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Power Generator Automation, Monitoring and Protection System

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Abstract

The aim of the article is to develop a system, which uses microcontroller as central part to control the system and monitor the electrical parameters of power generator. In this project microcontroller take the value of frequency and voltage from Analogue to digital converter (ADC) which is interfaced with Potential Transformer(P.T). For counting the frequency, the output of operational amplifier will be measured through microcontroller, in case the value of current shows any abnormal behavior the system will first display the load cut off reason on LCD and then cut off the load for the sake of protection through relay. Another feature of this project is the Auto transfer switch (ATS). If the power from utility companies is available then the generator will be in off state and whenever electrical power from the utility company is suspended, the ATS system will automatically turn on the generator and transfer the load to generator and as the power will be restored from utility company the generator will be automatically turn off and the load will be transferred to the mains line.

Keywords: Power generator, Protection system, Auto transfer switch, Potential Transformer, Current Transformer, LCD, Analogue to digital converter, Water and Power Development Authority (WAPDA).

I. Introduction

Advanced Generator monitoring system combines the power monitoring, generator protection, and metering functions to enable safe and efficient power delivery. They also reduce operation and maintenance costs for utilities. These systems protect transformers, circuit breakers, and other equipment at substations. They enable predictive maintenance by detecting and responding to fault conditions. They dynamically balance loads to conserve energy and also they monitor and control power quality. These advanced capabilities are critical to ensuring uninterrupted power delivery and supporting intelligent generator applications [I].

The objective of project is to design an electrical parameter monitoring circuit using microcontroller for generator which is capable of controlling, monitoring, protection and automation of the system and all the processes like, displaying system status on LCD and controlling the relay. In this project voltage and frequency of the system will be monitored on LCD and on the basis of collected data system can be controlled i.e. in case of any abnormal behavior of current the system will be trip off itself [II].

II. Block Diagram

The following is the block diagram of the project, which includes all the main components of the project, without which the completion of the project would have been impossible. The block diagram is shown in figure.

