NEAR EAST UNIVERSITY

Faculty of Engineering

Department of Electrical and Electronic Engineering

WATER LEVEL SENSING

Graduation Project
EE – 400

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ABSTRACT

As the life is getting more complicated, many people try to make their environment more safe and more comfortable, that leads to design some protection and luxury systems such as alarm systems. One of these alarm systems is water level sensing alarm which considered as an "intelligent" alarm can make our life more easy and safety.

Water level sensing alarm system depends on a sensitive element acts as the input of the alarm which is the photocell, photocell designed to act as high resistance under high-water condition and as low resistance when the level of water is low,

This project presents the design, test and building of a working alarm that is water level sensing. This is a simple but reliable circuit for your sump-pump, aquarium, and boat.

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INTRODUCTION

Generally, electronic security alarm systems are recognized in the entire world as an important contributor to the securing of life, property and possessions. A security system is an effective tool when used in conjunction with other sensible, an alarm system is installed to deter and detect the differences. A basic security system will consist of both perimeter and space protection to secure your premise

The aim of this project is to gain hands-on experience in designing and building electronic devices, and in solving problems encountered through out the project. Additionally, my objectives include

Chapter one will illustrate power electronics application, type, analysis of power devices, how it acts, also I explained the building a working water level sensing

main task of power electronics, main forms of conversion, power mosfet and the power losses in power transistor.

Chapter two of the project which is important one will present detailed technical information about this water level sensing alarm. Also it will include the components of this project and explanation of most important ones, in addition to some method of water level sensing.

CHAPTER ONE
POWER ELECTRONICS

1.1 Definition and Main Task of Power Electronics

Power electronics refers to control and conversion of electrical power by power semiconductor devices wherein these devices operate as switches. Advent of silicon-controlled rectifiers, abbreviated as SCRs, led to the development of a new area of application called the power electronics. Prior to the introduction of SCRs, mercury-arc rectifiers were used for controlling electrical power, but such rectifier circuits were part of industrial electronics and the scope for applications of mercury-arc rectifiers was limited. Once the SCRs were available, the application area spread too many fields such as drives, power supplies, aviation electronics, high frequency inverters and power electronics originated.

Power electronics has applications that span the whole field of electrical power systems, with the power range of these applications extending from a few VA/Watts to several MVA / MW.

The main task of power electronics is to control and convert electrical power from one form to another. The four main forms of conversion are:

Rectification referring to conversion of ac voltage to dc voltage,

DC-to-AC conversion,

DC-to DC conversion and

AC-to-AC conversion.

"Electronic power converter" is the term that is used to refer to a power electronic circuit that converts voltage and current from one form to another. These converters can be classified as:

Rectifier converting an ac voltage to a dc voltage,

Inverter converting a dc voltage to an ac voltage,

Chopper or a switch-mode power supply that converts a dc voltage to another dc voltage, and

Cycloconverter and cycloinverter converting an ac voltage to another ac voltage.

In addition, SCRs and other power semiconductor devices are used as static switches.

1.2 Additional Insights into Power Electronics

There are several striking features of power electronics, the foremost among them being the extensive use of inductors and capacitors. In many applications of power electronics, an inductor may carry a high current at a high frequency. The implications of operating an inductor in this manner are quite a few, such as necessitating the use of lets wire in place of single-stranded or multi-stranded copper wire at frequencies above 50 kHz, using a proper core to limit the losses in the core, and shielding the inductor properly so that the fringing that occurs at the air-gaps in the magnetic path does not lead to electromagnetic interference. Usually the capacitors used in a power electronic application are also stressed. It is typical for a capacitor to be operated at a high frequency with current surges passing through it periodically. This means that the current rating of the capacitor at the operating frequency should be checked before its use. In addition, it may be preferable if the capacitor has self-healing property. Hence an inductor or a capacitor has to be selected or designed with care, taking into account the operating conditions, before its use in a power electronic circuit.
In many power electronic circuits, diodes play a crucial role. A normal power diode is usually designed to be operated at 400 Hz or less. Many of the inverter and switch-mode power supply circuits operate at a much higher frequency and these circuits need diodes that turn ON and OFF fast. In addition, it is also desired that the turning-off process of a diode should not create undesirable electrical transients in the circuit. Since there are several types of diodes available, selection of a proper diode is very important for reliable operation of a circuit.

Analysis of power electronic circuits tends to be quite complicated, because these circuits rarely operate in steady-state. Traditionally steady-state response refers to the state of a circuit characterized by either a dc response or a sinusoidal response. Most of the power electronic circuits have a periodic response, but this response is not usually sinusoidal. Typically, the repetitive or the periodic response contains both a steady-state part due to the forcing function and a transient part due to the poles of the network. Since the responses are no sinusoidal, harmonic analysis is often necessary. In order to obtain the time response, it may be necessary to resort to the use of a computer program.

1.3 Power semiconductor

Power semiconductor device is a component that is controlled to either conduct a current When it is commanded ON or blocks a voltage when it is commanded OFF. This change of conductivity is made possible in a semiconductor by specially arranged device structures that control the carrier transportation. The time that it takes to change the conductivity is also reduced to the microsecond level as compared to the milli second level of a mechanical switch. By employing this kind of switch, a properly designed electrical system can control the flow of electric energy, shaping the electricity into desired forms.

If a power semiconductor device can block forward voltage as well as the reverse voltage during the OFF state, it is defined as a symmetrical device. On the other hand, a power semiconductor device that can only block the forward voltage during the OFF state is defined as an asymmetrical device.

Most of the semiconductor devices can only conduct forward current during the ON state. Therefore, the symmetrical device has three operation states: forward conduction mode, forward blocking mode and reverse blocking mode, as shown in Fig. 1.1(a). For an asymmetrical device, only two operation modes exist: forward conduction mode and forward blocking mode, as shown in Fig.1.1 (b).

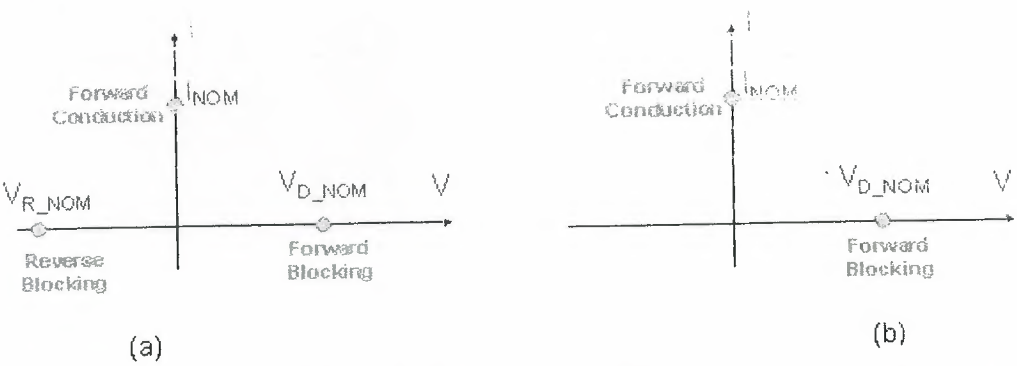
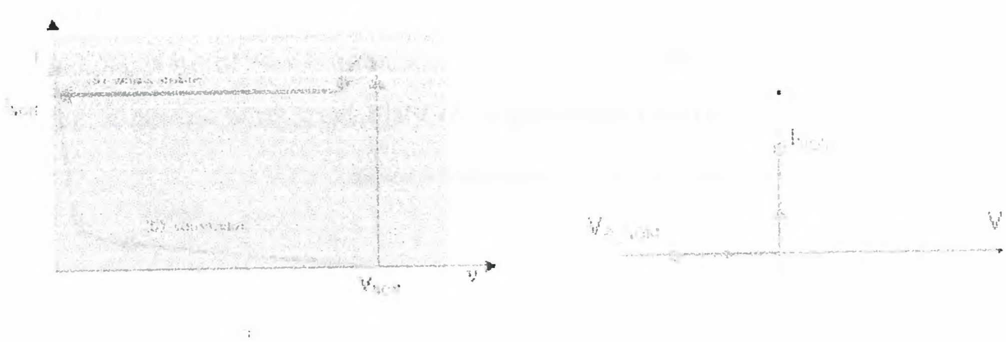


Figure 1.1: Device operation states for (a) symmetrical device and (b) asymmetrical device. A typical turn-on operation of a power semiconductor switch changes its operation state from its forward or reverse blocking mode to its forward conduction mode.

