CHAPTER-IV

DESIGN AND APPLICATION OF ELECTRONIC DEVICE FOR DETECTING STRIKING POINTS

In this chapter we have discussed the development, design and circuitary of an electronic device for detecting striking points. An applicability of such device has been tested at actual site of jaggery manufacturing units.

4.1 Introduction :

From our study & survey of different jaggery manufacturing units it has been noted that, temperature plays an important role in the manufacturing process of jaggery. Whatever may be the initial Brix of the sugarcane juice, the two important striking points are appearing at a fixed temperatures only. i.e. Kakavi stage and final striking stage. If pan is removed before the final striking point, the jaggery gets greenish tinge and if pan temprature is higher than striking temperaturs then jaggery becomes red and does not keep well [Shinde et.al. (1982)].

The present, manufacturing process is traditional one. In this process a skilled & experienced, person known as "Gulvaya" confirms the two stages (Kakavi stage and final striking stage). Slight variation in the judgements of "Gulvaya" affects the quality of jaggery and it can lead to the maximum loss of farmers.

In the present work we have designed and assembled an electronic circuit & developed an electronic device, which can precisely detects these two stages in jaggery manufacturing process.

4.2 Circuit blocks, design and adjustments

4.2.1. Circuit blocks :

The circuit consists of following blocks. Transducer amplifier, comparators, timing circuits, logic circuit solid state switch, and audio oscillater. Fig.4.1 shows a block diagrm of the circuit used for an electronic device to detect the two stages.

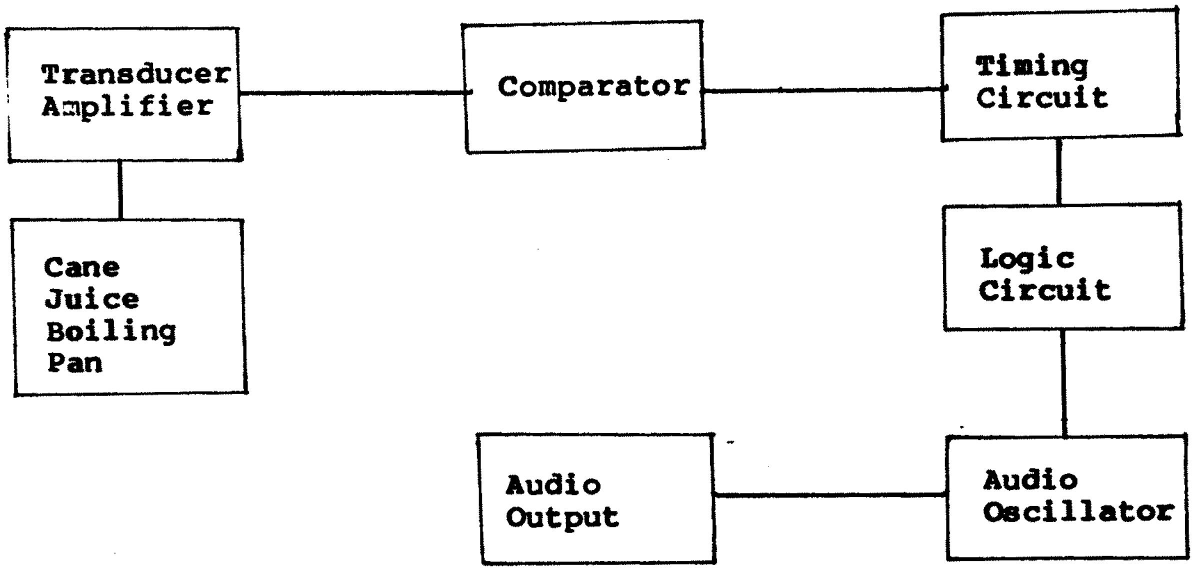

Fig 4.1 Block diagram of jaggery process control circuit.

In above circuit thermocouple is used as a temperature transducer. Cromel-Alumel is type K theromocouple. It is most widely used for temperature measurement. There are good reasons for this. It is resistant to oxidation, has a large seeback coefficient and is inexpensive. Nicro/NiAl is called as chromel-Alumel [Nakra(1985)]. Thermocouple work on seaback's principle of thermo .emf, shows that when two dissimilar metals are joined to form two junctions at different temperatures, then emf arises, causing a current to flow in the circuit [Chute (1971)].

4.2.2 OPAMP :

In present circuit we have chosen an operational amplifier because the great attraction of all OP.AMP applications lies in the ability to set a precise operation with a minimum number of precise compoents.