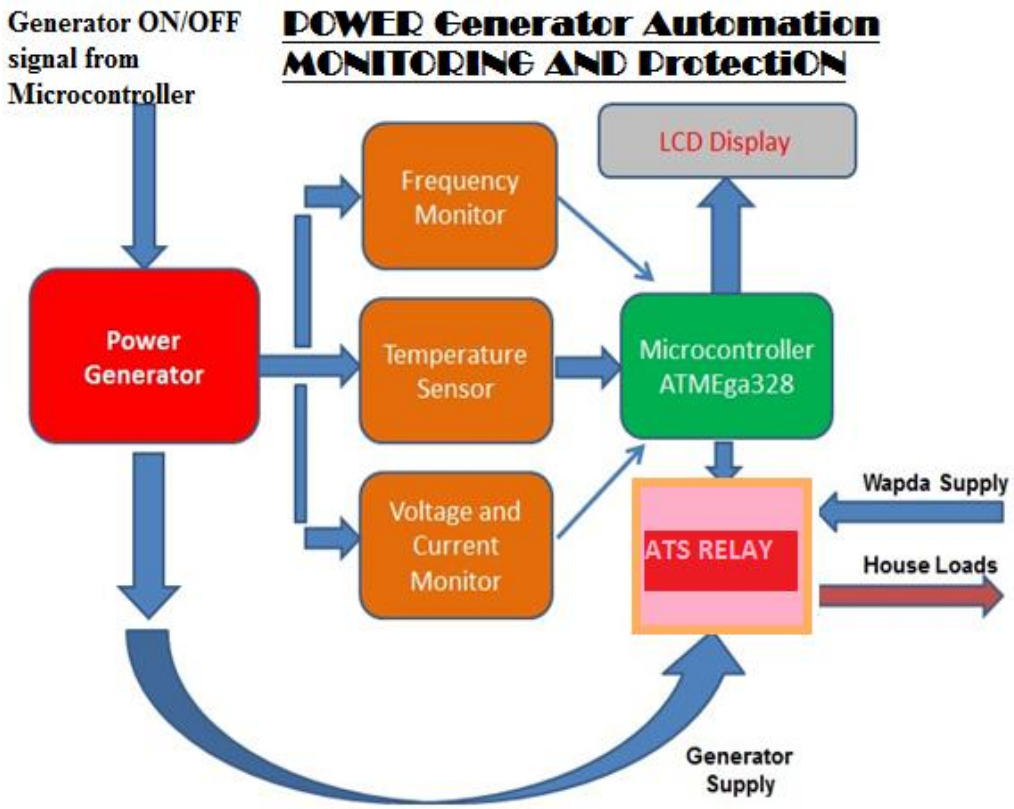

Figure1. Block Diagram

II.a Generator Watt/VAR Capability

The capability curve establishes the steady state (continuous) generator operating limits. The generator capability curve is normally published at generator rated voltage. Salient pole generators have a slightly different characteristic in the under excited region. The generator capability is a composite of three different curves: the stator winding limit, the rotor heating limit and the stator end iron limit.

The stator winding limit is a long-term condition relative to the generator winding current carrying capability [II].

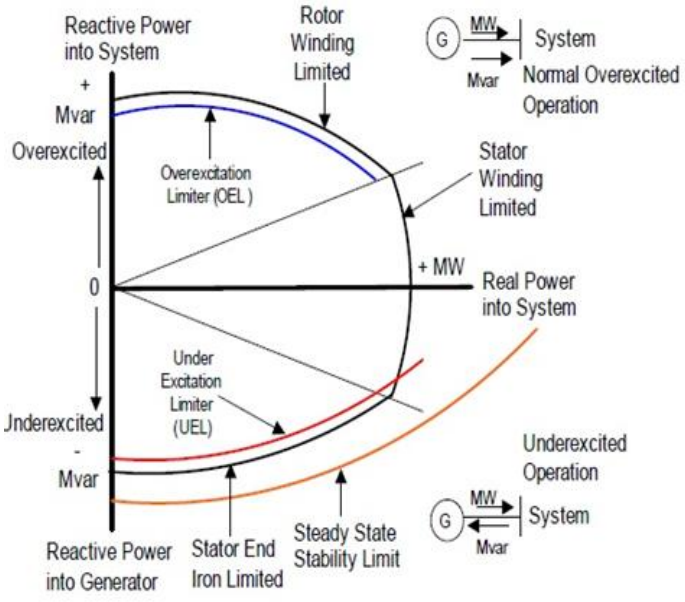

Figure 2. Typical Generator Capability Curve

II.b Generator Steady State Stability Basics

Losses of power into theload center can result in steady state instability. The ability to transfer real (MW) poweris described by the power transfer equation below and is plotted graphically in Figure 3.

