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Implementation of a Programmable load Shedding Time Management System for Power Utility Department

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Abstract:

This paper is on design and implementation of a programmable load shedding time management system for power utility department. This serves as a solution to the manual method of load shedding where the feeders are put ON/OFF by pressing their control switches on the control board located in the control room. The prototype developed comprises the power supply (AC and DC), micro-controller, load driver, loads (feeders), display, RTC module, input keys, current sensor and a serial communication module. The DC power supply provides the required 5volts to power up the micro-controller which contains in its memory, a program instruction which it executes according to the desired output inputted into it either through the input keys or the serial communication. The output from the micro-controller aid the energizing of the load driver which switches ON/OFF the power supply (AC) going to the feeders, the display helps the operator to see what is happening in the system. The current sensor provides feedback to the micro-controller on the load condition. The real time clock (RTC) helps the micro-controller to keep track of time when the system is on or off.

Keywords:- **Shedding, Load, Excess, Overload, Power, Switch**

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I. INTRODUCTION

The project "Design and implementation of a programmable Load shedding time management system for utility department" is a designed and constructed prototype of a load shedding device capable of automatically switching connected loads with respect to time. Load shedding is an intentionally engineered electrical power outage where electricity supply is stopped for non-overlapping periods of time over a particular zone. It is an elementary case of power economics electric load demand versus generation supply which is not always balanced. Demand is always more than the generated power as time progresses. So, it is necessary to shed the load of a particular geographical region. The project eliminates the manual ON/OFF switching of load. A real time clock (RTC) and a microcontroller are used to keep track the time and automatically switch ON/OFF the loads. A push buttons are used as interface with the microcontroller from where the specified time is input to the microcontroller when this input time equals to the real time, based on the commands the microcontroller initiates that particular relay to switch ON/OFF the load.

Reasons for Load Shedding

Load shedding in electrical supply networks is a controlled process in which the utility company drops off part of the load in order to balance the

demand and the generated capacity. This is often done whenever there is excess load on the system. In standby generators, it involves disconnecting or shedding some circuits to prevent an overload condition.

Power companies are required to supply sufficient energy to meet installed capacity. However, the demand may become inconsistent during peak periods. Whenever the power generated is insufficient to support the load, the electrical supply and distribution system becomes unbalanced and unstable.

If not controlled, the system can collapse and cause a total blackout. In such a situation, it may take hours or days to restore back the power. The utility monitors their systems and compare the load against the supply. If the difference between the two gets very narrow, some of the sections are disconnected so as to prevent the system from becoming unstable.

II. SYSTEM DESCRIPTION AND PROBLEM STATEMENT

I. System Description

Representation of the project block diagram is shown below;

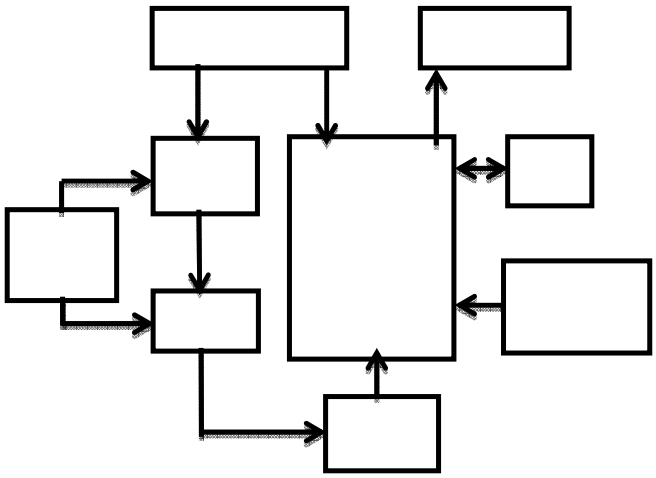

FIG.1: PROJECT BLOCK DIAGRAM.

When the load shedding system is turned ON, the power supply provides the power requirement for the entire circuit system. The circuit is supplied with an AC power source, due to the fact that the electronic components that made up the circuit require DC power, the AC power supply is rectified and filtered to a DC supply of 12vDC and 5vDC to supply the electronic components and the microcontroller.

The controller initializes to allow the operator select whether to set the Real Time Clock (RTC) to match the current local time or to continue, then whether to send new data for each area or to continue working with the previous data. The controller then asked for the preset rated current of the power supply. Then it is set for its control operation.

The RTC continuously sends the current time to the microcontroller, which is displayed on the LCD continuously, and the microcontroller continuously compares the current time with the preset time for each area. When the current time equals to the preset ON or OFF time for a particular area, that area will immediately turn ON or OFF, as the microcontroller triggers to change the state of its pin allocated to that area, causing the driving unit for that area to change its state. And the operation continues as the microcontroller keeps comparing the current time with the preset time of the other areas.

The load current drawn by the area under operation is measured by the current sensor and its result is fed to an input pin of the microcontroller, which uses ADC to convert the measured value to a readable value for the microcontroller. This measured load current from the current sensor is continuously compared with the present maximum rated current of the power supply. When the load current or the current drawn by an area exceeds the maximum rated current of the power supply, the microcontroller instantly triggers OFF that area and switch power to the next area. When the current drawn by all the areas exceed the rated current, then the load shedding system will give a report and the whole system will shut down.

