Protection of Micro Grid with Converter Interfaced Sources

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Abstract: Micro grid consists of a combination of generation resources and load. With the micro grid there are several renewable resources so it is effective and efficient to the remote are consumer. And also it is reliable with the use of mesh configuration of the grid. In the micro grid there are several generation sources so it having multidirectional power flow is there. And that multiple sources affect the traditional protection system. Also there are the converter interface sources like solar power plant are there in the micro grid, so more protection required at the point of common coupling (PCC). Overvoltage/Under voltage protection, over frequency/Under Frequency protection and reverse power flow protection is necessary for the PCC. In this paper we prepare a micro grid network using ETAP and take some analyses and give the protection to the PCC.

***Index Terms* - Power System, Microgrid, Load Flow, Short Circuit, Point of common coupling (PCC), Protection**

I. INTRODUCTION

Micro grid is defined as the energy system with the distributed generation and multiple loads. There are the various distribution resources includes the renewable sources like Hydro, Solar, Wind etc. When two or more DGs and energy storage system are connected together so that they act as single micro-source to fulfill the load demand, in presence of grid connected mode or absence of islanded mode is termed as micro grid. The advantages of MG with Dg are less pollution, high efficiency, flexible for location installation etc. it gives the uninterrupted power supply to the load.

With the multi directional power flow in the MG there will be the effect on the fault current in the microgrid. As the micro grid have two operational modes grid connected and islanded mode. The fault current is different in each mode. The changes of the fault level is depends on the type of distributed generation, location of the generation and there technologies. Synchronous generator is highest contributing DG to fault whereas the inverter interfaced DG supplied twice of the rated value of fault current. There are the major difference of the MG with the traditional grid is that it changes the short circuit capabilities, when it changes from the grid connected mode to the islanded mode. It changes the fault current magnitude and direction. As the fault current contribution is from grid or from the converter side the fault current is different. And there are also need some protection at the point of common coupling which is called PCC. As the converter based sources are connected the traditional overcurrent protection might be affected by those external sources. So, there are some more protection are required for the protection of PCC. In which it is the voltage protection, frequency protection and reverse power flow protection are necessary.

As the fault occur near to the PCC which is either symmetrical or asymmetrical the fault current and the voltage is also affected. So if the traditional overcurrent relay fails to operate the voltage relay will be operating. And also as the load demand changes or the variation of load the frequency might be affected so that protection required. And when the fault occurs as the grid side the voltage is drawn by grid is more than the PV so in that condition the PV sources acts as the impedance and as the voltage level decrease the power is reverse flowing to the PV source. Which cause hazarders effect on the PV sources or converter based source. So in this paper we prepare a micro grid network and give the protection on the PCC. So when the fault occurs near to the PCC or far and at the grid side PV or converter sources are protected by that fault. Here as the converter based sources we put PV based sources as our simulation.

In the ETAP we prepare a network which having 14 Bus interconnected network. Which having 5 generator sources, transmission parameters, load and the PV sources are there. And the load flow analysis is carried out which is given as the steady state power and voltage at the different buses. The direct analysis is not possible because the load is connected is in the terms of complex power and the generator behaves like power sources. Load flow analysis gives the information of the magnitude and power of load bus voltages, reactive power at the voltage phase angle, load bus voltage; real and reactive power flow in the transmission line and other variable is specified. With this information current monitoring of the current state is possible. And with this analysis we are interested with the voltage at different bus and power flow from the bus in the network. And using the ETAP software load flow studies is quite convenient. There is no need to calculate load flow studies on board. There are four methods for load flow studies which are Gauss-Seidel method; Newton-Raphson method, Decoupled load flow method and Fast Decoupled load flow method. In which here we are using Newton-Raphson load flow method.

