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A Smart Automatic Mains Failure Panel with Diesel Generator Control and Wi-Fi

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Abstract: **This paper focuses on the development of a smart Auto Mains Failure (AMF) panel meant for day to day electrical applications. AMF panel is unavoidable in industries, hospitals, educational industries etc. where generator is compulsory. It acts as the switching mechanism between the generator, load and the main power supply. It ensures consistent power supply to the load. An AMF panel, which can be controlled from a distance using Wi-Fi is presented here. The proposed system displays the generator parameters and indicates the type of fault in the supply mains and saves energy. The hardware model of the system is explained, which can be used for the validation of the results.**

Index Terms **Auto Mains Failure (AMF) panel, Diesel Generator (D.G), Liquid Crystal Display (LCD).**

I. INTRODUCTION

In the present world, uninterrupted power supplies are inevitable. Nowadays, a power system network is highly vulnerable to large scale failures [4]. However, building additional connections to the main supply unit can be expensive. In such cases, power generation by using D.G sets can be used [1]-[3]. However switching on and switching off a D.G set again and again manually and not feasible as it causes discomfort and delay. This made the entry of AMF panels. AMF panel acts as a switching mechanism between the generator, load and the supply. When the supply is available, AMF panel connect the load to the supply, whereas when the supply is unavailable, the AMF panel to the D.G set.

Initially, AMF panel had a start/stop switch only. With the technological advancement, present day AMF panel displays the voltage and current parameters of the main supply. An AMF panel is shown in fig. 1. The large energy wastage in D.G sets, frequent occurrence of fault and no provision for remote control of AMF panel and D.G set as the common problems faced in this field. These aspects of AMF panel increase the research interest in the modifications of the existing system. Hardware modeling of the overall system is quite important as it is essential for the performance analysis. Detailed block diagram of the hardware wiring model is presented. Along with this, a comparative study of the proposed system with existing system is made in order to strike out the disadvantages of the existing AMF panel with the smart AMF panel. Section II presents a block diagram level description of the proposed AMF panel with the D.G control and Wi-Fi. Section III deals with the hardware model of the proposed system. Section IV deals with the comparison of proposed and the existing system. Section v presents the analysis and discussion of hardware model.

II. AMF PANEL WITH D.G CONTROL AND WI-FI

The proposed system consists of an AMF panel indicating the three phases of the supply mains, measures the D.G parameters (fuel level) and indicates the type of fault occurring in the supply mains. A Wi-Fi module is incorporated, which displays the generator parameters from a distance and enables to control the AMF panel with necessary commands. Wi-Fi module is the wireless connection of the local area network, which is less secure than the wired connections [7]. However, there is no relevance talking about the

security aspects of Wi-Fi since the fuel level of the D.G set is transmitted through Wi-Fi, which is not much confidential. Two microcontrollers ATmega-16 and 8051 are used in the proposed system. Both are programmed in embedded-C language. The alarm display panel attached to the ATmega-16 makes the alarm when any of the phases of the supply goes off or when any fault (short circuit, under voltage, or over voltage fault) occurs. The voltage and current of the mains is continuously measured. If it goes beyond the pre-defined cut-off values of the current and voltage, as programmed in the microcontroller, the microcontroller sends signal to the relay to shift the load to the diesel generator. The auxiliary battery provides power to the load up to when the D.G acquires rated speed. Current and voltage of the diesel generator is also measured. If the D.G runs abnormally, the load is removed from the D.G and thus the load is protected. The LCD displays the current and voltage of the supply mains and when a fault arises, the type of fault is also displayed. The Wi-Fi module transfers the parameters regarding the D.G and AMF panel to remote wireless devices like mobile phones, laptops etc.

Fig. 1: AMF panel

Microcontroller 8051 is used to transfer the information about the fuel level in the D.G set to the LCD. Ultrasonic sensor module generates ultrasonic waves, which strike on the upper surface of fuel in the fuel tank. Distance between the fuel surface and the ultrasonic module is noted by the sensor. The module is calibrated initially such that the distance between the fuel surface and the sensor gives the fuel level in the tank. The module passes the information to the microcontroller and the LCD. The LCD displays the fuel level and the microcontroller transmits the information to the Wi-Fi module, with which the fuel level can be obtained from a distance through a laptop or a mobile phone.

