Design of Automated PC Shutdown Control System in Coastal/LPI Radar System Based on Microcontroller ATMega8L

Desain Sistem Pengendali *Shutdown* PC Otomatis Pada Sistem Radar *Coastal*/LPI Berbasis Mikrokontroler ATmega8L

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Abstract

One consideration during the design of long range controlled electrical system is the sudden outage of a Personal Computer (PC) caused by power failure. Frequent outage can damage the components inside the PC such that the whole system could be malfunction. This can affect the cost, time, and effort required to fix the system. Usually such system is equipped with a temporary power storage or UPS (uninterruptible power supply) with a small capacity, so the PC in the system can immediately be turned off before the UPS runs out. Therefore it is necessary to design a control system that can shutdown the PC automatically within a certain range of time after the outage. The implementation of designed system has used an ATmega8L microcontroller as a controller, an optoisolator PS2505-1 as isolator for electric components from AC signal, and Visual Basic as the programming language. The system has been tested with an input voltage of 220Vrms AC signal. The test result has shown that the PC was successfully shut down within a certain time range after the input was terminated.

Keywords: *Personal Computer, automated shutdown, Optoisolator, microcontroller, control system*.

Abstrak

Salah satu pertimbangan dalam perancangan sistem kendali listrik jarak jauh adalah pemadaman sumber catu daya Personal Computer (PC) secara tiba-tiba . Aliran listrik utama yang sering terputus mengakibatkan PC tidak melakukan proses *shutdown* secara normal. Hal ini dapat merusak komponen di dalam PC, dan kinerja PC tidak optimal sehingga dapat mempengaruhi biaya, waktu, dan upaya yang diperlukan untuk perbaikan sistem. Umumnya sistem seperti ini dilengkapi dengan penyimpan daya sementara atau UPS (*uninterruptible power supply*) dengan kapasitas kecil sehingga PC dalam sistem tersebut harus tetap segera dimatikan sebelum daya UPS habis. Oleh karena itu, menjadi penting untuk merancang sebuah sistem kendali yang dapat men-*shutdown* PC secara otomatis dalam rentang waktu tertentu setelah pemadaman. Implementasi sistem yang dirancang menggunakan mikrokontroler ATMega8L sebagai pengendali utama, opto isolator PS2505-1 sebagai isolator dari sinyal 220V AC, dan *Visual Basic* sebagai bahasa pemrograman. Sistem ini telah diuji dengan masukan dari sumber listrik utama 220V AC. Hasil pengujian menunjukkan bahwa saat aliran listrik utama padam, PC berhasil melakukan proses *shutdown* dalam rentang waktu tertentu, sebelum daya pada UPS habis.

Kata kunci*:* *Personal Computer, shutdown* otomatis, opto isolator, mikrokontroler, sistem kendali.

I. INTRODUCTION

Personal Computer (PC) has been an important devices in modern daily life. This device is used in various systems as executor and controller of various operations. One of the system where the role of PC becomes very important is the control and observation system from long range. Research Center for Electronic and Telecommunication (PPET) - LIPI, has been developed such control system to monitor radar system which is installed at Anyer, Merak, and Lampung from Bandung [1].

The sudden outage of electricity which happens frequently can damage the electronic components of the PC and cause it to malfunction [2]. This will require some cost, time, and effort to fix the system. The common solution to minimize the damage is to use back-up supply, known as Uninterruptable Power Supply (UPS) [3]. This device can supply power into PC when the AC supply is off. Some types of UPS are also equipped with software that can automatically shut down PC.

However, the use of UPS as back-up power supply has its own downside. Most software on UPS will execute shutdown command only after the power gauge of the UPS has dropped to certain level. If this outage happens on a huge network that connects several PCs with each equipped with UPS, the amount of energy needed to supply all PCs before all of them is turned off is very huge. Besides, on several cases, PCs are not the only devices that use AC power. For example, on installed radar system of PPET in Lampung, power supply is used by PCs, servo motors, tower lamp, and power line adapter. Because of the huge power consumption, UPS cannot supply the entire system for long enough time.