As the abnormal condition is occur from the symmetrical fault in the network. The fault is mainly divided into two types symmetrical and Asymmetrical. In the symmetrical there are the faults with LLLG or LLL. And the asymmetrical is LG, LLG; LL etc. Abnormalities are caused by accidently through insulation failure of equipment flashover on the lines etc. Thus the system is must protected by that heavy fault current in the network. This is done by the circuit breaker and protective relay. For the choice of circuit breaker and relay we estimate the magnitude of current which is flow in the short circuit condition. The majority of the fault is LG and occasionally LLG and rarely LLLG occur. Here we consider symmetrical fault condition. Because this type of fault leads most severe fault current flow and the network must be protected from that.
For the protection scheme design as the current transformer (CT) and potential transformer (PT) are there. The CT has the primary current and secondary current rating and PT having the voltage rating. As the voltage relay, frequency relay and reverse power flow relay is numerical type relay. The high voltage circuit breaker is used for tripping the lines. The CT and CB rating are carried out from the Indian standard (IS: 13118).

II. DETAILS OF THE ELECTRICAL NETWORK

Here we design the network using ETAP software. In which we have 14 bus networks. In which there are 5 synchronous generator and PV sources are there. The network is considered as distributed network which has 11 kV and 66 kV voltage rating. The synchronous generator is of 11 kV and 120 mva.

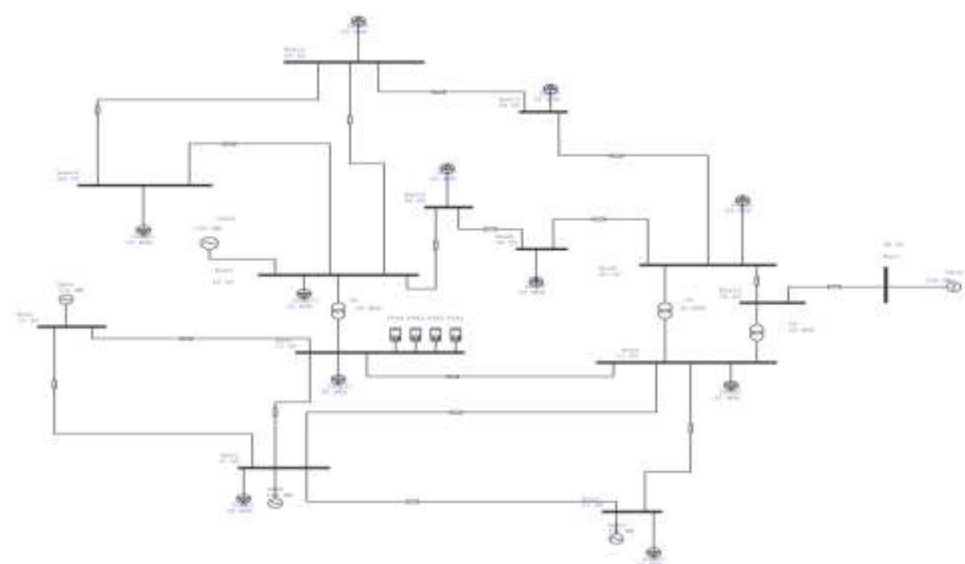

Figure 1 Electrical Network

In the network there are the PV connected bus is bus 5. The PV is taken from the ETAP which is a photo watt panel. This is having 110.3 volts per panel.

A. Load Flow Analysis

In a three-phase ac power system active and reactive power flows from the generating station to the load through different networks buses and branches the study of flow of active and reactive power flow is called load flow analysis. It mainly provides the solution of unknown electrical quantities, where the system is working at steady state condition along with certain inequality constraints.

