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Automatic Transfer and Controller System for Standby Power Generator

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Abstract: An automatic transfer system (ATS) was developed to monitor the a.c. voltage coming from Power Holding Company of Nigeria (PHCN) line for power failure conditions. Upon detection of an outage for a predetermined period of time, the standby generator is started, once is up to speed, the load is transferred from the PHCN line to the local Generator.

This ATS is capable of electrically monitoring fuel level, oil level, Battery strength, next maintenance schedule and then start or stop the unmanned Generator from the computer system located in the comfort of homes or offices outside the Generator site.

In this paper therefore, an Automatic Transfer System (ATS) for Power Generator is designed to improve the operation and maintenance of power generators. The ATS which includes both hardware and software module, provides a functionality that allows a power generator to be controlled and monitored from a remote location

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Introduction

In most developed countries of the world, residential and business owners have no business acquiring automatic change over switch for generators since their public power utility system is working and very reliable. Generator set are only used in very remote location where they go for picnic. In Nigeria, stand-alone power generating sets have become the main source of power supply for decades now especially for business owners, corporate bodies, industries as well as individuals due to the epileptic condition of the electric power utility. To ensure the continuity of electric power supply, many wealthy individuals and business owners depend upon utility service plus on-site generation.

The growing complexity of electrical systems therefore necessitate that attention be given to power-supply reliability. The stand alone generator and the automatic transfer systems shown in figure1 is unique in that many remote monitoring modules are incorporated through programmable logic controller so as to facilitate the management of the entire power system operation.

However, the management system remains a core challenge. The time lag between when the mains supply is off and when the standby power generator is on is usually long due to the processes involved and the human interactions that take place before the standby power generator is switched on. Time means money especially for business owners. The operation of the power generator enjoy much human interaction in switching (ON/OFF) and in monitoring the safety and control conditions that must be met before automatically starting the standby power generator.

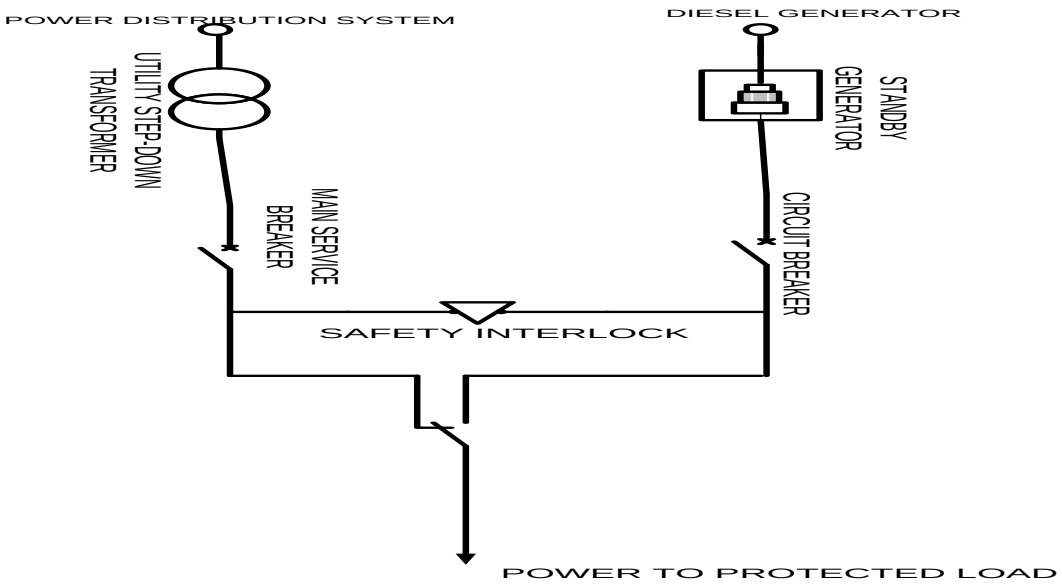

FIG1. STANDBY POWER SYSTEM USING GENERATOR SET

With the supervisory monitor systems (SMS), these human interactions that results in delay are eliminated. The health hazards associated to noise in the generator environment will also be eliminated if most of the monitoring is done remotely. Most often, the maintenance action is not properly scheduled because of lack of efficient monitoring process that ensures accurate and efficient maintenance timing.[1] The need to develop a system that ensures effective management and operation of standby power generators is therefore the major motivation for this work.

