GENERATOR AUTOMATIC START SYSTEM FOR BACKUP POWER

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ABSTRACT: *This paper proposes the implementation of an automatic system for starting a generator to supply consumers affected by the lack of supply voltage for a long time. The system has the role of supplying electricity to some consumers in case of interruption of the main power supply and switching to power supply from a secondary energy source (electric generator on gasoline or diesel engine). The concept of this automatic starting system is a stable one that can be easily adapted to existing electric generators on the market, with high flexibility, and at a low cost.*

KEY WORDS: Power supply, automation, monitoring, electricity consumers

1. INTRODUCTION

Currently, most activities in all areas are dependent on a source of electricity. Regardless of the field in which the activity takes place, the continuous supply of electricity has become mandatory, sometimes even vital. From home users to large industrial consumers, there are certain technological systems dependent on a continuous energy source, such as: condensing boiler, emergency lighting, anti-burglary systems, computer systems, electrical and electronic equipment in hospitals, monitoring systems in real time of a technological flow, etc.

As the lack of voltage has a negative impact on consumers, it was decided to implement this system in case of interruption of electricity supply from the national grid for a longer period, when the use of UPS systems becomes inefficient due to their high cost.

The very high cost of electric generators with automatic start and switching system in case of lack of voltage in the national electricity grid, compared to the relatively low cost of generators that are not equipped with this automatic system once again justifies the choice of this system. Taking into account all these aspects and analyzing both the advantages and disadvantages it can have, it was highlighted the great advantage that it is a solution that can be implemented on electric generators already owned by the user without major changes. Thus, the same results as an electric generator with automatic start panel and switching already existing on the market can be obtained at a lower cost.

In order to reach the desired result, it was necessary to study the market to optimize the final product, but also a series of tests and simulations in different conditions. The design of the system was made taking into account all risk factors, both external and internal, which occur during operation but also the related costs, based on a correct and safe operation of the entire installation, without any intervention from outside.

2. THE PROPOSED SYSTEM

The system is based on the use of an electric generator with manual start (turn on the start key) that is connected to the automatic start system. This system can be on a wifi network, thus becoming an IoT-type monitoring system. The structure of the system for backup power supply is shown in figure 1.

