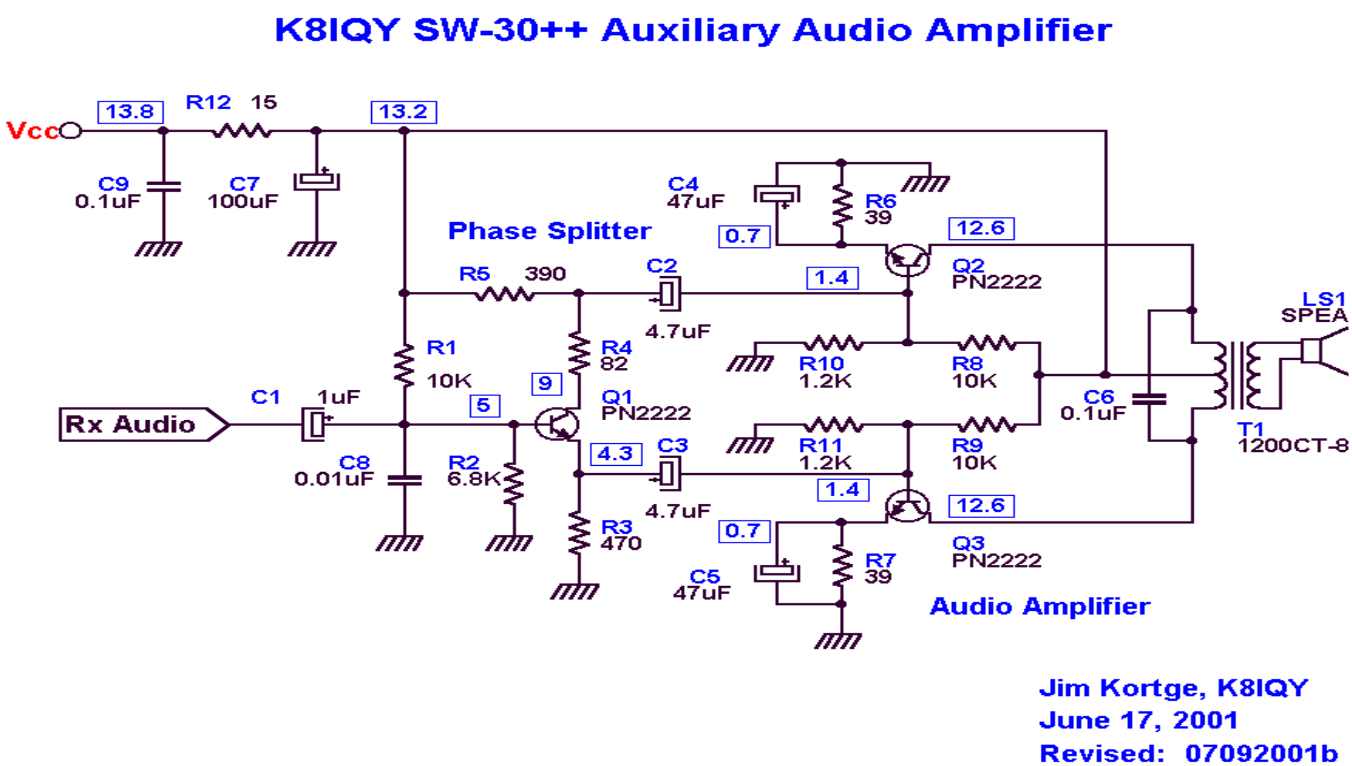
BIRZEIT UNIVERSITY

Electrical Engineering Department



ENEE 232

Project number 1

"Automatic Light controller "

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TALAHMA

Abstract:

The aim of the project :

Basically is to deal with real components we have been studying in the electronics course ,also to cover some dimensions in our thinking towards the real work that theoretical part cannot cover. In addition to facing reality problems and understand the affection of the ignored factors . Moreover , to learn how to deal with components we don't know before just as relay and LDR (light dependent resistor) .

The method used:

By connecting the components of the circuit on a board ,and using the multimeter to help understanding the relay and the potentiometer's mechanism.

