DESIGN OF AN INTELLIGENT SWITCH FOR LOW VOLTAGE DISTRIBUTION SYSTEM

ABU KHIR BIN ABU BAKAR

APRIL 2009

APPROVAL

“ I hereby declared that I have read through this report and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (*Industrial Power*).

Signature :

Supervisor’s Name : Prof. Madya Dr. Musse Mohamud Ahmed

Date :

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This Report Is Submitted In Partial Fulfillment Of Requirements For The Degree
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DECLARATION

I hereby declared that this report entitled **" DESIGN OF AN INTELLIGENT SWITCH FOR LOW VOLTAGE DISTRIBUTION SYSTEM "** is the result of my own work except for the excerpts that have been cited clearly in the references.

Signature	:	
Author's Name	:	Abu Khir b. Abu Bakar
Date	:	

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ABSTRACT

This project is to design an Intelligent Switch for Low Voltage Distribution. This project used the knowledge of electrical and electronics. This project has 2 main parts of circuits, which are step-down AC voltage (240 Volt) to DC voltage (9 Volt). The second part is as emergency supply which alerts for darkness condition and no power supply is needed. For the step-down voltage part, it converts high voltage to low voltage (240 V to 9 V). As been used for this application, I used step-down transformer as main equipment. And for other equipment as bridge rectifier, capacitor, two changeover contacts (relay normally closed). And for the emergency supply part, is to analyze the performance of the system in darkness and no power supply condition. For analyze the performance in darkness condition, it used phototransistor. In this section have a Darlington pairs (2 NPN transistors) and relay. Others objectives is to determine the characteristics of the phototransistor. For the last objectives is to provide education materials for students such as experiments or study case model. During completed this circuit, I have apply many skill from my study.

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ABSTRAK

Projek ini adalah suatu litar yang mempunyai suis serbaguna untuk voltan rendah. Projek ini dapat mengaplikasikan ilmu mengenai elektrik dan elektronik. Projek ini mempunyai 2 bahagian utama, iaitu langkah turun voltan tinggi (240 V) kepada voltan rendah (9 V). bahagian yang kedua mempunyai fungsi bekalan kecemasan, terdapat pengesan keadaan gelap dan tiada bekalan kuasa. Untuk bahagian langkah turun voltan, ianya menukar voltan tinggi (240 V) kepada voltan rendah (9 V). Dalam mecapai keberfungsian seperti itu, saya perlu menggunakan pengubah langkah turun sebagai komponen utama. Dan komponen lain seperti penerus diod, kapasitor, geganti biasanya tutup. Untuk bahagian bekalan kecemasan, ianya untuk analisis prestasi dalam keadaan gelap, akan menggunakan transistor peka cahaya. Dalam bahagian lain, ianya mempunyai 2 NPN transistor dan geganti. Objektif lain adalah memperlengkapkan keperluan pembelajaran bagi pelajar seperti eksperimen atau permasalahan. Sepanjang menyiapkan projek ini, saya telah menggunakan pelbagai kemahiran yang dipelajari semasa pembelajaran disini.

TABLES OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

cm	-	Centimeter
mm	-	Milimeter
m	-	Meter
n	-	Nano (10^{-9})
μ	-	Micro (10^{-6})
M	-	Mega (10^{6})
k	-	Kilo (10^{3})
Ω	-	Ohms, unit for resistance
V	-	Volts, unit for voltage
A	-	Ampere, unit for current
F	-	Farads, unit for capacitor
H	-	Henry, unit for inductor
°C	-	Celcius, unit of temperature
°F	-	Fahrenheit, unit of temperature
BATT	-	Battery
TNB	-	Tenaga Nasional Berhad
R	-	Resistor
C	-	Capacitor
L	-	Inductor

CHAPTER 1

INTRODUCTION

1.1 Project Background

This is intelligent simple switch circuit which enables automatic switching on of an emergency light system during darkness in the event of mains failure. The mains power failure condition is detected by the section consisting of mains step-down transformer X1 followed by bridge rectifier comprising diodes D1 through D4 and smoothing capacitor C1. If the main is available then it causes the relay RL1 to energize which has two sets of changeover contacts. The light/darkness condition is detected by the circuit comprising phototransistor FPT100/2N5777 followed by Darlington pair comprising transistors T2 and T3.