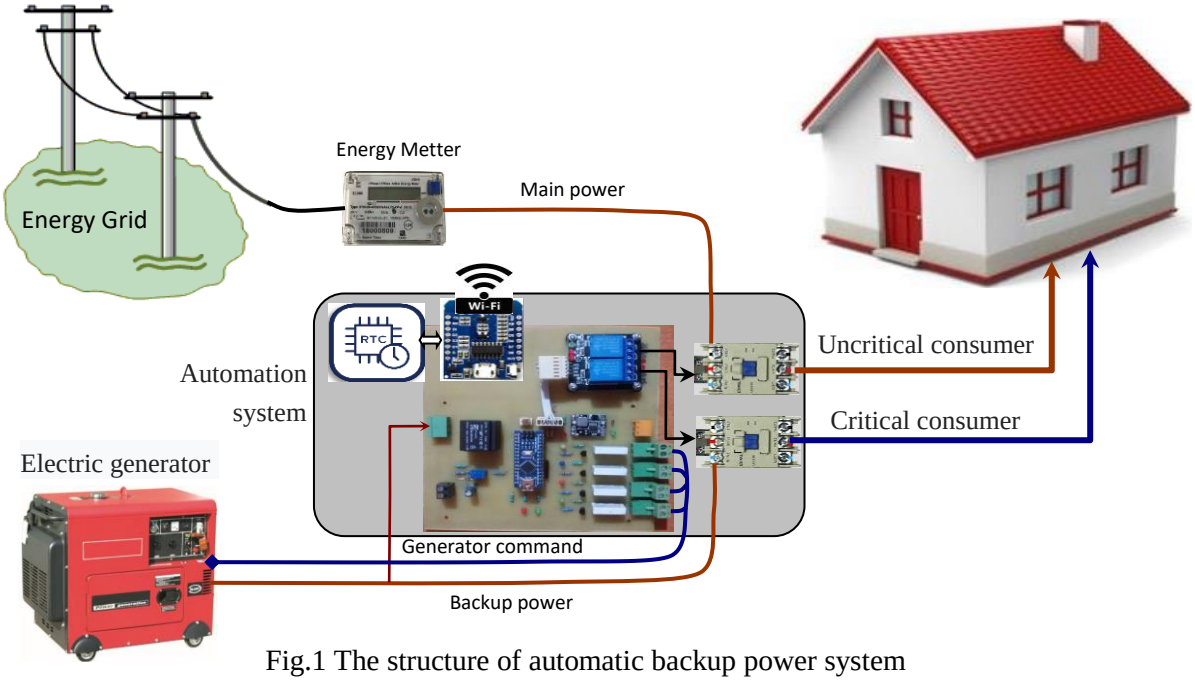

Fig.1 The structure of automatic backup power system

2.1 System description

The cost of electric generators is high, especially for powers higher than 20KW. That is why the system allows the supply of essential consumers. This is only possible if there are two power supply circuits for the consumers: a circuit for the essential consumers that will be supplied all the time and a circuit for the secondary consumers that can be switched off in the event of a power failure.

Electric generator

Electric generators are backup energy sources, dedicated to consumers who use power supply systems for buildings where power outages can cause malfunctions. The principle of operation [2] of an electric generator is given by a heat engine powered by diesel or gasoline that drives a rotor of an alternator, which produces electrical voltage at the terminals of its windings.

They are used in emergency response. In this operating mode, the electric generators are used as independent auxiliary sources used for the fall of the main power supply network. In principle, in this case, only those consumers considered vital are connected to the generator.

When the load is switched on, the electric generator does not behave in the same way as the energy supplier's network (national network) which can take on considerably high loads. The load that the electric generator can take over is strictly limited by its power. It is known that when coupling loads the instantaneous current becomes very high and can reach 3-10 times the rated current, depending on the nature of the load. For this

reason, the required instantaneous power is also high, as it cannot be practically covered by a proper oversizing of the group due to the high costs. Therefore, we must make a compromise between the size of the electric generator and the load we decide to power.

The generation of electrical voltage in the alternator (also called generator) is based on the inductive effect of electric current. Self-excited synchronous alternators are usually used for better adjustment of electrical parameters. As the load increases, the group speed tends to decrease. At this point, the speed controller intervenes, which controls the additional supply of the engine and the return to the nominal speed.

If the engine does not have enough or no oil, if its temperature is too high, if the speed is not right, the appropriate protections come into play to protect the engine, the most expensive element in this assembly.

Automation system structure

The automation system consists of a block for monitoring the parameters of the power supply network. When the parameters are not the right ones (lack of phase, voltage value, disturbances) the automatic system controls the start of the backup generator. If within a predetermined time the network parameters do not return to the normal ones, the system decouples the power supply to the consumers from the electrical network. At the same time the engine start is monitored. If the engine does not start at the first command, the automatic system knows how to give it several start commands, with start time and with corresponding pauses, so as not to block the engine. If the engine does not start, a fault is signaled. If it starts, wait for a while until the engine speed reaches the rated speed and the engine warms up enough. From this point on, the voltage monitoring block will read the voltage at the generator output to see if it is within the preset limits. At this point, vital consumers will connect. Premature coupling of a load to the limit can have the effect of stopping the engine immediately.

During the power supply from the electric generator, the automatic panel monitors the electrical and mechanical parameters of the group, stopping it in case of emergency to protect it and to protect the load. When the supply voltage returns, after a certain period of stabilization, the load is disconnected from the generator and reconnected to the electricity network. The engine will continue to run for a while, both for cooling and safety reasons.

The consumer connection scheme is one that contains power contactors that, in order not to be connected at the same accidental moment, have both software and electrical interlocks.

In order to monitor the operation of the automatic system, a monitoring and communication module was provided. It stores important data (number of starts, operating hours, start and stop times, etc.) data available via a wifi network on smart devices. Thus, the state of the system can be monitored or tested remotely.

The block structure of the system is shown in figure 2 where:

1. core with Arduino Nano mode
2. wifi communication system, real time clock and eeprom
3. power Monitoring
4. power contactors module
5. to critical consumer
6. to uncritical consumer
7. voltage generator monitoring
8. generator command
9. generator state

