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Microgrids Based on Regionalised Authority and Control

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ABSTRACT- Since its inception in the late 1800s, the electrical infrastructure has only grown throughout the previous century. The demand for and need for this infrastructure will increase as the world's reliance on electrical energy grows. This puts a burden on the present infrastructure, demanding frequent equipment improvements. With the fast adoption of electric vehicles, for example, power lines that were previously suitable for family and commercial loads will be stretched to their limits, and an upgrade may not be a possibility. In this case, microgrids, or localized generation and consumption, are a superior option. However, because to their dispersed nature, controlling and coordinating the generating sources is exceedingly challenging. To address this problem, an alternate microgrid architecture with control localized to individual sources is proposed. This is the essence of microgrid distributed control. This research describes and evaluates a micro-grid architecture that comprises many, independent sources connected by a shared DC bus, as well as built-in battery storage, power monitoring, and protection systems.

KEYWORDS- Decentralised Authority, Localised, DC bus, Vehicles

I. INTRODUCTION

As demand for power rises, current infrastructure will be insufficient to provide it, and generation will eventually peak. Several scattered sources, such as solar photovoltaic (SPV), wind turbines (WT), diesel generators (DGs), and even newer uses, such as electric vehicles (EVs) used as a battery source, are being integrated into traditional grid architecture to address this situation. This raises the question of how to coordinate and govern all of these sources. If a typical approach for relay protection is employed, as it is in substations, it will be more difficult to use for distributed sources, because existing relay systems are properly synchronized and monitored in operation, with GPS clock systems coordinating responsibilities. . To deal with this situation, the simplest solution is to install an independent control system at the distributed sources that can select when to activate the source and how to handle failures using standardised procedures and equipment. The usage of distributed renewable energy sources such as solar photovoltaics (SPV) and solar thermal power is growing at an unprecedented rate, making the microgrid the ideal option for future system changes. The goal of this paper is to construct a basic multisource system and a distributed control mechanism that allows each unit source to respond independently. After creating the system in Simulink and watching its behavior, this is performed by running a simulation in MATLAB. The data is explained and inspected to confirm that the system is working properly, and any inconsistencies are attempted to be explained..

II. OBJECTIVES

The purpose of this study is to demonstrate the advantages of a micro-grid system with decentralized control via simulation. The system is designed and implemented in Simulink, and the system data is reviewed, which includes the system's variable load and DC-AC conversion via an inverter.

III. LITERATURE REVIEW

Energy investments are expected to reach $40 trillion by the mid-2020s, according to the International Energy Agency [1]. Energy is no longer mainly generated in large power plants, as it was many years before [2]. As a result of new global standards and agreements, power generation models are developing, and these changes are presenting new opportunities. Decentralised power production (DG) is one option, which will make renewable energy a major player in the electricity market. This dispersion might be used to solve problems like reliability and fail-safety. Reduce greenhouse gas emissions while simultaneously benefitting consumers and producers [3,4]. Microgrid (MG) is a type of ecosystem that may provide such specialized power producing resources. Microgrids are classified in a number of ways. Microgrids, on the other hand, should have three important components, according to the majority of experts in the field: production and demand management systems, well-defined boundaries, and island capacity [5,6]. Renewable or conventional energy sources can be used in decentralized power generation. The microgrid is mostly electric and runs on either alternating current or direct current, but it may also have thermal components for heating. Because demand is so close to these generating regions, there are limits. The system isn't as big as the main network. The microgrid can function independently of the network, be linked to it while being disconnected from the broader grid, or simply operate in "island" mode [7, 10].

IV. METHODOLOGY

To determine the performance and implementation of a decentralized microgrid control architecture, the microgrid structure is designed in Simulink and simulated. The performance of the data obtained from it is evaluated, and a conclusion is formed.[8]

A. Microgrid and design in MATLAB

The configuration for this project is a microgrid simulation that includes three sources, two solar sources, and a storage battery source. There are two types of loads in the converter: those on the DC bus and those on the AC side. In this scenario, the inverter feeds three-phase energy to a variety of switching loads. Individual breakers are utilized to connect the sources, each with its own processing for faults, malfunctions, and connections to common power lines. The faults are simulated twice: once before the inverter and again after it. The findings are presented in the Results section[9]. To begin, all of the numerous components involved are outlined, as well as how they work. The implementation of these components is discussed in the next chapter, which includes MATLAB code for each component. Incoming radiation is converted into power using solar PV cells, which are semiconductor devices. The source in the case of SPV is solar in nature, or simply sunshine. Because the visible band contains the bulk of the radiation that reaches the earth's surface, these cells or units are designed to work best around the 540nm band, which is almost in the middle of the visible spectrum (Yellow-Green colour boundary).[4] The following stages are required for the operation of a photocell:

- Light absorption and electron-generated hole pairs
- Charge carriers of opposing types must be separated.
- Connect the charge carriers to the external circuit via wires.

Individual cells are integrated and formed into modules, which are rectangular in shape and have a protective transparent front and solid rear covering. UV radiation causes the semiconductor crystal structure to shatter at microscopic levels, therefore these housings shield the cells from UV-induced damage or decay. This eventually leads to overheating and a decrease in performance. Thus, a panel touted as capable of lasting 25 years will endure 25 years; nevertheless, performance begins to deteriorate rapidly after a few years, rendering the panel useless because the basic efficiency for this technology in commercial systems has yet to exceed 20%.[3]

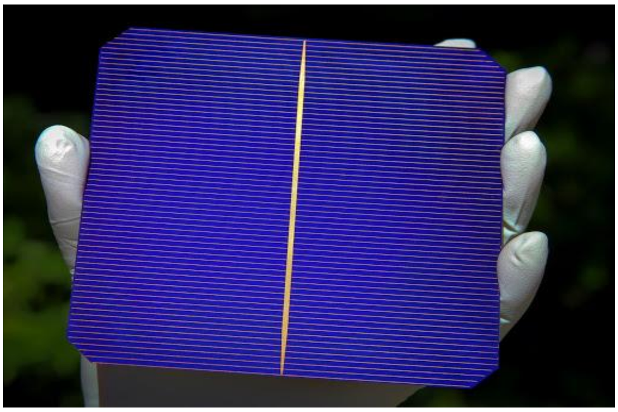

Figure 1: Single unit panel

This single unit is made up of multiple smaller horizontal stripes, each representing a different cell. as shown in figure 1. These components are connected to form panels, as seen below in figure 2.