Components required:

1- transformer
2-bipolar transistor
3-diodes
7-LDR sensor
8-the potentiometer
9-capacitors

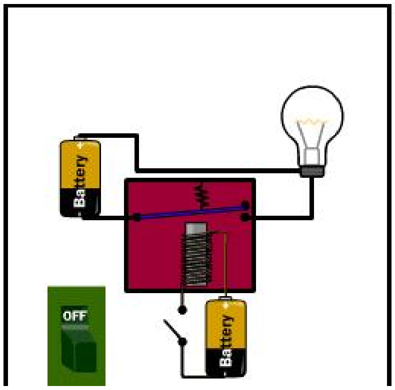
4-wires
5-multimeter
6-relay
13-board
10-resistors
11-ac source
12-lamp

Basic information of the project:

Here is an explanation of some elements in our project:

The relay:

If we place a magnetic object near such a coil for the purpose of making that object move when we energize the coil with electric current, we have what is called a *solenoid*. The movable magnetic object is called an *armature*, and most armatures can be moved with either direct current (DC) or alternating current (AC) energizing the coil. The polarity of the magnetic field is irrelevant for the purpose of attracting an iron armature. Solenoids can be used to electrically open door latches, open or shut valves, move robotic limbs, and even actuate electric switch mechanisms. However, if a solenoid is used to actuate a set of switch contacts, we have a device so useful it deserves its own name: the *relay*.



A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and most have double throw (changeover) switch contacts as shown in the diagram. Relays allow one circuit to switch a second circuit which can be completely separate from the first. For example a low voltage battery circuit can use a relay to switch a 230V AC mains circuit. There is no electrical connection inside the relay between the two circuits, the link is magnetic and mechanical.

Consider the simple circuit beside:

In this figure, we can see that a relay consists of two separate and completely independent circuits. The first is at the bottom and drives the electromagnet. In this circuit, a switch is controlling power to the electromagnet. When the switch is on, the electromagnet is on, and it attracts the armature (blue). The armature is acting as a switch in the second circuit. When the electromagnet is energized, the armature completes the second circuit and the light is on. When the electromagnet is not energized, the spring pulls the armature away and the circuit is open. In that case, the light is off.

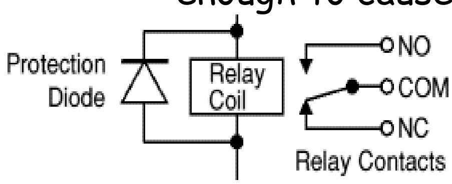
When you purchase relays, you generally should consider these variables:

- The voltage and current that is needed to activate the armature
- The maximum voltage and current that can run through the armature and the armature contacts

- The number of armatures (generally one or two)
- The number of contacts for the armature (generally one or two -- the relay shown here has two, one of which is unused)
- Whether the contact (if only one contact is provided) is normally open (NO) or normally closed (NC)

Transistors and ICs must be protected from the brief high voltage produced when a relay coil is switched off. The diagram shows how a signal diode is connected 'backwards' across the relay coil to provide this protection.

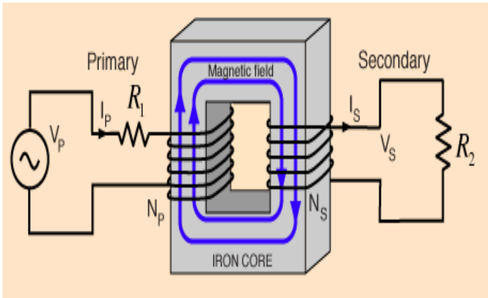
Current flowing through a relay coil creates a magnetic field which collapses suddenly when the current is switched off. The sudden collapse of the magnetic field induces a brief high voltage across the relay coil which is very likely to damage transistors and ICs. The protection diode allows the induced voltage to drive a brief current through the coil (and diode) so the magnetic field dies away quickly rather than instantly. This prevents the induced voltage becoming high enough to cause damage to transistors and ICs.



In our circuit ,we connected the coil with the circuit and the switch will be connected as shown :

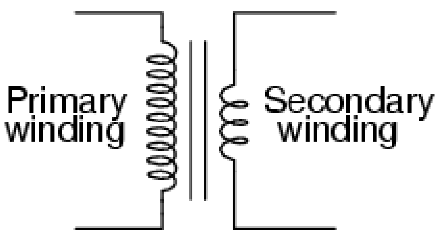
The normally open and closed will be taken in consideration when connecting the circuit .The normally open will be connected with the ac source (so with absence of the current throw the coil NO is off and the ac current will not pass throw the lamp).

The transformer:



A transformer is made up of two coils, each with a different number of loops, linked by an iron core so the magnetic flux from one passes through the other. When the flux generated by one coil changes (as it does continually if the coil is connected to an AC

power source), the flux passing through the other will change, inducing a voltage in the second coil. With AC power, the voltage induced in the second coil will also be AC.