Fig. 1 shows the block diagram of the smart AMF panel. The P.S.U block represents the power supply unit for the microcontrollers. Microcontroller AT 89S52 is the microcontroller 8051 produced by the manufacturer 'Atmel'. The voltage and current sensing network of the supply mains and the D.G is connected to the microcontroller AT Mega 16. If the supply mains is on, the supply voltage and current is measured by the voltage and current sensing network and through the microcontroller, the readings are displayed on the LCD. On the other hand, if the mains supply is off, that is when the power goes off, the voltage and current of the mains will be zero. When such a situation arises, the microcontroller is programmed in such a way that the relay will disconnect the supply mains and the load, and the generator and the load will get connected. The relay driver is an amplifier which will drive all the relays used in the whole mechanism. There will always be a time lag between the time when the generator attains the rated speed and the time when the generator is made on. The power demand for the load can be supplied by the generator only when it attains rated speed and this interrupts the continuous power supply to the load. The provision of an auxiliary battery, which is attached next to the relay solves this problem. Whenever the supply goes off, the relay switches and the auxiliary battery will get connected to the load. The battery will get disconnected only when the D.G attains rated speed. The time taken by the D.G to attain rated speed is noted and the microcontroller is programmed.

AT 89S52 is the version of the microcontroller 8051 produced by 'Atmel'. 8051 produced by 'Intel' can be programmed in parallel only. On the other hand, AT 89S52 can be programmed in serial and parallel and it has 'in circuit serial programming' facility. Moreover, it

has a RAM of 8 KB memory. The ultrasonic sensor module measures the fuel level which is in the ASCII format. The level converter converts the data in the ASCII format to TTL format and it is given to the microcontroller AT 89S52 and it is displayed on the LCD. P.S.U block represents the power supply block for the microcontroller AT 89S52. The microcontroller AT 89S52 is connected to the microcontroller AT Mega 16. The alarm display panel connected to AT Mega 16 displays whether the fuel level is normal, low or critical. The data is transferred to the distant places through the Wi-Fi module and the authorities will be informed about the fuel level in the D.G. The Wi-Fi module supports RS-232 serial communication protocol and the microcontroller supports data in TTL format only. The RS-232 to UART converter incorporated between the microcontroller and Wi-Fi module enables the interfacing between the two.

