DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
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COIMBATORE-641 006

# CERTIFICATE

P-205

*This is to certify that the report titled*

## A STATIC SERVO STABILIZER

*has been submitted by*

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SHANKAR. K

*in partial fulfilment for the award of Bachelor of Engineering in the Electrical and Electronics Engineering Branch of the Bharathiar University, Coimbatore-641 046 during the academic year 1994-95.*

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*HEAD OF THE DEPARTMENT*

*Certified that the candidate was examined by us in project work Viva Voce Examination held on .................... and the University Register Number was ....................*

*INTERNAL EXAMINER*

*EXTERNAL EXAMINER*

## Acknowledgement

We deem it as our proud privilege to have our Head of epartment, Dr.K.A.Palaniswamy,B.E, M.Sc.(Engg.), Ph.D, MISTE, .Eng(I),F.I.E, as the guide for our project titled 'A Static ervo Stabilizer'. We thank him for the invaluable guidance and ncouragement rendered to us.

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# S Y N O P S I S

The machines of the modern era require power supplies that are of a high level of accuracy and more or less a constant value of voltage.

Our project, titled 'A Static Servo Stabilizer', is a step towards ensuring a stable supply of power which is a pre-requisite for expensive machinery and computers.

This project basically deals with the design,fabrication and esting of the Static Servo Stabilizer. The Aluminium foil ransformer ensures that there are no moving parts in the stabiizer as in the case of the conventional voltage stabilizers that ncorporate Auto Variacs to control the voltage levels of the ervo motor.

Consequently,the size of the stabilizer has been reduced and Aluminium, being cheaper than Copper has ensured that the cost is also reduced.

The design particulars, fabrication details, mode of servo-mechanism and the testing procedures have been extensively dealt with in this report.

CHAPTER

CONTENTS

PAGE NO

# CHAPTER I

## Introduction

### .1 .Need for voltage stabilizers

he provisions of the Indian Electricity Act requires that wer supply voltage should not rise or drop by more than .But we find voltage fluctuations taking the 230v mains supply ltage to as low as 150v or as high as 300v occasionally. ch enormous increase in loads connected to a distribution nsformer,the electricity suppliers now find it exceeding ficult to maintain the voltage within the stipulated ues.This has made necessary the use of an automatic voltage bilizer for almost every instrument. Even domestic appliances refrigerators and t.v sets need a stabilizer before connect- power to them,not to speak of computers and other expensive pment.

Principle of voltage stabiliser

Fig. 1.1 shows the block diagram of a voltage stabiliser cted to an appliance or load. When there is a change in voltage from 170v to 260v, the output voltage mains con- d to the load maintains a voltage of 215v to 220v. The iser's size increases generally with its rating, which is in KVA.

## The types of voltage stablizers

various types of voltage stabilizers are:

Ferroresonant type stabilisers

Relay type stabiliser

Servo stabilisers

### Ferroresonant type stabiliser

bout 20 years ago, the most frequently employed volt-
abiliser was the ferroresonant type. This uses two trans-
, one with a saturating core and the other,ordinary. The
le of ferroresonance in the saturating core was used to
he output voltage constant even though the input voltage
ariations over and below the rated nominal voltage.Ironi-
he output voltage waveform in such a stabiliser is
d due to the saturation effects and some equipments
blems due to this.

ferroresonant type being all static,with no moving parts is
able and has a long life.

2 Relay type stabilizer

ay type automatic stabilizers cater for small variations in
voltage.Fig. 1.2 shows the relay operated voltage stabilis-

he relay contact changeover is done by a sensing uit.This compares a fraction of the input voltage with xed reference voltage and depending on the value being over ow the reference,it causes the relay to operate up or osition.

number of variations of this circuit are employed in
.

lly,these relay type voltage stabilisers have the g disadvantages:

1.Power is off momentarily during relay changeover, sensi-
e equipment like computers cannot afford this.

2.The voltage range is very limited.

3.Relay contact gives problems.

4.Accuracy is limited.

## 3 Servo Stanilizers

nventional servo stabilizers employ a toroidal auto former and a servomotor driven by a circuit which s the voltage.The toroidal auto transformer has a toroidal It has a contact arm housing a carbon brush,which makes a g contact with the coil wound over the toroid,just as in a iometer.The toroidal core is circular.

amelled copper wire which is wound around the toroid uni .is exposed at the top side where the contactis made by the brush of the moving assembly.The output voltage is ied automatically on varying the position of this contact. this purpose, a servomotor fitted with gears is coupled to contact arm.

The sensing circuit senses the voltage difference between the tput and the nominal voltage. It drives the servomotor er suitable power amplification in clockwise or anticlockwise ection. As the motor moves the contact on the winding of the transformer, it reduces the voltage difference which becomes when the output voltage reaches the nominal value. There is error signal. Now, the servomotor stops. Further variations mains causes the motor to move forward or backward again, thus ecting the voltage.

The servo stabilizer is quite accurate as its resolution is dant on the voltage across each turn of the toroidal wind- This resolution depends on the core size of the toroid.

A servo stabilizer,however, has the disadvantage that it ds to hunt if the input voltage fluctuates too often. Also it s slowly and cannot adjust to sudden shoots or dips of main tage. Actually,the servomotor takes atleast a moment for,say a input change. But if the voltage fluctuates suddenly from to 260 as is common when a heavy powerload is switched off on distribution line,it will take more than one second. During time, the equipment will be subjected to this sudden over age of 260v. In fact, it is these sudden fluctuations that ly spoil the equipment.

Hence there is a need for a Voltage stabilizer which will ect the voltage smoothly without hunting and quickly. In this ect an attempt is made to develop such a stabilizer.