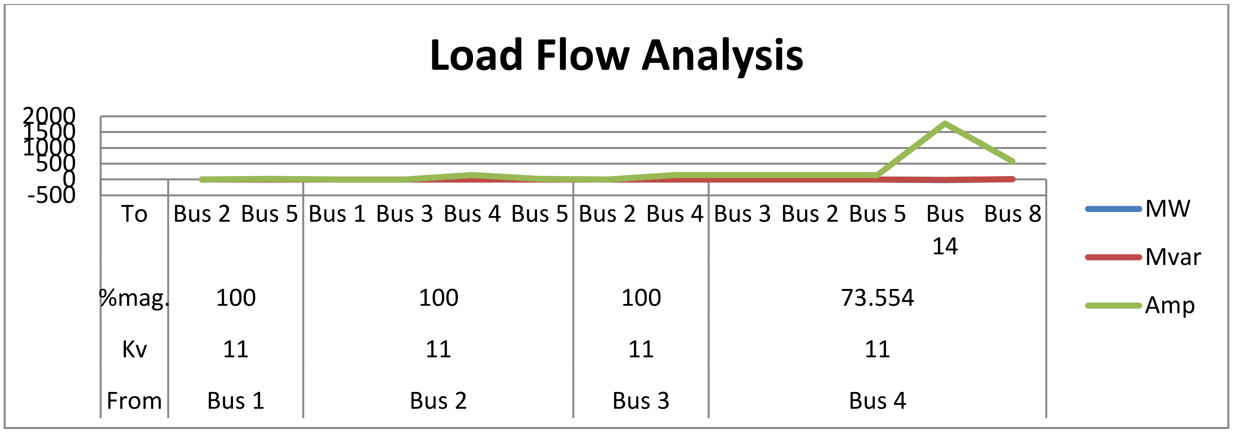

Figure 2Load Flow results of 1 to 4 Buses

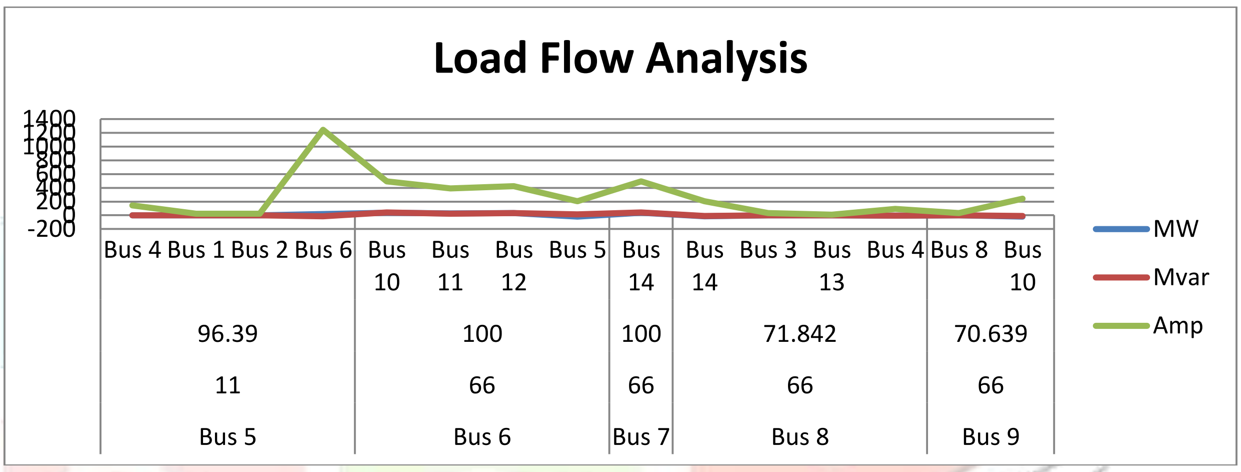

Figure 3Load Flow results of 5 to 9 Buses

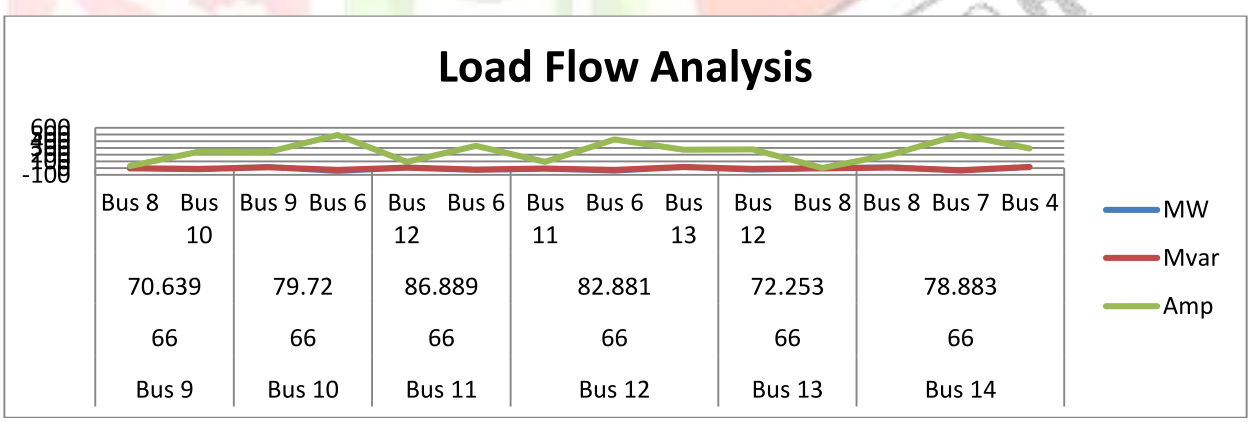

Figure 4Load Flow results of 10 to 14 Buses

Here we are using Newton-Raphson method for load flow analysis. From that we are using rated voltage and the rated current for the protection scheme design.

B. Short Circuit Analysis

The short circuit fault is occurring mostly due to failure of insulation. As the short circuit there are the faults current in the phases in network. In this paper fault is occur at bus no 5 which is the PCC of the network. In which the short circuit analysis is gives the information about the fault current of the phases and the voltage parameter of the network.

Table 1Short Circuit Analysis

Current	3 – Phase	L-G	L-L	LL-G
Initial symm. Current (kA)	32.749	29.247	28.203	32.618
Peak current (kA)	81.121	73.047	70.440	81.486
Breaking current (kA)	29.247	29.247	28.203	32.618
Steady state current (kA)	16.815	29.247	28.203	32.618

III. PROTECTION SCHEME DESIGN

Here for the protection of the network we built a protection scheme design. In which the network have the overcurrent protection and the over and under voltage, over and under frequency and reverse power protection at the PCC. Here in this paper we consider the protection of PCC and the overcurrent current protection will be the future work.

