DIGITAL DOSA MAKING MACHINE
(D^2M^2)

Project Report 2002-2003

Submitted by

MATHEWS CHACKO. I	**9927J0014**
SANTHOSH. M	**9927J0022**
VIJAYARAJ. S	**9927J0028**
SARAVAN PRABOO. D	**9927J0104**

Under the Guidance of

Mr. P. RAJENDRAN, B.E (Hons), M. Tech

Asst. Professor, Department of Mechatronics Engineering

In partial fulfillment of the requirement for the award of

'BACHELOR OF ENGINEERING' IN 'MECHATRONICS ENGINEERING'

under Bharathiar University

DEPARTMENT OF MECHATRONICS ENGINEERING

KUMARAGURU COLLEGE OF TECHNOLOGY

Coimbatore – 641 006

KUMARAGURU COLLEGE OF TECHNOLOGY
DEPARTMENT OF MECHATRONICS ENGINEERING

COIMBATORE – 641 006.

CERTIFICATE

This is to certify that the project report entitled

" DIGITAL DOSA MAKING MACHINE (D^2M^2)"

decribes the bonafide work done by

Mr.____________________________ **Reg No.**______________

during the year 2002-2003, under the guidance of

Mr. P. Rajendran B.E.(Hons), M.Tech

Asst. Professor, Department of Mechatronics Engineering

Place : Coimbatore

Date : 20/3/03

Guide

Submitted for University Examination Held on 21/3/03

....

dedicated to our parents
who gave everything they had
to make us as we are now

ACKNOWLEDGEMENT

We convey our deepest sense of gratitude to our Principal Dr.K.K. Padmanaban and the Head of the Department of Mechatronics Engineering, Dr.V.Gunaraj, under whose blessings this project has achieved its final shape.

Our wholehearted thanks to Mr. P. Rajendran, Asst. Professor, Department of Mechatronics Engineering who has guided us through out the project tenure.

We thank Mr. Mohandas Gandhi, Senior Lecturer, Department of Mechanical Engineering / Workshop Superintendent for according us permission to use the workshop facilities without which this project would not have been completed in time.

To conclude, we thank all the laboratory (Mechanical, Electrical and Electronics Department.) and workshop technicians, who have patiently provided us assistance through out the project tenure and without whose help our endeavor would have been in vain.

SYNOPSIS

A completely automatic machine, D^2M^2, will be the outcome of this project, which can prepare one of the most popular dishes in South India – *Dosa*.. D^2M^2 is an exclusive Mechatronics Product, which involves electronic control of different mechanisms. This project aims at bringing out a product that can be really correlated with our day-to-day life.

After filling up the batter in the machine's container, only a touch of a button is required to make a crispy and crunchy dosa. Since preparing a dosa involves a lot of skills, the perfection of this machine really matters and it is hard to build such a machine. Neverthless, such a machine will be surely inspired by the housewifes provided the cost is less. Hence cost factors have been considered and optimized without sacrificing the perfection and consistency of the machine.

An Electronic Control Unit consisting of timing circuits control the various mechanisms through the interfacing circuit. No manual intervention is required while preparing the dosa.

Owing to the overwhelming set of advantages compared to the traditional way of dosa making, this machine is worth to be produced and marketed.

CONTENTS

CONTENTS

INTRODUCTION

1. INTRODUCTION

Engineering products are generally done based on three aims:

- A new invention
- Modification of an existing in order to
    - Increase the performance
    - Decrease the cost
    - Retrofit the invention
- Case Studies and Suggestions

D^2M^2 is an innovative combination of the first two types. The advent of technology has reflected much on the home appliances. This reduces the fatigue of the consumers, improves their comforts to a great extent and gives increased performance. D^2M^2 is a machine developed with a similar aim.

Dosa is made by spreading the batter of suitable amount on a hot pan and spreading it in a circular shape. It is allowed to get roasted, then removed from the pan and served hot. It is a favourite dish for many people in India.

There are basically three motions controlled by three different motors. One motor controls the up/down movement of the spread blade motor to enable the blade to come in contact with the tawa. The second motor is for rotating the blade to spread the batter on the tawa. The third motor is for the sweeping action, which takes the roasted dosa out of the tawa to be served at the outlet. The nozzle lets the batter in the tank to flow on the tawa. The Electronic Control Unit consisting of Timer Circuits controls the nozzle and all the above motor functions. The outputs of the timers are connected to the motor through the relays (Interfacing Circuit). Thus all the mechanisms are automatic. The progress of all these mechanisms can be visualized by the indicators on the control panel.

Fill the tank with the batter, press the button and relax. That is all we have to do

D^2M^2 DIGITAL DOSA MAKING MACHINE

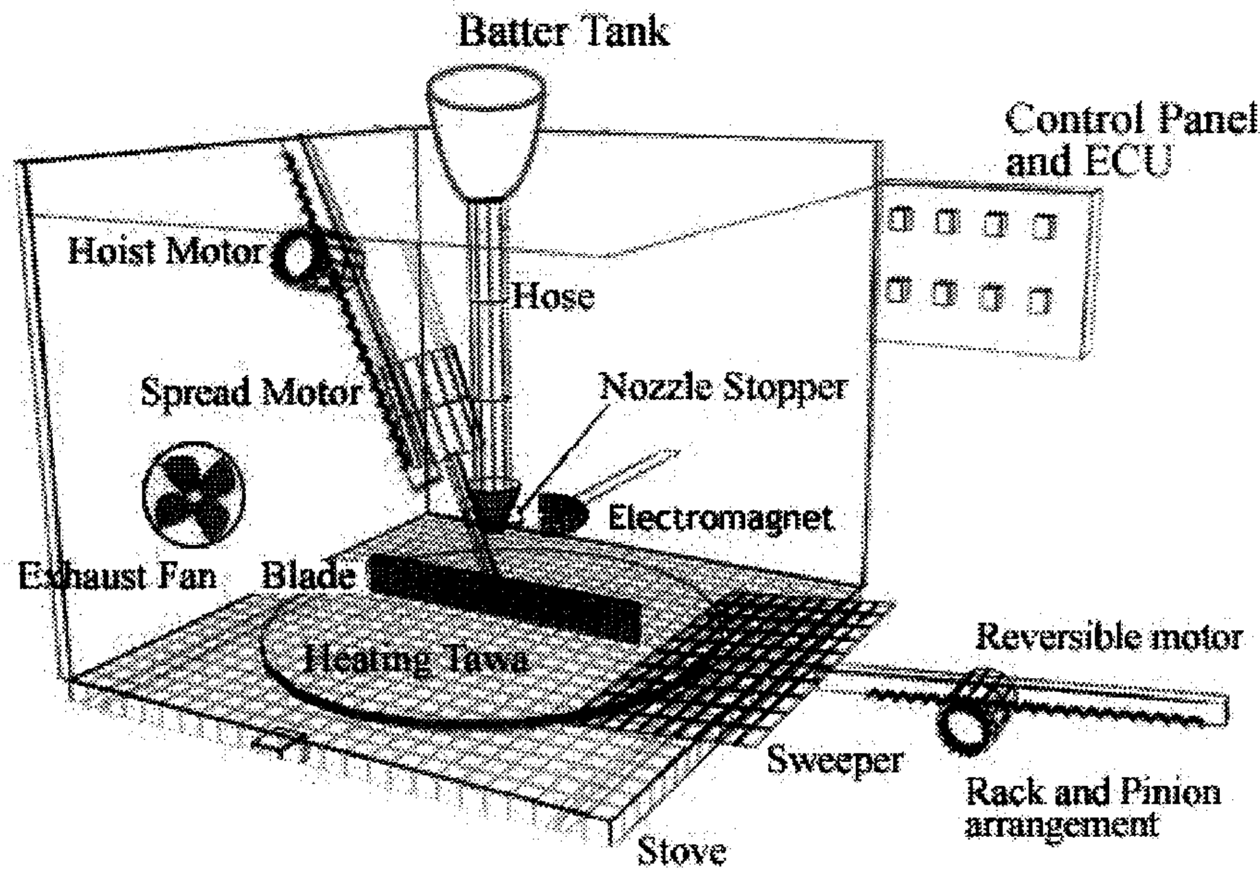


Fig 1.0 Schematic of D^2M^2

MECHANICAL COMPONENTS AND WORKING

2. MECHANICAL COMPONENTS AND WORKING

This section deals with the components used in the machine and the different mechanisms used to automate the operations like pouring the batter, spreading it, heating it and removing the dosa. Close timing control of these mechanisms is important and is dealt in the 'Electronic Control Unit' section. The specifications of all the components are also listed. While going through this segment, the 'Assembly of Components' section can be referred in chorus.

Mechanical components includes the following

1. Frame
2. The rack and pinion arrangement
3. Batter tank
4. Nozzle mechanism
5. Spread blade attachment
6. Sweeper attachment
7. Tawa

2.1 FRAME

The frame forms the supporting structure of the entire assembly. The frame is made of steel with slotted L-channel, which enables us to adjust the positions of the various components. The thickness of frame should be enough to provide the rigid support to the guideways.

SPECIFICATIONS OF THE FRAME

Material	:	Steel
Length	:	30 inches
Height	:	20 inches
Width	:	14 inches

Cross section	:	L channel
Thickness of channel	:	2.2 mm
Distance between slots	:	1.5 cm

2.2 RACK AND PINION ARRANGEMENTS

The rack and pinion arrangement is used to convert the rotary motion to linear motion. This mechanism is applied to raise and lower the spread blade motor in which the motor has to be lowered towards the tawa in order to spread the batter evenly over the tawa in circular shape. After spreading the batter the hoist motor has to be raised to a certain height to enable easy removal of the dosa from the tawa and to ensure a small amount of batter sticking on the blade does not affect the roasting of the next dosa.

To achieve this, the pinion is attached to the axis of the hoist motor through tight bushings. It is made to mesh with the rack at a pre-determined position. This engagement should be tight and vibration free. So, strong mountings are provided. The rack slides over the guideway. This metal guideway is clamped to the frame firmly by welding such that it does not move or vibrate when the motors operate. Grease is applied to the guide, the rack and pinion for frictionless movement. Now, when the ECU activates this motor, the motor rotates clockwise and the rack slides down through the guideway towards the tawa.

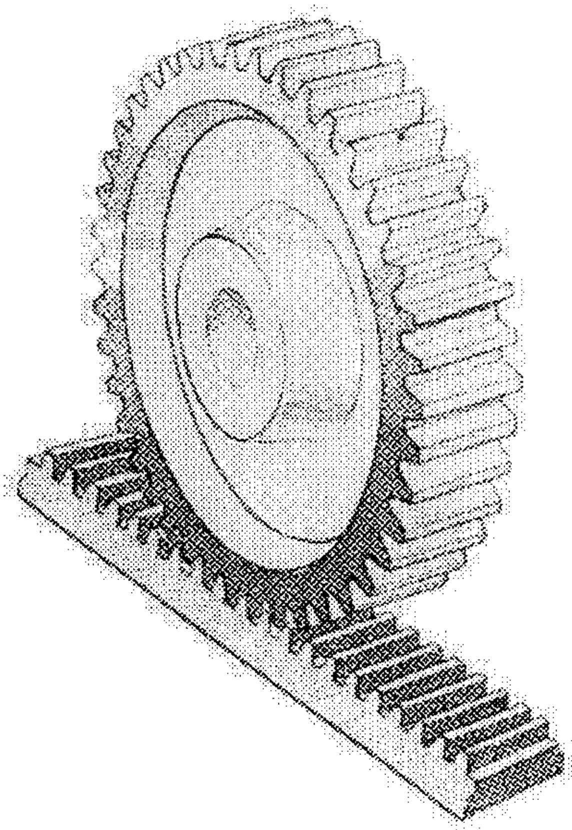


Fig 2.1 Rack and Pinion for hoisting

The spread blade attachment as discussed later is welded with the rack of the hoist motor at right angles.

The rack and pinion arrangement is also used for the sweeper motor that picks up the roasted dosa from the tawa. The pinion is attached to the shaft of the sweeper motor and the rack meshed with the pinion slides over the guide way.

The guide way is made of wood as it has following advantages compared to metallic guideway.

1. It is cost effective.
2. Easy to machine.
3. Less weight.

The sliding surface of the guideway is glued with mica sheet to provide frictionless movement. Two wooden leaves are nailed on the guideway such that the gap

0.1mm is left so that the rack freely moves through the guide. The specifications of the rack and pinion arrangement are as given below:

RACK AND PINION FOR HOISTING

1. Material used (Pinion and rack) : mild steel
2. Pitch diameter of Pinion : 4 cm
3. No. of teeth on pinion : 20
4. Length of rack : 30 cm
5. Face Width of rack & pinion : 7 mm
6. Module : 2

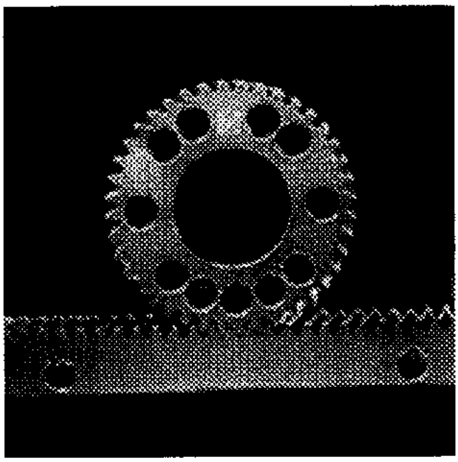


Fig 2.2 Rack and Pinion for Sweeping

RACK AND PINION FOR SWEEPING

1. Material used (Pinion and rack) : hardened steel
2. Pitch diameter of pinion : 2.5 cm
3. No. of teeth on pinion : 25
4. Length of rack : 30 cm
5. Face Width of rack & pinion : 2.5 mm
6. Module : 1

2.3 BATTER TANK

The batter tank is used to store the batter and it is connected with the nozzle mechanism by a flexible plastic hose. The batter tank is made up of glass and the plastic hose is sealed to this tank completely to prevent any leakage. It can be closed/opened by a lid. The batter tank is attached to the frame at a height for the batter to flow on the tawa by gravity. The other end of the plastic hose is connected to a steel tube. The batter is poured inside the tank through the opening at the top. The level of batter inside the tank is visible from outside since it is transparent. Once all the batter is exhausted it is again refilled manually through the lid opening. The batter cannot be stored for a long duration, as it becomes sour. This involves similar treatment as that in manual dosa roasting. If it is stored for a long time, it should be drained. In an optimized D^2M^2, separate control to open the nozzle is provided at the user interface to drain this sour batter. The size of the batter depends on the extent D^2M^2 is used.

SPECIFICATIONS OF THE BATTER TANK:

1. Material of the tank : Plastic
2. Capacity of the tank : 1.5 litre
3. Material of the hose : Plastic
4. Length of the hose : 9-12 inches
5. Diameter of the hose : 0.75 inches

2.4 SPREAD BLADE ATTACHMENT

The spread blade attachment comprises of a wooden blade attached to the spindle of the spread blade motor. The blade is attached in a horizontal direction in such a way that the center of the blade coincides with the axis of the motor for proper spreading of the batter. The length of the blade is such that it is at least 2 cm less than the diameter of the tawa. This allowance is to ensure that the blade does not hit the tawa clamping while rotating. The thickness of the blade is reduced to a minimum so that when the batter is poured from the top through the nozzle, it does not get stuck to the blade (in case the blade comes under the nozzle).

