B1 INSULATED CABLES
Towards Sustainability

Enhanced HV Cable Connection Alarm System: Introducing i-LinkBox™

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High-voltage (HV) cable systems have become essential for energy transmission and distribution in today's world. Among the critical components of these systems are link boxes, where HV cable joints and terminations are connected and grounded. These link boxes are also feature sheath voltage limiters (SVLs) to mitigate over voltages resulting from lightning strikes or switching events. However, ensuring proper link box performance is crucial, as failure can lead to malfunctions in costly HV cable systems. Challenging environmental conditions, such as humidity, heat, UV exposure, production errors, mechanical impacts, corrosion, and water ingress, pose significant risks to link box integrity. Water ingress, in particular, is known to cause cable joint failures. To address these challenges, many companies use link boxes equipped with SVLs designed to withstand short-circuit conditions and resist explosions. Selecting suitable SVLs is paramount, as unsuitable ones can be a leading cause of link box failures and damage to HV cable sheaths.

In this context, we introduce an economical and user-friendly alarm system named i-LinkBox™, specifically developed for monitoring shield link boxes and measuring the partial discharge (PD) levels in high-voltage cable accessories. The i-LinkBox™ incorporates a new intelligent shielded link box with an early warning system, allowing continuous monitoring of various parameters, including HV cable screen current and voltage, impulse voltage events, water ingress, temperature and humidity, internal pressure, link box cover condition, and partial discharge level of the high-voltage cable. Through a simple user interface integrated with the SCADA communication system, i-LinkBox™ enables users to easily understand and manage data. Each i-LinkBox™ can be monitored individually, and data can be conveniently compared for detailed analysis. The embedded advanced decision-making algorithms eliminate the need for end-users to deal with complex data, ensuring that operators receive alarms concerning abnormal behaviours of link boxes and cable accessories before catastrophic failures occur.

Intelligent shielded cable link boxes, such as i-LinkBox™, provide a means to prevent and continuously monitor faults in HV cable systems. These innovative solutions enhance the reliability of energy transmission-distribution systems by offering operators early warnings, ultimately preventing costly outages and damages. Prior to this study, discussions on HV cable fault diagnosis have focused on monitoring sheath currents. However, partial discharge

detection has been recommended as the best method for assessing the status of XLPE cable insulation by international authorities such as IEEE, IEC, and CIGRE. Consequently, various partial discharge monitoring systems have garnered increasing attention in recent years, particularly in Extra High Voltage (EHV) cable systems. Some energy companies mandate continuous real-time PDM (partial discharge monitoring) systems for 400 kV cable systems.

Although several commercial monitoring systems, especially PDM systems, are available in the market, many face challenges such as high costs, complex installation and operation, and the need for experienced manpower. Notably, until now, there has been no specialized monitoring system for link boxes, an integral part of HV cable systems. This research aims to develop an economic and user-friendly alarm system capable of continuously monitoring various parameters, including the partial discharge levels in link boxes and HV cable terminations. The next-generation intelligent link box (i-LinkBox™) allows continuous monitoring of multiple parameters, such as HV shielded cable current and voltage, impulse voltage events, water ingress, temperature and humidity, internal pressure, link box cover condition, and HV cable's partial discharge level.

PD measurement systems are highly effective systems developed for the early detection of cable faults. This unit is designed to be integrated into Intelligent Link Box combining EMELEC's expertise in Link Boxes and high voltage systems with the PD knowledge accumulated by IPEC-UK.

By integrating i-LinkBox™ with a user-friendly interface and advanced decision-making algorithms, the system becomes seamlessly integrated with the SCADA system, empowering end-users to focus on simple alerts rather than grappling with complex data. This capability enables potential faults in link boxes and cable terminations to be detected before causing serious damages.

The development of i-LinkBox™ represents a significant advancement in the field of HV cable system monitoring. With its user-friendly interface and comprehensive monitoring capabilities, this intelligent link box contributes to improved reliability, reduced downtime, and enhanced cost-effectiveness in energy transmission-distribution systems. By detecting and addressing potential issues proactively, i-LinkBox™ offers a valuable solution to prevent costly failures and ensure the seamless operation of HV cable systems.

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