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Therefore, PC needs to be shut down automatically within a certain time after the outage happens.

On PPET radar system, an ADAM data acquisition module is used previously to execute this task. However, this module is relatively too costly and its features are too luxurious for a rather simple control task. Thus, an automatic shutdown control system using microcontroller which has high utility and low cost will be designed.

II. SYSTEM DESIGN

The methodology of designing and implementing the system consist of these following steps:

1) System specifications.
   System specifications consist of the desired input, output, indicator, and function of system.
2) Block diagram construction.
   Block diagram of the system is a work flow that represents interactions inter components and signals involved in a system.
3) Hardware and software design.
   This process is a development from every component of the block diagram into a model whose behaviors are observable and controllable.
4) System simulation.
   The designed system will be simulated using a certain program on computer and has its behavior observed. If the observation result is not satisfying, the design process will be repeated.
5) System implementation.
   This step is an embodiment of design into physical form – an electrical circuit on a printed circuit board (PCB).
6) System testing.
   The system that has been implemented is tested under real testing environment.

A. System Specification

The first step in system design is the system specification. Main system specifications desired is as following:

1) System receives 220 Vrms AC inputs signal withfrequency of 50 Hz.
2) System generates output in form of bit data (0 or 1) which has information about the existence of AC input signal. If AC input signal is ON, the system will generate bit 1. If AC input signal is OFF, the system will generate bit 0.
3) System can shut down PC automatically if AC input signal is detected to be OFF for more than 20 seconds. The 20 seconds range is chosen to omit the cases where the outage only happens for a brief moment as a result of temporary overload.

Other than those aforementioned specifications, there is an additional one. That is an ability of the system to give indication about the existence of AC signal (on or off) that is observable by end-users.

B. Block Diagram Construction

Figure 1 shows the block diagram of the system. Opto isolator and microcontroller is on AC detector hardware part while in PC there is a program that will shut down PC automatically with input from AC detector. AC detector receives input of 220 Vrms AC signal and generates output in form of bit data. The output will be then transmitted to serial data transmission path in form of USB to Serial TTL module to PC. PC will then make the bit data into input for the installed program.

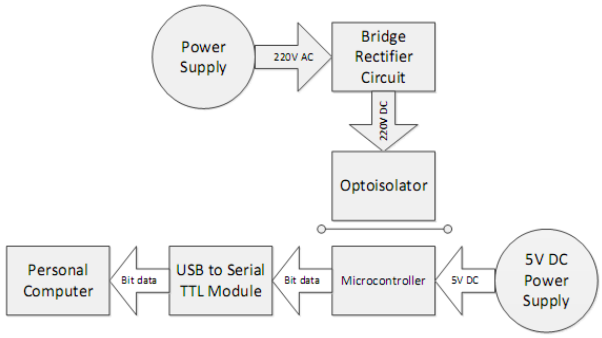


Figure 1. Block Diagram for Automated PC Shutdown Control System.

Microcontroller is a microprocessor system which has Control Processor Unit (CPU), Read-Only Memory (ROM), Random Access Memory (RAM), Input/Output (I/O), clock, and other interconnected internal components inside [4]. It is one of popular controllers used in many control systems design [5-7]. The ease and reliability of microcontroller to control and transmit data is already well-proven and implemented in many systems. The microcontroller used to design the AC detector device is AVR ATMega8L which is a 8-bit CMOS microcontroller with AVR Reduced Instruction Set Computing (RISC) architecture and has 8 KB in-system Programmable Flash working on low voltage –2.7 – 5.5 V [8]. Figure 2 shows the pin configuration of ATMega8L.

AVR ATMega8L microcontroller has Universal Synchronous/Asynchronous Receiver/Transmitter (USART) port on pin 2 and pin 3 to do data communication between two microcontrollers or between microcontroller and computer. USART can function as synchronous and asynchronous data transmission. Synchronous data means that the transmitter and receiver uses the same source of clock while asynchronous means that the transmitter and receiver uses different source of clock. In this design, synchronous data transmission will use crystal 11.0592 MHz as cock source. USB to Seral Transistor-Transistor Logic (TTL) module will be used as device for data transmission between microcontroller and PC.

