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International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 Issue: XI Month of publication: November 2021

DOI: https://doi.org/10.22214/ijraset.2021.39057

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue XI Nov 2021- Available at www.ijraset.com

Design Technique for Load-Sharing and Monitoring of a Power Plant Using an Intelligent Control Technique

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Abstract:** The application of Data Technology (IT) has been growing rapidly recently. IT utilized to monitor flowing power and distributing electrical energy which is produced by thermal power plant. This project explains how to build and design interface system. Electrical energy needs to be monitored in order to keep energy following. Single Board Computer (SBC), microcontroller, sensors, and transceivers are used in logging electrical power for this project. Following to the reliable need of an efficient power supply and the concern about poor electricity power supply, deregulation, consistent overload on already existing overstressed power supply system which has become a major concern to the social economic needs. The study case system generating capacity consist of 10 units of 2000KVA (20,000VA) = 16000W for power factor of 0.8 which is tied to the exiting load demand of 30MW capacity. Research identity mischarge between the generating capacity and the load demand requirement. That the generator can only a total load capacity of 15MW at one engagement on rationalization and subsequently take the next 15MW capacity to the generator supply. This sequence of operation has put the study zone into regular percentage (blackout) there by negatively affecting the economy activities of the area. This research work has proposed for an additional capacity of 2000 KVA (20 MVA =16 MW) generating power plant for a giving power factor of 0.8 on the view to notice the existing total load of 30MW without any form of rationalization and percentage (blackout) in order to improve the power quality and voltage profile without problem in the day-to-day occurrence activities. The concern for poor power grid supply in the study case (Bertoua community) for the given load of about 16M capacity are taken due consideration with 2MWW capacity thermal power plant on the view to propose solution to improve the quality of energy supply to the Bertoua community and environ. The system is designed with electronic circuitry that can be used to sense/monitor voltage, current, frequency, temperature, pressure and cool level. The design system is modeled in proteus and matrix laboratory (MATLAB) Environment with the application of isochronous mode of control with (10 unit of 2000kVA thermal plant. The improved mode of control (Isochronous technique) was preferred over droop type of generator load sharing techniques, because the improved versus allows and maintained constants speed and frequency regardless of gradual building up of the load to the peak demand scenarios. The modeled Simulink block are configured as an intelligent system multiple generators set in parallel state to monitor and control the gradual load increase from consumer-end to the generators capacity of 2mVA thermal power plant in order to allow load of 1×2000kVA, 2×2000kVA, 3×2000kVA, 4×2000kVA, 5×2000kVA, 6×2000kVA, 7×2000kVA, 8×2000kVA, 9×2000kVA, 10×2000kVA. Since the control system will become an essential factor for reliability of power plants and electrical distribution networks consumption and electric utility at large on the view to investigate appropriate load sharing and balancing, load scheduling, load forecasting, fuel-consumption pattern, optimizing generation capacity in order to optimize energy saving, cost-saving and performance.

Keywords: Load-Sharing, Monitoring

I. INTRODUCTION

An electric power system is an organization of electrical parts used to supply, send and utilize electric power. Power systems designing is a region of electrical designing those arrangements with the generation, transmission, circulation, and usage of electric power and the electrical device associated with so much systems as generators, engines, and transformers [1]. Electrical power generation is a non-storable wellspring of energy. It must be created transport along link lines and devour at the endpoint call (load) [3]. The electrical energy creation is consistently equivalent to that devoured in addition to some extra misfortune along the line. The production of electrical energy in high voltage from thermal power plants needs a lot of attention and care [6]. With all the mechanical work done by these GS, great care has to be taken to control these power stations. Nowadays, most big towns in Nigeria suffer the crises of power rationing.

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It's for this reason that I decided to carry out research work on the "Design of New Management Approach For Load Sharing And Monitoring of an Automated Thermal Power Plant", hence an Intelligent Power Plant (IPP). The circulation of dynamic KW and KVAR responsive power between equal associated Gensets should be controlled. Active power is constrained by the lead representative KW, and receptive power is constrained by the AVR [2]. This new approach would help to manage these plants and improve the efficiency of the plant and hence will reduce the crises of power rationing in Nigeria.

Interestingly, the management of inadequate electric power has been handed with different modeling approaches to solve the problem of load sharing and monitoring of power generation and distributing for efficient utilization in command to advance the required strength demand, particularly to the study area of the research work [4]. This research work will look at the mismatches in the load requirement as a form of energy demand for purpose of effective load sharing of the power plant, with the aim to design a power system generating plant for monitoring and control in order to satisfy energy balance criteria.

II. MATERIALS AND METHODOLOGY

The list of materials used for this study are; control circuit; Microcontrollers (PIC16F88, PIC16F884), Transistors (78L05, 78L12, LM34, LM193, MCP9701, OPAMP), Resistors, Capacitor series (A700V157M002ATE028), Alternator, Logic gate (AND), CORSAIR AXi (AX1000U16V), BRIDGE, Compiler, Crystal oscillators, DIODE, Temperature sensor (KTY81), LAMP, LDR, LED, Potentiometer, Relay, Thermistor (PTC NICEL) and Transducers, Transformers, DC motor, Switch and push button. The power circuit; 3 Phase series source, 3 phase series load, 3 Phase breaker, 3 Phase transformer, 15KV and 30KV busbar 3 phase V-I measurement, port block, Voltmeter, Ammeter, the RMS block, wattmeter, Idealized ADC quantizer (Idealized quantizer for a linear analog to digital converter), multimeter, constant which allow us to interpret vector parameter, To workspace (Write input to specified timeseries, array, or structure in a workspace. For menu-based simulation, data is written in the MATLAB base workspace.

Similarly, the methodology utilized is NRF24L01 is because of its effective and efficient for this proposed system. For the designing software, we split into two parts that is server side and node side [5]. This begins from designing Arduino Nano script as node side to make sensors are working well. Compiled the script using MikroProg Suite for PIC C language from PC. The calibration occurs in this progress. Voltage sensor should read voltage in parallel circuit and current sensor read current as in series circuit. Calibrating current sensor need a special sampling. Current sensor we are using is ACS712 which manufactured by Allegro MicroSystems. It performs based on Hall effect means converting DC or AC current into proportional voltage output within 0-5 volt range. Magnetic field is applied for this reading current sensor.

III. RESULTS

A. Simulation of the Phasor Matching Detecting Circuit.

Using the lamp technique as mentioned in the previous chapter, darkness occurs when all the three lamps are off (matching the bus-bar voltage phasor with that of the generator). Our circuit detects this darkness using LDR. Assume that the darkness occurs when the illumination is 3 Lux. Any illumination event above this value is seen as a situation at least one lamp is bright