The Bellow Mechanism

A bellow is used to connect the spread motor with the blade. The purpose of using bellows is to compensate for overtravel due to the reasons explained in section 'Overcoming Difficulties in D^2M^2'. The bellow can compress upto a length 'a', the distance between the spindle and the top edge of the guiding rod (2.5 cm in this design). A square bellow is better than a round one but fixing it on both the ends is difficult. So a cylindrical plastic bellow is connected at its one end with the spread motor and with the blade at its other end. (Fig 2.3)

The nylon bushes are drilled throughout its length. A guiding rod is inserted in the hole between the motor bush and the blade bush inside the bellow. This prevents

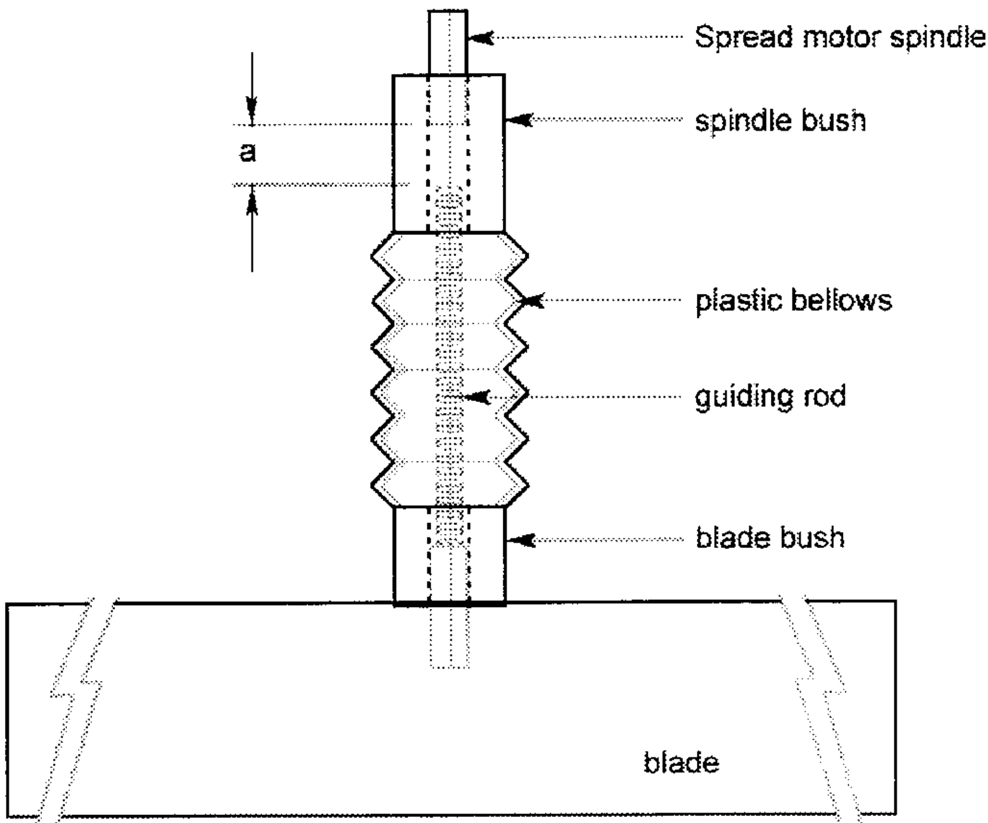


Fig 2.3 Bellow Mechanism

the blade from turning sideward away from the center of its axis. It should not touch the spindle motor bush as it will not allow compression. If the motor over travels, the bellow gets compressed and absorbs the overtravel distance thereby avoiding strain on the hoist motor and the spread motor (friction between blade and tawa increases the strain on the spread motor while rotating).

ADVANTAGES OF SELECTING WOOD AS BLADE MATERIAL:

1. Cost is less.
2. Does not get heated as metal when in contact with the tawa.
3. Does not affect the coating of tawa by scratching.
4. Easy to machine.

SPECIFICATIONS OF THE SPREAD BLADE ARRANGEMENT:

1.	Material of the blade	: wood
2.	Length of the blade	: 26 cm
3.	Height of the blade	: 3.5 cm
4.	Thickness of the blade	: 0.3 cm
5.	Material of bellow	: plastic
6.	Length of bellow	: 2.5 inch
7.	Diameter of bellow	: 0.75 inch

2.5 NOZZLE MECHANISM

The nozzle of the batter tank is made of a steel tube. A small slit is cut on the steel tube and a thermo set plastic material (stopper) of square cross section is inserted into it so that it entirely closes the nozzle and stops the flow of the batter.

The other end of this stopper is connected to the rod of an electromagnet. The plane of the stopper and the axis of the rod should coincide. When the Electronic Control Unit activates the electromagnet, it pulls the stopper by magnetization thereby opening the nozzle. Once it gets deactivated the spring arrangement pushes the nozzle outward and closes the nozzle.

The stopper material is chosen such that it has sufficient strength to withstand the forced exerted on it by the batter flowing through it. The assembly is arranged on a box made of thermo set plastic. It is attached to the spread blade motor so that it comes down along with the motor, pours the batter on the tawa and moves up.

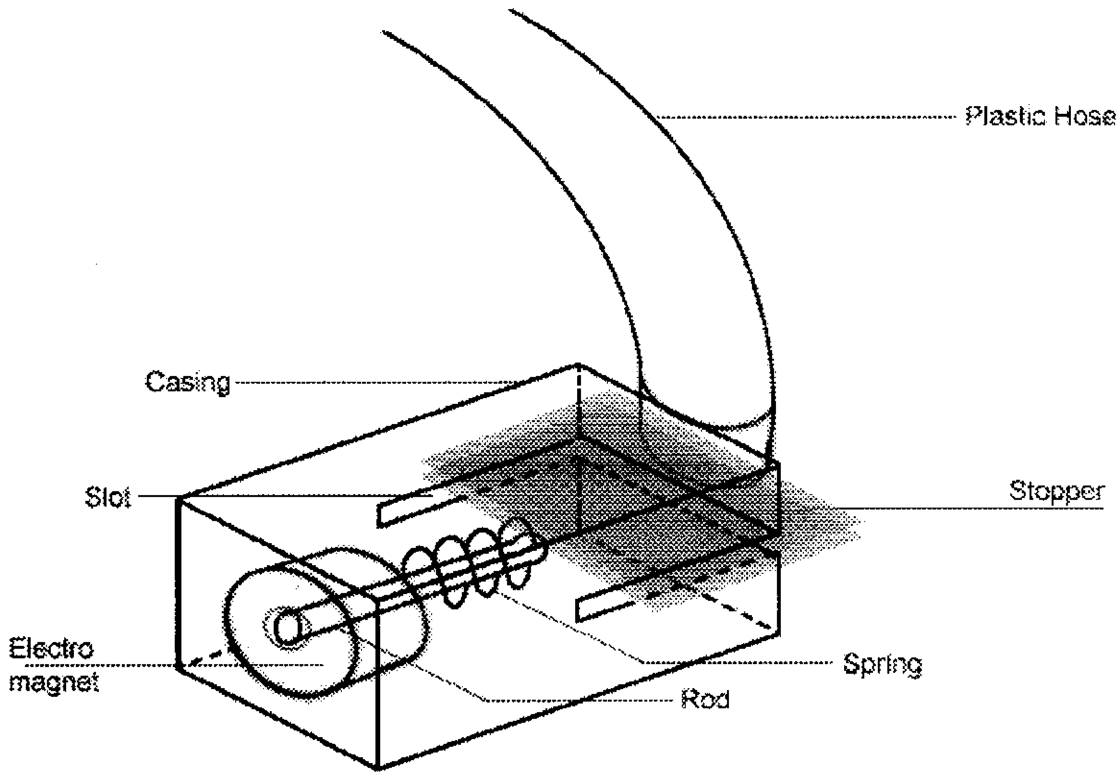


Fig 2.4 Electromagnetic Nozzle Mechanism

2.6 SWEEPER ATTACHMENT

The sweeper attachment comprises of a flexible wooden sheet (mica) attached to the rack. A metal clamp is attached with the mica sheet and the clamp is bolted to the rack. The arrangement is made to slide on the wooden guide way. The dimensions of the wooden sheet are fixed according to the diameter of the tawa. The sheet is kept at an angle to the tawa surface. When the sweeper moves over the tawa, this inclination causes a thrust created at its edges which is enough to pierce through the gap between the dosa and tawa and lift it up. Note that when the dosa is roasted its edges start to rise up. Thus as the sweep motor is activated by the Electronic Control Unit, the sweeper moves over the tawa with some pressure on its edges. The sweeper returns to its original position near a service outlet. The dosa is taken out from this outlet.

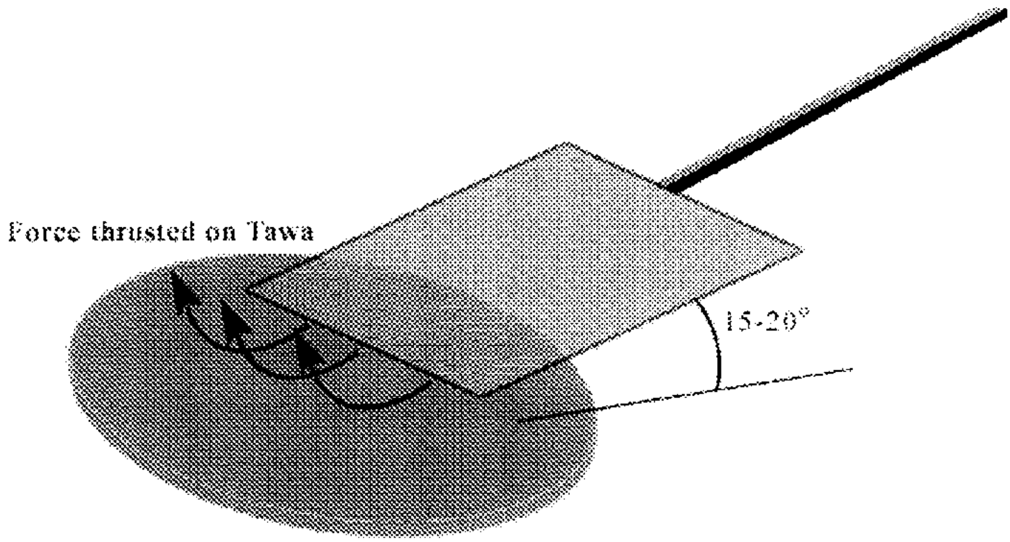


Fig 2.5 Sweeping Force exerted by the Sweeper

2.7 TAWA

Tawa is a circular metal plate used to roast the dosas, chappathis etc.,.. Almost every house in India will have one. The quality of the tawa is reflected on the appearance of the prepared dosa. In D^2M^2, the sweeping of the dosa is done in a single stroke only. So it becomes evident that the dosa should not stick to the tawa while sweeping especially since this is an automated process.. For this purpose a special non-stick tawa is used which will never allow the dosa to stick to it. This enables us to easily take out the dosa. Unlike conventional methods, oil is not required for this type of tawa. The coating is immune to scratches so it is carefully handled and maintained. The rim of the tawa is completely removed by machining it in the lathe as it will obstruct sweeping.

i) Material : 95% Al with Copper Bottom, Non-stick

ii) Make : Premier Non Stick Cookware

iii) Diameter : 28cm

iv) Thickness : 3 mm

ELECTRICAL COMPONENTS AND WORKING

3. ELECTRICAL COMPONENTS AND WORKING

This section mainly deals with the electrical segment of the machine. This emphasizes on the components that convert the electrical energy to other forms of energy (Motion, Heat). Being the major component under the electrical segment, *motors* are discussed in detail. Three major movements are obtained in virtue of these electric motors. Out of these, the rotary motion of the two motors is converted into linear motion. The other motor endows the rotary motion as such. The *interface* between the user and the machine also comes under this section together with the functioning of the Electric Stove. The *electromagnetic relay* is used as the main switching device for operating various mechanisms automatically. The power supplies are presented under the 'Electronic Control Unit' section.

This section will contain in-depth details about

- Motors
- Electromagnetic Relays
- User Interface
- Electromagnet for nozzle
- Electric Stove
- Wiring

3.1 ELECTRIC MOTORS

3.1.1.1.1 Introduction

Three electric motors are used in this machine to provide two linear motions and one rotary motion. The basic principle of electric motor is that "when a current carrying conductor is placed in a magnetic field, it experiences a mechanical force whose direction is given by Fleming's Left-Hand Rule" Its magnitude is given by

$$F = B\ I\ L \sin\theta$$

Where B is the flux density

θ is the angle between the conductor and the field

I is the current flowing through the conductor

L is the length of conductor

3.1.2 Construction details

It consists of a *yoke*, which provides mechanical support for the armature and field windings. It carries magnetic flux produced by the poles. Pole shoes are used to spread flux in the air gap and to reduce the reluctance of magnetic path. The pole coil, also called field coil consists of copper wire usually former wound and placed over the pole. Whenever they carry current, the poles are electromagnetised which produce the magnetic flux.

The armature core houses the armature conductors or coil and causes them to rotate and hence cut the magnetic flux of the field magnets. It provides a path of very low reluctance to flux through armature from an N pole to an S pole.

The armature windings are usually former-wound. Various conductors of the coils are insulated from each other. The conductors are placed in the armature slots, which are lined with tough insulating material.

The function of commutator is to facilitate collection of current from the armature conductors. This converts alternating current induced in the

Each commutator segment is connected to the armature conductor using copper lug to prevent them from flying out under action of centrifugal forces.

The function of the brushes is to collect current from commutator. The brush holder is mounted on a spindle and the brushes can slide in rectangular box open at both ends. The number of brushes per spindle depends on the magnitude of the current to be collected from the commutator.

3.1.3 Motors in D^2M^2

The linear motion is obtained by a rack and pinion arrangement for the hoisting mechanism and for sweeping mechanism. The type of motors used is DC motor.

The main characteristics of this motor as required by the machine are

- Medium torque
- Low Speed
- Self- locking
- Instant braking
- Small size

The torque of the motor need not be very high, as the machine does not involve any heavy loads. So a medium torque motor is sufficient.

DC motors are available in a wide range of speeds. But D^2M^2 has very slow movements and speeds as low as 50-75 rpm are required. In the case of spreading the batter on the tawa, if the speed is high, it will splutter outside the tawa. In the case of hoisting and sweeping, high speed may not help us in accurate positioning.

The speed, voltage and torque equations of a dc motor are given below:

$$\omega = V - (I_a R_a) / K_e\varphi \text{ rad/sec}$$

$$V = E + I_a R_a \text{ volts}$$

$$T = (P Z I_a Z \varphi) / 2\pi \text{ newton-metre}$$

Where
V – voltage at the terminals of the machine, volts
E – induced emf in the armature, volts
I_a – armature current, amps
R_a – armature resistance, ohms
A – no. of parallel paths in the armature
φ – flux per pole, Weber
Z – number of armature conductors
ω – angular speed of motor, rad/sec
T – torque developed by the armature.

To decrease the speed of the motor, we can reduce the voltage between the terminals. But we are using a standard 12 V power supply and also the reduction of voltage may weaken the coils. So speed reduction by reducing the voltage is not recommended. E and φ are constants and changing the resistance of the armature can be done only during manufacturing. So we are going for mechanical speed reduction techniques of which the *worm gear* gives a very high-speed reduction. Attaching a worm gear to a dc motor is a complex process instead, a motor used in a specific application with low speed is preferred. The *Wiper motor* used in light motor vehicles is a premium choice for our application.

3.1.4 The Wiper Motor

This motor connected with the Wiping Blades , has a very low speed through the worm-gear mechanism. The specifications of this motor are given later and the photograph of a wiper motor is shown in fig 3.1.

Not only this motor satisfies out low speed requirements, but also it possesses other excellent features like small size, high holding torque, instant braking. The motor does not involve high working torque, so the coils and hence the size of the motor is less. The other two features are not of electrical but of mechanical. i.e., they are the properties of the worm-gear mechanism.

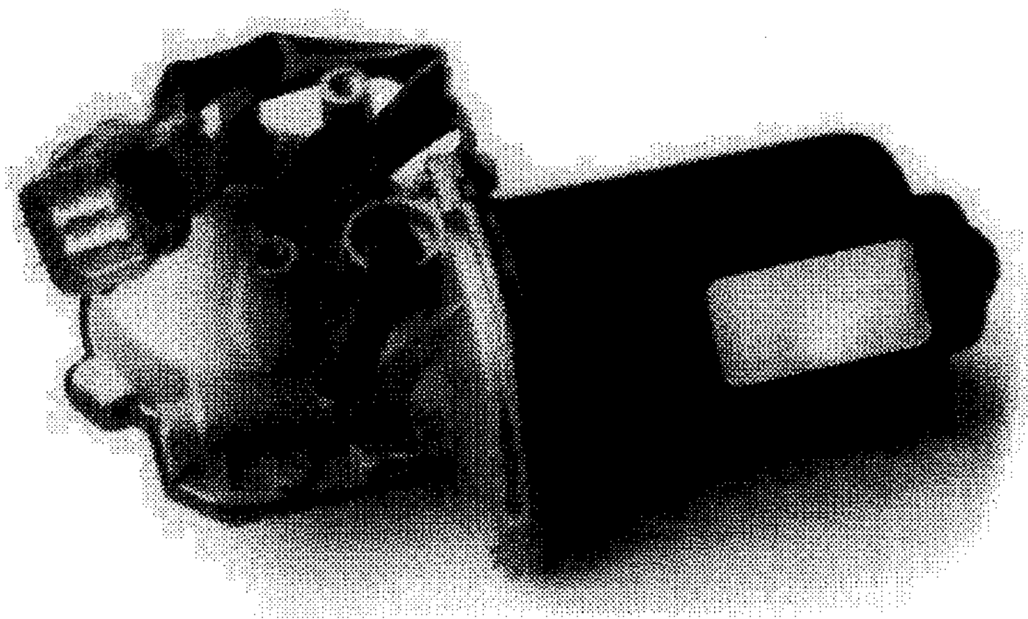


Fig 3.1 DC Wiper Motor

3.1.5 The Worm Gear Mechanism

An interesting feature of this motor is that the direction of motion cannot be changed. To be more clear, consider the two gears, the driver wheel and the be interchanged without any difficulty. But in case of worm-gear mechanism, it is not possible. Here the worm is the driver and the large pinion is the driven wheel and they cannot be interchanged. This motor is used for hoisting the spread motor up and down as seen in the 'Rack and pinion arrangement' sub-section. The spread motor is almost hovering in air except for the contact with the external pinion of the hoist motor. Hence due to gravity the motor will come down if there is no worm-gear mechanism. Also, if this mechanism is replaced by electrical means, it means that current is flowing in the opposite direction and the armature is held or not allowed to rotate. This is highly contradictory to the design of D^2M^2, as the motor should not rotate when power is off. Hence the worm gear mechanism is best suited for the hoist motor in terms of speed reduction and high holding torque when motor is off.