220 Vrms AC signal as system input cannot come in contact with microcontroller because it can only work at low voltage level. Some other electrical components such as resistor and ceramic capacitor used in the design also has low power rating – meaning that they cannot work with high voltage signal. Thus, opto isolator is required to isolate AC signal from microcontroller and those electrical components [9].

On the design process of AC detector, a PS2505-1 type optoisolator is used. This optoisolator is chosen because this device can receive AC signal input. This device has high isolation and collector-emitter voltage value (BV = 5000V_{rms}, V_{CEO} = 80 V). Besides, it also has high switching speed (t_r = 3us TYP, t_f = 5us TYP) [10].

Optoisolator PS2505-1 consists of an infrared Light Emitting Diode (LED) or infrared emitting-diode (IRED), light sensor or photo sensor, and transistor. Figure 3 shows the top level diagram of opto isolator PS2505-1. If LED is given an AC signal on its input port, it will emit infra-red during half of the signal period. Whereas, LED is expected to emit infra-red as long as there is AC signal. Thus, before entering the input port of LED, the AC input signal needs to be rectified by bridge rectifier circuit [11].

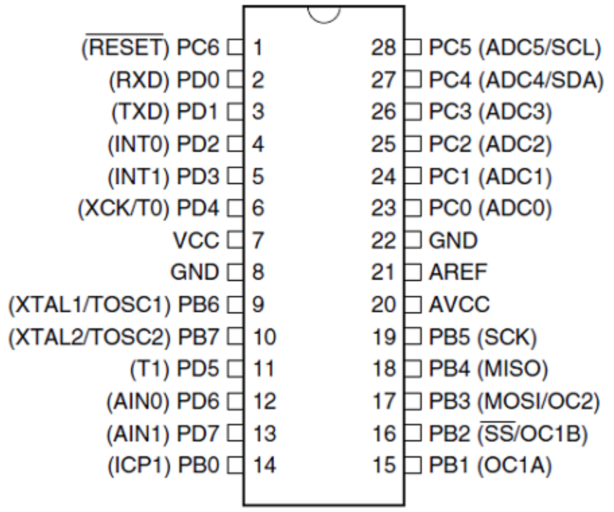


Figure 2. Pin configuration of ATMega8L

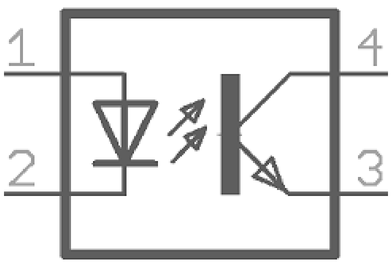


Figure 3. Top level diagram of Optoisolator PS2505-1

C. Hardware and Software Design

The system will consist of hardware and software. The hardware designed is an AC detector that will detect if there is AC signal on its input port and send information about it in the form of bit data that will be processed by the controlled PC. Meanwhile the software designed is a program that will be run on the controlled PC that will process the bit data from AC detector so that it can execute command to shut down PC when there is no AC signal. Microcontroller will be used as controller and optoisolator as isolator AC signal to implement the hardware. The software will be implemented using Visual Basic.

1) Hardware design

The designed AC detector consists of two subsystems. The first subsystem is the receiver – a circuit that is connected to the receiver part of optoisolator. The next subsystem is the transmitter – a circuit that is connected to the transmitter part of opto isolator. Included in the receiver subsystem is microcontroller ATMega8L. Between transmitter and receiver subsystems of AC detector, there is no transfer of electrical signal. In this design, the 5V DC Power comes from the USB to TTL module which converts its AC input power into DC. Generally, the 5V DC Power can come from many other sources like battery or UPS itself.

