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Design the generator Battery supervision in the Base Transceiver Station

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Abstract: This article presents a solution to design the generator battery supervision in the Base Transceiver Station (BTS) according to the method of measuring the voltage of the battery. From the design solution, the author's team has come up with the supervision process design, hardware, and software design. The device allows communication and sends alerts to the BTS station manager. Through the trial operation, the system has met the set requirements and can be easily integrated into BTSs.

Keywords: Battery, BTS Station, Battery supervision in BTS, Arduino Nano, Seven-segment, Arduino IDE software

1. Introduction

In our daily life, the communication of information is extremely important and indispensable. It determines the activities of many fields of the society and helps people to get much valuable information about culture, science, technology, education… in the quickest way. Today, with the increasing demand for information from humans, it is required that service providers have modern facilities to meet the needs of customers "anytime, anywhere". Today's telecommunications system is no longer too unfamiliar to Vietnamese people, especially mobile communication system is very popular, no longer only for high-income people like before, but is gradually becoming services for everyone.

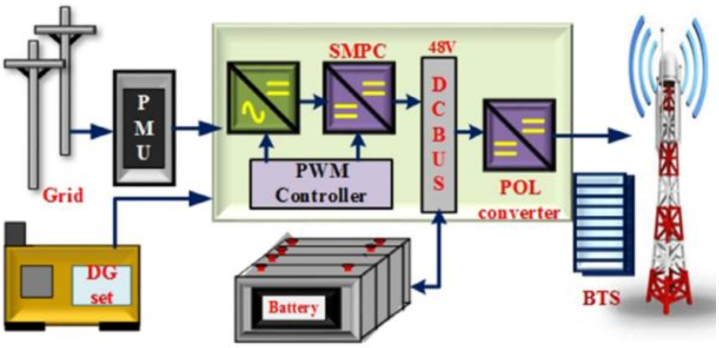

Figure 1. The architecture of the usual supply for BTS [1]

In the telecommunications system, transmission is a very important role, can be said to be the foundation for the whole system. Currently, the mobile communication network is used on GSM (Global System for Mobile Communications) technology. Mobile phone subscribers can connect to GSM network through the BTS (Base transceiver station). In a BTS station, in addition to the transceiver (antenna, fider tube, fiber optic cable, signal processing cabinet ...), there are other auxiliary components (such as air conditioner, fan, electric bulb, automatic transfer switch cabinet (ATS)). And an indispensable component to maintaining continuous information is the power supply system, including power source, battery, and generator. In the event of power outage, the battery system will be connected. When the battery voltage is below the specified level (about 48V), the generator must be switched on immediately.

There is a lot of research that has been focusing on the continuous power supply of the base transceiver station BTS. Researches mainly focus on improving the efficiency of using electricity [1] or researches that focus on installing solar battery systems for BTS station [3]. However, with the geographical features in the North of Vietnam, the efficiency of using solar cells is quite low and the investment cost is quite high, so now BTS stations are still using the main backup source, which is battery and generator.

Because the BTS station is an independent entity, often located on high hills, and large areas, generator maintenance cannot be done regularly. So there are times when the power is out, so the generator must be started but it doesn't work. One of the reasons for a generator not working is the fault of the generator battery. In the event of power outage, the backup battery has been exhausted, however, the generator (integrated ATS) is not working and contact is lost. However, no researches have focused on remote supervision and warning of the status of generator battery in BTS stations.

We can check the battery status by visual method, check discharge - charge status, or check capacity or load [6-8]. In this paper, we propose a design option for the generator battery supervision in the Base Transceiver Station according to the method of measuring the open-circuit voltage of the battery. From the proposed method, we devise a process to design the device, design the hardware and software, and then test and evaluate the results.