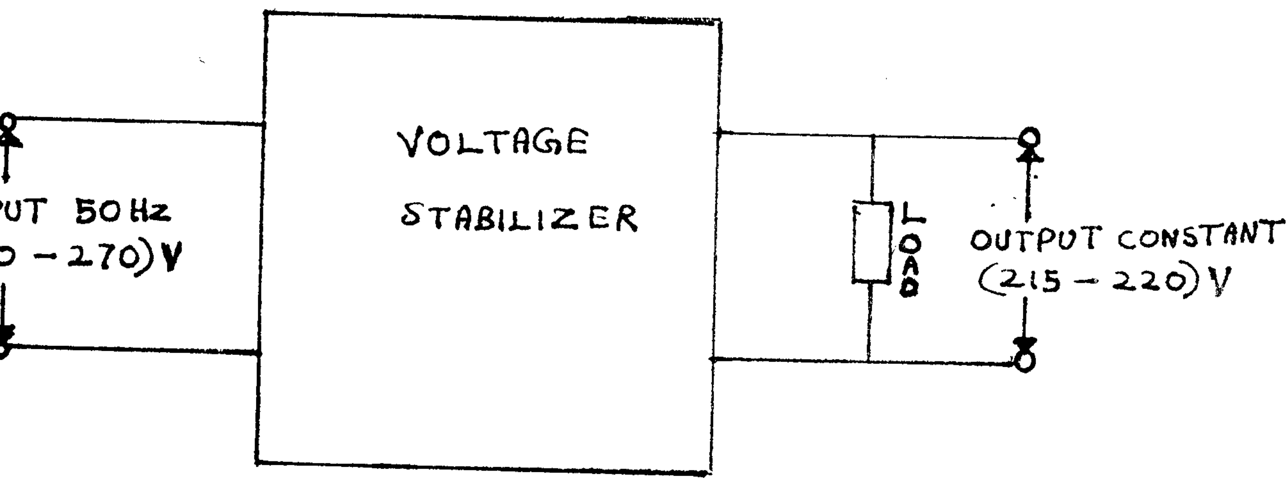



Fig 1.1 BLOCK DIAGRAM OF VOLTAGE STABILIZER

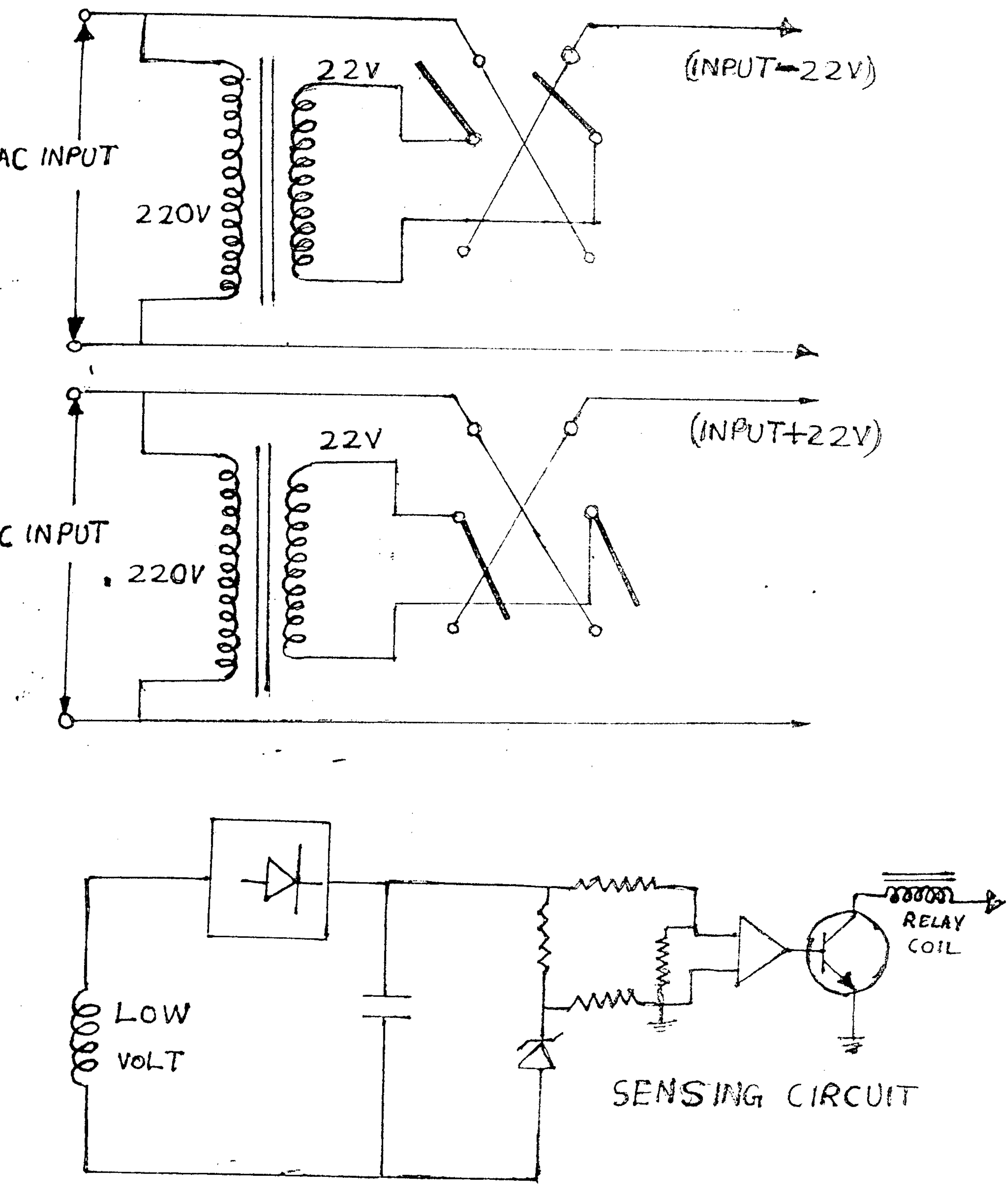



Fig 1.2. Relay operated voltage stabilizer

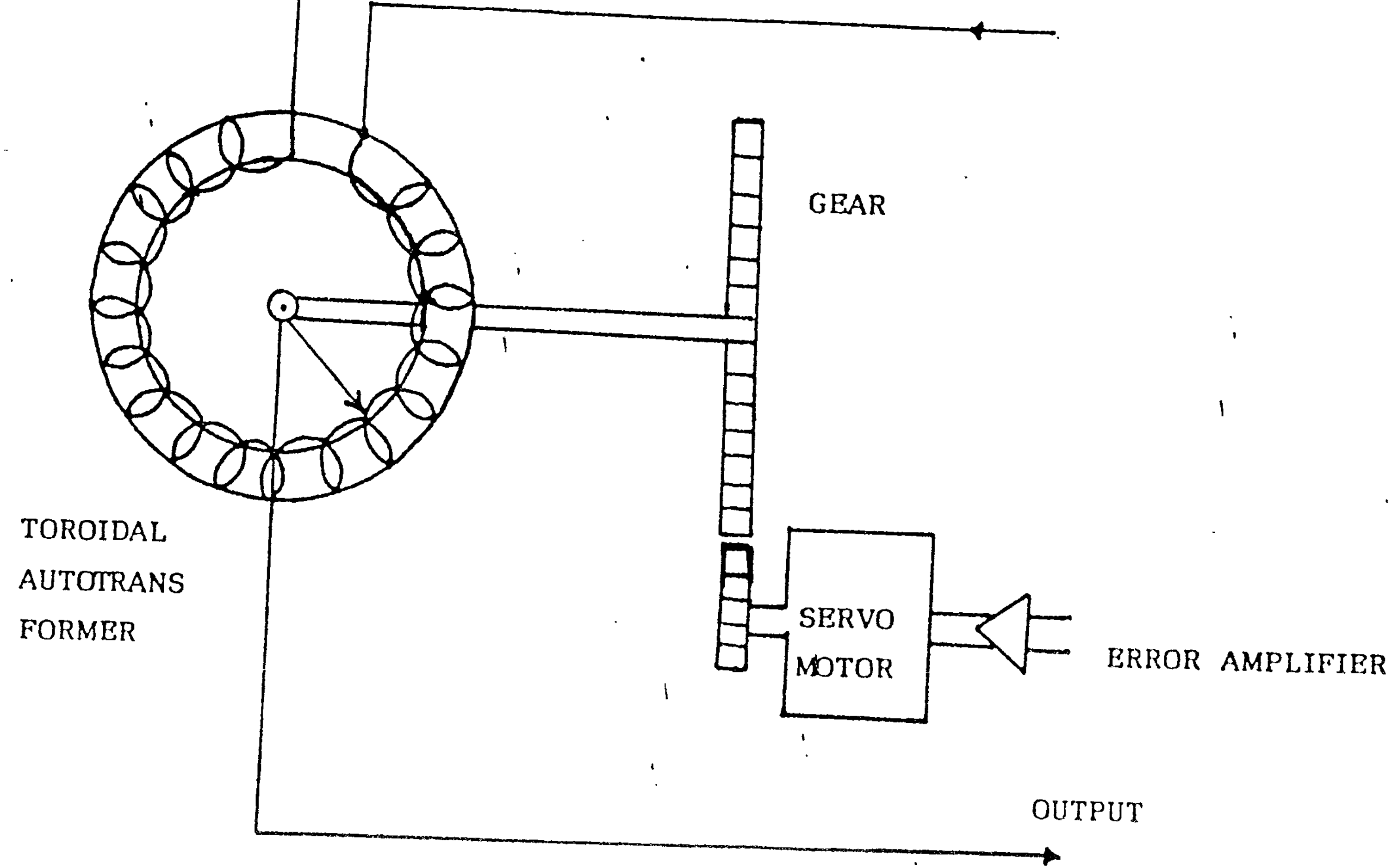



Fig 1.3 SERVO STABILISER WITH SERVO MOTOR

# CHAPTER II

## STATIC SERVO STABILIZER

### 1 Principle of operation.

Transformer is a high input impedance and low output
pedance electrical device.With its input impedance being high
e transformer can support the voltage applied to it draw-
g a small no-load current required for magnetisa-
on.The magnetic flux generated interacts with the output coil
ich can feed current to the load.The impedance of the output
il is therefore low to prevent a voltage drop across the
il.If the impedance of the output coil is increased,the
ltage across the coil starts dropping and the output voltage is
duced.As the coil resistance has not changed,the losses are
me for the required load.Hence,the voltage at the output gets
anged without a loss in efficiency.

The output impedance is varied by controlling the reactance
the limb supporting the output coil.The output voltage is

sed and fed back for error detection.Depending upon the error reactance of the support limb is controlled to rease/decrease the voltage available at the output.This is e by varying the ampere turns of the coil through an elec- nic switching system which facilitates quick response and t correction without overshoots.This makes the stabilizer a ole closed loop system.

The unique design of this transformer enables it to detect ıration on account of high input voltages or output short uit conditions.As the transformer does not work on the ciple of saturation,the detection of saturation enables it cutoff its input supply,to be restored manually by the .This is an additional safety precaution.

2 Block diagram description

Fig.2.1 shows the block diagram of a Static Servo Stabiliz-
r. The stabilizer can be broadly divided into the following
ocks.

(1) Main system block

(2) Feedback system block

(3) Protection block

The main system block consists of a three limb transformer d the triac card. The triac card has 7 triacs and one of these nducts at a time depending on the magnitude of the error volt- e. These can have a common heat sink as only one of the triacs going to be conducting at a time.