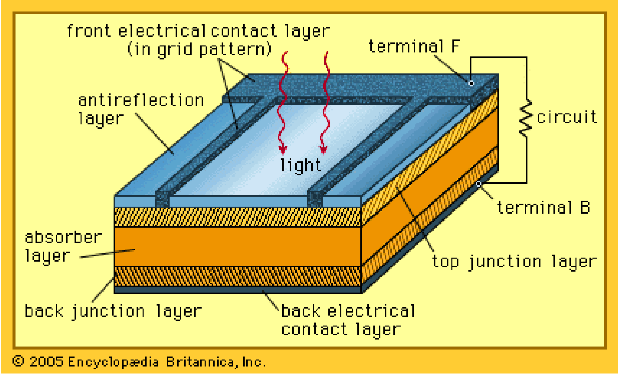

Figure 2: Solar photovoltaic cell

B. SPV operation

The photovoltaic effect, in which a photon supplies energy to an electron in a semiconductor, forcing it to cross the junction and create voltage, is used to power the SPV cell. Each cell has the potential to produce a very low voltage and power of around 1.2 volts. Multiple cells are connected in series for larger voltages and power ratings, and in parallel for higher current ratings. To depict the current generated as a function of incident light, voltage across the cell, internal drops, and terminal resistances, solar cells are usually described as a single current source in parallel with a diode and shunt and series resistances. The figure 3 can be used to quickly model the solar system.

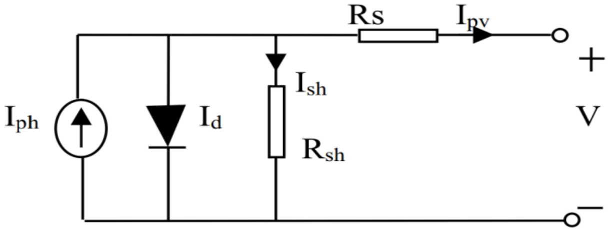

Figure 3: Kirchoff's circuit

Using Kirchhoff’s Laws, we obtain;

$$Ipv = I_{Ph} - I_d - \frac{V + IR_s}{R_{sh}}$$

The next component that is used to modify the voltage value is the DC-DC boost converter. This is a switch-operated voltage regulator. It uses an intermediate energy storage medium to control the output, and inductors are used to store the energy. The figure 4 shows a quick overview of the converter and its input/output connection. Closed loop regulators make up the bulk of DC-DC regulators..

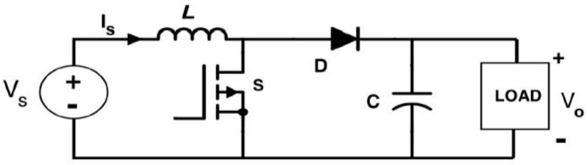

Figure 4: Circuit with load

Vs stands for the input source, L for the inductor, D for the diode, S for the switching device, which is usually a MOSFET, C for the output filter capacitor, and Vo for the voltage sensed by the load in this equation. The expression linking input and output in this case is;

$$V_o = \frac{V_s}{1-k}$$

The duty cycle of the PWM controlling the switch S is represented by k in this example. The converter operates by altering the switch's on and off duration, and hence the energy stored in the inductor. This helps to keep the output voltage level in check. The system, on the other hand, has a design flaw in that the output voltage is always greater than the input voltage and cannot be reduced. The switch is switched off, the inductor saturates, and the output equals the input when the duty cycle is zero. The converter is designed to work within a specific voltage range and cannot be used outside of that range without changing component values or the design.

C. Protection control

Protection relays and localized control; every generator and load is protected in some way. A circuit breaker provides protection in this case, which is controlled by on-site voltage and current sensors to make and execute the decision locally. If there is a failure near to the source that affects its performance, the breaker trips. To avoid any potential dangers, icrogrid must be separated from the main grid. Because this is not a fault state, the microgrid must be notified manually and isolation must be conducted. The solution to this problem is to use a maintenance communication connection, which might be based on wireless communication and isolates the microgrid from the grid.. The next part shows the relay-breaker design for this circumstance. A breaker set is included in the design, which is used to turn on and off the connection between the generator and the local transmission lines. Relays, on the other hand, detect abnormalities and send a tripping signal to breakers and the central controller, which then creates appropriate indicator signs or signals. This can be seen in figure 5, .