The goal of this work is to electrically monitor various operation parameters at an unmanned operating location. If a deviation in desired range parameters is noted, the solenoid coil of the starting circuit of the standby generator cannot be energized until the identified fault is cleared manually. This unique automatic transfer system (ATS) is programmed to define the source of control commands and the immediate respond to the control command depending on whether the ATS is on operator controlled or automatic mode.

The second stage considered the principle of operation and the methods adopted in achieving the outlined goals. The results obtained are discussed in the third stage while stages four and five looked at the future developments and the conclusion derived

.

Principle of Operation

The project work involves building a hardware module and developing an application. The hardware module comprises three stages: Serial Level Converter, the relay interface and the microcontroller stage. The serial converter changes the RS232 levels to a lower one for serial communication [2]. The relays interface serve as switches between the power generator and the microcontroller. The control actions are actually performed by the microcontroller. It processes the signals (requests) that are inputted from the computer as well as the observed operating conditions from the power generator system. The microcontroller is programmed to take in input signals from the computer as well as the input signals from the Generators via various sensors [3]. The operation parameters of the stand alone generator can be electrically monitored through these connected sensors. The output section of the microcontrollers is connected via relays for the desired operational actions.

The PIC is programmed using C language. The compiler has a USART Library that allows for serial port programming in C [4]. The desktop application Graphics User Interface (GUI) is developed using Microsoft Visual Basic 6.0. It has a communication control (MSCOMM) that provides access to the serial port for communication purposes.

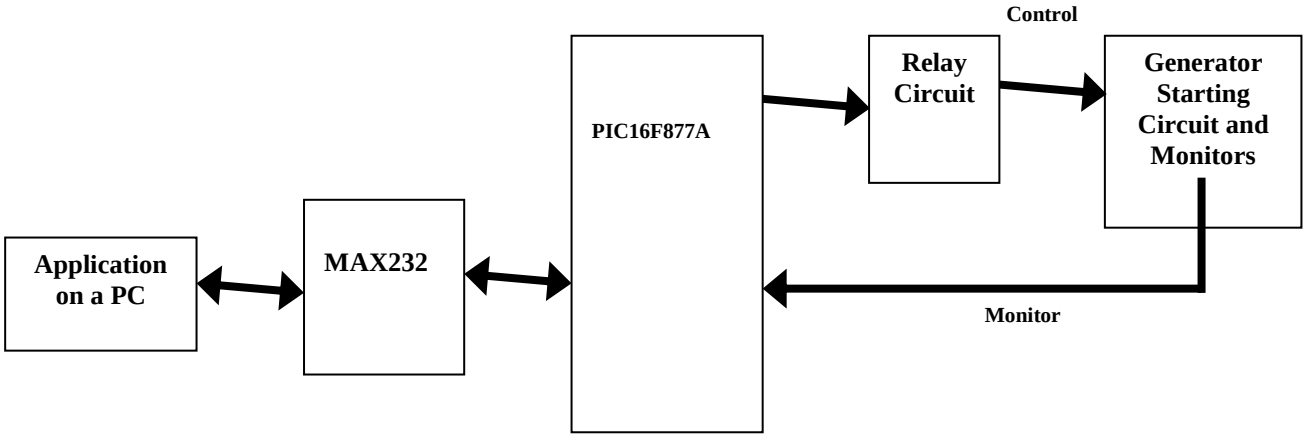

Figure 2: Block Diagram of the control part of ATS system.
ATS

Stages in the design

The design of the ATS is divided into three sections: the power supply unit, the interface between application PC and microcontroller, and the interface between system and the power generator. The hardware module is interfaced with the starting circuit of the power generator for effective monitoring purposes and it is interfaced with the PC through the Universal Synchronous Asynchronous Receiver Transmitter (USART) on the PIC and the serial port (on the PC) [5]. The block diagram in figure 2 shows clearly the working principles of the ATS control system and some of the critical components used in the design.