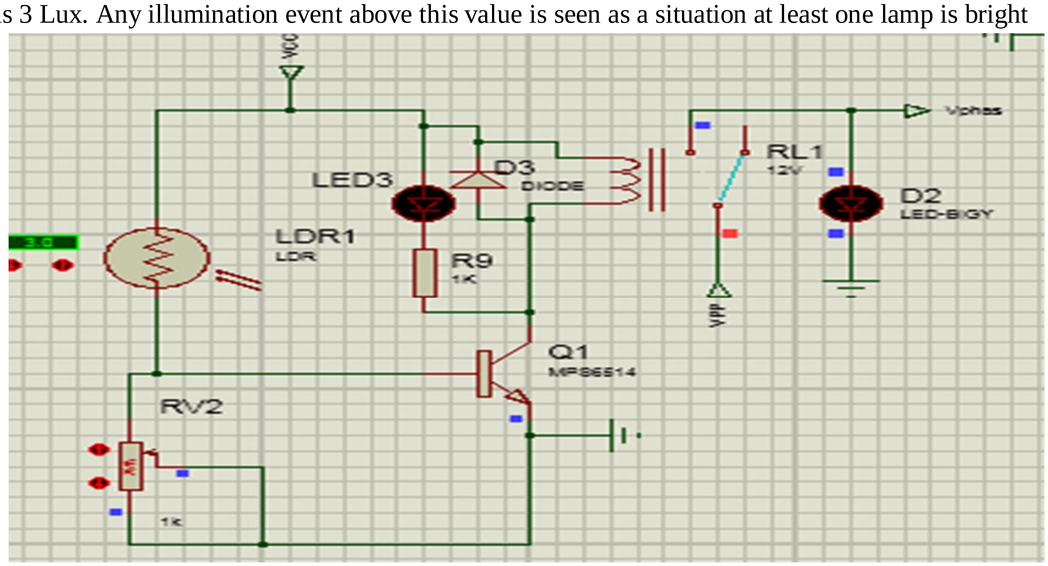

Figure 1: Simulation of the circuit when the illumination is below 3Lux

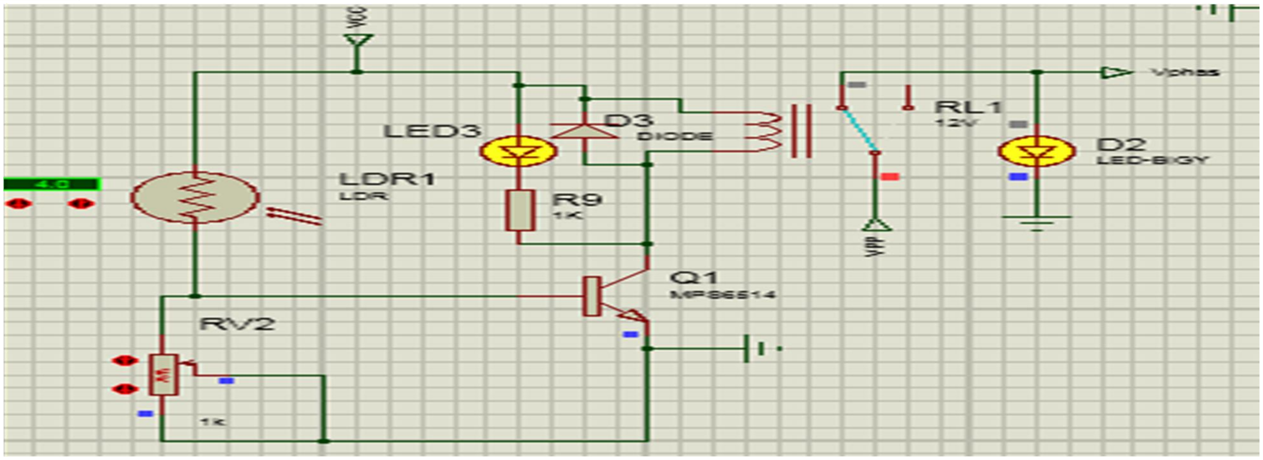

Figure 2: Simulation of the circuit when the illumination is below 4Lux upward.

The circuit outputs a 0-logic signal when there is darkness (phasor matching) and 1 logic signal when there is light (phasor do not match). Therefore, this circuit functions as expected.

B. Simulation of Voltages Magnitude Matching Detecting Circuit

For good synchronization to take place in the terms of voltages magnitude, both the bus-bar voltage magnitude and that of the generator much match. The following figures present the simulation of the circuit where the voltage has been brought down to instrument levels using a breakdown voltage transformer (230V/6V) not shown on the circuit.

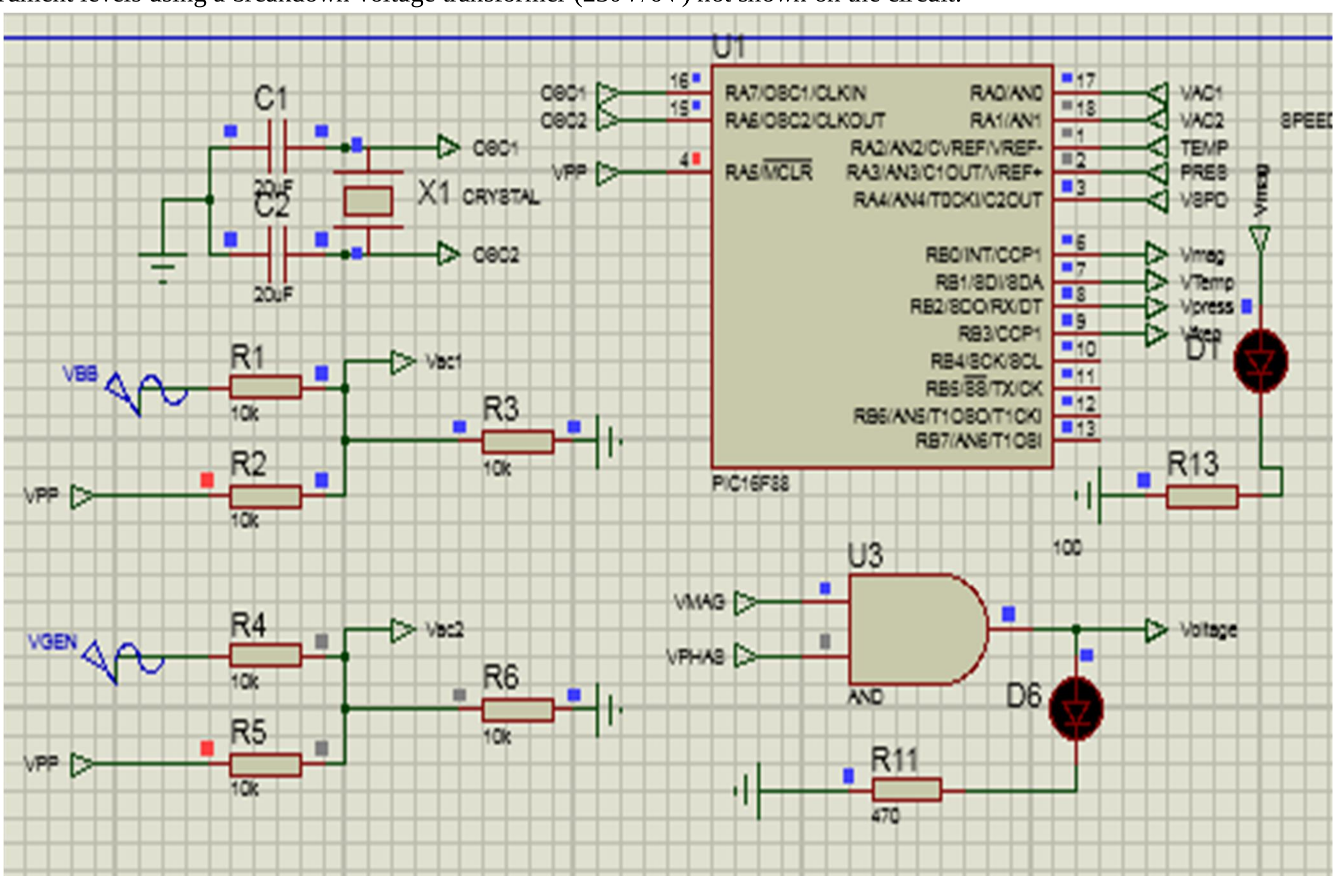

Figure 3 Simulation of the situation where the low voltage from the busbar voltage VBB=6V<0̊ and the low voltage from the generator VGEN=5.5V<0̊

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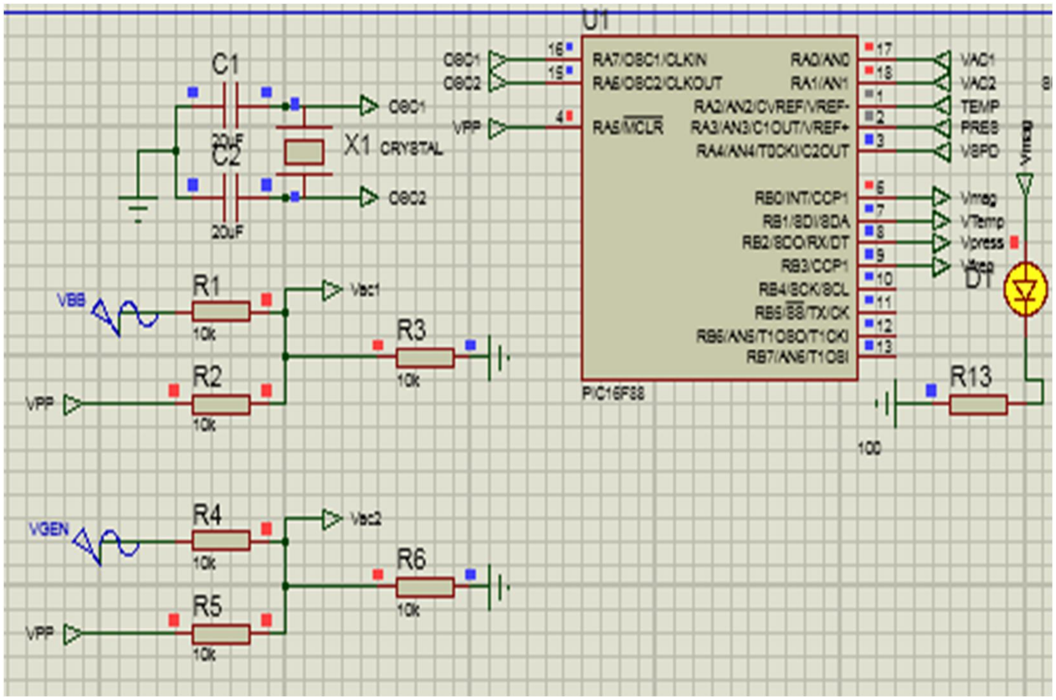

Figure 4 Simulation of the situation where the low voltage from the busbar voltage VBB=6V<0̊ and the low voltage from the generator VGEN=6V<0̊

When a non-zero voltage magnitude difference occurs, the circuit outputs a 0-logic signal (led off) while when a zero-voltage magnitude difference occurs the circuit outputs a 1 logic signal (led on)

C. Simulation of the Generator Temperature Level Detecting Circuit

The temperature of the generator must not exceed a certain value, here we show the simulation of the designed circuit for monitoring this constraint.