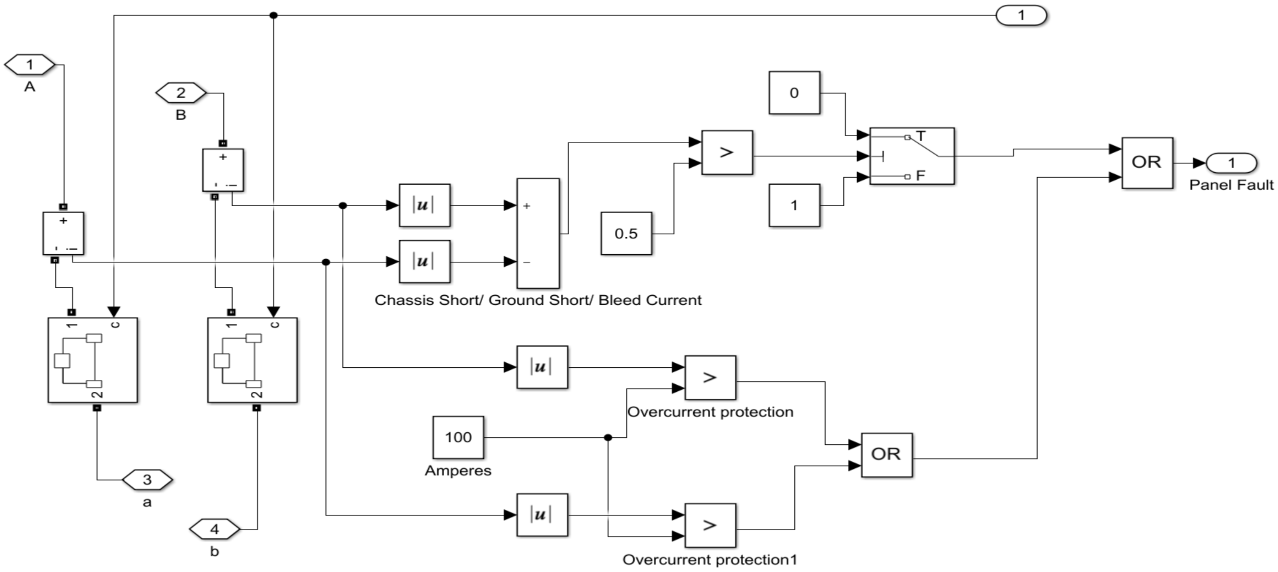

Figure 5: Circuit with relay breakers

On the left side, the circuit breakers appear to be closed. Because both lines in DC are referenced to each other and thus both are powered when in use, there are two circuit breakers. In this scenario, the protection system looks for two things: overload and short circuit. The first section compares the absolute magnitudes of the current in both lines to see if they are the same; if they differ by a certain amount, it is assumed that a leakage has occurred in the current path, which might be dangerous. When the bot breakers trip, the line is isolated and a trip signal is sent to the operator or a control system like a Scada utility. As soon as possible. The overcurrent or overload fault is the second component, which happens when the current exceeds the rated value for a lengthy period of time. If the current value exceeds the maximum specified limit again, the breakers are tripped, the system is disconnected, and a trip signal is generated to alert the control system and operator.t. The fault is purposefully produced after inverter 1, leading the pre-inverter breaker to trip in simulation. The second inverter, on the other hand, continues to receive and operate in this condition. This exemplifies the advantages of a microgrid with distributed control. Because the inverter may be immediately isolated at or near the source of the problem. The rest of the system is still up and running.

D. Simulation

The simulation is divided into two stages, the first of which simulates the three sources: two different solar PV designs and a lead acid battery bank storage source with a notional capacity of 400Ah and 160V. In the second simulation, the sources are replaced with simple regulated voltage source equivalents, and the DC bus is fed to two inverters that operate two different types of loads.. The inverters are single-phase H-bridges with a single control pulse provided to the switches through appropriate signaling circuitry. The control signal in this case is sinusoidal pulse width modulation, or SPWM. In the results area, you can see the waveform. The duty cycle is 10 kHz, the sin constant is 50 kHz, and the construction is under modulated with a modulation index of 0.9. This can be seen in figure 6.

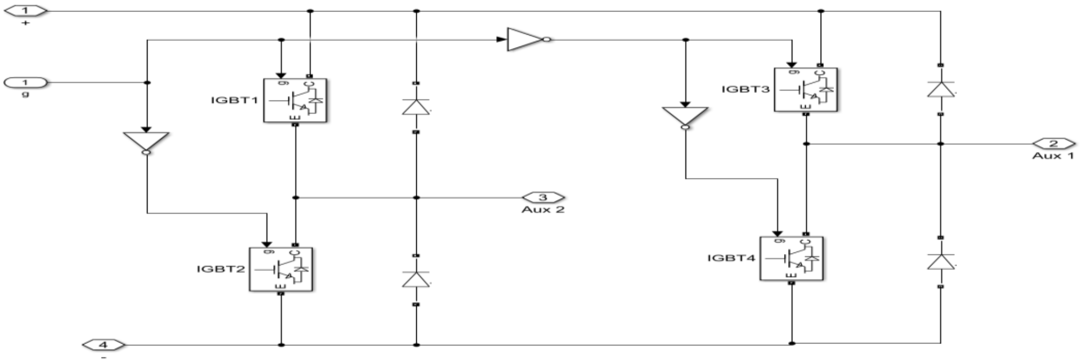

Figure 6: Simulink H bridge

H-Bridge design in Simulink The signal is conditioned by NOT gates so that no two switches in the same leg turn on at the same time. To prevent the leg from being shorted in real-world systems, the signal must be slightly offset to generate a delay known as dead time. SPWM schematic can be seen in figure 7.

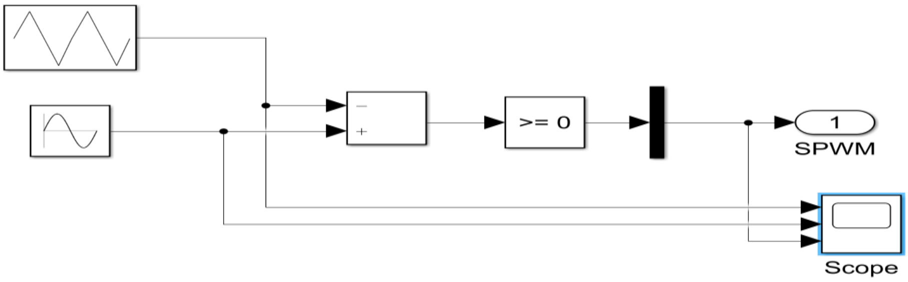

Figure 7: SPWM schematic

The carrier is compared to the reference, and the waveform that results is PWM, with a duty cycle that varies with the sine wave's rate of slope.