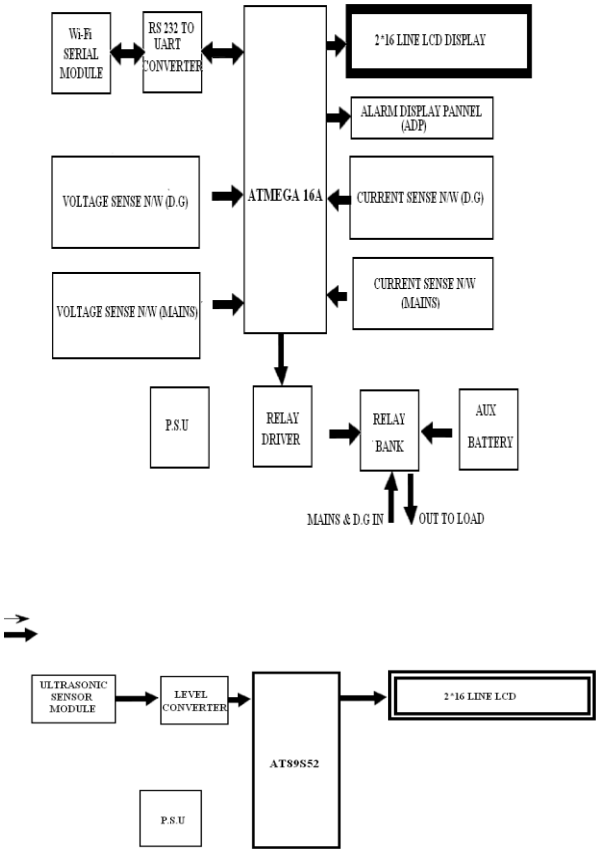

Fig. 2: Block diagram of the smart AMF panel

III. HARDWARE WORKING MODEL OF THE SMART AMF PANEL

Hardware working model of the system should be in such a way that it demonstrates the actual working of the system and the results obtained are accurate. Microcontrollers AT mega 16 and 8051 is not replaced. However, instead of a D.G, a battery (12 V) is used. In order to show the measurement of the fuel in the D.G, set a container with a suitable water level is kept. The ultrasonic modules are used to indicate the fuel level (water level in the container). An ultrasonic module is shown in fig. 3.

Fig. 3: ultrasonic sensor module

In order to demonstrate the fault occurring in the supply system, various fault conditions are initiated. A switch connection in between the supply and the hardware model is kept open, in order to show open circuit fault. A jumper is connected in between two phases to demonstrate short circuit fault. The µc is programmed in such a way that the normal current in the overall system is that current that is drawn by a bulb of sufficient rating (say 60 W). A bulb having a power rating above that rating (say 100 W) is introduced in the circuit in order to demonstrate overload. Wi-Fi module and ultrasonic modules are connected as in the block diagram. However, thermal are also used which is explained in section V.

IV. COMPARISON OF EXISTING SYSTEM AND PROPOSED SYSTEM

Present day AMF panel cannot be controlled from a distance, however in the proposed system a since a Wi-Fi module is incorporated, the AMF panel

can be controlled from a distance. Conventional AMF panel uses a resistive sensor in order to measure the fuel level in D.G set, paves the way for fire hazards, but here, with the use of an ultrasonic sensor that risk is totally eliminated. Industries always appoint a person, who is in charge with AMF panel room and its control. But in this system, manual supervision is not needed, since the

system is fully automatic. The proposed system indicates the type of fault with the supply system but this facility is not provided in the present day AMF panel. The generator takes time to attain rated speed; up to that time, the power supply to the load gets interrupted. In this system, such problems are solved by means of auxiliary battery which provides necessary power to the load up to the rated speed of the generator. The proposed system plays a great role in reducing the large amount of energy wastage associated with the D.G set, which is explained in detail in the next section.

V. ANALYSIS AND DISCUSSION

The proposed system measures fuel level with the use of ultrasonic sensor module as explained earlier. The circuit diagram for the same is shown in Fig. 4. The container is filled with water for the demonstration. The fuel level is passed to the microcontroller AT Mega 16, from where the Wi-Fi module transmits the data to distant places.

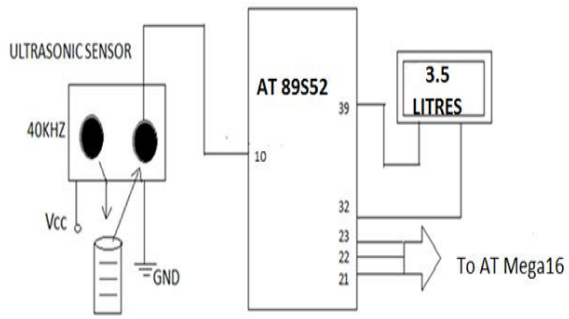

Fig. 4: Circuit diagram of ultrasonic sensor module

With the use of proposed system, a large amount of energy wastage in the D.G sets can be solved. The energy wastage is very crucial when the D.G set gets heated up with continuous usage. When the situations of long run power failure occur, the D.G has to work continuously with a large amount of energy wastage in the form of heat in the present day system, where as in the proposed system, the idea of multiple generators are entertained. Thermal sensors LM 35 are provided in the generators. Fig. 5 shows the circuit diagram of the thermal sensor. The power supply is given to the 1st pin and the 3rd pin is grounded. The output voltage for a particular value of temperature is given to the microcontroller. From that voltage, the microcontroller decides which D.G is to be made on, as it is programmed. The capacitors are provided in order to reduce the ripples formed in the D.C, in that circuit. When one of the generators gets heated up, after a particular limit, the thermal sensor detects it and gives information to the micro controller. The micro controller in turn operates the relay which switches back the load to the second generator. The procedure repeats

when second generator becomes heated. Thus, by the use of two generators, wastage of energy in the form of heat is tremendously reduced.

