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Designing and Implementing Control panel for Diesel generator

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Abstract. The Main goal of the study was to Build and implement a control panel to protect the diesel generator, and auto-starter with ability display the error using visual alarm and LCD, also, easily used by the operators. The purpose has been achieved as the test results show that it operated as intended. In this paper, we explain How the system works and How will respond to the error signals coming from the sensor (Thermostat, Coolant pump, Fuel, Lubricating, Stop emergency). We have Design and choose the components of the electrical circuit of the control panel to build a stable, reliable system and quickly responding system. It is also Protected from outside disturbance flaw such as over-voltage. The system can recognize the faults and initiate shut down on diesel generator also retain the fault indicator (LED and LCD notification) until the system is reset. Design and implementation of a microcontroller based automatic Diesel Generator controller. With the added ability to measure the amplitude and frequency of the generator's AC output, in addition to providing alarm state notification using LEDs and messages displayed on LCD.

1. Introduction

Diesel generators are increasingly being used in various applications, such as providing backup or standby power to various facilities and critical systems in case of power fail or emergencies, to avoid any power loss. Diesel generators are widely adopted in different industries due to their reliability, ability to generate adequate power for massive duty operations, portability, and efficiency. As a result, it is highly required to enhance both the efficiency and performance of the generator [1], [2], [3]. To address these concerns, current diesel generator control circuits are designed to monitor all parameters and sensors' data continuously and providing automatic on/off switch, if there is any power loss. All electrical machines have a set of nominal parameters under which they function at optimum levels, so any fluctuations in their parameters can cause these machines to run at lower efficiency. Power Generators are no exception to that; generators are typically designed to run most efficiently at or near sea level under standard conditions of temperature and pressure (STP) [4]. For proper ignition and functioning of generators, there must be appropriate ambient temperature and air pressure values. All generators, irrespective of the fuel that powers them, demand sufficient air for combustion. So, any deficiency in air density can lead to start-up fails. In diesel engines, air and fuel are infused together then the compressed air becomes hot, and when peak temperature and pressure values are achieved, diesel is injected, which then ignites under the given conditions [4].

For abnormal Circumstances, diesel generators must be equipped with a system to protect against costly damage. That protection system responds by shutting down the generator faster than a human operator when it detects unusual output or input values, which may cause damage. The quality and reliability of a protection system are paramount [3].



The protection system of a diesel generator set is aimed at preventing costly damage to the generator in the event of a mechanical or electrical emergency. The diesel engine is typically protected against low oil press, over-speed, and high oil temperature or water (coolant) temperature. The protection unit is designed to identify any abnormal condition within the engine through individual sensors and acts to shut down the engine [1].

The primary function of this smart Microcontroller based unit is to control and protect power generators in industrial applications; despite the sophisticated technology of the circuit, its interface is still user-friendly and straightforward to use by the operator. Thus, it does not require a professional nor a qualified worker to use it. The primary mode of operation is selected by a key switch, turning off the generator's control unit can be simply done by turning the key to "off" or by removing the key, and there is Push button for an emergency shutdown. Also, the unit allows you to control response time. The generator's control unit incorporates multi-function protection: an engine protection module, Auto starter, I/O monitoring Sensor signals, receiving analog or digital signals, monitoring the output voltage of the power generator, monitoring the output Frequency of the power generator, internal time clock, LCD provides helping messages which make using the unit intuitive.

2. Programming

2.1. Micro-controller programming

Microcontrollers are great when you need a few computer smarts in a physical system.[6] In this control unit, a higher-level language called MikroC with the integrated development environment (IDE) was used, it contains useful tools such as code editors, compilers, and debuggers. As the first step relates to programming, set data register manually to specialize Microcontroller for a specific task and activate some feats, this data register is unique each model or brand, so it must be checked from the datasheet. However, in our control unit, we selected two different microcontrollers ATMEGA 32/8. [2] In programming, We initialized the ports of microcontrollers as:

- Identify the input of the sensor and switches.
- Initialization of LCD ports.
- Activate the general Interrupt in the system
- Initializing of the timer setting.
- Identify the Output of the ports
- Initialization of external Clock Setting
- Activate the Emergency Interrupt
- Initializing of the counter with compare overflow set

