Retraction

Retraction: Quality Control and Communication in Smart Grid Using IED & PLCC (J. Phys.: Conf. Ser. 1916 012132)

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This article (and all articles in the proceedings volume relating to the same conference) has been retracted by IOP Publishing following an extensive investigation in line with the COPE guidelines. This investigation has uncovered evidence of systematic manipulation of the publication process and considerable citation manipulation.

IOP Publishing respectfully requests that readers consider all work within this volume potentially unreliable, as the volume has not been through a credible peer review process.

IOP Publishing regrets that our usual quality checks did not identify these issues before publication, and have since put additional measures in place to try to prevent these issues from reoccurring. IOP Publishing wishes to credit anonymous whistleblowers and the Problematic Paper Screener [1] for bringing some of the above issues to our attention, prompting us to investigate further.

[1] Cabanac G, Labbé C and Magazinov A 2021 arXiv:2107.06751v1

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Quality Control and Communication in Smart Grid Using IED & PLCC

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Abstract. In the era of growing power demand and power networks, continuous supply of power and data exchanges is inevitable nurturing the implementation of smart grid technology. The smart grid is a self-healing technology which promises the electricity consumers to be an active participant. However, Intelligent Electronic Device (IED) supports the SG as the backbone for operation imparting the functionalities such as protection and monitoring the power networks. But the limitations of the common IED are its finite allocation of functions without modifying its hardware. Moreover, these IEDs confront the communication problems during natural calamities and other network failures as it adopts the cellular communication topology. The limitations mentioned above can be overcome by adopting the flexible IEDs integrated with signal conditioning, filtering and discretization functions along with the implementation of Power Line Carrier communication. The flexible IED and the PLCC extends the scalability of the most reliable and highly efficient smart grid architecture.

Keywords: Smart grid (SG), flexible IED, Power line carrier communication (PLCC), SG architecture.

1. Introduction

The two factors that govern the growth of power networks are the government policies and the technology imparted need among the masses which expect un intermittent qualitative power as the fundamental element of life [1]. The government policies are weighing the power efficiency, less carbon foot steps and conservation of power, therefore, driving its advisory policies towards the renewable energy resources worldwide [2]. The focused drive provokes the innovation in the domain of conservatory power, renewable energy, sustainable development and other relatable aspects [3]. The spectrum of policy drives gradually making the electricity consumers engaging in the process of sustainable development as they receive incentives. The experimental innovations based on decentralized and distributed networks, electric vehicles, remote controlled home appliances & industrial operations empowered the power sector adequately. The inrush of these modern innovations raised the need for an efficient, conservative and intelligent grid which can be reliable, proactive and sustainable which in turn reinforced the concept of smart grid architecture for modern power networks. However, the architecture remained hypothetical and it had no distinctive definition as the
name entails. Numerous inter-disciplinary innovations were proposed to define the smart grid, though it failed to provide an overall distinctive feature of architecture [4]. Finally, the key attributes of SG are considered as the integration of renewable energy, enabling cyber-secure communication medium between grid and the data centre, optimized energy flow, improved functionalities to meet the future, operational flexibility, interoperability, implementation of distributed energy systems and reduced overall cost [5]. By the above key attributes, it can be noted that there’s a need to impart an intelligent system that can sustain the attributes of smart grid. The intelligent electronic device (IED) is the paradigm of innovation that specializes in the smart grid application. IEDs are used for monitoring the grid and protecting the grid meanwhile establishing the communication with the data centre. However, IEDs have limitations such as signal conditioning, filtering and discretization is not possible with common IED. In this paper, flexible IEDs are used which can be allocated with signal conditioning, filtering and discretization functions therefore it surpasses the aliasing effects and calibrates with high accuracy. In addition to this, the adoption of cellular communication is switched to power line carrier communication (PLCC). The PLCC is suggested in the paper to overcome the communication issues confronted during calamities and operator inefficiencies. In precise, the paper suggests an effective functional intelligent allocation in smart grid for imparting the self-healing, proactive and non-disruptive communication.