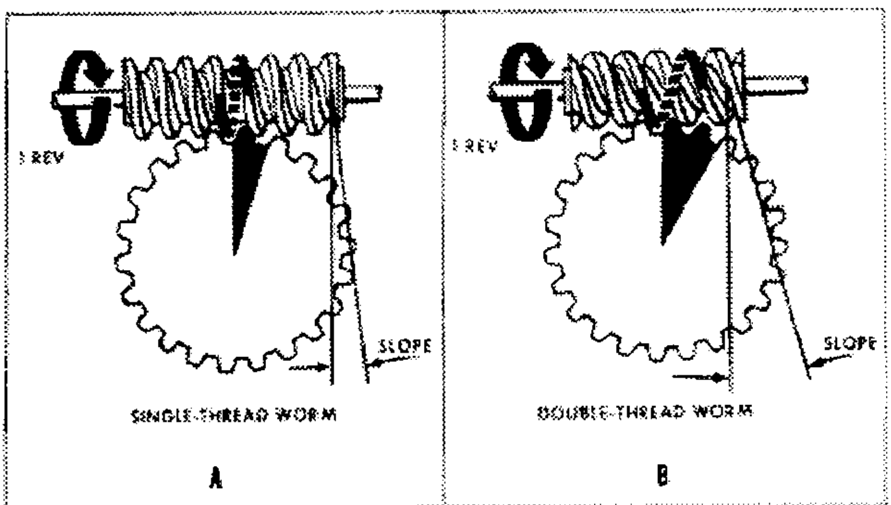


Fig. 3.2 Worm Gear Mechanism

From the Fig 3.2, it is clear that for single revolution of the worm, the gear rotates by α, one pressure angle for single threaded worm and 2α for double

Another important highlight of this motor together with worm –gear mechanism is that the gear stops rotating *almost* immediately when the power supply to the motor is cut off. This is analogous to the instant braking in electrical terms (power is fed back to the supply –undesirable) but more efficient than that. This is explained below:

If the armature of the motor rotates for 4 seconds, say the large pinion will give one half of rotation (180^0). If the time taken for the motor spindle to stop to 0 rpm is assumed to be 1 seconds, Then the pinion due to decreasing speed, will give *less* than 45^o rotation. In stepper motor terms, its step angle is *less* than 45^o which is fairly enough for our machine.

3.1.6 Specifications of the DC Geared motors

Supply Voltage	: 12 V
Input Current	: 1.25 A
Reversible	: Yes
Power consumed	: 15 W
Speed	: 675 / 1000 rpm
Gear type	: Worm and Worm Wheel
Gear Ratio	: 15
Reduced Speed	: 45 / 66 rpm
Worm material	: Steel
Worm wheel material	: Nylon
Type of worm	: Single Threaded
Diameter of worm wheel	: 6 cm
Length of the worm	: 5.5 cm

3.2 ELECTROMAGNETIC RELAYS

3.2.1 Prologue

Electromagnetic relays have been one of the best switching devices in electrical engineering. Their main advantage is that they can switch higher or lower voltage circuits compared to the voltage and current required to operate it. A commonly used relay has 5 pins. Two pins for energizing the coil of the electromagnet, one pin for input supply, and two for output. The input through the output is such that the input is normally in contact with one output pin (when it is not energized). This contact is called Normally Closed (NC) contact. The input pin is normally *not* in contact with the other pin and is called Normally Open (NO) contact. These pins will be shorted as the coil is energized. Thus one circuit can be enabled while the coil is not energized and another circuit can be closed while the coil is energized by the control line as shown in the Fig 3.3.

3.2.2 Classification

According to number of contacts, it is classified as

- Single throw contact relay
- Double throw contact relay

According to type of contact, it is classified as

- Single contact (shown in fig 3.3)
- Double contact

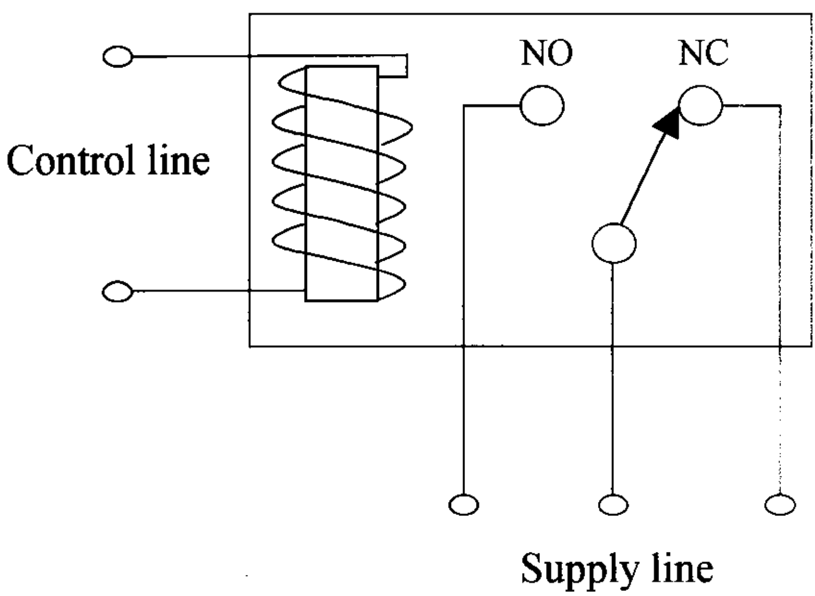
According to energizing current

- AC operated
- DC operated

Single throw contact has a contactor that closes/opens one Normally Closed circuit and one Normally Open circuit while double throw contact has two contactors that closes/opens two NC circuits and two NO circuits.
A single contact is one where the NO contact is missing. It is similar to an ordinary switch whose operation is controlled by a separate circuit. A double contact relay is what we are using, which is similar to a two-way switch.

3.2.3 Relays in D^2M^2

D^2M^2 uses single throw, double contact, dc operated relays for switching on/off various mechanisms. It is a small sized relay and can be fixed on a Printed Circuit Board. It is a 12 V relay whose control line is connected to the output of the timers through a transistor. Thus if the timer output is high for a pre-set duration, the relay will stay in energized condition in that duration. The relays are used in reversing the direction of the hoist motor and the sweeper motor as explained under the 'Interfacing Circuits Section'.



3.2.4 Relay Specifications

Type	: Single Throw, Double Contact
Make	: PC
Operating Voltage	: 12V DC
Operating Current	: 80 mA
Resistance	: 150 ohms
Max temperature	: 80° C
Switching Voltage	: 220 V AC/12V DC
Switching Current	: 5A AC / 3A DC

3.3 USER INTERFACE

The user interface includes the control panel consisting of the following:

i) Main Power switch or Emergency stop

ii) Start Button

iii) Indicators for displaying the status of the machine

iv) Buzzer

The Main Power switch can switch off the entire circuits, motors and stove. It also acts as the Emergency Stop button. In case of any accidents or malfunctioning, this button can shut off the whole system.

A push button (Start button) is provided for triggering the dosa making process.

Indicating LEDs are used to know the status of the machine and as progress indicators. As soon as the main power switch is on, the main power light glows.

A row of LEDs are connected to the output of all the timers and fixed on the control panel. Thus the sequence operations going on inside the machine can be visualized.

A buzzer connected to the last timer output is provided to indicate the end of all operations i.e., the dosa is ready.

3.4 ELECTROMAGNET FOR NOZZLE

The opening and closing of the nozzle is done by an ac electromagnet which comprises of a metal core wound by a coil of wire. When current is passed through the coil energizes and the metallic bar becomes as a magnet which attracts a rod suspended in the center of its axis. This rod is connected to the stopper, which aids in the opening and closing the nozzle. The electromagnet is operated by an ac voltage of 220 V. The effective stroke length (distance moved by the rod) is equal to the diameter of the nozzle, around 0.75 inch.

3.5 ELECTRIC STOVE

The Electric stove is the heating source of the tawa. It provides the necessary heat for roasting the dosa. Since D^2M^2 is an automatic machine, the switching off of the heating source and controlling its temperature should also be automatic. Hence the electric stove is used which can be switched on/off and a thermostat can control its temperature.

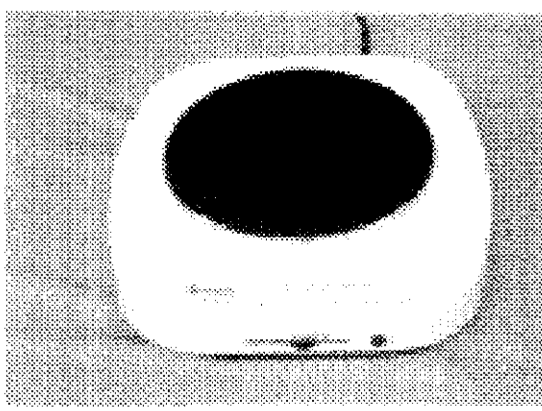


Fig 3.4 Electric Stove

The electric stove is preferred for normal gasoline stove for the following reasons:

i) Uniform heating of the tawa.

ii) Temperature is maintained constant by the thermostat

iii) No risk of fire.

iv) Easy to handle.

v) In case the LPG exhausts, the electric stove can be used for cooking provided power is available.

vi) Normal gasoline stove can be used for cooking other items, while this is used to make dosas.

CATALOG OF THE ELECTRIC STOVE:

1. Make	: Comforts
2. Voltage	: 220 V AC
3. Current	: 5 A max
4. Diameter of heating plate	: 18 cm
5. Height of the stove	: 10 cm
6. Time for heating	: 5-8 min

3.6 EXHAUST FAN

Exhaust fan is mounted just above the tawa to suck the fumes and vapour out of the machine. This prevents the machine to become dirty inside. The exhaust fan operates on 12 V DC supply. Its power rating is 2.5 W.

ELECTRONIC CONTROL UNIT AND INTERFACING

4. ELECTRONIC CONTROL UNIT AND INTERFACING

The Electronic Control Unit (ECU) forms the brain of the Digital Dosa Making Machine. The interfacing circuit combines the ECU with the mechanical parts of the Digital Dosa Making Machine. The ECU consists of the timing circuits formed by 555 timers. The output of the 555 timer stays high for a particular time duration, which is determined by the resistor and capacitor values connected with it. For varying this time duration we use variable resistors (potentiometers) along with the fixed resistors, calculated as later. All the 555 timers are connected in series so that the output of one timer triggers the next timer. Each of these output is connected to the relays in the interfacing unit to activate different mechanisms. As the ECU, the Interfaciong Unit and the electrical devices have different current and voltage ratings, three power supplies are used in this machine. This section details about all the components, used in the ECU and their working, specifications etc.,..

4.1 POWER SUPPLIES

This unit consists of transformers, rectifiers, filters and regulators. AC voltage typically of 220V is connected to a transformer, which steps down the voltage to the required level. The low ac voltage is fed to the diode bridge rectifier whose output is a full-wave DC. The ripples in the output DC is removed by a capacitor filter. A regulator IC is finally connected with this DC output to give a constant output voltage and current. This is depicted in the following block diagram.

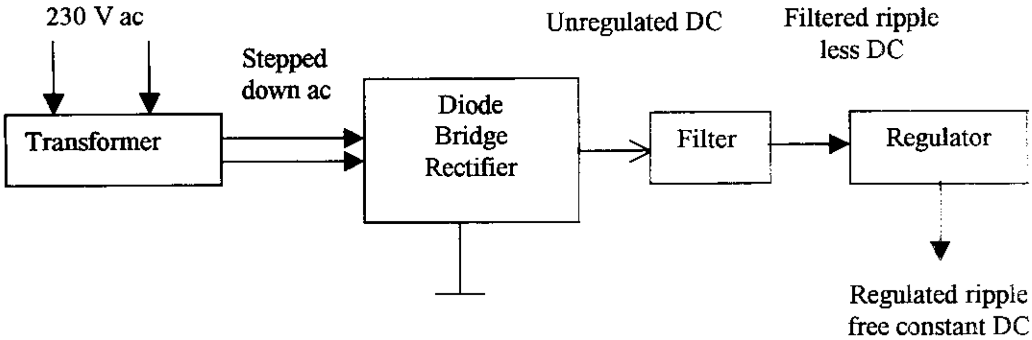


Fig. 4.1 Block Diagram of the Power Supply Unit

In the Digital Dosa Making Machine, we are using 3 power supply units:

- Supply to motors: 12 V, 3 A
- Supply to electronic control unit: 5 V, 100 mA
- Supply to relay: 12 V, 100 mA

4.1.1 Transformer

A transformer is a static electric device, which increases or decreases the voltage in a circuit with a corresponding decrease or increase in current without altering the frequency. It works with the principle of mutual induction. In this machine, we are using two core type–step down transformers:

-220 V/12 V ,3 A – for the motors

-220 V/ 12 V ,1 A – for ECU and the relay circuit

4.1.2 Rectifier

A rectifier converts the ac voltage at its input into a dc voltage. The output from both the transformers is rectified using IN4007 diodes in bridge configuration. During the first half cycle, two diodes conduct and during the second half cycle, the other two diodes conduct to give a full wave unidirectional current.

4.1.3 Filter

The capacitor filter is a commonly used filter, which can suppress the ripples at the output of the rectifier. At the peak f the ripple, the capacitor charges fully and as the ripple drops down, the capacitor slowly discharges to cancel out the ripples.

4.1.4 Regulator

The output voltage from the capacitor is an unregulated DC supply. i.e., the output may have voltage fluctuations. The voltage regulator is a device, which maintains constant output voltage irrespective of the change in supply variations, load variations, temperature changes and during short circuit at the output.

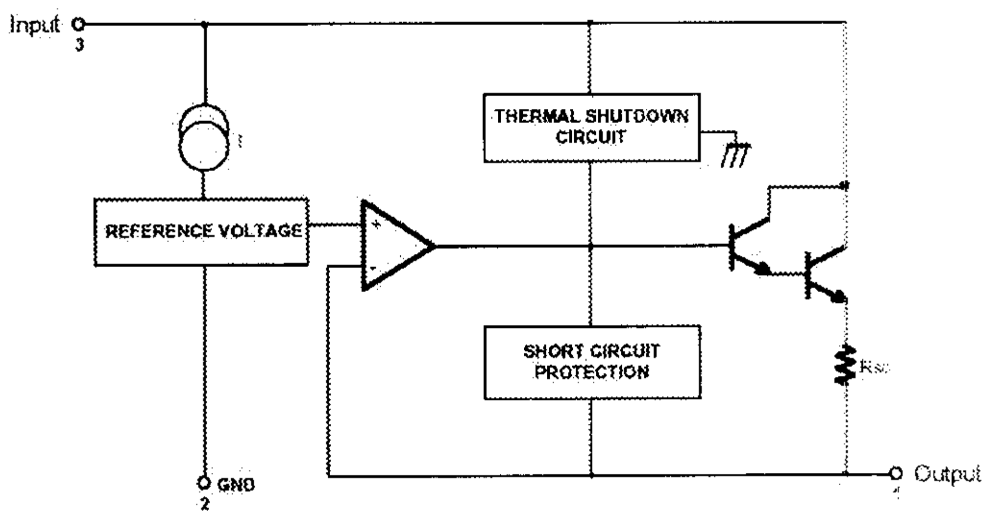


Fig. 4.2 Internal Block Diagram of a Regulator

In D^2M^2, we are using two fixed series voltage regulators:

- IC LM7812
- IC LM7806

The output from IC 7812 is +12 V regulated dc supply with 100 mA. This regulated dc voltage is applied to drive the relays.

The output from IC 7806 is ripple free +6 V regulated dc supply with 100 mA and is connected to the electronic control unit (ECU).