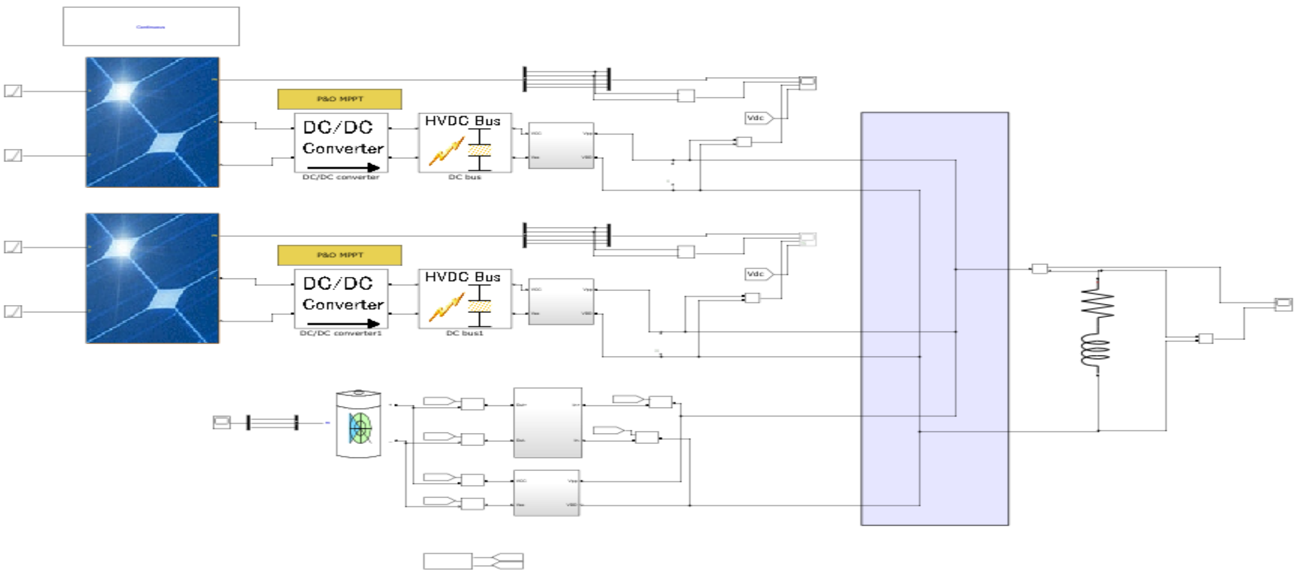

Figure 8: Proposed workflow

Figure 8 shows the proposal workflow. The primary simulation block is shown in blue, and it links several sources to the same DC bus.

The solitary PV source leg in this configuration is shown below in figure 9.

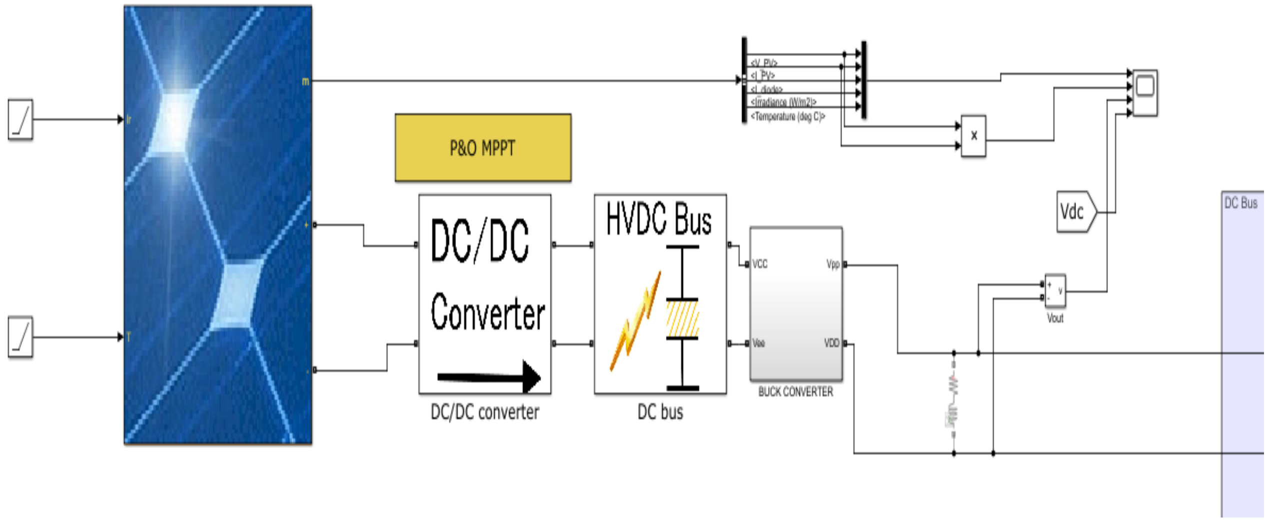

Figure 9: z PV Source leg

The PV panel array system feeds electricity to a maximum power point tracker, or MPPT block. To obtain the greatest power out of the panel, the perturb and observe strategy is used in this situation. The DC-DC boost converter, in combination with the HVDC filter capacitor block, performs MPPT. However, the buck converter that follows it is used to lower the high voltage to the 100V fixed level in order to acquire a fixed voltage on the DC bus. When many sources share a load, each source's voltage can be adjusted to control the amount of load handled by each source unit. A buck converter's internal architecture is as follows shown in figure 10. The inbuilt controller gain is 40000, and the switch's control frequency is 10kHz. At 100 volts, the condition is set..