Basically OP.amp is used in one of the two configuretions i.e. inverting configuration and non-inverting configuration. In both cases closed loop gain is determined by simply selecting two resistor values. The accuracy with which it is possible to set a precise gain is almost entirely dependent upon the tolerance in the resistor values used. The inverting circuit can give any gain from zero upwards. The lower limit for gain of follower circuit is unity.

Both configurations gives low output impedance (due to negative feed back). The main performance difference between them, apart from signal inversion, lies in their input impedance. In case of inverter signal source driving the circuit is loaded by resistor connected between signal source and inverting input of Op. amp. The follower on the other hand present a very high input impedance so that it gives negligible loading in most applications. Unity gain follower is used as a buffer stage to prevent interaction between signal and load [Greme (1986); Clayton (1986)].

4.2.3 Comparators :

A comparator is a device which is used to sense when a varying signal reaches some threshold value. Comparator finds application in may electronic systems. Comparator output may be used to drive digital logic circuit. Some operational amplifiers are specially disigned for comparator applications with fast response time. In present circuit we have used operational amplifier as a comparator. This comparator drives logic circuit and monostable multivibrator circuit. In case of regenerative comparator threshold value is given by,

$$\text{Threshold value} = Vo_{sat} \frac{R1}{R1 + R2}$$

Vo_{sat} may be Vo^{+}_{sat} or Vo^{-}_{sat} and amount of hysteresis is given by

$V \; (Vo^{+}sat - Vo^{-}sat) \, \beta$. Where, β represents Positive feedback fraction [Clayton (1986)].

4.2.4 Transducers :

Transducer is a device which provides a useful output in response to specific measurand. The measurand being a physical quantity, a property or condition which is measured. It can also be defined as a device which affects transformation of information from one energy to another. Thus in a transducer there can be maximum information transformation and minimum energy transformation. It performs two functions, to measure or sense and to convert measurand value to a useful output.

Type of transducers :

Transducer technology is quite varied in nature. Conventional technology uses the electric and electromechanical principles to sense various measurands.

There are various types of transducers such as silicon transducers, fibre optic transducers, displacement or motion transducers, pressure transducers, Piezoelectric transducers, liquid level transducer, temperature transducers etc. In present circuit we have used temperature transducer.

Temperature transducers :

The temperature measurement involves the expansion properties of solid, liquid or gases or changes in electrical properties of certain materials. For every high temperature, colour change is taken for measurement. The bimetal thermometer, vapour pressure theromometer are the examples which involve the expansion properties of solid, liquid and gases. The electrical temperature transducers are resistance thermometer, thermocouple, thermopiles etc. The optical methods are used for very high temperatures [Nakra (1985); Oliver (1986)].

a) Thermistors :

Thermistors are semiconducting resistance temperature transducers, with large coefficient of resistance. The negative TCR [Temperature Coefficient of Resistance] are more common in industry.

b) Pyrometers :

It is used when measurement transducers cannot be put into contact with the process. It may be due to high temperature (blast furnace) or when hot bodies are moving objects. In case radiation energy measured directly, it is called radiation pyrometry and when energy is measured by colour comparison it is called optical pyrometry. The optical pyrometer range is between 700^{o}c to 3000^{o}c.

c) Silicon temperature transducers :

These sensors make use of temperature dependence of resistivity exhibited by silicon. These are low cost devices offering high accuracy, stability and linearity. However they suffer from disadvantages of low output and limitted upper temperature range. Silicon process technology is highly developed and well suited to high volume production. With silicon sensors, the designer has additional degree of freedom created by the ability to integrate signal conditioning circuitary into the transducer chip. The advancement in microelectronics technology is bringing new improvement in silicon sensors have been developed.

d) Thermocouples :

These are most important transducers in industry applications. Type J thermocouples are useful in the environment where there is lack of free oxygen. Type K on the other hand is suited for oxidizing atmosphere where excess of free oxygen is present. Type R and S thermocouples are called noble metal thermocouples and are used for higher temperature range[Nakra(1985); Chute(1971)].

4.2.5. Timing Circuit :

The monostable multivibrator circuit is used as a timing circuit. It has only one stable state. OP.amp is used as monostable multivibrator. Whose time period is given by

$$T = RC \log \left(\frac{1}{1-\beta} \right)$$

This equation is used to design a time period of timing circuit..

4.2.6. Logic and output circuit :

In present circuit simple resistor-diode logic circuit is used to drive transistor solid state switch.

The truth table of such logic circuit is as follows

A	B	Q	$\bar{Q}$
1	0	0	1
0	1	0	1
1	1	1	0

1 - Logic high state.

