Digital Protection System of the Engine-Generator Based Microcontroller AT89C51

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Abstract:

This paper describes the design and implementation of the engine-generator protection circuit based microcontroller AT89C51, which is very popular and is used in a huge number of applications in professional systems and amateur projects. This digital electronic circuit shows further possibilities of improvements, and is employed as a device to protect the engine-generator from the fault type that may occur during operation of the generator such as over heat; oil alert; over speed; and over voltage that will damage the engine and exciter of the generator. It is also used to protect all devices that are connected to the generator. The engine–generator protection can be done by gathering data from the sensors attached to the microcontroller and some other electronic circuits.

1-Introduction:

At the beginning, the engine-generator sets have countless applications, often with multiple uses within the same facility. Most engine-generator systems provided for human safety and protection of property in applications such as office buildings, hotels, assembling facilities and government facilities. Hospitals and nursing houses have special needs vital to life, and these emergency power systems reflect these requirements [1]. In general, there are two types of generators *Synchronous Generator and Induction Generator*, but most applications today use the synchronous generator because of its versatility, reliability and capability of operating independently [1]. The digital generator protection system provides a wide range of protection, monitoring, controlling and recording functions for AC generator [2]. There are many variable parameters in the engine-generator that have been monitored, protected and controlled such as stator differential, current unbalance, loss of excitation, over and under voltage, over and under frequency, low level oil, and heated engine. An integral keypad, RS232 serial ports and printer port allow remote computer access to program the limitation variables parameters of the engine-generator. In this design of digital protection circuit, protection and monitoring of engine-generator from low level oil; increase the engine temperature, over frequency and over voltage is achieved by using micro controller AT89C51.

2- Hardware Design:

The hardware of the "Digital Protection System" device was designed while keeping in mind minimizing component count, and utilizing the microcontroller AT89C51 to improve its capabilities [3]. The block diagram of the Digital Protection system of the Engine Generator is shown in figure (1). The electronic circuit, which is shown in figure (2), underwent several refinements in order to improve performance, protect the

electronic circuit, and reduce component count and interface circuit to microcontroller.

To explain the electronic circuit operation with the microcontroller AT89C51, it is very necessary to divide this circuit into two stages with respect to the signals direction to or from microcontroller.

2-1 Digital input signals to the microcontroller:

The input signals to the microcontroller come from two different sources.

The first is digital signal (0-5v) DC voltage or logic signals on/off.

The second is generated power 220-volt AC 50 Hz signals that converted to logic signals and DC pulses signals.

2-1-1 Sensors (Oil, Temperature, and Dynamo):

The three input signals to the device "Digital Protection System" (DPS) are coming from special sensors which will be dedicated to measure oil level, monitoring of engine temperature and checking the battery charger "dynamo". All these sensors produce digital signals on/off (0-5) volt [4]. So the device will not use an A/D converter.

2-1-2 Over Frequency Detection Circuit:

This circuit is specially designed to detect any frequency changes over a specific frequencies (>51Hz) in the output of the generator. The circuit has high resolution and accurate input/output to sense any AC voltage changes from the voltage produced by the remaining flux in the generator to the full power operation "approximately for 1-250 AC volts". The electronic circuit output is square wave pulses which are applied to the first counter of the microcontroller AT89C51 to measure the frequency of the generated output and compare it with digital setting input to the microcontroller DIP switches (D7-D0) which adjusts the maximum possible frequency operation. To find the speed of the engine-generator which is suppose to be (3000 rpm) for gasoline generators and (1500 rpm) for diesel generators then both of these generators can be calibrated to 50Hz as normal operation and 55Hz as over frequency operation.

2-1-3 Over Voltage Detection Circuit:

This circuit is designed to detect the generated voltage of generator 250 AC volts. This can be done by attenuating and converting the AC voltage of the generator to the DC voltage range from (2.2 – 3.1 DC volt.) as shown in figure (2) then compare it with a reference DC voltage 3.1volt zener regulator voltage [5].

2-1-4 Start, Stop and Reset Switches:

These switches are attached to the card and provide a possibility of starting or stopping the engine-generator whenever the operator needs to do so. The reset switch is used to test all indicators LEDs in the start operation and reloading the program from the beginning.

2-2 Digital output signals from microcontroller:

The output signals from microcontroller are only one form of signals "digital signals" to turn on or off the engine generator and to indicate the LEDs on the front panel.

