Fuzzy Based Timing Generation Using Timer IC-555

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Abstract- *Simple circuit arrangement to generate square wave using IC-555 has been suggested with the required mathematical analysis. Design guidelines and selection criteria for the components have also been incorporated using conventional as well as fuzzy based approach. The results of fuzzy Logic Design compare nicely with that the conventional approach. By replacing the timing resistors by thermister or LDR, the circuit becomes either a temperature or a light sensor whose frequency renders directly the electrical equivalent of these physical parameters. A graph of variation of frequency with temperature is given. It is seen that a variation is linear up to 100 ^{0}C. This circuit can be used with microprocessor or micro-controller interface for monitoring and control of temperature within this range.*

Keywords- Timer-555, Astable Multivibrator, Design Criteria, Sensor

I. INTRODUCTION

SE/NE a monolithic IC-555 timer was first introduced by Signetics Corporation in the early 1970[1]. it is reliable, easy to use, TTL compatible and low cost device, Absolute ratings of this IC are given in table –1. Details of pin functions are available in many books (1-3); This IC is widely used as an astable multi-vibrator and a mono-stable multivibrator. Astable multivibrator can be designed with fixed and variable duty cycle ranging from 1% to 99% and with variable frequency.

However additional diodes are required to separate the charging and discharging paths to realize variable duty cycle and a capacitor bank to vary the frequency. Astable operation can be realized by a novel and simple single R-C connection as shown in fig. (a). This is a new configuration and gives 50% duty cycle. Design chart is also given for the selection of components.

Table – 1 Specifications of IC 555[2]

Parameter	SE-555	NE-555
Supply Voltage	5 to 18 V	5 to 18 V
Power consumption	600 mW	600m W
Package	T,V,F	T,V,F
Operating temperature range	-55 To 125 ^{0}C	-65 To 125 ^{0}C
Sinking or Sourcing	200m A	200mA
Frequency range	Fraction of a Hz to 100k Hz	Fraction of a Hz to 100k Hz

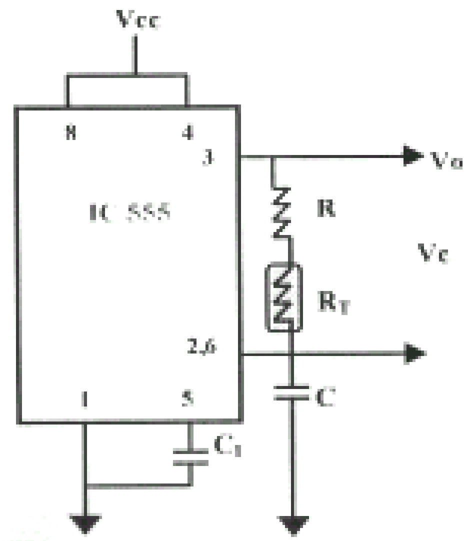

Fig.1. Inexpensive timer configuration

Fig. 1 . Circuit Diagram

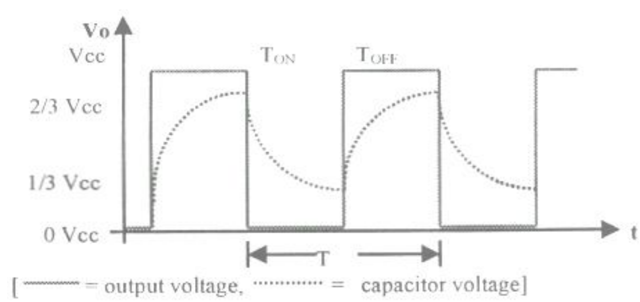

Fig. 2 . Output waveforms at pins 3 and 2, 6.

II. WORKING

The voltage at the pin 3 and pin 2 are out of phase which makes the circuit to work. At the switch on because of the transient behavior voltage across the capacitor being zero (<Vcc/3), the out put at the pin 3 is high. The capacitor charges through R from this output and voltage at the pin 2,6 increases exponentially till it because 2Vcc/3; at this point of time the output at pin 3 becomes low helps for the discharge of the capacitor. When voltage across capacitors pin 2 drops to Vcc/3, the output at pin 3 goes high and the entire cycle repeat's. The result is a square wave output as shown in fig.1 (b).