2 - Logic low state.

[Morris(1971); Signatics(1977)].

4.2.7. Design and adjustments :

1) Gain of Op.amp. follower (I)

$$\text{gain} = \left(1 + \frac{R_2}{R_1}\right)$$

R1 = 1k

R2=330 k

$$\text{gain} = 1 + \frac{330}{1}$$

2) Monostable multivibrator's time period design :

Formula for time period of monostable action is given by,

$$T = RC\ 109c\ \left(1 + \frac{R_6}{R_5}\right) \text{-----}(1)$$

Since V_D, diode forward voltage drop is less than saturation voltage (+6v) and R5=R6; So that β= the feedback fraction is 0.5 then(1) becomes

$T=0.069\ RC$

Let $R=R7=100k$

$C= 500\ \mu F$

$T= 0.069x100x10^3x500x10^6$

$T= 50x0.69$

$T= 34.5\ sec$

Design of c for 30sec period

Let $R= 100k$

$T= 30sec$

$30\ sec= 0.069x100x10^3xc$

$$C= \frac{30x10^{-3}}{0.069x100}$$

$$= 0.434\ x\ 10^{-3}$$

$C= 434\ \mu F$

In the circuit a capacitor $C=500\mu F$ is used [Clayton (1986); Sen (1992)].

3) Adjustments :

In order to get audio indication from the divice two presets VR_1 and VR_2 are adjusted in accordance with striking temperatures.

i) For Kakavi stage :

The striking temperature is 106 ^{o}c. The thermocouple output changes at the rate of 0.04 milivolt/ ^{o}c. Considering room temperature compensation the output of thermocouple is 3.26 milivolt which is amplifiered by op.amp. follower configuration giving 1079 milivolt with gain 331. Hence adjust V_{R1} = 1079 milivolt by preset of first comparator.

ii) For final striking stage :

The striking temperature is 120 ^{o}c thermocouple output is 3.80 milivolt with 331 gain of amplifier, the output of amplifier is 1257 milivolt. Hence adjust V_{R2} = 1257 milivolt by using preset of second comparator.

4.3 Circuit diagram and working of the circuit :

The over all function of following circuit is to sense the temperature corresponding to two striking stages and to give the audio indication to the supervisor in jaggery manufacturing process.

In circuit, operational amplifier (op.amp. I) is used in a follower configuration mode so that there is no loading effect on thermocouple. Op.amps II & III are used in comparator mode. op.amp IV. is used as