IC LM78XX:

The IC LM78XX series is available in aluminium TO-3 package which will allow a load current of 100 mA

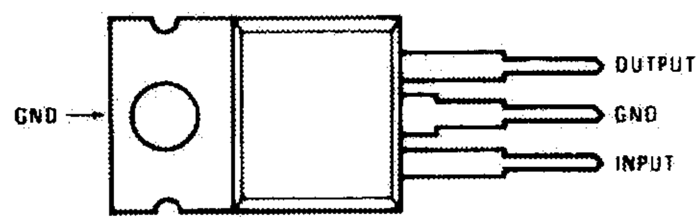


Fig 4.3 Pin Diagram of 78XX Package

VOLTAGE RANGE:

-LM7815C : 15 V

-LM7812C : 12 V

-LM7806C : 6 V

FEATURES OF LM78XX SERIES:

- Output current of 1 A or excess.
- Internal thermal overload protection
- No external component required
- Output transistor safe area protection
- Internal short circuit current limit
- Can be used in logic system

The internal circuits of the LM7812 and LM 7806 are shown below.

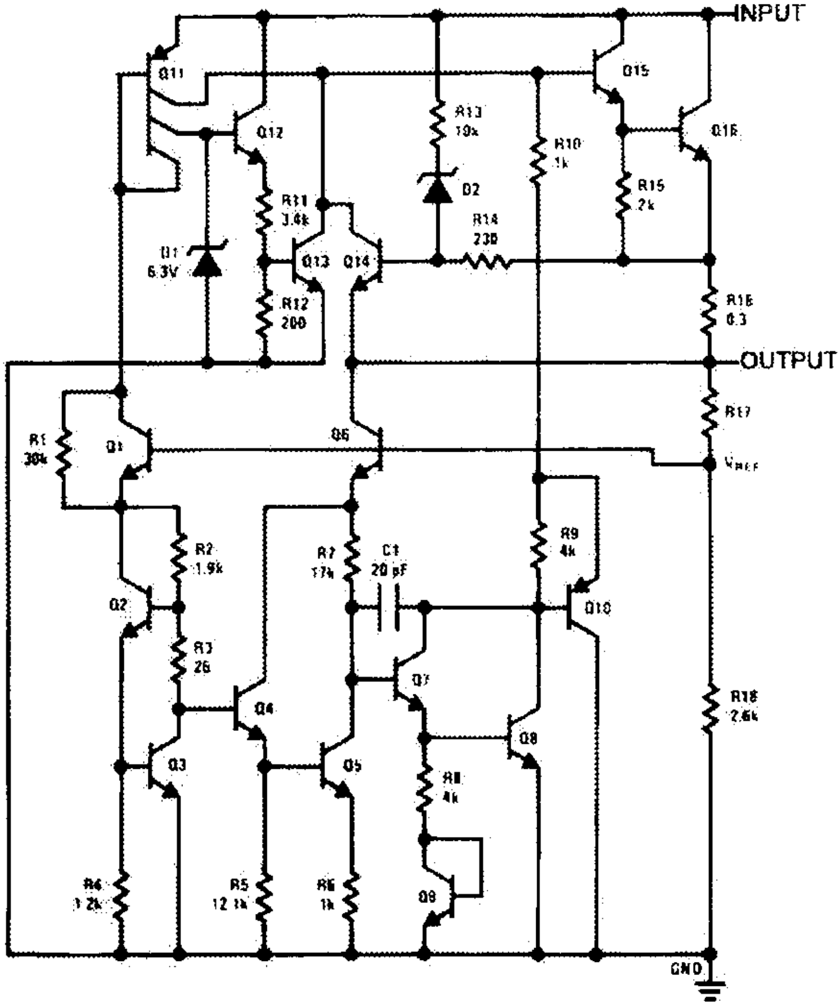


Fig. 4.4 Internal Schematic diagram of LM7812 IC

Current limiting is provided to limit the peak output current within safe value. Safe area protection circuit for output transistor is provided to limit internal power dissipation. If internal power dissipation becomes too high, the thermal shutdown circuit will prevent the IC from over heating. The overheating can be avoided by attaching a heat sink to the IC. The considerations for designing of the heat sink are given in the Appendix. It is not necessary to bypass the output, although this improves the transient response. Input bypass is needed only if the regulator is far from the filter capacitor of power supply.

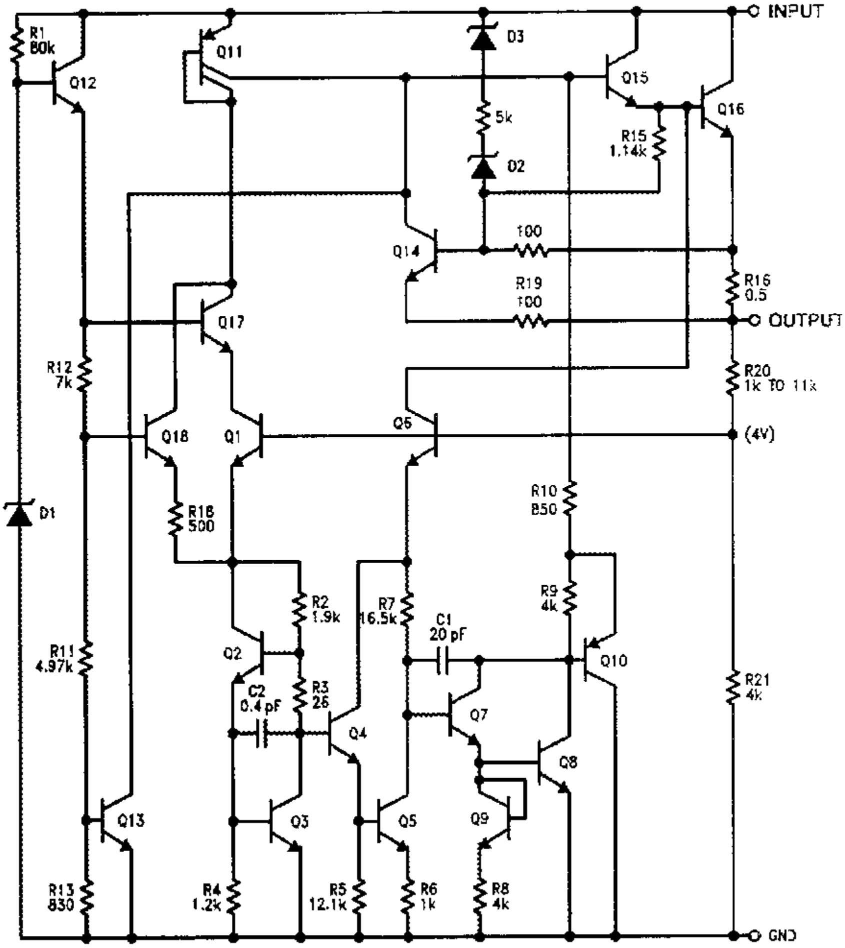


Fig. 4.5 Internal Schematic diagram of LM7806 IC

These regulators are used in instrumentation, logic circuits, HIFI and other solid state electronic devices. The construction details electrical characteristics and graphs are available in appendix.

4.2 THE 555 TIMER

The 555 timer was first introduced around 1971 by Signetics Corporation as the SE555/NE555. It was called "IC TIMER MACHINE". It is highly stable device for generating accurate time delay or oscillation. 555 timer is compatible with both TTL & CMOS logic circuits.

4.2.1 Pin configuration

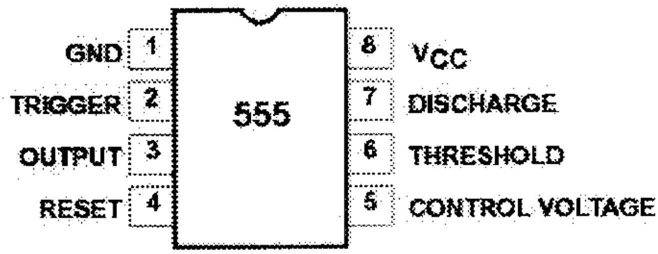


Fig. 4.6 Pin Configuration of 555 Timer IC

1) Ground :

The ground (or common) pin is the most-negative supply potential of the device, which is normally connected to circuit common (ground) when operated from positive supply voltages.

2) Trigger :

This pin is the input to the lower comparator and is used to

set the latch, which in turn causes the output to go high. A negative going trigger pulse is applied to the pin and should have its dc level greater than the threshold level of lower comparator (i.e. $V_{cc}/3$). The action of the trigger input is level-sensitive. The trigger pulse must be of shorter duration than the time interval determined by the external R and C. If this pin is held low longer than that, the output will remain high until the trigger input is driven high again.

One precaution that should be observed with the trigger input signal is that it must not remain lower than 1/3 V+ for a period of time longer than the timing cycle. If this is allowed to happen, the timer will retrigger itself upon termination of the first output pulse. Thus, when the timer is driven in the monostable mode with input pulses longer than the desired output pulse width, the input trigger should effectively be shortened by differentiation.

3) Output:

The output of the 555 comes from a high-current totem-pole stage made up of transistors. The state of the output pin will always reflect the inverse of the logic state of the latch. Actuation of the lower comparator is the only manner in which the output can be placed in the high state. The output can be returned to a low state by causing the threshold to go from a lower to a higher level , which resets the latch. output voltage available at this pin is approximately equal to the V_{cc} (6 V).

4) Reset:

This pin is also used to reset the latch and return the output to a low state. The reset pin is used to reset the flip-flop that controls the state of output pin 3. The pin is activated when a voltage level anywhere between 0 and 0.4 volt is applied to the pin. When not used, it is recommended that the reset input be tied to V+ to avoid any possibility of false resetting.

5) Control voltage:

This pin allows direct access to the 2/3 V+ voltage-divider point, the reference level for the upper comparator. It also allows indirect access to the lower comparator, as there is a 2:1 divider. The control voltage makes it possible to control the width of the output pulse independently of RC. In the event the control-voltage pin is not used, it is recommended that it be bypassed, to ground, with a capacitor of about 0.01uF (10nF) for immunity to noise, since it is a comparator input.

6) Threshold:

Pin 6 is one input to the upper comparator and is used to reset the latch, which causes the output to go low. Resetting via this terminal is accomplished by taking the terminal from below to above a voltage level of 2/3 V_{cc} (the normal voltage on pin 5). The action of the threshold pin is into this terminal from the external circuit. This current is typically 0.1μA, and will define the upper limit of total resistance allowable from pin 6 - V_{cc}.

7) Discharge:

This pin is connected to the open collector of a npn transistor, the emitter of which goes to ground, so that when the transistor is turned "on", pin 7 is effectively shorted to ground. The Conduction State of this transistor is identical in timing to that of the output stage. It is "on" when the output is low and "off") when the output is high. Saturation voltage is typically below 100mV for currents of 5 mA or less, and off-state leakage is about 20nA.

8) + V_{cc}:

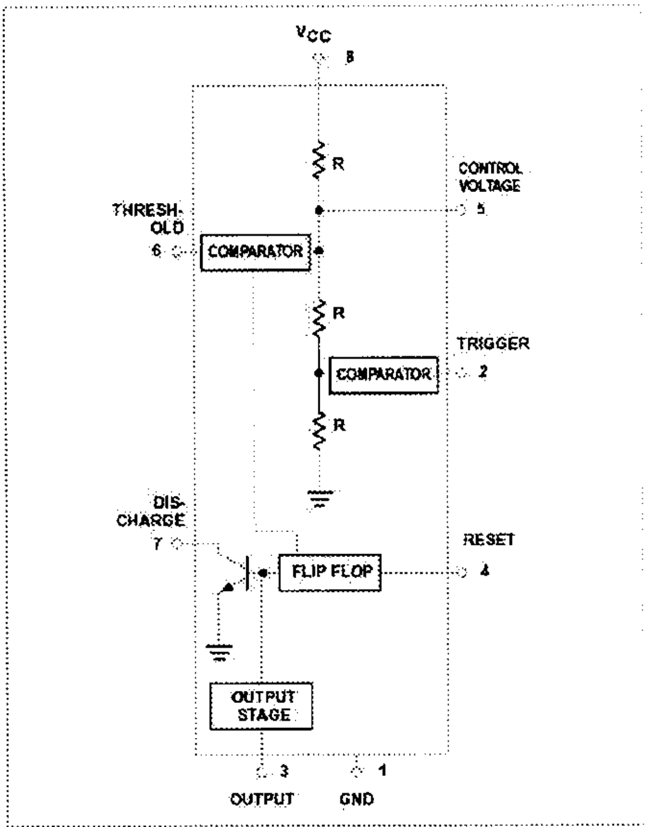
The V_{cc} is the positive supply voltage terminal of the 555 timer IC. Supply-voltage operating range for the 555 is +4.5 volts to +16 volts, and it is specified for operation between +5 volts and + 15 volts. Actually, the most significant operational difference is the output drive capability, which increases for both current and voltage range as the supply voltage is increased. Sensitivity of time interval to supply voltage change is low, typically 0.1% per volt.

4.2.2 Modes of Operation

The 555 timer has two basic operational modes:

- Monostable mode and
- Astable mode.

BLOCK DIAGRAM



EQUIVALENT SCHEMATIC

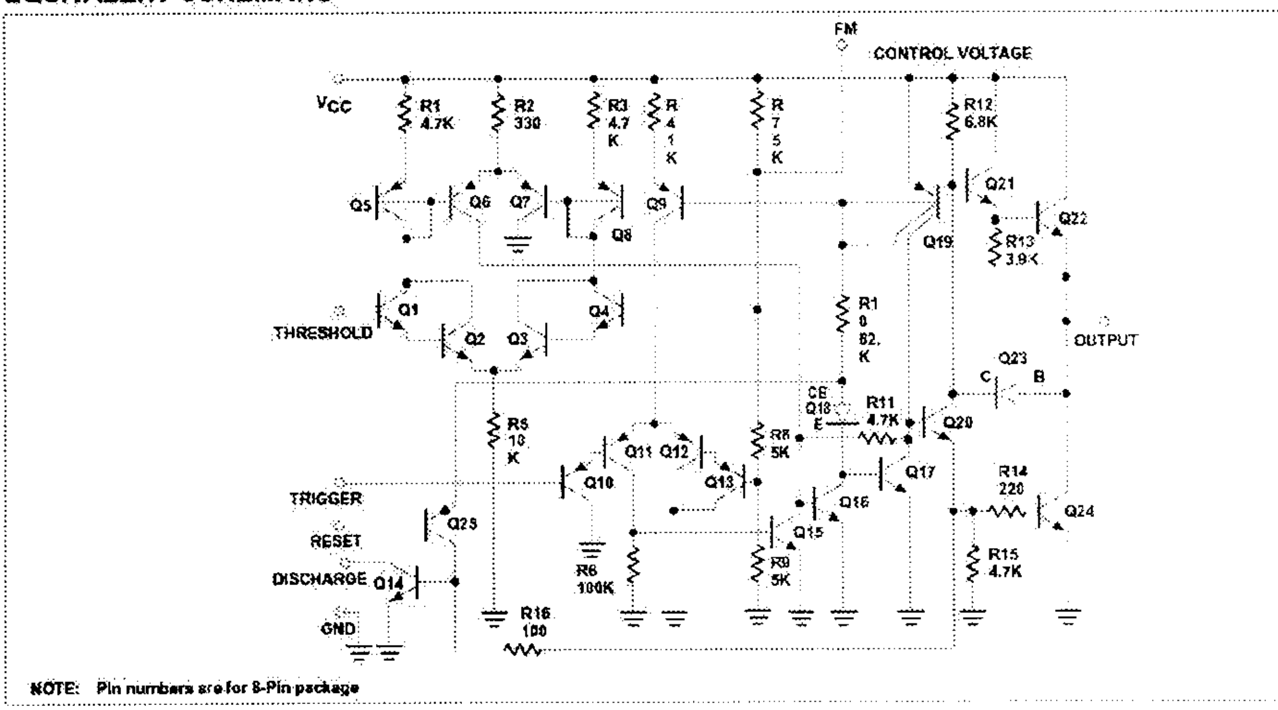


Fig. 4.7 Block diagram of 555 and Internal circuitry

In the one-shot mode, the 555 acts like a *monostable multivibrator*. A monostable is said to have a single stable state i.e., the OFF state. The monostable circuit generates a single pulse of a fixed time duration each time it receives and input trigger pulse. Thus the name one-shot. When multiple one-shots are cascaded, a variety of sequential timing pulses can be generated. Those pulses will allow you to time and sequence a number of related operations.

The other basic operational mode of the 555 is as and *astable multivibrator*. An astable multivibrator is simply and oscillator. The astable multivibrator generates a continuous stream of rectangular off-on pulses that switch between two voltage levels. The frequency of the pulses and their duty cycle are dependent upon the RC network values.