Changing a device's operation state from forward blocking mode to forward conduction mode is defined as a forced turn-on, while changing a device's operation state from reverse blocking mode to forward conduction mode is defined as a load-commutated turn-on. The turn-on trajectory is determined by circuits rather than by the device itself. During the forced turn-on transition, the switch may simultaneously undergo both high voltage and high current, as represented by curve (a) in Fig. 1.2(a), where the device's voltage stays constant while its current increases until it hits the device's nominal current level. This kind of turn-on, also called a snubberless turn-on, happens in most power converters. So the device stress is high in this case.

The current overshoot occurs due to the reverse-recovery of an associated diode (or a switch). With a snubber circuit, the voltage-current trajectory can be shaped as curve (b) shown in Fig. 1.2(a), where the device voltage collapses before the current increases to the normal value, resulting in dramatically reduced device stress. During the load-commutated turn-on transition,
The device begins to conduct current only after the device voltage becomes positive, as
Shown in Fig. 1.2(b). Therefore, the device stress is usually low in this case.



(b)

Figure 1.2 Snubber circuit

The forward biased safe operation area (FBSOA) defines a maximum forward voltage-current region in which the device can be commanded to operate with simultaneous high voltage and current, The device current can be controlled through its gate (or base), and the length of the operation is only restricted by its

Thermal limitation. Devices with FBSOA normally have an active region in which the device current is determined by the control signal level.

A device with FBSOA (such as a MOSFET) normally has the self-current-limiting capability, the ability for a switch to limit its maximum current regardless of the voltage applied, and its typical I-V curve is shown as curve (a) in Fig. 1.3. In contrast, a device without FBSOA (such as a GTO) cannot self-limit its current, and its typical I-V curve is shown as curve (b) in Fig. 1.3. For a device with good FBSOA, hence the self-current limiting capability, the turn-on di/dt can be controlled through the gate, and most importantly no current crowding occurs during the turn-on transient. Therefore, snubberless turn-on can be applied to these devices. On the other hand, for a device without FBSOA, the turn-on di/dt is uncontrollable, and current crowding may happen in a localized area.

This is particularly true for large area devices; therefore, a snubberless turn-on is not possible in these devices, and an external snubber circuit needs to be used to avoid current-crowding problems.

The snubber circuit will increase a system's component count, size and cost. Therefore, a device with good FBSOA is preferred in a power conversion system.

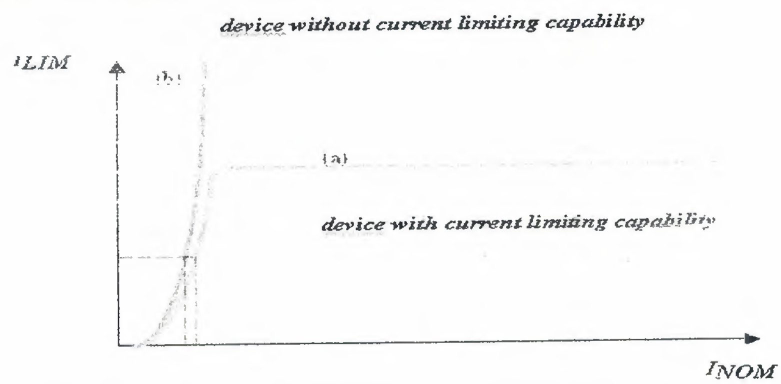


Figure 1.3: Forward I-V characteristics of two types of devices with / without self-current Limiting capability.

A typical turn-off operation of a power semiconductor switch change its operation state from forward conduction mode to forward or reverse blocking mode. Changing a device's operation state from forward conduction mode to forward blocking mode is defined as a forced turn-off, while changing a device's operation state from forward conduction mode to reverse blocking mode is defined as a load-commutated turn-off. During the forced turn-off transition, the switch may simultaneously undergo both high voltage and high current, as represented by curve (a) in Fig. 1.4(a), where the device's current stays constant while its voltage increases. Once the device voltage reaches its nominal value, the device current begins to decrease. So the device stress is high in this case. The voltage overshoot occurs due to the di/dt applied to the stray inductance in the current-commutation loop. With a snubber circuit, the voltage-current trajectory can be shaped as shown by curve (b) in Fig. 1.4, where the device current decreases before the device voltage increases to the normal value, resulting in dramatically reduced device stress.

During the load-commutated turn-off transition, the device current begins to decrease first while the voltage does not change much until the device current becomes negative. When the negative device current increases, the negative device voltage also increases. The negative device current begins to decrease once it reaches its peak value, resulting in a negative over-voltage as well as high stress on the device, as shown by curve (a) in Fig.1.4 (b). Similarly, with a snubber circuit, the voltage-current trajectory can be shaped as Shown by curve (b) in Fig. 1.4(b) with much lower device stress.

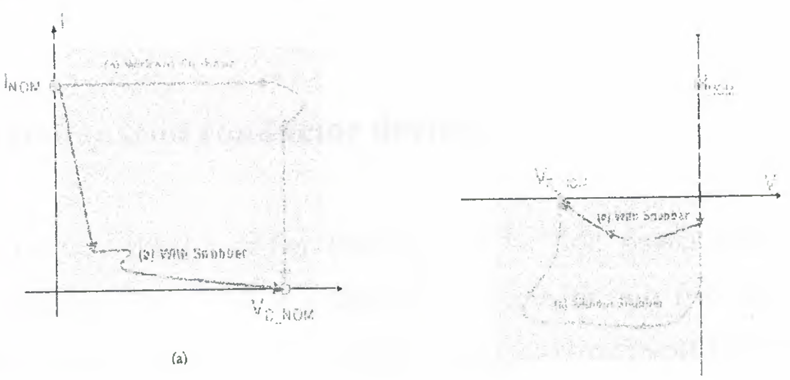


Fig 1.4: I-V trajectories of a device for (a) forced turn-off with or without snubber circuit and (b) load-commutated turn-off with or without snubber.

The reverse biased safe operation area (RBSOA) is defined as the maximum voltage and current boundary within which the device can turn off without destructive failure.

Obviously, a device's RBSOA should be larger than all its possible turn-off I-V Trajectories. Advice with out sufficiently large RBSOA needs an external circuit (snubber) to reduce the size of its turn-off I-V trajectory in order to ensure safe turn-off Operation.

The switching operation conducted without the help of a snubber is called snubberless switching, while the process utilizing a snubber is called snubbered switching. Since a snubber increases the system's component count, hence its size and cost, the snubberless switching capability for a device is preferred.

There are two basic topologies for DC/AC energy transfer: the voltage source converter (VSC) and the current source converter (CSC). In a VSC, the dc voltage always has one polarity, and the power reversal takes place through reversing the direction of the dc current.

In contrast, the direct current of a CSC always has one polarity, while the power reversal happens when the dc voltage polarity is reversed. Since the DC voltage does not reverse in a VSC, an asymmetrical device can be used. On the other hand, the device in a CSC will undergo reverse voltage, so a symmetrical device is needed to block the forward voltage as well as the reverse voltage.

1.4 power semi conductor devices

Silicon controlled rectifier (SCR) was the first power semiconductor switch to be put into use. The SCR is a latch-up device with only two stable states: ON and OFF. It does not have FBSOA. The SCR has a good trade-off between its forward voltage drop and blocking voltage due to the strong conductivity modulation provided by the injections of both electrons and holes. With a simple structure, the size of a single SCR can be easily increased to a six-inch diameter in order to increase the current rating of the device. Based on a six-inch silicon wafer, 8.0- kA/10.0-kV SCRs are commercially available. The SCR can also block reverse voltage due to its symmetrical structure. However, SCRs cannot be turned off through their gate controls, and instead must use a load-commutated turn-off, such as that shown in Fig.1.5 (b).