The feedback system block is concerned with the feedback op of the system. The system is closed loop feedback and the curacy is more.This consists of current transformer for sensing rrent, power transformer for supplying power to the various rking components. The sensing transformer is for getting a mple of the output voltage.

The cntrol card shown in fig. 2.2 is one of the main parts f the system. This has the control logic which decides which riac is to be fired. The display card indicates the status with ne help of 7 LEDs.

The protection block essentially consists of the various vices which are used for over-current and over-voltage protec- on to the stabilizer and the load. This includes the fuse, MCB, ne filter, Metal oxide varistor, On/off switch and the cut-off ay. The cut-off relay is used for protection of the load.

.3 Working of Static Servo Stabilizer

Each functional block does a specified function in achieving the final objective mentioned.The function of each block is xplained and the operation of the stabilizer is explained with eference to the functional blocks.

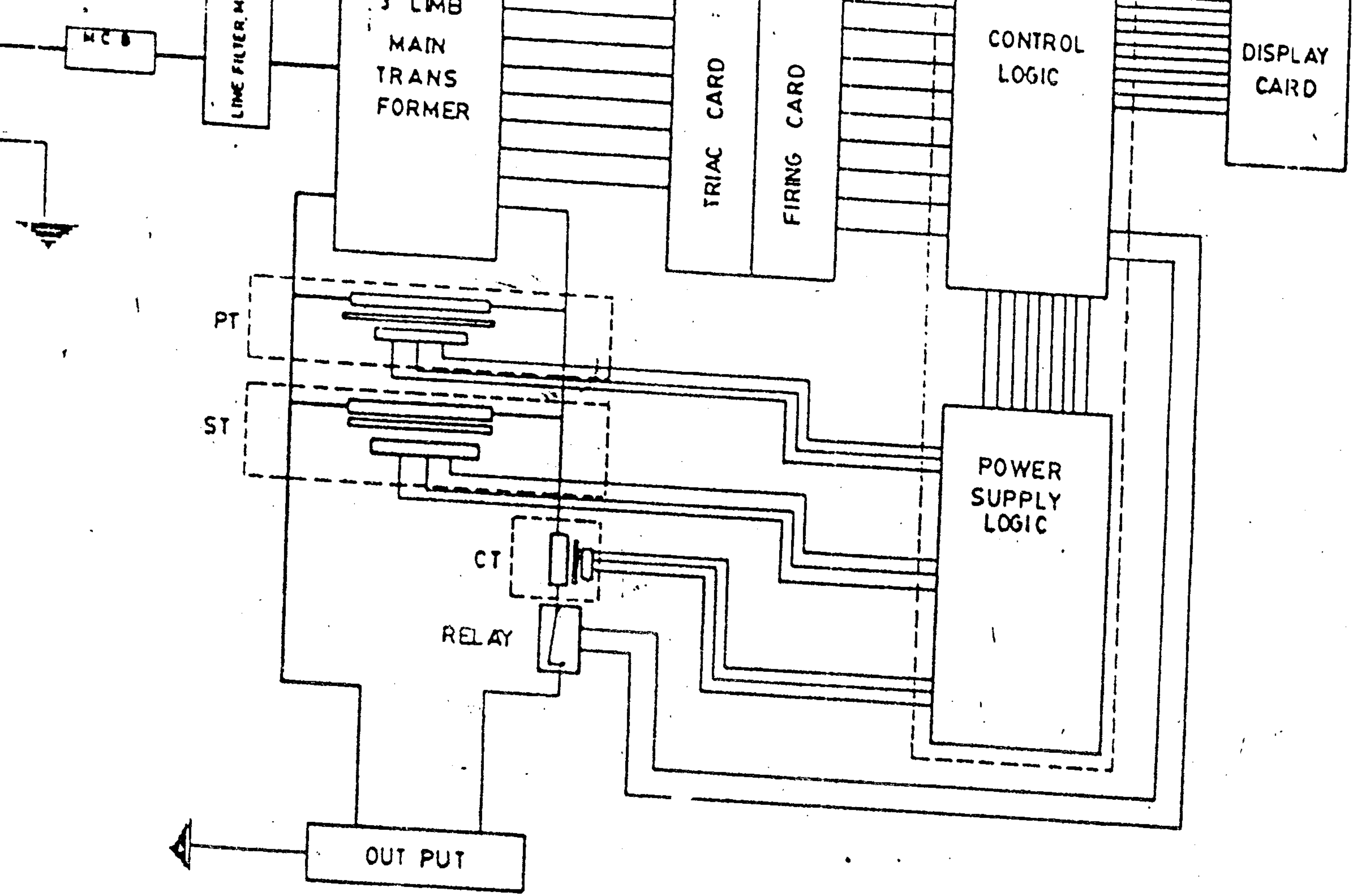
The control circuit which senses the output voltage through e voltage-sensing transformer determines how much voltage ould be added or subtracted from the input voltage so as to intain the output voltage constant at the specified level.

The protection part of the control circuit determines taking to account the output voltage sensed through the voltage nsing transformer,whether or not the output voltage is within e specified cutoff limits.It also senses the output current by ans of the current sensing transformer,whether or not the tput current is within the permissible limits.If the output tage is above the upper cutoff limit or below the lower

toff limit or if the output current is above the permissible mit the protection circuit de-energises the cutoff relay and sconnects supply to the output terminal.Thus any load con-cted to the output terminal is protected from damage through der/over voltage and overload.