The power supply unit

The power supply for the control unit is designed to incorporate LM7812 and LM7805 as the voltage regulator IC which have black plastic bodies with metal tab heat sink. This metal tab is electrically connected to the center pin which is the output pin. The input pin is on the right side and the adjustment pin is on the left [6]. Fixed regulators such as the LM7812 (12 volt) need no resistors and may be mechanically grounded without insulation since the tab is internally connected to ground. Either way, these three-terminal regulators perform well and offer built-in current limiter and thermal overload circuitry. Input and output capacitors shown in figure 3 are included in the design and implemented by mounting them near the regulator IC.

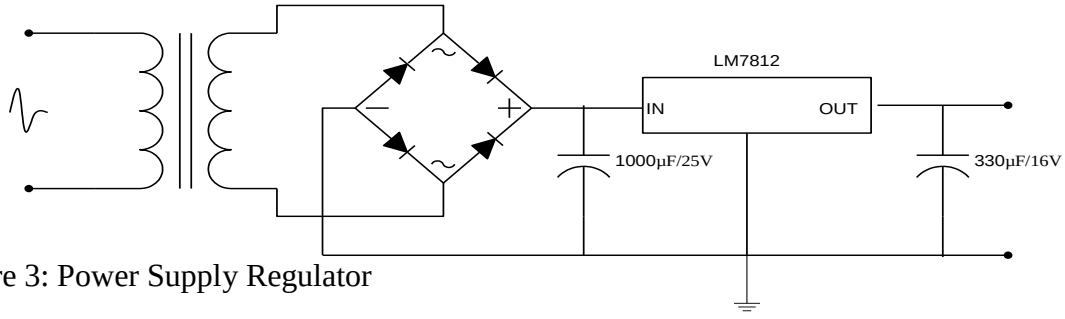

Figure 3: Power Supply Regulator

Results and Discussion

The system provides a two-way functionality as shown in figure 2, a forward functionality from the PC to the generator and a backward functionality from the generator to the PC.

Forward functionality (Control)

The control of the ATS system starts from the application on the PC, as shown in figure 2, which sends signals in voltage ranging between -15Vdc to +15Vdc through a serial communication port

(RS-232) to MAX-232. The function of the MAX-232 is for communication between the PC and the microcontroller (PIC 16F877) by reducing the voltage signal ranging between 0Vdc to +5Vdc which is sent to the input pins on the PIC which in turn sends signals to the generator via the relay circuits. The signal from the PIC output is not sufficient to energize the relay **(**PIC provides 25mA maximum, relay requires 100mA minimum), an amplifier using an NPN transistor technology was used to amplify the current to a level sufficient to energize the relay. When a logical one is delivered to transistor base, the transistor activates the (ON) relay. The relay circuit once energized closes the normally open contact which triggers the solenoid of the Generator's starter switch that turns on the Generator.[6]
The implementation of this part is as shown in figure 4.

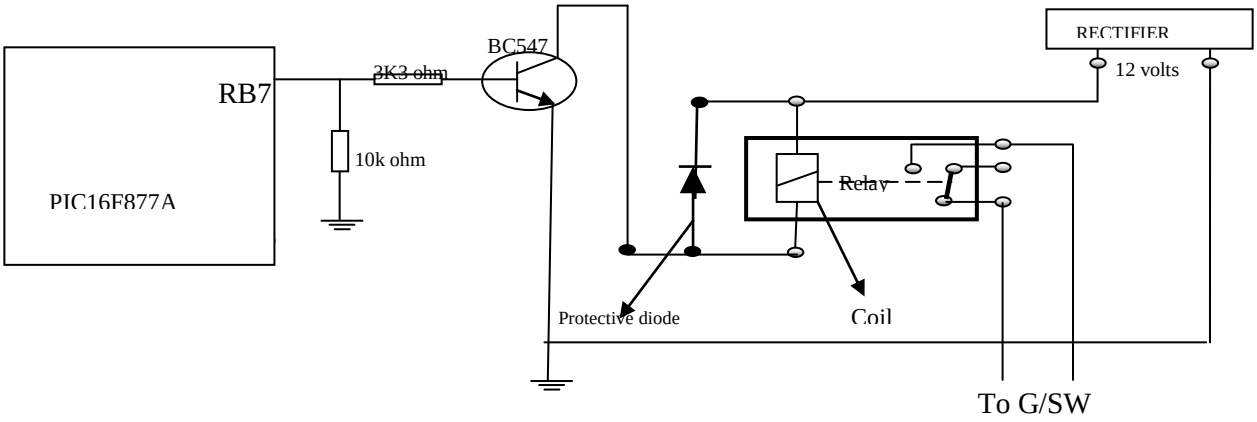

Figure 4: PIC16F877A, NPN transistor and a Relay

Backward Functionality (Monitor)

