大、电阻越小,其e指数衰减越慢;信号检测起点由含匹配电阻接收线圈的阻尼特性决定.通过校准线圈的曲线特性和装置位移实验,得出反映装置特性的时间常数实测误差小于1.3%,验证了线圈电路模型和装置空间模型.本文提出的模型和方法同样适用于偏心补偿式HTEM系统校准的研究和高阻地层上已知环线的静态检测.

关键词: 航空电磁法 直升机时间域电磁法 吊舱装置 校准装置 补偿环

Abstract: The multiple instrument calibrations of flying helicopter-borne time-domain electromagnetic method (HTEM) can eliminate the environmental time-varying effect on the system during flight. Using the bird calibration device to solve the problem that the wire-loop method can't achieve, we consider the bird model of HTEM with the concentric bucking loop, propose the bird device space models and the coil circuit models, and analyze the transmitter magnetic field distribution, the bucking loop's effect and the relationship between it and the receiving coil, the space information of the calibration device and its signal detecting method. Conclusions are as follows: (1) the bucking loop that losses 0.89% of the transmitting area can increase 44.5 dB of the signal dynamic range. (2) The calibration device is levelly placed between the bucking loop and the transmitting coils. If it has more turns and greater radius and it is closer to the bucking loop, its signal response is stronger. (3) When the inductance of calibration coil becomes greater and its resistance is less, its exponential decay becomes slower. The signal detection time point is directly decided by damping character of receiver coil which has matching resistance. We do experiments about the calibration curve characters and the device coil displacement. The relative error about the time constant of the device characteristics is less than 1.3%, which proves the validity of the coil circuit models and device space models. The proposed models and approaches are also applicable to the bird calibration device research about HTEM with the eccentric bucking loop and the known wire-loop static testing on the high resistance ground.

Keywords: Airborne electromagnetic method Helicopter-borne TEM Bird device Calibration device Bucking loop

Received 2010-11-24;

Fund:

国家高技术研究发展计划(863计划)(2006AA06A205)和吉林大学科学前沿与交叉学科创新项目(421030090537)资助.

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