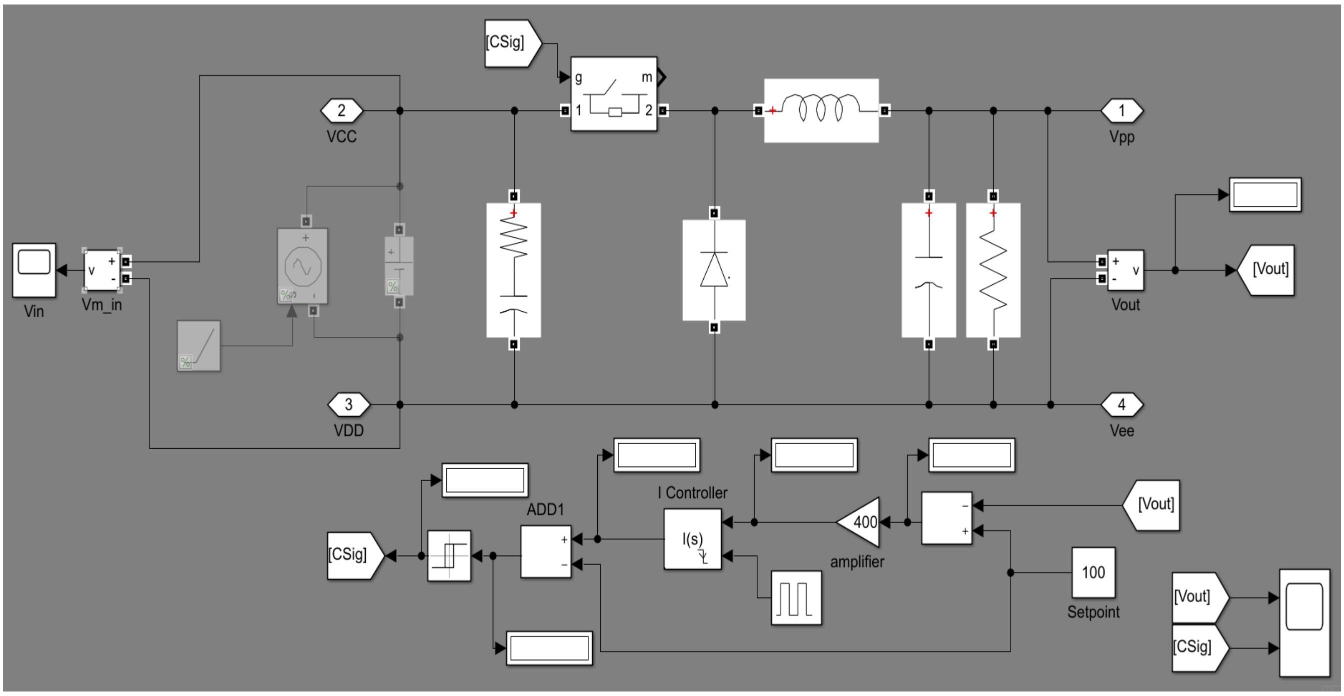

Figure 10: System circuitry

The battery stores energy while the load is low and then uses it until the prices are high, both during blackouts that occur all through night as seen in figure 11.

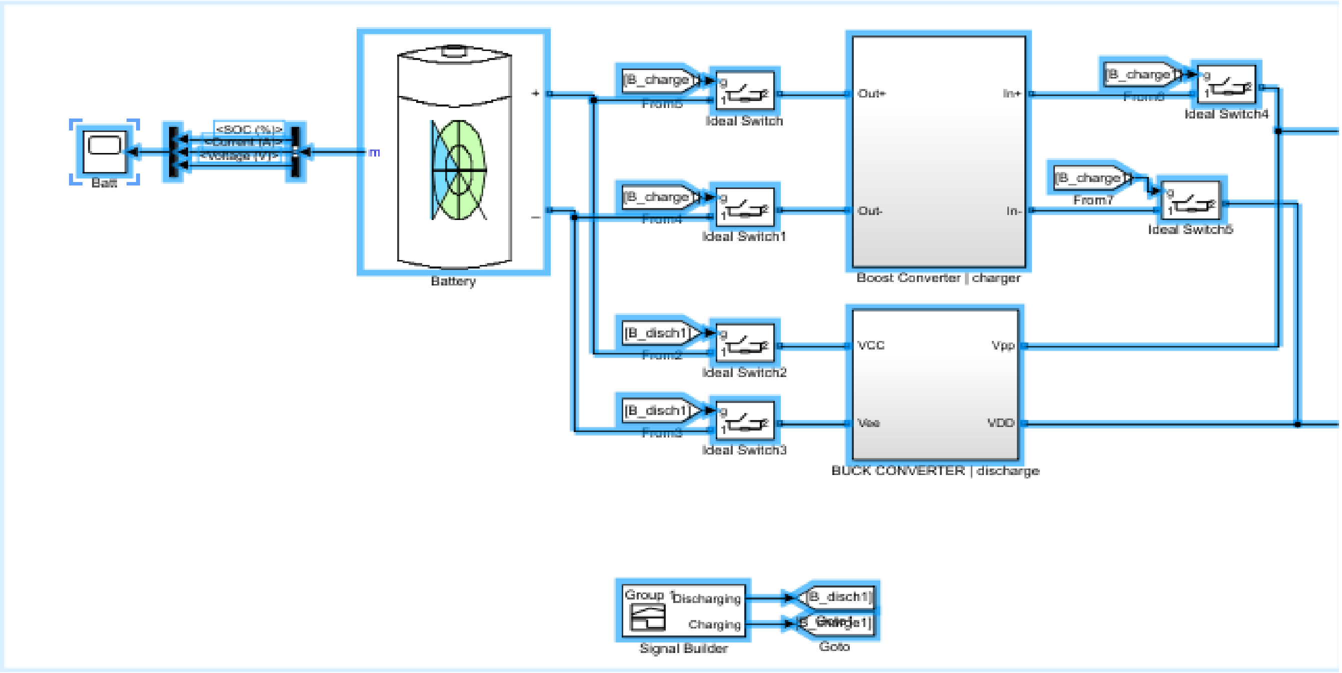

Figure 11: Battery charging

The battery has a 160V nominal voltage. Charging, on the other hand, necessitates a higher voltage, in this case 200V. The boost converter is used to acquire a greater charging voltage, and the buck converter is used to drop voltage to the DC-bus level of 100V when the battery provides energy. The switches and signal building block are in place to keep the power flow from becoming too irregular. As a result, the battery may only charge or drain at any one time. The boost converter block is configured to generate 200V for charging, as seen in the image below in figure 12 .