Since the SCR cannot be turned off through the gate, the gate turn-off (GTO) thyristor With forced turn-off controllability was subsequently developed. The basic structure of a GTO is similar to that of an SCR, except that many gate fingers are placed around the cathode of the GTO. Because of the gate control, the latch-up mechanism can be broken during the turn-off transition, resulting in full gate-control capability. For a fully controllable device, the GTO has the highest power rating and the best trade-off between the blocking voltage and the conduction loss. However, GTOs' dynamic performance is poor. Since the GTO lacks FBSOA and has poor RBSOA, a dv/dt snubber is required during turn-off, and a di/dt snubber is required during turn-on. As a current- driven device, it also requires a complicated gate driver, resulting in high gate-driver loss. GTOs can be made to be either symmetrical or asymmetrical.

The bipolar junction transistor (BJT) is the earliest controllable device, and served as the workhorse device for power-conversion applications up until two decades ago. With fairly good FBSOA and RBSOA, its dynamic performance and switching speed are better than those of the GTO. However, the trade-off between its blocking voltage and its forward voltage drop is poor, and so no power BJT with a good forward voltage drop is designed beyond 1.5 kV.

The control circuit is usually complicated and loss since the BJT is a current-driven device. The RBSOA and FBSOA are also significantly limited by the second breakdown of a power BJT . BJTs are asymmetrical devices.

The power MOSFET is a voltage-controlled device with excellent dynamic performance due to its majority-carrier current-conduction mechanism. Except that its power rating is limited by the resistive conduction loss, the power MOSFET has become a nearly perfect power switch for applications below 600 V due to its fast switching speed, voltage control and excellent FBSOA and RBSOA. Snubberless turn-on and turn- off can be achieved in MOSFETs. The MOSFET is also an asymmetrical device.

Based on the idea of a MOS-controlled BJT, the insulated gate bipolar transistor (IGBT) was developed. The IGBT fundamentally changes the BJT's current control into voltage control while maintaining the BJT's advantages. IGBTs have excellent RBSOA and FBSOA. In addition, the use of a wide-base PNP transistor in the IGBT structure results in a much better conductivity modulation effect than is achieved with a conventional BJT; thus, the voltage rating of the IGBT can be pushed toward that of the GTO.

To date, IGBTs have become the best device for applications in the range of 600v to3000.Most commercial IGBTs are asymmetrical device although theoretically a symmetrical device can also be developed.

For high power applications, traditionally, a high power SCR is used as the symmetrical power semiconductor device for a CSC. Since the SCR does not have the forced turn-off capability, the operation of the thyristor in a CSC is totally load- commutated at the line frequency. Due to its low switching frequency, its dynamic response speed is low and a large filter is needed to attenuate the harmonics.

The symmetrical GTO with capabilities of both forced turn-off and reverse voltage blocking. Using a symmetrical GTO device, the Sinusoidal Pulse Width Modulation (SPWM) scheme can be used to modulate device switching. Compared to the SCR, The switching frequency for a symmetrical GTO is higher. Therefore, the dynamic response speed and output current harmonics are greatly improved for a symmetrical GTO based CSC.

However, the GTO has several disadvantages. During the turn-off transient, the P-N-P-N four-layer structure causes inhomogeneous transient current distribution that result in a small RBSOA. A dv/dt snubber is needed to ensure that the GTO operates within the RBSOA during the turn-off process. During the turn-on transient, the P-N-P-N four-layer structure latches quickly and causes a current-crowding problem. Therefore, a turn-on di/dt limiting snubber is demanded. Furthermore, since the GTO is a current- controlled device, its gate driver is bulky and dissipates hundreds of watts in a typical application. The large parasitic inductance in GTO gate drivers usually result in a very long storage time and a turn-off gain of between three and five. The operation frequency of the GTO is therefore limited to less than 500 Hz.

The dominant position of GTOs in megawatt applications is being challenged by high power IGBTs that offer higher speed, a larger and easier controls .However, the conduction loss of the high power IGBTs is still much higher than that of the GTO. The IGBT's high conduction loss results in lower system efficiency.

Furthermore. since no symmetrical IGBTs are commercially available now, the IGBT

Based CSC is not feasible. This situation will continue into the near future.

On another hand, a lot of efforts have recently gone into improving the switching performance of the GTO-oriented devices. One type of GTO-based semiconductor device with a wider RBSOA is the Integrated Gate Commutated Thyristor (IGCT) with dramatically improved turn-off performance; the IGCT will help to maintain the domination of GTO technology in high power areas. Symmetrical GCTs have also been introduced to the market for industrial drive applications. In an IGCT based

CSC, the dv/dt snubber is dramatically reduced due to the improved turn-off performance of the IGCT. However, the IGCT does not have an FBSOA, so a di/dt snubber is still needed. The fairly high gate drive power is one of the limitations for high-frequency switching. Besides, the cost of the symmetrical IGCT is high due to its specially designed device structure.

The Emitter Turn-off (ETO) Thyristor is another type of GTO based superior high power semiconductor device. Based on the mature technology of the GTO

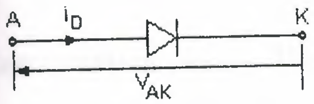
and power MOSFET, the ETO provides a low-cost and advantageous solution to megawatt applications.

Theoretical analysis and experimental results suggest that the ETO has the combined advantages of both the GTO and the IGBT: GTOs' high voltage and current ratings and low forward voltage drop; IGBTs' voltage control, high switching speed, and wide RBSOA. High power asymmetrical ETOs with current ratings of 1 kA to 4 kA, and voltage ratings of 1 kV to 6 kV have already been demonstrated.

In this dissertation, a novel semiconductor device, the symmetrical ETO with good RBSOA and FBSOA, is developed and characterized, and its application in the high- power CSC is investigated.

1.4.1 Power Diodes

Diode Operation



A diode is a two terminal device consisting of an anode and a cathode. The diode conducts when its anode voltage is more positive than that of the cathode. If the cathode voltage is more positive than its anode voltage, the diode is said to be in the blocking mode.

Diode Types

There are three types of power diodes:

a) General purpose

b) High speed (or fast recovery) – used for higher frequency switching of power converters

c) Scotty – have low on state voltage and very small recovery time, typically nanosecond

1.4.2Thyristor and triac

The thyristor, also called a silicon-controlled rectifier (SCR), is basically a four-layer three-junction pnpn device. It has three terminals: anode, cathode, and gate. The device is turned on by applying a short pulse across the gate and cathode. Once the device turns on, the gate loses its control to turn off the device.

The turn-off is achieved by applying a reverse voltage across the anode and cathode.

The thyristor symbol and its volt-ampere characteristics are shown in Fig.1.5. There are basically two classifications of thyristors: converter grade and inverter grade. The difference between a converter-grade and an inverter –grad thyristor is the low turn-off time (on the order of a few microseconds) for the latter. The converter-grade thyristors are slow type and are used in natural commutation (or phase-controlled) applications. Inverter-grade thyristors are used in forced commutation applications such as dc-dc choppers and dc-ac inverters. The inverter-grade thyristors are turned off by forcing the current to zero using an external

Commutation circuit. This requires additional commutating components, thus resulting in additional losses in the inverter.

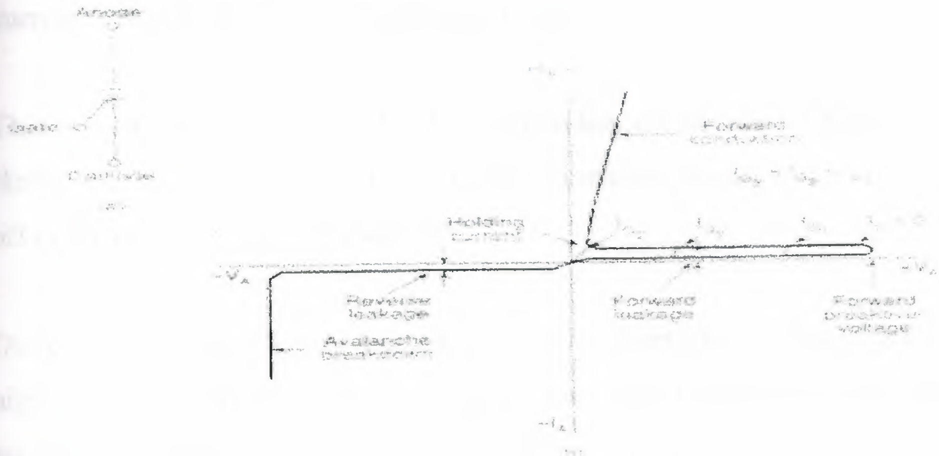


FIGURE 1.5: (a) Thyristor symbol and **(b)** volt-ampere characteristics.