In a standard transformer, the two coils are usually wrapped around the same iron core, ensuring that the magnetic flux is the same through both coils. The coil that provides the flux (i.e., the coil connected to the AC power source) is known as the primary coil, while the coil in which voltage is induced is known as the secondary coil. If the primary coil sets up a changing flux, the voltage in the secondary coil depends on the number of turns in the secondary:

$$V_s = -N_s \Delta\Phi / \Delta t$$

Similarly, the relationship for the primary coil is:

$$V_p = -N_p \Delta\Phi / \Delta t$$

Combining these gives the relationship between the primary and secondary voltage:

$$V_s / V_p = N_s / N_p$$

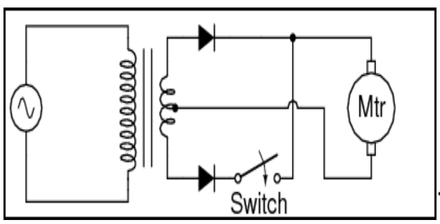
Energy (or, equivalently, power) has to be conserved, so:

$$P = V_s I_s = V_p I_p$$

$$\text{So,} \quad V_s / V_p = N_s / N_p = I_p / I_s$$

If a transformer takes a high primary voltage and converts it to a low secondary voltage, the current in the secondary will be higher than that in the primary to compensate (and vice versa). A transformer in which the voltage is higher in the primary than the secondary (i.e., more turns in the primary than the secondary) is known as a step-down transformer. A transformer in which the secondary has more turns (and, therefore, higher voltage) is known as a step-up transformer.

The full wave rectifier ;



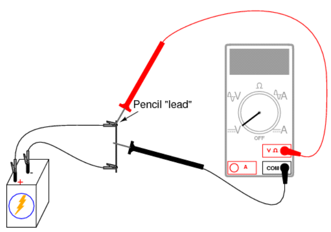
This rectifier circuit is called *full-wave* because it makes use of the entire waveform, both positive and negative half-cycles, of the AC source voltage in powering the DC load. As a result, there is less "ripple" voltage seen at the load. The RMS (Root-Mean-Square) value of the rectifier's output is also greater for this circuit than for the half-wave rectifier.

Use a voltmeter to measure both the DC and AC voltage delivered to the motor. You should notice the advantages of the full-wave rectifier immediately by the greater DC and lower AC indications as compared to the last experiment.

An experimental advantage of this circuit is the ease of which it may be "de-converted" to a half-wave rectifier: simply disconnect the short jumper wire connecting the two diodes' cathode ends together on the terminal strip. Better yet, for quick comparison between half and full-wave rectification, you may add a switch in the circuit to open and close this connection

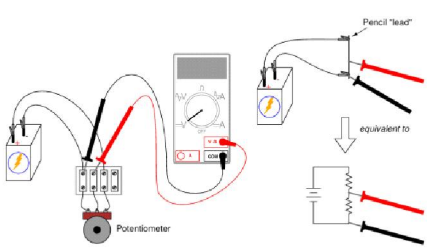
The potentiometer:

Potentiometers are variable voltage dividers with a shaft or sliding control for setting the division ratio. They are manufactured in panel-mount as well as breadboard PCB (printed-circuit board) mount versions. Any style of potentiometer will suffice for this experiment.



If you salvage a potentiometer from an old radio or other audio device, you will likely be getting what is called an *audio taper* potentiometer. These potentiometers exhibit a logarithmic relationship between division ratio and shaft position. By contrast, a *linear* potentiometer exhibits a direct correlation between shaft position and voltage division ratio .A Linear potentiometer is used for this experiment, and for most experiments in general.

INSTRUCTIONS

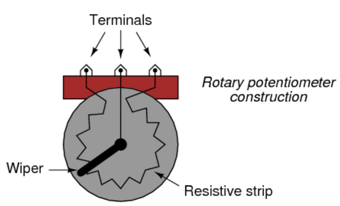


Begin this experiment with the pencil "lead" circuit. Pencils use a rod made of a graphite-clay mixture, not lead (the metal), to make black marks on paper. Graphite, being a mediocre electrical conductor, acts as a resistor connected across the battery by the two alligator-clip jumper wires. Connect the voltmeter as shown and touch the red test probe to the graphite rod. Move the red probe along the length of the rod and notice the voltmeter's indication change. What probe position gives the greatest voltage indication?

Essentially, the rod acts as a *pair* of resistors, the ratio between the two resistances established by the position of the red test probe along the rod's length:

Now, change the voltmeter connection to the circuit so as to measure voltage across the "upper resistor" of the pencil lead, like this:

Move the black test probe position along the length of the rod, noting the voltmeter indication. Which position gives the greatest voltage drop for the meter to measure? Does this differ from the previous arrangement? Why?