However, this is section will function only when mains supply is not available (i.e. when relay RL1 is in de-energized state) since battery supply (negative leads) path gets completed via lower N/C contact of relay RL1. During daylight, phototransistor conducts and places transistor T2 base near ground potential. Thus Darlington pair remains cut-off and relay RL2 remains de-energized. However, during darkness, phototransistor is cut-off and therefore transistor T2 receives forward base bias via resistor R1 (connected to positive rail), as resistor R2 is no more grounded (via phototransistor T1).

As a result, relay R2 gets energized. Thus, it would be observed that when mains is absent (relay RL1 de-energized) and it is dark (relay RL2 energized), the switch output path is complete. In any other condition switch output path would get broken. The switch output terminals can be used (in series with supply) to control a lighting system directly or indirectly through another contractor/heavy-duty relay depending upon the load.

1.2 Problem Statement

Before make any project or big plan, I must make some research from all community which is can solve any problem for people. By creating new technology or equipment, its can make more effective and simple life for all human. In my research, my focus is equipment that related my course study (power industry).

About 2 weeks, I found that many work only can be done when has current or power supply. When don't have any power throw the circuit, many work cannot be completed such as operated in switchgear which is used relay as important equipment. As basic, we look that relay just small equipment in switchgear but the function is very important.

After that, I plan to the intelligent switch which is has step-down transformer and phototransistor. This is new technology which can operate when there is no main power supply and in the darkness condition (don't have light).

It's function just like an emergency circuit as usual but has some adjustment in that circuit to make more perfect equipment for the future. This circuit as backup supply for relay in switchgear when no supply. This circuit also can have an application of phototransistor which made the intelligent circuit for anyone.

1.3 Objectives

For all projects must have a objectives. Its can make the overview of project more details and focus what must be done to achieve the objectives. I already listed three main objectives for my final year project which can guide me during do all working progress.

Firstly, my main objective is to design an intelligent switch for low voltage distribution system. In this circuit, it can convert high voltage to low voltage (230V to 9V). For have this application, I must used step-down transformer as main equipment. And for other equipment as bridge rectifier, capacitor, two changeover contacts (relay normally closed).

Secondly, my main objective is to analyze the performance of the system in darkness and no power supply condition. For analyze the performance in darkness, it used phototransistor. In this section have a Darlington pairs (two NPN transistors) and relay.

Others main objective is to determine the characteristics of the phototransistor. For the last objectives is to provide education materials for students such as experiments or study case model. During completed this circuit, I have apply many skill from my study.

1.4 Scope of the Project

In this final year project, I had designed a circuit which can be applied for many application or work. As we know the basic of this project is similar as emergency supply. Just make some adjustment for make the ideal circuit in any industry.

The scope of this project is the application for user such as Petronas or Tenaga Nasional Berhad (TNB) that used the relay in switchgear. The relay must have in switchgear as protection and backup power supply until have permanently supply.

Based on my research, the relay must be in the on condition which is always has power supply through it. Relay act as important equipment in switchgear. When relay don’t have any power supply, its contact will be changeover to other side such as used normally closed relay. In no power supply condition, the contact will be at closed contact (depends on the circuit which is in open or closed circuit).

Besides that, the functional of relay in switchgear is very important for a transmission and distribution power supply system. This is the main scope of the project that made more efficient system for the future.