Thyristors are highly rugged devices in terms of transient currents, di/dt, and dv/dt capability. The forward voltage drop in thyristors is about 1.5 to 2 V, and even at higher currents of the order of 1000 A, it seldom exceeds 3 V.

While the forward voltage determines the on-state power loss of the device at any given current, the switching power loss becomes a dominating factor affecting the device junction temperature at high operating frequencies. Because of this, the maximum switching frequencies possible using thyristors are limited in comparison with other power devices considered in this section.

Thyristors have I 2t with stand capability and can be protected by fuses. The non repetitive surge current capability for thyristors is about 10 times their rated root mean square (rms) current. They must be protected by snubber networks for dv/dt and di/dt effects. If the specified dv/dt is exceeded, thyristors may start conducting without applying a gate pulse. In dc-to-ac conversion applications it is necessary to use an ant parallel diode of similar rating across each main thyristor. Thyristors are available up to 6000 V, 3500 A.

A triac is functionally a pair of converter-grade thyristors connected in antiparallel. The triac symbol and volt-ampere characteristics are shown in Fig. 1.6. Because of the integration, the triac has poor reapplied dv/dt, poor gate current sensitivity at turn-on, and longer turn-off time. Triacs are mainly used in phase control applications such as in ac regulators for lighting and fan control and in solid-state ac relays.

Gate Turn-Off Thyristor (GTO)

The GTO is a power switching device that can be turned on by a short pulse of gate current and turned off by a reverse gate pulse.

This reverse gate current amplitude is dependent on the anode current to be turned off. Hence there is no need for an external commutation circuit to turn it off. Because turn-off is provided by bypassing carriers

Directly to the gate circuit, its turn-off time is short, thus giving it more capability for high- frequency operation than thyristors. The GTO symbol and turn-off characteristics are shown in Fig. 1.7.

GTOs have the I2t withstand capability and hence can be protected by semiconductor fuses. For reliable operation of GTOs, the critical aspects are proper design of the gate turn-off circuit and the snubber circuit.

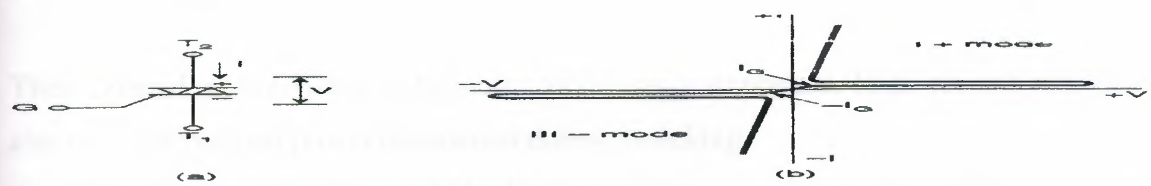


FIGURE 1.6: (a) Triac symbol and (b) volt-ampere characteristics.

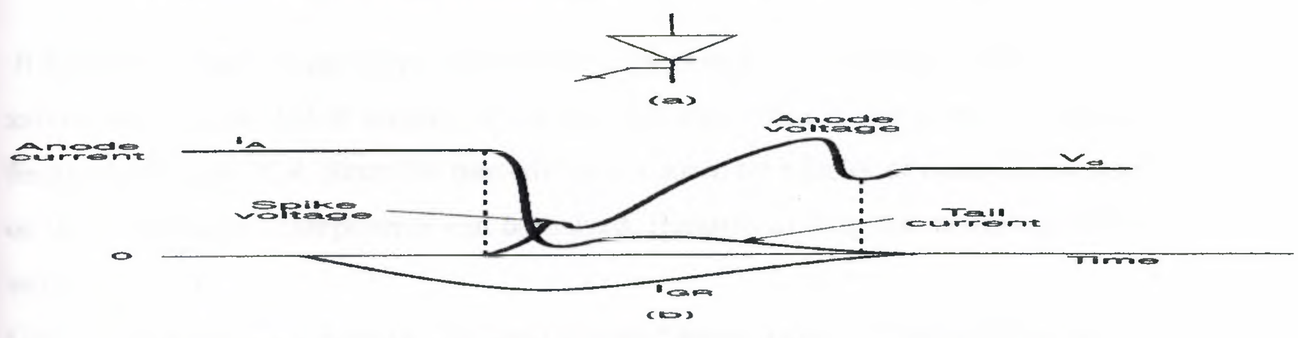


FIGURE 1.7: (a) GTO symbol and (b) turn-off characteristics.

A GTO has a poor turn-off current gain of the order of 4 to 5. For example, a 2000-A peak current GTO may require as high as 500 A of reverse gate current. Also, a GTO has the tendency to latch at temperatures above125 C.

GTOs are available up to about 4500 V, 2500 A. Reverse-Conducting Thyristor (RCT) and Asymmetrical Silicon-Controlled Rectifier (ASCR)
Normally in inverter applications, a diode in antiparallel is connected to the thyristor for commutation/free- wheeling purposes. In RCTs, the diode is integrated with a fast Switching thyristor in a single silicon chip.

Thus, the number of power devices could be reduced. This integration brings forth a substantial improvement of the static and dynamic characteristics as well as its overall circuit performance.
The RCTs are designed mainly for specific applications such as traction drives. The ant parallel diode limits the reverse voltage across the thyristor to 1 to 2 V. Also, because of the reverse recovery behavior of the diodes, the thyristor may see very high reapplied dv/dt when the diode recovers from its reverse voltage. This necessitates use of large RC snubber networks to suppress voltage transients. As the range of application of thyristors and diodes extends into higher frequencies,

Their reverse recovery charge becomes increasingly important. High reverse recovery charge results in high power dissipation during switching.
The ASCR has a similar forward blocking capability as an inverter-grade thyristor, but it has a limited reverse blocking (about 20–30 V) capability.

It has an on-state voltage drop of about 25% less than an inverter-grade thyristor of a similar rating. The ASCR features a fast turn-off time; thus it can work at a higher frequency than an SCR. Since the turn-off time is down by a factor of nearly 2, the size of the commutating components can be halved. Because of this, the switching losses will also be low.
Gate-assisted turn-off techniques are used to even further reduce the turn-off time of an ASCR. The application of a negative voltage to the gate during turn-off helps to evacuate stored charge in the device and aids the recovery mechanisms. This will in effect reduce the turn-off time by a factor of up to 2 over the conventional device.

1.4.3 Power Bipolar Junction Transistors (BJT)

Power transistors are used in applications ranging from a few to several hundred kilowatts and switching frequencies up to about 10 kHz. Power transistors used in power conversion applications are generally npn type. The power transistor is turned on by supplying sufficient base current, and this base drive has to be maintained throughout its conduction period. It is turned off by removing the base drive and making the base voltage slightly negative (within –VBE (max)). The saturation voltage of the device is normally 0.5 to 2.5 V and increases as the current increases.

Hence the on-state losses increase more than proportionately with current. The transistor off-state losses are much lower than the on-state losses because the leakage current of the device is of the order of a few mills amperes. Because of relatively larger switching times, the switching loss significantly increases with switching frequency. Power transistors can block only forward voltages. The reverse peak voltage rating of these devices is as low as 5 to 10 V.Power transistors do not have I2t withstand capability. In other words, they can absorb only very little energy before breakdown. Therefore, they cannot be protected by semiconductor fuses, and thus an electronic pro-section method has to be used.

To eliminate high base current requirements, Darlington con- figurations are commonly Used. They are available in monolithic or in isolated packages.

The Darlington configuration presents a specific advantage in that it can considerably increase the current switched by the transistor for a given base drive. The VCE (sat) for the Darlington is generally more than that of a single transistor of similar rating with corresponding increase in on- state power loss. During switching, the reverse-biased collector junction may show hot spot breakdown effects that are specified by reverse-bias safe operating area (RBSOA) and forward bias safe operating area (FBSOA). Modern devices with highly inter- digital emitter base geometry force more uniform current distribution and therefore considerably improve second breakdown effects. Normally, a well-designed switching aid network con- strains the device operation well within the SO As.