Microcontroller ATMega8L receives power supply of 5 V DC taken from PC through USB to Serial TTL module. In this design, when AC signal is ON, microcontroller will receive input 0 and sends output 1 and vice versa. To fulfill this condition, a pull-up resistor is applied. Figure 4 shows a concept of pull-up resistor usage.

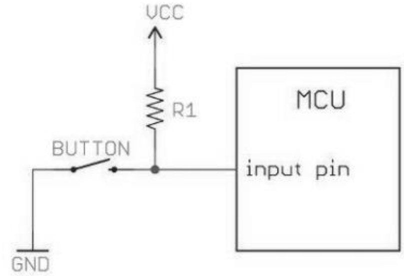


Figure 4. Concept of pull-up resistor usage

Transmitter subsystem receives 220 Vrms AC input signal and generates infra-red light output continuously as long as the input signal is ON. The schematic diagram of this subsystem can be seen on Figure 5. Element F1 is a fuse that works to protect the whole circuit from damage caused by short-circuit. Element R_1, R_2, and R_3 are resistors as load before the current enters components' terminals. D_1, D_2, D_3, and D_4 are diodes which form bridge rectifier circuit. C_5 is a capacitor to filter noise. A^+ and A^- are LED terminal that works as indicator if there is AC signal on AC detector input.

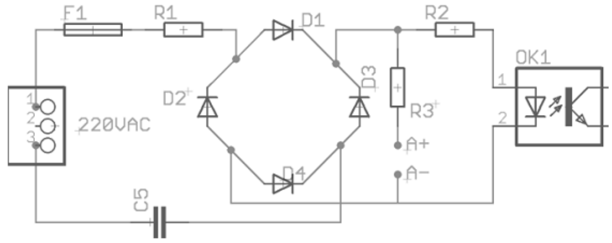


Figure 5. AC detector transmitter subsystem schematic diagram

The receiver subsystem can be viewed on Figure 6. This subsystem receives infrared light input and generates bit data output. Element R_4 is a low-resistance resistor which becomes load for microcontroller power supply. Element D_5 is a diode which works as circuit protector from returning current. Element C_1 is capacitor to filter noise. Point labeled INPUT is connected directly to input pin of microcontroller which will process the detected voltage between that point and ground.

If AC signal is ON, most of current from power supply will flow through transistor on optoisolator such that there is only low amount of voltage on INPUT-ground terminal. This voltage is sufficiently low to be viewed as '0' logic by microcontroller. Otherwise, if AC signal is OFF, most of the current from power supply will flow through INPUT point such that the voltage on INPUT-ground terminal is almost equal to the voltage from power supply. This voltage is viewed as '1' logic by microcontroller.

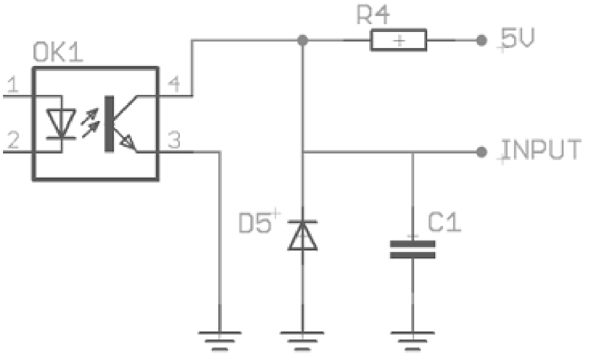
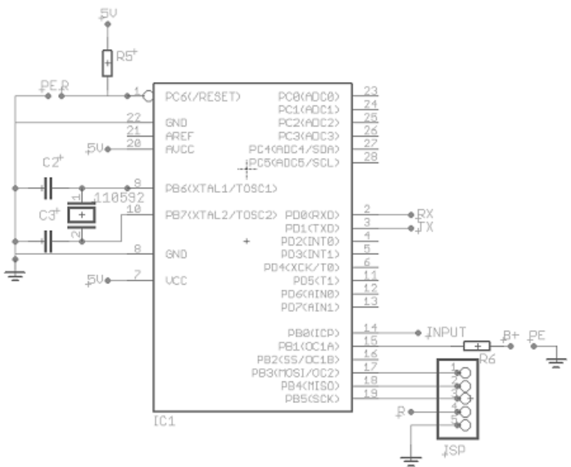