The article is divided into 5 parts: **Introduction - Design solution - Designing hardware and software - Experiments and results - Conclusion.**

2. Design solution

2.1 Solution and design process for the supervision

As introduced in part one, the cause of a generator not working during a power outage is a fault of the generator battery. The batteries used to start the generator are usually 12V-DC batteries. Several methods for determining generator battery fault are given in[5]. Methods of determination include:

1. Visual inspection
2. Check charging status
   a. Specific gravity;
   b. Open-circuit voltage measurement
3. Check capacity or load.

In our research, the team plans to design a circuit that quickly determines the status of the battery and sends supervision and warning information to the station manager. The visual determination method (visually checking if the battery is blistering ...) cannot be used since we use remote supervision. The method of testing capacity or load requires specialized machines, so the cost is very high, if each station equips one machine, the total cost will be very large. For the purpose to designing the supervision set of generator battery in BTS stations which is a simple set, reasonable price. The team used open-circuit voltage measurement to determine the battery's status.

To determine the working condition of the battery through open-circuit voltage measurement[7], we perform the following steps:

- Use a digital voltmeter to check the open-circuit voltage of the battery. Analog gauges are inaccurate and should not be used.
- Disconnect the battery from the load, switch the meter to VDC measurement mode, properly connect the digital meter poles to the battery terminals, and measure.
- Reading the index meter to determine the status of the battery.

Table 1.BCI standard table for estimating the SoC of starter batteries

Approximate state-of-charge	**Average specific gravity**	**Open circuit voltage**			
		2V	6V	8V	12V
100%	1.265	2.10	6.32	8.43	12.65
75%	1.225	2.08	6.22	8.30	12.45
50%	1.190	2.04	6.12	8.16	12.24
25%	1.155	2.01	6.03	8.04	12.06
0%	1.120	1.98	5.95	7.72	11.89

Table 1 shows Acquy's SoC estimates started with the BCI (Battery Council International) standard[8]. A fully charged battery will have an open-circuit voltage of 12.6V. On the other hand, a completely dead battery will have an open-circuit voltage of less than 12.0V.

From the above studies, the authors give the following procedure to design a generator battery supervision in BTS stations:

- Design voltage measurement instead of using digital meters
- Design the switch to open the battery circuit to the load when performing the measurement.
- Every 30 days, measuring the battery's open-circuit voltage to determine the status of the battery and send an alert to the BTS station manager.
- During the periodic inspection, if the generator is working, the test should not be carried out. To not affect the working process of the generator, so on the circuit, it must be determined the working condition of the machine.

- The power source for the circuit is independent, does not use the voltage of the generator's battery.

2.2 Block diagram of generator battery operation supervision in the BTS station

From the design solution to the problem, we build the block diagram of the generator battery operation supervision in the BTS station as shown in Figure 2.

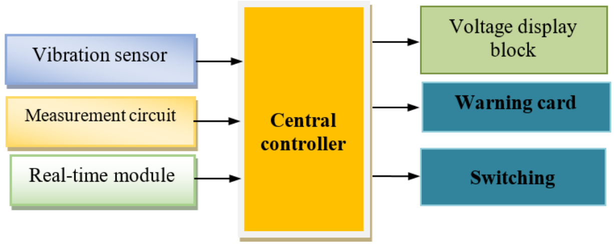

Figure 1. The diagram of equipment

Function of blocks:

- Central controller: Arduino Nano is used to process input information and send signals to the switching block, warning card and voltage display block.
- Vibration sensor: Determine if the generator is working.
- Measurement circuit: Used to measure the voltage on the battery.
- Real-time module: Determine the time of checking battery status.
- Voltage display block: Display the measured voltage value
- Warning card: The fault warning signal battery will be sent to the warning card (has been integrated into the ATS cabinet or an external alarm) and send a warning to the manager.
- Switching: Used to disconnect the load from the battery in open-circuit voltage measurement mode.

3. Designing Software and Hardware

3.1 Designing hardware

The generator battery operation supervision in the BTS station consists of six main parts: (1) The central microcontroller using the Arduino Nano board, (2) circuit to detect vibration sensor circuit, (3) Voltage measurement circuit, (4) Display circuit, (5) Real-time block and (6) Switching block.