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1.4.4 Power MOSFETs

Power MOSFETs are marketed by different manufacturers with differences in internal geometry and with different names such as MegaMOS, HEXFET, SIPMOS, and TMOS. They have unique features that make them potentially attractive for switching applications. They are essentially voltage-driven rather than current-driven devices, unlike bipolar transistors.

The gate of a MOSFET is isolated electrically from the source by a layer of silicon oxide. The gate draws only a minute leakage current of the order of nano amperes. Hence the gate drive circuit is simple and power loss in the gate control circuit is practically negligible. Although in steady state the gate draws virtually no current, this is not so under transient conditions. The gate-to-source and gate-to-drain capacitances have to be charged and discharged appropriately to obtain the desired switching speed, and the drive circuit must have a sufficiently low output impedance to supply the required charging and discharging currents. The circuit symbol of a power MOSFET is shown in Fig. 1.8.

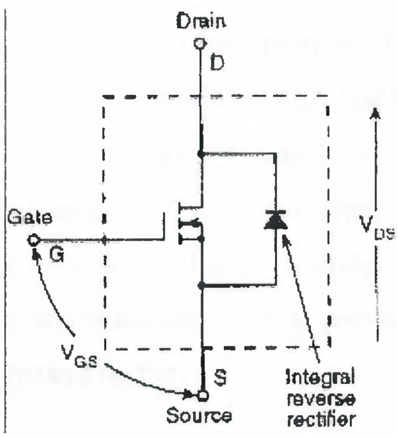


FIGURE 1.8: symbol of a power mosfet

Power MOSFETs are majority carrier devices, and there is no minority carrier storage time. Hence they have exceptionally fast rise and fall times.

They are essentially resistive devices when turned on, while bipolar transistors present a more or less constant VCE (sat) over the normal operating range. Power dissipation in MOSFETs is Id2RDS (on), and in bipolar it is ICVCE (sat).

At low currents, therefore, a power MOSFET may have a lower conduction loss than a comparable bipolar device, but at higher currents, the conduction loss will exceed that of bipolar. Also, the RDS (on) increase with temperature.

An important feature of a power MOSFET is the absence of a secondary breakdown effect, which is present in a bipolar transistor, and as a result, it has an extremely rugged switching performance. In MOSFETs, RDS (on) increase with temperature, and thus the current is automatically diverted away from the hot spot. The drain body junction appears as an ant parallel diode between source and drain. Thus power MOSFETs will not sup—port voltage in the reverse direction .Although this inverse diode is relatively fast, it is slow by comparison with the MOSFET.

Recent devices have the diode recovery time as low as 100 ns. Since MOSFETs cannot be protected by fuses, an electronic protection technique has to be used.

With the advancement in MOS technology, buggerized MOSFETs are replacing the conventional MOSFETs. The need to buggerize power MOSFETs is related to device reliability. If a MOSFET is operating within its specification range at all times, its chances for failing catastrophically are minimal. However, if its absolute maximum rating is exceeded, failure probability increases dramatically. Under actual operating conditions, a MOSFET may be subjected to transients — either externally from the power bus supplying the circuit or from the circuit itself due, for example, to inductive kicks going beyond the absolute maximum ratings. Such conditions are likely in almost every application, and in most cases are beyond a designer's control. Rugged devices are made to be more tolerant for over-voltage transients.

Ruggedness is the ability of a MOSFET to operate in an environment of dynamic electrical stresses, without activating any of the parasitic bipolar junction transistors. The rugged device can withstand higher.

1.4.5 Insulated Gates Bipolar Transistors (IGBT) and Static Induction Transistors (SITs)

The IGBT has the high input impedance and high-speed characteristics of a MOSFET with the conductivity characteristic (low saturation voltage) of a bipolar transistor. The

IGBT is turned on by applying a positive voltage between the gate and emitter and, as in the MOSFET, it is turned off by making the gate signal zero or slightly negative. The IGBT has a much lower voltage drop than a MOSFET of similar ratings. The structure of an IGBT is more like a thyristor and MOSFET

1.5 Power convention

Power conversion deals with the process of converting electric power from one form to another. The power electronic apparatuses performing the power conversion are called power converters. Because they contain no moving parts, they are often referred to as static power converters. The power conversion is achieved using power semiconductor devices, which are used as switches. The power devices used are SCRs (silicon controlled rectifiers, or thyristors), triacs, power transistors, power MOSFETs, insulated gate bipolar transistors (IGBTs), and MCTs (MOS-controlled thyristors). The power converters are generally classified as:

1. ac-dc converters (phase-controlled converters)
2. Direct ac-ac converters (cycloconverters)
3. dc-ac converters (inverters)
4. dc-dc converters (choppers buck and boost converters)

1.5.1 AC-DC Converters

The basic function of a phase-controlled converter is to convert an alternating voltage of variable amplitude and frequency to a variable dc voltage.
The power devices used for this application are generally SCRs. The average value of the output voltage is controlled by varying the conduction time of the SCRs. The turn-on of the SCR is achieved by providing a gate pulse when it is forward-biased. The turn-off is achieved by the commutation of current from one device to another at the instant the incoming ac voltage has a higher instantaneous potential than that of the outgoing wave. Thus there is a natural tendency for current to be commutated from the outgoing to the incoming SCR, without the aid of any external commutation circuitry. This commutation process is often referred to as natural commutation.

A single-phase half-wave converter is shown in Fig. 1.9. When the SCR is turned on at specific angle, full supply voltage (neglecting the SCR drop) is applied to the load. For a purely resistive load, during the positive half cycle, the output voltage waveform follows the input ac voltage waveform. During the negative half cycle, the SCR is turned off. In the case of inductive load, the energy stored in the inductance causes the current to flow in the load circuit even after the reversal of the supply voltage, If there is no freewheeling diode DF , the load current is discontinuous. A freewheeling diode is connected across the load to turn off the

SCR as soon as the input voltage polarity reverses, When the SCR is off, the load current will freewheel through the diode. The power flows from the input to the load only when the SCR is conducting. If there is no freewheeling diode,

During the negative portion of the supply voltage, SCR returns the energy stored in the load inductance to the supply. The freewheeling diode improves the input power factor.

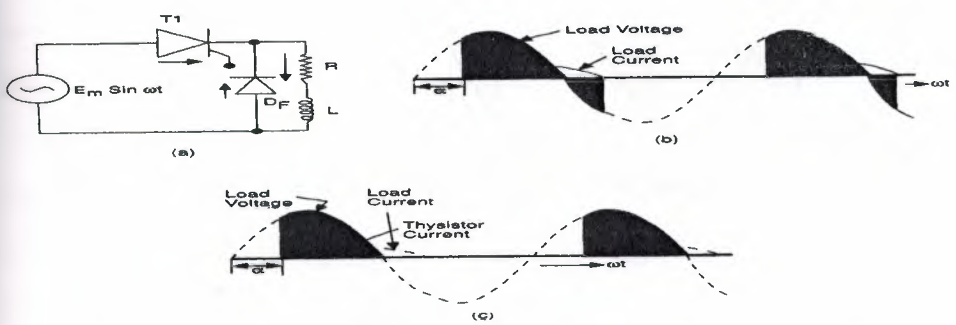


FIGURE 1.9: single-phase half-wave converters with freewheeling diode.

(a) Circuit diagram; (b) waveform for inductive load with no freewheeling diode; (c) waveform with freewheeling diode.

The controlled full-wave dc output may be obtained by using either a center tap transformer or by bridge configuration (The bridge configuration is often used when a transformer is undesirable and the magnitude of the supply voltage properly meets the load voltage requirements.

Where Em is the peak value of the input voltage and the firing angle. The output voltage of a single-phase bridge circuit is the same. Various configurations of the single-phase bridge circuit can be obtained if, instead of four SCRs, two diodes and two SCRs are used, with or without freewheeling diodes. A three-phase full-wave converter consisting of six thyristor switches.

This is the most commonly used three-phase bridge configuration. Thyristors T1, T3, and T5 are turned on during the positive half cycle of the voltages of the phases to which they are connected, and thyristors T2, T4, and T6 are turned on during the negative half cycle of the phase voltages.