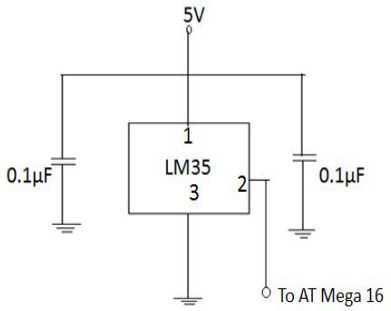

Fig. 5: circuit diagram of thermal sensor LM 35

The voltage measurement of the supply mains and the D.G is by the means of voltage divider network, which is shown in Fig. 7. Instead of a D.G, here, a 12 V, 1 A hr, lead acid battery is used and this makes the source voltage 12 V. we know that the maximum voltage to the microcontroller is 5 V.

From the voltage divide rule,

$$V1 = V \times \frac{R1}{R1 + R2} \qquad (1)$$

Assume R1 to be 10 K. then from equation (1),

$$R2 = R1 \times \frac{V}{V1} - 1 \qquad (2)$$

$$R2 = 5\ K$$

Take R2 = 4.7 K (approx.)

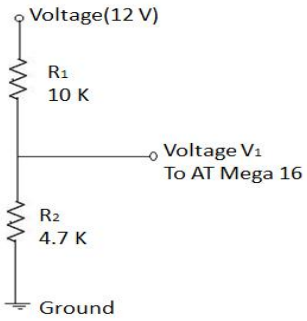

Fig. 7: voltage divider network

The load is provided with necessary power up to the rated speed of generator by the auxiliary battery. The auxiliary battery is also an equipment to save the energy. Irrespective of the load, the D.G output is always rated. On the other hand,

the load on the D.G varies at every instant. When the load is rated, the D.G output is fully utilized, and when the load is not rated, large amount of power gets wasted. The auxiliary battery is a mechanism to solve this problem of energy wastage. The excess power provided by the D.G is used to charge the auxiliary battery.

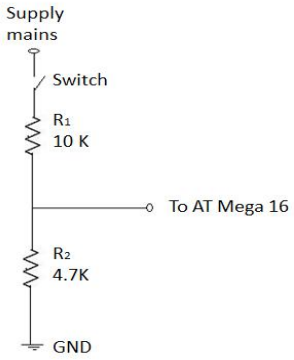

Fig. 6: Circuit diagram for the supply mains failure detection

In the hardware model, the supply mains failure is indicated by a voltage divider network attached with a switch. When the switch is closed, it makes 5 V to go to the microcontroller, indicating that the mains power supply exists. Whereas, when the switch is made open, the voltage drop across the resistor R2 will become 0 and thus the voltage to the microcontroller will be 0. This indicates the failure of the supply mains and the microcontroller makes the D.G and the load connected. The design of the resistors is same as that of the design of the resistors in the voltage divider network.

The measurement of current in the D.G and the supply mains is done with the help of a resistor. A known value of resistance is introduced in the circuit and the voltage drop across the resistor is measured.

We know that, in an electrical circuit, the current (I), voltage (V) and the resistance (R) is related as,

$$I = \frac{V}{R} \qquad (3)$$

From the above equation, the current can be found out. This method is very simpler and less expensive than other methods.

VI. CONCLUSION

A detailed study about the drawbacks of present day AMF panel is carried out and a new idea for an advanced AMF panel is put forward. It is capable of fault identification in the supply mains, conserving energy and can be controlled from a distance, since a Wi-Fi module is incorporated. The proposed idea can be modeled as hardware to carry out the demonstrations. Hardware modeling will be helpful in order to validate the results completely. The proposed idea solves the disadvantages of the present system and moreover it is an

innovative concept in the field of energy conservation. The proposed system is unavoidable in the present era having crucial energy crisis.

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