The programming flowchart can be seen in Figure 1:

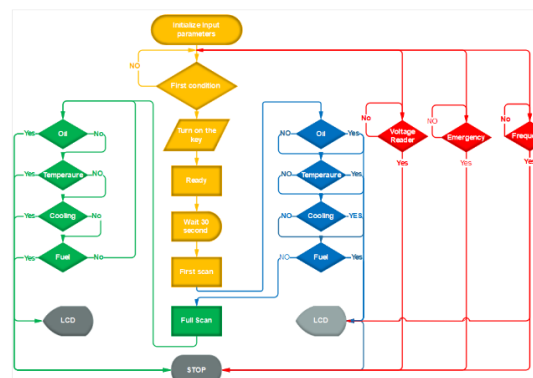


Figure 1 The flowchart of the program and How the system works

2.2. First scan

When the generator reaches a set point, the unit will scan for the first time; it will display all problems on the LCD if any. In the case of more than one problem at the startup of the generator, then, after displaying all error messages, the control unit will turn on the LED alarm, and shutdown the generator. As demonstrated in Figure 2:

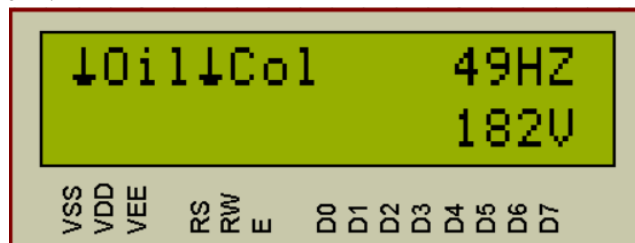


Figure 2 The error message for the first scan

3. Schematic project

3.1. Input

The optocoupler is an LED chip integrated into the same package with a light-sensitive device such as a photodiode or a phototransistor, the two components being electrically separate but optically coupled. For Microcontroller pins, as shown in Figure 3, we use optocouplers to provide isolation between pins and sensors to take precautions against input abuse or over-voltage coming from outside the control system. Also, it is a standard method used to achieve electrical isolation. Also, the LEDs are connected as a part of the sensors instead of being connected to the microcontroller's pins [5].

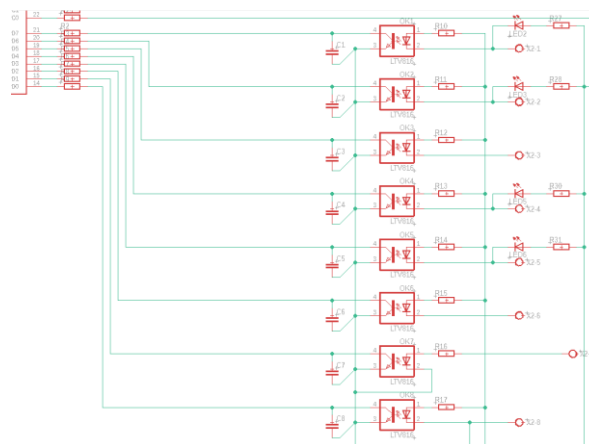


Figure 3 The schematic of input sensor connected to the Microcontroller pins

3.2. Auto starter and Coolant Pump

Until now microcontrollers can't drive electrical equipment directly. Consequently, we use relays. A Relay is just a switch that's opened and closed by an electromagnet, so they're the easiest to understand. Run a current through a coil, and it pulls a piece of metal into contact with another piece of metal and your switch closes. However, when the magnetic field collapses, it generates a reverse voltage, which can be quite large. To avoid the effects of that reverse voltage, we use Diode [6]. After Initializing the microcontroller and the system, it will scan the status of the sensors (First Condition), if all the sensors are on normal mode, you will be able to Switch the key to the "on" position. Meanwhile the microcontroller switches on the port which controls the NPN transistor to latch the starter relay, in addition, turning "on" the LED which is connected it.

After ignition engine start, it is required to wait for 30 seconds until the system reaches set point afterward it will scan the sensors. The microcontroller will provide the on/off signal to the base of this transistor. Which will be driven to saturation, and a current will start to flow. Obviously, in Figure 4, the microcontroller drives two relays:

One of them is used as a starter relay, the other one for turning on the coolant pump during high temperatures in the generator.

