Power System Protection For Islanded Microgrids

Electrical Power Analysis (EE 436) – Midterm 2 – Research Proposal

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***Abstract* — In this Paper, a protection strategy is proposed for assuring reliable and safe operation of an islanded microgrid system using digital current sensors and circuit breakers.**

***Keywords* — Microgrid, DG-distributed generation, Protection, Fault, Islanded.**

I. INTRODUCTION

Microgrid is an evolving form of power distribution system which is embedded with a combination of different kinds of power generation sources, identical to renewable energy sources, combined heat and power (CHP), and distributed energy resources (DER). The advantages of Microgrid formation are low power transmission and low power distribution cost, and, potentially, high reliability, high efficiency and low environmental impact. Micrograds are comprised of low voltage (50-100V_{rms}) distribution systems with distributed energy resources (DER) and controllable loads which can operate connected to a medium voltage grid or can be islanded in a controlled and coordinated way. Distributed generation, also known as distributed energy by a variety of small, grid connected devices mentioned as distributed energy resources (DER). Microgrids are modern small-scale centralized electricity system. DER include those technologies that allow generation in a small scale also known as micro-sources and Renewable energy sources such as solar, wind or hydro-electric. In addition to the power generation they may include energy storage systems such as batteries and flywheel [1].

The microgrid has an advantage of reducing transmission losses by being close to the load and preventing network congestion i.e. insufficient energy to meet the demands of all customers. This is overcome due to the availability of adjacent micro-sources. Micro-grids generally span a geographical area of 1km and rarely do they exceed 1 MVA [1].

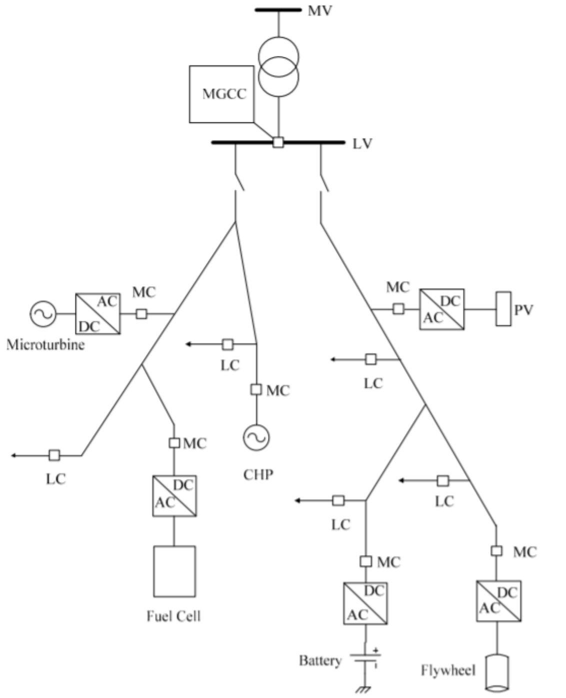

Figure 1: Microgrid Construction

Where; *MGCC → Microgrid Control Center*
CHP → Combined Heat & Power Distribution System
PV → Photovoltaic Arrays
MV → Medium Voltage Distribution System
LV → Low Voltage Distribution System

II. BASIC PROTECTION ISSUES

The microgrid needs to be protected in both island and grid modes. A static switch exists between the main grid and the microgrid that connects the microgrid to the main grid. In case of a fault within a section of the microgrid, the static switch opens. The fault then needs to be cleared within the microgrid before the main grid is connected back. Major issues occur with inverter based sources such as those present with photovoltaic cells which cannot source sufficient fault hence traditional protection schemes that require a high magnitude fault current cannot be used [1] [2].

Furthermore, short circuit currents which are used in over current protection relays depend on a connection point and a feed-in power from distributed energy resources will vary due to varying nature of operating conditions due to the intermittent micro sources and periodic load variations [2].

Differential relays are generally used to detect single line to ground faults within an islanded microgrid but it greatly depends on the layout of the microgrid i.e. how the zones are connected with each other in some zones the differential relays may only detect upstream or downstream faults or no faults at all due to the presence of distributed generation sources. In such circumstances a loss of relay coordination may occur and selective operation for all possible faults may not be achieved [2].

III. PROPOSAL

Considering the fact that Microgrids are small in geographical area and the line currents in different zones vary over time, we propose a centrally controlled adaptive protection scheme that is totally digital. Every zone is monitored via current where digital current sensors which relay the current information to a central hub. The hub then monitors and calculates the actual current values based on the sensed values. In case of a fault the hub actuates circuit breakers where the fault occurs. When the fault is eliminated power is restored to that section of the microgrid. Alternatively, instead of having one hub, a number of hubs can be introduced which monitor sub sections of the microgrid which further decrease the lag time and actuation time.

A. Advantages

It is a selective based protection scheme and takes in account the varying nature of the microgrid currents as everything is being monitored in real time based on adaptive algorithms. It is responsive as the microgrid is small due to which the sensing and actuating signals do not have to travel far enough in order to monitor or influence the microgrid therefore minimal lag time is expected.