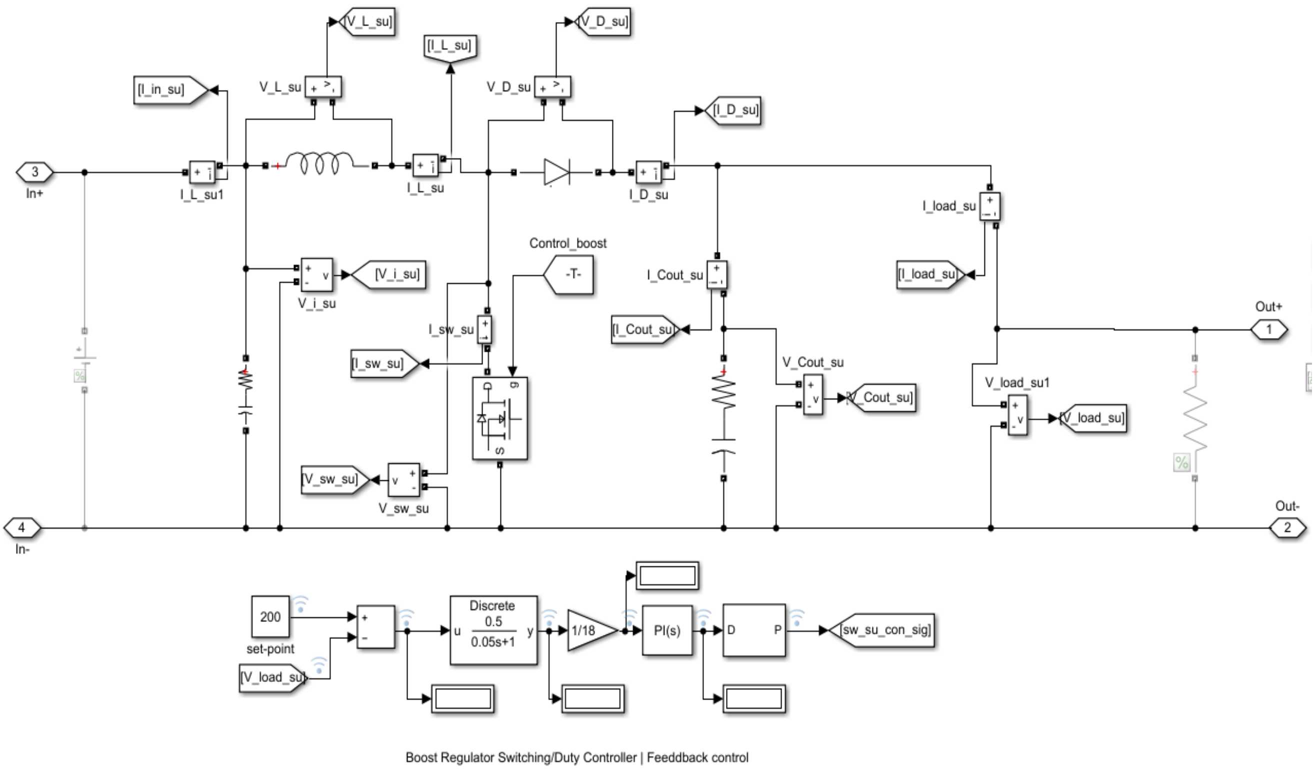

Figure 12: First simulation

The simulation's next component is the protection plan. The use of regulated DC sources to emulate sources and the use of breakers were previously described.

The figure 13 shows the second simulation design..

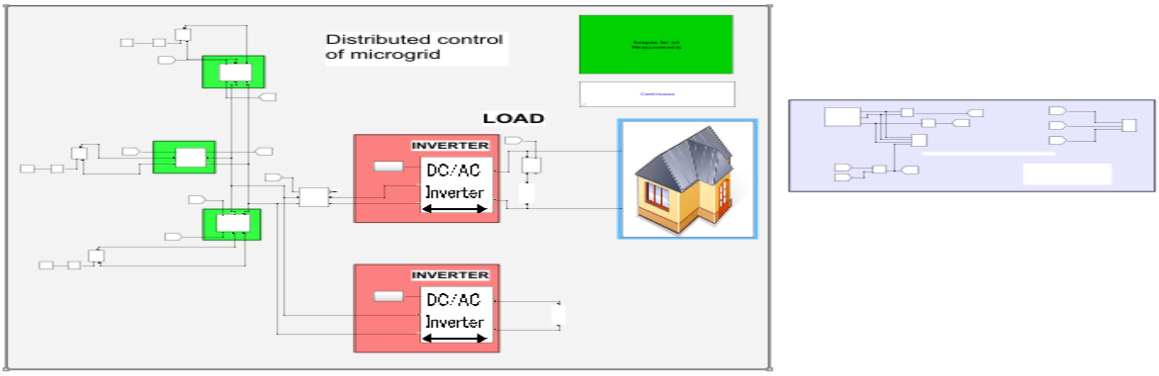

Figure 13: Simulation methodology

The following figure 14 the control for generating and monitoring of trip events and faults;