$$P_e = \frac{|Eg||Es|}{X} Sin\ (\theta_g - \theta_s) \quad (1)$$

Where,

E_g = Voltage at Generation

E_s = Voltage at System

Pe = Electrical Real Power Transfer

X = Steady State Reactance between Generator and System

θ_g = Voltage Angle at Generation

θ_s = Voltage Angle at System

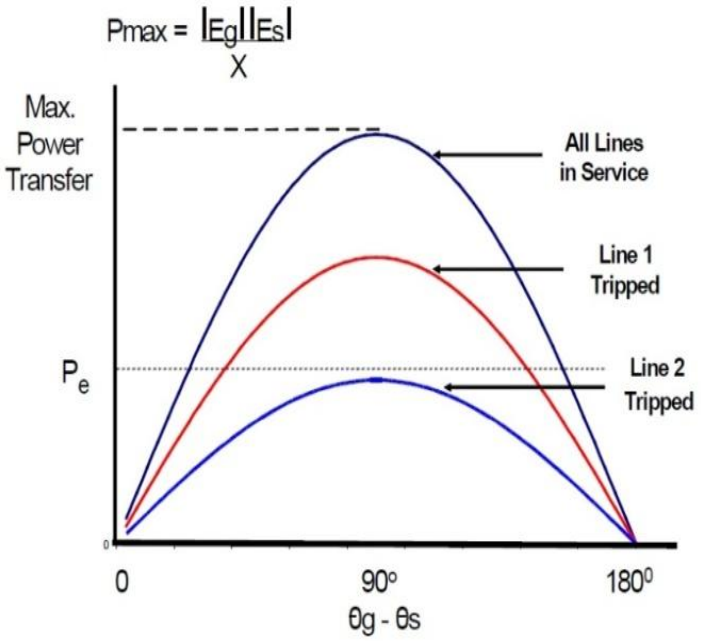

Figure 3. Power Angle Analysis - Steady State Instability

From the power transfer equation above it can be seen that the maximum power (P_{max}) that can be transmitted is when θ_g-θ_s = 900 i.e. sin 900 = 1. When the voltage phase angle between local and remote generation increases beyond 900 the power that can be transmitted is reduced and the system becomes unstable and usually splits apart into islands. If enough lines are tripped between the load center and remote generation supplying the load center the reactance (X) between these two sources increases to a point where the maximum power (Pmax), which can be transferred, is insufficient to maintain synchronism [III].

II.c Flow Chart

The flow chart shown in Figure 4. is purely based on controller programming, which shows different loads were managed by different sources on the basis of voltage comparison (battery voltage of solar and wind), where the second part represents the selection of generator or grid Water and Power Development Authority (WAPDA) So, that management starts between two sources, instead of three.