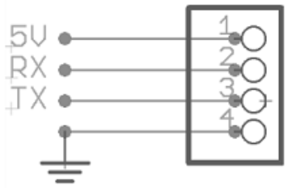
Figure 6. AC detector receiver subsystem schematic diagram

Microcontroller part of circuit diagram can be seen on Figure 7. Figure 7(a) shows minimum system circuit of ATMega8 microcontroller used in this design. Pin 2 and pin 3 are respectively pin RX and pin TX connected to USB to TTL connector. B^+ and PE are the LED terminal. Figure 7(b) show diagram of USB to Serial TTL connector pins while Figure 7(c) shows LED and push button pins.

Microcontroller work flowchart is shown by Figure 8. Microcontroller does an input reading every 1 second. If the input detected is 1, microcontroller will generate output of bit data 0. Otherwise, it will generate output of bit data 0.



(a)



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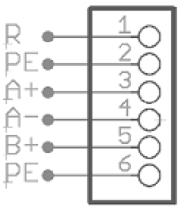

(c)

Figure 7. (a) ATMega8 microcontroller diagram, (b) USB to Serial TTL connector pin diagram, (c) LED and push button pin diagram

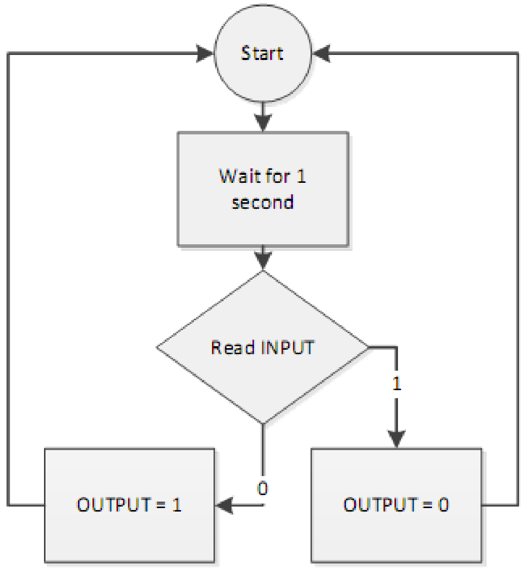

Figure 8. Flowchart of microcontroller ATMega8L program

2) *Software design*

After passing through USB to Serial TTL, bit data sent by microcontroller will be received by PC. To process that bit information into a command to execute PC shutdown, a program is designed. The flowchart diagram of the program is shown by Figure 9.

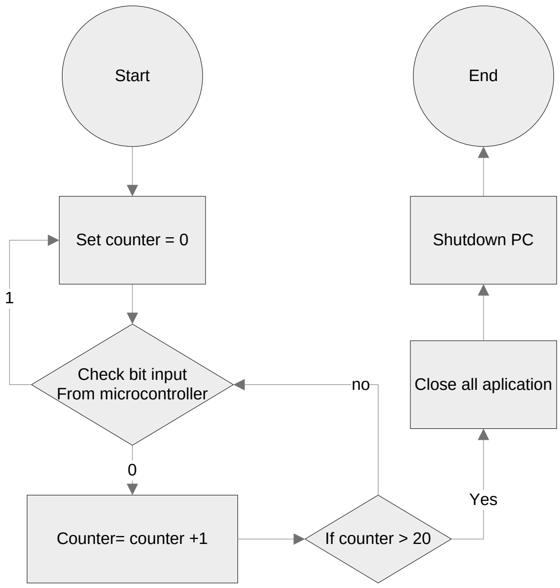

Figure 9. Flowchart of automated PC shut down program

On PC memory, a variable 'Counter' which has initial value '0' is declared. When AC input signal is ON, PC will keep receiving and checking input data sent by microcontroller to it. If PC reads the input as bit '1', program will reset the value of variable 'Counter' to '0'. If PC reads the input as '0', program will add the value of variable 'Counter' by 1. In this design, it is assumed that microcontroller will only send input '0' or '1' to PC.