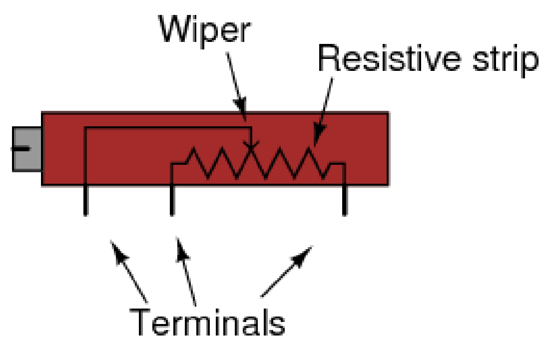


Manufactured potentiometers enclose a resistive strip inside a metal or plastic housing, and provide some kind of mechanism for moving a "wiper" across the length of that resistive strip. Here is an illustration of a rotary potentiometer's construction:

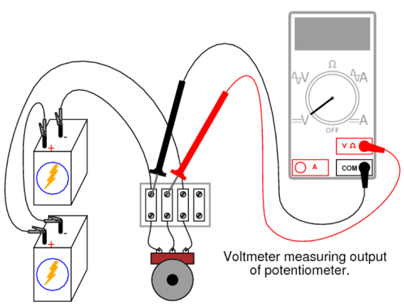
Some rotary potentiometers have a spiral resistive strip, and a wiper that moves axially as it rotates, so as to require multiple turns of the shaft to drive the wiper from one end of the potentiometer's range to the other. Multi-turn potentiometers are used in applications where precise setting is important.

Linear potentiometers also contain a resistive strip, the only difference being the wiper's direction of travel. Some linear potentiometers use a slide mechanism to move the wiper, while others a screw, to facilitate multiple-turn operation:

Linear potentiometer construction



It should be noted that not all linear potentiometers have the same pin assignments. On some, the middle pin is the wiper.



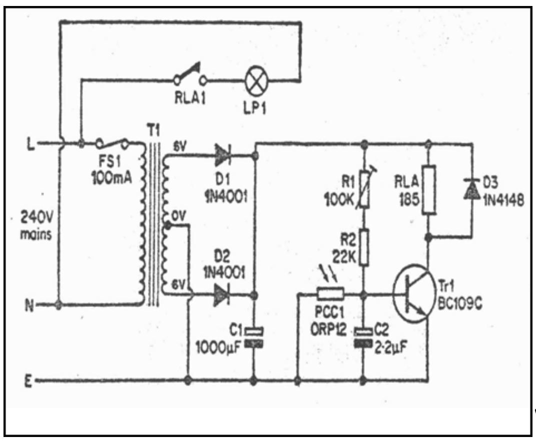
Set up a circuit using a manufactured potentiometer, not the "home-made" one made from a pencil lead. You may use any form of construction that is convenient.

Measure battery voltage while powering the potentiometer, and make note of this voltage figure on paper. Measure voltage between the wiper and the potentiometer end connected to the negative (-) side of the battery. Adjust the potentiometer mechanism until the voltmeter registers exactly 1/3 of total voltage. For a 6-volt battery, this will be approximately 2 volts.

Now, connect two batteries in a series-aiding configuration, to provide approximately 12 volts across the potentiometer. Measure the total battery voltage, and then measure the voltage between the same two points on the potentiometer (wiper and negative side). Divide the potentiometer's measured output voltage by the measured total voltage. The quotient should be 1/3, the same voltage division ratio as was set previously.

A quick view over the circuit:

Consider the circuit in figure beside;



We can divide the circuit into multi-stages as:

Stage 1:dc power supply:it is known that the dc power supply change the ac signal into almost purely dc signal throw multi stages as follow:
1-center tapped transformer full wave rectifier-used here-:
From the circuit beside, the output of the transformer is divided into two 180 degrees out of phase with same magnitude signals.
In the center tapped step down transformer the secondary coil is divided into two same number of turns coils which are less than the primary coil, and are connected in a away that they produce two out of phase wave forms.
In general ,the rectifier converts the ac voltage (zero average value) into a positive or negative pulsating voltage signal (non zero average value).

For our circuit ,the period of the output signals is less than the input signal by half ,and the signal is up to the time axes(positive always).