CHAPTER 2

LITERATURE REVIEW

2.1 Constructing a Universal Power Supply [9]

This is a basic, text-book, Universal Power Supply voltage regulator circuit using an LM317, 3-terminal regulator in a TO-220 package. The Universal Power Supply output voltage can be set to anywhere in the range 1.5V to 30V by selecting two resistances. By using a potentiometer, R2, as one of the resistors you can dial up the output voltage wanted. Either AC or DC input can be supplied to the PCB via a socket or terminal block. Connection can be either way around. This is because we have provided a bridge rectifier on board. The input DC voltage to the regulator must be at least 2.5V above the required output voltage. An off/on switch is provided.

For many applications (say 12V at 60 mA) a heat sink will not be necessary. The LM317 will provide slightly higher output voltages than 30 volts. However, for most hobbyists over 30V will not be needed. So to make a small PCB we have used some electrolytic capacitors rated to 35 volts. To be safe for continuous operation the maximum input DC voltage to the regulator should not be over 33V. With a 2.5V to 3.0V drop across the regulator this will give a regulated output of 30V. You can draw up to 1.5A from the LM317. If you need more higher then use an LM338T rated to 5A.

When external capacitors are used with any IC regulator it is good practice to add protection diodes to prevent the capacitors discharging back into the regulator in the event of abnormal operating conditions, like a sudden short circuit on the input or the output, or a back emf from an inductive load. That is the function of D1 and D2.

The value of R1 can range anywhere from 120R to 1200R (see Data Sheet on www.ti.com) However, circuits from most other sources settle on using either 220R or 250R. We have used 240R or 250R. The voltage drop across R1 is 1.25V for all values, and this is the key to the design. 1.25V is the reference voltage of the regulator.

Whatever current flows through R1 also flows through R2, and the sum of the voltage drops across R1 and R2 is the output voltage. (Additional current Id also flows in R2 but it is typically 50uA so is negligible.)

The design formula is:

VOUT = 1.25 (1 + R2/R1) volts, or alternatively

R2/R1 = (VOUT/1.25) – 1

So if you know VOUT and R1 is 250R then you can calculate R2. If you find that the 5K potentiometer used for R2 does not give you the degree of fine control over the voltage output range that you want then you can use these formulae to adjust R1 and R2 to better suited values.