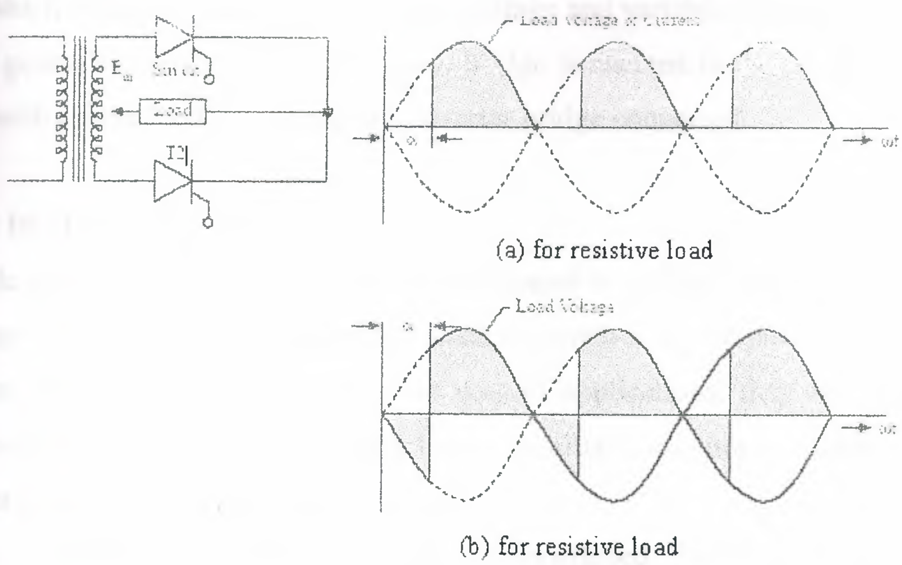


FIGURE 1.10: Single-phase full-wave converters with transformer.

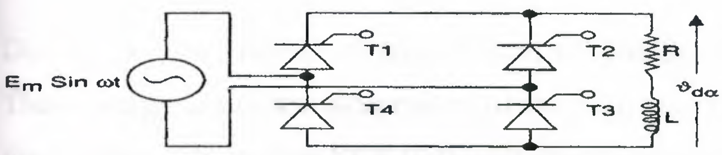


FIGURE 1.11: Single-phase bridge converter.

1.5.2Cycloconverters

Cycloconverters are direct ac-to-ac frequency changers. The term direct conversion means that the energy does not appear in any form other than the ac input or ac output. The output frequency is lower than the input frequency and is generally an integral multiple of the input frequency. A cycloconverter permits energy to be fed back into the utility network without any additional measures. Also, the phase sequence of the output voltage can be easily reversed by the control system. Cycloconverters have found applications in aircraft systems and industrial drives. These cycloconverters are suitable for synchronous and induction motor control.

1.5.3 DC-to-AC Converters

The dc-to-ac converters are generally called inverters. The ac supply is first converted to dc, which is then converted to a variable-voltage and variable-frequency power supply. This generally consists of a three-phase bridge connected to the ac power source, a dc link with a filter, and the three-phase inverter bridge connected

1.5.4 DC-DC Converters

DC-dc converters are used to convert unregulated dc voltage to regulated or variable dc voltage at the output. They are widely used in switch-mode dc power supplies and in dc motor drive applications. In dc motor control applications, they are called chopper-controlled drives. The input voltage source is usually a battery or derived from an ac power supply using a diode bridge rectifier.

These converters are generally either hard-switched PWM types or soft-switched resonant-link types. There are several dc-dc converter topologies, the most common ones being buck converter, boost converter, and buck-boost converter.

1.6 Power Losses in a Switching Power Transistor

During the "on" period of power transistor-switch "conduction losses" will appear. These energy losses are independent of the switching frequency and are equal to about the on-state voltage drop VCE (sat) multiplied by the average output current. During the "off" period "turn-off losses" will appear. These energy losses are usually very small and are equal to about the off-state voltage drop Vcc multiplied by the turn-off leakage current. Energy losses during the on-off and off-on transition names as "switching losses" will produce power losses proportional to the switching frequency. Power losses of a switching device in power converter are the summation of conduction losses, turn-off losses, and switching losses. Excessive power losses which in turn means excessive junction temperature and may incur the thermal run-away phenomenon this degrades the performance and reliability of the power switching device. The problem resides in how to reduce the conduction losses and switching losses of the power transistor in turn means to reduce the junction temperature to increase the safe operating range and reliability.

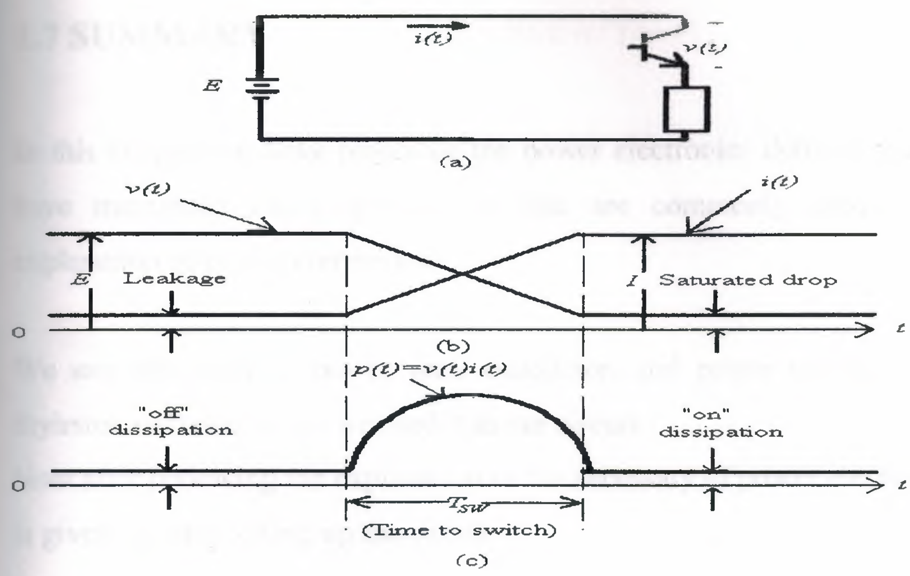


FIGURE1.12: illustrates the switching action of a simple switching transistor circuit.

When the transistor is off or open, the collector-emitter voltage is assumed to be E volts. Actually, the off-state transistor voltage would be slightly less than the dc supply voltage because of the load voltage drop due to the leakage current. The collect current flowing when the transistor is on is assumed to be I amperes. In addition, the instantaneous collect-emitter voltage v (t) and collect current i (t) are both assumed to change in a linear fashion during the switching interval. Although this is not exactly the case in practical situation, the linear variations are a reasonably good approximation, and they most clearly illustrate the important switching characteristics.

The total average dissipation in a switching element is obtained by adding the on-state, off-state, and switching losses.

1.7 SUMMARY

In this chapter we have presented the power electronics definition and principles. We have mentioned many applications that are commonly used in this field. And explanation of power conversion

We saw the main of power semi conductor, and power mosfet.we concentrated on thyirstor and triac which we used it in our circuit
Now after reviewing the explanation of the necessary of power electronics for the circuit is given, its time sitting up the circuit.

CHAPTER TWO

WATER LEVEL SENSING

2.1 Over view

This chapter is dealing with the design of water level sensing containing an ac input circuit, its functions and the use of it. This chapter contains a brief explanation about the circuit and the component to be used.

2.2 Introduction

The circuit in fig 3.2 uses an incandescent lamp to detect water level sensing. In such a way that when the water level reach to the wires (as we all know, water has positive and negative ions that function as a conductor) the open circuit becomes short circuit which allows the current flow through the water to reach the control circuit which has a lamp. As soon as the current reaches to the lamp, it lights.

2.3 Schematic

The schematic shown below shows the water level sensing

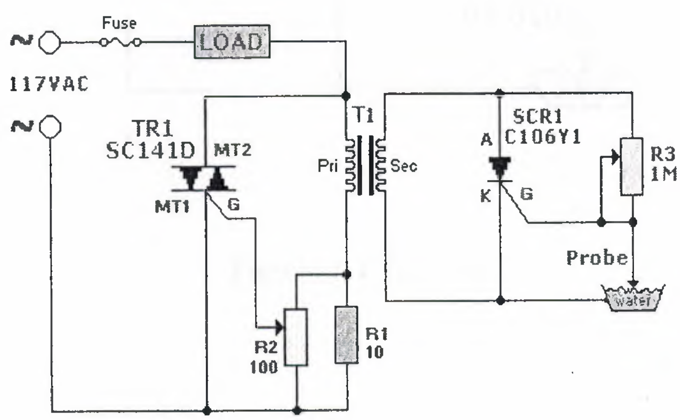


Figure 2.3: water level sensing

2.4 Working principles and the description of the stages used.

We divide the circuit into two stages:

2.4.1 first stage

The circuit in Fig 4.1 consists of probe (wires), variable resistor, silicon controller Rectifier, secondary side of transformer, and small tank.