B. Disadvantages

Some problems that we may expect are: the hub needs to be completely isolated from the grid i.e. it needs to run on its own power in case a fault occurs in the region supplying power to the hub. Backup power for the hub needs to be provided in case it goes down. A safety switch needs to be in place which causes a grid wide blackout in case the hub goes down as in this case the grid remains unmonitored and which may cause undetected faults to damage essential power equipment. Many zones need to be monitored therefore, many current parameters need to be taken into account not to mention new current parameters as the zone is expanded. The system is costly as it requires digital equipment hence, it may be applicable to small microgrid such as those in military applications.

Although, the disadvantages of the system outnumber the advantages of the system however, it must be noted that the system will surely protect against faults as everything is being monitored. A conceptual and a proof of concept is required in order to assess the complexity of the system. Once the system is designed, tested and implemented it may lead to further research into cheaper current sensors. Microgrids offer various advantages to end-consumers, utilities and society, such as:

- Improved energy efficiency.
- Minimized overall energy consumption.
- Reduced greenhouse gases and pollutant emissions.
- Improved service quality and reliability.
- Cost efficient electricity infrastructure replacement.

In light of these, the microgrid concept has stimulated many researchers and attracted the attention of governmental organizations in Europe, USA and Japan [Kropos2008, EU2006, and SGrids2006]. Nevertheless, there are various technical issues associated with the integration and operation of Microgrids.

IV. PROJECT TIMELINE & BUDGETING

The timeline shown in figure 2 is based on the fact that we need to make a microgrid of our own to test our system. The designing and simulations need to be done before the system is complete to account for the limited budget and resources such that no parts get damaged while in use. Some parts are easy to procure therefore, some segments of the grid can be installed. Data collection and analysis can only start once the system is completely installed. Data collection and analysis can only start once the system is completely installed. After sufficient data is collected and the system and the algorithms can be analyzed and the findings published. Figure 3 shows the costing breakdown.

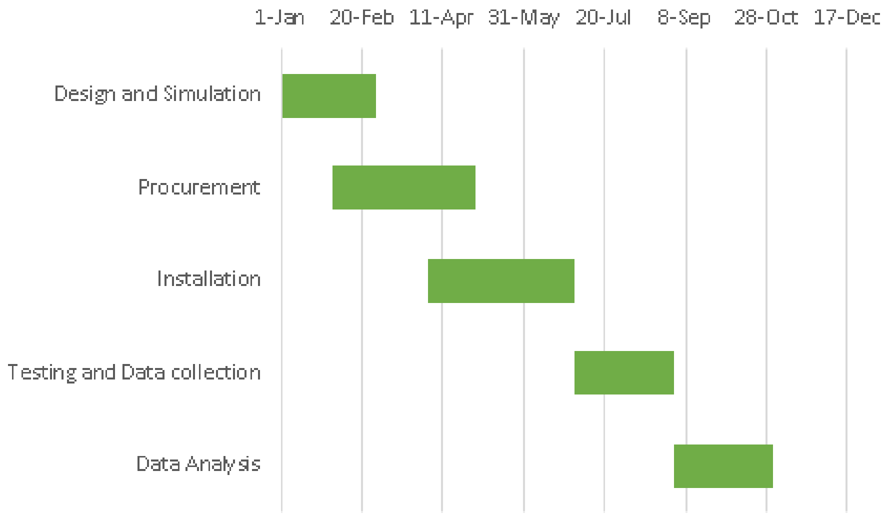

Figure 2: Project Timeline Gantt Chart

Power System Protection For Islanded Microgrids - Budget

Under/Over : $6,750.00

Budget summary

Category	Total	Description
Total Budget	***200,000.00***	
Property Charges	30,000.00	Property rental costs for one calender year - $2,500 per month
Photovoltaic Cell with Inverter	18,000.00	10kW VFD off grid solar panel inverter - $1,800 per unit (100 units)
Digital Sensors & Digital Relays	11,200.00	Digital sensing relay - $1400 per unit (8 units)
Transmission Line	12,000.00	$1,200 per metric ton (10 metric tons)
Circuit Breakers & Static Switches	7,050.00	$800 per CB & $650 per SS (8 CB + 1 SS)
Gas Generators & Fuel	10,000.00	25kVA - $4,000 per unit (2 units + fuel)
Batteries	7,000.00	10kWh
Time Varying Load	10,000.00	Motors, heaters, resistive loads, etc.
Computers & Programming	25,000.00	Algorithm design and managing team
Digital Hardware Interfacing	18,000.00	Computer interfacing and hardware
Setup & Installtion	25,000.00	Equipment and infrastructure establishment
Transformers	8,000.00	Low/medium voltage transformers - $2,000 per unit (4 units)
Miscellaneous Expenses	12,000.00	Maintenance, travelling, shipping and administrative expenses
Total Expenses	***193,250.00***	

Figure 3: Project Budget

V. BIBLIOGRAPHY

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