For the protection of PCC there are the relays required which is voltage relay, frequency relay and reverse power flow relay. For the relay there are the measuring transformer are there. And also high voltage circuit breakers are there for trip the circuit when abnormalities sense by the relay.

A. CT Rating

The current transformer is used for the measurement of the current passing through it. In which the CT is measuring the alternating current. In which CT have the two winding inside the primary winding and secondary winding are there. The primary winding is connected in the series with the measuring lines. The CT used in the protection is the protection class CT.

Where the CT having the primary and secondary rating is based on IS: 13118. In which the primary rating is from the rated current flow in the CT. which is taken from the load flow analysis. Secondary rating is 1 A or 5 A for measurement. Here we are using 1 A for secondary of the CT.

B. CB rating

The high voltage circuit breaker is used for tripping the network when abnormality sense by the relay. in which the circuit breaker having the rating followed by the IS: 13118 for the rated current, rated kV, making current, breaking current etc. for the rated kv of circuit breaker it is usually 1.05 times of the rated voltage of network. The rated normal current is 400 A, 630 A, 800 A, 1250 A etc.

The breaking current of the circuit breaker is the rated current in which breaker is operated or withstand capacity of the circuit breaker. The breaking current of the circuit breaker is 6.3 kA, 8 kA, 10 kA, 12.5 kA, 16 kA, 20 kA, 25 kA, 31.5 kA, 40 kA etc. which is taken again from the IS: 13118.