The annunciator circuit is shown in Fig. 2.3. It displays e operational status on 7 LEDs.The power transformer sup-ies the power necessary for operation of the control,protec-on and annunciator circuit.

The earth terminal on the input and the output terminal cks is connected to the chassis of the stabilizer,so as to ntain the stabilizer body at earth potential and avoid sibility of any electrical shock.




G 2.1 BLOCK DIAGRAM OF STATIC SERVO STABILIZER

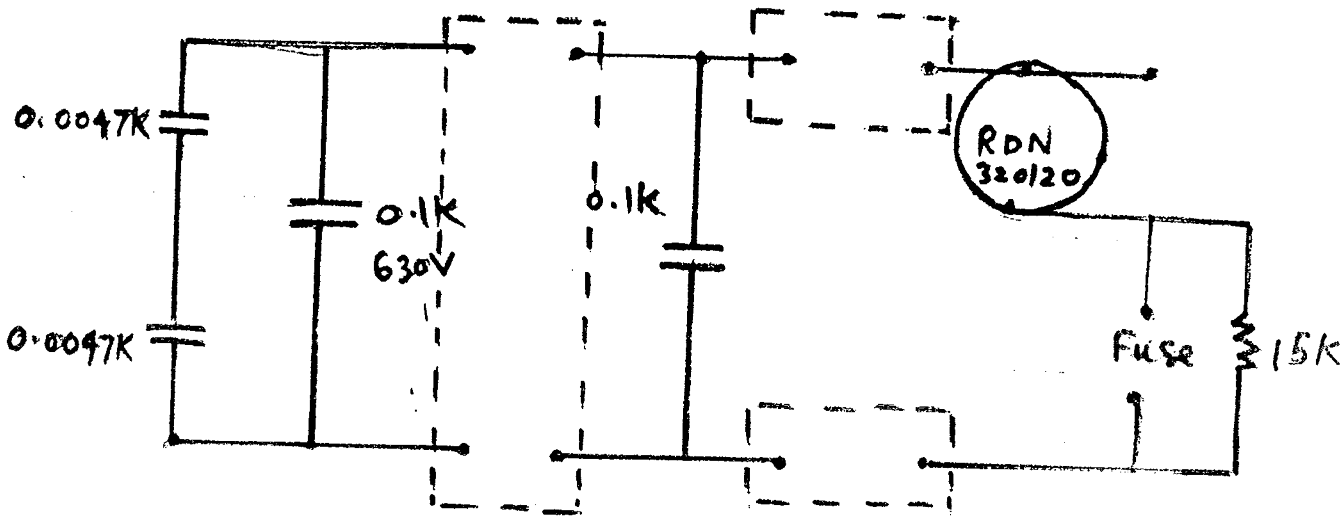



Fig. 2.2. CONTROL CARD

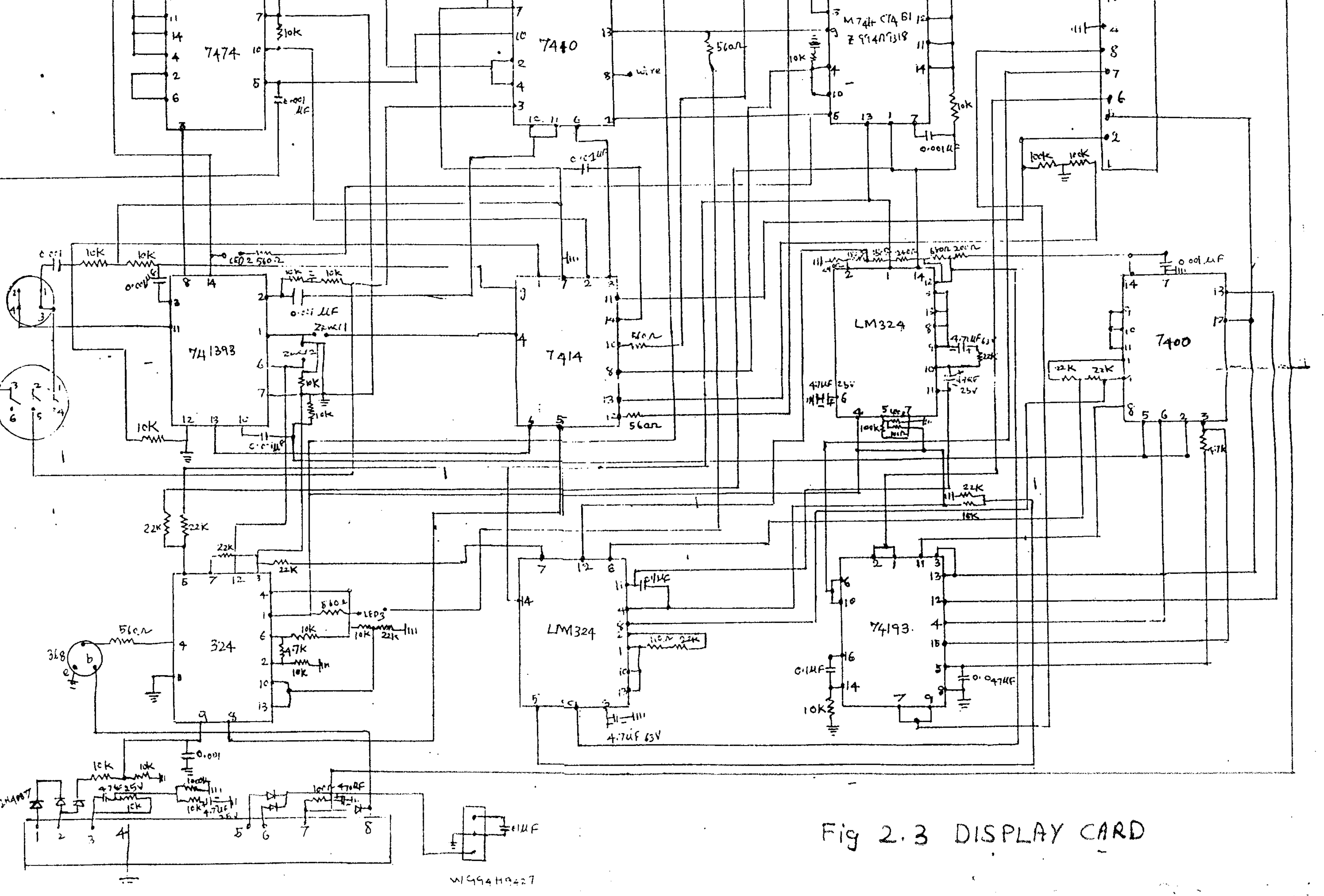



Fig 2.3 DISPLAY CARD

## CHAPTER III

## CONTROL OF VOLTAGE

### 1 The Triac

The triac structure is considerably more complicated than conventional thyristor. In addition to the P1 - N1- P2- N2 nctions there is a junction gate N3 and N4 region in contact ch MT1.

The triac can switch the current in either direction by olying low voltage,low current pulse of either polarity between gate and one of the two main terminals M1 and M2.

The current voltage charectrestics and the device symbol the triac are shown in fig.3.1 . The triac is a symmetri- triode switch that can control loads supplied with ac power. integration of two thyristors on a single chip results in one haif of the structure being used at any one time.

