Energy Monitoring in Substation Using MATLAB

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Abstract-In the rapidly evolving energy sectors, efficient monitoring and management are pivotal for ensuring the reliability and sustainability of power distribution system. The paper titled "Energy Monitoring in Substation Using MATLAB" focuses on the development and implementation of an advanced system to monitor and manage energy in electrical substations. MATLAB, with its powerful simulation capabilities, aids in the modeling, analysis, and visualization of energy flows and parameters within substation. This paper aims to capture real-time data on energy flow, consumption, and health of system. The collected data is processed and visualized through a user-friendly interface, enabling operators to make decisions, optimize energy distribution, and reduce losses. The "Energy Monitoring in Substations" paper stands as testament to the integration of technology and smart design. Its implementation provides not only a more efficient and reliable substation operation but also a sustainable power grid.
Keywords- MATLAB, Substation, Energy flow.

1. Introduction

The growing demand for electricity coupled with the push for sustainable and efficient power distribution has put substations at the forefront of modern power system research. Substations, being pivotal nodes in the power transmission and distributiongrid ,require meticulous monitoring to ensure their efficient operation and to detectany anomalies promptly. Given the increasing complexity and sophistication of modern power systems, traditional methods of monitoring are no longer sufficient. This project leverages the computational prowess of MATLAB, a leading numerical computing environment, to monitor, analyze, and optimize the energy flow in substations. By integrating advanced algorithms and data-driven approaches, this venture aims to revolutionize how we perceive energy monitoring and ensure a more resilient and efficient power grid for the future.

The economic and social effects of loss of electric service have significant impacts on boththeutilitysupplyingelectrical energy and the end users of electric service. The cost of major power outage confined to one stable can be on the order of tens of millions of rupees. If a major power outage effects multiple states, then the cost could exceed million Reliability overall can be improved byloweringeitherthefrequencyortheduration ofinterruptions.Preventivemaintenanceactivitiescouldimpact on the frequency by preventing the actual cause of the failure. Consequently, preventive measures are cost-effective when the reliability benefit outweighs the cost of implementing the preventive measures. There is ,therefore ,a need for utilities to incorporate systematicmethodswhichrelatemaintenanceofsystemassetsmanagement.Assetmanagementinvolves making decisions to allow the network business to maximize long term profits. While delivering high service, maintenance planning techniques have separately been well developed, with reliability assessment in starting. However, few techniques are generally put in practice. The reason for this the lack of suitable input data and a reluctance to use theoretical tools to address the practical problem of maintenance planning.

2. Modeling of Three Phase Energy Monitoring System

The simulation was studied on three phase energy monitoring system using MATLAB Simulink software. The performance of 33KV/11KV substation was analyzed with different types of loads. This simulation model of three phase energy monitoring help to provide data to the engineer towards consumption of energy by showing their energy pattern of their daily utility.Fig2.1showstheflowchart for modeling energy monitoring system using MATLAB / Simulink Software. The voltage and current were measured for different loads of R-L load.This system used to measure the energy consumption by the consumers. The value of voltage and current depends on the load used.The measurement of the energy consumption can be seen interm of graphical display of the different load used.