Also rated making current is 2.5 times of the circuit breaker rated current. And the circuit breaker withstand capacity is in terms of time. Which is 1 sec or 3 sec. for high voltage the short time withstand capacity and for low voltage the fault clearing withstand capacity is low.

C. Voltage Relay

For protection of PCC through the fault over voltage (59) and under voltage (27) relay is used. Here consider the voltage is going 10 % for over and 5 % of under voltage. The relay have to sense that the voltage ratio in that margin. Also if the ratio will be extend due to the fault there is the signal going through the circuit breaker and circuit breaker will be operated.

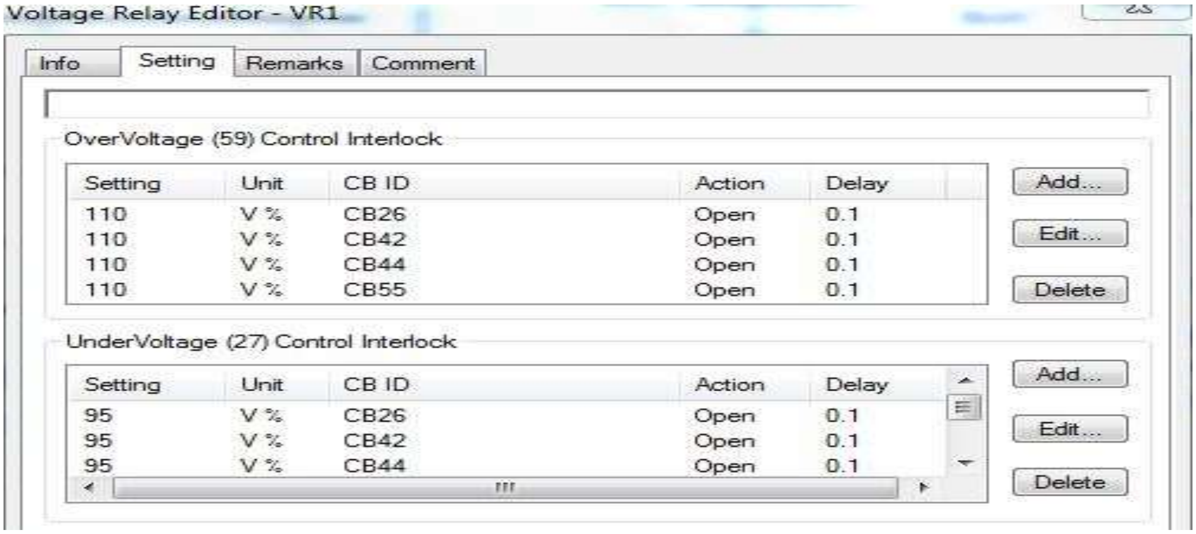

Figure 5Voltage Relay

D. Frequency Relay

Frequency relay is used for protection of PCC with the change in frequency. Frequency is change mainly due to the variation of load or due to the effect of disturbed synchronism in the network.

Here the frequency relay (81) having the ration of over frequency and under frequency. Here we are giving the frequency ration of 101 % and 99 % which is the ratio of the rated frequency 50 Hz. The relay is having the frequency rating of 49.5 Hz to 50.5 Hz. So if the frequency varies the given circuit breaker will be operated.

