الآية

قال تعالي

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

(وَقُلْ رَبِّ زِدْنِي عِلْمًا)

صدق الله العظيم

سورة طه الآية(١١٤)

DEDICATION

To whom the paradise is under her feet ,my mother.

To who assisted my scientific intention to be possib,my father.

To all who assisted me, I offer my humble effort asking God to give them long life to see the result of their efforts.

ACKNOWLEDGMENT

With great pleasure I offer my grateful thanks to my Supervisor Ust. Abd Allah Salih Ali who supported me with all his knowledge and experience and advices.

All my best thanks and wishes to my favorite University of Karari and Sudan University of Science and Technology.

I will not forget to offer my thanks and respect to Ust.Elzain Elmahi and Engineer Abubaker Faisal and to all who supported me to continue in steady steps on my studies up to the completion of the work.

ABSTRACT

The speed regulation of servo motor can be improved by using phase locked loop. The speed of motor must be converted to digital pulse train using a speed encoder. The output of the encoder acts as speed feedback signal.

A phase detector is used to compare the reference pulse with feedback frequency and provide a Pulse Width Modulation (PWM) output voltage which is proportional to the difference in phases and frequencies of reference and feedback pulse trains. The phase detector (or comparator) is available in integrated circuits. A low-pass filter converts the pulse trains to continuous dc level which varies the output of the power converter and in turn the motor speed.

When the motor runs at the same speed as the reference pulse the two frequencies would be synchronized or locked together with a phase difference.

The output of the phase detector would be constant voltage proportional to the phase difference and the steady-state motor speed would be maintained at a fixed value irrespective of the load on the motor. Any disturbances contributing the speed change would result in a phase difference and the output of the phase detector would respond immediately to vary the speed of the motor in such a direction and magnitude as to retain the locking of the reference and feedback frequencies. The response of the phase detector is very fast. As long as the two frequencies are locked, the speed regulation should ideally be zero. However, in practice the speed regulation is limited to 0.002%, and this represents a significant improvement over the analog speed control system.

المستخلص

تنظيم سرعة محرك المؤازرة يمكن أن تحسن بإستعمال حلقة الطور المغلقة، سرعة المحرك يجب أن تحول الي نبضات رقمية باستعمال مشفر السرعة خرج مشفر السرعة يعمل كإشارة راجعة.كاشف الطور يستعمل لمقارنة الإشارة المرجعية مع تردد التغذية الراجعة ،ويدعم تعديل عرضالنبضة خرج الفولتية الذي يتناسب مع الاختلاف في الموجات وترددات الإشارة المرجعية وقطارات نبض التغذية الراجعة ،كاشف الطور (أو المقارن) متوفر داخل الدائرة التكامليةمرشح المرور المنخفض يحول قطارات النبضة الي المستوي المستمر الذي يغير ناتج المحول الكهربائي وتباعاً سرعة المحرك.عندما يعمل المحرك بنفس سرعة النبضة المرجعية الترددان سيتزامنان أو تفعلان سوياً مع إختلاف الموجة.

ناتج كاشف الموجة سيكون فولطية ثابتة تتناسب مع إختلاف الموجة وحالة الإستقرار للمحرك السرعة ستبقي ثابتة بصرف النظر عن الحمل علي المحرك ،أي إضرابات تساهم في تغير السرعة يؤدي الي اختلاف في إختلاف الموجة . خرج كاشف الموجة يستجيب فوراً للإختلاف في سرعة المحرك في مثل هذا الإتجاه والمقدار يحتفظان بقفل الإشارة المرجعية وترددات التغذية الخلفية .إستجابة كاشف الموجة سريعة جداً طالما الترددان مغلقان ،تنظيم السرعة يجب أن يكون مثالياً صفر،علي أي حال في الممارسة تنظيم السرعة تحدد الي ٠٠٢%،وهذه تمثل تحسين هام علي نظام سيطرة السرعة المناظر.

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CHAPTER ONE
INTRODUCTION

1.1General The speed of a servo motor is sensed by tachometer which compared with reference speed to generate the error signal to vary armature voltage of the motor.The speed sensor and comparing signals are not ideal and the speed regulate is more than 0.2%. The speed regulator can be improved if phase locked loop control is used.

1.2Problem Statement

Servo motor using phase locked_loop (PLL) is used to control the airplane when its landing or take off and also opening and closing of the air plane plates need precise control for safety landing and take off of the airplane .The above action was achieved by locking the frequency in the rang (200 to 600)kHz. The regulator of the speed is about 0.2%.

1.3 Objective

1. To adjust the center frequency of phace_locked loop.
2. To observe the locked range.
3. To measure the maximum and minimum capture frequencies.
4. To measure the Direct current (DC) voltage from the Frequency Modulation output.

1.5 Methodology

1. **S**tudy of servo motor and Phase Lock Loop
2. **S**tudy and understand main components.
3. Design the complete hardware circuit.
4. Evalute performance of servo motor based an experiment result.

1.5 The layout

This research consists of fivechapters. The scope of each chapter is explained as stated below:

Chapterone presents general concepts, problem statement,objectives, and methodology.Chapter two includes the previous works, control systems types,compensation, performance specifications, design procedure and servo motor.

Chapter three the implementation of control circuit is introduced.

Furthermore, main components of main circuit are discussed.

Chapter four presents the simulation are experimental results.

Finally, chapter five provides the conclusion and recommendation.

CHAPTER TWO

CONTROL SYSTEM

2.1PreviousStudies

Guan-Chyun use phase-locked loop which is a technique has contributed significantly toward the technology advancement in communication and servo motor control systems in the past 30 years. Inventions in phase-locked loop schemes combining with novel integrated circuit (IC) technology have made phase-locked loop devices important system components. The development of better modular phase-locked loop IC's is continuing. As a result, it is expected that it will contribute to improvement in performance and reliability for future communication systems. It will also contribute to the development of higher accuracy and higher reliability servo motor control systems, such as those involved in machine tools .This paper serves as an introduction for this phase-locked loop special section. It provides a concise review of the basic phase-locked loop principles applicable to communication and servo control systems, gives the configuration of phase-locked loop applications, and reports a number of popular phase-locked loop chips[5].

Dennis use phase-locked loop to measure its response in time domain, and present an all-digital measurement circuit that enables wafer-level test and characterization of phase-locked loop response. Through modifications only in the phase-locked loop feedback divider state machine, this technique facilitates accurate estimation of phase-locked loop frequency-domain closed-loop bandwidth and gain peaking by respectively measuring the time-domain crossover time and maximum overshoot of phase error to a self-induced phase step in the feedback clock. These transient measurements are related back to bandwidth and peaking through the proportionality relationships of crossover time to reciprocal bandwidth and maximum overshoot to peaking. The design-for-test circuit can be used to generate a transient plot of step response, measure static phase error, and observe phase-lock status. We report silicon results from two demonstration vehicles built in a 45-nm SOI-CMOS logic technology for high-performance microprocessors [6].

Wisnu Djatmiko and otherconsider controlling motor terminal voltages using chopper method. The input DC voltage is chopped byInsulated Gate Bipolar Transistor (IGBT). Phase Locked Loop (offer a stable frequency controller system. It has been widely used in communications, instrumentation and motor controlled. We synthesis a phase-locked loop system using Field Programmable Gate Array (FPGA)chip and an analog Voltage Controlled Oscillator (VCO). Phase comparator (phase detector) and programmable counter (frequency divider) are implemented in FPGA. The result of the experiment shows that motor speed is not affected so much with the varying loads. In this experiment, the motor speed is holding constant, Independent of the motor load, which is a voltage generator with a constant current source load. On loading the motor speed slow down for about283 rpm (10%) in 1780 milliseconds, on unloading the motor speed is hunting about 100 rpm (3%) in 1220 milliseconds. The DC motor used in this experiment is a DC motor with rated speed of 8000 rpm and rated voltage of 100 Volt and rated current of 1 Ampere [7].

2.2 Type of Control Systems

The are many type of control systems, the most popular control systems are presented below.

2.2.1Feedback Control Systems

A system that maintains a prescribed relationship between the output and the reference input by comparing them and using the difference as a means of control is called a feedback control system. An example would be a room-temperature control system. By measuring the actual room temperature and comparing it with the reference temperature (desired temperature), the thermostat turns the heating or cooling equipment ON or OFF in such a way as to ensure that the room temperature remains at acomfortable level regardless of outside conditions. Feedback control systems are not limited to engineering but can be found in various nonengineering fields as well. The human body, for instance, is a highly advanced feedback control system. Both body temperature and blood pressure are kept constant by means of physiological feedback. In fact, feedback performs a vital function: It makes the human body relatively insensitive to external disturbances, thus enabling it to function properly in a changing environment. Control system can be classified as open loop and closed loop systems [1].