2 Operation of triac

Fig.3.2 shows the construction of a triac. When the main rminal MT1 is positive with respect to MT2 and a positive ltage is applied to the gate, the junction J4 is reverse ased and is inactive , the gate current is supplied through e gate near the N3 region. Since junction J5 is also reverse biased and inactive, the main current is carried through e left side of P1 -N1 - P2 - N2 section.

When MT1 is negatively biased with respect to MT2 and VG positively biased, the junction J3 becomes forward biased tween M2 and the shorted gate. Electrons are injected into and diffuse to N1, resulting in an increase in the forward as of J2. By the regenerative action,eventually full current carried through the short at MT2. The gate junction J4 is verse biased and is inactive. The full device current is rried through the right side of P2 -N1 - P1 - N4.

## Triggering of Triac

Trigger pulses are used to start the triac. Each triac ducts through trigger pulses applied between two of its pins and G.

There are many triacs in the circuit. Depending upon the r between the voltage at input and standard reference voltage of the triacs gets signals to trigger it to conduction. The c is divided by the magnitude of the difference in volt- . Thus the output voltage is adjusted to buck or boost input.

The pulse circuit produces coinciding with the zero cross- f the ac voltage wave and hence any triac starts conduction zero of voltage wave.

If the voltage rises at the input, the trigger pulse goes
the next lower triac, but only at the immediately coming zero
ossing of the voltage wave and till then only the former triac
uld have been conducting. Thus the output voltage varies only
the zero crossing of the voltage wave.

4 Voltage correction

The transformer used in this project has 3 windings. There a Primary and a Secondary limb and in addition there is a ıtral limb common to both. The Secondary is divided into 7 ɔpings, each section wound for 12.5 volts. By connecting the ıse of the mains supply, we can get upto 40 v above or below e input voltage by taking the output from one of the Second-'s tappings.

Fig. 3.3 shows the triac card which controls the triggering the triacs. The control circuit triggers one of the 7 triacs ɔending on the voltage correction and when the input voltage is ıced to a value less than the nominal value, the triac con-ted to one of the upper 3 taps will be triggered. The lower input the higher is the tap which is selected for triggering triac connected to it. The other terminals (MT2) of all the acs are joined together and go to the output connection.

Each triac conducts through trigger pulses applied to the
1 and G. A comparator integrated circuit provides 7 outputs
pending on the input voltage to one of the pulse transformers.
ven gates are wired between the pulse forming circuit and the
lse transformer, and only one of them is activated as and when
quired. There is a seven output comparator which enables one of
; 7 outputs to open one of the 7 gates. Thus, depending on the
ror between the voltage input and a standard reference voltage,
of the 7 triacs gets pulses to trigger it to conduction. The
ac is decided by the error magnitude. Thus the output voltage
adjusted so as to Buck or Boost the input.

The pulse circuit produces pulses coinciding with the zero-
ssing of the AC voltage , and hence any triac starts conduc-
n from the zero of the voltage wave.

If the voltage rises at the input, the trigger pulse goes to e next lower triac, but only at the immediate coming zero-ossing of the Sine wave and till then only the former triac uld have been conducting. Thus the output voltage varies only the zero crossing of the voltage wave.

