Reverse Power Protection of an Alternator

Lakith G[1], Divyashree B P[2], Nandini S Patil[3] , Vidyarani K P[4]

[1]Asst., Prof, Department of Electrical & Electronics Engineering & SJCE, JSSSTU, Mysuru, India

[2]Asst., Prof, Department of Electrical & Electronics Engineering & SJCE, JSSSTU, Mysuru, India

[3]Asst.Prof, Department of Electrical & Electronics Engineering & BITM, Bellary, India

[4]Department of Electrical & Electronics Engineering & SIT, Tumkur, India

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Abstract - Power plant generators are important components of an electrical energy system. They should be constantly monitored and protected in order to maintain the quality and reliability of the power supply. Otherwise generator may operate incorrectly resulting in poor power quality and instability during events like faults, equipment failure, reverse power flow(RPF) etc., the presence of large distributed energy resources is the major cause to the reverse power flow during low loads/excess generation at distribution level. If reverse power flow (RPF) is not resolved, it leads to incorrect operation of generators or affect connected devices. Therefore it is necessary to monitor and prevent reverse power flow condition. This paper deals with reversepower flow protection, here hardware model representing generator connected to the grid is developed using low rating permanent magnet motors, sensors, PIC16F877A microcontroller, regulated power supply, relay driver, Liquid Crystal display (LCD) and relay, to monitor and protect generator from RPF.

Key Words: Reverse power flow, Permanent magnet motors, PIC16F877A Microcontroller, Changeover & protection relay.

1. INTRODUCTION

In earlier days centralized generation supplying electricity to the load side. In the present scenario due to the evolution of decentralized generation i.e., distributed energy resources (DERs) at distribution level, DERs have become a popular alternative for electric power generation as they are mainly renewable, reduce transmission power losses, etc. However, some of the drawbacks ofDERs are harmonics, reverse power flow, over voltage etc. Apart from DERs, another reason for reverse power flow (RPF) is loss of synchronization, failure of prime mover and it may be becauseof failure of Governor or failure of Governor Valve or incorrect operation of Boiler Pressure Control System.

In reverse power flow condition the power flows to generator from grid and if not prevented generator operates like a motor driving prime mover as a load may lead to instability of the system. The consequences of generator operating like a motor and the level of power drawn from the grid will be dependent on the type of prime mover asunder this condition prime mover acts as a load. For steam turbines, the motoring power is around 0.5 to 3 % of rated power of generator. Therefore it is necessary to monitor and prevent the RPF to maintain stability and reliability of the system.

Various reverse power flow (RPF) protection techniques have been reported in literature. Overview of generator protection on power system is addressed in [1] and [2]. In [3] reverse powerdata are collected from a cogeneration power plant generators protection relays. The relays are able to detect disturbances and when these occurs, all digital and analogical signals are stored in its memory, including the pre-fault, fault and post-faultintervals. Co-ordination of reverse power, overcurrent, under-frequency, and under-voltage relays using transient stability analysis in real plant applications is discussed in [4]. Modelling and simulation of generator protection for power system using digital reverse power relay is addressedin [5]-[9]. In [10] Reverse power protection of alternator interfaced with GSM is analyzed with laboratory model.

In this paper a hardware model is developed with the help of low rating permanent magnet motors,current flow sensor, microcontroller, regulated power supply, relay driver, LCD, change over & protection relay to detect reverse power flow (RPF) condition and protect generator by isolating it from grid with the help of relays.

This paper is organized as follows: Section 2 presents methodology and hardware model of the proposed work, Section 3 presents results and discussion. Finally, Section 4 concludes the proposed work.

2. METHODOLOGY

As discussed earlier, the hardware model is developed to detect the reverse power flow condition. The block diagram, circuit diagram and hardware model of the proposed work is shown in Figure1, Figure 2 & Figure 3 respectively.