II. Problem Statement

NIGERIA is a developing country with a fast growing economy. Unfortunately, a greater population of Nigeria lacks access to electricity notwithstanding the great economic potentials Nigeria is resonated with. This is a general problem as in most cases power generated is less than demand mostly in developing countries like ours. Load shedding become more important to be able to distribute power to a larger population. In most developing countries manual switching is employed for load shedding. The project eliminates manual load shedding system with the introduction of an automatic load shedding system that operates automatically with the inputted instructions. However our project is affected negatively by the following as a result of present accessible technology;

- Electrical surge disrupts the control system when it occurs while the system is in operation.
- The display panel control does not include present date of operation. That is, it only displays present time with no date.

III. IMPLIMENTATION AND EXPERIMENTAL RESULTS

The project work is divided into the following units and when combined together the design was implemented and tested for result.
These units are;

- The DC power supply unit: This unit consists of the transformer, rectifier and filter which aid the step down of alternating current (220/240volts) to 12volts and converted to DC of 5volts for the micro-controller and 12volts for the driver unit.
- Micro-controller unit: The micro-controller unit includes the micro-processor and its required circuitry connections. It receives 5volt DC from the DC power unit to power up. The micro-controller is programmed to operate in two different modes (single and dual) using C programming language which automatically controls the actions of the entire system when given instructions via the communication unit. When in single mode, the controller instructs the driver to switch ON a feeder one at a time. When in dual mode two feeders are switched ON at a time leaving only a feeder OFF. The PIC16F887 IC was used for the micro-controller.
- Timing unit: The timing unit generates the time used by the micro-controller to keep track of the local time in the real world. It sends its generated time continuously to the micro-controller at a very high speed. The timing unit was achieved using an real time module (RTC) DS3231 which has 16 pins, uses 5volts DC power supply, output 32KHz.
- Communication unit: This unit enables the micro-controller to receive the preset time for each location from the operator. This unit only aids the controller to receive data. This unit uses a USB to TTL serial communication module (RS-232).
- Driver unit: This unit connects the AC supplied to the micro-controller. This was achieved using a load driver module (ULN2804) and sets of relays for switching purpose. The relay driver serves as a switch for each of the feeders, it is energized (either to ON/OFF) based on the instruction coming from the controller through the driver module.
- Feedback unit: This unit was provided to monitor and measure the current drawn by the overall load in any of the feeders. The feedback element used is ACS714-30A

which operates with 5volts DC, capable of withstanding up to 30A of feeder current.

- Field display unit: The display unit is of two, one is installed in the process and the other is in the control dashboard of the system application which is programmed basically for the communication interface found in control room.

Rate of Load Reduction

Load must be shed fast enough to attain the required load reduction before plant frequency has deteriorated to an unacceptable level. The rate of frequency change can be estimated from the following formula:

$$R = pL(f_1 - f_0) / H(1 - f_1^2 / f_0^2)$$

where:

R = Average rate of frequency change, Hz per second

p = Power factor of machine

L = Average per unit overload = (Load-Power Input)/(Power Input)

f_o = Initial frequency,

f_1 = Final frequency, Hz

H = Inertial constant of machine, MW sec/MVA

V. RESULT

The above units was designed and implemented, tested and combined to form the load shedding system presented in this work. Below are images of the system in operation;

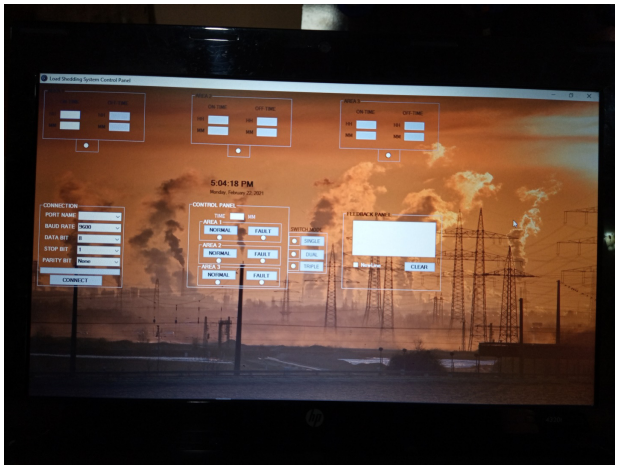

Fig.2: Control room dashboard

Fig.3: The load shedding system operating in single mode with feeder one ON.

Fig.4: The load shedding system operating in dual mode with feeders one and two ON

The implemented design was tested for different duration in two operating modes (single and dual), below is a table of system response with the different time sitting;

IV. CONCLUSIONS

A successful attempt has been made to design and implementation a proto-type of a Programmable Load Shedding Time Management System for Power Utility Department. The system is capable of switching power distribution between different geographical areas, supplied by individual power feeder for a given period of time. The system distributes power from one supply to different geographical area for a given interval of time per area, preset by the operator. Also, the system is capable of shutting down and switching to the next geographical area, when the load on a given area exceeds the rating of the power supply. The completed work has been tested and worked satisfactory. A research approach was adopted in the implementation of this system, from whence a workable circuit was designed. The design was done using embedded system technology. This is to reduce component count, keep the system simple and cost effective.

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