2.2.2Open-loop control system

These systems in which the output has no effect on the control action are called open-loop control systems. In other words, in an open-loop control system the output is neither measured nor fed back for comparison with the input. One practical example is a washing machine. Soaking, washing, and rinsing in the washer operate on a time basis. The machine does not measure the output signal, that is, the cleanliness of the clothes. In any open-loop control system the output is not compared with the reference input. Thus, to each reference input there corresponds a fixed operating condition; as a result, the accuracy of the system depends on calibration. In the presence of disturbances, an open-loop control system will not perform the desired task. Open-loop control can be used, in practice, only if the relationship between the input and output is known and if there are neither internal nor external disturbances. Clearly, such systems are not feedback control systems. Note that any control system that operates on a time basis is open loop. For instance, traffic control by means of signals operated on a time basis is another example of open-loop control [1].

The major advantages of open-loop control systems are as follows:

1. Simple construction and ease of maintenance.
2. Less expensive than a corresponding closed-loop system.
3. There is no stability problem.

4. Convenient when output is hard to measure or measuring the output precisely is economically not feasible. (For example, in the washing machine system, it would be quite expensive to provide a device to measure the quality of the washer's output, cleanliness of the clothes).

The major disadvantages of open-loop control systems are as follows:

1. Disturbances and changes in calibration cause errors, and the output may be different from what is desired.
2. To maintain the required quality in the output, recalibration is necessary from time to time.

2.2.3 Closed-Loop Control Systems

Feedback control systems are often referred to as closed-loop controlsystems. In practice, the terms feedback control and closed-loop control are used interchangeably.In a closed-loop control system the actuating error signal, which is the difference between the input signal and the feedback signal (which may be the output signal itself or a function of the output signal and its derivatives and/or integrals), is fed to the controller so as to reduce the error and bring the output of the system to a desired value. The term closed-loop control always implies the use of feedback control action in order to reduce system error. The important advantages of the closed loop control systems over open loop control systems are:

1) An advantage of the closed-loop control system is the fact that the use of feedback makes the system response relatively insensitive to external disturbances and internal variations in system parameters. It is thus possible to use relatively inaccurate and inexpensive components to obtain the accurate control of a given plant, whereas doing so is impossible in the open-loop case.
2) From the point of view of stability, the open-loop control system is easier to build because system stability is not a major problem. On the other hand, stability is a major problem in the closed-loop control system, which may tend to overcorrect errors and thereby can cause

oscillations of constant or changing amplitude. It should be emphasized that for systems in which the inputs are known ahead of time and in which there are no disturbances it is advisable to use open-loop control. Closed-loop control systems have advantages only when unpredictable disturbances and/or unpredictable variations in system components are present. Note that the output power rating partially determines the cost, weight, and size of a control system.

3) The number of components used in a closed-loop control system is more than that for a corresponding open-loop control system. Thus, the closed-loop control system is generally higher in cost and power. To decrease the required power of a system, open-loop control may be used where applicable. A proper combination of open-loop and closed-loop controls is usually less expensive and will give satisfactory overall system performance.
4) Most analyses and designs of control systems presented in this research are concerned with closed-loop control systems. Under certain circumstances (such as where no disturbances exist or the output is hard to measure) open-loop control systems may be desired. Therefore, it is worthwhile to summarize the advantages and disadvantages of using open-loop control systems.

2.3 Compensation

Setting the gain is the first step in adjusting the system for satisfactory performance. In many practical cases, however, the adjustment of the gain alone may not provide sufficient alteration of the system behavior to meet the given specifications. As is frequently the case, increasing the gain value will improve the steady-state behavior but will result in poor stability or even instability. It is then necessary to redesign the system by modifying the structure or by incorporating additional devices or components to alter the overall behavior so that the system will behave as desired. Such a redesign or addition of a suitable device is called compensation.

A device inserted into the system for the purpose of satisfying the specifications is called a compensator. The compensator compensates for deficient performance of the original system.Compensation is the modification of the system dynamics to satisfy the given specifications. The approaches to control system design and compensation used in the root-locus approach, frequency-response approach, and the state-space approach.

In the actual design of a control system, whether to use an electronic, pneumatic, or hydraulic compensator is a matter that must be decided partially based on the nature of the controlled plant. For example, if the controlled plant involves flammable fluid, then we have to choose pneumatic components (both a compensator and an actuator) to avoid the possibility of sparks. If, however, no fire hazard exists, then electronic compensators are most commonly used. In fact, we often transform nonelectrical signals into electrical signals because of the simplicity of transmission, increased accuracy, increased reliability, ease of compensation, and the like) [1].

2.4 Performance Specifications

Control systems are designed to perform specific tasks. The requirements imposed on the control system are usually spelled out as performance specifications. The specifications may be given in terms of transient response requirements (such as the maximum overshoot and settling time in step response) and of steady-state requirements (such as steady-state error in input signal) or may be given in frequency-response terms. The specifications of a control system must be given before the design process begins. For routine design problems, the performance specifications (which relate to accuracy, relative stability, and speed of response) may be given in terms of precise numerical values. In other cases they may be given partially in terms of precise numerical values and partially in terms of qualitative statements. In the latter case the specifications may have to be modified during the course of design, since the given specifications may never be satisfied (because of conflicting requirements) or may lead to a very expensive system. Generally, the performance specifications should not be more stringent than necessary to perform the given task. If the accuracy at steady-state operation is of prime importance in a given control system, then we should not require unnecessarily rigid performancespecifications on thetransient response, since such specifications will require expensive components. Remember that the most important part of control system design is to state the performance specifications precisely so that they will yield an optimal control system for the given purpose [1].

2.5 Design Procedures

In the process of designing a control system, we set up a mathematical model of the control system and adjust the parameters of a compensator. The most time-consuming part of the work is the checking of the system performance by analysis with each adjustment of the parameters. The designer can use MATLAB or other available computer package to avoid much of the numerical drudgery necessary for this checking. Once a satisfactory mathematical model has been obtained, the designer must construct a prototype and test the open-loop system. If absolute stability of the closed loop is assured, the designer closes the loop and tests the performance of the resulting closed loop system. Because of the neglected loading effects among the components, nonlinearities, distributed parameters, and so on, which were not taken intoconsideration in the original design work, the actual performance of the prototype system will probably differ from the theoretical predictions. Thus the first design may not satisfy all the requirements on performance. The designer must adjust system parameters and make changes in the prototype until the system meets the specifications. In doing this, he or she must analyze each trial, and the results of the analysis must beincorporated into the next trial. The designer must see that the final system meets the performance pacifications and, at the same time, is reliable and economical [1].

2.6 Servo Motors

Electrical servos may be (a) Entirely DC operated, using voltage dividers, DC amplifiers, and DC driving motors, (b) Entirely Alternative Current (AC) operated using synchros, AC amplifiers and 2-phase AC driving motors, or (c) AC/DC operated using AC error detection, phase sensitive rectification and DC driving motors [4].The are a number of types of servo motor, most popular ones are:

2.6.1 Split Field Motor

Small DC servo motors are generally of the split-field type as shown in Figure 2.1. Neglecting saturation and assuming a constant armature current, the output torque will be proportional to the net field current, and will reverse when this net field current reverses. The field may be fed from a push-pull amplifier stage. If the armature is not fed from a constant-current source, the build-up of armature e.m.f. with speed causes a falling torque/speed characteristic, which is equivalent to viscous-friction damping in the servo system.Approximately constant armature current can be achieved by feeding the armature through a high resistance from a high-voltage DC supply.

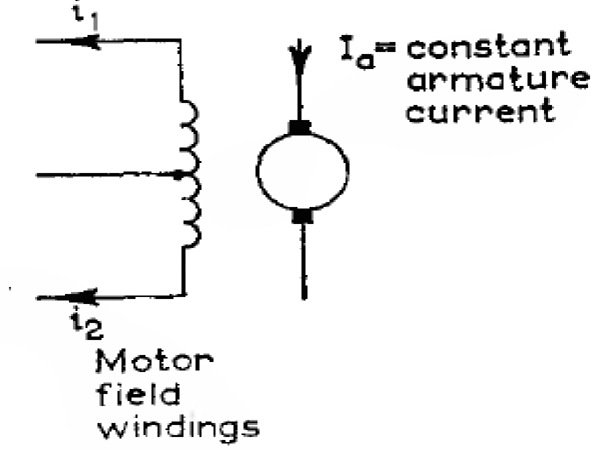


Figure 2.1: The DC servo motor

Figure 2.2 shows the phase sensitive rectifier circuit. An AC error signal may be used with a Phase-Sensitive Rectifier (PSR) to produce a DC error voltage. The basic operation of a PSR shown in Figure 2.2,when there is no error voltage, each diode conducts during positive half-cycles of the reference voltage and there is no net voltage between A and B. The peak error signal, v_e, is arranged to be smaller than the reference voltage, v_r. When the error signal is in phase with the reference voltage, the voltage applied to D_1 during the positive half-cycles of v_r, i.e. ($v_r + v_{ei}$), is greater than that applied to D_2 (v_r — v_{e2}), and hence A is positive with respect to B. During the negative half-cycles of v_r both diodes remain non conducting (since $v_R > v_e$). If the error voltage is now changed in phase by 180°, D_2 has a larger voltage applied to it during the positive half- cycles than D_1 and B is positive with respect to A.Hence the voltage between A and B gives the magnitude and sense of the error, and may be applied direct to the bases of a long-tailed pair. The capacitors provide smoothing of the output signal [4].