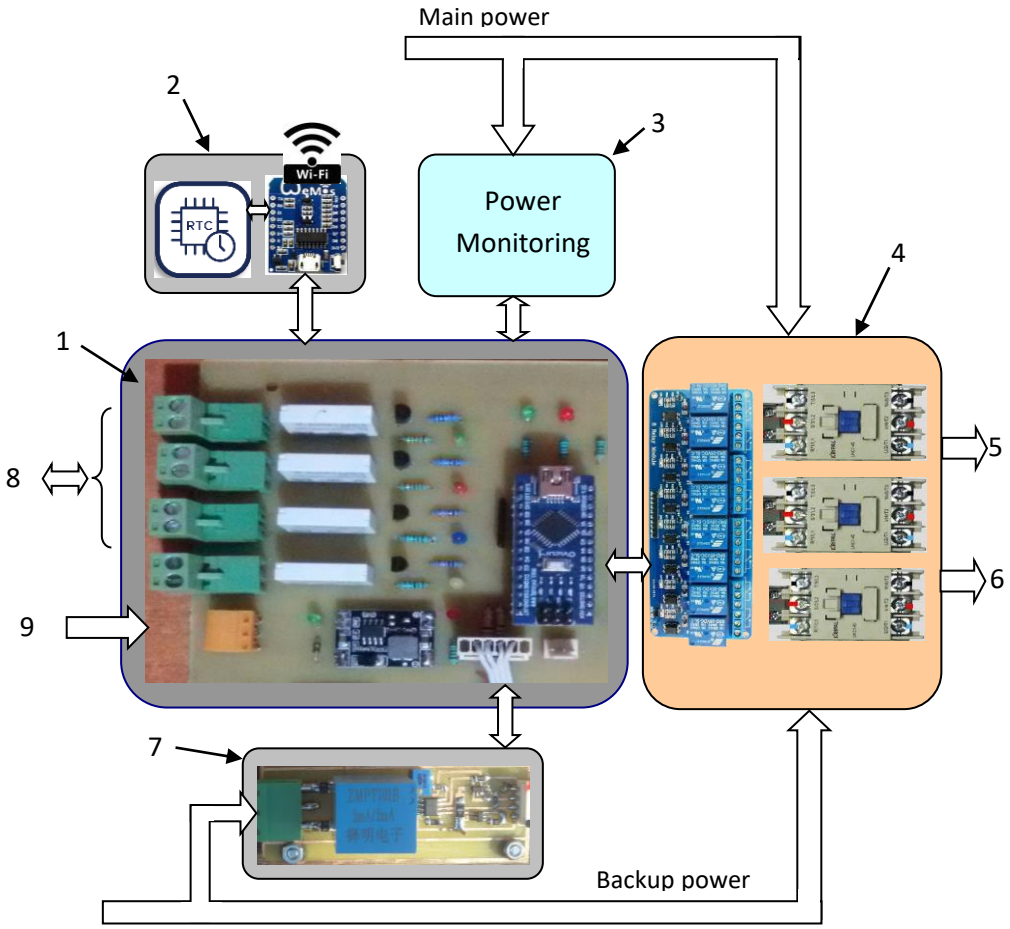

Fig.2 System structure

Power monitoring

The power generator will turn on automatically when the power supply system parameters change. Most often this system involves a simple detection of the lack of a phase. To monitor the lack of a phase in a three-phase electrical system, we opted for a simple solution with 3 relays each powered by a phase whose contacts are connected in series and connected to the automation system. The simplified scheme of this solution is shown in figure 3.

The operation of the circuit is very simple. When a phase of the power supply network disappears, the corresponding contact opens an event notified by the automation system. At this point, the generator is started. If a monitoring of the parameters of the power supply network (voltage, frequency) is desired, a dedicated system (digital protection relays) will be used.

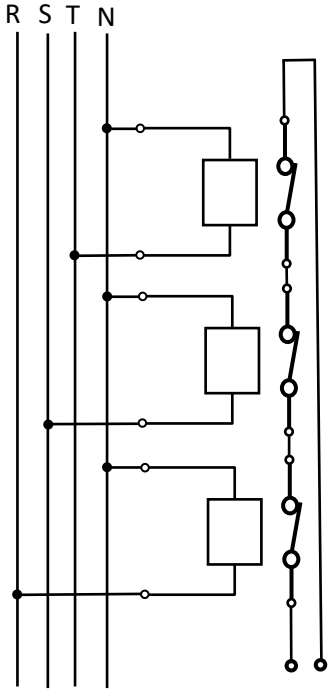

Fig.3 Lack of a phase detection circuit

Changes to the generator are minor. Thus with only 2 contacts of some relays placed in parallel with the contacts from the manual start key the generator is ready to be connected to the automation system. To start, the two relays are controlled according to the generator start mode. At start-up, the automatic system tests that the output voltage falls within the preset range (180V-240V). At this point, consumers can be connected.

Coupling one of the power circuits made with contactors can only be done if all contactors are disconnected. This prevents accidental connection of the mains and the generator. For this, both software and electrical interlocking is performed.