4.2.3 Operating Mode of 555 in D²M²

In Digital Dosa Making Machine the 555 timer is connected to operate in

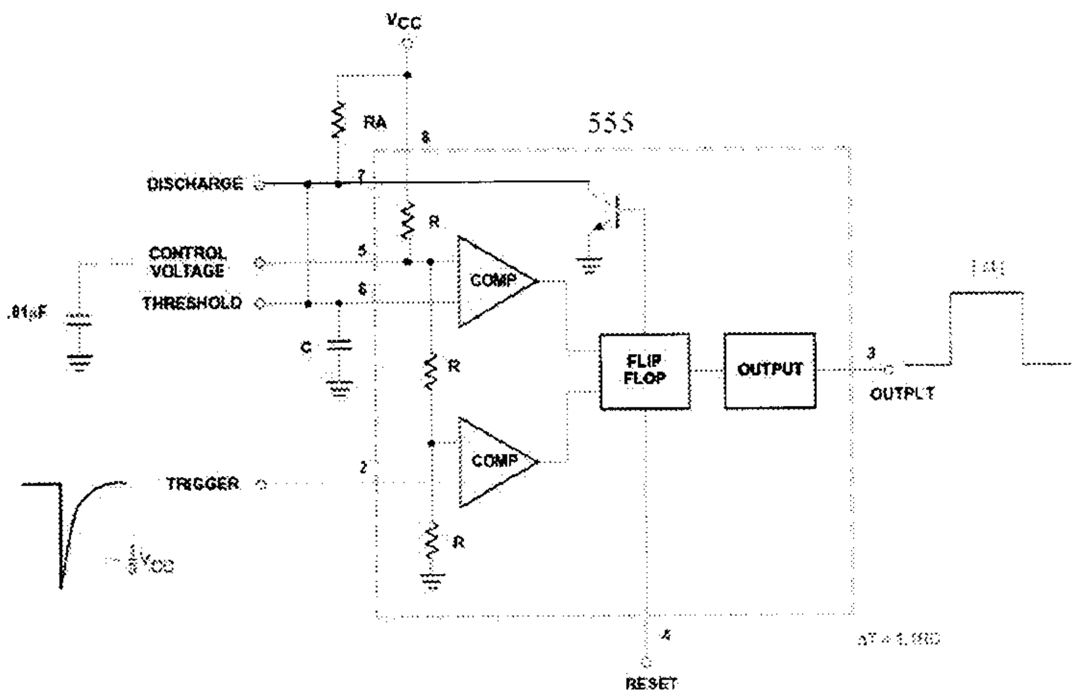


Fig 4.8 Monostable operation of 555

monostable mode. When the trigger switch is pressed, trigger input is pulsed to low from high. In the standby state, FF holds transistor Q1 on, thus clamping the external timing capacitor c to ground. The output remains low. As the trigger passes through Vcc/3,the FF is set. This makes the transistor Q1 off and short circuit across the timing capacitor c is released. As $Q^{|}$ is low, output goes high.

The timing cycle now begins. Since C is unclamped, voltage across it rises exponentially through R toward V_{cc} with a constant RC. After a time period T the capacitor voltage is just greater than 2/3Vcc and the upper comparator resets the FF this makes the output $Q^{|} = 1$, transistor Q1 goes on, thereby discharging the capacitor C rapidly to ground potential. The output returns to the standby state.

The voltage across the capacitor is given by

$$V_c = V_{cc}(1-e^{-t/RC})$$

where V_{cc} is the supply voltage

At t=T, $$V_c = V_{cc}(2/3)$$

Therefore, $$2/3\ V_{cc} = V_{cc}\ (1 - e^{-T/RC})$$

Or, $$T = RC\ \ln(1/3)$$

Or, $$\boxed{\mathbf{T=1.1\ RC\ sec.}}$$

It is evident that the timing interval is independent of supply voltage. Hence by varying the capacitor value or resistor value, we can change the time delay. This is the time period during which the timer is high and is used to trigger various mechanisms in D^2M^2. In our machine separate potentiometers are used to vary the time duration of all timers.

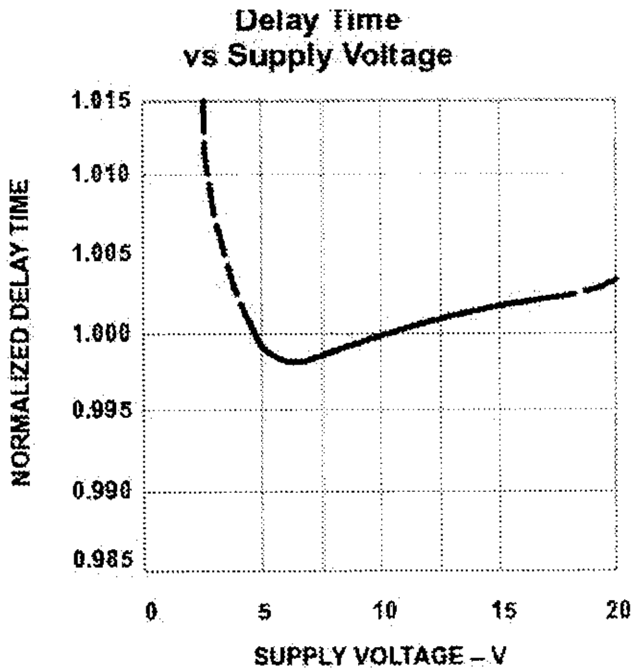


Fig. 4.9 Supply Voltage Vs Delay time

4.2.4 Ratings of 555 Timers

The absolute maximum ratings (in free air) for 555 IC

Vcc, supply voltage	: 6V -18V
Input voltage (CONT, RESET, THRES, TRIG)	: Vcc
Output current	: 100 mA (approx)
Operating free-air temp. range:	: 0°C - 70°C

More details about the 555 Timer IC- characteristics, graphs, design considerations, features etc.,.. are given in the Appendix.

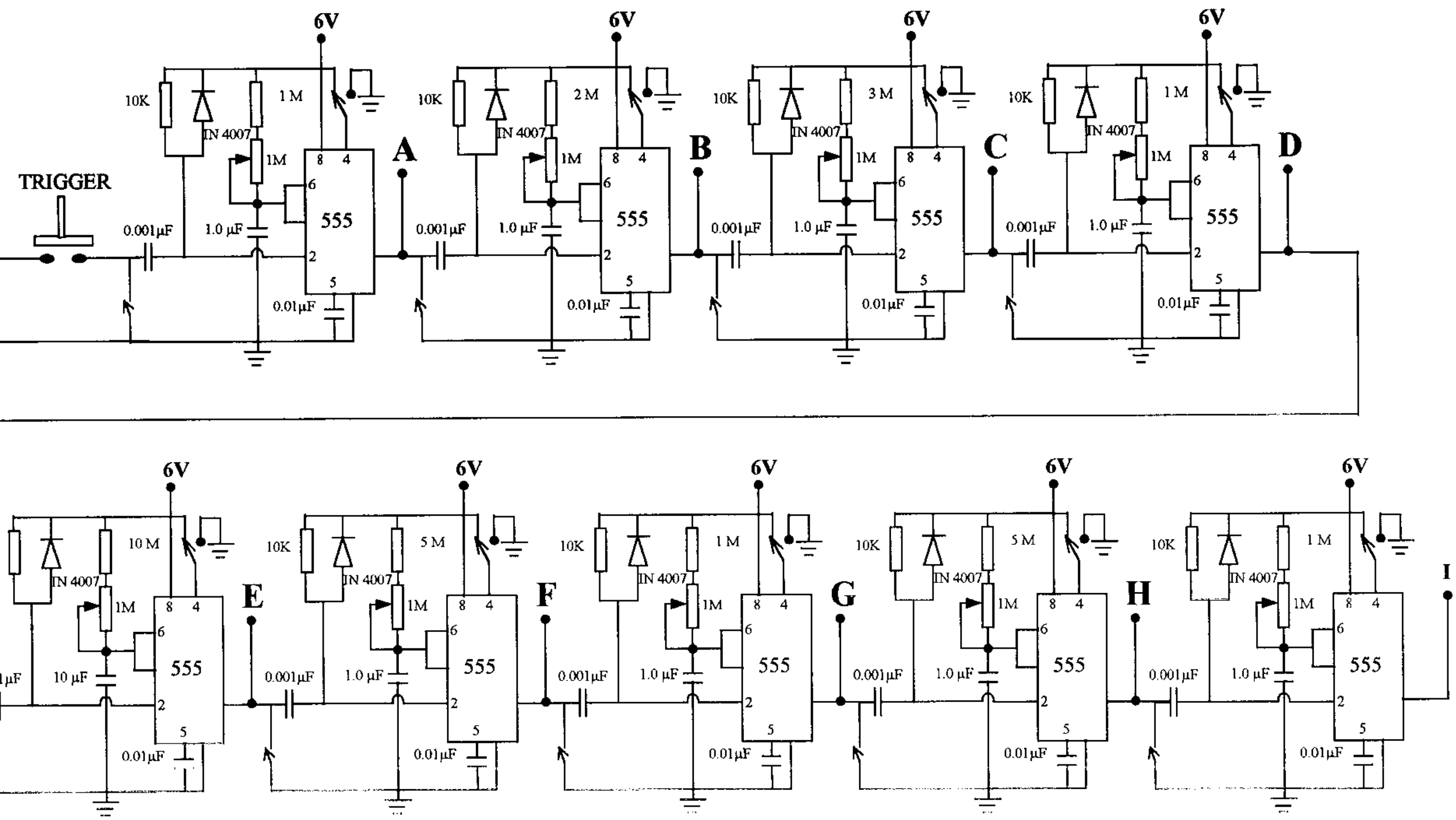


Fig. 4.10 Electronic Control Unit (Timing Circuit)

4.3 INTERFACING CIRCUIT

This circuit board consists of relays arranged in a sequence and are coupled with the appropriate timers. The relays are operated by 12V 100 mA supply. Apart from the fuction of switching the mechanisms, the relays are also used to reverse the 2 motors automatically by reversing the direction of current flowing through the motor.

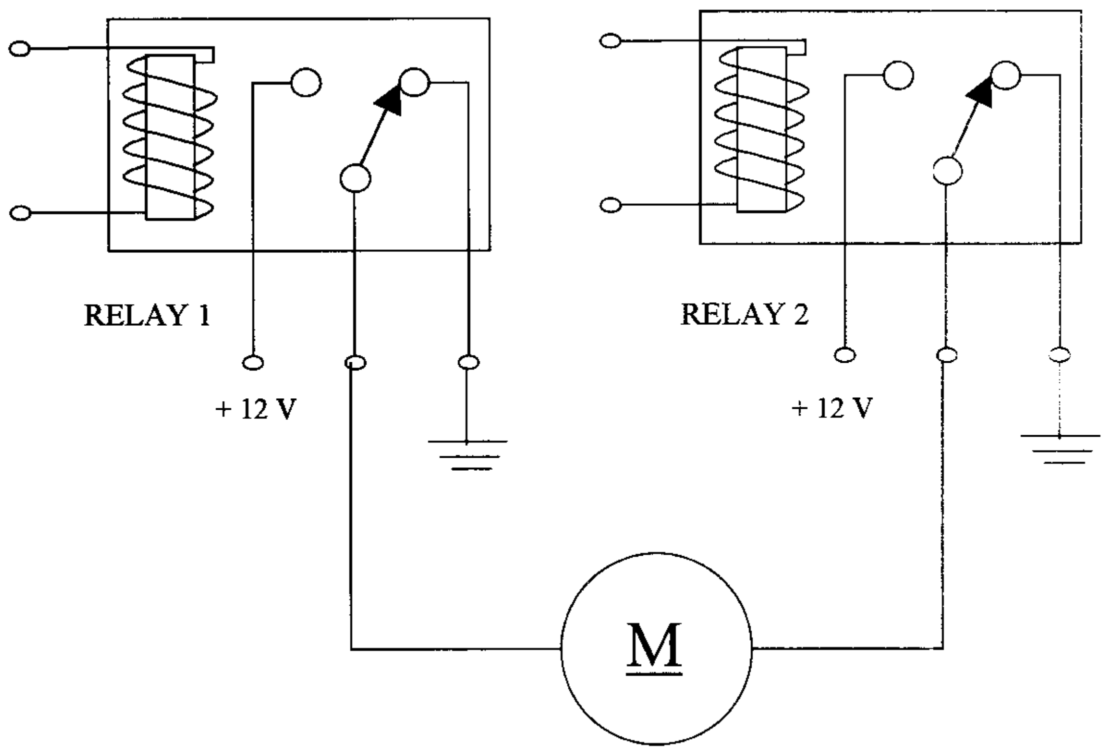


Fig 4.11 Reversing of motor using relays

Initially, both the relays are off and both the terminals of the motor are grounded. Hence the motor does not rotate. When the blade has to come down or the sweeper has to move towards the tawa, the relay 1 (not the actual sequence) is energized by the corresponding timer. This allows the current to flow from relay 1's terminal to relay 2's terminal through the motor and the motor rotates in forward direction.

Again, when the blade has to go up or the sweeper has to come back, the relay 2 is the current flowing through the motor is in the reverse direction and the motor also rotates in the reverse direction.

As far as other relays are concerned, the rotate motor is connected to the power supply through a relay in normal configuration. The switching voltage is 12 V and 3A supply.

The electromagnet is connected with 220 V /5A ac supply through another relay. In this regard care has to be taken that 'Arcing' does not affect the operation of the relay.

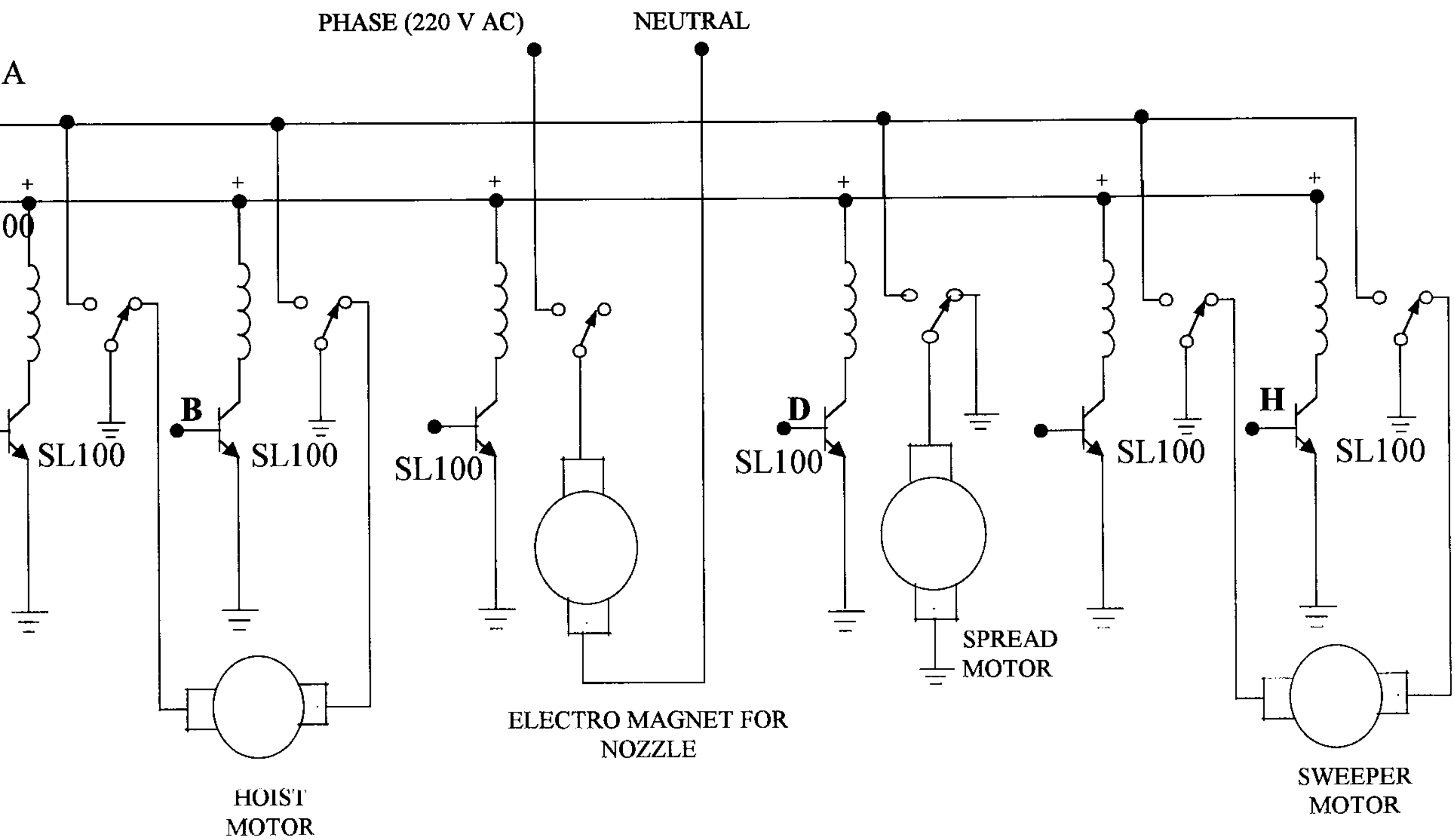


Fig . 4.12 Interface Circuit

ASSEMBLY OF COMPONENTS

5. ASSEMBLY OF COMPONENTS

The accuracy of assembling of the digital dosa maker determines the quality of output. The assembly of various motors and the guideways arrangement is the most difficult part of this project. The entire assembly is done on a slotted steel frame, which has provisions for altering the positions by bolting.