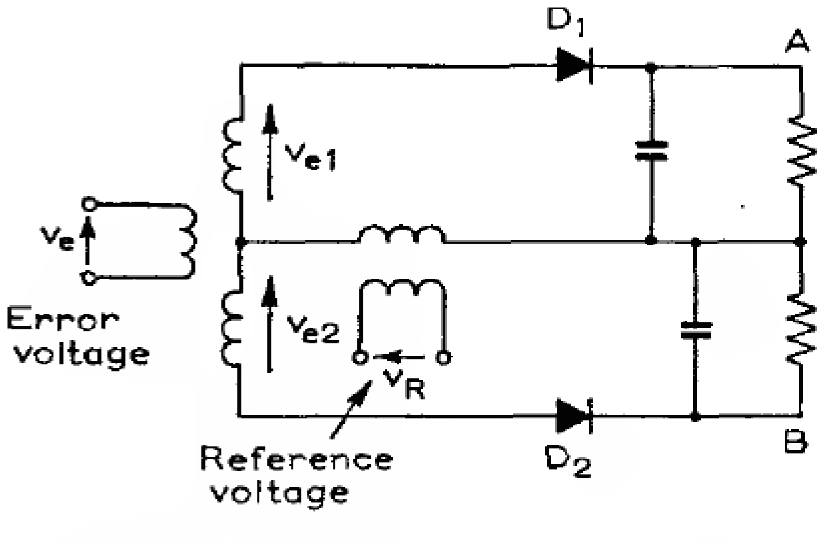


Figure 2.2: Phase sensitive rectification

2.6.2 Two phase servo motor

In an auxiliary,Servo the error signal from a synchro is fed to an AC. amplifier, whose output feeds one phase of two-phase motor. The phase of the voltage applied to this winding is arranged to be in quadrature with that applied from a constant reference source to the second winding of the motor (the reference winding), as shown in Figure 2.3.

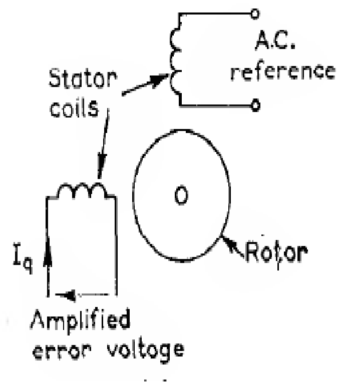


Figure 2.3: The two phase servo motor.

When there is no error voltage, only the reference winding is energized and the rotor is locked in position. The motor is designed to give maximum torque at standstill. The size of the output torque will depend on the magnitude of the error signal, and the direction of the torque will depend upon whether the error signal lags or leads the reference voltage by 90°. Typical characteristics are shown in Figure 2.3.

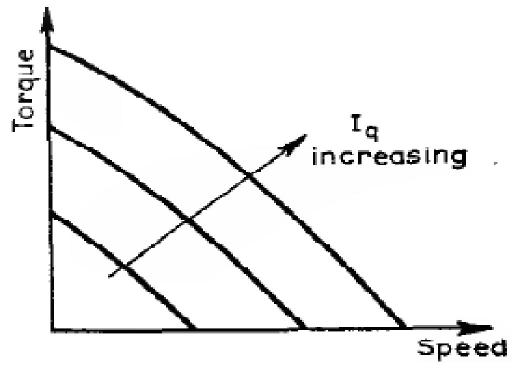


Figure2.4: Speed torqure carve

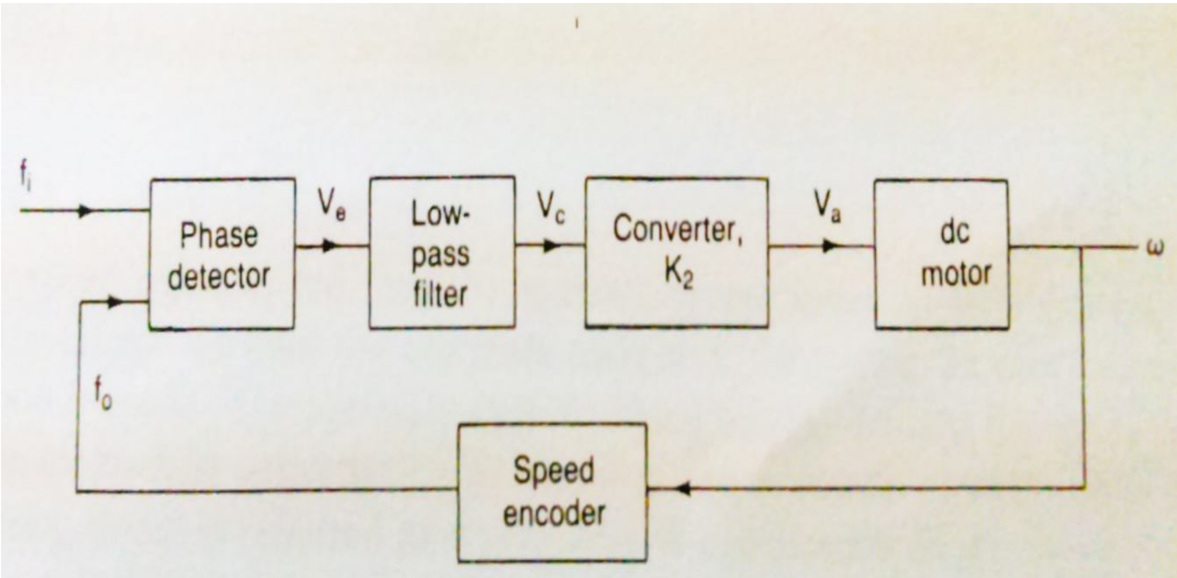
The AC servo is not used where large power is required, because the electronic amplifier has a limited power output. In such cases rotating DC amplifiers (amplifying or metaldyne type) or magnetic amplifiers are used with DC driving motors. High-power servos will not be dealt here.Note that in both DC and AC servo motors the armatures are usually long and of small diameter in order to give a high torque/inertia ratio [4].

CHAPTER THREE

IMPLEMENTATION OF CONTROL CIRCUIT

3.1 Design of Main Circuit

Figure 3.1 shows the block diagram of the control circuit. It consists of the following elements: phase detector, filter, DC motor and speed encoder. Figure 3.2 shows the detail of figure 3.1.



Fiqure 3.1: block digram of the control circuit

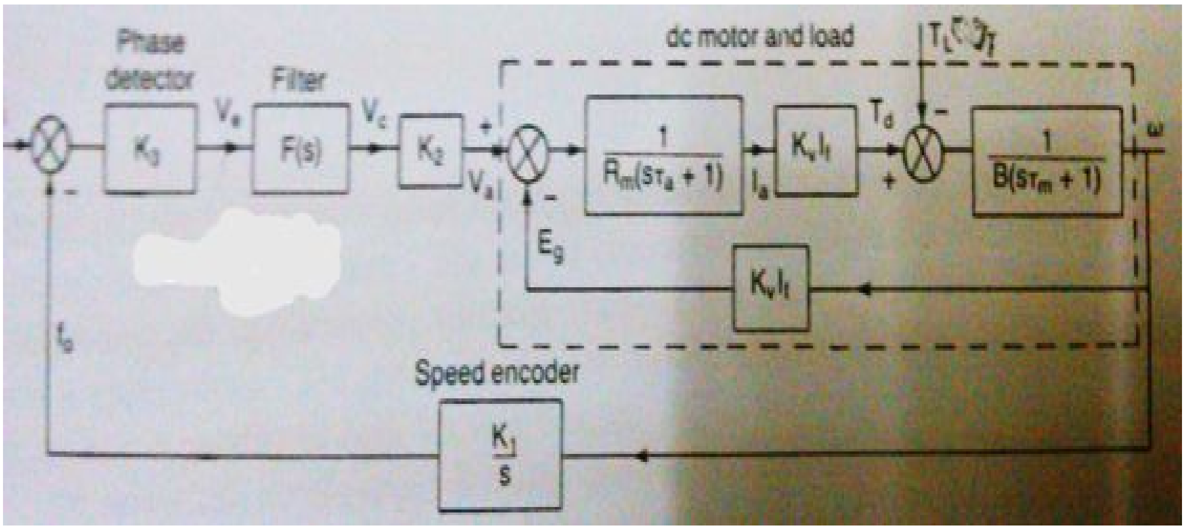


Figure3.2:shows the detail of Figure3.1

3.2 Timer IC Unit Operation

Another popular analog–digital integrated circuit is the versatile 555 timer. The IC is made of a combination of linear comparators and digital flip-flops as shown in Figure 3.3 .The entire circuit is usually housed in an 8-pin package as specified in Figure 3.3. A series connection of three resistors sets the reference voltage levels to the two comparators at $2V_{CC}/3$ and $V_{CC}/3$, the output of these comparators setting or resetting the flip-flop unit. The output of the flip-flop circuit is then brought out through an output amplifier stage. The flip-flop circuit also operates a transistor inside the IC, the transistor collector usually being driven low to discharge a timing capacitor[3].

