# Integration of Ground Fault Detector (GFD) Equipment in the UFD Network

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**Abstract —** *This master's thesis focuses on integrating Ground Fault Detectors (GFDs) into UFD's electrical distribution network, addressing technical challenges related to their implementation. The study aims to analyse GFD performance, automate device integration into management systems, and streamline data collection. Additionally, it consolidates relevant documentation to create a comprehensive resource. While the GFDs have enhanced network monitoring, the findings reveal disparities in effectiveness across different centres, highlighting the need for targeted strategies to optimize deployment. The successful automation of processes lays a strong foundation for UFD's ongoing digitalization efforts.*

**Keywords — Ground Fault Detectors, UFD, electrical distribution network, digitalization, real-time monitoring, automation, asset management, data integration, operational performance.**

## I. INTRODUCTION

This master's thesis investigates the integration and performance of Ground Fault Detectors (GFDs) within UFD's electrical distribution network. This project is a cornerstone of UFD's digitalization strategy, aimed at enhancing the safety, reliability, and efficiency of its network infrastructure. The GFDs play a crucial role in monitoring the grounding systems across the grids, detecting faults early to prevent potential hazards, reduce outage times, and maintain the integrity of electrical systems. This study examines the technical and operational aspects of deploying GFDs, providing a comprehensive analysis that informs future strategies for UFD's network management.

## II. PROJECT DEFINITION

The primary objectives of this master thesis were defined as follows:

- ***Documentation Consolidation and Organisation:***

The first objective was to consolidation and organisation of diverse documents and information related to GFDs within UFD. Given the proprietary nature of how different companies implement these devices in their databases, this objective aimed to centralize and clarify information, creating a more coherent and structured understanding of GFD deployment within UFD.

- ***Analysing the Performance of GFD Devices:***

A important part of the project was the evaluate the operational performance of GFD devices installed across UFD's network. This involved assessing the effectiveness of these devices in detecting ground faults, their reliability, and their overall contribution to network safety. The goal was to identify areas for improvement in the deployment and operation of GFDs.

- ***Automating Integration of New GFD Devices into Management Systems:***

Another key objective was to automate the process of integrating new GFD devices into UFD's Asset Management Interface (GdA) and Intelligent Network System (eSIR). The aim was to streamline the integration process, reduce manual errors, and ensure that data from newly installed devices are accurately and efficiently reflected in the management systems.

- ***Automating Data Collection:***

The thesis also aimed to implement automated processes for the collection and analysis of data generated by GFD devices. This automation was intended to enhance real-time monitoring capabilities, improve data consistency, and support more informed decision-making within UFD's operations.

## III. METHODOLOGY

The first stage of this master's thesis consisted of a comprehensive analysis and documentation consolidation of information of the GFD technology. The project began with an in-depth review of the technical specifications of GFDs, focusing on their operational parameters and the standards governing their use. Next step focused on the review and organized the diverse range of information created by all different departments inside UFD.

The second stage included the automation of device integration into UFD's existing systems, which required the development of custom interface rules to ensure seamless data flow. Also, data collection was automated using advanced software tools used to capture and analyse data from GFDs in real-time.

The third and final stage of this master's thesis focused on

analysing the performance of the GFD devices deployed across UFD's network. This phase involved a detailed evaluation of the operational effectiveness of the devices, comparing the number of devices budgeted, installed, and those that were operational. Additionally, this stage included the synthesis of all gathered data and insights into comprehensive conclusions, offering strategic recommendations for future improvements in the implementation and management of GFD technology within UFD.

## IV. RESULTS

The results of this project provide a detailed overview of the implementation and performance of Ground Fault Detectors (GFDs) within UFD's network.

- ***Analysis of GFD Performance:***

This section focused on the deployment and operational performance of Ground Fault Detectors (GFDs) within UFD's network during the years 2023 and 2024. The initial two years of the project were dedicated to pilot testing, with significant deployment efforts and results emerging in 2023 and 2024.

