

# 长周期分布式大地电磁观测系统

Distributed Long-period magnetotelluric sounding system

通过国家 863 计划重大项目的支持，成都理工大学成功研制了低噪声、低温漂、高分辨力的一体化磁芯三轴磁通门传感器（LMT-FS01）和分立式磁芯三轴磁通门传感器（LMT-FS02）。集成研制了一套分布式长周期大地电磁观测仪器系统（CDUT-LMT）。集成研发了一套大口径屏蔽桶、高屏蔽效能的屏蔽式三维静磁场发生器，建立了三轴磁通门传感器实验室标定环境。

Supported by the national major project - 863 Program, Chengdu University of Technology has independently developed three-axis fluxgate sensor (LMT-FS01), having an integrated magnetic core, and three-axis fluxgate sensor (LMT-FS02), having a split core. They all have advantages of low-noise, low temperature drift and high resolution. The research group has also independently developed a distributed long-period magnetotelluric sounding system(CDUT-LMT). And even the research group has developed a large caliber shielding barrel and a shielded three-dimensional magnetostatic field generator, having high shielding effectiveness, which establishes laboratory calibration environment of three-axis fluxgate sensors.

一体化磁芯三轴磁通门传感器（LMT-FS01）和分立式磁芯三轴磁通门传感器（LMT-FS02）的主要性能指标与英国 MAG-03 和乌克兰 LEMI-029 三轴磁通门传感器相当。

The performances of the three-axis fluxgate sensor (LMT-FS01), having an integrated magnetic core, and three-axis fluxgate sensor (LMT-FS02), having a split core, are similar to that of British MAG-03 and Ukraine LEMI-029.

<p>LMT-FS01 一体化磁芯磁通门传感器</p> <p>分立式磁芯磁通门传感器 LMT-FS02</p>	<ul style="list-style-type: none"> <li>● 磁场测量范围: <math>\pm 100\mu\text{T}</math></li> <li>● 测量带宽:                     <ul style="list-style-type: none"> <li>✓ DC~20Hz (LMT-FS01)</li> <li>✓ DC~1KHz (LMT-FS02)</li> </ul> </li> <li>● 噪声水平: <math>&lt; 6\text{pTrms}/\sqrt{\text{Hz}}</math> @1Hz</li> <li>● 正交误差: <math>&lt; 0.5\%</math></li> <li>● 功耗: <math>\leq 1000\text{mW}</math></li> <li>● 温度漂移: 50ppm</li> <li>● 重量: <math>&lt; 500\text{g}</math></li> </ul>	<ul style="list-style-type: none"> <li>● Magnetic Measuring Range: <math>\pm 100\mu\text{T}</math></li> <li>● Measurement Bandwidth:                     <ul style="list-style-type: none"> <li>✓ DC~20Hz (LMT-FS01)</li> <li>✓ DC~1KHz (LMT-FS02)</li> </ul> </li> <li>● Noise Level: <math>&lt; 6\text{pTrms}/\sqrt{\text{Hz}}</math> @1Hz</li> <li>● Quadrature Error: <math>&lt; 0.5\%</math></li> <li>● Power Dissipation: <math>\leq 1000\text{mW}</math></li> <li>● Temperature Drift: 50ppm</li> <li>● Weight: <math>&lt; 500\text{g}</math></li> </ul>
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长周期大地电磁观测仪器包括三分量磁通门传感器、不极化固体电极和电磁场信号采集器以及分布式 LMT 数据处理软件，与 LEMI-417 野外对比试验结果表明观测数据基本一致。

The long-period magnetotelluric sounding system(CDUT-LMT) consists of three-axis fluxgate sensor, non-polarizable solid electrode, electromagnetic signal collector and distributed LMT data processing software. And its observational data essentially in agreement with LEMI-417.