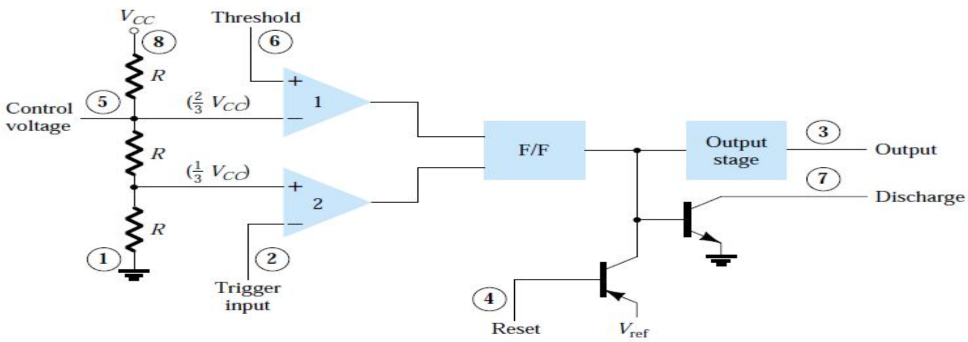
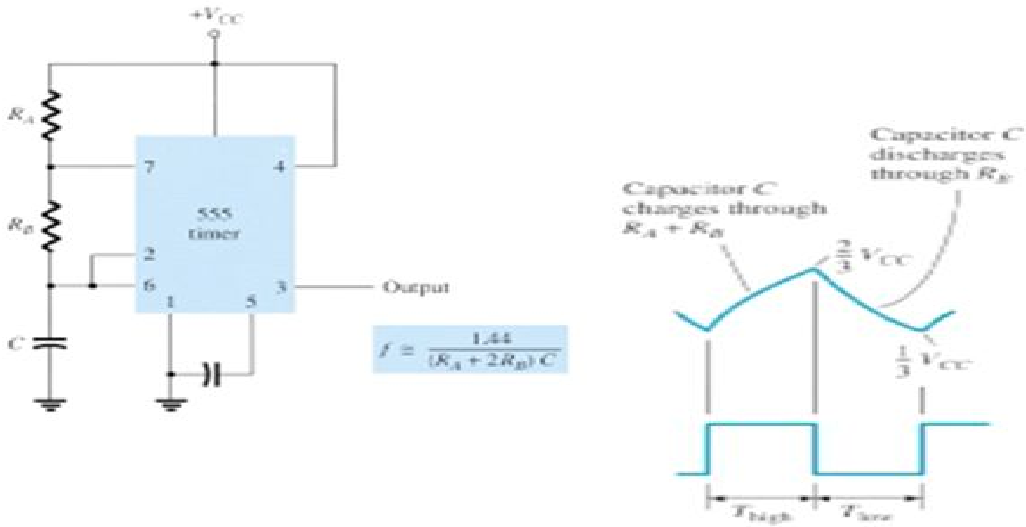


Figure 3.3: Details of 555 timer IC.

3.2.1 Astable operation

One popular application of the 555 timer IC is as an a stable multivibrator or clock circuit. The following analysis of the operation of the 555 as and a stable circuit includes details of the different parts of the unit and how the various inputs and outputs are utilized. Figure 3.4 shows and a stable circuit built using an external resistor and capacitor to set the timing interval of the output signal.

Capacitor C_1charges toward V_{CC}through external resistors $R_A$and R_B. Referring to figure3.4, the capacitor voltage rises until it goes above $2V_{CC}/3$. This voltage is the threshold voltage at pin 6, which drives comparator 1 to trigger the flip-flop so that the output at pin 3 goes low. In addition, the discharge transistor is driven on, causing the output at pin 7 to discharge the capacitor through resistor R_B. The capacitor voltage then decreases until it drops below the trigger level ($V_{CC}/3$).



(a) A stable circuit (b)Output of waveform of a stable circuit

Figure 3.4:A stable multivibrator using 555 IC

The flip flop is triggered so that the output goes back high and the discharge transistor is turned off, so that the capacitor can again charge through resistors $R_A$and $R_B$toward VCC. Figure 3.4 shows the capacitor and output waveforms resulting from the stable circuit. Calculation of the time intervals during which the output is high and low can be made using the relations in Equations (3.1) and respectively (3.2), as follows:

$$T_{high} \approx 0.7(R_A + B_B)C \quad (3.1)$$

$$T_{low} \approx 0.7R_BC \quad (3.2)$$

The total period is

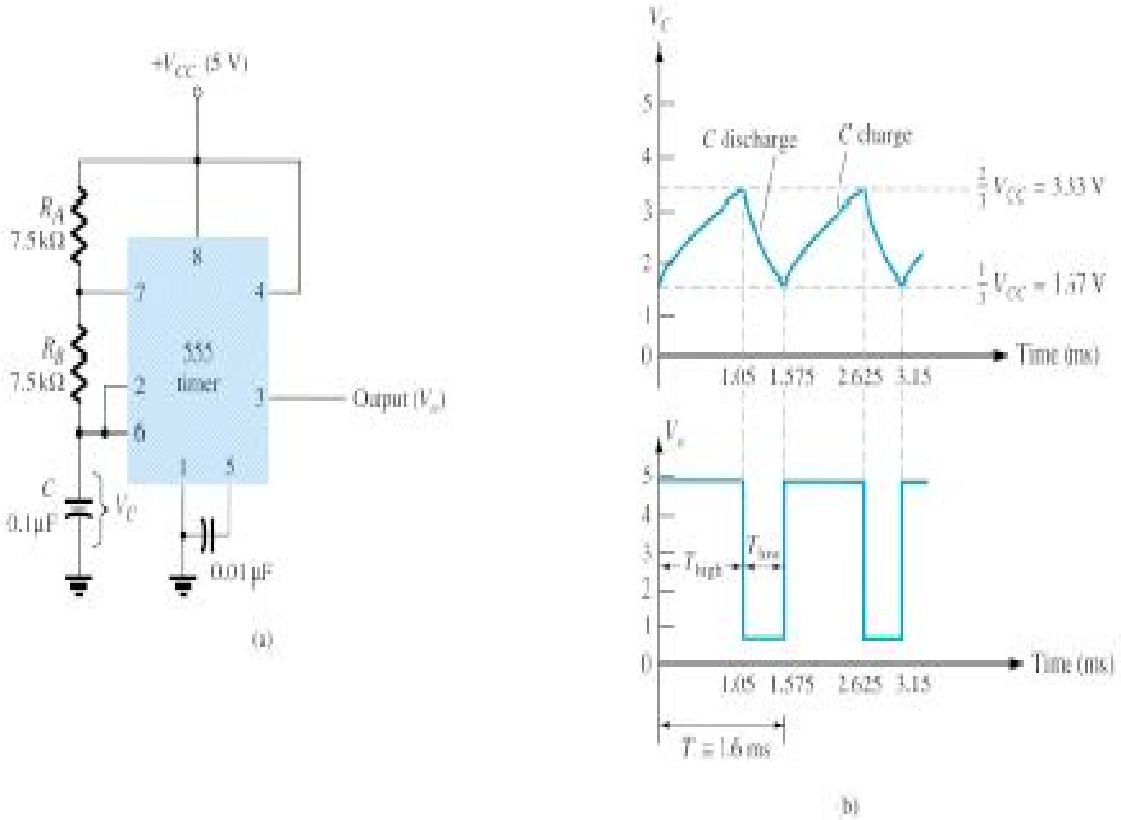
$$T = Period = T_{high} + T_{low} \quad (3.3)$$