2-2-1 Run/ Stop solenoid valve, Alarm and Driver DC Motor:

The output terminals for this card can be arranged in three circuits. These circuits' commands are fed from the microcontroller AT89C51. The first circuit is run/stop solenoid valve of the fuel, in which relay circuit control is used [6]. The second circuit is the alarm indicator which shutdown the engine automatically because any fault has been occurred such as "oil level low, engine temperature is very high, over speed and over voltage" and also used relays circuit control. The third circuit is the driver DC motor for starting the engine running; this signal is manual control from push – bottom switch to relay circuit control. All these relays can be supplied from engine-generator battery of 12 or 24 DC volts.

2-2-2 The Panel Indicator:

Seven LEDs are provided on the front panel of the device for easy and immediate indication of the fault type such as "Dynamo failure, oil level low, engine temperature is very high, over speed, over voltage, alarm and solenoid valve state. These signals come from the output port of the microcontroller AT89C51.

Figure (3) shows the prototype that was assembled on a 150mm*85mm standard Euro card prototyping board that has accommodated all the electronics of the Digital Protection System (DPS).

Figure (4) is the front panel of the device panel that has three switches "Start, Stop, and Reset" and seven LEDs indictors "Dynamo, Oil, Temp, Over Speed, Over Voltage, Alarm and Solenoid valve state".

3- Software Design:

The program was written using assembly language of AT89C51 microcontroller [3]. In this section, the program is discussed, which is especially designed to fulfill the requirements of the circuit, that circuit acts as a protection circuit for a generator, and the microcontroller acts as the main controller in the generator. The algorithm of the AT89C51 assembly language program is explained below:

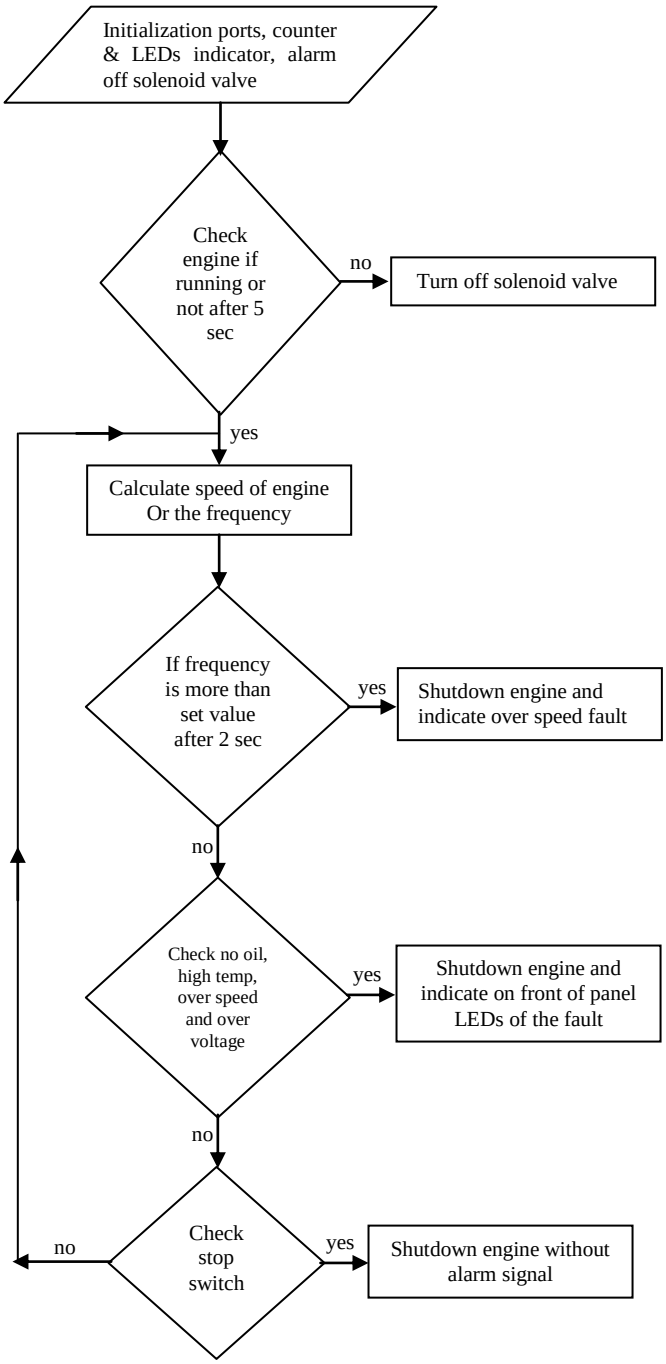
Algorithm & Flowchart

1- Initialization ports and registers to test and then turn off LEDs indicator, alarm off and run solenoid valve on.
2- Check engine is running or not from the sensor of oil for 5sec. If not operate off solenoid valve. Else go to step 3.
3- Initialize the counter 0 and counter 1 to delay one second as a sampling time and calculate the frequency or the engine speed.
4- If the frequency is more than the setting value delay two second and return checks if still up shutdown engine and indicate over speed. Else go to step 5.
5- Check oil, temp, over voltage, and over speed if any fault happened shutdown engine and indicate on the

front of panel LEDs of the fault. Else go to step 6.

6- Check stop switch if it is not pressed then go to step three. Else turn off engine without alarm signal.

Flowchart



4- Conclusions & Results:

The device *"Digital Protection System"* in its final form has been tested using many types of generators such as 5.5KAV to 100KAV and test all faults "Dynamo failure, oil level low, over heated, over speed, over voltage, alarm and solenoid valve state. The operations were carried out successfully and no error happened.

Reference

[1] Internet site: Ecmweb.com/mag/electric-guidelines-enginegenerator-application/index.html

[2] www.Geindustrial.com/pm

[3] I. Scott Mackenzie "The 8051 Microcontroller" Prentice-Hall. Inc, 3st edition 1999.

[4] Willis J. Tompkins and John G. Webster "Interfacing Sensors to the IBM PC" Prentice – Hall. Inc 1988.

[5] C.J. Savant and martin S, Roden and Gordan L. Carpenter "Electronic Circuit Design" the Benjamin/Cummings Publishing Company Inc. 1991.

[6] Steven J. Faulkenberry "Introduction to Operational Amplifiers with Linear Circuit Applications"John-Wiley Inc. 1986.

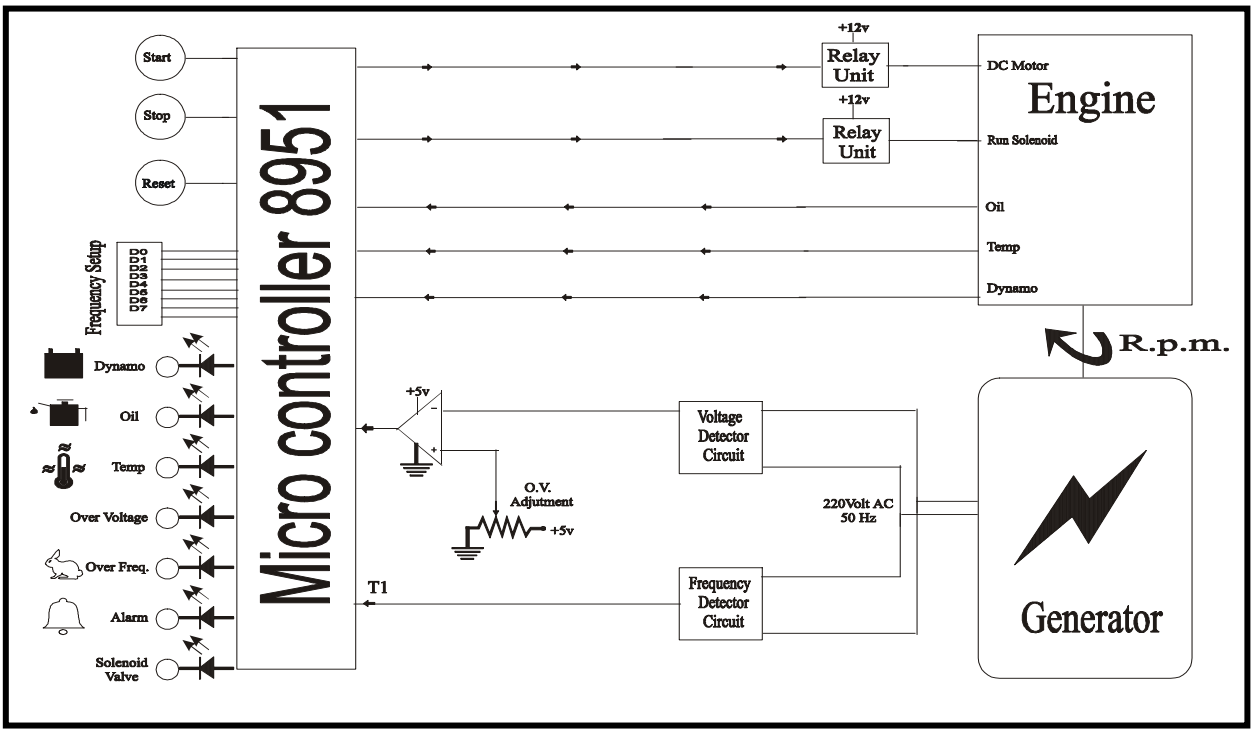


Figure (1): The Block Diagram of the Digital Protection System.