	<ul style="list-style-type: none"> <li>● 观测频率范围: 10Hz~50,000 秒</li> <li>● 磁场测量范围: <math>\pm 78000\text{nT}</math></li> <li>● 磁场分辨率: 20pT</li> <li>● 电场测量范围: <math>\pm 2500\text{mV}/1\text{km}</math></li> <li>● 电场分辨率: 20nV</li> <li>● 测量信号动态范围: <math>\geq 120\text{dB}</math></li> <li>● AD 转换分辨率: 24bit</li> <li>● 温度范围: <math>-20^\circ\text{C} \sim 50^\circ\text{C}</math></li> <li>● 功率消耗: <math>&lt; 6\text{W}</math> (无线传输未开启)</li> <li>● 重量: <math>&lt; 5\text{kg}</math> (不含传感器)</li> </ul>	<ul style="list-style-type: none"> <li>● Observed Frequency Range : 10Hz ~ 50,000s</li> <li>● Magnetic Measuring Range: <math>\pm 78000\text{nT}</math></li> <li>● Magnetic Resolution: 20pT</li> <li>● Electric Measuring Range: <math>\pm 2500\text{mV}/1\text{km}</math></li> <li>● Electric Resolution: 20nV</li> <li>● Measured Signal Dynamic Range <math>\geq 120\text{dB}</math></li> <li>● ADC Resolution: 24bit</li> <li>● Temperature Range: <math>-20^\circ\text{C} \sim 50^\circ\text{C}</math></li> <li>● Power Dissipation : <math>&lt; 6\text{W}</math> (Wireless transmission unopened)</li> <li>● Weight: <math>&lt; 5\text{kg}</math> (Exclude sensor)</li> </ul>
<p>彭州测点结果 (视电阻率和相位曲线)</p> <p>CDUT-LMT</p> <p>LEMI-417</p>	<ul style="list-style-type: none"> <li>● 处理周期: 10.3~12500s, 频率可自定义, 并分为 7 个子频段处理</li> <li>● 基于最小二乘、重复中值估计 Robust 算法实现张量阻抗估算</li> <li>● 基于斯外夫特、Barr 分解、相位张量分解算法实现张量阻抗分解</li> <li>● 基于磁场相关算法实现远参考处理</li> </ul>	<ul style="list-style-type: none"> <li>● Processing Period : 10.3-12500s, this frequency can be defined by users, and divided into 7 sub frequency bands to process.</li> <li>● Tensor impedance estimation based on least square and repeated mean estimation Robust algorithm</li> <li>● Tensor impedance decomposition based on Swift decomposition, Barr decomposition and phase tensor decomposition algorithm.</li> <li>● Remote reference technique based on field</li> </ul>

屏蔽式三维静磁场发生器采用四层坡莫合金制作了国内最大的屏蔽筒，剩磁 $< 1\text{nT}$ ，采用三轴等径圆形亥姆霍兹线圈制作了三维磁场发生器。

The three-dimensional magnetostatic field generator is made of four layers of permalloy. It is the largest shielding cylinder in China and residual magnetism is less than 1nT. The three-dimensional magnetic field generator is generated by three-axis equal-radius Helmholtz coils.

<p>屏蔽桶</p> <p>三轴磁通门计</p> <p>三轴亥姆霍兹线圈</p> <p>温度控制器</p> <p>三轴亥姆霍兹线圈驱动电源</p>	<ul style="list-style-type: none"> <li>● 屏蔽桶内腔尺寸: <math>\varnothing 800\text{mm} \times 900\text{mm}</math></li> <li>● 最大中心磁场强度: 1Gs</li> <li>● 线圈平均直径: 640mm</li> <li>● 产生磁场均匀区: <math>\varnothing 80\text{mm}</math> 球体 (1/1000)</li> <li>● 产生磁场均匀度: 1/1000</li> </ul>	<ul style="list-style-type: none"> <li>● Bore size of the shielding cylinder : <math>\varnothing 800\text{mm} \times 900\text{mm}</math></li> <li>● Maximum central magnetic field strength: 1Gs</li> <li>● Mean diameter of coils: 640mm</li> <li>● Generated range of the uniform magnetic field: <math>\varnothing 80\text{mm}</math> sphere (1/1000)</li> <li>● Generated uniformity of the magnetic field: 1/1000</li> </ul>
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