Dc Battery Optimization in 275 Kv Main Gardu to Improve The Reliability of the Control System

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Abstract. This research focuses on optimizing the DC 110 V battery at the 275 KV substation in Pijorkoling Padangsidempuan, North Sumatra. By measuring the inverter connected to the battery side and the Human Machine Interface, it is found that the value of harmonic currents is in several orders, but because harmonic currents are in the 5th order, 11th order, 15th order, the author makes the LCL Passive Filter. on the output side of the inverter and Human Machine Interface in the hope of reducing the harmonic current. To make it easier for the author in the research, it was carried out using a matlab-simulink simulation. The result is that the THDi inverter on the inverter decreases from 110.9% to 49.57% or it is reduced by 223.72%.

1. Introduction

Distribution Substation is a convenient point for control and protection of the distribution network. The substation usually has the following equipment: bus substation, power transformer, circuit breaker, isolation switch, CT, PT, shunt capacitor, protection relay, lightning rod, station battery, earthing, structure, etc. The control system contained in the substation must remain ON even if a black out occurs or in the event of a disruption in the power supply from the power plant. This means that the Human Machine Interface (HMI), which is a monitor to see all control systems installed at the substation, must not turn off, or flash, even if it's only a few milliseconds. From this situation, we need a power supply that comes from a DC battery which is then converted by an inverter to an AC source as a supply to the Human Machine Interface (HMI). This is because the control system contained in the HMI if it dies will be very difficult to turn it back on and this HMI may be damaged. Moreover, this HMI system is quite expensive equipment.

The uninterrupted operation of the DC system of the distribution substation ensures the reliable function of not only the substation and its consumers, but also the entire node of the power grid. The reliable operation of the DC system is ensured not only by reliable selection of the element and power source (battery), but also by the quality of the design. The DC system has an important role in the operation of the substation. It is used for protection relay operation, control (DC 110 V and 220 V) and Scadatel operation.

The main parts of the system equipment are the DC Rectifier or Charger, batteries, conductors and terminals. Rectifier or charger is a series of electrical devices to convert alternating current (AC) electricity to direct current (DC). The battery is a storage area for direct current electrical energy devices, which serves as a backup source to the load. The conductor functions as a conductor of direct current electrical energy from the source to the load. While the terminal functions as a branching point where electrical energy is sent or divided by the load.

The 110 V DC battery will be connected to an inverter. The inverter is an electronic circuit that functions as a DC (Direct Current) converter which can come from batteries, solar panels, and other
DC sources. Inverters can be grouped based on the number of phases, the power components used, the output waveform, the type of control, and the circuit topology.

Previous research conducted by Harun et al which discussed monitoring systems for electrical energy parameters such as voltage, current, frequency, and phase differences received by customers. This system is intended to convince consumers about the quality of the electrical energy they receive. Another study has been conducted by Firdaus et al regarding the monitoring system for currents and voltages in network distribution transformers. Roy designed a system for monitoring different bus parameters at the substation from a centralized control room with the help of a Zigbee enabled wireless sensor network.

Other research focuses on Islanding Fault of Rectifier and Inverter substations in HVDC systems, both back to back and long transmission line systems. The effect of the system short circuit ratio (SCR), was studied as well. Action of system controllers, blocking of pulses from faulty converters and operation of the rectifier to inversion mode are the three control schemes studied here. Finally the results are compared with each other and with a system that has no control measures and the best method for each error is determined. All of these simulations were carried out using MATLAB-SIMULINK.

From the description above, it can be seen how a DC battery is very influential for a substation and other systems. For example, the use of a Protection Relay system, an inverter as a conversion tool from DC to AC, a control or control system or to operate the Human Machine Interface (HMI) connected to the inverter. Thus, the authors are interested in knowing how the battery is able to supply constant the parts referred to above and optimize it so that system reliability is better. To facilitate the process, the authors plan to create a MATLAB-SIMULINK simulation to facilitate the research process.

2. Methodology

The inverter used is a single phase inverter with a full wave system, with input of 110 VDC from 9 batteries with each battery having a voltage of 12 VDC. The inverter output is 220 VAC voltage, 5 Ampere current, 1200 Watt power. Inverter load is 500 Watt. The simulation carried out in this study uses the MATLAB-Simulink program by using a passive LCL filter that is installed parallel to the inverter and the load. Then the THDi is 110.9% which is converted into amperes and voltage units. When compared with the IEC61000-3-2 class A standard, there are several IHDi orders of measurement results that do not comply with the standard. Next, we observe the sinusoidal waves generated by the inverter.