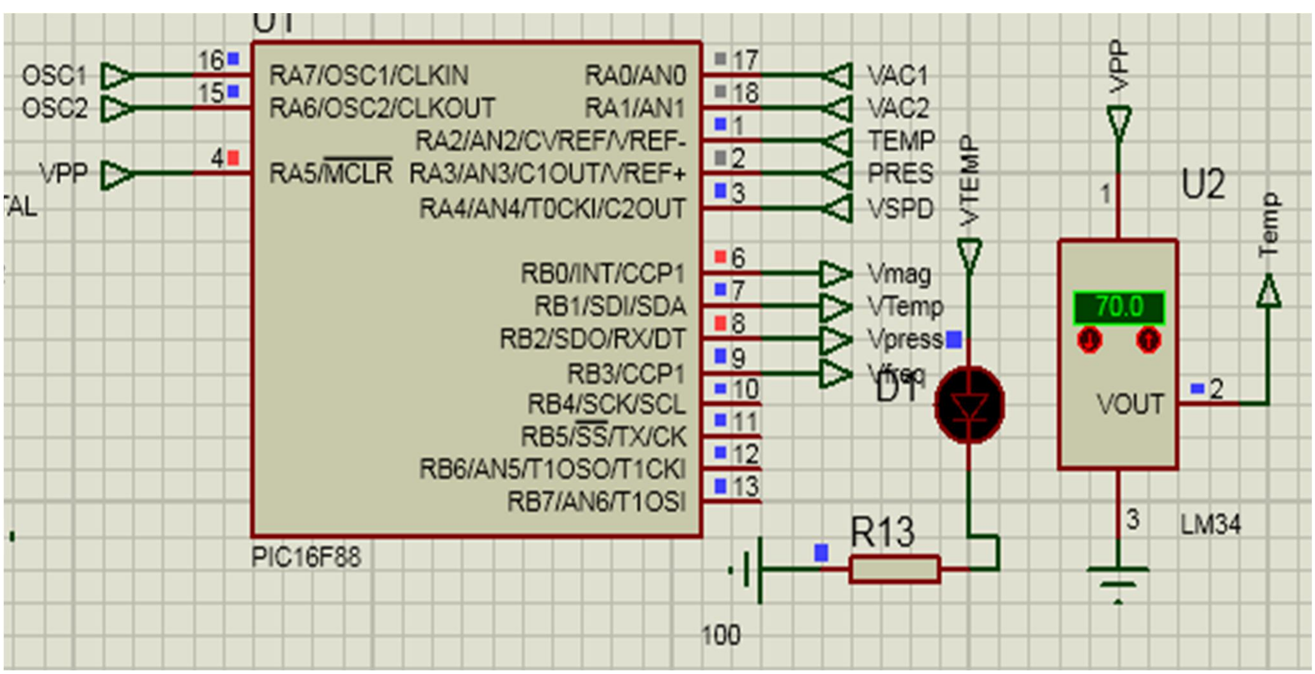

Figure 5 Simulation of the circuit for temperature below 70°C

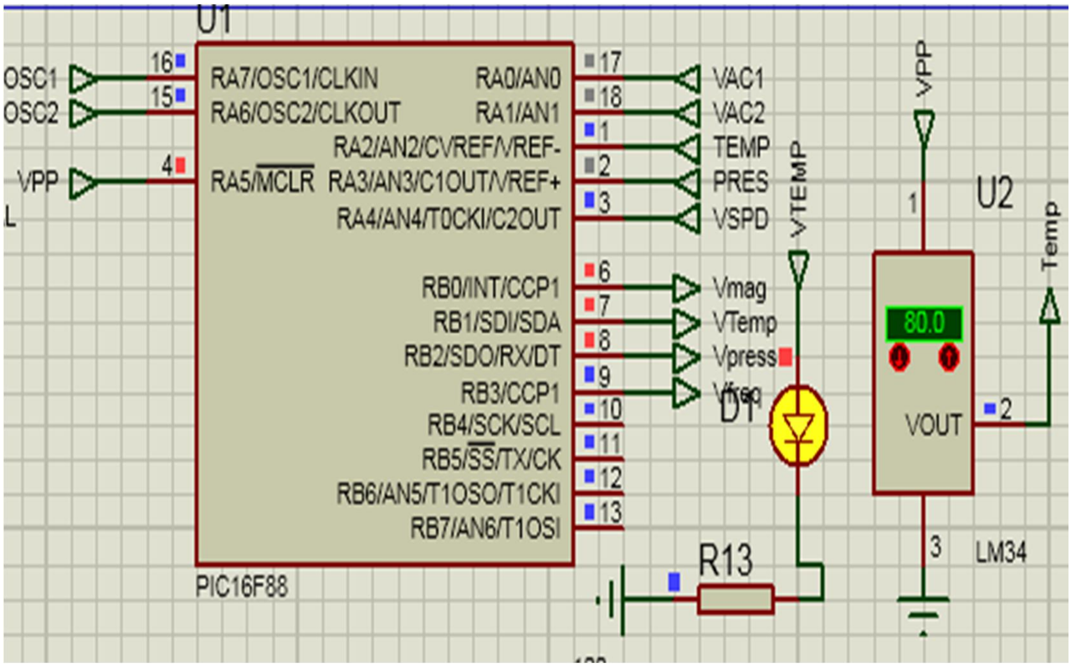

Figure 6 Simulation of the circuit for temperature below 70°C

The temperature sensor LM34 is an animated device in which the input temperature can be varied. By varying the input temperature, it is observed that when the temperature is below the threshold value of 70°C a logic signal (fig. led off) is generated on the TEMP output of the PIC 16F88 while it outputs a 1 logic signal (fig. led on) for the other values of input temperatures.

D. Simulation of the Turbine inlet Pressure level Detecting Circuit

The steam turbine pressure should not exceed a certain value for security purposes. The pressure sensor used here is the MPX4115.