When the level of water is high, the probe arrive the water, so we have a closed circuit which secondary side can effect on silicon control rectifier, then the gate of silicon rectifier is trigged "on". It conducts and imposes a heavy load on Transformer T1's secondary winding. That load is reflected back into the primary side of transformer. The main task of variable resistor to change the brightness of the lamp.

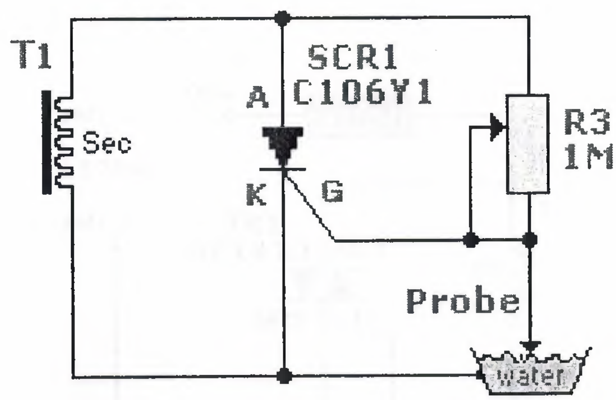


Figure 2.4: first stage

2.4.2 Second stage

The second stage which shown in fig 2.4 consists of an ac source with 117 volt, lamp, and primary side of transformer, triac, fixed and variable resistor.

This stage depending on the first stage; when the transformer T1's secondary winding imposed by SCR, it effects on primary side, gating TR1 on which energizes the load so the triac energizes a load which might control a valve, indicator light.

On other hand when the level of water is low the, the probe is out of the water and SCR1 is triggered "on". It conducts and imposes a heavy load on Transformer T1's secondary winding. That load is reflected back into the primary, gating TR1 on which energizes the load. So we have a weak bright

Additionally; we have to add a (slow-blow) fuse to protect a circuit, and consider the PH level of water.

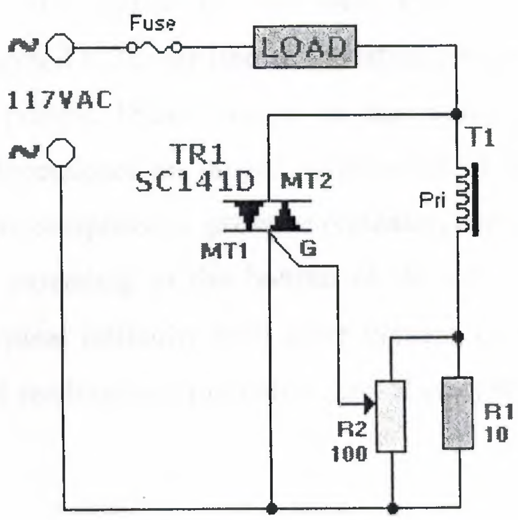


Figure 2.4.2:second stage

2.5 Level sensing

The simplest application of a control is to detect the presence or absence of water at a specific level. A simple probe, at the desired level, when the water is touching the probe a current path exists through the water and probes, causing the control circuit to operate. As water recedes from probe, the current path is broken and the circuit is reenergized. Out put may be an alarm, indicator

2.5.1 Methods of level sensing that we use in water and wastewater treatment applications are:

Bubbler system

This system is often used in sewage lift stations because of its ability to measure the level of dirty liquids in corrosive environments. A small flow of compressed air is fed into a tube of relatively large diameter which is installed in the wet well with an open end near the bottom. The air is permitted to escape from the open end where it bubbles to the surface. The pressure in the air line is then constant at every point and is controlled by the level of liquid in the wet well. Pressure switches or a pressure transducer may be connected to the air line at a location remote to the wet well to read the level and control pumps. Disadvantages to this system are cost, parts count, maintenance, and the dependence on proper adjustments. A bubbler system typically consists of one or two air compressors, pressure regulator, needle valve, pressure gauge, airflow meter, air line extending to the bottom of the wet well, and three or more pressure switches. A typical difficulty with these systems is undetected air leaks that result in inaccurate level readings and premature loss of compressors.

Float switches

These may be used in both water and wastewater applications. They are available in normally open and normally closed types. In most cases, the normally open type is used in situations where the tank is to be pumped down or as a low water cutout. The normally closed type is usually used in applications where the tank is to be filled. Float switches are used in sewage, lift stations because of their ability to function in dirty, corrosive environments. s. They are also the most common source of control problems in this application since they are exposed to these elements and subject to wear and tear due to mechanical motion. The lower two float switches in lift stations fail first. They can be expected to last about five years. It is often not possible to detect float switch failure with an ohmmeter since the switch can behave differently under load than under test conditions. Problems can also occur when the wet well is allowed to accumulate a thick blanket of grease that can lift the float switches out of the water as the level rises. Often a separate backup level sensing system is designed into lift station controls in order to provide a higher level of dependability.

Pressure switches

Pressure switches have been used for level control in both water and wastewater applications. There can be disadvantages in specific applications. Attempts to use pressure switches located at a pumping station to control the level in a remote tank usually fail due to the increased pressure encountered when the pump is running as well as the influence of water use along the line in a distribution system. If pressure switches can be connected to the remote tank and not its fill line, then better results are obtained. For an elevated storage tank, however, it may not be possible to adjust the dead band of a pressure switch to a value as small as that desired. An advantage, however, is that the unit is mounted at the bottom of the tank so that no climbing is required. Pressure switches and their water lines will require freeze protection if they are subject to freezing conditions. Simply insulating them will not work since there is no liquid flow to provide heating. A disadvantage to using pressure switches in wastewater systems is possible clogging of sensing lines, and so they are usually only used as a backup system or with air lines in a bubbler system in wastewater applications.

Pressure transmitters

The same considerations apply to pressure transmitters as to pressure switches, except that smaller dead band values are possible using pressure transmitters. Another advantage is that only one pressure transmitter is required per tank even if multilevel control is desired, since the electronic level signal from the unit is typically sent to a controller from which multiple set points are obtained. This also permits a record to be kept of tank levels over time. Although a disadvantage to this system is its higher cost, it is generally the best choice for level control in water systems.

Probes

Probes are often used on water systems. They are inappropriate for wastewater because they will fail to conduct once they become coated with the grease found in wastewater. They are particularly suitable for use in hydro tanks because the conductor entrances can be sealed and the probes are unaffected by the pressure. Probes require special relays that can react to the relatively poor path of conduction that the liquid provides. Probes will require periodic cleaning to remove deposits that would hamper conduction. The time between cleanings will vary depending on the characteristics of the liquid and the frequency of wet/dry cycles. Advantages are cost, simplicity and durability.

Disadvantages are the cleaning requirement and the fact that probes are mounted at the top of a tank, making maintenance difficult for elevated tanks. Cleaning the probes mounted in a hydro tank can be a problem since the pressure must be released to remove them. However, external hydro tank probe systems are available, such as the one manufactured by H2O system.

2.6 Components Used in water level sensing

The components used in the water list level sensing circuit are listed below

Table 2.5: Components list

Symbol of the component	Value and description
R1	10 ohm,10 watt, wire wound
R2	100 ohm, potentiometer, wire wound
R3	1 mega- ohm potentiometer
T1	Transformer,12.6v, 1.2 amp (min)
SCR	Silicon controlled rectifier
Tr1	Triac,sc141d rated 6 to 10 amp at 200 to 400 v
Fuse	Slow-blow , 2 amp

2.6.1Explanation of the component listed

2.6.1.1 Resistor

Electrons move more easily through some materials than others when a voltage is applied. In metals the electrons are held so loosely that they move almost without any hindrance. We measure how much opposition there is to an electric current as resistance.

Resistors come somewhere between conductors, which conduct easily, and insulators, which don't conduct at all. Resistance is measured in ohms after the discoverer of a law relating voltage to current. Ohms are represented by the Greek letter omega.