3.1.1 The central microcontroller

The Arduino Nano board is one of the smallest versions of the Arduino board. Arduino Nano has all the functions and programs available on Arduino Uno due to the same use of MCU ATmega328P [9]. Thanks to the use of the paste IC of the ATmega328P instead of the plug IC, so the Arduino Nano has more than the Arduino Uno 2 pins Analog. Arduino Nano is connected to the computer via mini USB port and uses CH340 chip to convert USB to UART instead of using ATmega16U2 chip to emulate COM port like Arduino Uno or Arduino Mega, so the production cost is reduced. The Arduino Nano board is shown in Figure 3.

Table 2. Technical Data Sheet of Arduino Nano

Technical Specifications	
Microcontroller	Atmel ATmega328
Operating Voltage (logic level)	5 V
Input Voltage (recommended)	7-12 V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	8
DC Current per I/O Pin	40 mA
Flash Memory	32 KB (ATmega328) of which 2 KB used by bootloader
SRAM	2 KB (ATmega328)
EEPROM	1 KB (ATmega328)
Clock Speed	16 MHz
Dimensions	0.73" x 1.70"

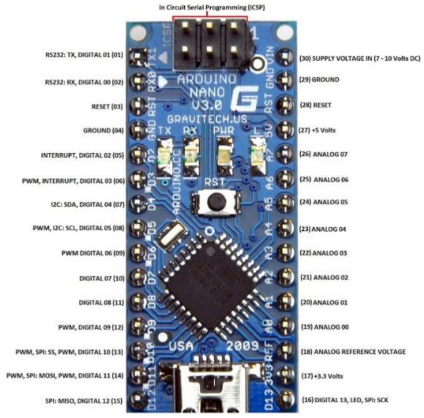

Figure 1. Arduino Nano board image

From the analysis of the features and specifications of the Arduino Nano board, we choose it to design the central controller of the device.

3.1.2 Designing a circuit to detect vibration sensor circuit.

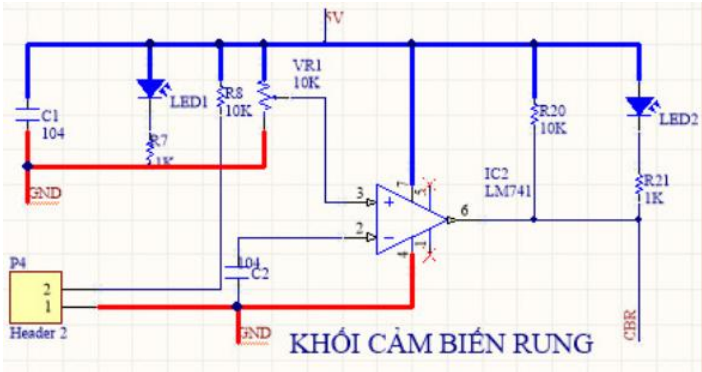

Figure 2. Vibration sensor circuit

The vibration sensor (P4) is the HDX-1801 type of vibration sensor that works as a switch when vibration is received.

When the generator is not working, the vibration sensor (P4) does not sense the vibration, input pin 2 of the IC LM741 is low, the CBR output signal is low. When the generator is working, the vibration sensor (P4) senses the vibration, the input pin 2 of the IC LM741 is high, the CBR output signal is high. The output signal from the vibration sensor (CBR) circuit to the input of the Arduino Nano board.

3.1.3 Voltage measurement circuit

To determine the voltage between the two battery electrodes (V + and V-), a voltage divider circuit consisting of two resistors R_2 and R_3 is connected between the two electrodes. The voltage Vin measured from the bias circuit will be calculated by the equation:

$$Vin = \frac{R_3}{R_2 + R_3} V+ \qquad (1)$$

With the value of voltage across 2 electrodes of battery are: $V_- = 0V$, $V_{max+}=15V$, $V_{in}= 0V \div 5V$. We select: $R_3=5k\Omega$, $R_2=10\ k\Omega$ to ensure the exact measurement results.