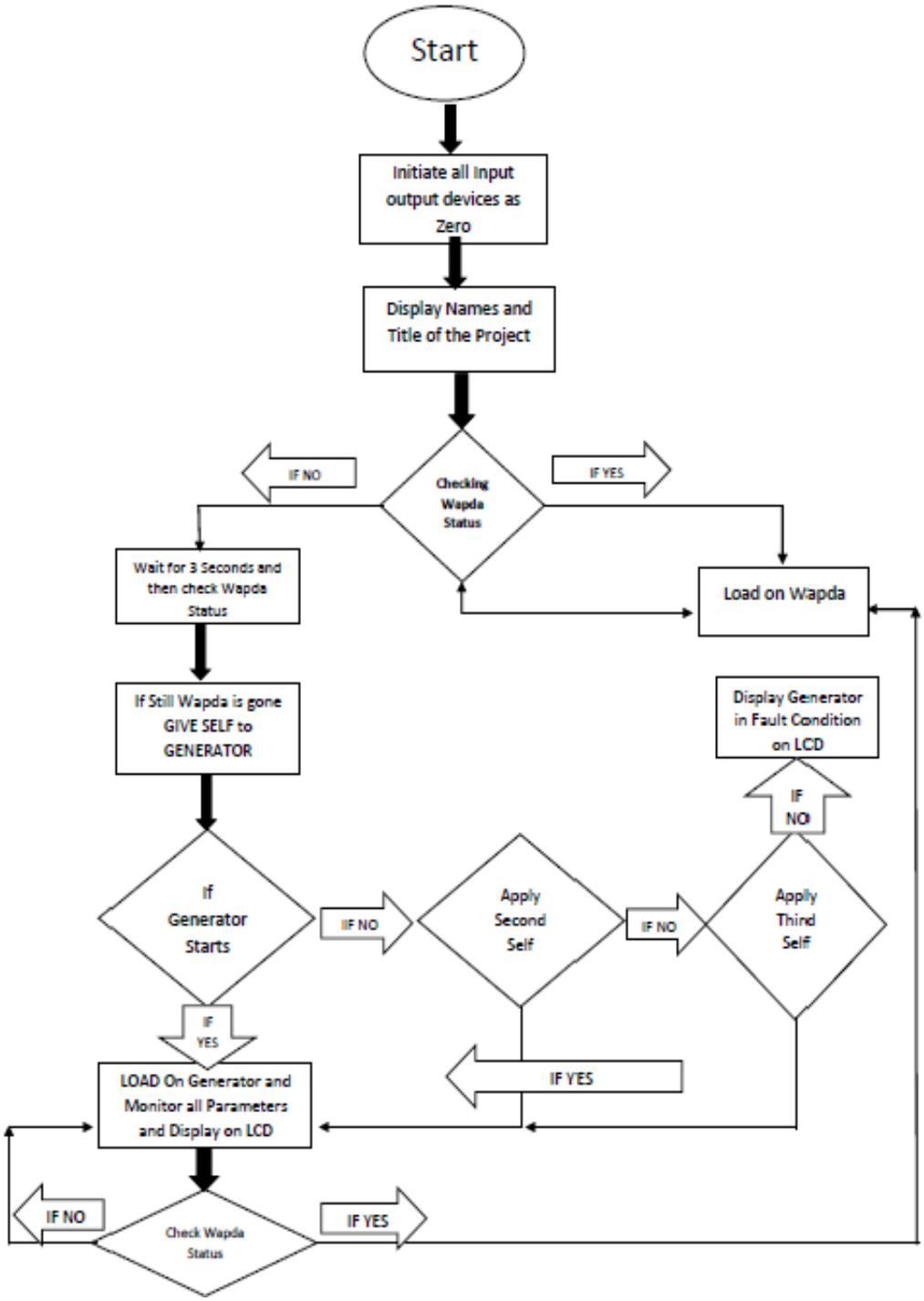

Figure 4. Flow Chart

III. Components and their Usage

Following are the component used in this project;

1. Relay
2. ULN2003 (Relay Driver)
3. Temperature Sensor LM35
4. Micro-controller ATMEGA328p
5. LCD Display (4x20)
6. Different types of Resisters and Capacitors
7. Bridge Rectifiers
8. Voltage Regulator
9. Transformers

These components along with their usage in this project are discussed below in detail.

III.a Relay

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and most have double throw (changeover) switch. Switching capacity available by 10A in spite of small size design for high density P.C. board mounting technique. Relays allow one circuit to switch a second circuit which can be completely separated from the first. The relays used here ranges from 28V to 30V DC and 125V to 250V AC for 10A current [II].

III.b ULN2003 (Relay Driver)

A ULN2003A is a high-voltage, high-current Darlington transistor array. It is a relay driver used to operate the 12V relay. It amplifies the 5V DC signal received form micro-controller to a 12V DC signal [IV].

III.c Temperature Sensor

The LM35 series are precision integrated-circuit temperature sensors with an output voltage linearly proportional to the Centigrade. Which are calibrated directly in ° Celsius (Centigrade), Rated for Full −55°C to +150°C Range, Operates from 4 to 30 V. it is connected with micro-controller at pin no 25 [V].

III.d Micro-controller (Atmega-328p)

It is the main part of this project all the measurements and controlling are done through it. It is an 8-bit micro-controller which is used having a 28 pin, RAM of 2 Kbytes and flash memory of 32 Kbytes. It is a simple, low-powered, low-cost micro-controller to which all the components are interfaced [V].

III.e LCD

A 16x2 LCD is used here, it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix [IV].

III.f Resistors and Capacitors

Resistors and capacitors are used for lowering the voltage and filtering. Resistors act to reduce current flow, and, at the same time, act to lower voltage levels within circuits. The resistors used in this circuit ranges from 100Ω to 1kΩ. Capacitors used in this circuit ranges from 220µF to 1000µF [IV].

III.g Bridge Rectifier

A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction to direct current (DC), which flows in only one direction [IV].

III.h Voltage Regulator

This is an IC with the purpose of conversion of 12V DC to 5V DC, as many of the components like Micro-controller, ADC, and LCD Display works only with a supply of 5Volts. Whereas the component like Relays are operated by 12V Supply. This IC has three pins. One is directed to the GND, second to 12V and the third pin gives the output voltage which is the 5V required voltage [IV].