2-Low pass filter:

The filter is very important stage of the dc power supply ;it is used to smooth out the pulsating dc produced by the rectifier by removing its ac rippling contents and planing its dc component(average value). For very large value of time constant comparing to period of the wave voltage of the capacitor decreases so slowly – almost stay the same- ,so the signal will be almost dc .and the performance of this stage measure by a factor called the ripple factor which equal to the rms value of the ripple divided by the average value of the output signal.

The other stages are explained below:

After we get a dc current from the last stage, we have the potential meter that is a variable resistor which can be controlled by hand to obtain the specific resistance .then we have a junction which contains a parallel capacitor with LDR sensor and bipolar transistor .the sensor can be (theoretically) replaced by a variable resistor controlled by light .It has very large resistance when the light is absence in mega ohms and very small one in the light existence in small kilo ohms .So when light is present LDR sensor will act as a low impedance ,so the current prefers to pass throw the LDR to the ground more than the base. The voltage on base will be less than 0.7,so the bipolar will be in the cut of mode(like an open circuit) and no current will continue passing throw the circuit then the coil of the relay will have no feed on and turn off in it turn to cut the current from the ac lamp .

When light is absence the LDR acts as a high impedance so voltage on the base V_{BE} will be more than 0.7 and current passes throw the base puts the transistor in the active mode . Transistor in our project acts as a gate . Current passes from emitter to collector to feed the coil of the relay with enough current to conduct the armature and close the lamp ac circuit .

Simulation and conclusion:

Advantages of relays:

- Relays can switch **AC and DC**, transistors can only switch DC.
- Relays can switch **higher voltages** than standard transistors.
- Relays are often a better choice for switching **large currents** (> 5A).
- Relays can switch **many contacts** at once.

Disadvantages of relays:

- Relays are **bulkier** than transistors for switching small currents.
- Relays **cannot switch rapidly** (except reed relays), transistors can switch many times per second.
- Relays **use more power** due to the current flowing through their coil.
- Relays **require more current than many ICs can provide**, so a low power transistor may be needed to switch the current for the relay's coil.

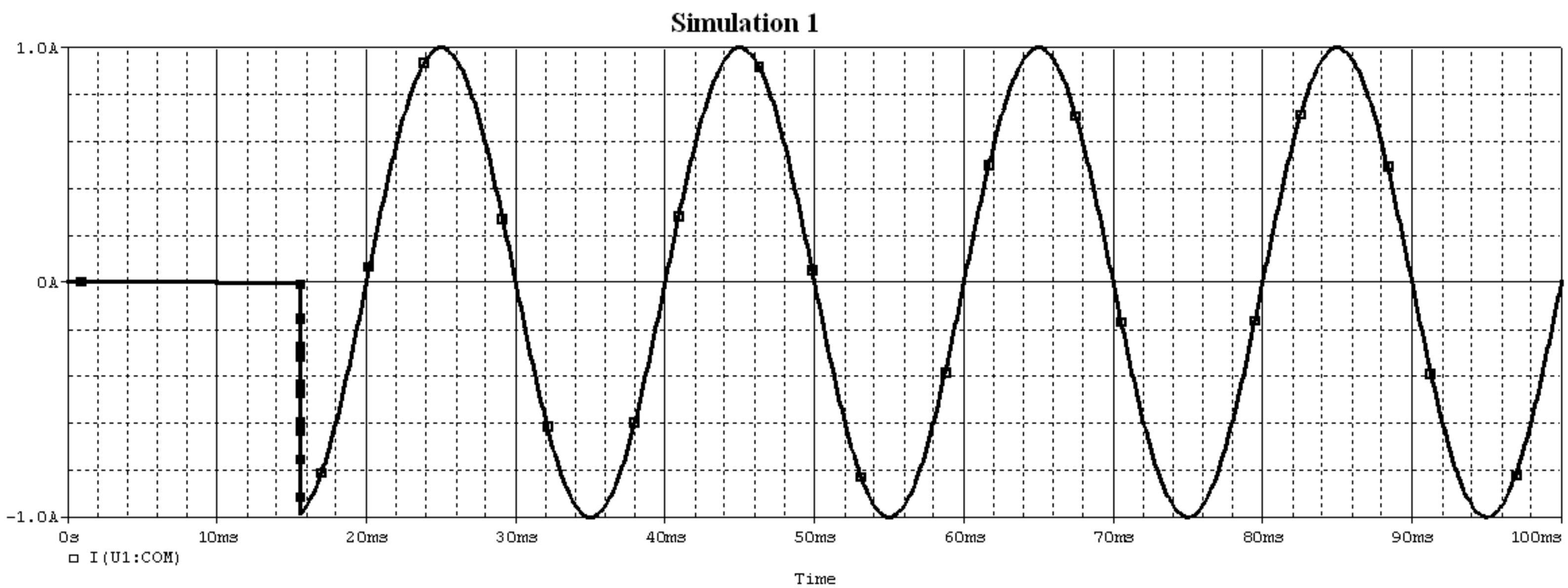
At night : LDR resistance is quite high 30 k ohm
So output of the circuit – lamp – is on.