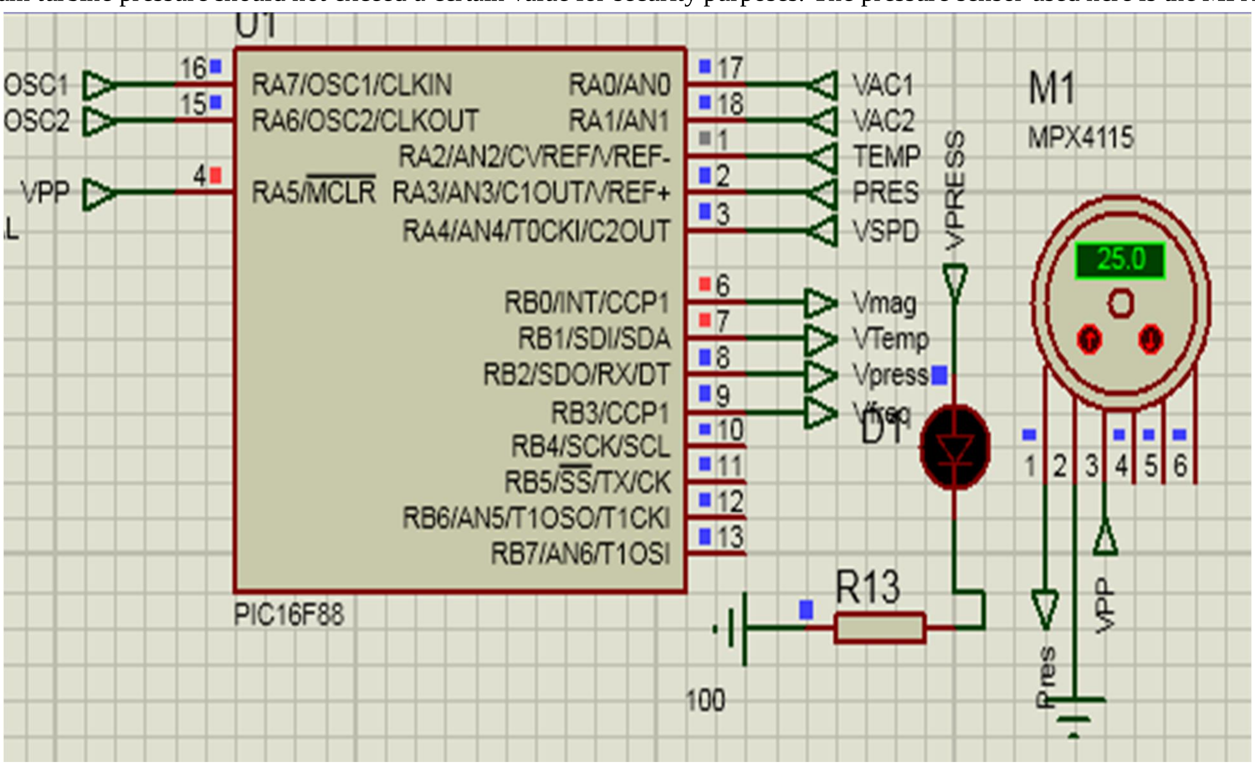

Figure 7 Led off when the pressure is below 45Kpa

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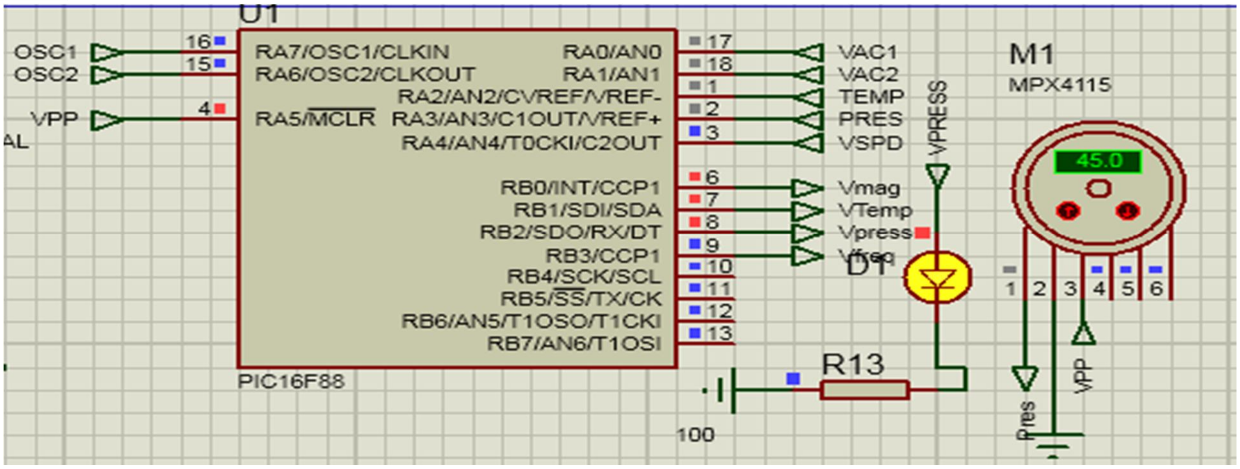

Figure 8 Led off when the pressure is 45Kpa

From the observations of Figures 8, the circuit generates a high-level logic signal when the pressure (from the pressure sensor MPX4115) is above the value ok 45Kpa and a low-level logic signal when the pressure is below 45Kpa.
The speed monitoring circuit function analogically as that of temperature and pressure

E. Load Management Circuit Simulation

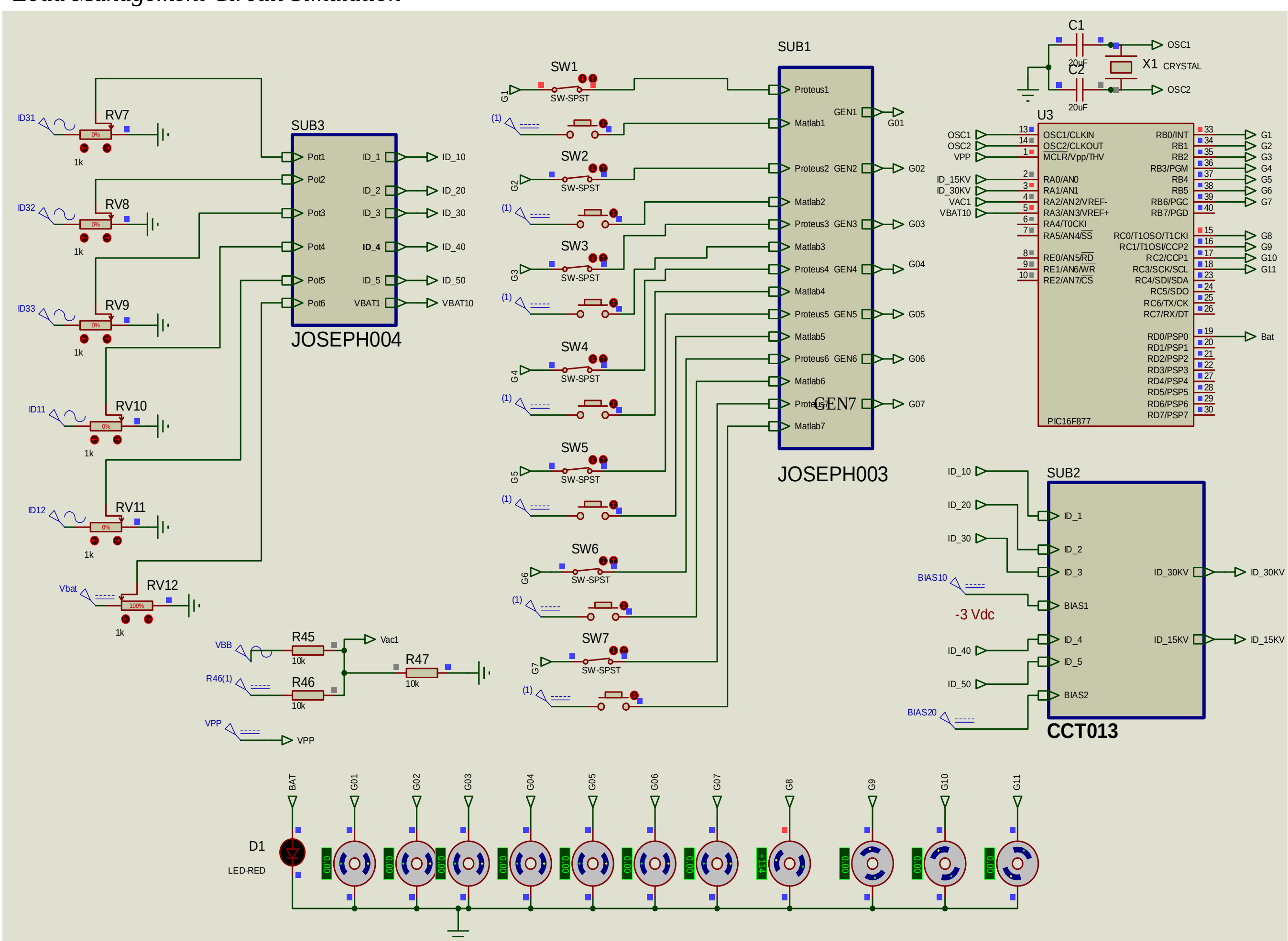

Figure 9: Simulation lay out when the battery level is okay and the no-loadcurrent (potentio meter brought to zero position). Electronic circuitry general layout