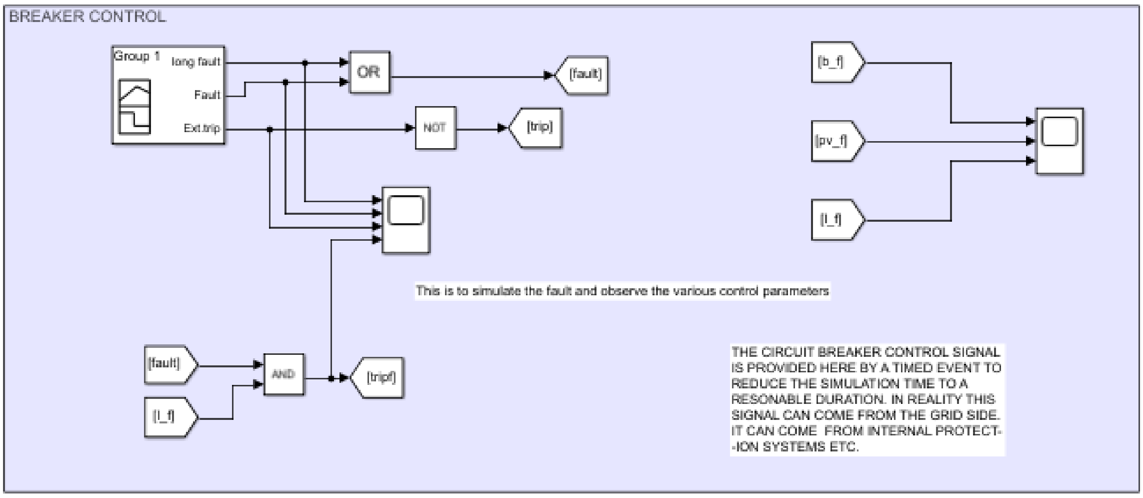

Figure 14: Second simulation

The below figure 15 shows the load diagram

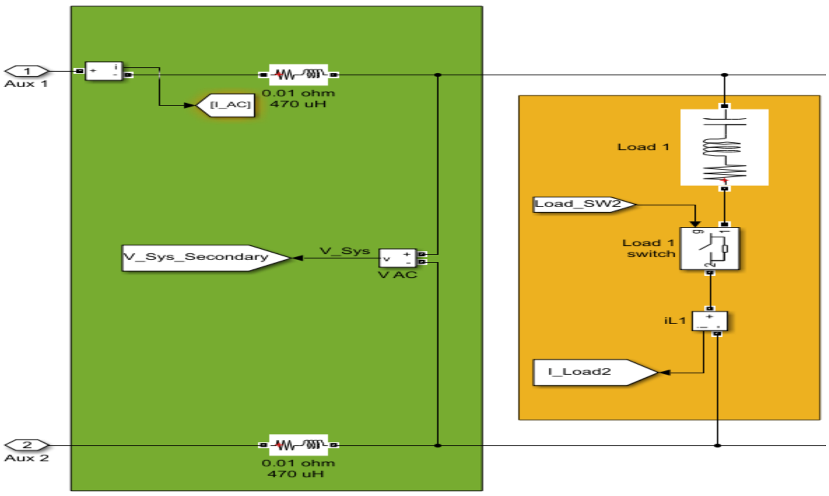

Figure 15: Load diagram

V. SIMULATION AND RESULTS

. The first simulation looked at the behavior of a distributed control microgrid system with two solar sources synchronized over a common DC-link, while the second looked at the distributed control architecture in combination with numerous loads [inverters]. The scope data snapshots below are displayed. The figure 16 shows the output of a single SPV unit, including the PV array output, PV array output power, final output voltage at the DC-link, and voltage at the MPPT HVDC block's output.

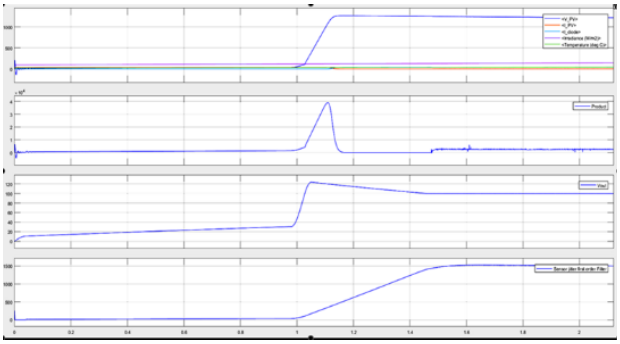

Figure 16: Output of a single SPV unit

The buck converter's output eventually settles at 100V, as shown in figure 17. The blue line depicts the switching waveform of a buck converter. The switch says off between 1 and 1.4 to compensate for the overshoot..

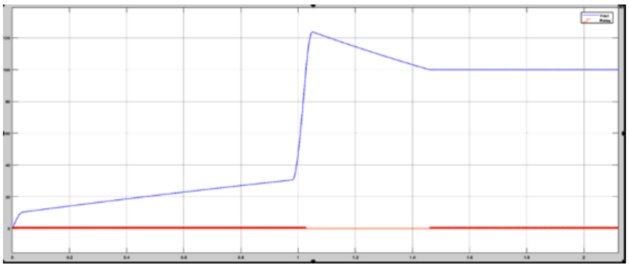

Figure 17: Switching waveform

The battery attributes are depicted in the accompanying figure, which are individually labeled with a legend. The activation of the battery discharging mechanism causes the blue spike. The spike is 8kA, however this will not happen in real life since the cables contain resistance, but the connections in MATLAB are not resistive as shown in figure 18

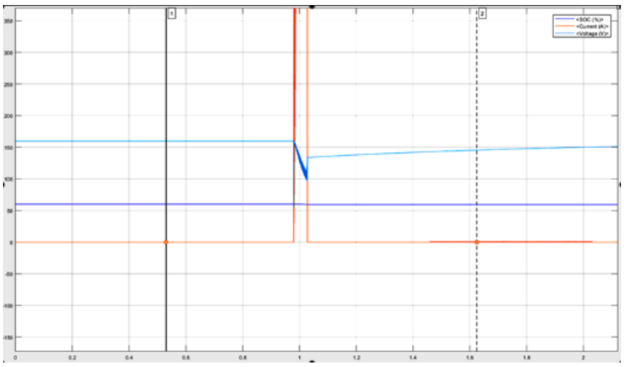

Figure 18: Battery properties

The voltage waveform for the second buck converter for the second source is shown in the figure 19 and figure 20 next two photos, and the buck converter for the battery giving 10A at 100V to the DC-link is shown in the figure 21

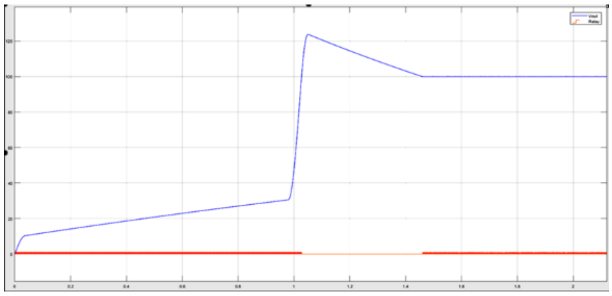

Figure 19: Waveform for second buck converter

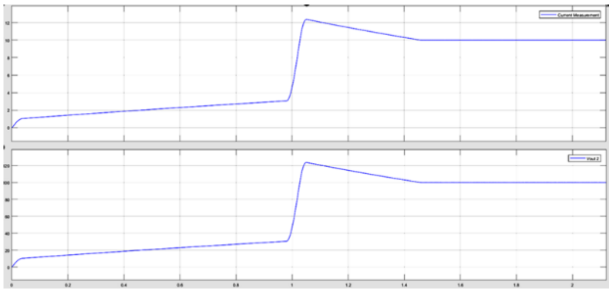

Figure 20: Waveform for second source

The on-off control signals for the loads and other components are presented below to run the loads in the second simulation.