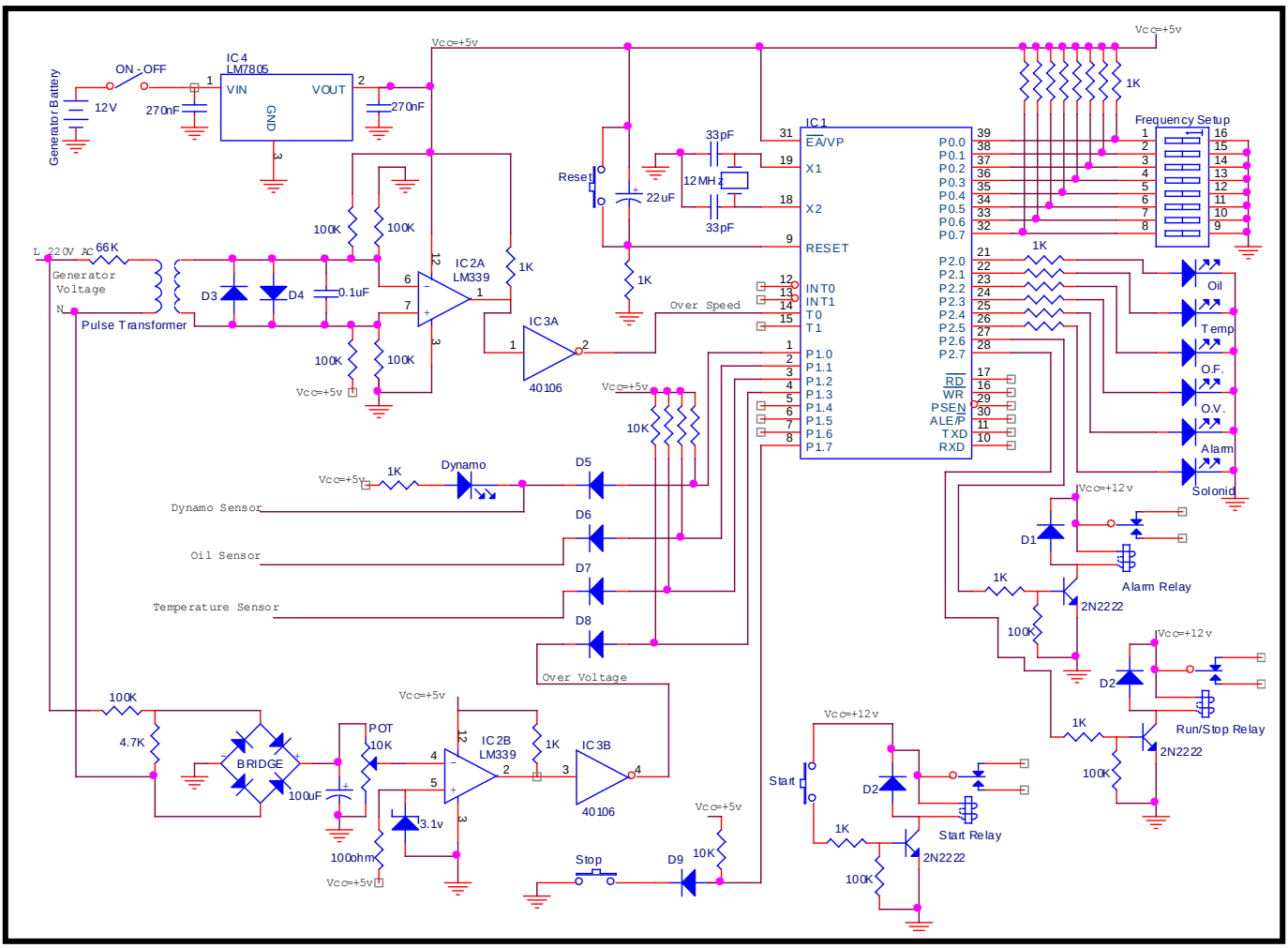


Figure (2): The Microcontroller Circuit of the Digital Protection System

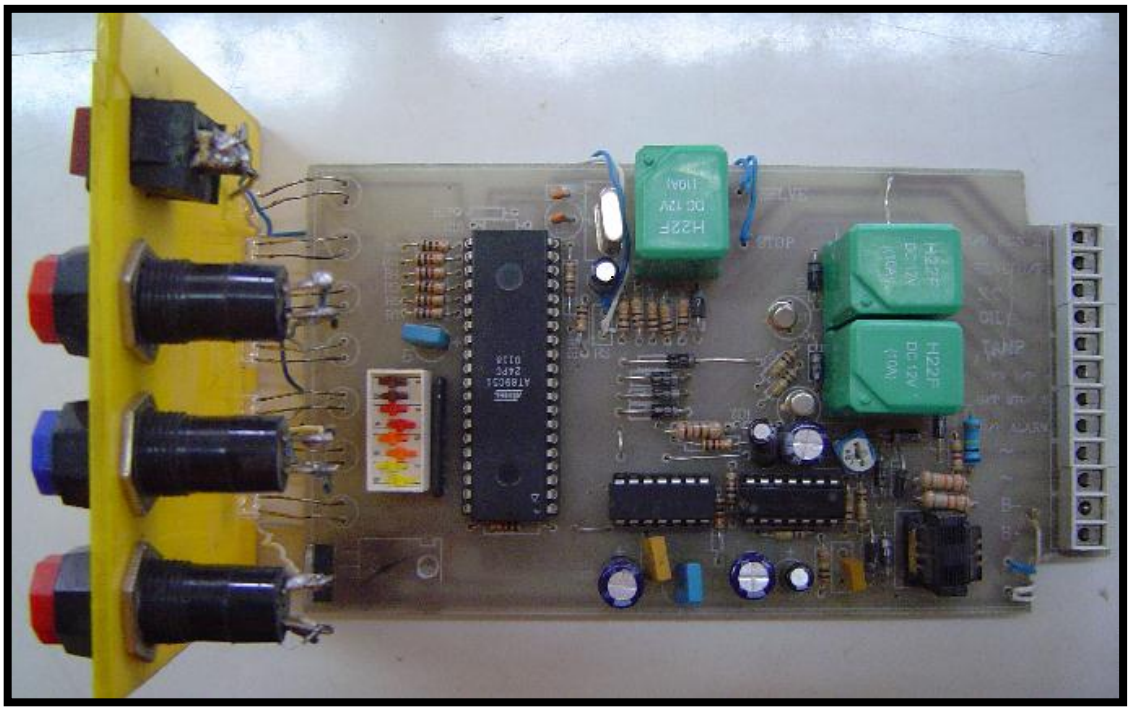


Figure (3): Photo of the Digital Protection System of the Engine-generator Prototype

Figure (4): Photo of the Panel Indicator & Operator for Digital Protection System of the Engine-generator Device.

نظام حماية رقمي لمحرك مولدة أساسه المسيطر المايكروي AT89C51

الخلاصة

في هذا البحث، تم تصميم وتنفيذ دائرة الحماية لمحرك مولدة أساسه المسيطر المايكروي AT89C51 ذات الاستخدام الأكثر شيوعا في العديد من التطبيقات للأنظمة المحترفة ومشاريع الهواة. أن الدائرة الإليكترونية الرقمية المعروضة تعزز إمكانيات تحسين و توظيف كجهاز لحماية محرك المولدة من أنواع الأخطاء التي قد تحدث أثناء العمل ومنها ارتفاع درجة حرارة المحرك، انخفاض مستوى زيت المحرك، السرعة العالية لدوران المحرك وارتفاع فولتية المولدة . حيث أن هذه الأخطاء قد تؤدي إلى تحطيم محرك المولدة وكذلك المحفز لها وكذلك يوفر حماية لكل الأجهزة المتصلة بالمولدة.

تم عمل هذا الجهاز من خلال تجميع البيانات من المتحسسات المتصلة ببعض الدوائر الإليكترونية ومن ثم بالمسيطر المايكروي وتحليل الإشارات، وبعد ذلك إعطاء الاستجابة المناسبة لعمل المحرك للمولدة.