STEPS INVOLVED IN ASSEMBLY OF D^2M^2 :

1. Slotted steel frame of required thickness and length is bought.
2. The size and weight of all the motors and the electric stove are calculated.
3. Since the dimension of the entire assembly has to be kept to a minimum, the minimum height and width of the assembly is calculated to save space.
4. The frame is cut into small pieces of required dimensions and it is welded together to form a skeletal box.
5. The electric stove is fixed to the base of the framework by screwing it to another steel rod and welding it to the framework. Insulating packing is provided between them to avoid heat conduction from the stove to the frame.
6. Then the safe height at which the spread blade motor can be operated is fixed.
7. The spread blade motor is clamped tightly by a steel bar and it is welded to the rack of the hoist motor. Rubber packing is given between the motor and steel bar to avoid vibrations during operation.
8. The guideway is fixed vertically above the tawa at the predetermined height, by welding it to the frame.
9. The rack is placed on the guideway after applying grease on the guideway and the rack.

10. Care should be taken to align the spread blade at right angles with the rack of the hoist motor.
11. The pinion is fixed firmly to the shaft of the hoist motor by suitable bushing.
12. The pinion is made to mesh with the rack at the calculated height accurately.
13. A separate clamp is provided to fix the motor tightly with the frame.
14. A batter tank is built with open top preferably of glass or stainless steel. A lid is provided to close the container.
15. A flexible plastic hose is connected to the tank. Its length should be sufficient for free up/down movement of the mechanism.
16. The other end of the hose is fitted with a small metal pipe of slightly bigger diameter.
17. A thin slot is made in the metal hose for the plastic stopper such that the stopper can slide freely through it. This also supports the weight of the batter acting on the stopper.
18. A suitable casing for the electromagnetic nozzle is built with a slot in it and the electromagnet is placed inside the casing such that the height of its shaft coincides with the height of the slot.
19. A plastic stopper is connected to the shaft of the electromagnet by bonding.
20. The nozzle assembly is fixed with the spread motor by riveting so that it comes down along with the spread motor and pours the batter on the tawa from correct height.
21. The batter container is fixed to the framework above the tawa by suitable clamping.
22. The wooden guideway is kept at a certain angle of about 15 to 20 degrees to the horizontal plane. This provides the necessary sweeping force for easy removal of the dosa as shown in the Fig. 2.4
23. The position of the guideway is noted and it is fixed at a suitable height

24. The sweeper (mica) sheet is cut according to the dimensions of the tawa.
25. The sweeper sheet is fixed to the rack by gluing at right angles.
26. The rack is inserted through the wooden guideway.
27. The pinion is attached to the shaft of the sweeper motor firmly.
28. It is made to mesh with the rack at the pre-determined position.
29. Another clamp is provided for the motor and it is welded to the frame. Perfect contact of the pinion with the rack is ensured.
30. Exhaust fan is fixed to the frame by bolting above the tawa.
31. The terminals of the motors, nozzle, fan, etc., are connected with the interface circuit.
32. The control panel is built with adequate openings for switches, and indicators and is mounted on the frame at a corner.
33. The input terminals of all the Power supplies are connected to a common plug such that the Main Power switch activates all these supplies.
34. The electric stove is also connected with this common plug through an Emergency switch.
35. The electronic control unit is safely fixed inside the machine and connections are given to all the devices and the supply.
36. The power supplying units are also kept inside the machine.
37. The machine is covered with suitable casing with provisions for the Service outlet, exhaust fan, control panel and for maintenance purpose.

INTERACTIVE WORKING OF D^2M^2

6. INTERACTIVE WORKING

1. The Main Power is switched on. This immediately switches on the electric stove. After some time the stove maintains a constant temperature controlled by a rheostat.
2. 'The Start button' is pressed. From this instant **all** the operations till the dosa is served at the outlet is *Automatic* and no manual intervention is required.
3. This button is enabled only after the tawa attains the preset temperature.
4. The Start signal activates the first timer and its output goes high for about 1.3 seconds. This activates the first relay, which in turn switches on the hoist motor.
5. The hoist motor moves downward and the blade touches the tawa.
6. Once this time elapses, the output of the timer goes low and this level change triggers the succeeding timer.
7. This timer goes high for a duration of 2.5 seconds to open the nozzle through a relay. The batter flows on the tawa. After 2.5 seconds the nozzle closes and the next timer for spreading is activated.
8. This output of the timer is high for about 3.5 seconds and the spread motor rotates.
9. The next timer is triggered which reverses the hoist motor and the blade moves up.
10. Next, a delay of 2 to 3 min (adjustable) is allowed for the dosa to get roasted.
11. After the delay, the sweeper motor is activated by a timer for a duration of 5 seconds.
12. The sweeper attached to the rack moves towards the tawa at an inclination, knifes through between the dosa and the tawa.
13. The sweeper lifts the dosa and it retracts to its original position. Thus it brings the dosa near the service outlet.
14. A small delay of 1 second is given before retracting of the sweeper in order to

15. As the sweeper moves back, a sponge attached to the bottom of the sweeping sheet, cleans the tawa surface.
16. A row of LEDs on the control panel indicates the progress of all these operations.
17. Finally a buzzer indicates that the dosa is ready (end of all the operations).
18. The machine is now ready to roast another dosa. If the emergency button on the control panel is hit, it shuts off the whole system in case of accidents.

OVERCOMING DIFFICULTIES IN D^2M^2

7. OVERCOMING DIFFICULTIES IN D^2M^2

7.1 Avoiding overtravel of the Blade

The hoist motor is a DC motor utilized from the car wiper mechanism. Though it has good power due to the worm-gear mechanism and high speed, it should not be forced to stop, which can result in the burning of the motor's coil. This forced stopping of the motor can happen when the blade connected to this motor through the spread motor overtravels and hits the tawa surface.

In this analysis, it was found that the rack and pinion arrangement for the hoisting mechanism gives a long distance movement for short rotation of the hoist motor.

The reasons behind this are

1. The spindle of the motor is attached with a large size pinion (due to availability problem). This means that a small rotation of the pinion (spur gear) results in long movement of the rack.
2. The distance between two successive teeth on the rack or the angle between two successive teeth on the pinion is large.
3. The hoist motor does not give constant number of rotations each time it is given a pulse of constant duration.
4. The motor does not stop immediately when pulse is stopped.
5. Thus the accuracy of controlling the dc motor is lost i.e., the tolerance of linear movement of rack versus rotation of the hoist motor has become very large. This definitely leads to the overtravelling of the blade over the tawa surface for same control of the dc motor. This puts huge force on the spread motor for rotating the blade and this large thrust stops the spread motor from rotating. The
6. The hoist motor is forced to stop when current is flowing in it. Also the thickness of the dosa is reduced.

Some possible solutions for this problem can be:

1. To reduce the size of the pinion
2. To increase the number of teeth for same length of the rack and same dia of the pinion.
3. To replace the motor with a stepping motor
4. To use a limit switch for stopping rotation
5. To provide a mechanism to compensate with the overtravel

The first two solutions cannot be implemented due to availability problems. If the size of the pinion is small, the width of the teeth will also be small in most cases, which will not be enough to lift the weight of the spread blade mechanism.

The third solution is to replace the motor with a stepper motor and it gives accurate positioning of the spindle. But an entirely different control circuit has to be provided for controlling this motor, unlike simple control of dc motor. Also it is very much a costlier option.

Consider a limit switch is being provided to avoid overtravel. Even then the motor gives a small movement after the pulse signal is cut off by the limit switch. This extra movement is not constant every time and hence cannot be calculated and compensated.

We are left with one last solution to prevent the damage of the motor.

A compressing mechanism can be provided which can bear the overtravel without giving much strain to the motor.

The three compressing devices which can provide compression of atleast 2 cm (the maximum error of overtravel) are

- a spring
- a bellow

The spring and ariel are excellent compressing devices but the drawback is that they do not give enough twisting force to rotate the blade i.e., it is not stiff on the rotation axis. The ariel can be rotated (undesirable) and it cannot retain its original length.

The bellow mechanism is discussed in the section 1.3.

Here 'a' is the overtravel distance that can be compensated by the bellow. Thus when the motor overtravels due to any of the above reasons, the bellow compresses reducing the strain on the spread motor. The spread motor can now rotate freely and the hoist motor is safe as well. When the blade moves up, the bellows expand to its original length.

7.2 Avoiding overtravel of the Sweeper

Harmonious to the overtravel of the hoist motor, there are chances for the sweeper to overtravel. The overtravel of the motor can be in two directions. The cnsequences of the first problem will be such that the rack whose other end is

free will come out of contact with the pinion. The reciprocation of the sweeper becomes impossible. The overtravel in other direction may result in a crash between the sweeper and the guideways which result in collapse of the sweeper mechanism.

The remedy for this problem is as discussed below:

The size of the pinion can be very well reduced as it does not involve much load- just the weight of the sweeper board. So, this can avoid the overtravelling problem. Also the number of teeth on the pinion and the rack is increased to minimize the error tolerance. For eg, if the pinion circumference is 20 cm and the error is (+/-) half rotation, the distance moved by the rack is (+/-) 10 cm. If a smaller pinion `of dia 8 cm is used, for same error the distance moved is (+/-) 4 cm. If number of teeth increases, the precision increases. The specification of the rack and pinion arrangement for the sweeping mechanism in 'Construction' section indicates about the smaller dia pinion used in this machine.

7.3 Adjusting the quantity of batter

The amount of batter flowing on the tawa can sometimes be significant if the viscosity of the batter varies each time. This can be solved if the control of the duration of nozzle open is left to the user. The user can set the time between two safe limits on the interface board and is discussed in detail under the 'Including Additional Features' section.

7.4 Interrupting of input Start signal during operation

This is an important feature in this machine is that it will not accept input Start signal while the process is going on. To achieve this, a separate relay logic can be implemented such that as soon as the input Start signal is issued, the relay gets de-activated ignoring any further inputs and the pulse from the last timer output activates the relay again.

7.5 Controlling Stove/ Tawa Temperature:

One of the primary function of the Digital Dosa Making Machine is to control the temperature of the tawa. The impact of over-heating or under-heating of the tawa is reflected on the quality of the dosa. Thus maintaining the tawa at constant temperature becomes very necessary. In this regard, a thermostat is used to do the task of temperature controlling. A thermostat is a heat transducing device which can close/open a circuit. It consists of a bi-metallic strip that can bend according to the temperature at which it is placed. This movement of the bi-metallic strip is aided with a switch. This is used to switch on/off the stove. The distance between the two contacting points in the thermostat can be adjusted by a knob and thus the temperature at which it is cut-off can be adjusted. This knob can be made available at the user-interface.

7.6 Eccentricity of Nozzle away from the Center axis

The spread motor is mounted co-axially with the center of the tawa. Hence the nozzle is mounted away from the center of this axis. Eventhough the batter flows over the tawa at an eccentric distance, the spread blade wipes it evenly throughout the tawa surface as it rotates.

7.7 Reducing the size of the machine

As D^2M^2 is a home appliance, the size of the machine should be kept as minimum as possible. Hence the layout of all the components is arranged properly. The minimum stroke length of the motors required for perfect operation is calculated and all the motors are fixed accordingly. The electronic control unit is placed under the sweeper blade to save the space.

7.8 Cleaning of the tawa

After the Dosa is roasted, some dosa scraps may lie on the tawa. A sponge attached to the bottom of the sweeper cleans away these pieces as it retracts. Hence these scraps do not affect the preparation of next dosa. The cleaning of this sponge comes under bi-monthly maintenance.

7.9 Exhaust of whiff and vapour inside the machine

The heat of the tawa produces some whiff and some vapours are produced while dosa is roasted. This affects the internal appearance of the machine and in long time run, it becomes dirty. Hence an exhaust fan is used to suck these fumes and let it out. The fan operates as soon as the Main Power is switched on.

COST FACTORS

8. COST FACTORS

Since D^2M^2 comes under commonly used home appliances, the total cost of the machine is ought to be minimum. So we have considered all the factors affecting the total cost of the machine. Also this machine if manufactured in bulk quantities, will cost about 30% to 40% less than the cost of this prototype.

8.1 Cost Optimization

8.1.1 Motors

The major cost involved is in that of the motors. We are using three different motors for different mechanisms. A dc motor as such cannot be used in this machine as its speed is high and it does not possess the required holding torque when it is off. Hence we have to go for speed reduction. A pre-fabricated DC motor is available with high speed reduction ratio in the form of 'Wiper motor' used in light motor vehicles. Worm-gear is used for speed reduction, which has high holding torque. Its cost is less than the more accurate stepper motor. The inaccuracy of controlling the DC motor is compensated by aforesaid mechanisms, so the stepper motor is not needed.

8.1.2 Frame

The frame is the main supporting structure of the machine. Number of channels are used in fabricating this machine. Comparing plain with slotted channels, plain channels are cheaper. But its is not flexible i.e., mounting of components is difficult and we have to go for welding. Bolting is easier and cheaper than welding and it is adjustable too. Hence the comparative cost will almost be same.

8.1.3 Electronic Control Unit

Cost and efficiency are two main characteristics of the ECU. The timing circuits using 555 timers are cheaper compared to microcontroller. But microcontrollers this application involves only timing operations, use of microcontrollers leads to under-utilization of it. The timing adjustments can be done by varying the RC values of 555 and the timing errors of it are compensated here, so 555 timers are best suited for this type of controlling.

8.1.4 Miscellaneous

Other components such as the blade for spreading, mica sheet for sweeping, guideways for sweeper rack are made of wood which is cheaper than its alternative, metal.

8.2 Cost Estimation

Sno.	Components	Approx. cost (RS.)
1.	Motors	2,100
2.	Frame	350
3.	Rack and pinion arrangement	150
4.	Control unit	325
5.	Interfacing unit	145
6.	Power supply	200
7.	Tawa	400
8.	Electric stove	475
9.	Exhaust fan	50
10.	Batter tank, hose	75
11.	Switches, wiring, electrical accessories	85
12.	Electromagnet	50
13.	Miscellaneous	100
	Total Cost	**4505**

INCLUDING ADDITIONAL FEATURES

9. INCLUDING ADDITIONAL FEATURES

Due to limited time duration, the designing and fabrication process of D^2M^2 has been limited and hence the capabilities of the machine have also been limited. When we analyze about the additional features that can be included with the machine, we arrive at certain prominent features as explained below:

9.1 Converting D^2M^2 into a productive machine

As D^2M^2 comes under home appliances it was not necessary to cook more than one dosa at a time. When we want this machine to be applied for large scale hotels or restaurants, we can increase the productivity by applying any of the following methods in the machine: With little knowledge about a productive machine if already exists, some of the following methods can be assumed as suggestions.

- We can initially think of a large sized circular tawa on a big stove, fixed over an indexing table. The indexing of the table has to be controlled automatically. In this case, some intelligent methods of electronic control has to be implemented. By programming a microcontroller we can easily control the indexing of the table. The electric stove of this size may not be efficient. It consumes lot of power. So, we can go for direct flame heating by using LPG. For this we have to concentrate more on the flame control and hence the tawa temperature control. If this can be accomplished, a very high productivity can be obtained as flame heating is highly efficient.

The sequential procedure of such a machine will look like this:

Initially as the machine is switched on, the indexing table will take the home position. At one point on the large tawa, flour is poured. The table is then indexed to rotate the tawa to bring another area under the nozzle. Then again the flour is poured. Just behind the nozzle the sweeping mechanism can be mounted which continuously take the dosas from the tawa.

- If we think of a static table and tawa, we must have multiple nozzle stop mechanism. This different case may not be that easy as the spreading of the dosa becomes difficult. Therefore we should have multiple spreading mechanism and controlling such a machine would result in complex electronic circuits.