Voltage generator monitoring

The voltage at the generator output is constantly monitored to see if it is within normal operating limits. If there is a voltage drop for a longer period than the established one, the consumers are switched off and switched to emergency mode when sonar, optical warning systems are started and via the wifi network.

ZMPT101 miniature voltage transformer [3] is designed for applications where AC voltage signals must be transformed accurately into a lower voltage signal appropriate for micro-processor based circuits. ZMPT101 current-type voltage transformer is a kind of mA current transformer, which turn ratio between primary and secondary is similar to 1:1. a limiting resistor is nessary to be in it with primary winding. ZMPT101 is popular to a limited internal space of devices. The sensor has a very good linearity of 0.1%. The output characteristic according to three values of the load resistance as well as the picture of the sensor are shown in figure 4.

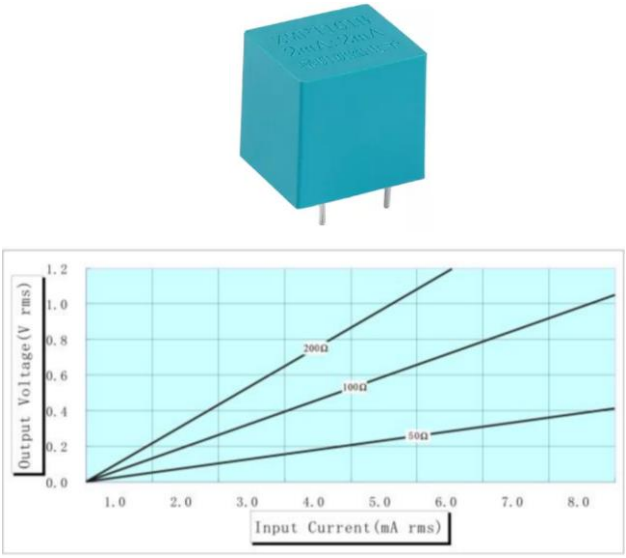

Fig.4 ZMPT101 sensor voltage characteristic

The electronic scheme of the measuring circuit and the associated waveforms are shown in figure 5.

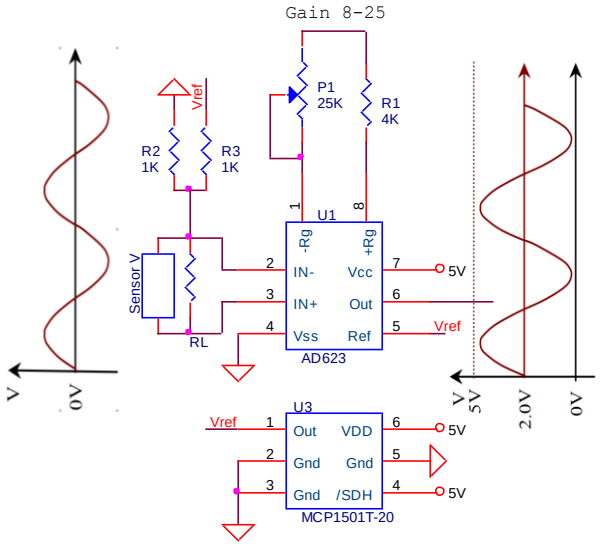

Fig.5. Circuit and signals for voltage measure

Communication circuit

The automation system communicates with the existing wifi network via the built-in wifi communication module of the WeMos D1 Mini type [4]. This is a miniature wireless 802.11 (WiFi) microcontroller development board. It turns the very popular ESP8266 wireless microcontroller module into a fully fledged development board.

This module is connected to an EEPROM memory to store a larger amount of data and to a real time clock.

Important data related to the operation of the automatic system will be recorded, such as the time at which the generator started and stopped, the number of operating hours, errors in operation. These values can be accessed via a local display but the proposed option is to access data remotely via a smart system (phone, tablet, PC).

3. CONCLUSIONS

The proposed system is a simple and strong one useful for power supply of vital consumers in case the supply voltage disappears. The system uses existing generators with manual turnkey start which with minimal modifications can be started automatically without the intervention of the human operator. Consumers will also automatically connect to the available electricity source depending on the implemented scenario. The programming of the system can be done according to the particular conditions of each location where it is mounted. The use of wifi communication transforms this automation system into an IoT type. You can remotely view the status of the system, receive notifications of events (power outage, generator connection, operating errors) or you can order the generator to turn on and off, connect or disconnect consumers to a particular power source in safety conditions.

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