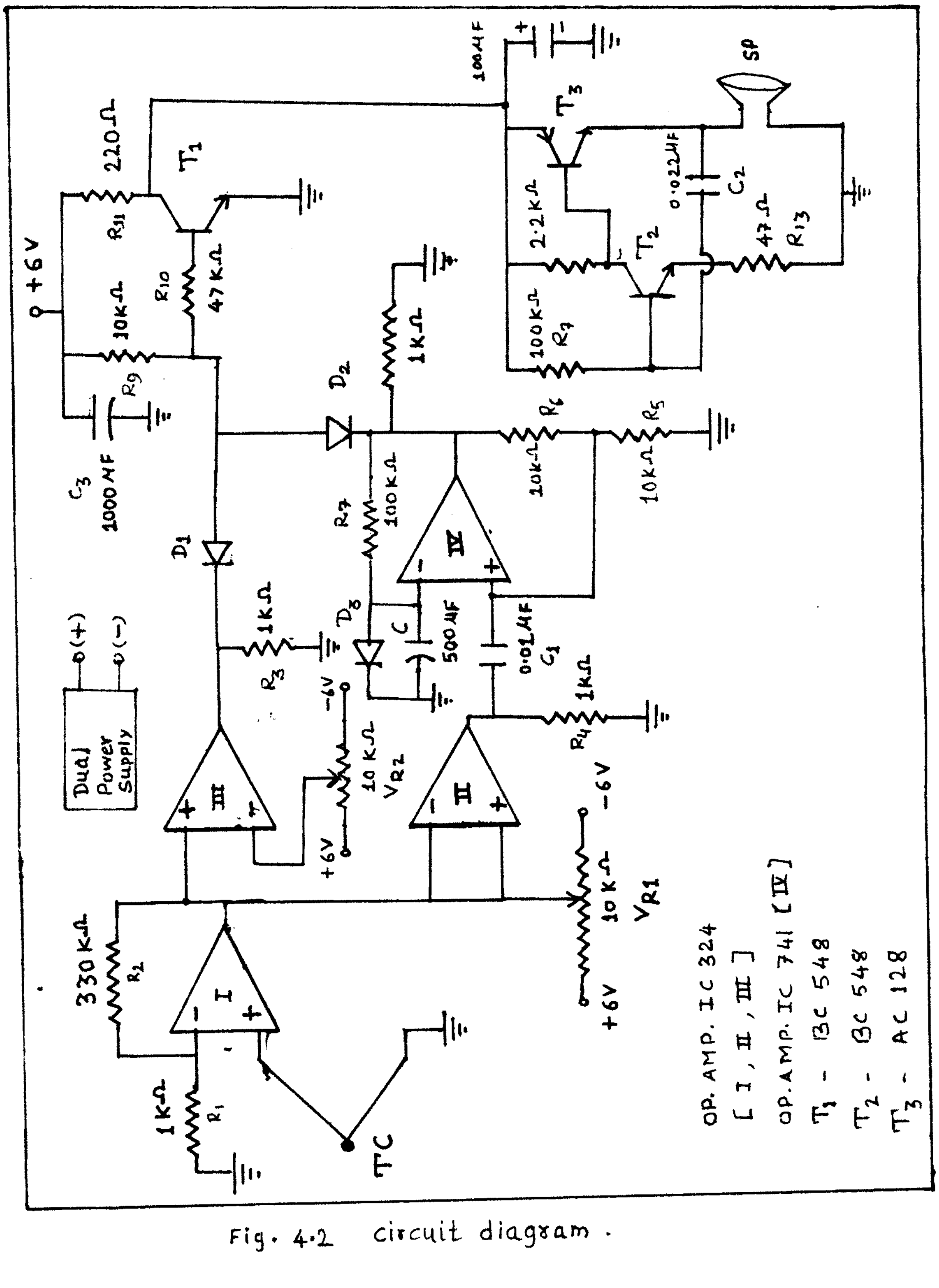

Fig. 4.2 circuit diagram.

monostable multivibrator which determines the first stage audio indication timing. Diodes D_1 & D_2 along with resistors R_9, R_3 & R_8 forms a logic circuit. Transistor T_1 is used as a solid stage switch. Transistor T_2 & T_3 forms a complimentry pair audio a frequency oscillator, whose frequency of oscillation is determined by $f = \frac{1}{RC}$ where R_7 & C_1 used in the circuit.

Working :

As temperature of the boiling pan increases output voltage of amplifier I increases linearly. By using V_{R1} reference voltage of comparator op.amp II is set corresponding to first striking stage temperature i.e. $105^{o}c-106^{o}c$ (Kakavi stage) & with the help of V_{R2} the reference voltage of comparator op.amp .III is set corresponding to second striking stage i.e.Golli stge temperature at $118^{o}c - 120^{o}c$.

When amplifier I output voltage equals V_{R1}, output of first comparator changes from +6 v to -6 v and through capacitor C_1 the monostable multivabrators triggers. Its output goes to lower state for the time 55 sec. and during this time solid state switch T_1 becomes off and audio oscillator circuit gives audio indication through the speaker. After 10 to 15 minutes, when output voltage of amplifier I equals the voltage V_{R2}, the comparator op.amps. III output voltage changes from +6 to -6 v and again transistor switch T_1 becomes off and audio oscillator circuit becomes on and gives audio indication corresponding to second striking stage.

4.4 Testing and application :

With the help of above designed circuit a device is assembled and it is shown in plate no. 2 & 3. These device has been tasted at 11 jaggey manufacturing units in Satara district and 12 units at Kolhapur district. It has resulted in giving us closely correct audio indication of Kakavi and jaggery stages.

Plate No.2 : Field Measurements and Observations

Plate No.3 : Field Test with Jaggery Process Control Device

4.5 Conclusion :

In order to obtain good quality jaggery, precise stages indicating device may be useful. It will give better results as compaired to 'Gulvya' in jaggery manufacturing process. Thus we have successfully designed, developed and used an electronic device which could stbstitute traditional 'Gulvaya' in the jaggery manufacturing process. Generally jaggery manufacturing process starts in the month of November and ends in March. The wage of skilled person Gulvaya is Rs. 125/- per day The cost of our unit is Rs. 1500/-. As compaired to 'Gulvaya' this device is highly benefitial to farmers in all respects.

Extension of the work :

The device can be improved by using silicon temperature sensors like LM 35. This sensor gives 1 milivolt per degree centigrade output, whilch is quite linear. Since it has temperature range from $-55\,^{o}c$ to $150\,^{o}c$. It will be more suitable and accurate for our purpose. We are undertaking the design and development of such device in our laboratory in near future.

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