The frequency of the a stable circuit is then calculated using:

$$f = \frac{1}{T} \approx \frac{1.44}{(R_A + 2R_B)C} \quad (3.4)$$

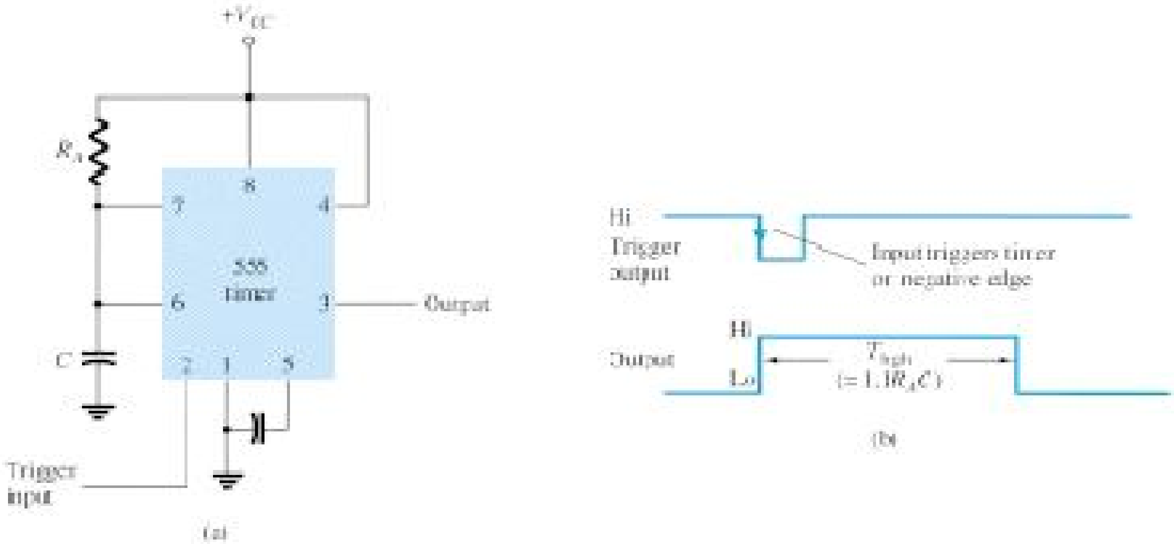
3.2.2 Monostable operation

The 555 timer can also be used as a one-shot or monostable multivibrator circuit, as shown in Figure 3.5. When the trigger input signal goes negative, it triggers the oneshot, with output at pin 3 then going high for a time period T high = $1.1R_AC_1$ referring back to Figure 3.4, the negative edge of the trigger input causes comparator 2 to trigger the flip-flop, with the output at pin 3 going high. Capacitor *C* charges toward V_{CC}through resistor R_A. During the charge interval, the output remains high. When the voltage across the capacitor reaches the threshold level of $2V_{CC}/3$, comparator 1 triggers the flip-flop, with output going low. The discharge transistor also goes low, causing the capacitor to remain at near 0 V until triggered again.



(a)The circuit (b) waveformsFigure 3.5: Astable multivibrator

Figure 3.6 shows the input trigger signal and the resulting output waveform for the 555 timer operated as a one-shot. Time periods for this circuit can range from microseconds to many seconds, making this IC useful for a range of applications [3].



(a)The circuit(b)One shot pulses

Figure 3.6: One shot monostable multivibrator

3.3 Phase Detector

Suppose we have a mixer with input frequencies of 50 Hz and 50 Hz. Then the deference frequency is 0, which represent DC. In other words, a DC voltage comes out of a mixer when the input frequencies are equal.A phase detector is a mixer optimized for use with equal input frequencies. It is called a phase detector (or phase comparator) because the amount of DC voltage depends on the phase angle ϕ between the input signals. As the phase angle changes, so too does the DC voltage. Figure 3.7 illustrates the phase angle between two sinusoidal signals. When these signals drive the phase detector of Figure. 3.8DC voltage comes out. One type of phase detector has a DC output voltage that varies as shown in Figure. 3.9,when the phase angle ϕ is 0, the DC voltage is maximum. As the phase angle increases from 0 to 180°, the DCvoltage decreases to a minimum value. When ϕ is 90°, the DC output is the average of the maximum and minimum outputs.For example, suppose a phase detector has a maximum output of 10 V and a minimum output of 5 V. when the two inputs are in phase, the DC output is 10 V. when the inputs are 90° out of phase, the DC output is 7.5 V. when the inputs are 180°out of phase the DC output is 5 V. The key idea is the dc output decrease when the phase angle increases.

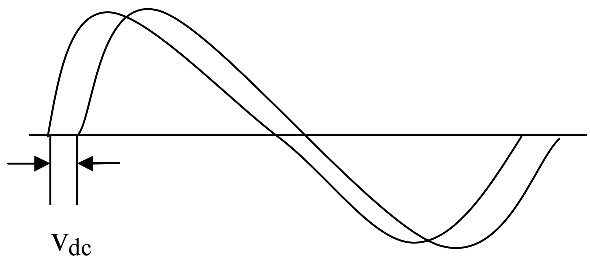


Figure 3.7:phase angle between signals

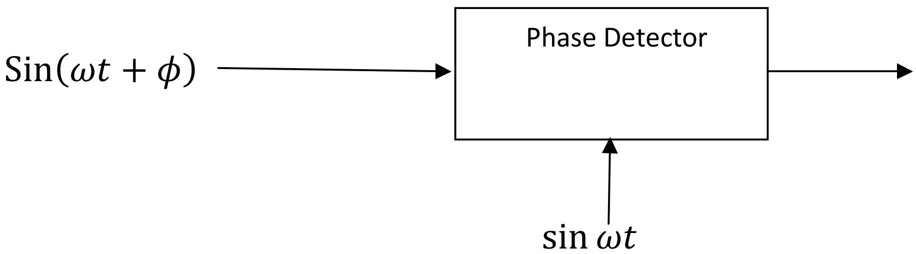


Figure3.8: Phase detector

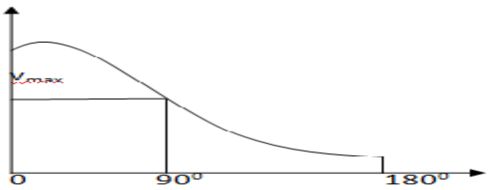


Figure3.9:output of phase detector

3.4Voltage_Controlled Oscillator

Voltage-Controlled Oscillator (VCO) is a circuit that provides a varying output signal (typically of square-wave or triangular-wave form) whose frequency can be adjusted over a range controlled by a DC voltage. An example of a VCO is the 566 IC unit, which contains circuitry to generate both square-wave and triangular-wave signals whose frequency is set by an external resistor and capacitor and then varied by an applied DC voltage. Figure 3.10 shows that the 566 contains current sources to charge and discharge an external capacitor $C1$ at a rate set by external resistor $R1$ and the modulating DC input voltage. A Schmitt trigger circuit is used to switch the current sources between charging and discharging the capacitor, and thetriangular voltage developed across the capacitor and square wave from the Schmitt trigger are provided as outputs through buffer amplifiers [3].Figure 3.11 shows the pin connection of the 566 unit and a summary of formula and value limitations. The oscillator can be programmed over a 10-to-1 frequency range by proper selection of an external resistor and capacitor, and then modulated over a 10-to-1 frequency range by a control voltage, V_C. A free-running or center-operating frequency, f_o, can be calculated from Equation

$$f_o = \frac{2}{R_1 C_1}\left(\frac{V^+ - V_c}{V^+}\right) \qquad (3.5)$$

as follows:

with the following practical circuit value restrictions:

1) R_1 *should be within the range* $2\ K\Omega \le R_1 \le 20K\Omega$
2) V_c *should be within the range* $\frac{3}{4}V^+ \le V_c \le V^+$
3) *f_o should be below 1 MHz.*
4) *V^+ should range between 10 V and 24 V.*