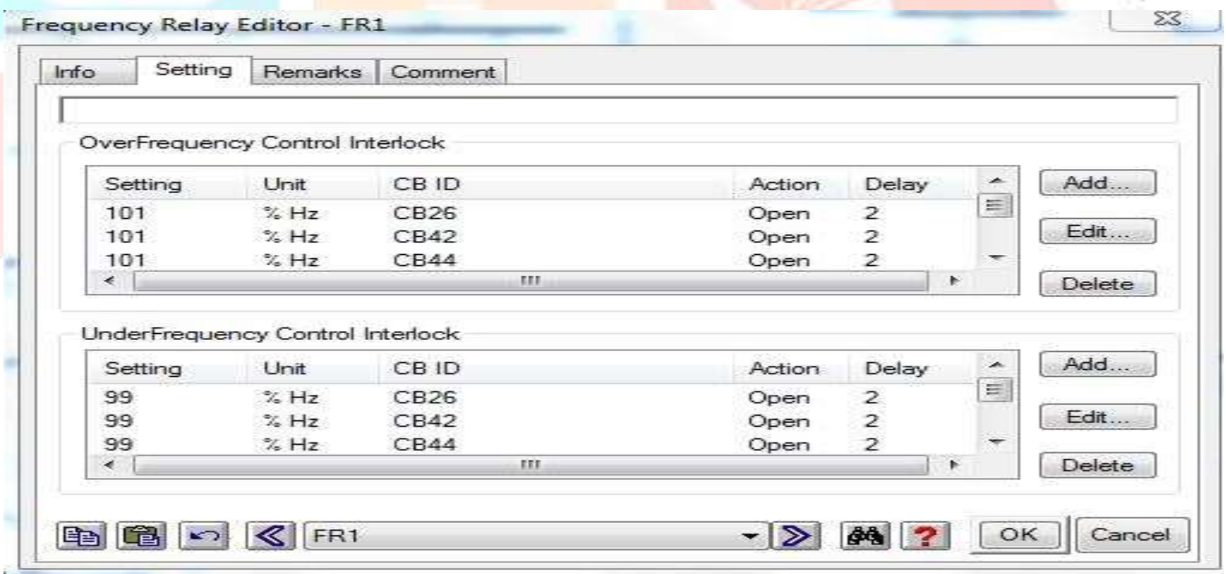

Figure 6Frequency Relay

E. Reverse power Relay

As the fault occurs near to the PCC the fault current is feed by the PV. But problem arise when the fault occur from the grid side or near to the generator. The fault current is feed by the generator and in that case the fault current may flow in the reverse direction if the PV voltage is down to the grid voltage.

Here we are using revere power relay (32) for protection of the reverse power flow to the PCC. The measurement is in the active power in which the over power and under power interlock are there.