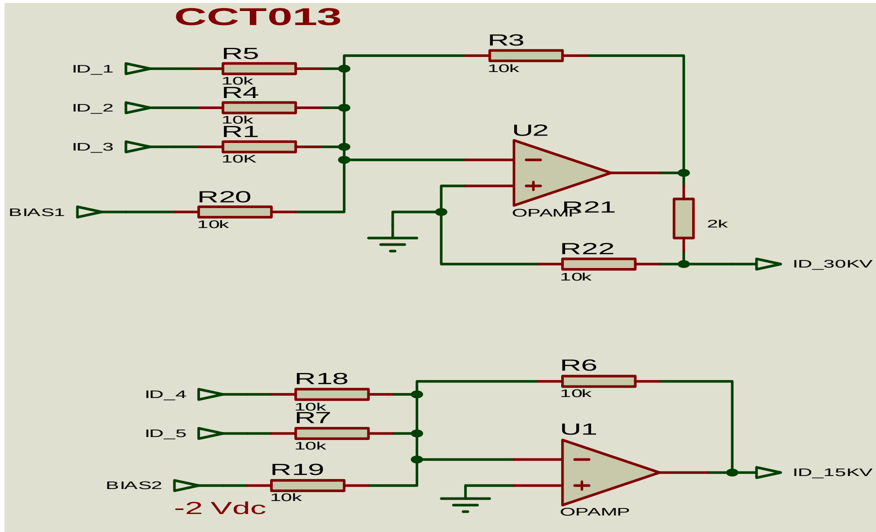

Figure 10: Simulation Circuit 1

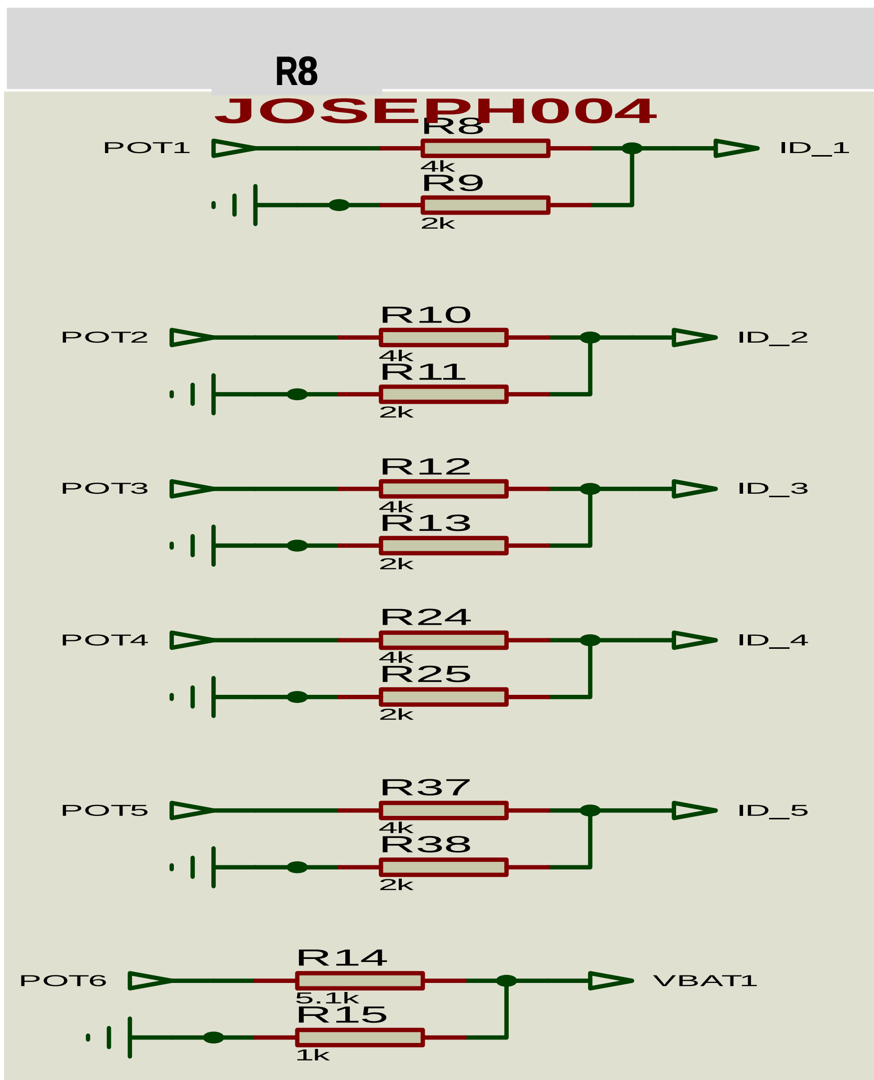

Figure 11: Simulation Circuit 2

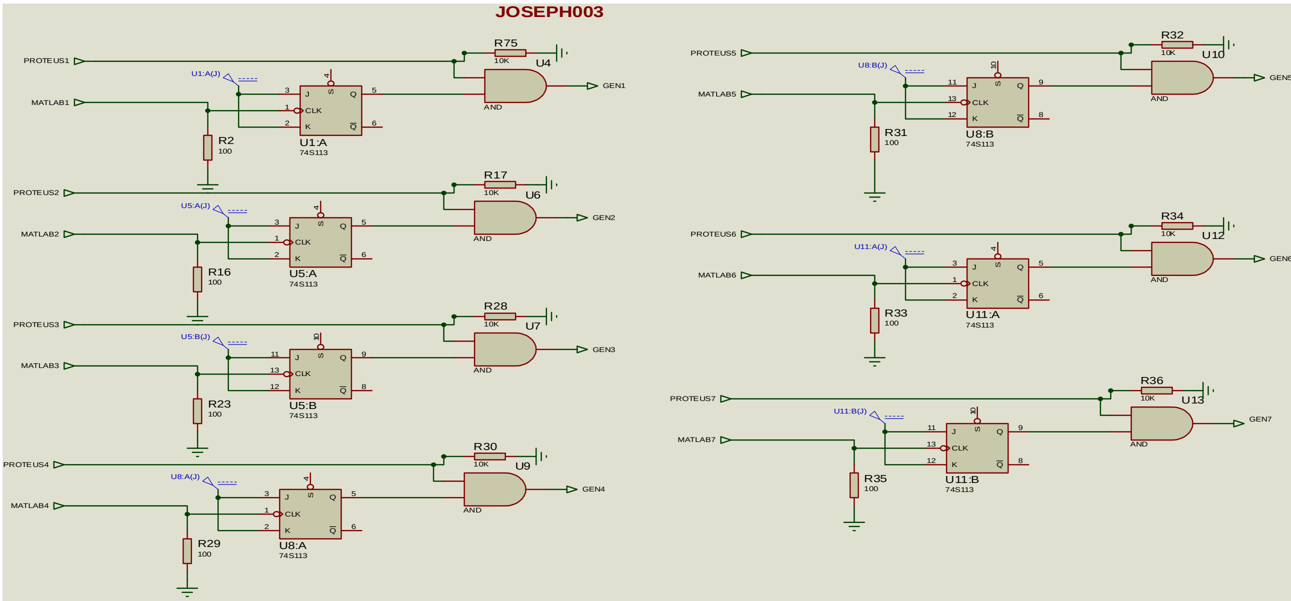

Figure 12: (a) CCT013, (b) JOSEPH004, and (c) JOSEPH003 blocks are sub-circuits as presented below.

CCT013 is playing the role of current summer and JOSEPH004 is mainly playing the role of the voltage divider. JOSEPH003 plays the role of generator start/stop. Generators (gen01 to gen07) are started (Boolean one) only when both orders are given from the GUI (Matlab impulse) and from the load sharing electronic circuitry (Proteus high), once any of them sends a stop (zero), the generator automatically receives a stop order (Boolean zero). Gen8 to gen9 are solely controlled from the load sharing circuitry just to emphasize the need of controlling all of them from GUI and the electronic circuitry. (JK flip-flops are in negative transition triggering mode).