- So far we have seen the dosa machine that is fabricated and machines that can be manufactured for roasting circular dosas. This is the instance in South India where dosas ought to look round. If this is not given much importance, i.e. if we can go for square dosas as well, then the machine becomes more productive.

A lengthy tawa can be used. A nozzle of rectangular cross section of required width is connected to a sliding mechanism. i.e. the nozzle can move over the surface of the tawa linearly, at some height. The flour is poured at discrete intervals as calculated. The spread blade attached with the nozzle spreads the flour evenly. The space between the spread blade and the tawa is again the thickness of the required dosa. After some time a cutting blade plunges on the tawa to cut the dosa. The cutting points are same so tawa is not damaged. The dosas are dispatched by a similar mechanism.

9.2 Different types of Dosas

Very similar to other food items, dosa itself is a big family. Some members of this family are onion dosa, egg dosa, masal dosa, ghee dosa, rava dosa, green dosa, dhal dosa, tomato dosa, mixed vegetable dosa, nutty dosa and many more...! Out of these, some types are prepared by a homogeneous mix of some ingredients with the dosa flour (type-1) and others are prepared by placing the ingredients over the dosa just as it begins to roast (type-2). For those readers who don't know much about dosa- if the flour quantity is more and the size of the dosa is large then it is called a 'Roast'. If the flour quantity and the thickness are more it is called an 'Uthappam'.

In the later type, it has to be flipped over and the discussion of this case is not included here.

For type-1, the existing tank must be bigger, having partitions in it. The different types of flour mixtures are poured into separate sections and multi stopping nozzle mechanism is adopted. The level of these mixtures should be as per the requirement.

For type-2, the extra attachments include another big tank containing sections in it which contains those ingredients. After the dosa is spread, these ingredients are poured/placed over the dosa by suitable automated mechanism. Care should be taken that decaying items are not stored in large amount.

9.3 Automatic Cleaning

In D^2M^2, the cleaning of components like nozzle, blade, and the sweeper are manual except the tawa is cleaned automatically by a sponge fixed under the sweeper. If the cleaning of other components really concerns, especially for productive machines, cleaning can also be automated.

The nozzle cleaning can be done by water gushing through it from a seperate tank. While the blade cleaning is done by a suitable mechanism, the automatic cleaning of the sweeper surface will not be a complicated one. The cleaning of the tank is advised to be manual.

9.4 Utilizing the Electric Stove for other cooking purposes

This is an excellent feature of the D^2M^2 that was not implemented due to lack of time. Here, the electric stove is mounted on a guideway such that it can be pulled outside the machine. The stove can be separately switched on and can be used to cook other items. If the LPG stove is not enough or if the LPG cylinder we are in some houses (esp. bachelors) if other means of heating is not available, they can simply use the machine's stove for cooking as well!

9.5 Adjustment controls in the user interface

If there are some timing adjustments that can be adjusted as per the user's refinement, they will be:

- Adjusting the amount of batter and henceforth the size of the dosa
- Adjusting the time period of roasting

If the nozzle is opened for a longer/shorter duration, then the size of the dosa can be changed as bigger/smaller.

If the delay given for roasting the dosa is lessened/lengthened the dosa can be slightly under-roasted/ over-roasted as per the user's taste.

Adjusting the variable resistor can do this. We mean that the resistor can be provided at the user-interface board with a knob, instead of being in the control unit. The higher end and lower end of the timing in both case should be reasonable and safe and can be graduated. Analogous to controlling the period of roasting through electronic means, it can be controlled through electrical means as well. i.e., the stove temperature can be controlled by connecting a thermostat with the tawa, which can maintain a constant preset temperature. This preset can be adjusted and this adjustment can be provided at the user-interface *instead* of the timing adjustment. The thermostat is described in the section "Overcoming difficulties – Controlling Tawa temperature"

COMPARITIVE STUDY

10. COMPARATIVE STUDY

10.1 ANALYSIS

We know D^2M^2 is an automatic machine that can replace manual dosa making process. The traditional way of dosa making is still powerful and not everyone uses machines. But when we compare this automatic way of dosa making with traditional way, a big list of advantages arise very easily. This emphasizes that implementing D^2M^2 in our day-to-day life is not impossible. It can be strongly recommended owing to the favourable or beneficial circumstances that D^2M^2 provide. A table comparing all the features of D^2M^2 and traditional methods of dosa making is given below:

Sno.	D^2M^2	Conventional methods
1.	The productivity is very large	The production rate is less
2.	Dosas prepared are very much consistent, same quality always	They are not same always
3.	A lot of time is saved when used in peak hours	Consumes lot of time and is irritating job when lot of dosas are required
4.	No worries of dosas being irregularly roasted or torn out	Torn and irregular dosas are very common

5.	No need of LPG stoves or any other stoves	Other heating source is required
6.	The same stove can be used for cooking other items	The same stove can be used for cooking other items
7.	Power is consumed in the form of Electricity	Power is consumed in the form of LPG
8.	No extra utensils are required	Many other utensils are required
9.	The user need not be skilled, simple to operate	Very much skilled user is necessary
10.	Ergonomically designed, almost no strain to the user	Causes fatigue to the user
11.	Very less human intervention. except for some cleaning	Fully manual
12.	Transporting at one shot	All utensils, stove, etc.,.. have to be transported
13.	Does not require frequent cleaning	Immediate cleaning is required
14.	Expansion of the machine	All other varieties are possible

15.	Cooking and eating simultaneously is possible	It is almost impossible
16.	No oil is required	Oil is required for conventional tawas
17.	No risk of fire/ burn accidents	Careless use leads to burns or even major fire accidents
18.	Best suited for bachelors	Not suited for bachelors
19.	D^2M^2 is an Eco-friendly machine	It is not an Eco-friendly machine
20.	On production cost is very affordable compared to other machines like bread toaster	Cost is less, but separate equipments are necessary
21.	Overheating is not possible	Cooking entirely ceases when over-heated
22.	Progress indicators save our time	User has to keep her/his eyes on the tawa.

10.2 LIMITATIONS

i. Power consumption is more

ii. Preparing other varieties need expansion of the system

CONCLUSION

11. CONCLUSION

As technology creeps into every aspect of life, it has also engraved its feet on the home appliances. Every equipment like refrigerator, washing machine, coffee maker etc.,. has started to stick towards the technological upgradation The thought of automating a very common cooking process – *Dosa making* have paved way to the development of D^2M^2.

D^2M^2, being a completely automatic machine assuages its user by its exquisite features. This project was developed by keeping one thing in mind: *Application.* How much is the possibility that this project can *really* be applied in our day-to-day life? was the first question that was answered.

D^2M^2 is only a prototype with minimal optimization executed on it. A machine that can be produced and marketed, D^2M^2 will surely satisfy the needs of modern mothers. This machine may not have involved much complexities in its design both by mechanical and electronic means, but the practical execution of the design was indeed very intricate. The successful design and development of D^2M^2 has proved it is worth in an emphatic way.

BIBLIOGRAPHY

12. BIBLIOGRAPHY

1. Roy Choudry, *Linear Integrated Circuits,*
2. B.L.Theraja, *Electrical Machines,*
3. C.E. Shannon, *A symbolic analysis of relay and switching circuits*
4. Mohammed Rashid, *Power Electronics*
5. A. Wagle, D.E Brusher, *Geared Motors*
6. Allen Mottershed, *Electronic devices and circuits*
7. David A Bell, *Solid state circuits*
8. *www.national.com*
9. *www.tonh.net*
10. *www.sspremier.com*

APPENDIX

Absolute Maximum Ratings (Note 3)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Input Voltage	
(V_O = 5V, 12V and 15V)	35V
Internal Power Dissipation (Note 1)	Internally Limited
Operating Temperature Range (T_A)	0°C to +70°C
Maximum Junction Temperature	
(K Package)	150°C
(T Package)	150°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec.)	
TO-3 Package K	300°C
TO-220 Package T	230°C

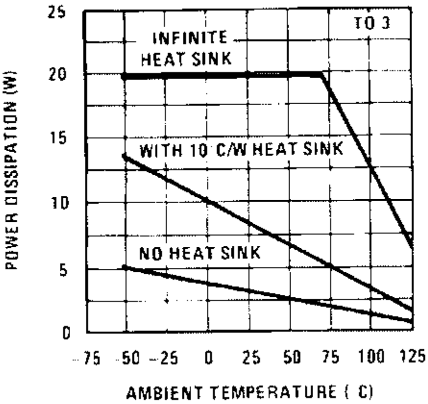
Electrical Characteristics LM78XXC (Note 2)

0°C ≤ T_J ≤ 125°C unless otherwise noted.

		Output Voltage		5V			12V			15V			Units
		Input Voltage (unless otherwise noted)		10V			19V			23V			
Symbol	Parameter	Conditions		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
V_O	Output Voltage	Tj = 25°C, 5 mA ≤ I_O ≤ 1A		4.8	5	5.2	11.5	12	12.5	14.4	15	15.6	V
		P_D ≤ 15W, 5 mA ≤ I_O ≤ 1A		4.75		5.25	11.4		12.6	14.25		15.75	V
		V_{MIN} ≤ V_{IN} ≤ V_{MAX}			(7.5 ≤ V_{IN} ≤ 20)			(14.5 ≤ V_{IN} ≤ 27)			(17.5 ≤ V_{IN} ≤ 30)		V
ΔV_O	Line Regulation	I_O = 500 mA	Tj = 25°C		3	50		4	120		4	150	mV
			ΔV_{IN}		(7 ≤ V_{IN} ≤ 25)			(14.5 ≤ V_{IN} ≤ 30)			(17.5 ≤ V_{IN} ≤ 30)		V
			0°C ≤ Tj ≤ +125°C			50			120			150	mV
			ΔV_{IN}		(8 ≤ V_{IN} ≤ 20)			(15 ≤ V_{IN} ≤ 27)			(18.5 ≤ V_{IN} ≤ 30)		V
		I_O ≤ 1A	Tj = 25°C			50			120			150	mV
			ΔV_{IN}		(7.5 ≤ V_{IN} ≤ 20)			(14.6 ≤ V_{IN} ≤ 27)			(17.7 ≤ V_{IN} ≤ 30)		V
			0°C ≤ Tj ≤ +125°C			25			60			75	mV
			ΔV_{IN}		(8 ≤ V_{IN} ≤ 12)			(16 ≤ V_{IN} ≤ 22)			(20 ≤ V_{IN} ≤ 26)		V
ΔV_O	Load Regulation	Tj = 25°C	5 mA ≤ I_O ≤ 1.5A		10	50		12	120		12	150	mV
			250 mA ≤ I_O ≤ 750 mA			25			60			75	mV
		5 mA ≤ I_O ≤ 1A, 0°C ≤ Tj ≤ +125°C				50			120			150	mV
I_Q	Quiescent Current	I_O ≤ 1A	Tj = 25°C			8			8			8	mA
			0°C ≤ Tj ≤ +125°C			8.5			8.5			8.5	mA
ΔI_Q	Quiescent Current Change	5 mA ≤ I_O ≤ 1A				0.5			0.5			0.5	mA
		Tj = 25°C, I_O ≤ 1A				1.0			1.0			1.0	mA
		V_{MIN} ≤ V_{IN} ≤ V_{MAX}			(7.5 ≤ V_{IN} ≤ 20)			(14.8 ≤ V_{IN} ≤ 27)			(17.9 ≤ V_{IN} ≤ 30)		V
		I_O ≤ 500 mA, 0°C ≤ Tj ≤ +125°C				1.0			1.0			1.0	mA
		V_{MIN} ≤ V_{IN} ≤ V_{MAX}			(7 ≤ V_{IN} ≤ 25)			(14.5 ≤ V_{IN} ≤ 30)			(17.5 ≤ V_{IN} ≤ 30)		V
V_N	Output Noise Voltage	T_A = 25°C, 10 Hz ≤ f ≤ 100 kHz			40			75			90		μV
$\frac{\Delta V_{IN}}{\Delta V_{OUT}}$	Ripple Rejection	f = 120 Hz	I_O ≤ 1A, Tj = 25°C or	62	80		55	72		54	70		dB
			I_O ≤ 500 mA 0°C ≤ Tj ≤ +125°C	62			55			54			dB
		V_{MIN} ≤ V_{IN} ≤ V_{MAX}			(8 ≤ V_{IN} ≤ 18)			(15 ≤ V_{IN} ≤ 25)			(18.5 ≤ V_{IN} ≤ 28.5)		V
R_O	Dropout Voltage	Tj = 25°C, I_{OUT} = 1A			2.0			2.0			2.0		V

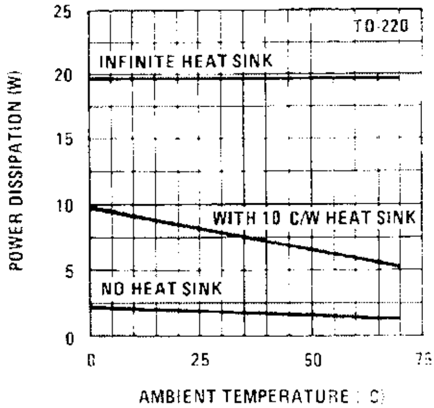
Typical Performance Characteristics

Maximum Average Power Dissipation

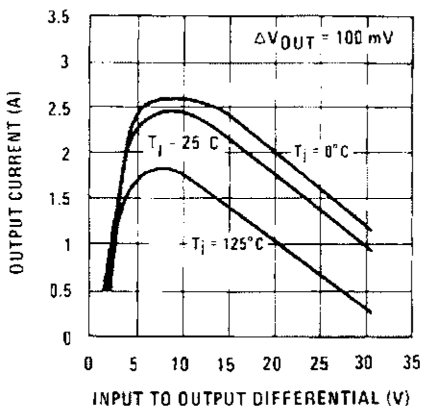


DS007746-5

Maximum Average Power Dissipation

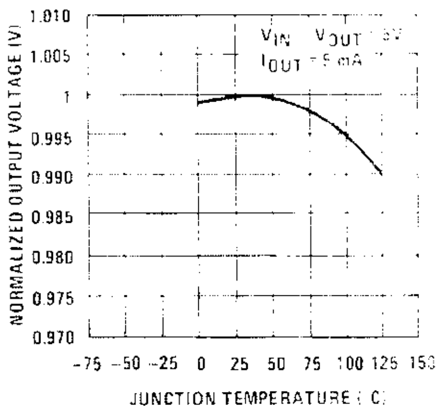


Peak Output Current

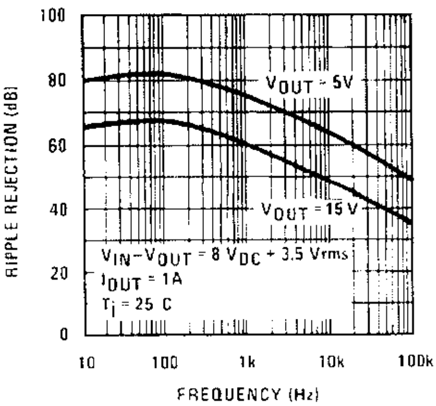


DS007746-7

Output Voltage (Normalized to 1V at T_J = 25°C)

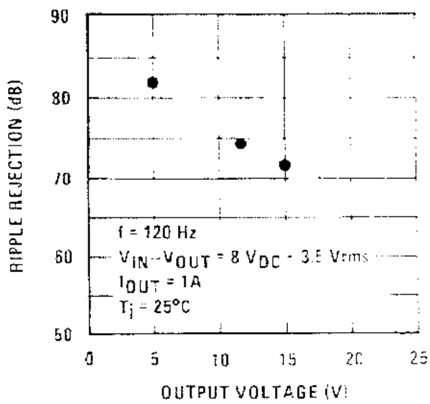


Ripple Rejection



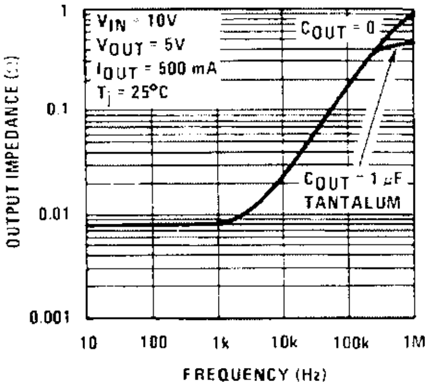
DS007746-9

Ripple Rejection



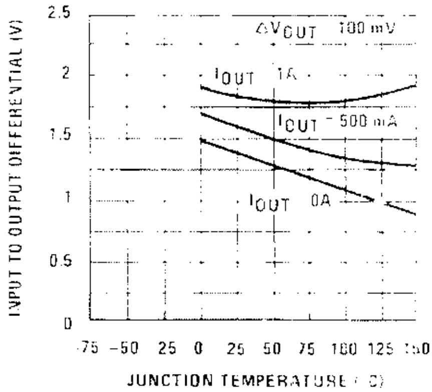
Typical Performance Characteristics (Continued)