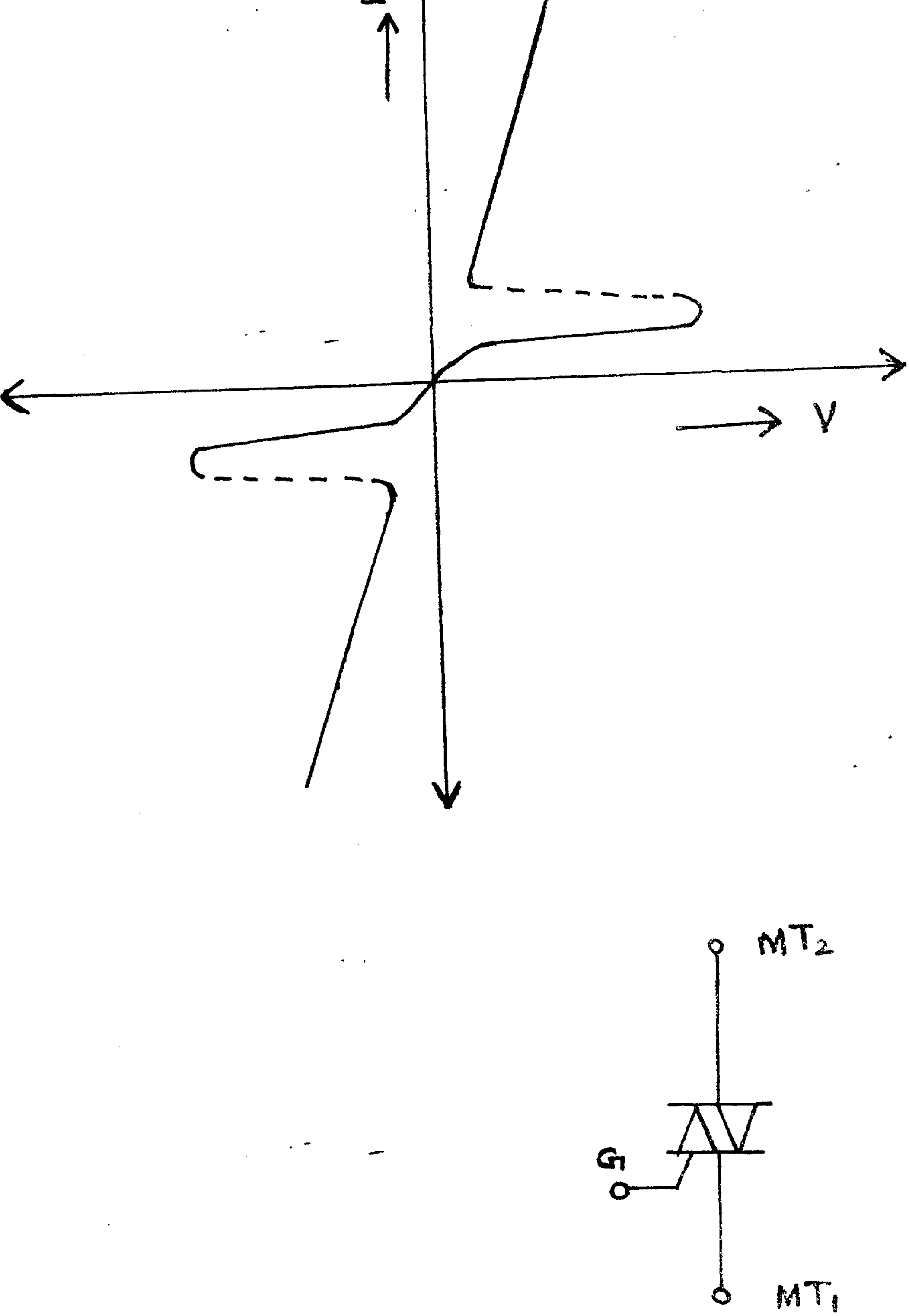



Fig 3.1 V-I CHARACTERISTIC OF TRIAC
AND TRIAC SYMBOL

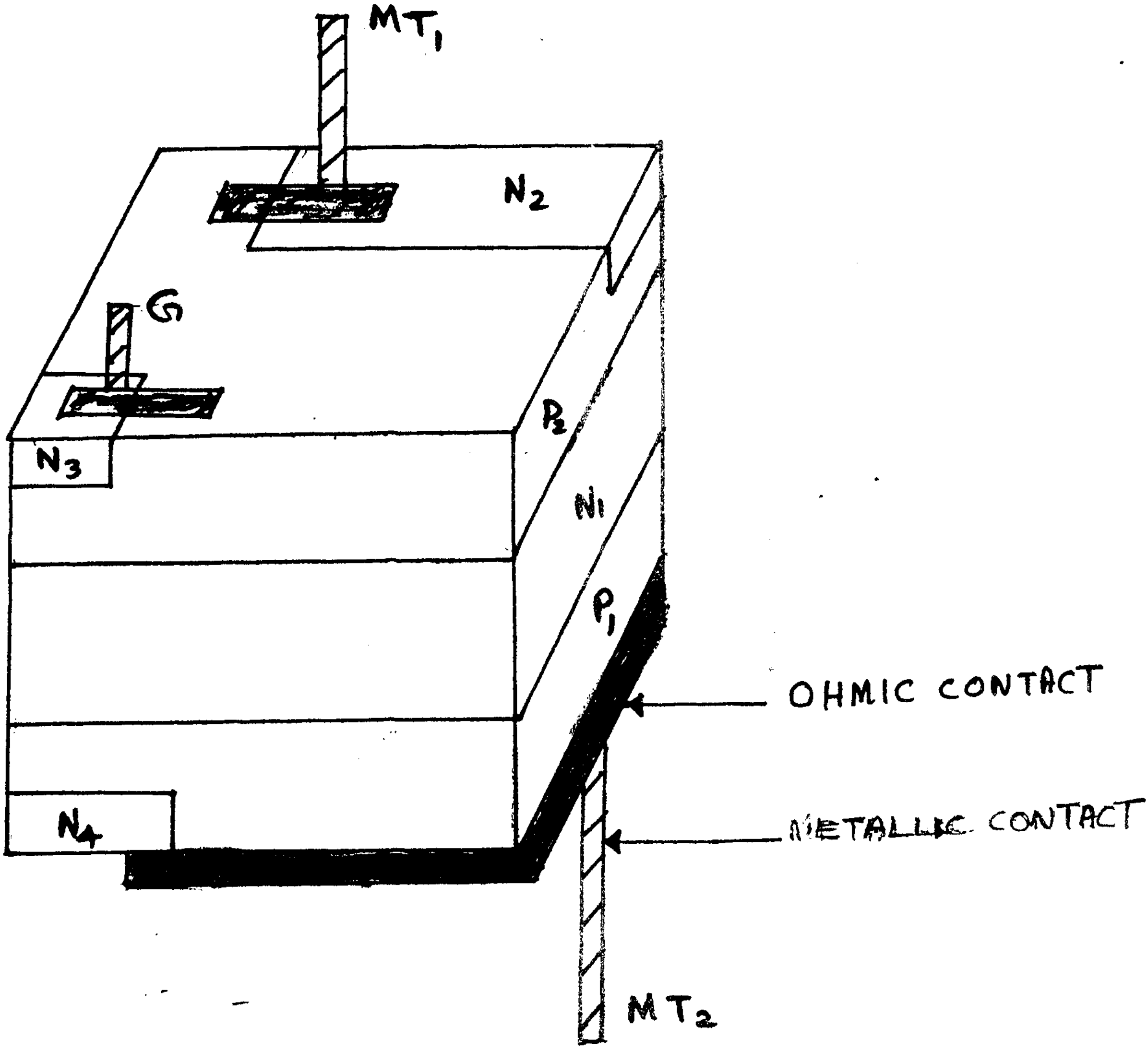



Fig 3.2 CONSTRUCTION OF TRIAC

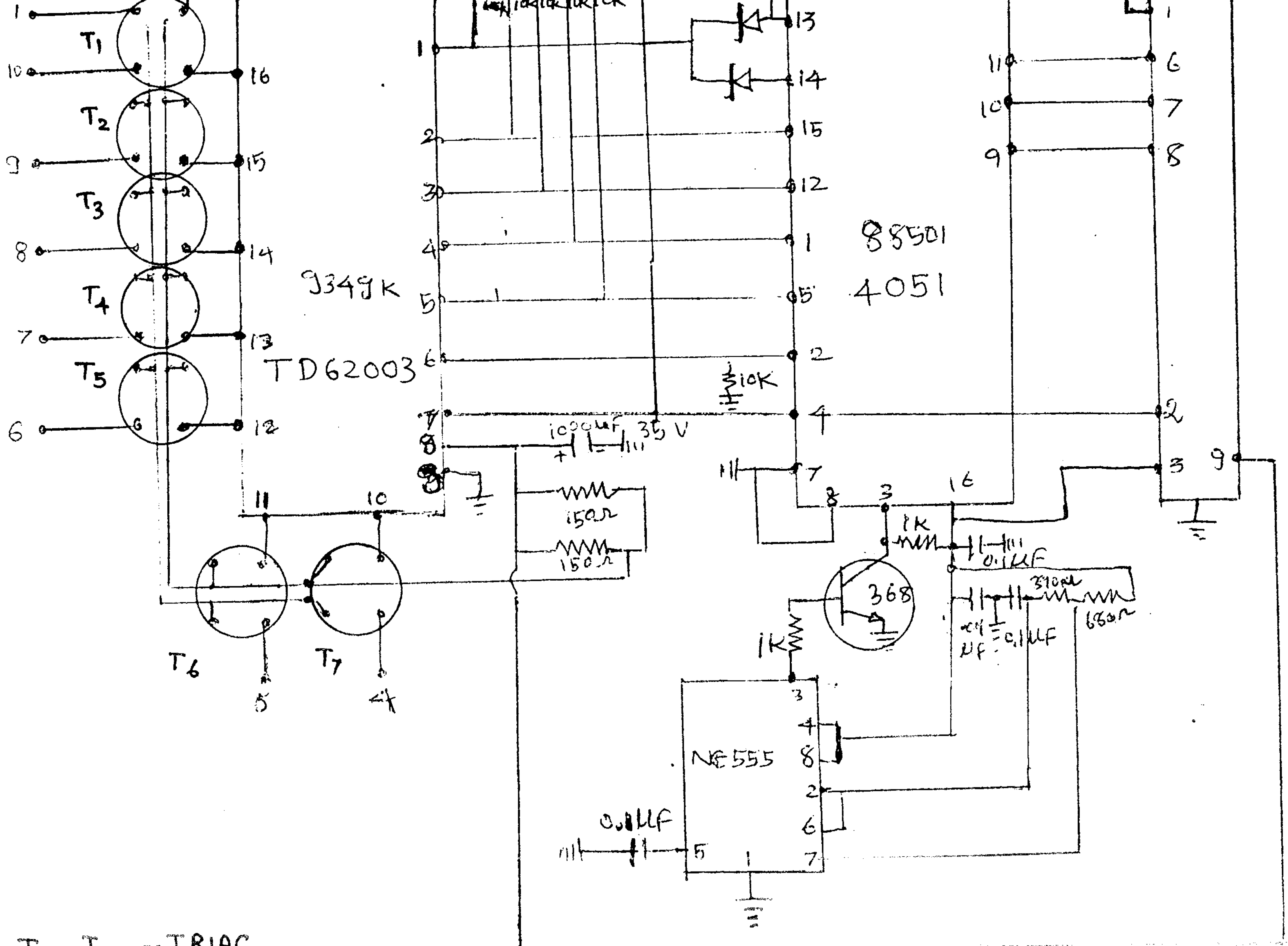



Fig 3.3 TRIAC CARD

# CHAPTER IV

## DESIGN AND FABRICATION

1 Design of transformer

Rating of the transformer = 1 KVA.