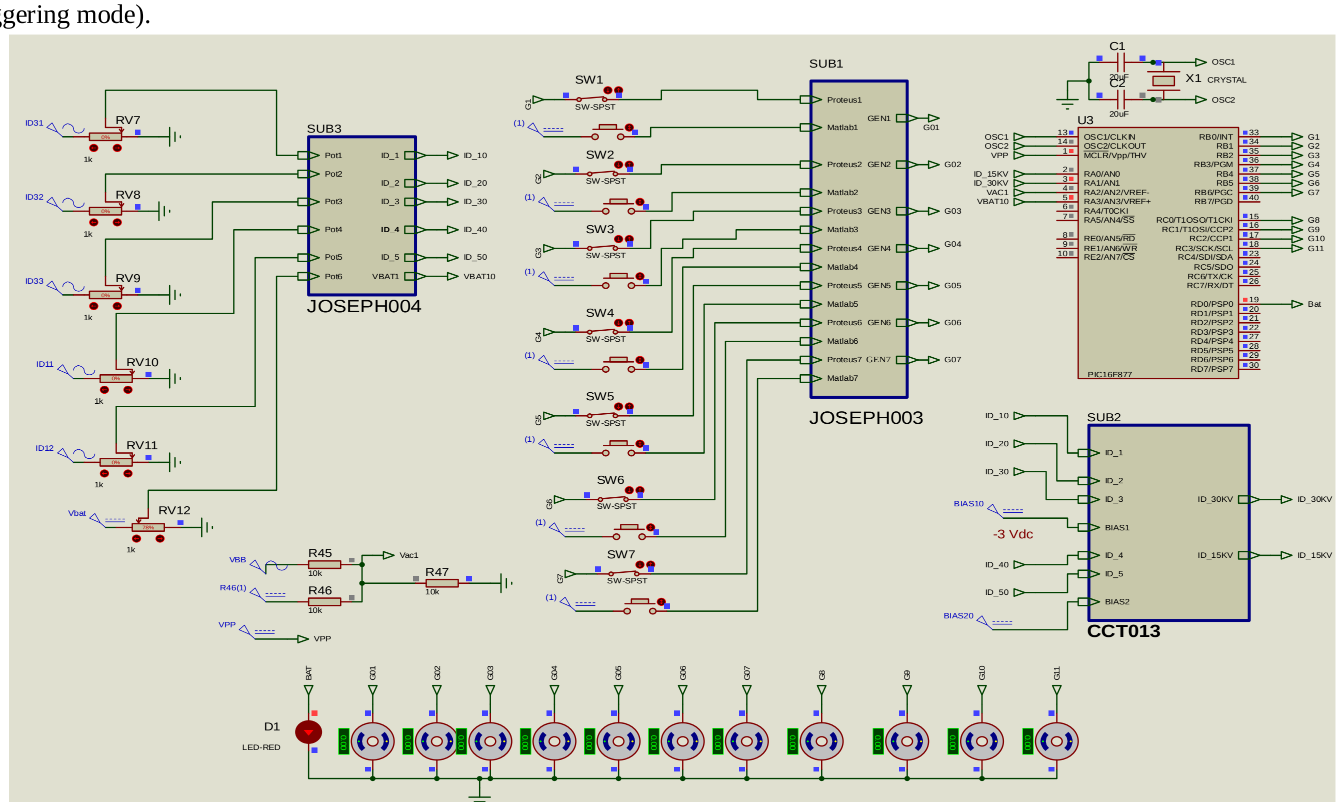

Figure 13: Simulation layout when the battery is low and the load current is not zero (potentiometers not all at zero position) led D1 shines signaling low battery.

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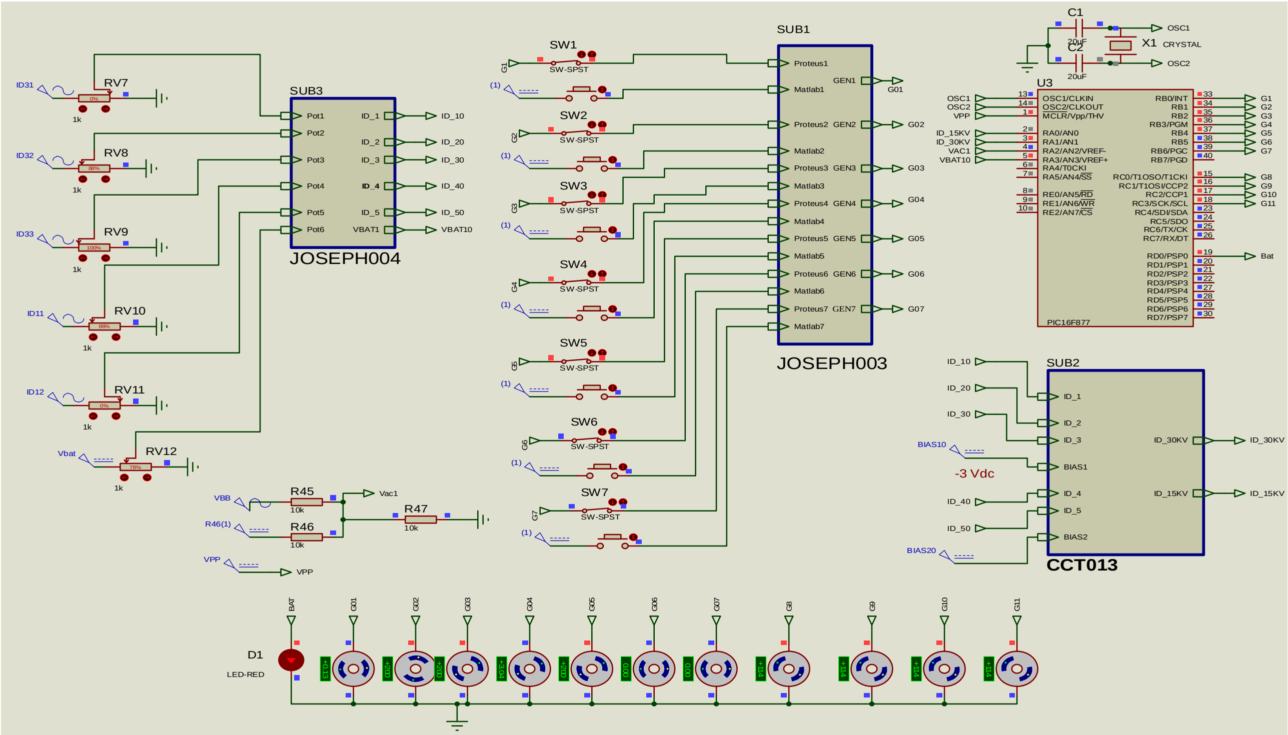

Figure 14 : Simulation layout when the battery level is low and the load current (potentiometers not all at highest position).

Matlab push buttons sws-spst : (a) all pressed and released; all generators are running except G06 and G07, (b) GEN1 and GEN4 sw-spst buttons pressed once more then released; G01 and G04 stop running suddenly. LED D1 is on when the battery is low and is off on the contrary. The generators are switched on accordingly to load power requirements.

F. Graphical User Interface

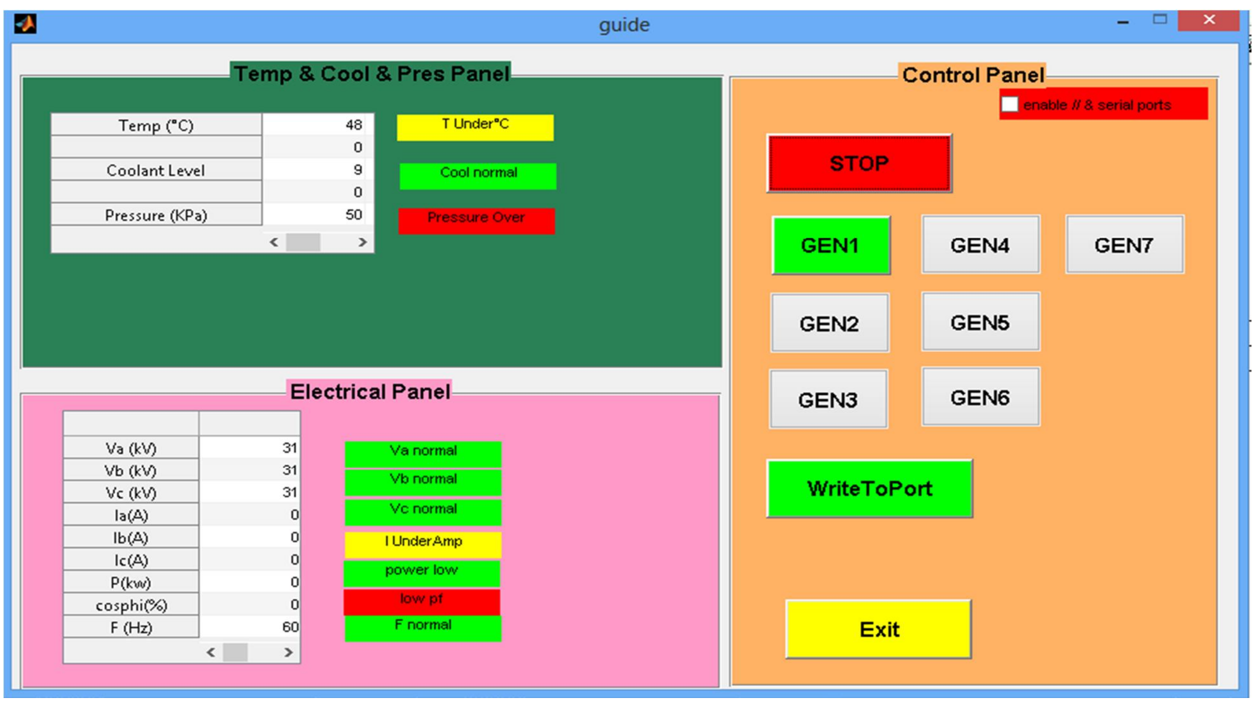

Figure 1: GUI display for four scenarios: (a) Scenario 1 GUI:

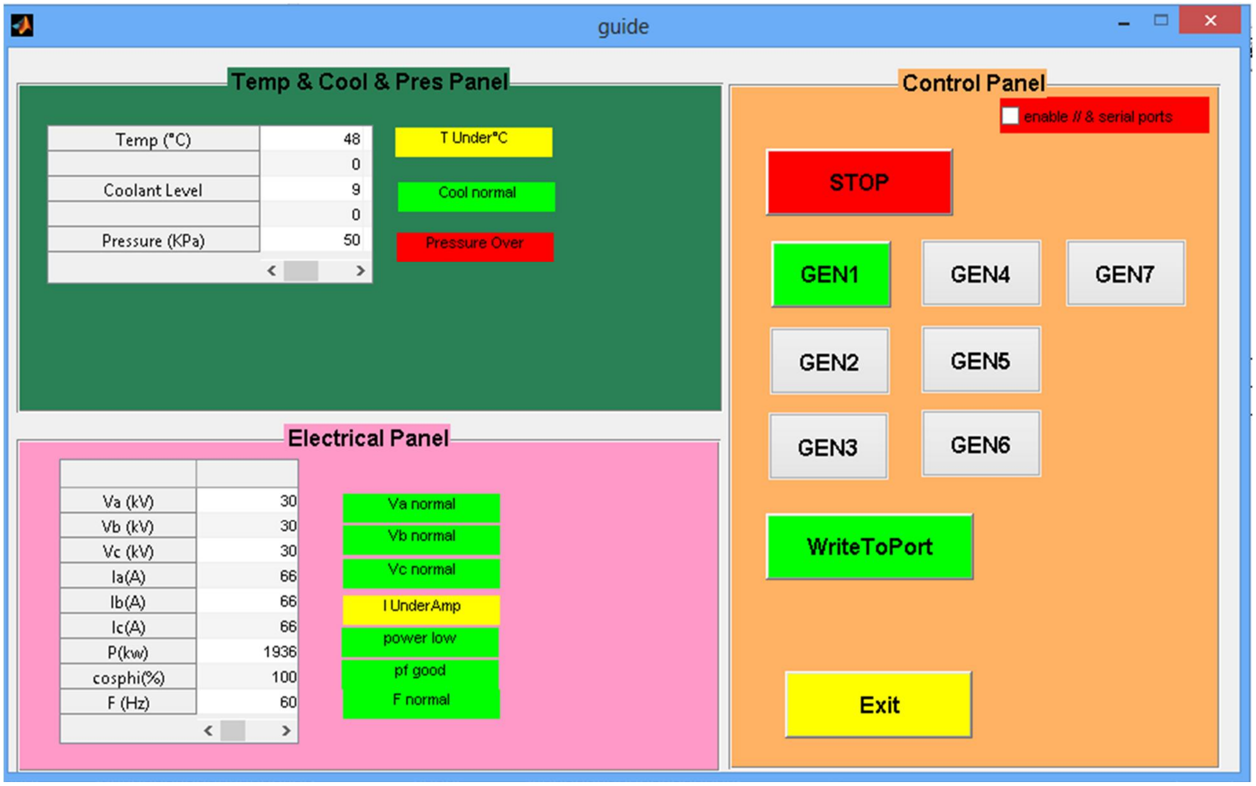

Plate 2: GUI display for four scenarios : (b) Scenario 2 GUI.