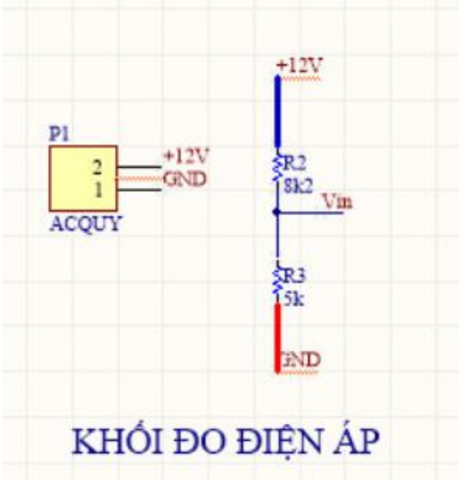

Figure 3. Circuit diagram of voltage measurement circuit

In order to Arduino to read V_{in+}, we have to use an Analog-to-digital converter ADC, Arduino Nano has a 10-bit ADC converter corresponding to 1024 levels. The resolution of the ADC is:

$$\text{Resolution}=\frac{V_{ref+}-V_{ref-}}{1024-1} \qquad (2)$$

Arduino Nano has V_{ref+}=5V and V_{ref-}=0V, so resolution is:

$$\text{Resolution}=\frac{5-0}{1023}=4{,}8876mV \qquad (3)$$

Means that the input increases 4.876mV then the ADC value goes up by 1. The Vin voltage measured is:

$$V_{in}=\frac{V_{ref}\,\text{xADC\_value}}{1023}=\frac{5\,\text{xADC\_value}}{1023}(\text{V}) \qquad (4)$$

3.1.4 Voltage display circuit

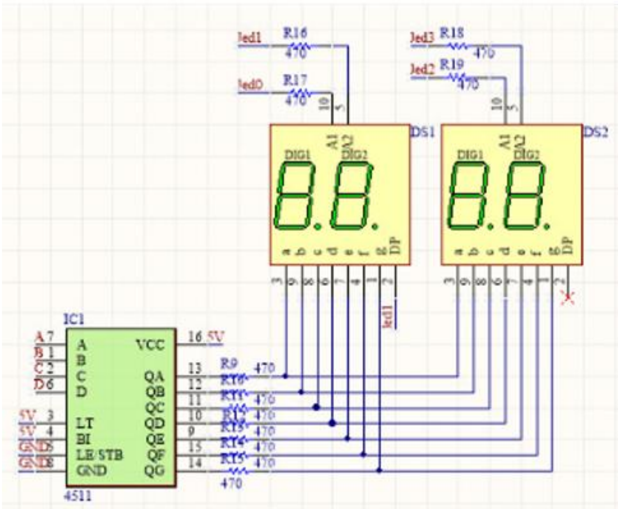

Figure 6. The diagram of the voltage display circuit

Battery voltage value will be displayed on 4 seven-segment display type common cathode and uses IC 4511 to decode signals from Arduino.

3.1.5 Real-time block

The DS1302 module uses the DS1302 IC clock chip [11], consisting of a real-time clock/calendar and 31 bytes of static RAM, communicating via a simple serial interface to the microcontroller. Real-time clock/calendar circuit providing seconds, minutes, hours, day, week, month, year and information, the number of days per month, and date jump can be automatically adjusted. Clock operation can be set to 24 or 12 hour AM / PM format. Common chips can be used to receive and process data such as 8051, AVR, PIC, Arduino. . .