Output Impedance

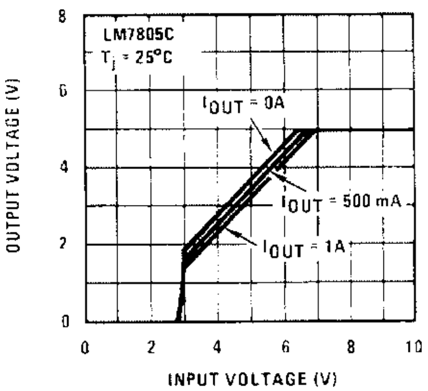


DS007746-11

Dropout Voltage

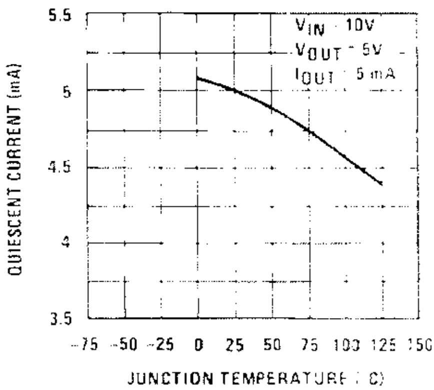


Dropout Characteristics

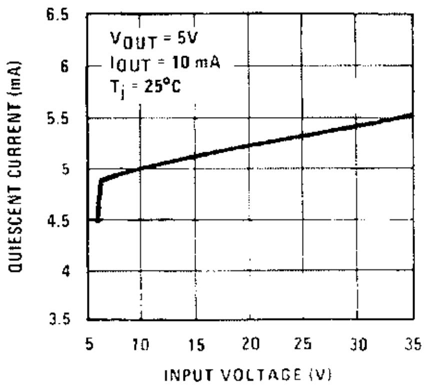


DS007746-13

Quiescent Current

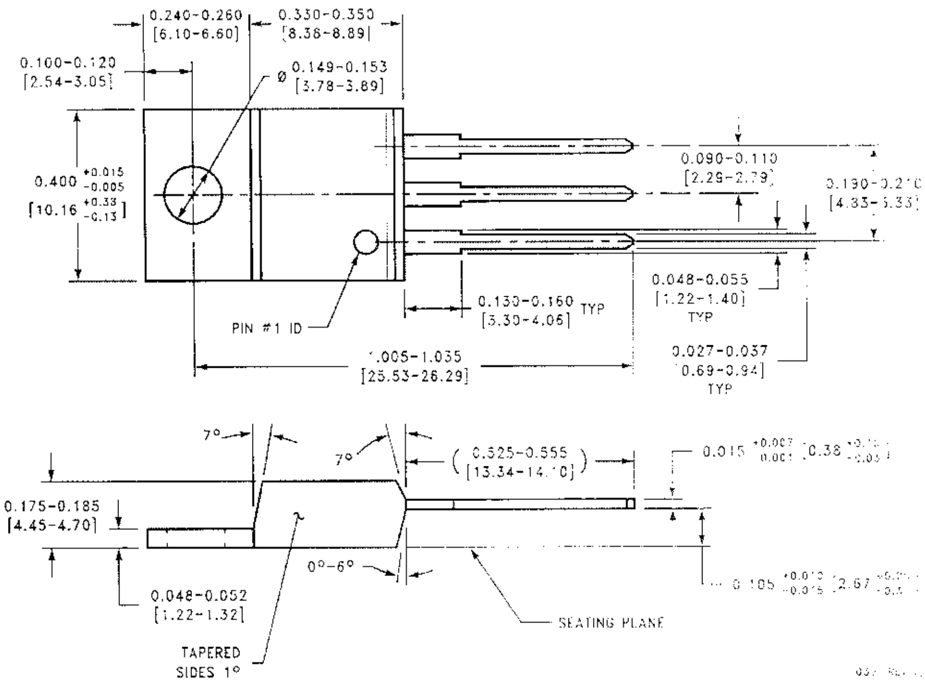


Quiescent Current



DS007746-15

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



TO-220 Power Package (T)
Order Number LM341T-5.0, LM341T-12, LM341T-15, LM78M05CT, LM78M12CT or LM78M15CT
NS Package Number T03B

Timer

NE/SA/SE555/SE555C

DESCRIPTION

The 555 monolithic timing circuit is a highly stable controller capable of producing accurate time delays, or oscillation. In the time delay mode of operation, the time is precisely controlled by one external resistor and capacitor. For a stable operation as an oscillator, the free running frequency and the duty cycle are both accurately controlled with two external resistors and one capacitor. The circuit may be triggered and reset on falling waveforms, and the output structure can source or sink up to 200mA.

FEATURES

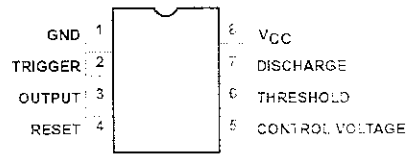
- Turn-off time less than 2μs
- Max. operating frequency greater than 500kHz
- Timing from microseconds to hours
- Operates in both astable and monostable modes
- High output current
- Adjustable duty cycle
- TTL compatible
- Temperature stability of 0.005% per °C

APPLICATIONS

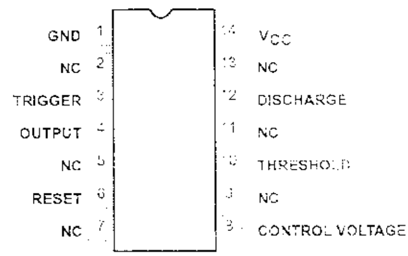
- Precision timing
- Pulse generation
- Sequential timing
- Time delay generation
- Pulse width modulation

PIN CONFIGURATIONS

D, N, FE Packages



F Package



TOP VIEW

ORDERING INFORMATION

DESCRIPTION	TEMPERATURE RANGE	ORDER CODE	DWG #
8-Pin Plastic Small Outline (SO) Package	0 to +70°C	NE555D	0174C
8-Pin Plastic Dual In-Line Package (DIP)	0 to +70°C	NE555N	0404B
8-Pin Plastic Dual In-Line Package (DIP)	-40°C to +85°C	SA555N	0404B
8-Pin Plastic Small Outline (SO) Package	-40°C to +85°C	SA555D	0174C
8-Pin Hermetic Ceramic Dual In-Line Package (CERDIP)	-55°C to +125°C	SE555CFE	
8-Pin Plastic Dual In-Line Package (DIP)	-55°C to +125°C	SE555CN	0404B
14-Pin Plastic Dual In-Line Package (DIP)	-55°C to +125°C	SE555N	0405B
8-Pin Hermetic Cerdip	-55°C to +125°C	SE555FE	
14-Pin Ceramic Dual In-Line Package (CERDIP)	0 to +70°C	NE555F	0581B
14-Pin Ceramic Dual In-Line Package (CERDIP)	-55°C to +125°C	SE555F	0581B
14-Pin Ceramic Dual In-Line Package (CERDIP)	-55°C to +125°C	SE555CF	0581B

ABSOLUTE MAXIMUM RATINGS

SYMBOL	PARAMETER	RATING	UNIT
V_{CC}	Supply voltage		
	SE555	+18	V
	NE555, SE555C, SA555	+16	V
P_D	Maximum allowable power dissipation[1]	600	mW
T_A	Operating ambient temperature range		
	NE555	0 to +70	C
	SA555	-40 to +85	C
	SE555, SE555C	-55 to +125	C
T_{STG}	Storage temperature range	-65 to +150	C
T_{SOLD}	Lead soldering temperature (10sec max)	+300	C

NOTES:

1. The junction temperature must be kept below 125°C for the D package and below 150°C for the FE, N and F packages. At ambient temperatures above 25°C, where this limit would be derated by the following factors:
   D package 160°C/W
   FE package 150°C/W
   N package 100°C/W
   F package 105°C/W

DC AND AC ELECTRICAL CHARACTERISTICS

T_A = 25°C, V_{CC} = +5V to +15 unless otherwise specified.

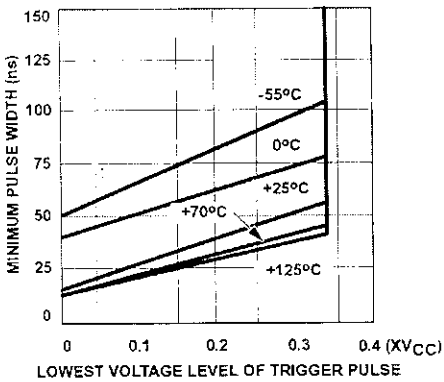
SYMBOL	PARAMETER	TEST CONDITIONS	SE555			NE555/SE555C			UNIT
			Min	Typ	Max	Min	Typ	Max	
V_{CC}	Supply voltage		4.5		18	4.5		16	V
I_{CC}	Supply current (low state)[1]	V_{CC}=5V, R_L=∞		3	5		3	6	mA
		V_{CC}=15V, R_L=∞		10	12		10	15	mA
	Timing error (monostable)	R_A=2kΩ to 100kΩ							
t_M	Initial accuracy[2]	C=0.1μF		0.5	2.0		1.0	3.0	%
$\Delta t_M/\Delta T$	Drift with temperature			30	100		50	150	ppm/°C
$\Delta t_M/\Delta V_S$	Drift with supply voltage			0.05	0.2		0.1	0.5	%/V
	Timing error (astable)	R_A, R_B=1kΩ to 100kΩ							
t_A	Initial accuracy[2]	C=0.1μF		4	6		5	13	%
$\Delta t_A/\Delta T$	Drift with temperature	V_{CC}=15V			500			500	ppm/°C
$\Delta t_A/\Delta V_S$	Drift with supply voltage			0.15	0.6		0.3	1	%/V
V_C	Control voltage level	V_{CC}=15V	9.6	10.0	10.4	9.0	10.0	11.0	V
		V_{CC}=5V	2.9	3.33	3.8	2.6	3.33	4.0	V
V_{TH}	Threshold voltage	V_{CC}=15V	9.4	10.0	10.6	8.8	10.0	11.2	V
		V_{CC}=5V	2.7	3.33	4.0	2.4	3.33	4.2	V
I_{TH}	Threshold current[3]			0.1	0.25		0.1	0.25	μA
V_{TRIG}	Trigger voltage	V_{CC}=15V	4.8	5.0	5.2	4.5	5.0	5.6	V
		V_{CC}=5V	1.45	1.67	1.9	1.1	1.67	2.2	V
I_{TRIG}	Trigger current	V_{TRIG}=0V		0.5	0.9		0.5	2.0	μA
V_{RESET}	Reset voltage[4]	V_{CC}=15V, V_{TH}=10.5V	0.3		1.0	0.3		1.0	V
I_{RESET}	Reset current	V_{RESET}=0.4V		0.1	0.4		0.1	0.4	mA
	Reset current	V_{RESET}=0V		0.4	1.0		0.4	1.5	mA
V_{OL}	Output voltage (low)	V_{CC}=15V							
		I_{SINK}=10mA		0.1	0.15		0.1	0.25	V
		I_{SINK}=50mA		0.4	0.5		0.4	0.75	V
		I_{SINK}=100mA		2.0	2.2		2.0	2.5	V
		I_{SINK}=200mA		2.5			2.5		V
		V_{CC}=5V							
		I_{SINK}=8mA		0.1	0.25		0.3	0.4	V
		I_{SINK}=5mA		0.05	0.2		0.25	0.35	V
V_{OH}	Output voltage (high)	V_{CC}=15V							
		I_{SOURCE}=200mA		12.5			12.5		V
		I_{SOURCE}=100mA	13.0	13.3		12.75	13.3		V
		V_{CC}=5V							
		I_{SOURCE}=100mA	3.0	3.3		2.75	3.3		V
t_{OFF}	Turn-off time[5]	V_{RESET}=V_{CC}		0.5	2.0		0.5	2.0	μs
t_R	Rise time of output			100	200		100	300	ns
t_F	Fall time of output			100	200		100	300	ns
	Discharge leakage current			20	100		20	100	nA

NOTES:

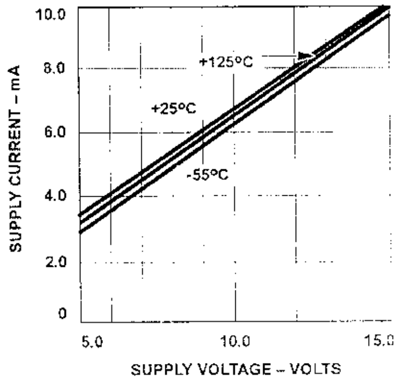
1. Supply current when output high typically 1mA less.
2. Tested at V_{CC}=5V and V_{CC}=15V.
3. This will determine the max value of R_A+R_B, for 15V operation, the max total R=10MΩ, and for 5V operation, the max. total R=3.4MΩ.

TYPICAL PERFORMANCE CHARACTERISTICS

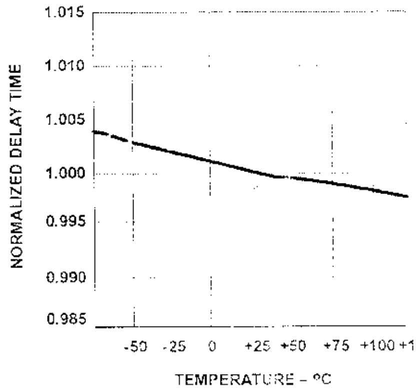
Minimum Pulse Width Required for Triggering



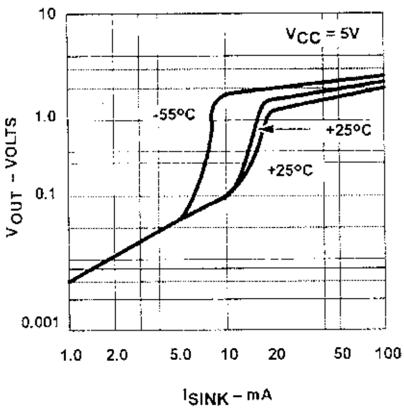
Supply Current vs Supply Voltage



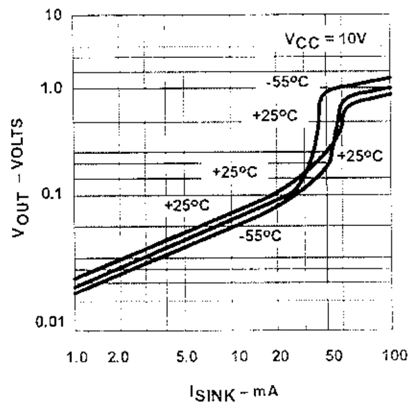
Delay Time vs Temperature



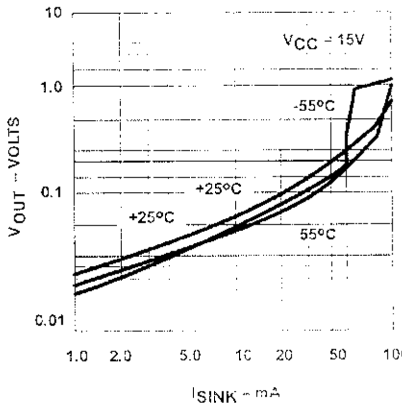
Low Output Voltage vs Output Sink Current



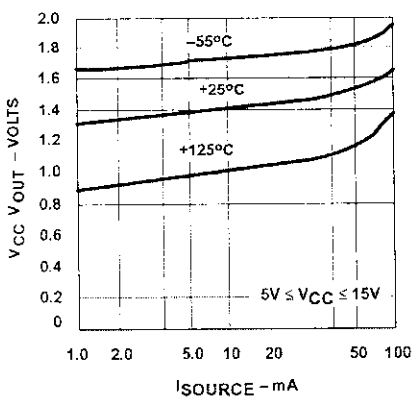
Low Output Voltage vs Output Sink Current



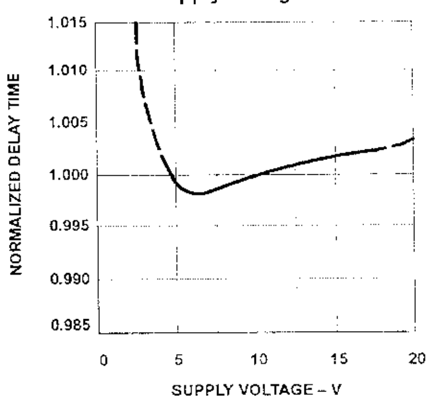
Low Output Voltage vs Output Sink Current



High Output Voltage Drop vs Output Source Current



Delay Time vs Supply Voltage



Propagation Delay vs Voltage Level of Trigger Pulse