III. THEORY

Voltage across the capacitor at any instant t is given by

$Vc(t) = Vi + (Vf – Vi)\ e^{-t/RC}$

Vi = initial voltage across the capacitor

Vf = finial voltage to which it will charge (source voltage)

Ton lasts till Vc (t) = 2 Vcc/3

$2Vcc/3 = Vcc/3 + (Vcc – Vcc/3)e^{-Ton/RC}$

T_{on} = RC In 2

For T_{off}

Vi = 2Vcc/3 and Vf = 0

T_{off} lasts till Vc(t) = Vcc/3

$Vcc/2 = 2\ Vcc/3 + (0 – 2\ Vcc/3)\ e^{-Toff/RC}$

T_{off} = RC In 2

Here $T_{on} = T_{off}$ i.e. duty cycle is 50% i.e. output is symmetrical square wave with amplitude equal to Vcc.

Total time period $T = T_{off} + T_{off}$

T = 2RC In 2

T = 1.4 RC

VI. DESIGN GUIDDELINES[3]

Limit on R : 1KΩ < R < 3.3 MΩ

A decoding decoupling capacitor (CI) above 10 μF is recommended to remove unwanted spiked in the output. Pin 5 is PWM input, use C2 in the range 0.1 to 10 μF to avoid PWM due to external voltage or noise.

The minimum value of the timing capacitor C should be greater than the parasitic non-linear capacitance at the pin 6 and 7 (C>100 p.f.) Choice of the large value of the leakage current. Tantalum capacitor with the low leakage current is suitable as a large value capacitor. Design chart is tabulated and given in Fig. With the help of which a stable multivibrator for the required period can be designed.

Alternatively the formula

T = 1.4 RC

can be used for design, with the same rules followed for selection of R and C.

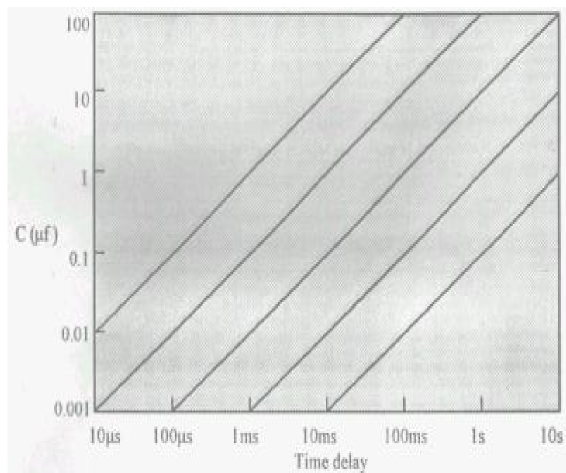

Fig. Design Chart

V. FUZZY LOGIC BASED DESIGN

Designing of 555 timer using the underlying principles of fuzzy sets and fuzzy logic comprises the following steps[4-7]

1. Fuzzification
2. Knowledge Representation
3. Decision Logic
4. Defuzzification

Fuzzification :

The frequencies have been divided into various routes such as 0-10Hz, 10-100Hz, 100-1KHz etc and one group in the range 1 KHz to 10 KHz is selected for design. The fuzzy subsets are shown in the fig. (a & b). These subsets appropriately labeled as “f(n)”, where “ι(n)” [DoM = Degree of Membership].

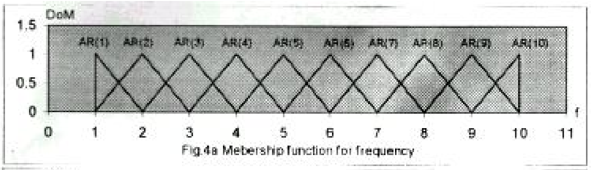

Fig.4a Mebership function for frequency

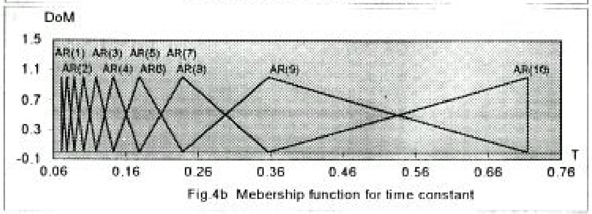

Fig.4b Mebership function for time constant

Knowledge Representation :

The Knowledge-Base (KB) consists of two parts-the-Base (DB) and the Rule-Base (RB). The Knowledge relating to range of input frequency and the appropriate size of the capacitor C and hence R formulated in terms of fuzzy inference rules kept stored in the Rule-Base. The information about the membership functions, the partition-ranges, tuning and scaling factors are kept stores in the Data-Base. The general format of fuzzy inference rule is –

"IF the f is AR(n) THEN ι is AB (11-n)

Where n = 1 to 10

Decision Logic :

The decision logic is based on the Mamadani's direct method of inference [4,5]. During the inference process the Clipped Fuzzy Sets (CFS) are generated that represent the overall ι at a particular frequency.