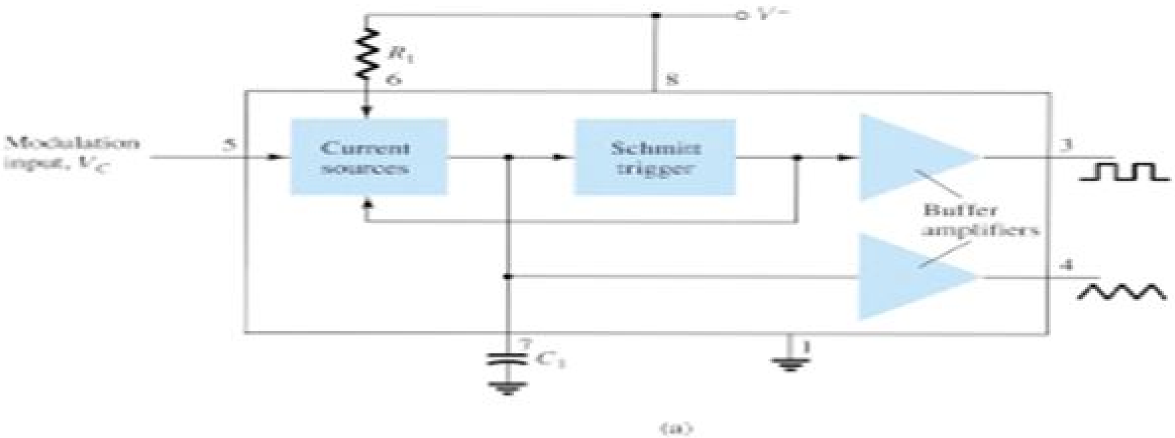


Figure 3.10: The block diagram of the 556 function generation

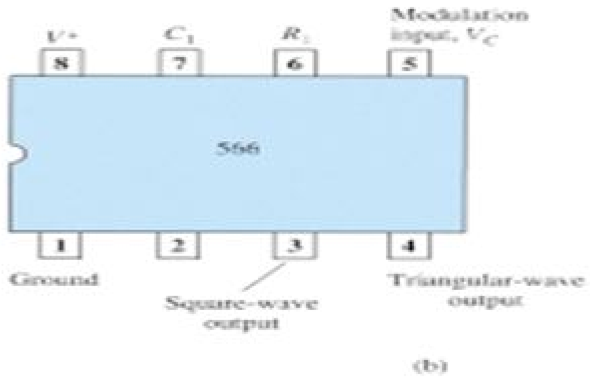


Figure 3.11: pin configuration of the 556 function generator

Figure 3.12 shows an example in which the 566 function generator is used to provide both square-wave and triangular-wave signals at a fixed frequency set by R_1, C_1, and V_C. A resistor divider R_2 and R_3 sets the DC modulating voltage at a fixed value.

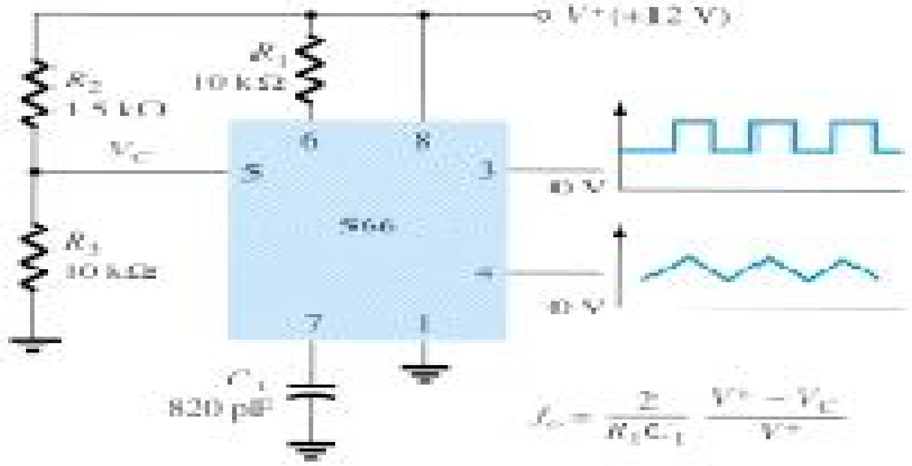


Figure 3.12Connection of 566 VCO unit

$$V_c = \frac{R_3}{R_2 + R_3} \qquad (3.6)$$

The circuit in Figure 3.13 shows how the output square –wave frequency can be adjusted using the input voltage, $V_C$to vary the signal frequency.

Potentiometer R_3allows varying V_C from about 9V to near 7V, over the full 10-to-1 frequency range. With the potentiometer wiper set at the top, the control voltage is:

$$V_c = \frac{R_3 + R_4}{R_2 + R_3 + R_4} \qquad (3.7)$$

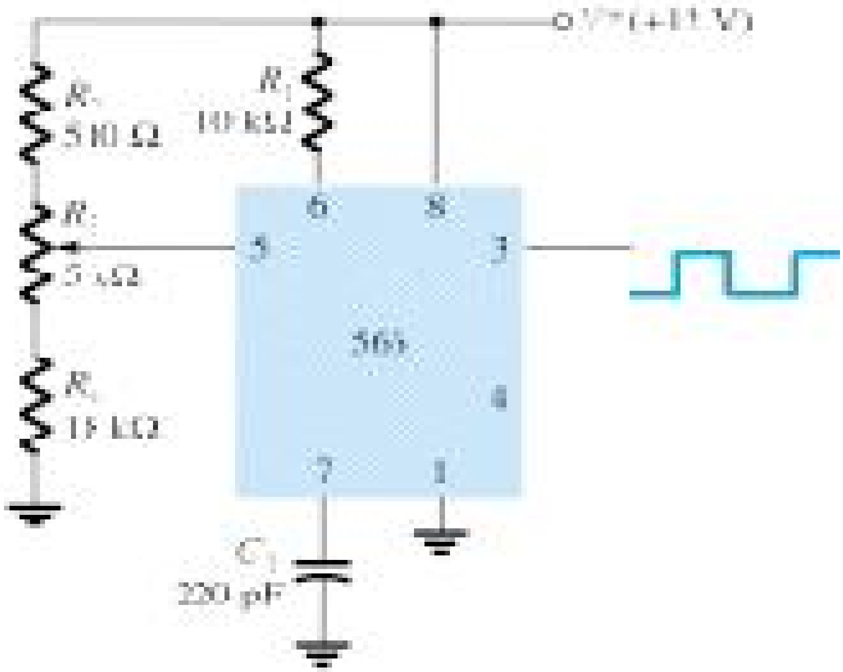


Figure 3.13 Connection of 566 as a VCO unit

3.2.4 Phase-Locked Loop

A phase-locked loop (PLL) is an electronic circuit that consists of a phase detector, a low-pass filter, and a voltage-controlled oscillator connected as shown in Figure 3.14. Common applications of a PLL include: (1) Frequency synthesizers that provide multiples of a reference signal frequency [e.g., the carrier frequency for the multiple channels of a Citizens' Band (CB) unit or marine-radio-band unit can be generated using a single-crystal-controlled frequency and its multiples generated using a phase-locked loop]; (2) FM demodulation networks for FM operation with excellent linearity between the input signal frequency and the PLL output voltage; (3) Demodulation of the two data transmission or carrier frequencies in digital-data transmission used in Frequency-Shift keying (FSK) operation; and (4) A wide variety of areas including modems, telemetry receivers and transmitters, tone decoders, AM detectors, and tracking filters. An input signal, Vi, and that from a VCO, V_o, are compared by a phase comparator providing an output voltage, V_e, that represents the phase difference between the two signals. This voltage is then fed to a low-pass filter that provides an output voltage (amplified if necessary) that can be taken as the output voltage from the PLL and is used internally as the voltage to modulate the VCO's frequency.The closed-loop operation of the circuit is to maintain the VCO frequencyLocked to that of the input signal frequency [3].

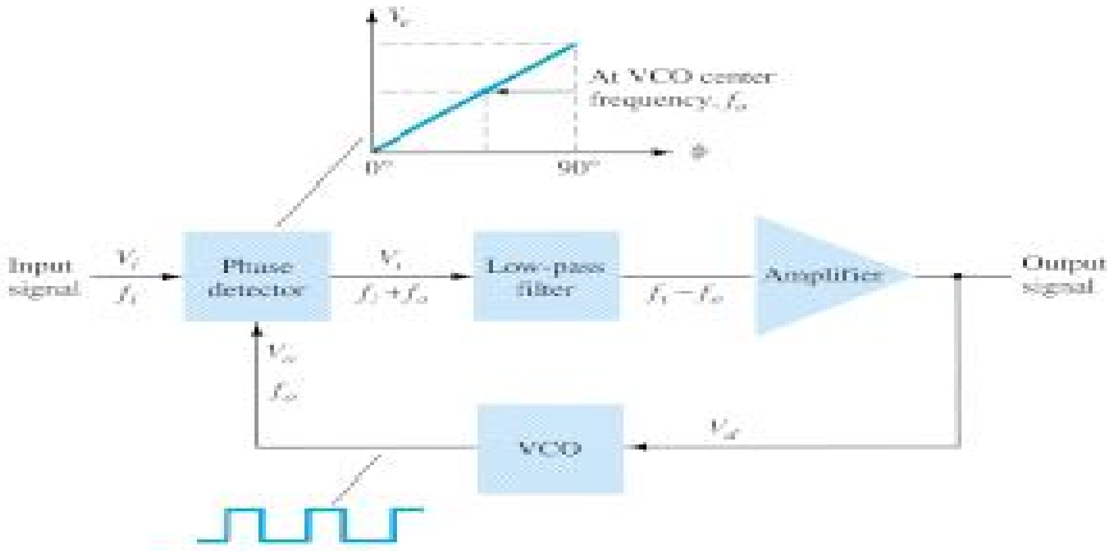


Figure 3.14: Block diagram of basic phase-locked loop

3.5.1Basic phase-locked loop operation

The basic operation of a PLL circuit can be explained using the circuit of Figure 3.14 as reference. We will first consider the operation of the various circuits in the phase locked loop when the loop is operating in lock (the input signal frequency and the VCO frequency are the same). When the input signal frequency is the same as that from the VCO to the comparator, the voltage, *Vd*, taken as output is the value needed to hold the VCO in lock with the input signal. The VCO then provides output of a fixed-amplitude square-wave signal at the frequency of the input. Best operation is obtained if the VCO center frequency, f_o, is set with the DC bias voltage midway in its linear operating range. The amplifier allows this adjustment in DC voltage from that obtained as output of the filter circuit. When the loop is in lock, the two signals to the comparator are of the same frequency, although not necessarily in phase. A fixed phase difference between the two signals to the comparator results in a fixed DC voltage to the VCO. Changes in the input signal frequency then result in change in the DC voltage to the VCO. Within a capture-and-lock frequency range, the DC voltage will drive the VCO frequency to match that of the input. While the loop is trying to achieve lock, the output of the phase comparator contains frequency components at the sum and difference of the signals compared. A low pass filter passes only the lower-frequency component of the signal so that the loop can obtain lock between input and VCO signals.