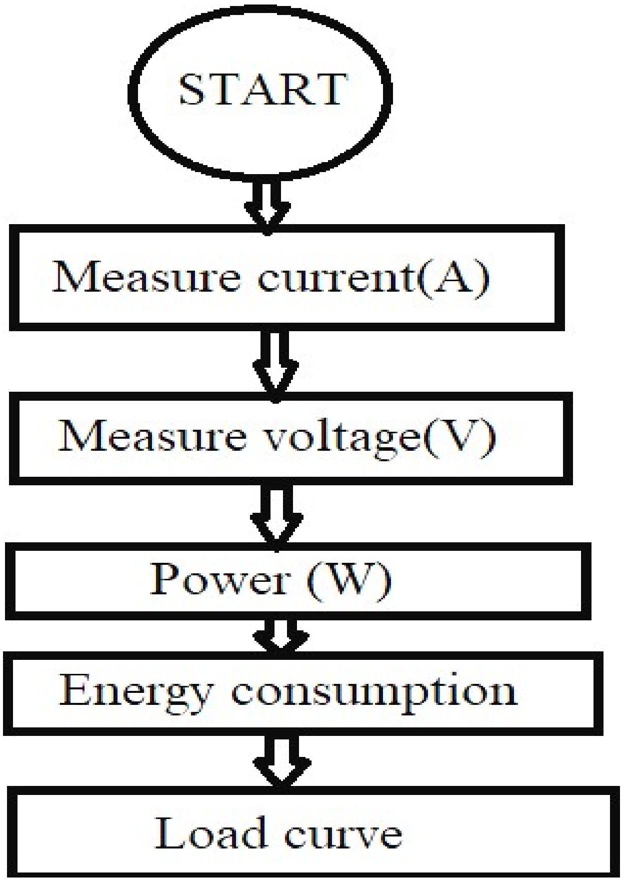

Fig2.1Flow Chart for Modeling of Energy Monitoring system

3. Block Diagram

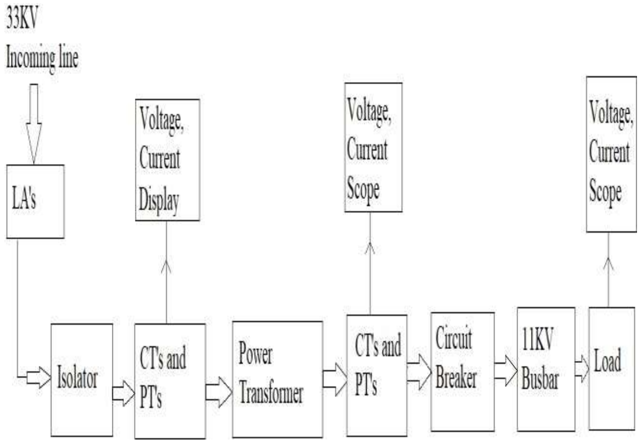

Fig3.1BlockdiagramofEnergyMonitoringsystem

A33/11kVsubstationprimarilytransformspowerfromahighervoltage (33kV)to a lower-voltage(11kV)suitable for distribution to homes, industries, and other consumers.Thehigh-voltagelinescarrypowerfromthegenerationplantorahigherlevelsubstationintothe33/11kVsubstation.

1. **33kVBus-Bar**:
Once the electricity enters the substation, it is directed to the 33kV bus-bar. A bus-bar is a conductor that distributes power to various outgoing lines. Some substations have multiple bus-bars for flexibility and redundancy.

2. 33/11kVTransformer:
This is the heart of the substation. The 33kV power is fed into this transformer, which steps it down to 11kV. This transformer is typically oil-filled to provide cooling and insulation. There are often protections, metering, and monitoring equipment attached to ensure the transformer operates efficiently and safely.

3. 11kVBus-Bar:
After stepping down, the 11kV power is fed to the 11kVbus-bar, which distributes it to the various outgoing 11kVfeeders.

4. 11kVFeeders:
Thesefeederscarrythestepped-down11kVpowertovarious parts of a city, town, or rural area. Each feeder can serve a specific region or type of consumer (like a large industrial complex). After distribution on the bus-bar, the electricity is sent out on 11kV feeders. These will further branch out, and transformers along these routes will stepdown the voltage further for consumption by end-users.

4. Simulink Blocks

1. Threephasesource: TheThree-phaseSourceblockimplements a balanced three phase voltage source with aninternalR-Limped-ance.ThethreevoltagesourcesareconnectedinYwithaneutralconnectionthatcanbeinternallygroundedormadeaccessible.

2. Threephase VI measurement:The Three-PhaseV-I Measurement block is used to measure instantaneous three phase voltages and currents ina circuit.When connectedin series with the three phase elements, it returns the three phase to ground orphasetophasepeakvoltagesandcurrents.

3.Threephasetransformer: Thisblockimplementsathreephasetransformerusing-threesingle-phasetransformers.

4.Threephasebreaker: The Three-PhaseBreaker blockimplementsathree-phasecircuitbreakerwheretheopening and closing times can be controlled either from anexternalSimulationsignal(externalcontrol).

5.D.emux: The Demux block extracts the components of aninputvectorsignalan-doutputsseparatesignals.Theoutputsignalportsareorderedfromtoptobottom.

Scope: This block is used to view the waveform of variouselectricalquantities.

6.Root mean square (rms): The RMS block computes thetrue rootmeansquare (RMS)value of the input signal.The true RMS value of the input signal is calculated over arunningaveragewindowofonecycleofthespecifiedfundamentalfrequency.

7.Step: The Step blockprovidesastepbetweentwodefinablelevelsataspecified-time.Ifthesimulationtimeislessthanthe Steptime parametervalue,theblock'soutput is the Initial value parameter value. For simulationtime greaterthanorequal to the Step time, the output istheFinalvalueparametervalue.