III.i Transformers

A transformer is a static electrical device that transfers energy by inductive coupling between its winding circuits. A varying current in the primary winding creates a varying magnetic flux in the transformer's core and thus a varying magnetic flux through the secondary winding. This varying magnetic flux induces a varying electromotive force (emf) or voltage in the secondary winding.

The transformers used in this circuit are 9 volts for voltage and frequency measurement connected with micro-controller at pin no 23 and 12 volts for current measurement connected with micro-controller at pin no 24.In Figure 5.a and 5.b Project schematic diagram is shown [V].

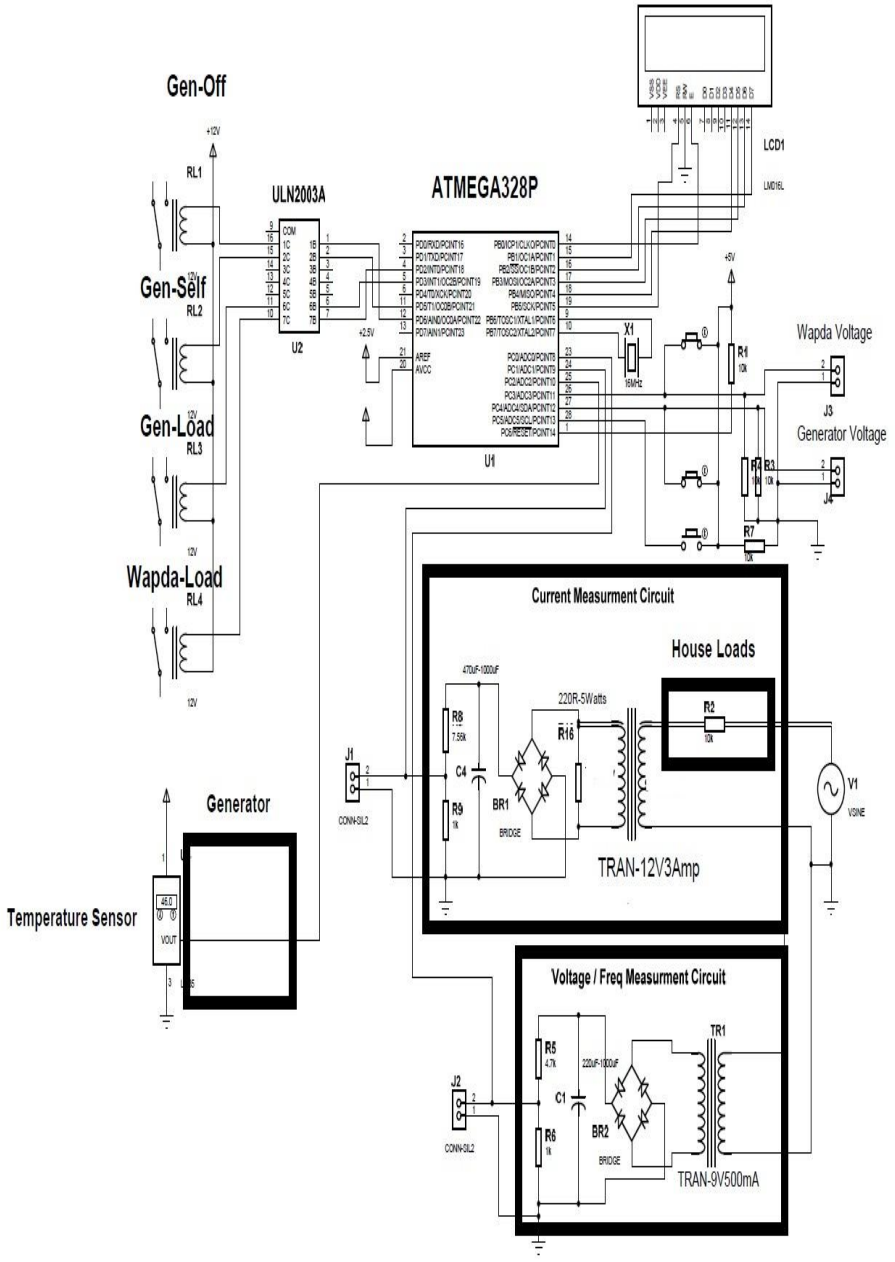

Figure 5.a.Project Schematic diagram

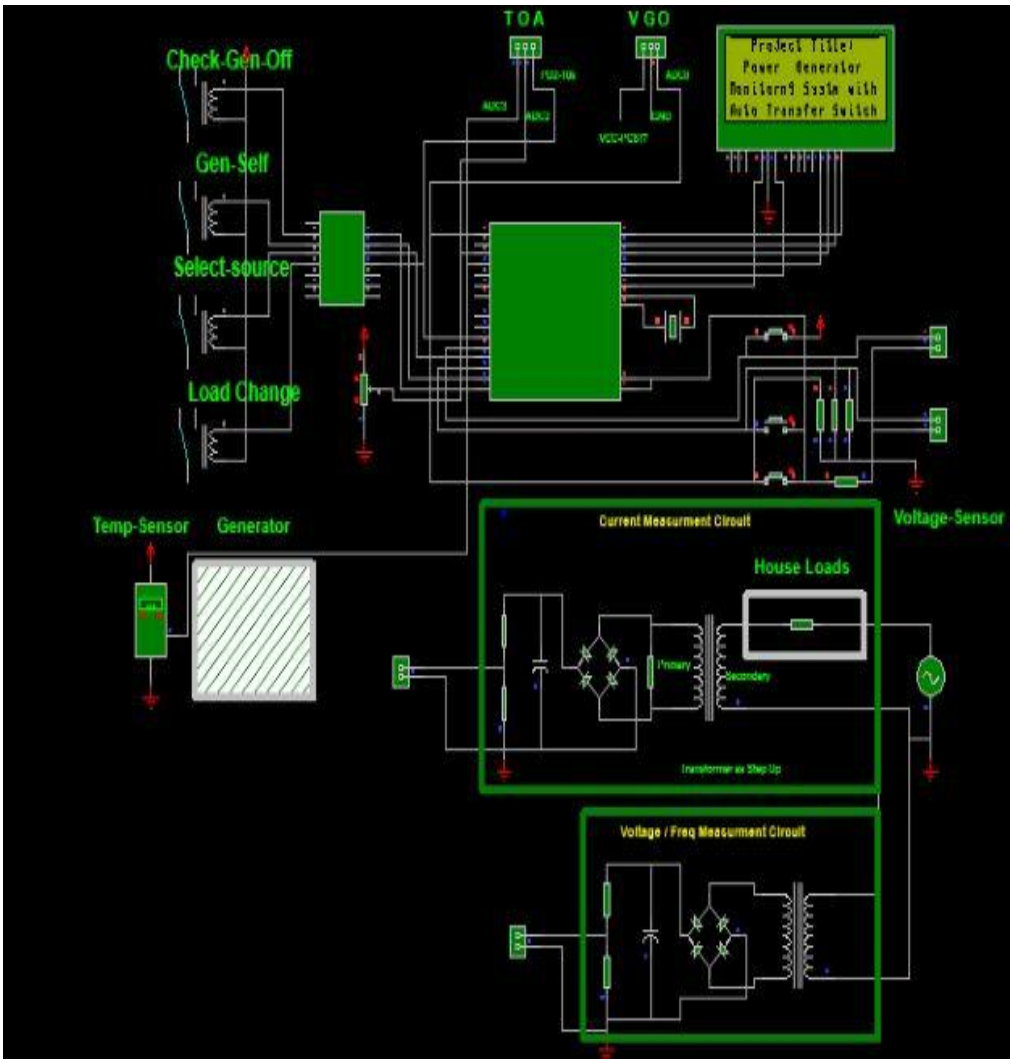

Figure 5.b. Project Schematic diagram

IV. Methodology

The circuit will do nothing when the loads are feed through WAPDA. Whenever WAPDA voltage goes off the micro-controller will try to start the generator by giving self through the relay RL2. Three attempts are to be made, in case if there is fault in generator the status will be shown no LCD. Now the circuit starts measuring different parameters including heat, current, voltage and frequency and show the status on LCD do auto controlling for overload protection and heat. For heat to be detected and measured LM35 temperature sensor is attached with generator and connected with micro-controller at pin no 25. For current measuring there is a potential transformer used to which the load is connected on series, i-e the load neutral and phase are attached to the transformer primary windings which will induce some voltage in the secondary windings .which is then directed to the capacitors for

filtering,resistor of 100 ohm(5w) and a bridge rectifier. Which is then forwarded to the micro-controller at pin no 24 .For voltage and frequency measuring there is another transformer used connected to the micro-controller at pin no 23.

The ULN2003a is basically a relay driver to which a 5v dc signal is send by micro-controller and then convert that 5v dc to 12v dc signal to drive the relay .As the relay requires 12v dc to be operated.

For overload protection the relay RL3 act. The circuit is able to supply power to only 200watts loads. Exceeding the limit this relay will try to isolate the load from generator. After a delay of 3 seconds through micro-controller this relay will try to reconnect the affordable load to the generator. If load is normal then this relay can withstand it but having gain overload this relay will try to cut-off power provided to loads by generator showing the status. In the diagram the relay RL1 is used to switch off the generator and the relay RL4 is used for changing load to WAPDA whenever WAPDA power is restored.

In Figure 6,Hardware assembling is shown; the project software implementation is shown in Figure 7, while overall project module is shown in Figure 8.