Owing to the limited operating range of the VCO and the feedback connection of the PLL circuit, there are two important frequency bands specified for a PLL. The capture range of a PLL is the frequency range centered about the VCO free running frequency, f_o, over which the loop can acquire lock with the input signal. Once the PLL has achieved capture, it can maintain lock with the input signal over a somewhat wider frequency range called the *lock range* [3].

3.5.2Applications

The PLL can be used in a wide variety of applications, including frequency demodulation, frequency synthesis and Frequency-Shift keying decoders.

3.5.3Interfacing circuitry

Connecting different types of circuits, either in digital or analog circuits, may require some sort of interfacing circuit. An interface circuit may be used to drive a load or to obtain a signal as a receiver circuit. A driver circuit provides the output signal Connection of 565 as Frequency-Shift keying decoder. voltage or current level suitable to operate a number of loads, or to operate such devices as relays, displays, or power units. A receiver circuit essentially accepts an input signal, providing high input impedance to minimize loading of the input signal.

Furthermore, the interface circuits may include strobing, which provides connecting the interface signals during specific time intervals established by the strobe. Figure 3.15 shows a dual-line driver, each driver accepting input of TTL signals, providing output capable of driving TTL or MOS device circuits. This type of interface circuit comes in various forms, some as inverting and others as no inverting units. The circuit of figure 3.16 shows a dual-line receiver having both inverting and no inverting inputs so that either operating condition can be selected. As an example, connection of an input signal to the inverting input would result in an inverted output from the receiver unit. Connecting the input to the no inverting input would provide the same interfacing except that the output obtained would have the same polarity as the received signal. The driver-receiver unit of Figure 3.16 provides an output when the strobe signal is present (high in this case) [3].

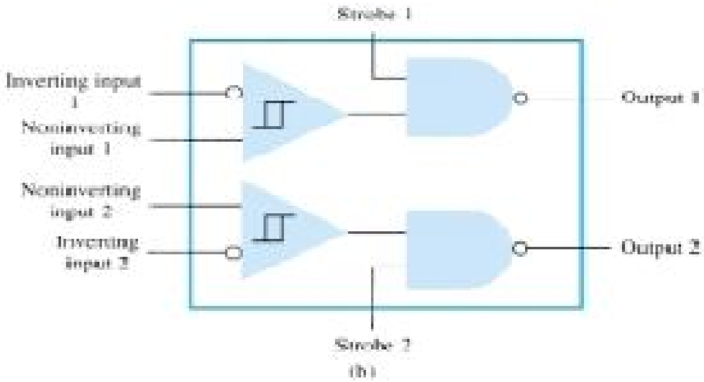


Figure 3.15: Dual line drivers

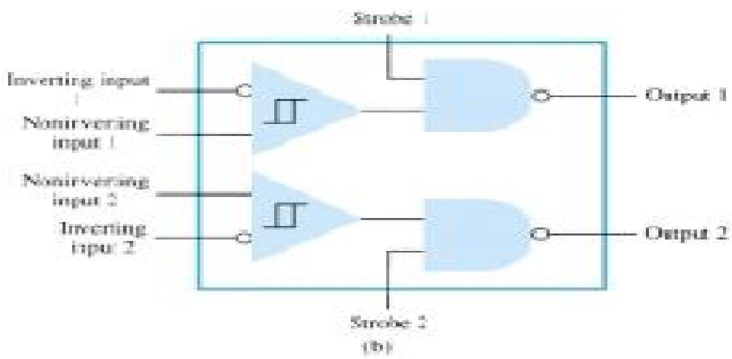


Figure 3.16: dual-line receivers (SN75152)

Another type of interface circuit is that used to connect various digital input and output units, signals with devices such as keyboards, video terminals, and printers.One of the electronic industry standardsis referred to as RS-232C. This standard states that a digital signal represents a mark (logic-1) and a space (logic-0). The definitions of mark and space vary with the type of circuit used (although a full reading of the standard will spell out the acceptable limits of mark and space signals).

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

Figure 3.13 The circuit Diagram The chapter demonstrators the experimental results of the servo motor.

4.2 Circuit Test

Figure 4.1 shows the complete simulation circuit using the proteus software.