2. Proposed system

The figure 1 consists of the block diagram of proposed SG architecture in which the Intelligent Electronic Device (IED) is placed in between the generator and the transmission line and load. The communication established is the power line carrier communication (PLCC) which is fed from the IED. In real time, the power line carrier is implemented through PLCC MODEM equipment which does the function of injecting the data into the power line, sustaining the data without the loss or damage caused to it and extracting the sustained data at the other end. The PLCC MODEM equipment is bonded to the IED of the servicing area’s transmission line and interfaced to the medium voltage (MV) line of substation where data is monitored and stored. The above schematic employs the Orthogonal Frequency Division Multiplexing (OFDM) to disintegrate the PLCC MODEM signal to the wide bandwidth using n-number of narrow band sub-carriers. The PLCC communication is adopted to overcome the impacts inefficient network operator’s services. The flexible IEDs are used against common IEDs. In this paper, IED 61850 is presented. The below is the schematic of PLCC MODEM architecture.
The above schematic employs the NCN49599 which has the operational voltage range of 3V to 3.3V. The NCN49599 is compact and has high precision which is built on 4800 baud based on S-FSK technology. It is highly robust and has configurable GPIO pins and it is very suitable for metering purposes Figure 2. The PLCC communication is adopted to overcome the impacts inefficient network operator’s services. The flexible IEDs are used against common IEDs. In this paper, IED 61850 is presented. The power flow management of this IED is implemented through TivaC platform. The model IED 61850 has simple structure, highly compatible and high data exchange capability compared to other models. It consists of three core functions including digital signal processing (DSP), Filed Programmable Array (FPGA) and Power PC for good performance. The presented flexible IED can measure various parameters including voltage, current, temperature etc., at low cost. As it is processed through microcontroller platform, it shows high performance and security and can acts as the energy meter, dynamic controller as well as the supervisory controller. The features of this IED include the low cost, interoperability, high security, scalability and optimal acquisition. This IED is used for optimal acquisition of data, optimal data processing capacity and fast analog to digital conversion. The main aspects behind the use of flexible IED in this paper is its low cost, signal sensing, conditioning and filtering as well as discretization and signal processing. This feature shows high performance in analog to digital conversion rate and it acts as anti-aliasing filter which leads to better accuracy and reliability on the system. The other advantage of this IED is the inbuilt communication feature of Hybrid Network Architecture (HNA). It is compatible with electrical network which makes it suitable for power line communication topology. The SG thus, becomes robust and reliable under every environmental and power condition. As flexible IED and PLCC makes it so. Moreover, it is important to note that adding more functions to the IED demands high signal processing devices which proportionally increases the capital. But the presented system is complete for a robust SG and it can be implemented at low cost itself. However, PLCC MODEM equipment requires some substantial capital but it is a one-time investment, so it can be opted for the reliable SG design architecture.

3. Research Background

The recent proposal [1] advocates the employment of Wireless sensor networks distributed throughout the power network for power quality monitoring. It is designed for only 2-generation plants. The solar generator is equipped with the power conditioning unit (PCU). In this the power quality impacted by the varying consumer loads are sent to the communication controller. Therefore, it is evident that the paper proposes a monitoring method through wireless sensor networks which increases the capital cost that also impacts the operational efficiency and it has its own limitation for 2-generation plants. The paper [3] “Research and Implementation of ZFW20A-252 GIS Intelligent Control Unit” proposes a special function IED for GIS station which is responsible to provide EM shielding, stability and energy durability. In this the IED is connected with the primary equipment to monitor the operations.
However, the IED proposed has no anti-aliasing ability which leads to inaccuracy and therefore less operational efficiency. The paper [6] “IEC 61850 based substation automation system: A survey” interprets the various aspects of the hardware IEC 61850 such as information modelling, network architecture, hardware architecture, simulation studies, analytical modelling of traffic and deterministic architecture. The study shows that the interoperability and communication architecture make it best suitable for adaptive protection and Human Machine Interface (HMI) applications. The paper [7-9] “An analytic hierarchy process-based novel approach for benchmarking the power quality performance of grid-integrated renewable energy” explains about the PQI techniques elaborately and classifies it into two VQI and CQI. However, it didn’t advocate the temperature and other environmental effects on the power quality performance benchmark.

4. Design and Implementation

For robust Smart grid architecture as mentioned, intelligence must be imparted to make it self-healable and automated. It requires IEC 61850, PLCC MODEM equipment/PLCC Modem and other smart grid components. Each of the above consists of different components and functions. The flexible IED is composed of high-performance power PC, better digital signal processing functionality and FPGA features. The PLCC MODEM equipment as mentioned above consists of injectors, repeaters and extractors for effectively carrying the data to the other end of the power entity.