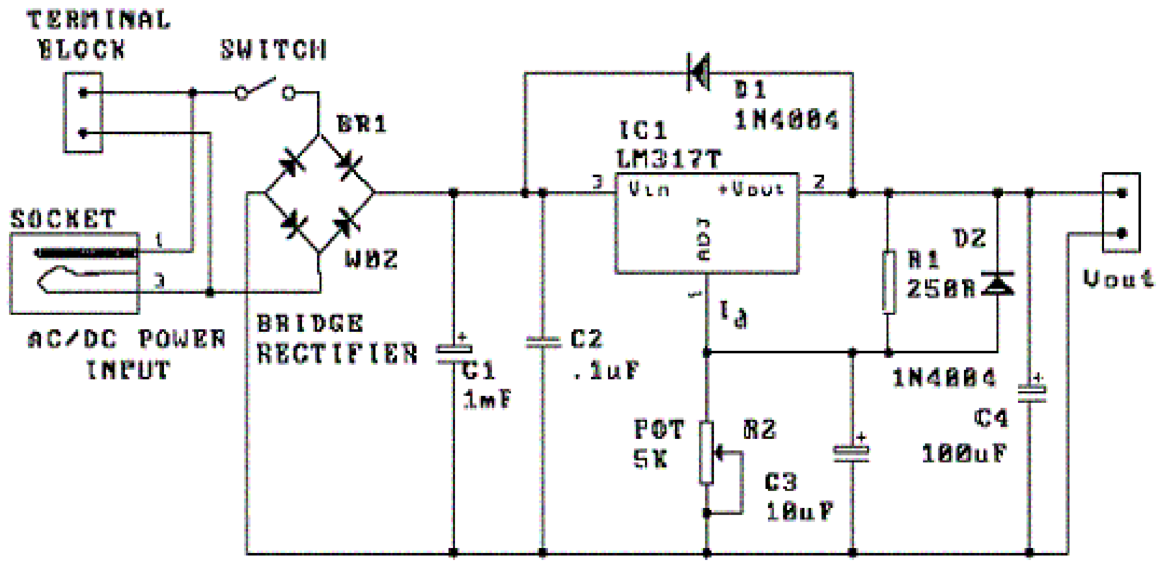

Figure 2.1: Universal Power Supply Schematic Diagram

COMPONENTS		
2 pole edge connector		2
1N4004 diode	D1 D2	2
Mono cap .1uf (104)	C2	1
5K potentiometer	R2	1
Electrolytic capacitors:		
1000uF/35V	C1	1
10uF/50V	C3	1
100uF/35V	C4	1
Resistor 240R or 250R, 5%	R1	1
LM317T regulator		1
Bridge rectifier W02		1
SPDT switch		1
PCB		1
PCB mounted power jack		1
Heatsink		1
Nut & bolt set 6mm or 8mm		1

Table 2.1: Universal Power Supply Parts List

2.2 Fundamental Phototransistor Circuits [10]

Figures 9 and 10 show the fundamental phototransistor circuits. The circuit shown in Figure 9 (A) is a common-emitter amplifier. Light input at the base causes the output (VOUT) to decrease from high to low. The circuit shown in Figure 9 (B) is a common-collector amplifier with an output (VOUT) increasing from low to high in response to light input. For the circuits in Figure 9 to operate in the switching mode, the load resistor (RL) should be set in relation with the collector current (IC) as VCC < RL × IC.

The circuit is shown Figure 10 (A) uses a phototransistor with a base terminal. A RBE resistor connected between the base and emitter alleviates the influence of a dark current when operating at a high temperature. The circuit shown in Figure 10 (B) features a cascade connection of the grounded-base transistor (Tr1) so that the phototransistor is virtually less loaded, there are by improving the response. This phototransistor is sensitive to normal visible light (800 nm). Infrared phototransistors can be used, but won't be as sensitive to flashlights and other household sources.

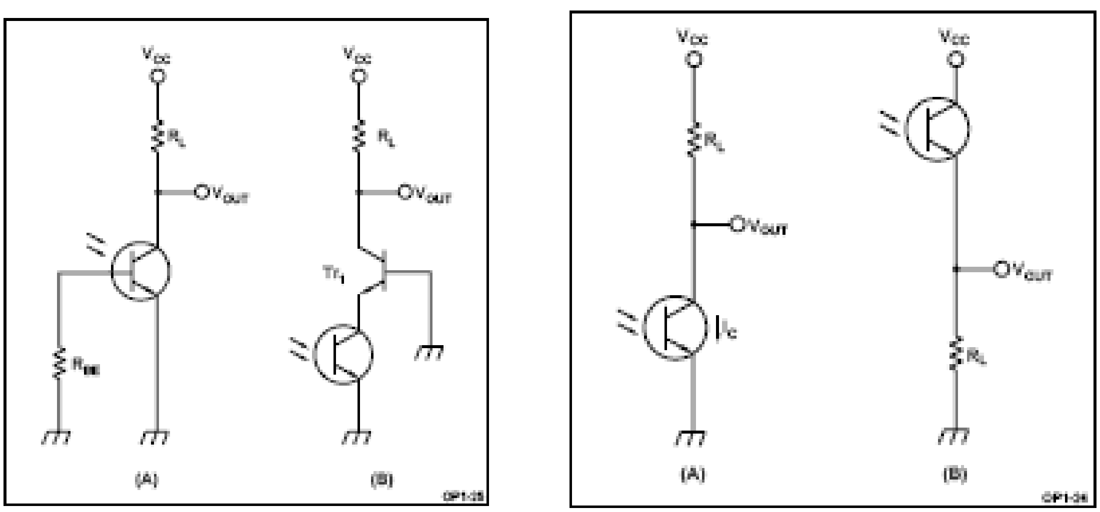

Figure 2.2: Fundamental Phototransistor Circuit (II)