![Research systematic diagram](image)
Table 1. PICOC Criteria

| Population | Distribution Substation is an important and main part to control and provide protection of distribution networks. The substations generally have the following parts of equipment: bus substations, power transformers, circuit breakers, isolation switches, CT, PT, shunt capacitors, protective relays, lightning rods, battery compartments, grounding, line diagram structures and human machine interfaces |
| Intervention | The system works without interruption from the DC battery part of the distribution substation to ensure reliable function to serve consumers and the entire network of electrical nodes. The reliable operation of the DC battery system is determined by the selection of equipment elements, and the quality of the system design. The DC system is used to operate the protection relay, control (DC 110 V and 220 V) and SCADATEL operation (DC 48 V) |
| Comparison | Previous research conducted by Harun and others discussed monitoring systems for electrical energy parameters such as voltage, current, frequency, and phase differences received by customers. This system is intended to convince consumers about the quality of the electrical energy they receive. Firdaus and others have conducted studies regarding the monitoring system for current and voltage distribution network transformers. Roy designed a system to monitor different bus parameters at the substation from a centralized control room with the help of Zigbee activated via a wireless sensor network |
| Outcomes | From the description above, it can be seen how the DC battery is very influential for a substation and other systems. Such as the use of the Relay Protection system, Inverters as a conversion tool from DC to AC, a control or control system or to operate the Human Machine Interface connected to the inverter. To facilitate the research process, the authors made a simulation using Mathlab-Simulink |
| Context | From several previous studies, books, it can be seen that research using human machine interfaces is very diverse, such as research in the field of industry, distribution substations, electric trains and others. so that in the future the use of the human machine interface is predicted to be increasingly complex to the point of touching the fields of plantations, tourism and hotels as well as the fields of military or police defense |

Table 2. Research Question (RQ)

| ID | Research Question | Motivation |
|----|-------------------|------------|
| RQ1 | How Inverters connected to a DC battery in a distribution substation | The inverter will function to convert DC voltage into AC voltage, this inverter is located between the battery and the human machine interface |
| RQ2 | How the Human Machine Interface (HMI) works at Distribution Substation | The human machine interface works with an AC voltage supply that comes from the inverter output. HMI functions to display and control the control system with the help of SCADA so that the electrical substation can be observed through a monitor in the form of a touch screen or a manual screen |
| RQ3 | How is the continuous availability of power supply when the battery is used | The availability of electrical power at the substation has a very big effect. Because if the input voltage source to the substation is disturbed, it will affect the control system such as the Human Machine Interface, while the HMI cannot be turned off. Because it can cause damage to the HMI with a fairly expensive repair cost |
| RQ4 | How to optimize the battery at the substation | To optimize the performance of the battery, a passive LCL filter is added to the inverter output and connected to the human machine interface |
3. Result and Discussion

To create a mathlab-simulink simulation configuration, the measured data and the amount of power, voltage, RMS current, IHDi current in each order of Inverter harmonics are used and the calculation of the RLC values of the passive LCL Filter is used. The simulation used in this study is MATLAB-Simulink by adding a passive LC filter that is installed parallel to the inverter and the load. Then compare the IHDi value that has been suppressed by the inverter, where before the THDi filter is added, it is 110.9%, and after installing the passive LC Filter the THDi is 49.57%.

Figure 2. Inverter simulation circuit with the addition of an LCL filter on the matlab-simulink

Figure 3. Sinusoidal waves after adding the LCL filter

Figure 4. Current Spectrum after adding the LCL Filter
By adding a passive LCL filter to the inverter, it can reduce the harmonic current flowing in the circuit released by the inverter. From the display of Figure 2.4, a study is obtained that the passive LCL filter is able to reduce the harmonic value of the current released by the inverter which gets an input of 110 V DC from the battery.

4. Conclusion
The measured inverter produces THDi of 110.9% with several harmonic orders that do not comply with the IEC61000-3-2 Class A standards, namely order 5, order 11, order 13, order 15.

Then after installing the passive LC filter on the THDi inverter the inverter decreased from 110.9% to 49.57% or reduced by 223.72%. After the simulation using MATLAB-Simulink by adding a passive LCL filter on the inverter side and the load that is installed in parallel, the results of changes in harmonic currents and waveforms are obtained. Thus, if, for example, there is a blackout in the substation system, the DC battery will work to supply DC voltage to the inverter.

In the inverter the process will issue an AC voltage. This AC output will be streamed to the passive LCL filter. The output of the LCL passive filter will be reduced in harmonics or muted and the sinusoidal current waveform is corrected. Furthermore, the current, voltage and harmonic waves from the passive LCL filter will be channeled to the Human Machine Interface (HMI) system, where the HMI operates with a 220 VAC source issued by the inverter. The function of this LCL Filter can be seen when a black out occurs, meaning that with the addition of a passive LCL filter on the inverter side, the current flowing from the inverter to the filter side will store the current before it is flowed to the Human Machine Interface (HMI) side.

Conversely, if a passive LCL filter is not added, the harmonic current value, the waveform does not meet the IEC61000-3-2 standard and if a blackout occurs, the HMI system will completely shut down. To restart it takes a very long time and has the potential to damage various equipment such as the Human Machine Interface as a smart computer that displays the substation control line diagram and its parameters. The next research is expected to conduct trials by adding an LC passive filter instead of LCL to find out the difference between the two in filtering the harmonic currents released by the inverter connected to the 110 V DC battery.

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