When the value of variable 'Counter' reaches 20, program will execute a command to shut down PC. First, program will close all application windows being active on PC. After that, program will star shutting down PC. There is no particular reason to choose 20 seconds as the

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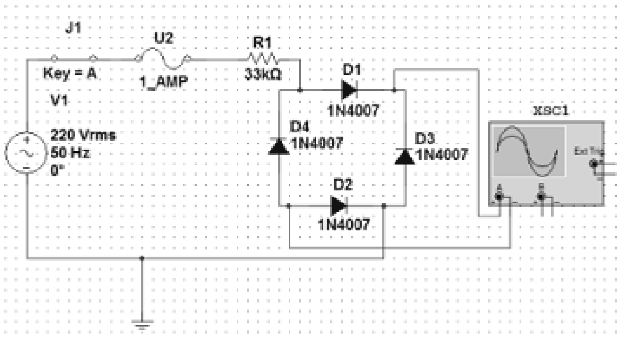
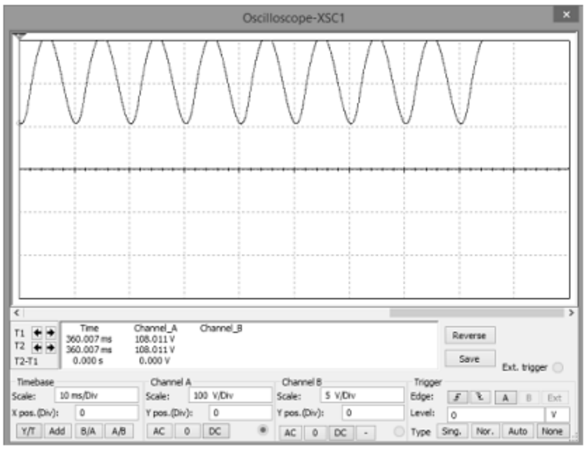
gap between the outage and the initiation shutdown procedure. It just needs to be long enough to distinguish the brief outage from a long outage. It also needs to be short enough such that the energy from UPS is not much wasted.

III. SIMULATION

The simulation applied to system consists of observation of voltage signal on optoisolator input terminal which has passed through Rectifier Bridge. The expected result is a full signal wave which always has positive value so the LED will always emit infrared light. This simulation is done using computer software Multisim 12. The simulated circuit and simulation result are depicted on Figure 10(a) and 10(b) respectively. Simulation result shows that the signal measured by simulator oscilloscope forms full signal with minimum value of 100 V. This suits the expectation.



(a)



(b)

Figure 10. (a) Simulated circuit, (b) simulation result

IV. DESIGN IMPLEMENTATION AND ANALYSIS

A. Design Implementation

After the system and circuit has been designed and simulated, the next step is to implement the design. The implementation process is done using EAGLE 5.6.0 to print the circuit in to PCB. The board design is shown by Figure 11.

B. Design Testing

System testing is followed after the design is implemented into an electrical circuit. First, a test will be done on its input-output. The initial condition of testing is as following:

1) Input of detector has been connected to AC signal source.
2) Output of detector has been connected to PC through Serial to USB TTL module.
3) A program that is able to read bit data sent by AC detector as output through USB to Serial TTL module has been installed on PC that can display it on screen at real-time and periodically.