Table 3. Technical Data Sheet of DS1302 module

Technical Specifications	
Size	47mm x 17mm x6 mm
Main chip	DS1302 real-time IC
Voltage range	7-12 V
Digital I/O Pins	DC 3.3 ~ 5V)
Temperature range (degrees C)	0 ~ 70
I/O mode	Serial

Figure 4. Real-time block

3.1.6 Switching block

When the circuit is not in voltage measurement mode, the Central Control supplies logic level "1" to the Vmo pin, leading to transistor Q1 open, relay sucks contact, maintaining closed circuit between generator's battery and generator. When the circuit switches to the battery's open-circuit voltage measurement mode (according to the preset schedule), the central controller supplies logic level "0" to the Vmo pin, which leads to transistor Q1 locked, Relay release contact, open circuit between the generator's battery and the generator, then the voltage measuring circuit takes measurements to ensure exact measurement.

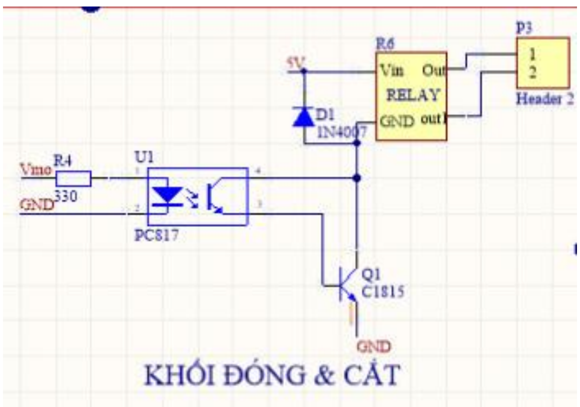

Figure 5. Switching block

3.2 Designing sotfware

From the above algorithm flowchart, the authors write a software program in C language for the central controller. Using Arduino Nano microcontroller to program through Arduino IDE software.

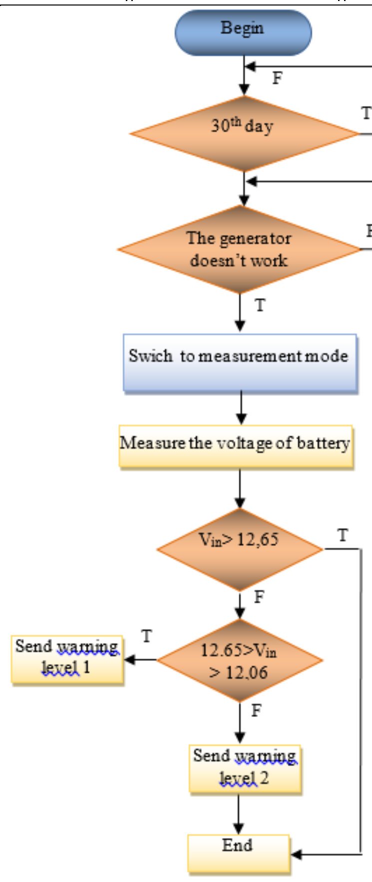

Figure 6. Algorithm flowchart of battery's voltage warning and measurement circuit

4. Experimnet and Results

Figure 10 shows a general principle diagram of a generator battery operation supervision in a BTS station. In addition to the main components designed in part 3 of the article, the circuit also has an independent power supply circuit using a 5v lithium battery.

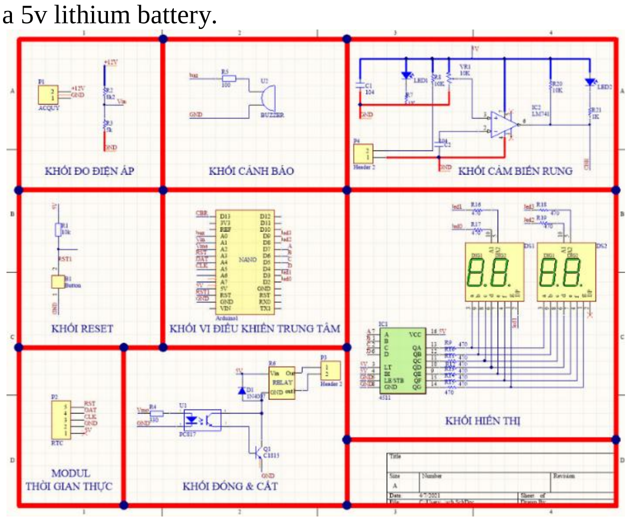

Figure 1. General principle diagram of the equipment

To design printed circuit boards, the team used Altium Designer software. Figure 11is a 3D diagram of the board.