This is the part of the system that process the various input signals from the different monitoring points. In this work, the parameters that are monitored are fuel level, oil level, the battery power and the switch positions. The monitoring device operates based on logic I and 0 representing fuel level full or empty. This is made possible through an NPN transistor circuit which sends the signal in binary form to port A on the PIC. The MAX-232 and the serial port on the other hand is set between -15Vdc and +15Vdc signals which aid the application on the PC. This means that when it is -15Vdc, the fuel level monitored on the generator indicates RED light meaning fuel tank is empty, and when it is +15Vdc, it indicates GREEN light meaning fuel tank full. The monitored parameters are connected in series via normally closed contacts of the different sensors between the generator set and input terminal of the controller. The ATS can only be energized if and only if all the monitored parameters are in normal operating mode. This is implemented in figure 5. This shows that if any of the monitored parameters are violated, the ATS will not be closed for normal operation.

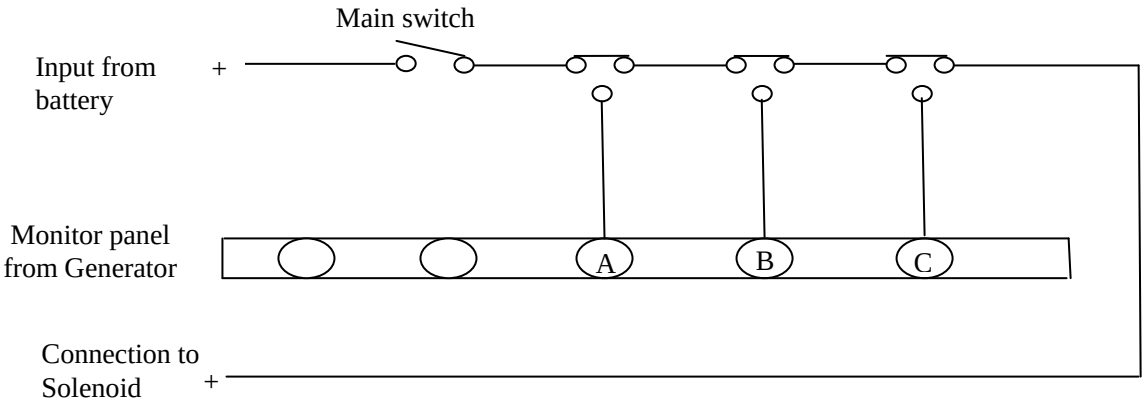

Figure 5: Switching and monitoring panel.

The functionality of the ATS has to do with communication between hardware and software. The RS-232 standard (serial port) provides the communication standard required. Hardly any measurement instruments are designed to use the RS-232 interface, since it lacks the speed and flexibility of the IEEE-488.2 bus [7]. However, for specific applications, such as reading in data from remote dc sensors and sending data to loggers, it can be very useful. The PIC is the basic device that the application communicates with, but the signal generated by the serial port cannot be understood by the PIC without a conversion.

PC Application Development

The software part of the ATS package is developed using Microsoft Visual Basic 6.0 (VB6). An application is developed using VB6 by putting controls on forms and linking forms together. The MSCOMM control is used for serial communication, it is activated (the OnComm event of MSComm) when the timer control is activated at the instance of the command button linked to it. The OnComm event of the MSComm sends the pre-defined hexadecimal number through the serial port
[8]. The OnComm event also retrieves information (in hexadecimal value) on the status of the power generator parameters and changes the color property of the labels used based on the received byte.

At startup, the program attempts to determine and open the PC Com (serial) port available for communication by checking the next com port when error is encountered in opening the first (or previous) Com port. The program can check up to four different Com ports available on the PC. Also at startup the program reads the data file on the C drive that stores the pre- set maintenance date [9]. The maintenance scheduling can be performed manually by selecting a date on the calendar provided in the application or by allowing the system to calculate the date based on the running hours of the generator system automatically.