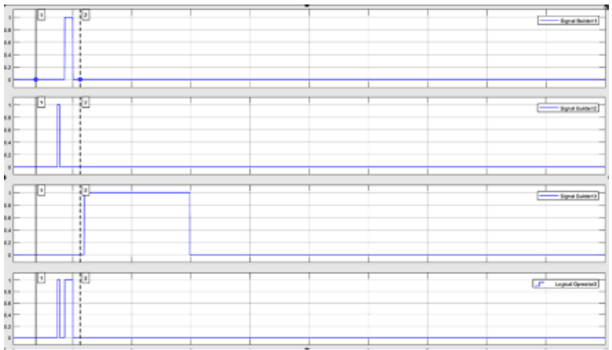

Figure 21: On off control signals

The figure 22 depicts the load current for inverter 1 when the load is turned on and the fault is active and not eliminated.

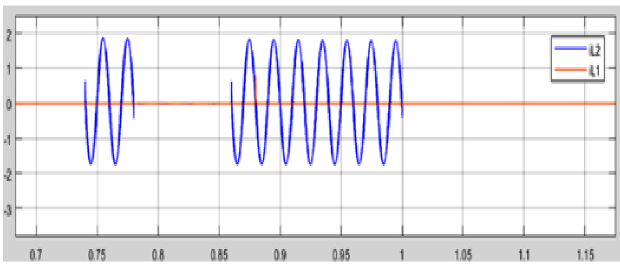

Figure 22: load current of inverter 1

The power given to the load during a failure state is depicted in the figure 23 . The fault, as can be observed, uses the great majority of the power. The breaker trips at 1s..

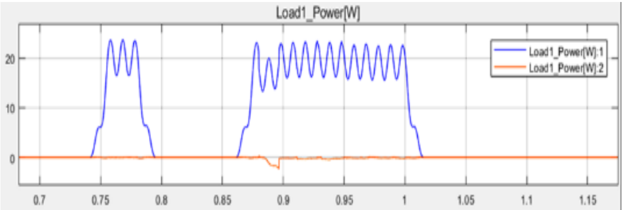

Figure 23: Power provided to the load

The waveform below in figure 24 depicts the formation of SPWM, with the carrier at the top, followed by sine and produced PWM.

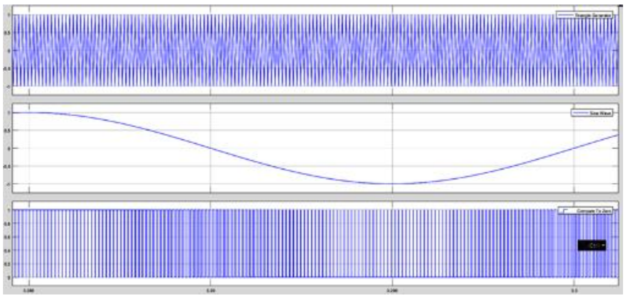

Figure 24: Formation of SPWM

VI. CONCLUSION

In this thesis, approaches for improving power quality in DC microgrids are proposed. First, we use state feedback control to a DC-DC converter in power generation instead of PI or PID control. As a result, we can easily insert poles and zeros while designing microgrids. We show that state feedback control may also control HVDC voltage and track intended output voltage and input current. Although microgrids feature multiple DC-DC converters, the voltage of common DC buses is brilliantly maintained by state feedback control in our simulator. When power is exchanged, regulating the voltage of a common DC bus implies an improvement in power quality. We can achieve high-quality power transfer in DC microgrids by using these strategies. This research will be followed by a slew of other projects. First, a PSPWM DC-DC converter implements state feedback control according to the user's specifications for the controller. Internal parameters may be monitored and states can be successfully adjusted using the state feedback approach. The state feedback controller may be developed utilizing the relationship between phase shift timings and output variables. Another project involves using a virtual resistor in the controller to inhibit circulating current for power augmentation in renewable energy power generation. This is a virtual resistor, not a real resistor. This strategy is employed in PI controllers, however in a state feedback controller, we use a virtual resistor.

REFERENCES

[1] U.S. Energy Information Administration. Energy Information Administration. International Energy Outlook 2016; U.S. Energy Information Administration: Washington, DC, USA, 2016; Volume 484, ISBN 2025866135.

[2] International Energy Agency. World Energy Investment Outlook; International Energy Agency: Paris, France, 2014; Volume 23, p. 329.

[3] REN21. Renewables 2018 Global Status Report; REN21 Publications: Paris, France, 2018; ISBN 9783981891133

[4] Aris L. Dimeas, Nikos D. Hatziargyriou, "Operation of a Multi-agent System for Microgrid Control", Power Systems, IEEE Transaction on, vol. 20, no. 3, pp. 1447-1455, 2005.

[5] Palak Jain, Satish. J. Ranade, "Capacity Discovery in Customer-Driven Microgrids," Power Symposium, Proc. of the 41th Annual North American, Mississippi State University, Oct. 2009.

[6] M. Pipattanasomporn, H. Feroze, S. Rahman, "Multi-Agent systems in a distributed smart grid: design and implementation," Power Systems Conference and Exposition, Seattle, WA, March 2009, pp. 1-8.

[7] J. Oyarzabal, J. Jimeno, J. Ruela et al., "Agent-based Microgrid Management System," Future Power Systems, International Conference on, Amsterdam, Nov. 2005, pp. 1-6.

[8]. CIGRÉ 635—Microgrids 1 Engineering, Economics, & Experience; WG C6.22; CIGRÉ: Paris, France, 2015; ISBN 9782858733385.

[9]. Soshinskaya, M.; Crijns-Graus,W.H.J.; Guerrero, J.M.; Vasquez, J.C. Microgrids: Experiences, barriers and success factors. Renew. Sustain. Energy Rev. 2014, 40, 659–672.

[10]. Parhizi, S.; Lotfi, H.; Khodaei, A.; Bahramirad, S. State of the art in research on microgrids: A review. IEEE Access 2015, 3, 890–925. [CrossRef]