2.6.1.2 Fixed value resistors

During manufacture, a thin film of carbon is deposited onto a small ceramic rod. The resistive coating is spiraled away in an automatic machine until the resistance between the two ends of the rod is as close as possible to the correct value. Metal leads and end caps are added; the resistor is covered with an insulating coating and finally painted with colored bands to indicate the resistor value Carbon film resistors are cheap and easily available, *with values within ±10% or ±5% of their marked or 'nominal' value.* Metal film and metal oxide resistors are made in a similar way, but can be made more accurately to within ±2% or ±1% of their nominal value. There are some differences in performance between these resistor types, but none which affect their use in simple circuits.

2.6.1.3 Variable Resistors

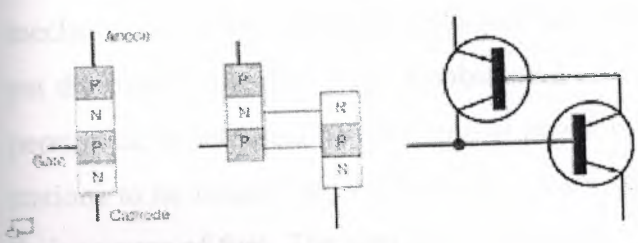
Unsurprisingly, variable resistors are resistors whose resistance can be varied. The variable resistors (called presets) have a metal wiper resting on a circular track of carbon. The wiper moves along the track as the preset is turned. The current flow through the wiper; and then; through part of the carbon track. The more of the track it has to go through the greater the resistance. The presets have three legs. The top leg connects to the wiper and the other two legs to the two ends of the track. Generally only one of the track legs is actually used. Variable resistors are used in circuits to vary things that need changing, like volume.

2.6.1.4 Silicon Controlled Rectifier

Silicon control rectifier (or **semiconductor controlled rectifier**) is a 4-layer solid state device that controls current flow.

Theory of operation

An SCR can be seen as a conventional rectifier controlled by a gate single. It is a 4-layered 3-terminal device. P-type layer acts as anode and n-type layers as a cathode; the p-type layer closer to the n-type acts as a gate.



Modes of operation

In the normal 'off' state the device restricts current flow to the leakage current. When the gate to source current exceeds a certain point, the device turns 'on' and conducts current. The device will remain in the 'on' state even after gate current is removed so long as current through the device remains above the holding current. Once current falls below the holding current the device will switch off. If the applied voltage increases rapidly, it may induce enough leakage current to trigger the device into the on state, but this is harmful to the device. The reverse blocking voltage is limited in any device.

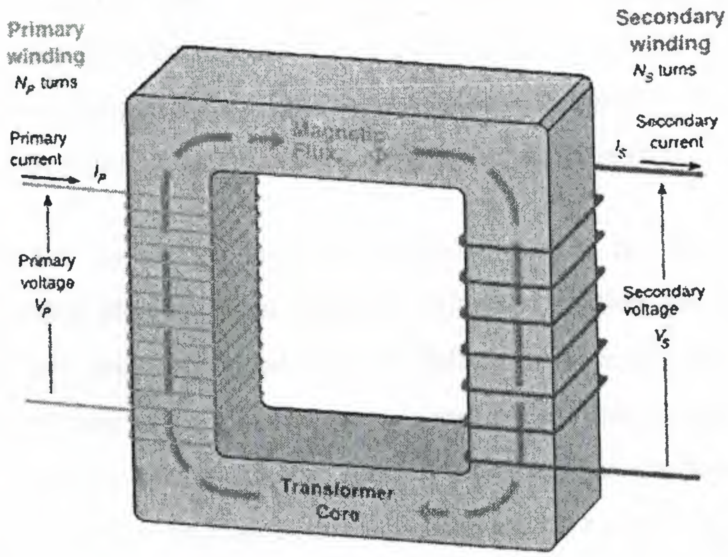
2.6.1.5 TRIAC

A TRIAC or TRIode for Alternating Current is an electronic component approximately equivalent to two silicon control rectifier joined in inverse-parallel (paralleled but with the polarity reversed) and with their gates connected together. These results in a bidirectional electronic switch which can conduct current in either direction when it is triggered (turned on). It can be triggered by either a positive or a negative voltage being applied to its gate electrode. Once triggered, the device continues to conduct until the current through it drops below a certain threshold value, such as at the end of a half-cycle of alternative (AC) mains power. This makes the TRIAC a very convenient switch for AC circuits, allowing the control of very large power flows with milliamp ere- -scale control currents. In addition, applying a trigger pulse at a controllable point in an AC cycle allows one to control the percentage of current that flows through the TRIAC to the load (so-called phase control).

2.6.1.6Transformer

The transformer is one of the simplest of electrical devices, analogous to the gear box in mechanics. Its design and principles have changed little over the last one hundred years, yet the transformer still plays a substantial role in high-voltage power transmission. It permits the economical transmission of power over large distances, allowing generating stations to be located physically further from sites of electricity demand and nearer to their sources of fuel. The simplicity, reliability, and economy of conversion of voltages by stationary transformers were the principal factor in the selection of alternating current power transmission.

Flux coupling



A simple single phase transformer consists of two electrical conductors called the primary and the secondary. The primary is fed with a varying (alternating or pulsed continues) electric current which creates a varying magnetic field around the conductor and in the magnetic core (shaded grey). The secondary, which is placed in this varying magnetic flux, develops an electromotive force or emf. If the ends of the secondary are connected together to form an electric circuit, this EMF will cause a current to flow in the secondary. In this way, the electrical energy fed into the primary winding is delivered to the secondary winding. In most practical transformers, the primary and secondary conductors are coils of conducting wire because a coil creates a denser magnetic field (higher magnetic flux) than a straight conductor.

Electrical laws

Transformers alone cannot do the following:

- Convert DC to AC or vice versa
- Change the voltage or current of DC
- Change the AC supply frequency.

However, transformers are components of the systems that perform all these functions.

Consider the following two laws:

1. According to the law of conversion of energy, the power delivered by a transformer cannot exceed the power fed into it.
2. The power dissipated in a load at any instant is equal to the product of the voltage across it and the (in phase) current passing through it.

It follows from the above two laws that a transformer is not an amplifier If the transformer is used to change power from one voltage to another, the magnitudes of the currents in the two windings must also be different, inversely proportional to the voltages. If the voltage were to be stepped down by the transformer, the secondary current available to the load would be greater. For example, suppose a power of 50 watts is supplied to a resistive load from a transformer with a turn's ratio of 25:2.

P = E·I (power = electromotive force · current)

50 W = 2 V · 25 A in the primary circuit

Now with transformer change:

50 W = 25 V · 2 A in the secondary circuit.

The high-current, low-voltage windings have fewer turns of (usually) thicker wire. The high-voltage, low-current windings have more turns of (usually) thinner wire.

The electromotive force (EMF) developed in the secondary is proportional to the ratio of the number in the secondary coil to the number of turns in the primary coil. Neglecting all leakage flux, an ideal transformer follows the equation:

$$\frac{V_P}{V_S} = \frac{N_P}{N_S}.$$

Where V_P is the voltage in the primary coil, VS is the voltage in the secondary coil, N_P is the number of turns of wire on the primary coil, and N_S is the number of turns of wire on the secondary coil. This leads to the most common use of the transformer: to convert power at one voltage to power at a different voltage.

2.7 Summary

In this chapter the water level sensing circuit was presented. Also we have explained the two stages of the circuit, the diagram of the first and second circuit also showed. And the components for all of them were listed on the table 2.5 .Working principles of scr, triac and behavior of the circuit are explained in details. Some experimental data are included in the explanation part.

CONCLUSION

Electronic fields are considered as a real revolution in the world. As we did see in the project chapters, that we can create something useful, practical and vital to the people life using those components.

Water level sensing considered one of those important devices that make vital key role to the people's life, as in our case water level can economize on the peoples by operating certain functions automatically as were mentioned in the project chapters.

Since this project deals with under graduated electrical and electronic engineers, the aims of this project were:

- To have a hand-on experience with electronic project.

This aim was accomplished by the search of this project and having mostly detailed ideas about electronic world.

- To design, build and implement a water level sensing.

This aim was accomplished by having practical experience of implementing.

- To investigate areas of used applications.

This aim was accomplished by referring to many references and having real-life applications to this project.

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