MAX232 is an IC designed to convert between serial and logic voltage levels [10]. RS-232 standard works with voltage range of -15V to +15V for low and high states while TTL logic operates between 0V and 5V which is the voltage levels that can be handled by PICs [11]. The IC has the capability to change the serial voltage level output from the PC to the logic level input into the PIC and also convert the logic level output from the PIC to serial level input into the PC. The IC works with a 5V power supply and transmits data through its 2-RS232 drivers/receivers at 120Kbps.

The implementation arrangement is as shown in figure 6.

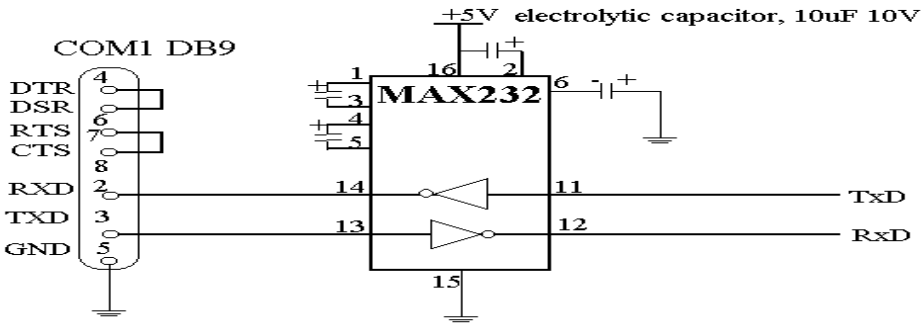

Figure 6: MAX232 Serial Converter.

Microcontroller PIC16F877A

This implements the software based control and monitoring processes. The PIC has an addressable USART which it uses for serial communication with the MAX232. The PORT B of the PIC is configured as the output that sends control signals to the power generator starting circuit through the relay circuit and the PORT A is configured as analog input to receive voltage values that specify the state of particular generator parameter. The PIC is interfaced with the parameter controls of the power generator to measure or determine the state of the parameters. The voltage is read through the PORT A of the PIC as analog input and is interpreted to mean high or low depending on the input. PORT a status is read, the status determine if the generator can be started or not. The condition of the generator is also sent to the PC via the PIC USART for the user to know the state of the generator parameters [12]. The PIC16F877A communicates serially with other devices that are serial communications enabled using the USART.

Relay Circuitry

The relay circuit shown in figure 7 is responsible for performing the switching action that energizes the generator starting circuit for operation [13]. The relay circuit transforms the electrical signal from the PIC into mechanical movement that performs a switching mechanism to allow the generator to start or go off depending on the operation mode desired by the operator.

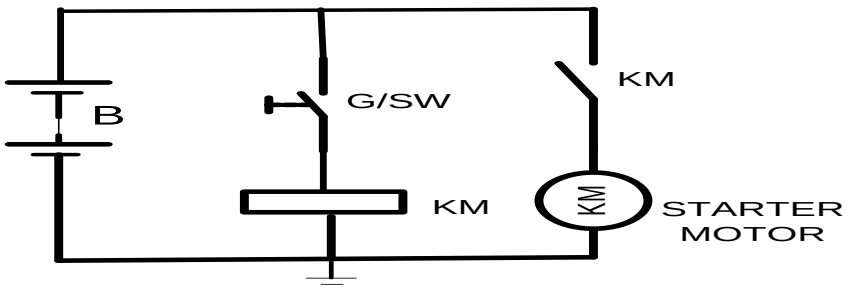

FIGURE 7 BASIC STARTING CIRCUITRY FOR GENERATOR

New Development.

The next stage that is being considered is the development of a supervisory monitor and control that will make use of the telephone dial-up network and possibly a standard push-button telephone to communicate with the remote site. This development will include the provision of voice synthesis equipment at the remote location to communicate information to the user and correct fault on the generator remotely.

Conclusion

Control and monitor units had been incorporated into the ATS system. The programmable control and monitoring device that the operator can perform with his PC at the comfort of his office or home without going to the location of the generator made the ATS system different from others presently available. The scope of the work was achieved successfully. The ATS system was able to switch on/off a 5KVA generator at a remote location after verifying that all the monitored parameters are in normal operating conditions.

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