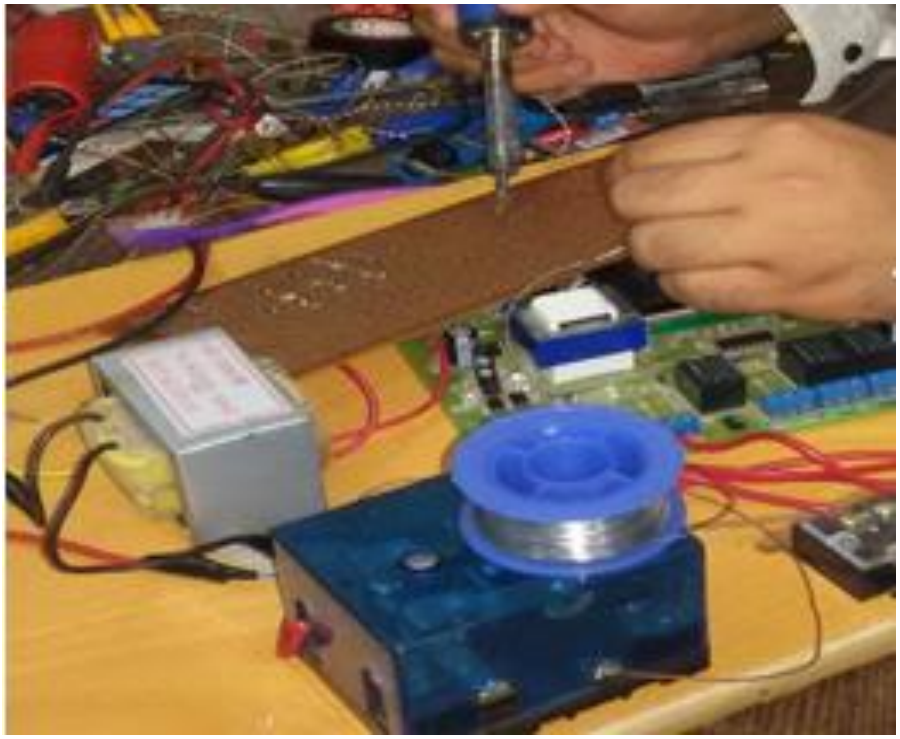

Figure 6. Hardware assembling

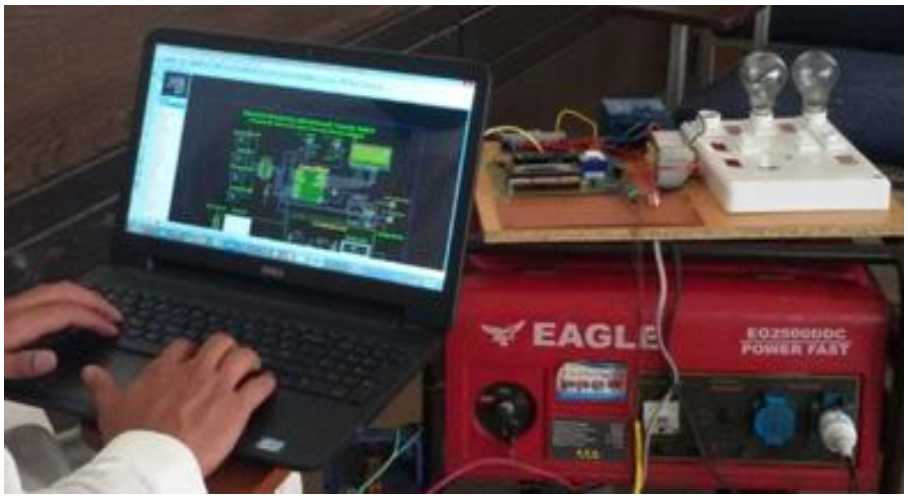

Figure 7. Project software implementation

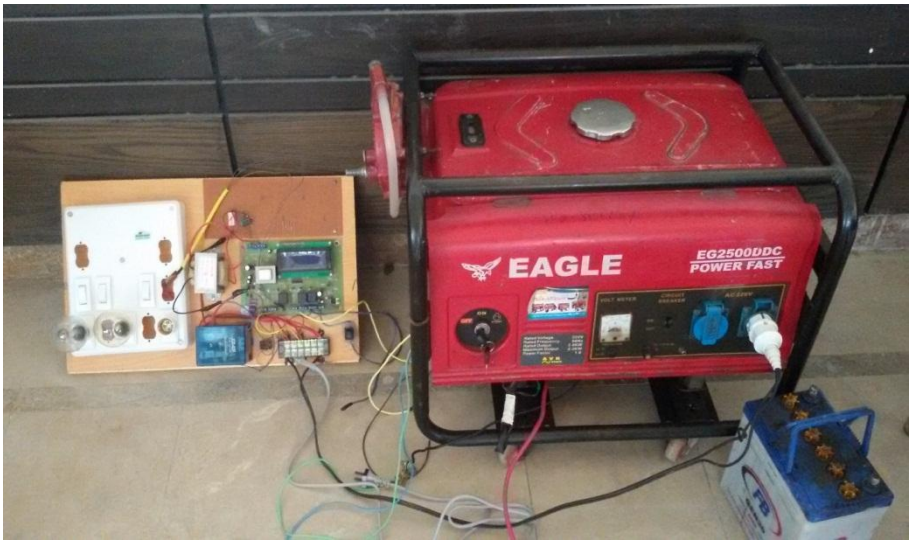

Figure 8. Overall Project integrated with Home Generator

V. Conclusion

To provide a means for easy starting and stopping of generator from within the apartment aside from the generator point. It can be automatically and manually operated. The main gain and benefit of the project is the reliability and safety in switching from one system of electricity (Power) source to alternate power source. Today's world, especially in this part of the subcontinent, the electricity users are confronted with shortage and load shedding/sharing. The manual systems are not only inefficient but also in-convenient. The proposed project will resolve these problems and will provide ease in accessibility and monitoring.

VI. Acknowledgement

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