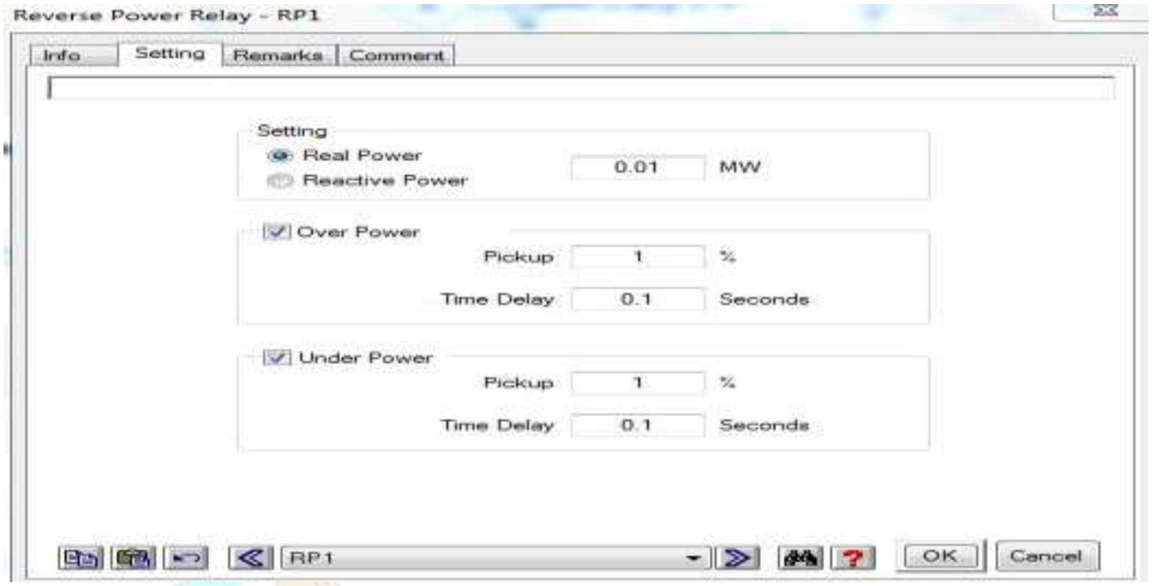

Figure 7Reverse power Relay

IV. Results and Conclusion

Here we are simulate the network and do some analysis which is load flow analysis and short circuit analysis and take the rated current and short circuit current from that analyses respectively. And design a protection scheme to protect the PCC from the abnormal condition like disturbance in voltage, frequency and power flow.

Also simulate the three phase short circuit near to the PCC to see the protection scheme is withstand to the short circuit fault or not.

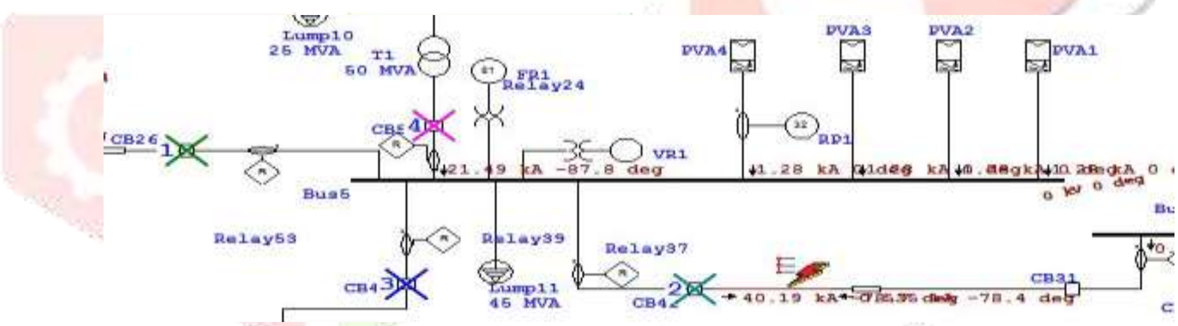

Figure 8tripping by voltage relay

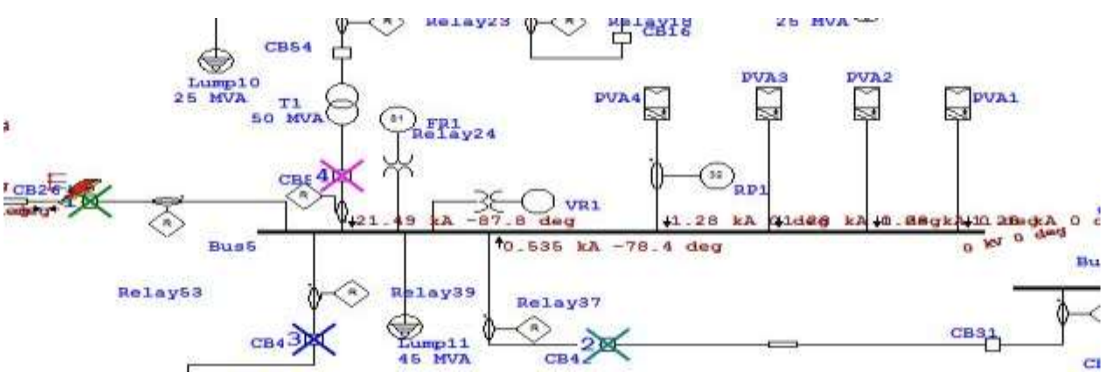

Figure 9tripping by voltage relay

So here under voltage relay operated because we are performing the three phase fault so as the three phases the voltage goes down and current is higher. Also the frequency relay will be working as the voltage relay works if the change in frequency.

But in the reverse power relay there are the power flowing in the reverse direction is not detected by the relay because in this limited bus such a small network the power is not more flow with the short circuit. And considering the micro grid network the reverse power flow is very low to detect it with this relay.

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