4.1. Flexible IED:

The IEC 61850 is implemented through TivaC platform and the launch pad used is EK-TM4C1294XL. The TM4C1294NCPDTI microcontroller based platform is used. The specifications of Tiva microcontrollers are 1 Mb of flash memory, 256 Mb of RAM and 6 kb of EEPROM. By this it is observed that it consists of large space for processing and storing. Besides it has multiple peripherals and multiple serial communication ports Figure 3.

Figure 3. Picture of Tiva C series TM4C1294

The Tiva C series is integrated with the simplified signal conditioning circuit which consists of Difference amplifier, anti-aliasing filter, programmable gain amplifier, Offset generator and digital potentiometer. The gain of PGA is set to 1:11 ratio which imparts safe measurement of voltage in the range of 30V (peak to peak) figure 4.

Figure 4. Signal conditioning circuit
**Differential Amplifier** – The differential amplifier produces the gain of the difference between the two sources.

**Anti-aliasing filter** – The frequency more than 10% are removed so that it satisfies the condition of Nyquist theorem to achieve optimal sampling.

### 4.2. PLCCC Modem

The PLCC MODEM does the function of injecting the data into the power line, sustaining the data without the loss or damage caused to it and extracting the sustained data at the other end. PLCC MODEM is said to have the capacity to authorize data transmission along the power lines to the homes and industries at data rates ranging from 500 kilo-bits per second or Kbps to 3 mega-bits per second or Mbps that is approximately equal to most cable modem transmission rates. Therefore, PLCC MODEM bestows modern complementary conventional method in order to procure high-speed data exchange capability or accessibility. Thus, this system is connected with the HNA of Tiva C series therefore reinforcing a reliable communication. In this, the injectors are used to incorporate the data within the electrical lines and the repeaters are used to optimize preventing from the loss of data through transmission. Finally, the extractors are used to extract the data and display it through the end-devices. The proposed system utilizes the OFDM as its modulation scheme. Rather employing a device that uses low voltage power lines, the proposed system does extraction of PLCC MODEM signals from the medium voltage lines and it is transformed into human readable data in the data centre. The duplex communication can be achieved therefore remote control over the grid is possible using this PLCC MODEM technology.

### 4.3. Smart Grid

Smart grid can be defined as the bidirectional information flow between utility services and consumers. The intelligence can be integrated within all kinds of smart grid architectures such as simple, complex, dynamic, massively interconnected system. The IEDs and PLCC will make the smart grid robust and intelligent Figure 5. To be precise, an intelligence layer is added to the smart grid architecture model (SGAM) in the proposed system which has the combination of three layers such as information, communication and function layer. A predefined data models are fed to flow within these layers of smart grid by the flexible IED and the IEDs make decisions regarding the functions and controls. It will protect the smart grid by isolating sending control signals to circuit breaker, monitors the power quality continuously and mitigates them by sending the control signals to the respective components, mitigates sag and swell and other PQ issues by reacting to the transients in the power networks, maintains high power factor thus making the smart grid more efficient Figure 6 and 7.

![](image)
4.4 Future Enhancement

The intelligent layer can be well established and defined with minimal component need and more functional allocation. The intelligent layer can be integrated with artificial intelligence for forecasting demand and sustaining the power quality and make the power network more interactive using wireless sensor networks and so on. Therefore, the grid can become more robust against vulnerabilities and might have a broader functional feature. Integration of such intelligent layer with AI also decreases the ecological footprint and carbon footprint eventually strengthening sustainable development.

5. Conclusion

The implementation of flexible IEDs in the smart grid and establishment of power line carrier communication makes the grid architecture immune at the time of crisis, may it be the power quality issues or natural disasters. As every single IED is connected through power lines, even if one part of the grid is isolated because of a fault, the information is sent to the control centre through the power line regardless of wireless network requirements. Moreover, flexible IEDs can be allocated with more functions as per the consumer requirements. Therefore, IED and PLCC proves to be an efficient, modular, interoperable and most reliable system that is best suited for Smart Grid Architecture model (SGAM).

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