Primary voltage = 230 V.

Therefore,

$$\text{Primary current} = \frac{\text{KVA Rating}}{\text{Primary voltage}}$$

$$= \frac{1000 \text{ VA}}{230 \text{ V}}$$

$$= 4.37 \text{ A.}$$

Secondary voltage = 220 V.

Secondary current = 4.5 A / for user specification.

Type of Core : Ferrite, CRNO type( cold rolled non - grain oriented )

Maximum flux density of CRNO type core,

Bmax = 11,625 lines/sq.cm.

Area of the core = (Stack height x Tongue width)

Stack height = 7.62 cm.

Tongue width = 2.54 cm.

Therefore,

Area of the core = 7.62 x 2.54

= 19.35 sq. cm.

$$\text{Maximum flux density} = \frac{\text{Primary voltage} \times 1\text{ E }08}{4.44 \times f \times Tp \times Ai}$$

$$\text{Primary Turns} = \frac{230 \times 1\text{ E }08}{4.44 \times 50 \times 11{,}625 \times 19.35}$$

= 460.46 (or) 461 turns approx.

e voltage at secondary ,

$$V_s = \frac{I_p \times V_p}{I_s}$$

$$= 223 \text{ V.}$$

d according to formula,

$$\frac{\text{Primary voltage}}{\text{Secondary voltage}} = \frac{\text{Primary turns}}{\text{Secondary turns}}$$

erefore,

$$\text{Secondary turns} = \frac{461 \times 223}{230}$$

$$= 447 \text{ turns}$$

ination type : 16 B.

de of core : 74 E-I.

ulation : Class E.

## .2 Fabrication

The cover for the stabilizer was fabricated at M/s. Vintech vt, Ltd.,Coimbatore. 4 mm. thickness metal sheet has been used or this purpose. A handle has been provided to make the stabi- izer portable.

The Aluminium foil is of a few microns thick. The printed ircuit board (PCB) work was done at M/s. Zenith Circuits. The anufacture of this prototype on a large scale would make it heaper.

The transformer was fabricated at M/s. Indian Transformers vt. Ltd., Coimbatore. The E-I stampings of grade 74 E-I were sed for fabrication.

.3 Testing

The static stabilizer was tested at M/s. Ohm Sun Electron-
ics, Coimbatore using suitable testing kit. Voltages in the range of 170 to 270 volts were given and it was found that the output voltage corrected itself to 230 V intantly.

When a voltage of less than 170 V was given using an Auto transformer, the stabilizer tripped and there was no output to the load. Similarly when a voltage of magnitude greater than 270 V was given, the stabilizer tripped.

It was found that the stabilizer operated only in the input range of 170 to 270 V. The operating status of the stabilizer was indicated on the front panel with the help of 7 LEDs.

## 4.4. Advantages of static servo stabilizer

The advantages of using this stabilizer are

1) There is no servo motor involved. Because of this there are no moving parts. This totally eliminates the wear and tear of the system and there are no mechanical losses. This causes an improvement in the operating efficiency of the system.

2) There is no need for any bulky variable transformers.

3) The stabilizer is fast acting unlike the conventional stabilizer and can correct at a speed of 100 v/sec.

4) It can accept a wide range of input voltages (170 to 270 v).

5) The same circuit can be used for any capacity and only values of the individual components need to be altered.

6) It is highly efficient.

7) We use Aluminium foils instead of copper wires and this considerably reduces the production cost. This makes the system cost economical when compared to that of the conventional servo stabilizer that employs Copper windings.

8) Over-voltage and over-current protection is provided to the load.

9) There are LEDs which indicate the operating status and this eliminates the need for a separate Voltmeter.

10) It is portable as weight of the unit is less.

4.5. Applications

Servo stabilizers are used in a variety of applications.In fact they are fast replacing the conventional voltage stabilizers as they have many advantages over them.

1) One of the most important applications of the servo stabilizer is in the field of computers.The computers are highly sensitive to fluctuations in the voltage and even a small change in the voltage could cause loss of data.This has to be prevented at all costs.The servo stabilizer is instrumental in preventing such abnormalities.

2) The servo stabilizers are also used along with equipments which are sensitive to voltage fluctuations like T.V,fridge VCR etc.

3) They are used in environments that are sensitive to the slightest fluctuation in voltage for example computerized numerically controlled machines and xerox machines.

4) This finds wide application in the field of Robotics.This is used to control the signals given to stepper motors to control the movements of robots.

5) This is also used in Defence and Aviation equipments.

CHAPTER V

# CONCLUSION

In this project, a Static servo stabilizer has been successfully designed,fabricated and tested. The novelty of this project is that contrary to the conventional servo stabilizers that are in use today,this stabilizer has absolutely no moving parts.

The advantages of having no moving parts is that the efficiency is improved as there are no friction losses.

The wear and tear of the components has also been considerably reduced and this has ensured a longer life for the stabilizer.

This stabilizer has many advantages when compared with other types of voltage stabilizers. They are reduction in size, increased efficiency and low cost. The use of triacs has considerably improved the correction rate to around 100 volts/second.

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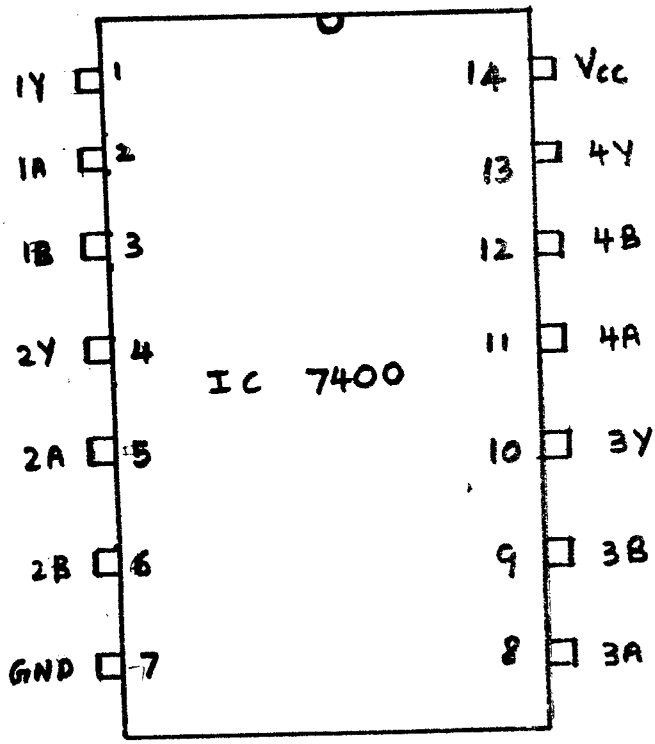
# Appendix

## The IC Details

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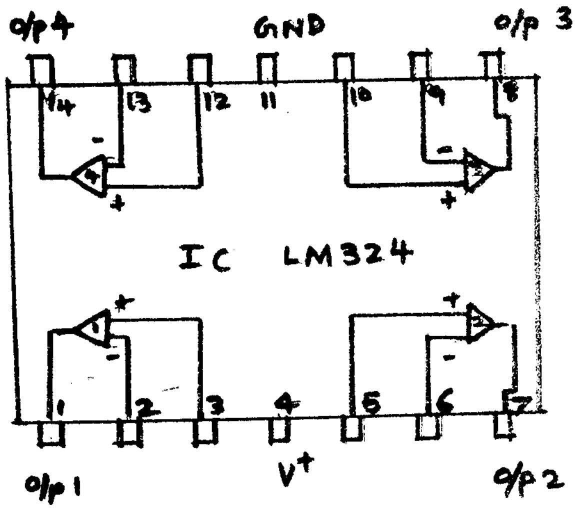
The IC 7400 contains fouf independent 2-input nand

s. Here the output is high when the two inputs are of two erent levels.When both the inputs are same, the output is

This is equivalent to an AND gate with an inverter.