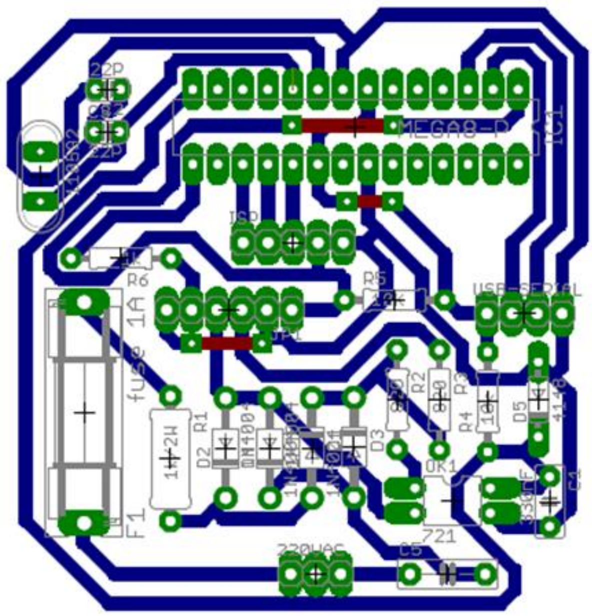


Figure 11. Implementation of circuit into board using EAGLE 5.6.0

The testing procedure is as following:

1) Bit data displayed on screen is observed when AC signal is ON. It's expected for bit 1 to keep appearing when the signal is ON.
2) Bit data displayed on screen is observed when AC signal is OFF. It's expected for bit 0 to keep appearing when the signal is OFF

After that, a test will be done to the system as a whole. The initial condition for testing is as following:

1) Detector input has been connected to AC input signal.
2) Detector output has been connected to PC through USB to Serial TTL module.
3) Automated PC shut down program has been installed on PC

The procedure of testing is as following:

1) Cut off the AC signal input.
2) Observe the PC. If PC has started operation of automated shutdown within 20 seconds, it is concluded that the system has worked properly.

The testing has been conducted in the laboratory and the result shows that the design has worked well. This device has been implemented in the integrated LPI radar system of Indonesian Research Center of Electronics and Telecommunication inside its shelter. This device can control the shutdown process of not only one but many PC's in the same network, such as the PC's for the radar display and instrument PC (e-PC). Figure 12 shows the picture of the implementation of our device in the radar system.

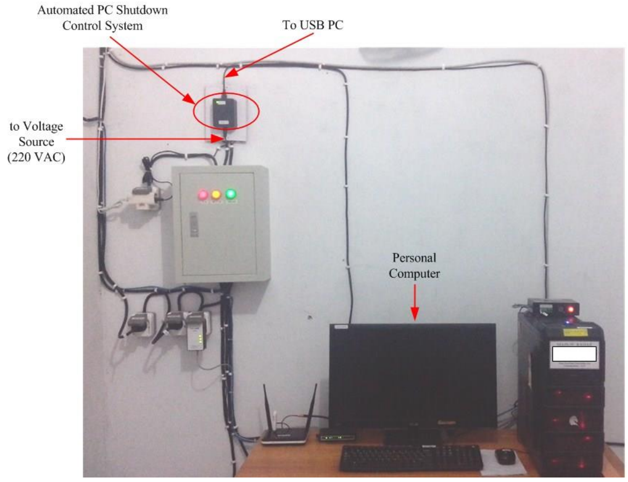


Figure 12. Implementation of the device in the radar system inside a shelter.

The disadvantage of this device is that it completely depends on the UPS condition. If the UPS somehow malfunctions, our device cannot control the shutdown of the PC's anymore. Therefore, it's important to have a very good and durable UPS in the system and do a routine UPS check to ensure that it works well.

CONCLUSION

The designed AC detector is able to work properly. The device is able to send output to PC in form of bit data 1 when AC signal is on and 0 when AC signal is off. Automated PC shutdown control system has worked properly. The PC is shut down during 20 seconds after the outage happens. Control system using microcontroller as controller is suitable as alternative of data acquisition module such as ADAM. Optoisolator PS2505L-1 can become an alternative to substitute PS2505-1 used in this paper because in PS2505L-1 there is already a rectifier in form of two LEDs installed in parallel. The microcontroller ATMega8 used in this paper can be substituted with other types of microcontroller with lower cost and smaller size as long as it can provide the pins required to design AC detector or with additional feature.

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