In 2023, UFD had budgeted for the installation of 5,000 GFDs across various operational centres. By the end of the year, a total of 1,738 devices had been installed, reflecting an installation rate of 34.76%. Out of these installed devices, 788 were reported as operational (OK), resulting in an operational effectiveness rate of 15.76%. Below can be seen differences between installed and budgeted devices:

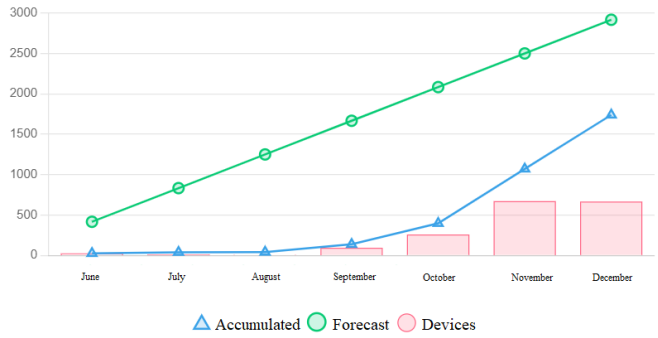


*Figure 1. Yearly Overview of Budgeted, Installed, and Cumulative GFDs for 2023.*

The deployment plan for 2024 had allocated 3,854 GFDs for installation. By August 2024, 2,557 devices were successfully installed, achieving an installation rate of 66.33%. The number of devices that were operational by this time was 1,471, leading to an operational effectiveness rate of 43.49%. Below can be seen differences between installed and budgeted devices:

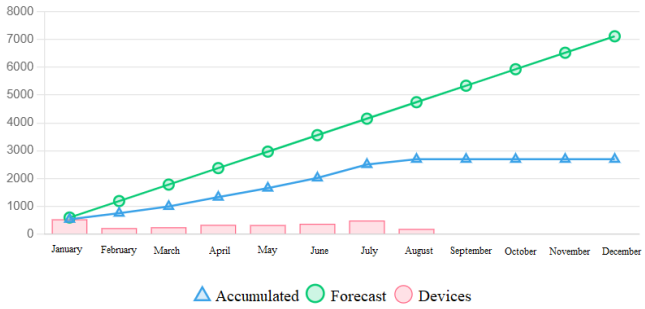


*Figure 2.Yearly Overview of Budgeted, Installed, and Cumulative GFDs for 2024.*

Over the entire period from 2021 to 2024, UFD had budgeted a total of 8,854 GFDs for installation across the network. Of these, 4,442 devices were installed, resulting in an overall installation rate of 50.17%. However, only 2,266 devices were reported as operational, leading to an overall operational effectiveness rate of 25.59%.

When analysing the performance by operational centres over the entire period:

- ***OP MAD MUNICIPIOS NORTE:***

This centre had an installation rate of 206.11% (270 devices installed out of 131 budgeted) with an operational effectiveness rate of 63.36% (83 operational devices out of 131 budgeted).

- ***OP C. REAL OESTE:***

Achieved an installation rate of 79.77% (205 devices installed out of 257 budgeted) and an operational effectiveness rate of 58.37% (150 OK devices out of 257 budgeted).

- ***OP MAD CAPITAL SUR:***

Recorded an installation rate of 21.43% (12 devices installed out of 56 budgeted) with no operational devices, leading to an operational effectiveness rate of 0%.

- ***OP MAD CAPITAL NORTE:***

Had an installation rate of 28.57% (6 devices installed out of 21 budgeted) and an operational effectiveness rate of 4.76% (1 operational device out of 21 budgeted).

- ***Automation of Device Integration***

The automation of integrating GFDs into UFD's systems was a major focus of this project. By the conclusion of the project, 4,335 GFDs were registered in the G-DFT application, which is the primary tool for managing these devices. However, in the broader network management system, eSIR, only 3,442 devices were successfully integrated. This represents about 79.45% of the devices recorded in G-DFT. Additionally, within eSIR, 36 devices were identified with duplicated serial numbers, and 6 devices were found without

properly assigned BDI registration number.

This dissertation also addresses the various scenarios for data management and integration in GFD deployments within UFD's network. The focus was on ensuring that all new assets, requiring monitoring via GFDs, are seamlessly integrated into the company's systems. The accompanying flowchart illustrates the most common steps involved in integrating a new asset into UFD's network, showcasing the crucial process for registering and monitoring these assets across different platforms within the company, including G-DFT, GdA, eSIR, ATOM/ARGOS, and IGEA. This standard process ensures that every new installation is accurately documented and operationalized, facilitating consistent and reliable data collection and system management.