2.3 Making a Light and Dark Sensor [11]

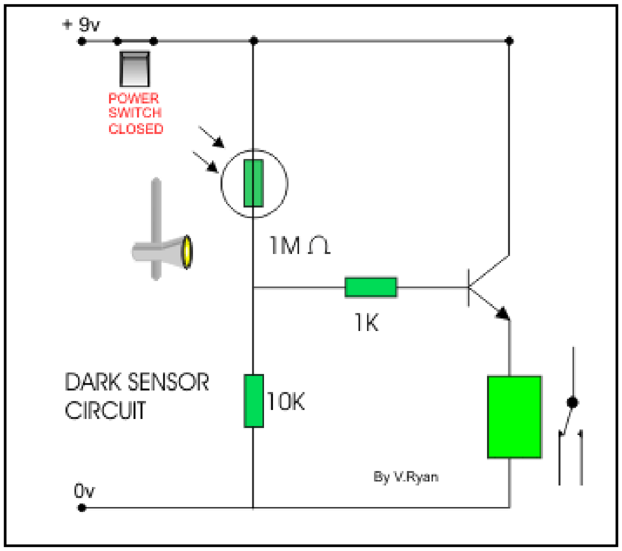

Figure 2.3: Circuit of Light and Dark Sensor

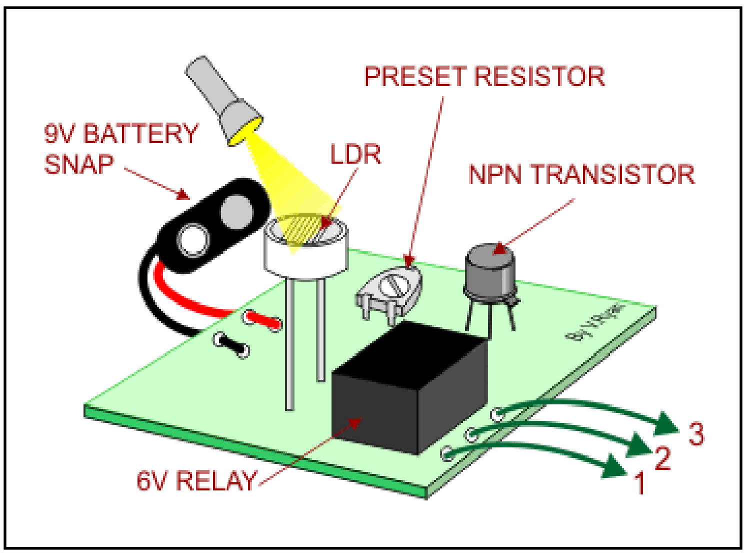

Figure 2.4: Diagram of circuit Light and Dark Sensor

Opposite is a simple light/ dark sensor. This can be connected as an input or switch to another circuit. The sensors have three green wires (1, 2 and 3). Wire 2 should always be connected to one of the inputs. If wire 1 is also connected then the sensor acts as a dark sensor. If wires 2 and 3 are connected to the inputs then sensor operates as a light sensor. The preset resistor allows the person using the circuit to alter its sensitivity to light/dark.

2.4 Light Detection Using a Phototransistor [12]

This page describes an example project that turns on a red LED when light is dim and a green LED when light is bright. Or more to the point, changes color when objects (such as a fan blade) pass in front of it.

Because the lighting required to enable either LED is controlled by individual potentiometers, they can be set such that either, neither or both LEDs turn on. That is, the red LED doesn't have to turn on simply because the green LED turned off.

This is also a good example of how to use a phototransistor, rather than a cadmium sulfide photocell to detect light. Phototransistors react much more quickly, and are much more sensitive. Couldn't you create a simple robot that seeks light (or dark) by turning on motors rather than LEDs?

2.4.1 Application of the Project

For a prototype hand held tachometer project, a microcontroller analyzed a phototransistor and a pair of potentiometers using three built-in analog-to-digital (ADC) converters. Unfortunately, that design required the microcontroller to spend most of its time reading the phototransistor's voltage in order to detect a passing line or mark.