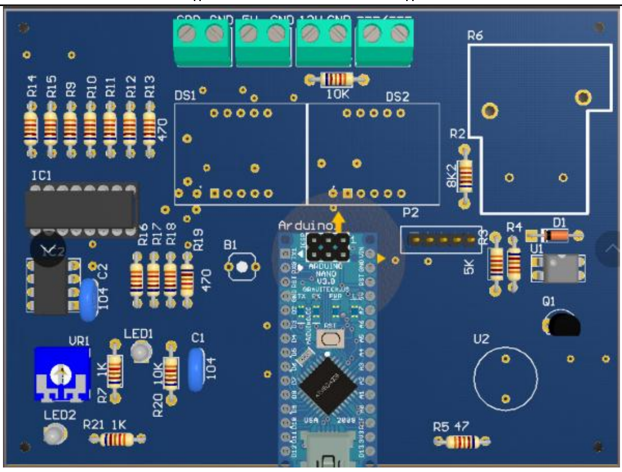

Figure 2.3D PCB diagram

Figure 12 is a circuit image of the generator battery operation supervision in a BTS station after completion. Figure 13 shows a test image of the production's features by design goal.

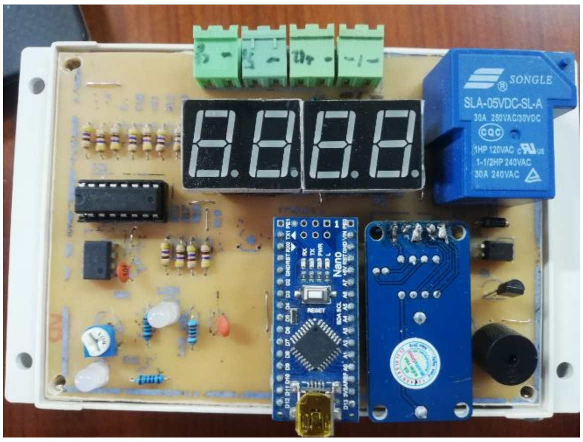

Figure 3. a circuit of the generator battery operation supervision in a BTS station after completion.

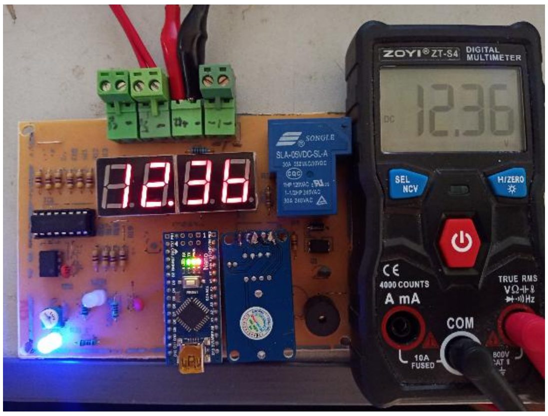

Figure 4. Test the product

After designing the hardware and programming the software, the authors tested the results of the circuit measurement with the actual battery (Figure 13). The measurement value of the supervision device has the same value as the result measured on the multimeter with many different measurements, which proves that the measurement system is accurate. Next, the team tested other features of the device and the results met the requirements.

5. Conclusion

The solution to design the generator battery operation supervision in a BTS station is simple, effective, affordable, and easy-to-integrate solution. In this article, the authors surveyed the power supply system for BTS stations, learned about methods to determine the condition of the batteries, proposed solutions, built a test system in the laboratory of Electronic Engineering major, Faculty of Electronic Engineering, Thai Nguyen University of Technology. Experimental results have shown that the system operation is reliable, and meets the requirements of the problem.

Acknowledgements

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