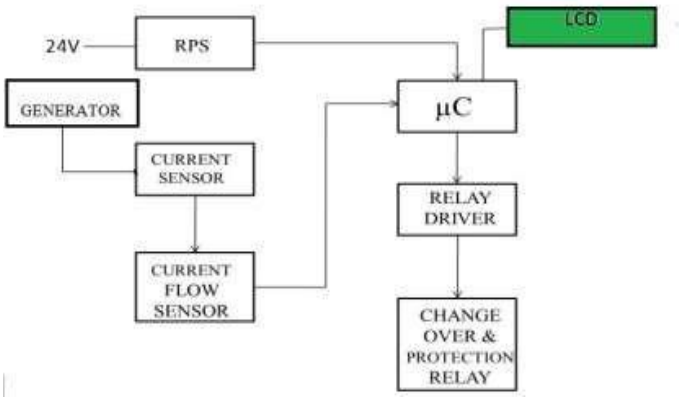

Fig -1: Block Diagram of the proposed work

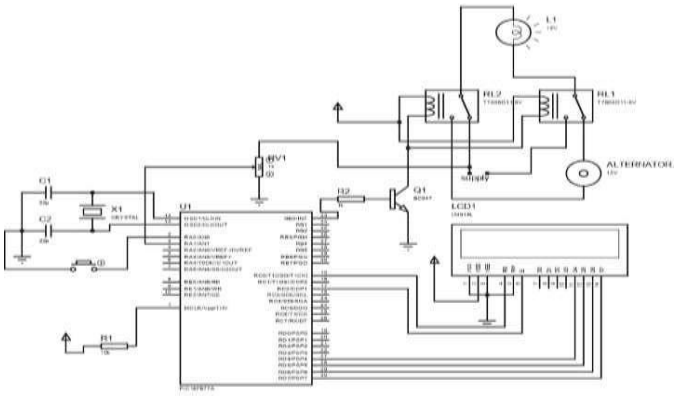

Fig -2: Circuit diagram of the proposed work

Practically Generator is coupled to a prime mover. In our hardware model we are replicating the reverse power flow condition with the help of two low rating permanent magnet motors, one actingas generator and other as prime mover. To detect the reverse power flow condition and protect the generator with the help of current flow sensor, microcontroller, regulated power supply, relay driver, Liquid Crystal Display (LCD) , change over and protection relay.

i. D.C supply is given to the permanent magnet motor which act as a prime mover. We ensure that the generator is working in normal condition and status is observed on LCD.

ii. Then supply is given to PIC16F877A microcontroller (µC) with the help of regulated power supply. Output current from the generator is sensed by current sensor and then information is sent to the µC.

iii. Reverse current is initiated with the help of microcontroller to the generator.

iv. As we discussed earlier, in reverse power flow condition the current flows from grid to generator. This change in direction of current flow is sensed and the status is displayed on LCD as “R-Power Flow” and generator is isolated from grid by changeover and protection relay.

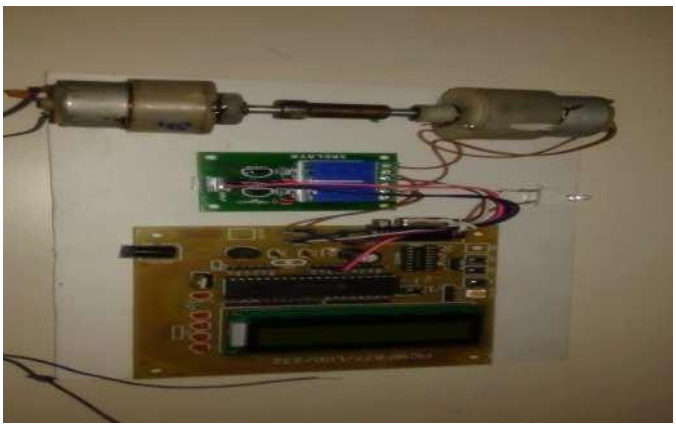

Fig -3: Hardware model of the proposed work

3. RESULTS AND DISCUSSION

The reverse power flow condition is analyzed with the help of cathode ray oscilloscope (CRO). Initially the direction of power flow is from generator to grid, the same is observed on CRO and the status is displayed on LCD as “R-Power Flow OFF” implying normal operation as shown in figure 4.

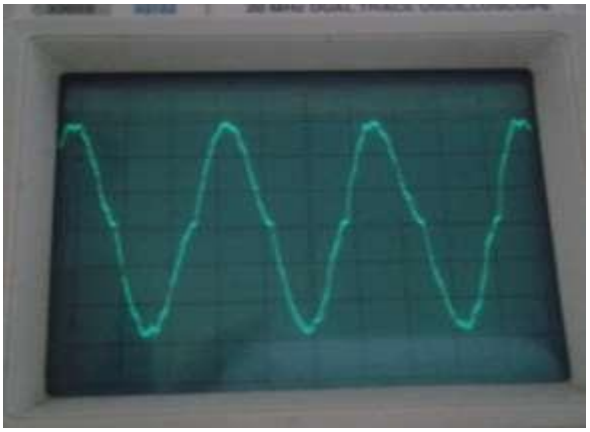

Fig -4: Waveform of normal condition

After a short interval of time, a reverse current is initiated with the help of microcontroller to create reverse power condition and it is monitored on CRO and status is displayed on LCD as “R-Power Flow” asshown in figure 5 and the same is detected by changeover and protection relay, isolating generator from grid.

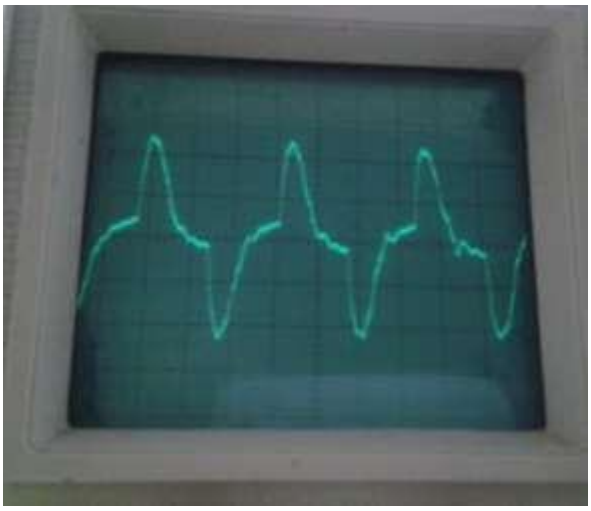

Fig -5: Waveform of Reverse power flow

4. CONCLUSION

The operation of generator connected to grid during normal operation and reverse power flow condition is monitored. In this proposed work, the hardware model developed is capable of detecting reverse power flow condition and isolates generator from grid with the help ofmicrocontroller, sensors and relays.

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