It turns out that a dedicated comparator chip is a superior solution. Comparators constantly compare pairs of voltages and provide a digital indication ('1' or '0') of which voltage is higher. Using the dedicated chip frees the microcontroller, which is now only interrupted when the digital signal changes.

If your project requires a microcontroller, but the microcontroller doesn't have any available ADCs, perhaps adding a comparator chip would provide a faster, less expensive solution.

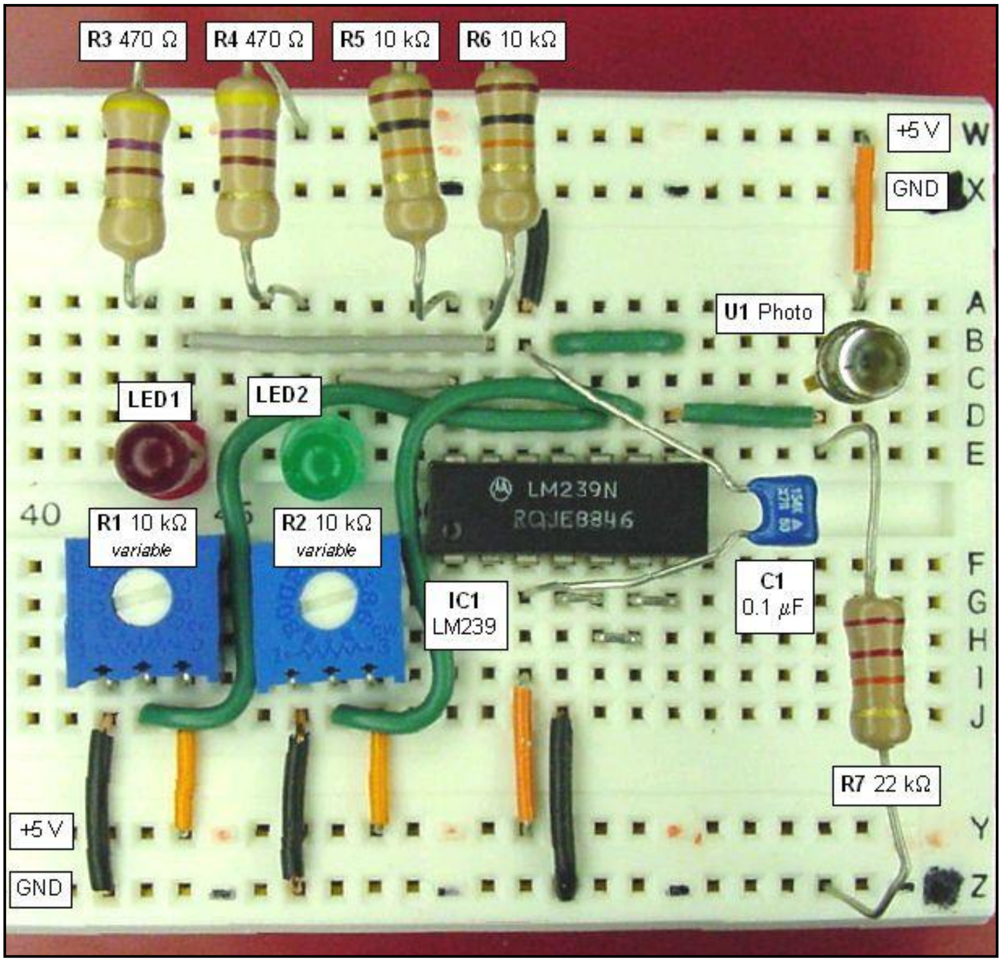

Figure 2.5: Light Detector Circuit

2.4.2 Function of the Components

1) U1

This phototransistor is sensitive to normal visible light (800 nm). Infrared phototransistors can be used, but won't be as sensitive to flashlights and other household sources. Sensor can be purchased from Jameco Electronics, part number 120221, product number BPW77.