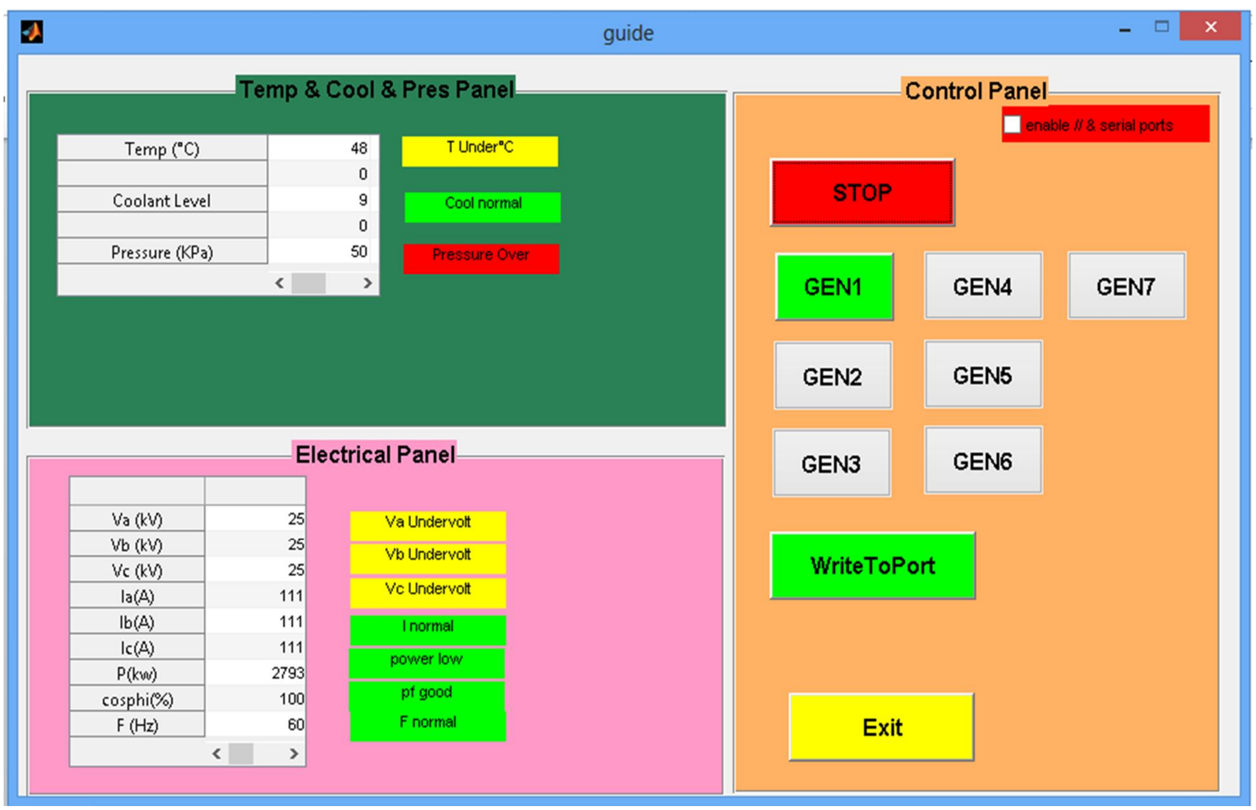

Plate 3: GUI Display for Four Scenarios: (c) Scenario 3 GUI

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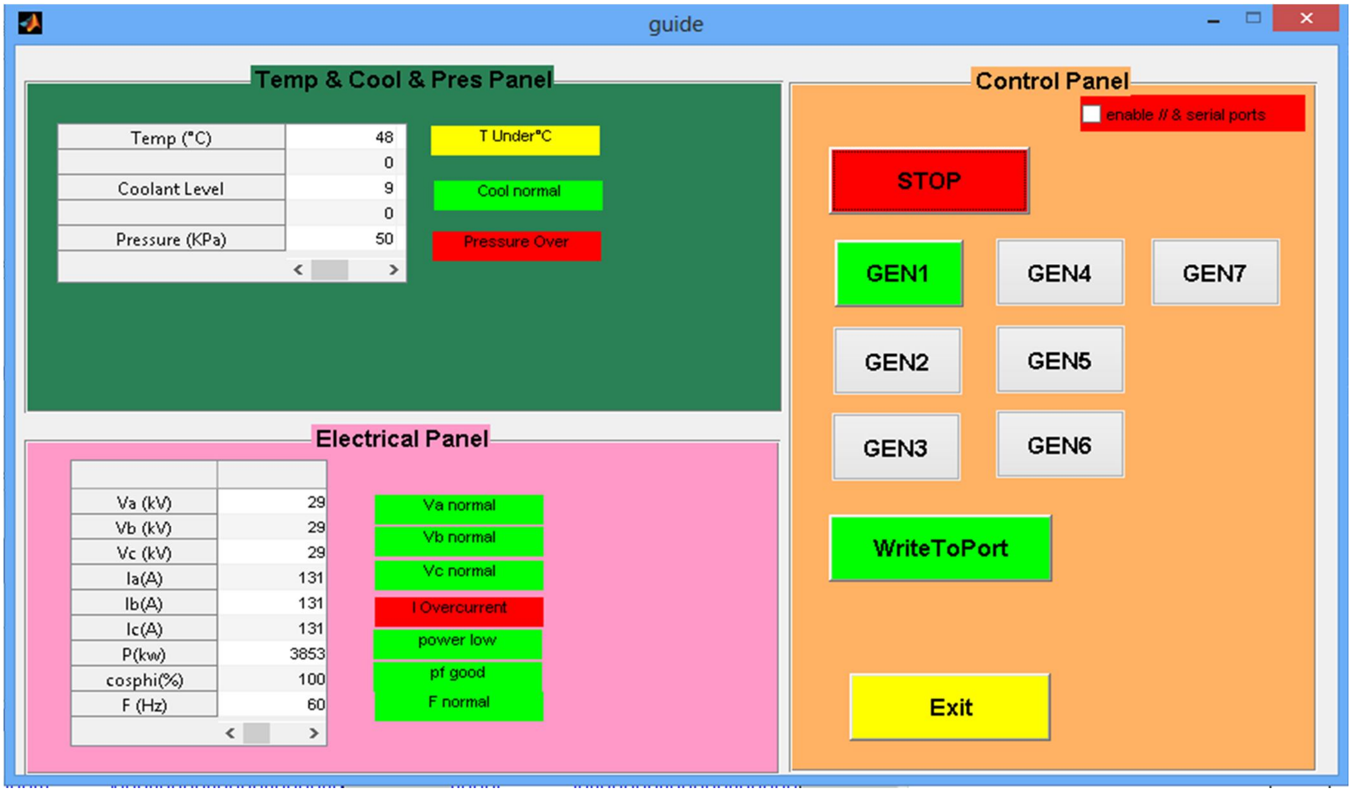

Plate 4: GUI Display for four Scenarios: (d) Scenario 4 GUI

IV. DISCUSSION

As mentioned earlier, the concept of this project will lead to the monitoring of Gentset in Bertoua thermal power plant in. This system can also be developed in any location in Nigeria because the temperature and humidity levels are not yet a major problem when using this system. Figure 1 to figure 14 shows the basic concept of the project. The temperature, voltage, current, pressure of the circuit is controlled by the adjusting system using DC devices. If the temperature recorded in the system is less than 70°C as the coding requires, the cooling system of the Gentset will not run, the reverse occurs if the temperature recorded was 70°C and above. The temperature of Generator rates plays an important role for good combustion of fuel in the combustion chamber as design by the manufacturer. By varying the input temperature, it is observed that when the temperature is below the threshold value of 70°C a logic signal (fig.6 led off) is generated on the TEMP output of the PIC 16F88 while it outputs a 1 logic signal (fig.7 led on) for the other values of input temperature. In this project, the steam pressure is automatically controlled using a sensor MPX4115 that works to bring the pressure of oil to the normal demand needed by the manufacturer. In this project, the different sensors will bring each parameter to be recorded to the logic signal before an order is send to GUI for the user to execute the command. All Units Gentset are always on standby during base period but start running automatically during peak period but can't be couple or synchronize on to the busbar until the all the conditions are filled. This for controlling the power demand level on the load as well as to prevent fuel consumption and from preventing the generators from damaging when not in service in the plant. Any user also has the option either want the system works by using a solar panel or DC supply. Fig. 4 shows the mechanical design (prototype) for the project.

V. CONCLUSION AND RECOMMENDATION

The study was found that the thermal power plant in Bertoua has no proper control rooms, their adjustment is made at simple loop but lacks a level of centralization of all activities that would lead to better performance. This is the first proposal to use a host computer to monitor the installation; we highly recommend the company to consider it has the key solution in running its power stations. Comparing the advantages to the actual limitations of the proposed solution, we recommend the Bertoua thermal power station management to consider the benefits of automating the monitoring of the power station; these benefits go first to the company which cares about its personnel, equipment, finances, and service quality as well.

The local inhabitants are the second beneficiaries of such a solution in the sense that the power supply will be more reliable and their equipment will run good electrical parameters therefore better efficiency and reduced damages. Prototyping this solution should be done then tested on an isolated installation part for a good while, it is only after all the amendments done from observed behaviors of the prototype that one can think of implementing it on the whole station.

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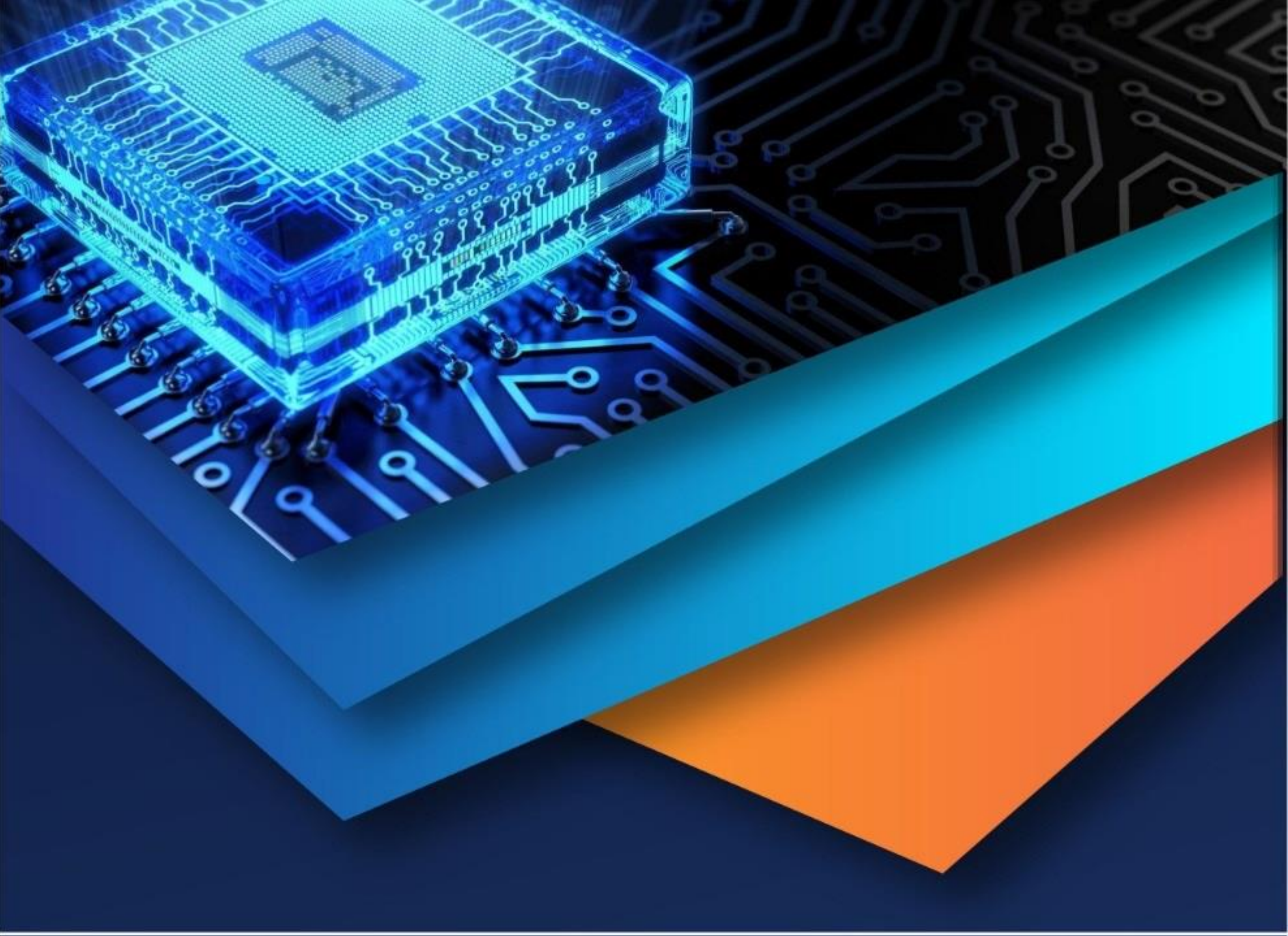

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