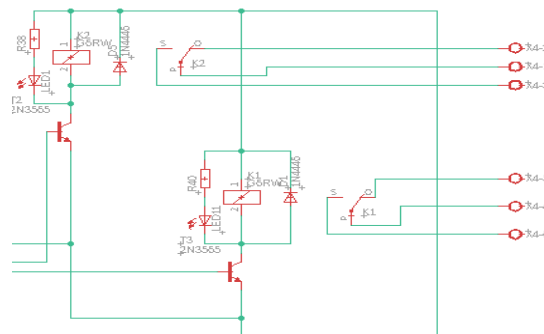


Figure 4 The schematic of the system output (Starter Relay, Coolant pump)

The Control panel typically protects the diesel Generator against High Temperature, Cooling system, Fuel System, Emergency, Overspeed and High Amplitude. Since about one-third of the heat is a result of fuel combustion inside the engine, it must be removed to the outside environment. Thus, a precise cooling system is needed to avoid high temperature, which might cause the generator to shut down [7].

The thermostat sensor is generally used in internal combustion engines, so it can be used to send the signal to the system when there is an over-temperature situation [1], when the system receives a signal from the thermostat, first of all, it will turn on a coolant pump, afterward, the response depends on settings put in the device and give the operator option to shut down immediately or wait (30/60/120) Seconds before shut down and during this period check the thermostat and other sensors. The flowchart in Figure 5 shows the overall workflow for such a case. Error messages will be displayed on LCD for temperature and coolant, as shown in Figure 6 and Figure 7.

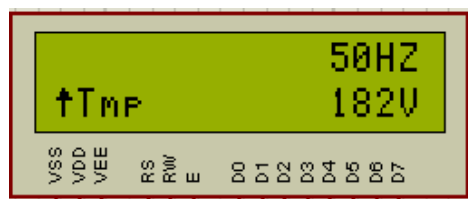


Figure 5 The Error message of high temperature

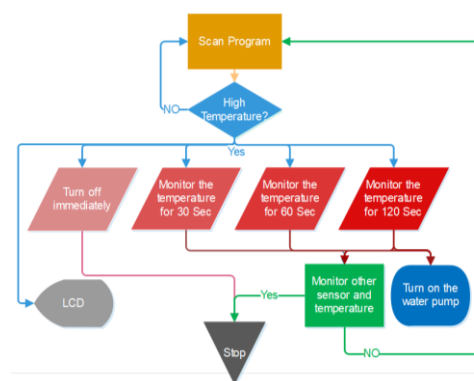


Figure 6 The flowchart of the program in case of high temperature and how it will respond

Generally, applied protection sensors are temperature switches and indicating gauges monitoring the temperature of the coolant. There is a useful protection feat by a low-pressure sensor positioned in the inlet to the engine's coolant system. It will detect any fail occurring in the coolant circulation with pressure sensitive device operating before a rise in temperature of the engine [1] when the system receives the signal from the sensor demonstrating that there is a problem in the cooling system, it will respond to this situation in the following steps :

- Shutdown the generator immediately.
- Turn on the alarm LED.
- Display the error on the LCD as shown in Figure 7