5.Simulink Design

1. **With Variable Load:**

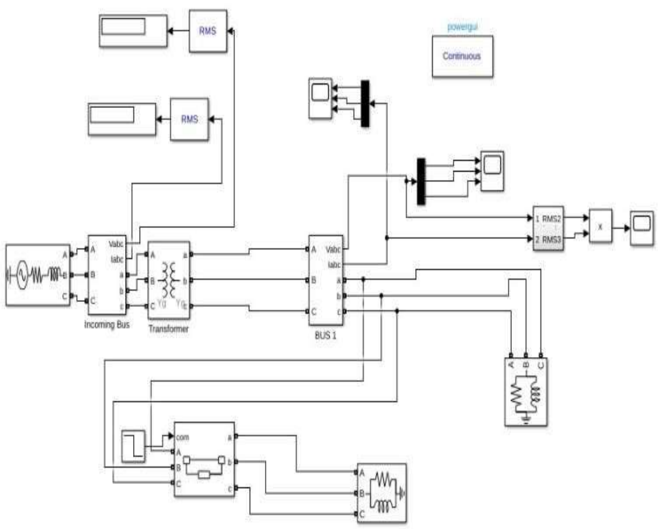

Fig 5.1:Simulink design with variable load

2. With Constant load

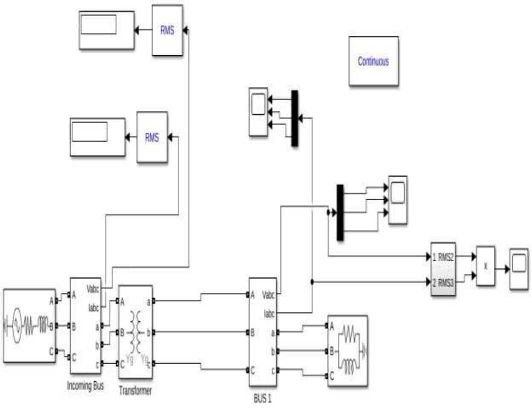

Figure5.2:Simulink design with constant load

6. Results

1. **With Constant Load:**

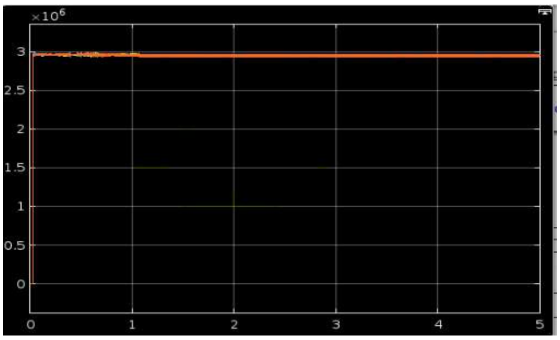

Fig6.1: Simulation result with constant load

2. With Variable Load:

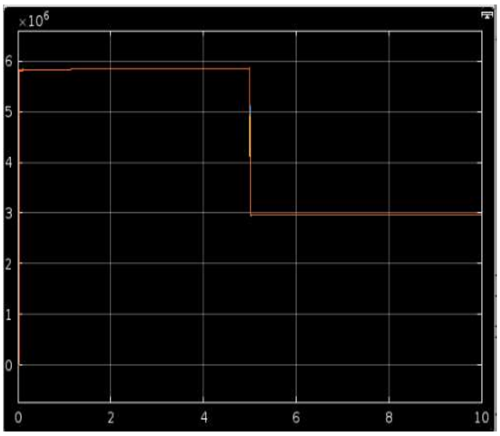

Fig6.2:Simulation result with variable load

7. Conclusion

Thus in this paper we have designed energy flow model in MATLAB Simulink, and showcased current, voltage and power waveforms under different timings in day in MATLAB Simulink. The coordination between all equipments present in the substation results in proper operation of the system. Thus the peak value of energy required in a day can be observed in the output waveforms. We can take necessary inputsforefficientandeffectiveoperationofthepowersystem.Inconclusion, as the energy sector continues to evolve and technology advancements occur, the scope for projects related to energy monitoring in substations using MATLAB is vast. It can play a crucial role in optimizing energy usage, ensuring equipment longevity, enhancing security, and much more.

8. Future Scope

The effect of the simulation parameters such as power system data, transmission line data, load data and fault data on fault needs to be studied. For future enhancement, the model can be extended for every substations. Researcher can also think to implement monitoring modeling in real time system of power system. As IoT devices become more prevalent in energy systems, integrating them with MATLAB for real-time data monitoring can enhance the accuracy and efficiency of energy monitoring. As the energy sector shifts towards more renewable sources like solar and wind, MATLAB can be employed to optimize and balance the energy from these sources in the substation..As smart grids become more popular, substations will play a pivotal role in ensuring the grids' efficiency and reliability. MATLAB can assist in creating algorithms and tools that help in the seamless integration of traditional grids with smart grids. As many industries move their operations to the cloud, integrating MATLAB's energy monitoring capabilities with cloud platforms can offer more scalability, redundancy, and remote monitoring capabilities.

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