At light : LDR resistance is quite low 5 k ohm

So output of the circuit – lamp - is off .

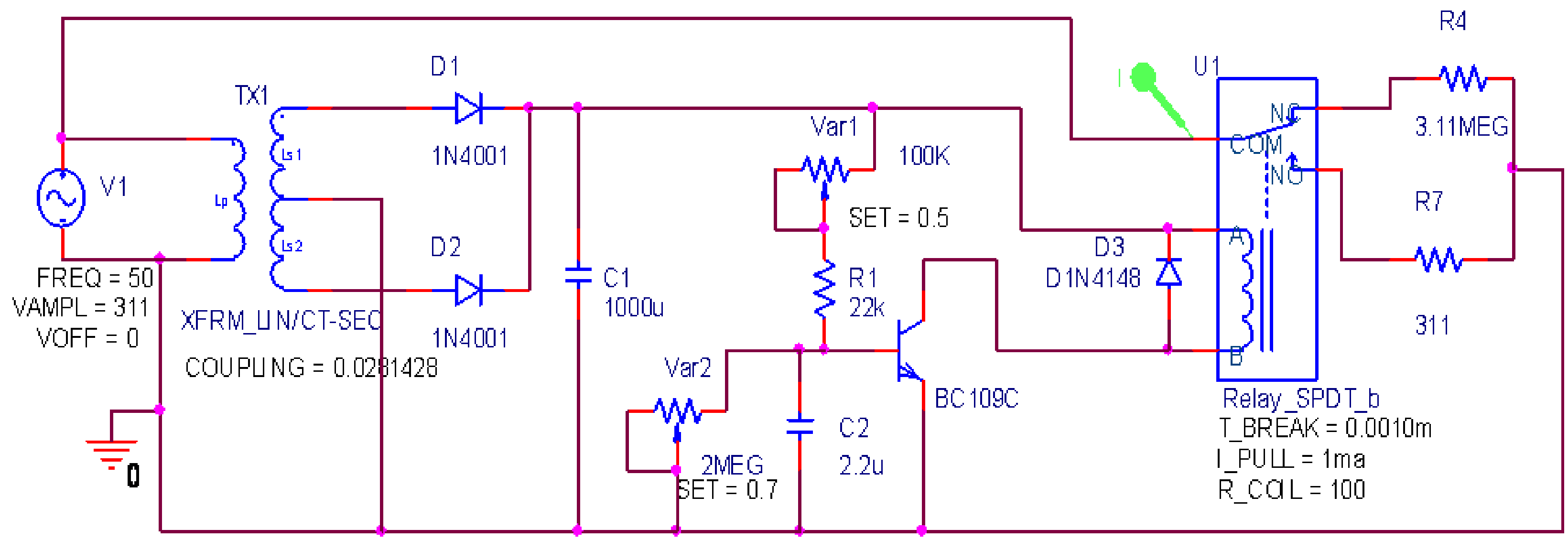
A 311 ohm resistor is chosen to connect the ground with NO relay pin to notice a 1A (as the Vpeak of 220rms = 311volt) peak current in simulation when relay is on , in the same way , 3.11 Mega ohm resistor connects the ground with the NC relay pin to notice a 100u A peak current , and understand then that relay is off.

Next two pages the circuits with simulations of <u>ON</u> , <u>OFF</u> situations ,respectively.