Defuzzification :

The single valued ι at a particular frequency is computed by defuzzifying the Clipped Fuzzy Sets obtained during inference process. Many defuzzification method[5] are available, however Height Defuzzification (HD)[3] being computationally simple and fast is employed in fuzzy based design.

5.0 Temperature sensor :

In an application IC-555 is designed to give frequency of 140 Hz at room temperature using C = 0.47 μf and R = 10.8 KΩ. Here R is taken as combination of thermistor with resistance 4.7 KΩ and carbon resistor of value 6.1 KΩ is connected in series with it in order to make the frequency variation linear. It is seen fig. 5, that variation is almost linear up to 100^{0}C. A microprocessor or micro – controller based system can be designed for temperature control using a particular frequency as a set point.

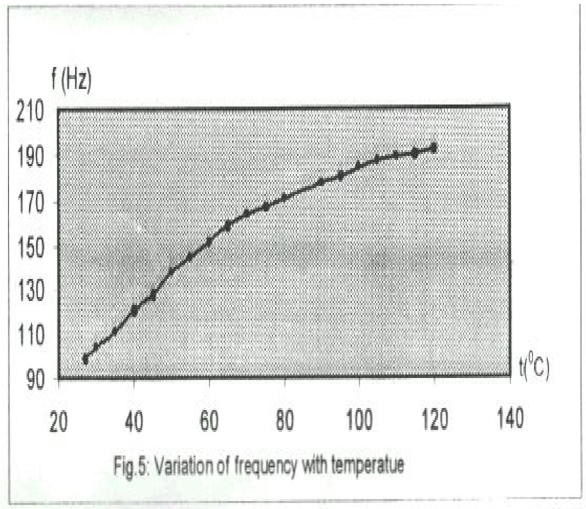

Fig.5: Variation of frequency with temperatue

VI. RESULT

The error in R is negligible. The value of R obtained from graphical method may not be so accurate. The advantage of fuzzy methodology is that he software uses fixed values of R in the range 1 K to 10 K. for all the decade frequency ranges i.e. 0-10Hz, 10-1000Hz, 100-1KHz etc. the value of C divided by factor of 10 for every higher. frequency range starting with C = 0.07 μf for 0-10Hz. All the components are standard and easily available.

Table 11 : Comparison of Conventional and Fuzzy Design routes

Mode	Frequency	Selected Capacitor (C)	Resistor (R)	Error in R value
By formula	2.25KHz	0.07μf	4.54 KΩ	
By fuzzy route	2.25KHz	0.07μf	4.60 KΩ	1.3 %

VII. CONCLUSION

Use of fuzzy logic allows embedding the thumb rules in the designing process. The circuit is inexpensive. The output is symmetrical square wave. Only one register is required, against two resistors normally required to implement astable mode. The circuit is easy to assemble and design. Slight output ringing could which can be eliminated by putting the capacitor to Vcc instead of ground. Only single duty (i.e. 50%) is possible.

REFERENCES

[1] R. B. Dhumale, Gaurav Kate, Saprem Kulkarni, N. D. Thombare, “Reservation based S-Park System using Embedded Server and Android Application”, International Journal of Research in Engineering and Technology, vol. 5, iss. 8, pp. 115-119, Aug. 2016.
[2] R. B. Dhumale, N. D. Thombare, P. M. Bangare, Chetan Gawali, “Internet of Things for Smart City”, International Research Journal of in Engineering and Technology, vol. 04, iss. 06, pp. 792-797, Jun, 2017.
[3] R. B. Dhumale, N. D. Thombare, P. M. Bangare, “Supply Chain Management using Internet of Things ”, International Research Journal of in Engineering and Technology, vol. 04, iss. 06, pp. 787-791, Jun, 2017
[4] R. B. Dhumale, Gaurav Kate, Saprem Kulkarni, N. D. Thombare, “Reservation based S-Park System using Embedded Server and Android Application”, International Journal of Research in Engineering and Technology, vol. 5, iss. 8, pp. 115-119, Aug. 2016