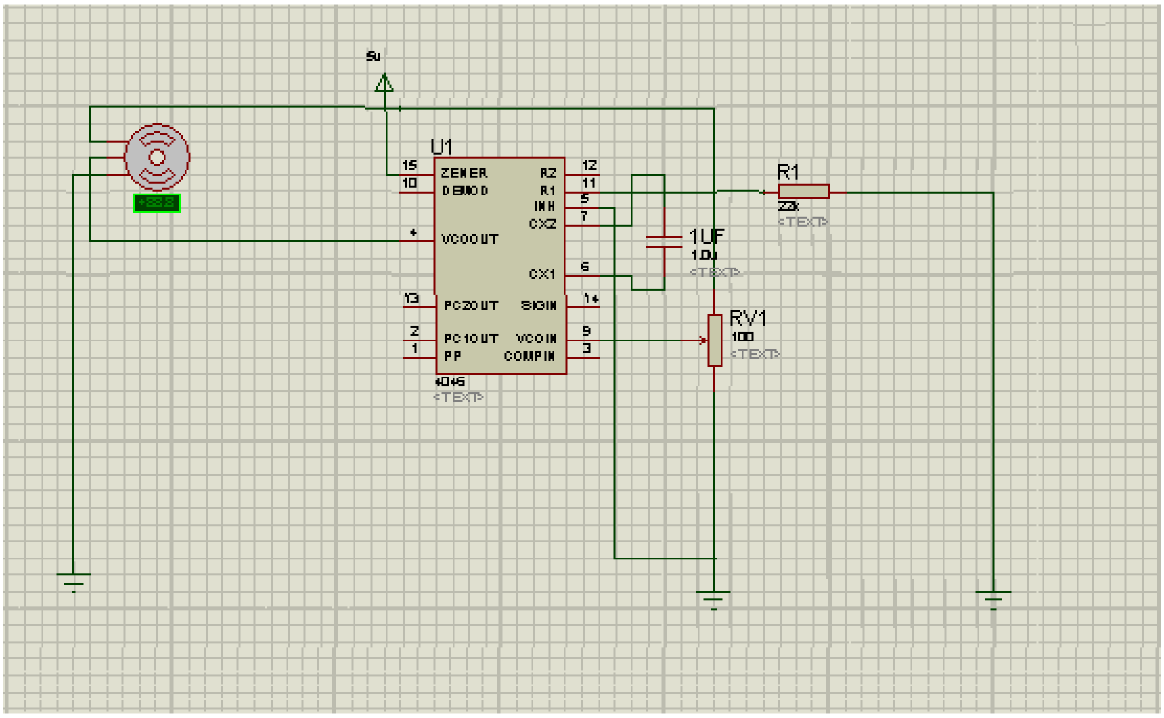


Figure 4.1: The complete simulationcircuit

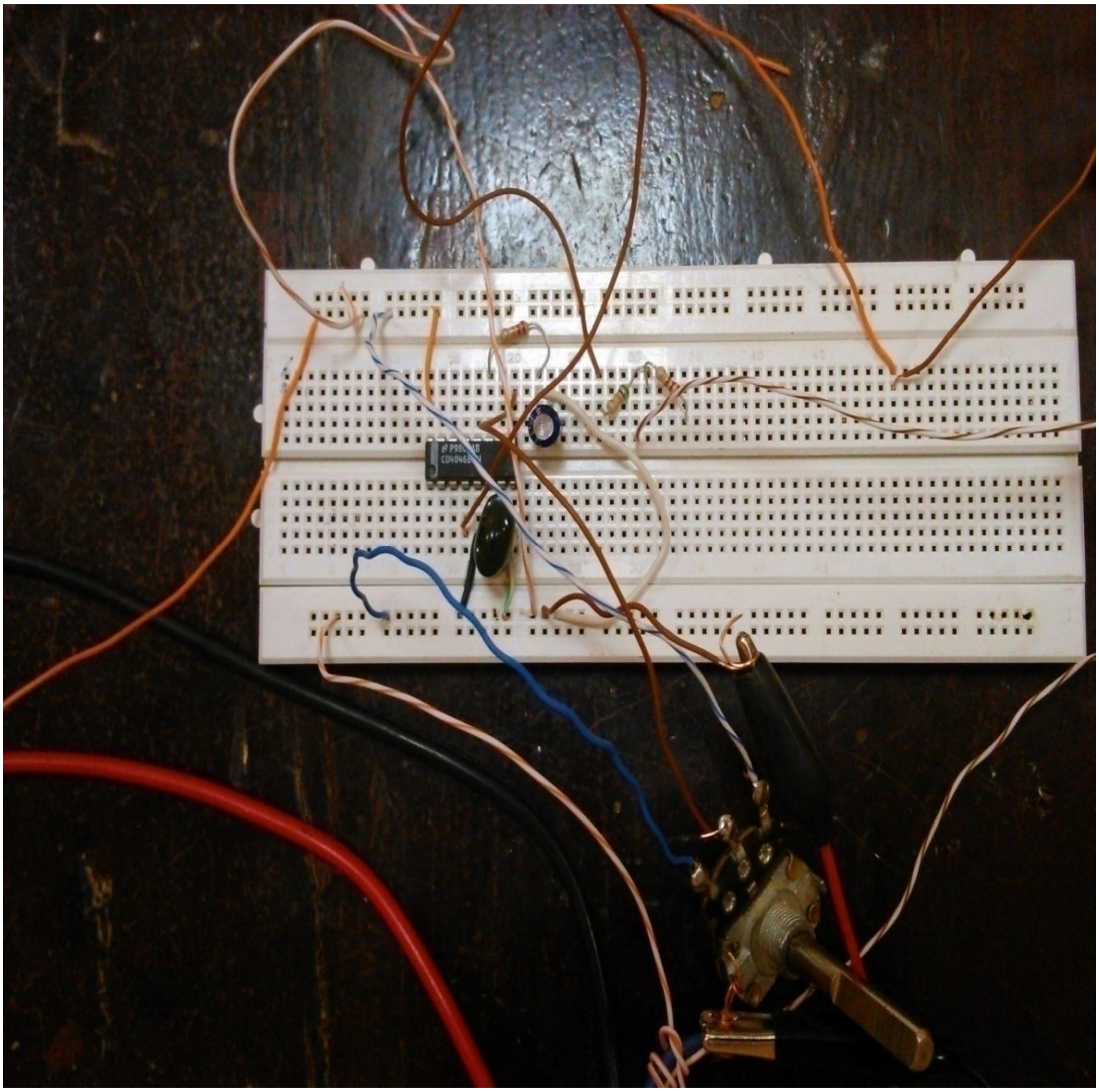


Figure 4.2: The circuit implementation using phase locked loop

Figure 4.3 shows the experimental result at 207KHz.

Figure 4.3: The frequency locked at 207KHz

As it appears in the results, at 207KHz the phase locked loop shows agood tracking to the input signal, but the response of the actuatoris relatively slow, thus it’s suitable to be used for low flying speeds. Figure 4.3 shows the experimental result at 301KHz.

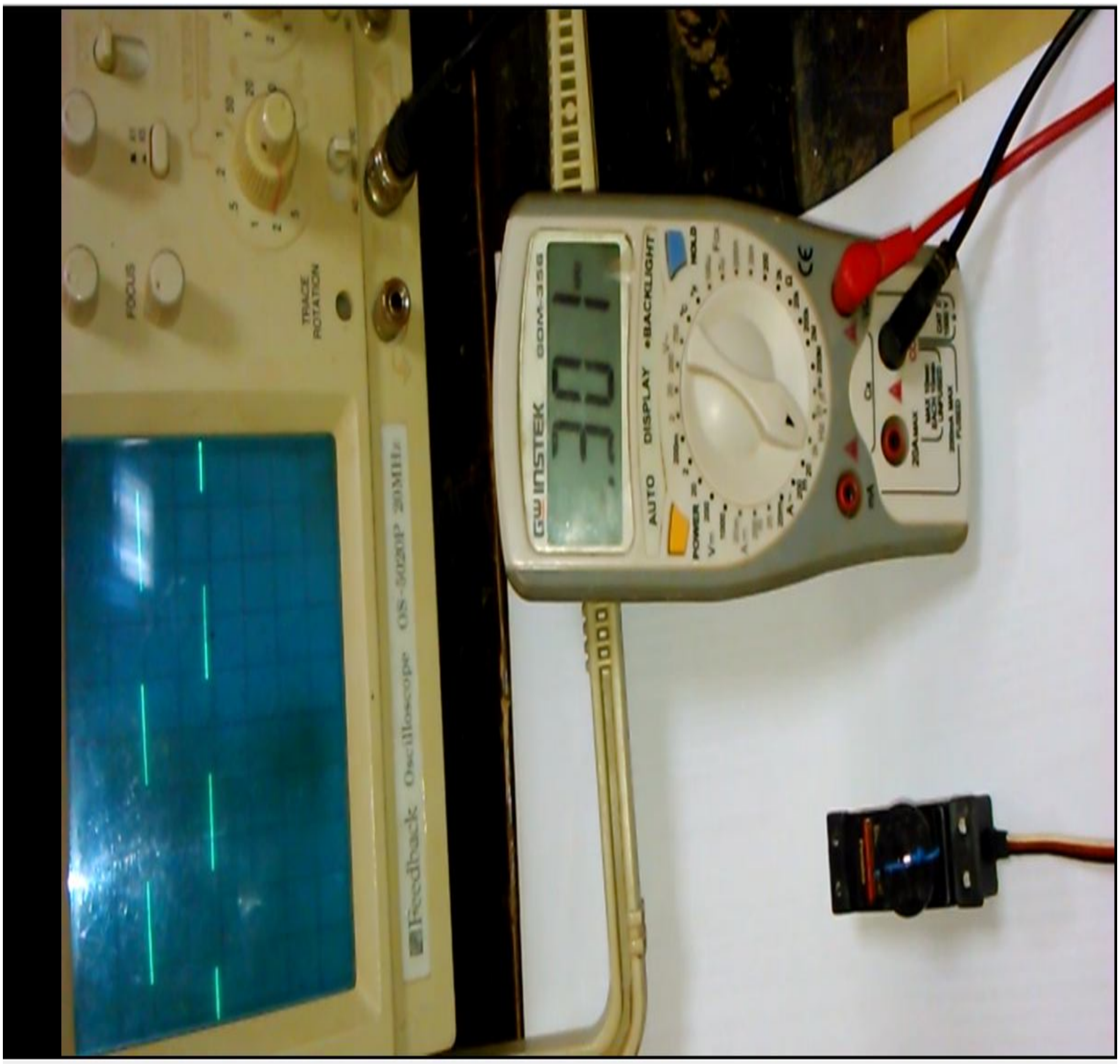


Figure 4.4: The frequency locked at 301KHz.

At301KHz the phase locked loop tracks the input signal appropritely, thus keeping the VCO output at the required level,also the response of the actuator is increased reasonably good thus it’s compatible for medium speeds of flight. Figure 4.3 shows the experimental result at 617KHz.

Figure 4.5: The frequency locked at 617KHz.

While at 617KHz the phase locked loop tracking and the actuator response are extremely rapid and accurate, thus it will be optimum for high speed of flight.

CHAPTER FIVE

CONCLUSION and RECOMMENDATIONS

5.1 Conclusion

The phase locked loop (PLL) used to control the landing, take off and change of direction using servo motor. The output of the phase detector would respond immediately to vary the speed of the motor in such a direction and magnitude as to retain the locking of the reference and feedback frequencies. The response of the phase detector is very fast. As long as the two frequencies are locked, the speed regulation should ideally be zero. However, in practice the speed regulation is limited to 0.002%, and this represents a significant improvement over the analog speed control system.

The PLL synthesis by Voltage Control Oscillator, phase detector, low pass filter. The result of the experiment shows the servo motor has lock rang 200kHz to 600kHz and capture range can controlled by Phase Locked Loop between (200-600)KHz must be at minimum greater than 200KHz or equal and maximum less than 600KHz or equal.

5.2 Recommendations

1. Use phase locked loop (PLL) for reversing speed direction.
2. To determine the feature phase locked loop control scheme, it is recommended to use a pulse width modulation circuit and compare the control results with phase locked loop circuit.
3. Using discrete component such as OP_AMP and transistor.

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