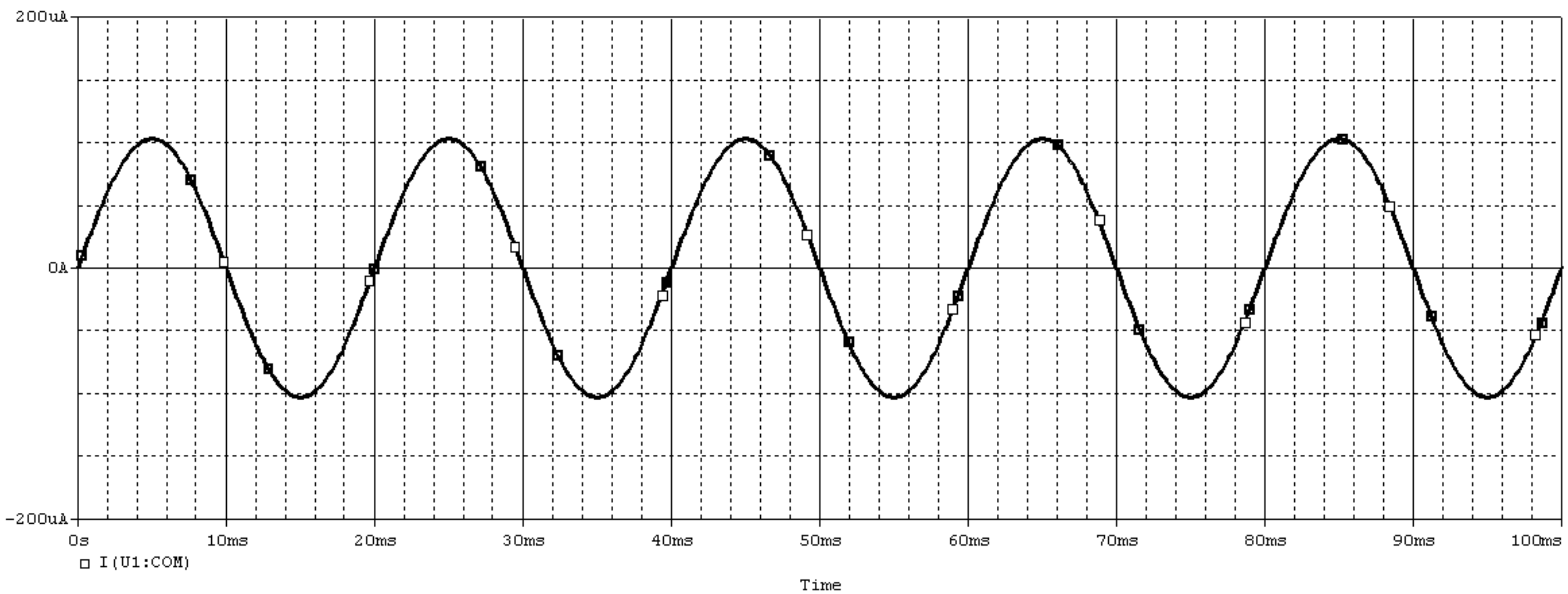


Simulation 1
1.0A
0A
-1.0A
0s
10ms
20ms
30ms
40ms
50ms
60ms
70ms
80ms
90ms
100ms
I(U1:COM)
Time