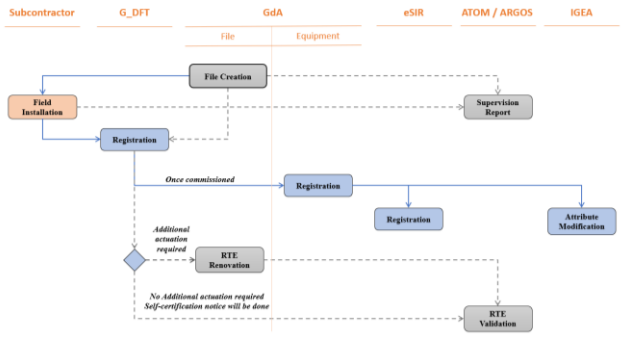


*Figure 3. Flowchart of the integration of a new GFD.*

- ***Data Collection and Analysis***

Automated processes were implemented to enable continuous collection and analysis of data generated by GFDs within the Intelligent Network System (eSIR). These processes aimed to significantly enhance UFD's real-time monitoring capabilities by ensuring timely and accurate fault detection across the network. As part of this implementation, existing templates were carefully filled out to define how eSIR should process the incoming data from the new assets. This step was crucial to ensure that the incidents reported by GFDs are correctly interpreted and managed by UFD's operational teams.

While the automation led to improvements in incident response times and enhanced data consistency in certain regions, challenges persisted. The quality and integration of data varied across different operational centres, underscoring the need for ongoing refinement of the data collection and integration processes. This experience highlights the importance of continuous improvement in the automation systems to achieve uniform data quality and reliable network monitoring across UFD's entire operational area.

- ***Documentation Consolidation***

This project involved an extensive effort to consolidate and organize the wide range of documentation related to Ground Fault Detectors (GFDs) within UFD. The documentation consolidation covered several critical aspects:

- ***Technical Characteristics of GFD Equipment:***

Detailed analysis of material, construction, functional, dimensional, and electrical characteristics of the GFDs. It included aspects such as auto-calibration protocols, digital signals, communication ports, and degree of protection.

- ***Monitored Assets with GFD Equipment:***

Documentation of various assets monitored by GFDs, including Secondary Substations (SS), Switching Centres (SC), and Frequented Supports. Each category was assessed for its specific requirements and configurations related to GFD integration.

- ***Applicable Regulations and Standards:***

A thorough review of the regulations and standards governing the deployment and operation of GFDs, ensuring compliance with both national and international guidelines.

- ***Conditions and Procedures for Installation:***

Comprehensive guidelines for the installation of GFDs, covering general conditions, grounding characteristics, and preliminary grounding system measurements. These procedures are vital for ensuring the correct and safe installation of GFD equipment.

- ***Communication of GFD Devices with the Manufacturer's Application (G-DFT):***

Analysis of the system and data architecture, communication protocols, and security measures in place for the effective operation and integration of GFD devices within UFD's digital ecosystem.

By consolidating this information, the project provided UFD with a unified and organized repository of GFD documentation. This resource supports ongoing operations and offers a valuable reference for future projects, ensuring that UFD maintains high standards in network management and operational efficiency.

## V. CONCLUSIONS

The implementation of Ground Fault Detectors (GFDs) within UFD's network has yielded mixed results, reflecting both the successes and challenges encountered throughout the project. The analysis of GFD performance across various operational centres revealed significant disparities in effectiveness, with some centres demonstrating commendable performance while others struggled to achieve operational success. The overall effectiveness rate of 25.59% highlights the challenges faced in ensuring consistent performance across all centres.

The automation of device integration into UFD's systems marked a significant advancement, improving operational efficiency and reducing manual errors. However, the discrepancy between the number of devices registered in the G-DFT application and those successfully integrated into eSIR indicates that further improvements are needed. This gap suggests that, while automation has made strides in optimizing network management, the process is not yet fully aligned, and additional refinements are required to achieve comprehensive integration.

The data collection and analysis processes implemented during the project demonstrated the potential for enhancing real-time monitoring and incident response. However, the variability in data quality and integration across different centres underscores the need for continued efforts to ensure consistent and reliable data flow throughout the network. These challenges indicate that the current automation processes, while beneficial, require further optimization to fully realize their potential.

The documentation consolidation effort provided a valuable outcome, creating a centralized and organized repository of information related to GFDs within UFD. This consolidation has improved the accessibility and coherence of critical information, supporting UFD’s ongoing and future operations. However, the project also highlighted the fragmented nature of the information prior to this the effort, emphasizing importance of maintaining an organized and up-to-date repository as the GFD deployment continues to evolve.

In summary, while the project has achieved significant progress in several areas, including device integration and documentation consolidation, the findings suggest that there are still some areas that require further attention. The lessons learned from this deployment will be beneficial in guiding future improvements, ensuring that UFD can optimize the effectiveness and efficiency of GFD deployment across its network. The project’s outcomes provide a strong foundation for continued innovation, but also highlight the need for ongoing refinement to meet the network’s operational and strategic objectives.

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