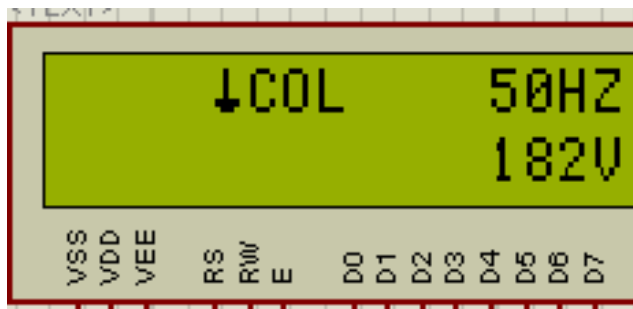


Figure 7 The error message of the cooling system

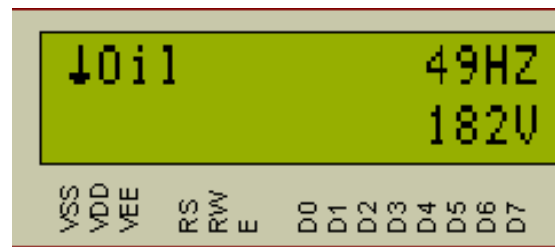


Figure 8 The error message of the oil system

4. Lubricating system

The lubrication system serves to lubricate and cool the pairings of the crankshaft drive, the valve train, and other moving components and to remove local contaminants, wear particles and combustion residues [7]. Sometimes oil press falls because of some reason such as too much tolerance between the piston ring and journals or overheating in the engine. So, any trouble in the system of lubrication will cause clattering sounds coming from the engine during operation due to high friction in the engine's components, causing damage or wearing the engine [1]. If the system receives a signal from the oil press sensor, it will respond to this situation in the following steps :

- Shutdown the generator immediately.
- Turn on the alarm LED.
- Display the error on the LCD as shown in Figure 8

5. Fuel System:

Sometimes due to a fault in Filters, Valves or Press controller, etc., which affects the fuel flow rate and press to the injectors, this fault leads to a drop in the fuel system press, which is needed to cause ignition in the diesel engine. [7]

The system will respond to this situation in the following steps :

- Shutdown the generator immediately.
- Turn on the alarm LED.
- Display the error on the LCD as shown in Figure 9

6. Stop Emergency:

In emergencies, there is a button for the operator to press, which immediately shuts down the generator, Turn LED on, and display the error as it is shown in Figure 10.

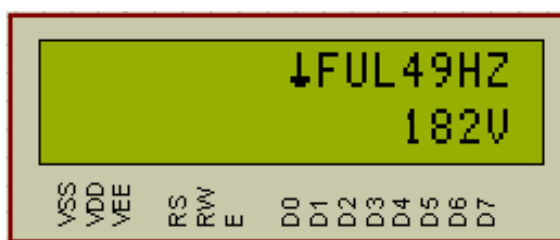


Figure 9 The error message of the fuel system

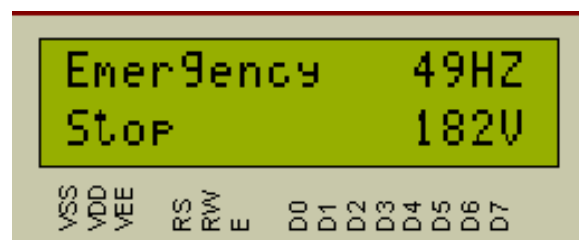


Figure 10 The error message of Emergency

7. Final Board:

In the end, we design with two options:

- ATmega 32 comes with LCD.
- ATmega 8 just necessary feats and without LCD, with only LEDs to show the errors.

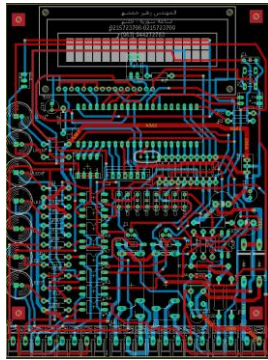


Figure 11 The PCB for ATmega 32

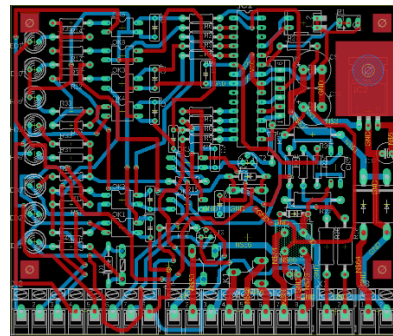


Figure 12 The PCB for ATmega 8

8. Conclusion:

The Main goal of the study was to Build and implement a control panel to protect the diesel generator, and auto-starter with ability display the error using visual alarm and LCD, also, easily used by the operators. The purpose has been achieved as the test results show that it operated as intended. In this paper, we explain How the system works and How will respond to the error signals coming from the sensor (Thermostat, Coolant pump, Fuel, Lubricating, Stop emergency). We have Design and choose the components of the electrical circuit of the control panel to build a stable, reliable system and quickly responding system. It is also Protected from outside disturbance flaw such as over-voltage. The system can recognize the faults and initiate shut down on diesel generator also retain the fault indicator (LED and LCD notification) until the system is reset.

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