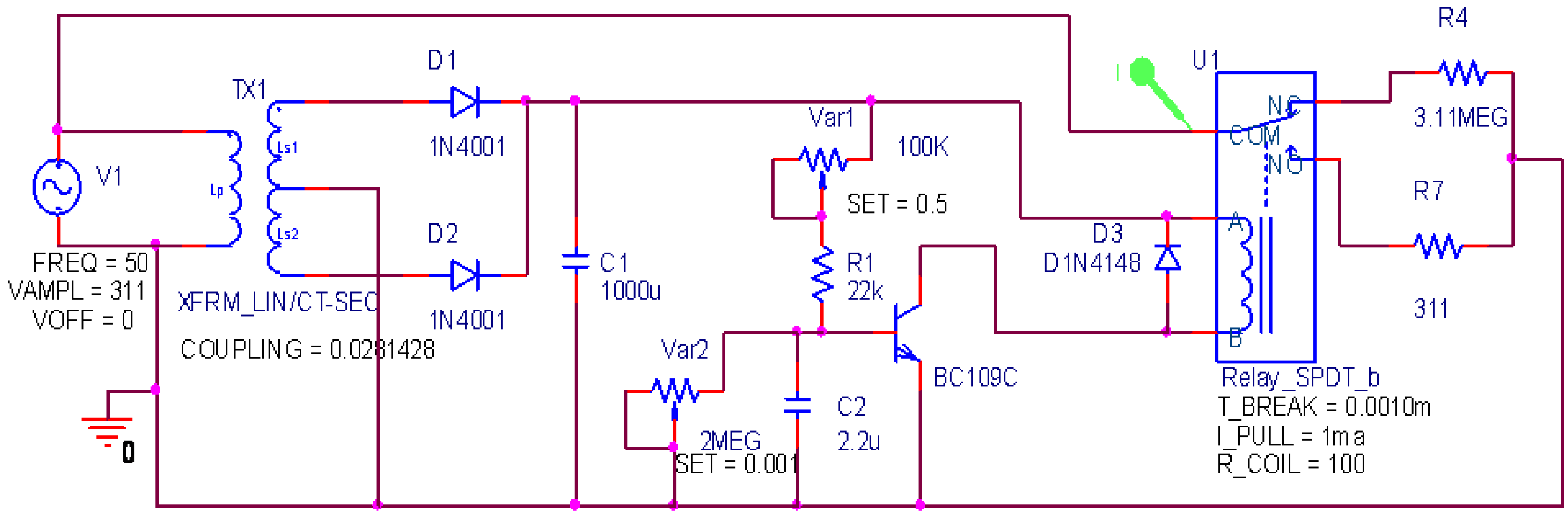
Circuit 1


TX1
D1
1N4001
D2
1N4001
V1
FREQ = 50
VAMPL = 311
VOFF = 0
XFRM_LIN/CT-SEC
COUPLING = 0.0281428
0
C1
1000u
Var1
100K
SET = 0.5
R1
22k
Var2
2MEG
SET = 0.7
C2
2.2u
BC109C
D3
D1N4148
U1
COM
NC
NO
A
B
Relay_SPDT_b
T_BREAK = 0.0010m
I_PULL = 1ma
R_COIL = 100
R4
3.11MEG
R7
311

Simulation 2



Circuit 2



V1
FREQ = 50
VAMPL = 311
VOFF = 0
0
TX1
Lp
Ls1
Ls2
XFRM_LIN/CT-SEC
COUPLING = 0.0281428
D1
1N4001
D2
1N4001
C1
1000u
Var1
100K
SET = 0.5
R1
22k
Var2
2MEG
SET = 0.001
C2
2.2u
BC109C
D3
D1N4148
U1
NC
COM
NO
A
B
Relay_SPDT_b
T_BREAK = 0.0010m
I_PULL = 1ma
R_COIL = 100
R4
3.11MEG
R7
311

The simulation is run on the OrCAD program .

The Vsin is chosen to supply the circuit with ac sinusoidal wave , its amplitude is set to be . About the transformer , we can play with the coupling to get the desired voltage between the ground and any of the sides of it . After many trials the best estimation for the coupling is chosen as it clear in the circuit figures , in order to make the voltage about any of secondary coils equals 6 rms volts.

An 1000 u F capacitor is preferred to be used as mentioned before in order to decrease the rippling factor as possible ,but one may ask why this large amount ? That is to done in order not to use voltage regulator or zener diodes . Capacitor make the signal smooth so no need to cut it and regulate it .

Continuing with the circuit , the potentiometer Var1 is put it order to adjust the circuit to run in different light amounts modes , that to run it in a sunny place for example the adjustment differs from running it in the room light. Here it is adjusted to be at 0.5 of its full value .

Moving to the LDR sensor which is connected in parallel with a 2.2 uF capacitor and are connected to the base - the LDR is replaced in OrCAD by a potentiometer with value 2 MEGA -of the BJT npn transistor ,this capacitor protects the circuit from highly pulsating inputs, that when some thing cover and get away the light from the LDR is high speed the circuit should respond this rapid change and this may affect the relay or at least this rapid pulsating is undesired so the capacitor is connected to the base in order to keep the transistor running for a minimum amount of time more than the pulsating undesired time.

About the relay , the relay we choose –its name in the circuit figures- has properties settings that other relays don't . From these important settings the I_PULL , I _DROP ,T_BREAK and R_COIL and others ,I drop must be less than I pull , and I pull have to be small enough to run the relay that's because the transistor may not have the sufficient power to supply the relay with high current so we choose it to be 1 mA after trials.

After doing this and check all the connection for the circuit a simulation error arises which is an error of convergence so we were exhausted until we discovered that the convergence problem is due to the relay closing time , it seems to make errors in calculations with OrCAD simulation, that's because it have relatively large time , when we decrease it by a factor of 1% the simulation ran with no errors.

Commenting on simulation 1 figure , the first wave from 0 to 20 ms is distorted , or exactly about 0.75 of it is distorted and then it is normally sinusoidal wave as in calculations , and that is referred to the time which the 100 uF capacitor takes to charge remembering that the capacitor have resistance so it need time to charge the 2.2uF capacitor charging issue also , and finally the inductor of the relay charging time all arises to make the time to about 15 ms when the current in the relay coil reaches 1mA - the current we set it to run on.