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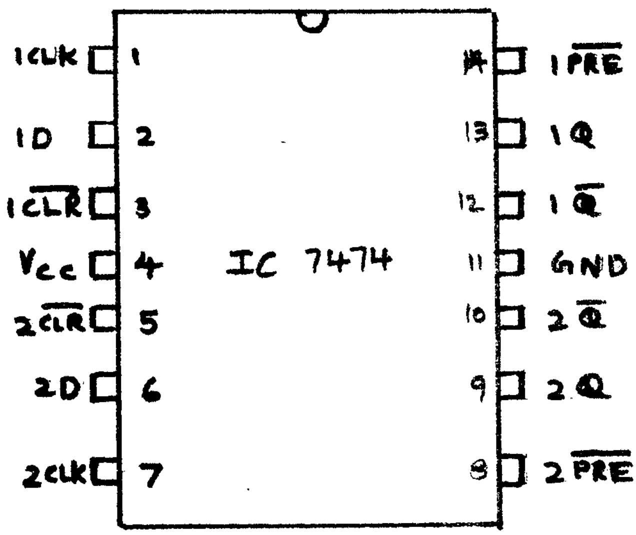
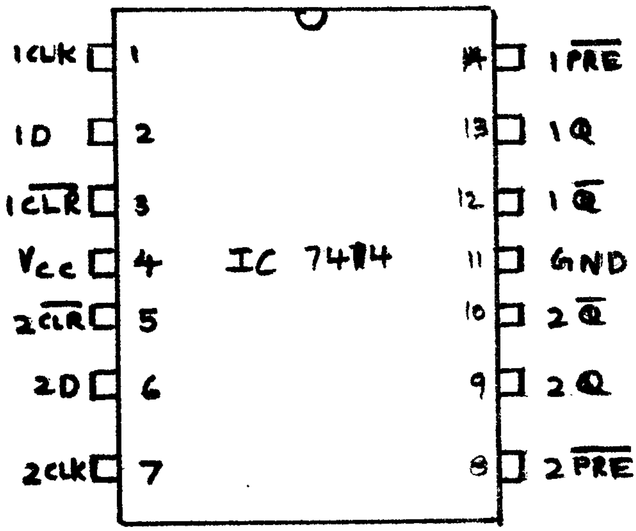
This series consists of four independent high gain, nally frequency compensated operational amplifiers which is ned specifically to operate from a single power supply over e range of voltages. Operation from split power supplies is possible. The unity gain cross frequency is temperature nsated. This is compatible with all forms of logic.




74

These devices contain two D-type positive-edge-triggered
lops. A low level at the preset or clear input sets or
s the output regardless of the level of the other in-
This can operate within the tempereture limits of 0-70
es.

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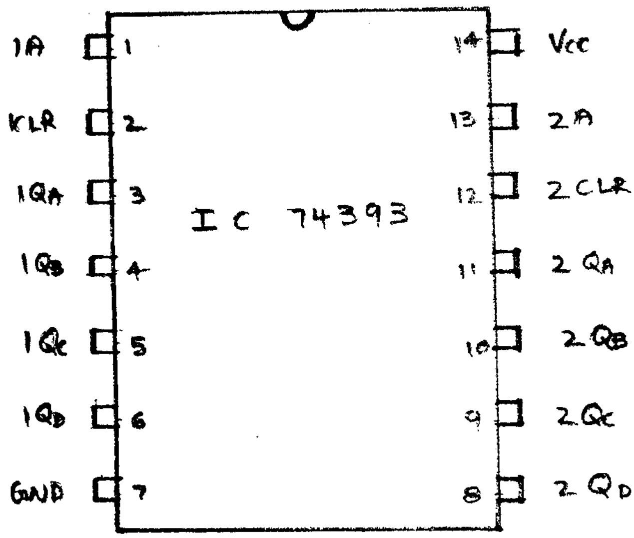
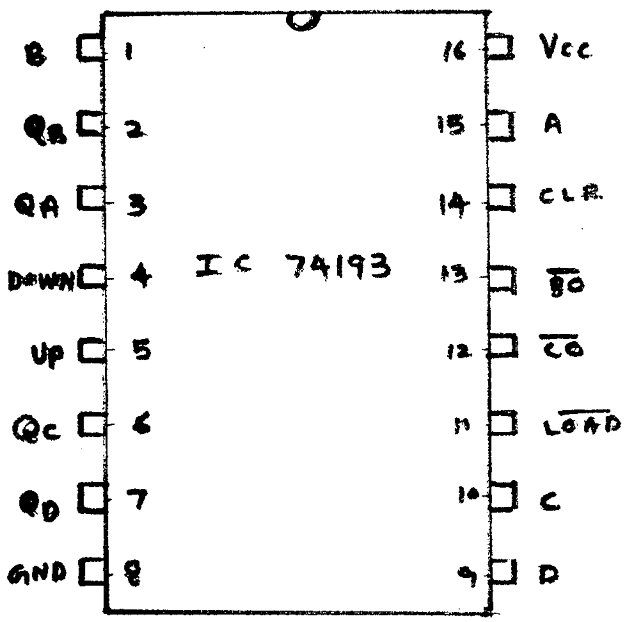
The each circuit functions as an inverter, but because of chmitt action, it has different input threshold levels for ive and negative going signals. These circuits are tempera- compensated and give clear output signals for the inputs ded.




393

The IC 74393 monolithic circuit contains eight master-flipflops and additional gating to implement two induvidual bit counters in a single package. There is parallel output each counter stage so that any submultiple of the input frequency is available for system-timing signals.

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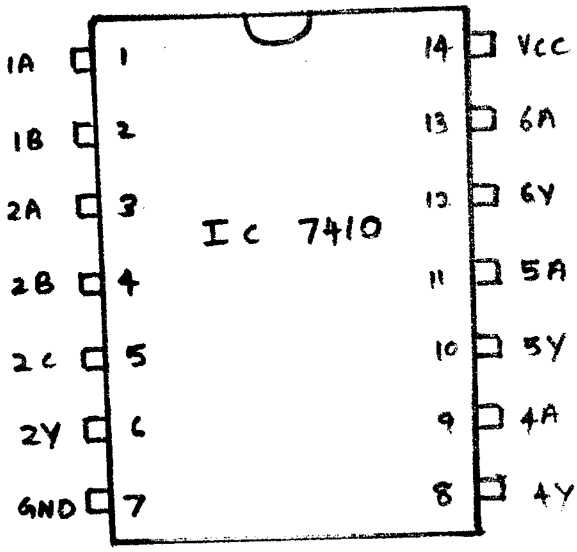
These monolithic circuits are synchronous reversible
ers having a complexity of 55 equivalent gates. Synchro-
operation is provided by having all flipflops clocked
taneously so that the outputs change coincidentally with
other when so instructed by the steering logic. This
of operation eliminates the output counting spikes.




410

This IC 7410 contains three independent three input NAND

s. This is equivalent to the three input and gate whose

ut is passed through an inverter. The output is low when all

inputs to the nand gate is high. in the other cases the

ut is low only.