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METAL DETECTOR FOR A MICROWAVE OVEN

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Abstract

The aim of the project is to provide a warning if a metal object is inserted into the microwave oven. The basic principle is to pass the dish through a rectangular coil wound on a frame surrounding the microwave door and then detecting the change in frequency of the circuit. The project also involves setting a cooking time and setting a power control for the oven.

1. Block Design

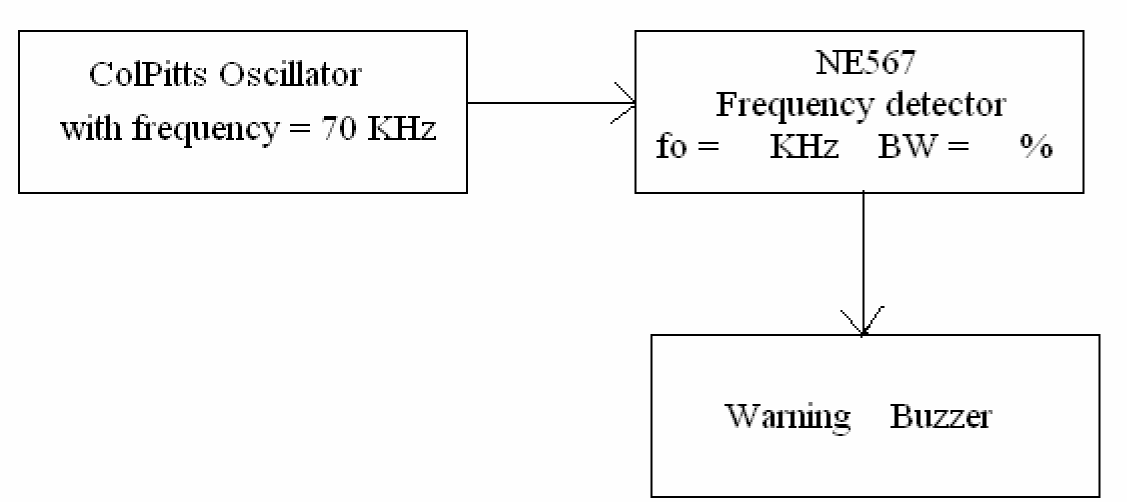

Figure 1

1.1 Colpitts oscillator

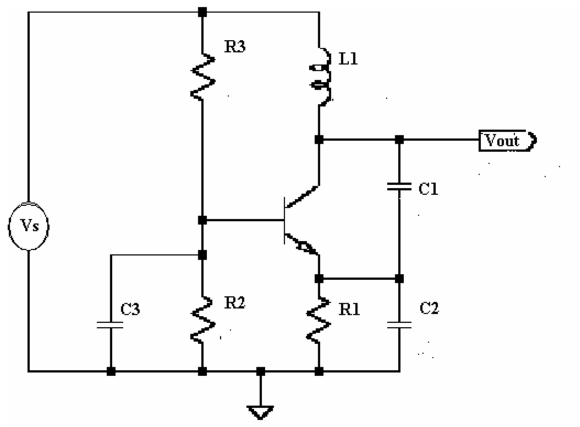

Figure 2 [1]

Passive elements values

R1 =   C3 =
R2 =
R3 =

The design of the detector requires a LC oscillator. The designs that can be used are:

- Hartley Oscillator
- Colpitts Oscillator
- Crystal Equivalent Oscillator

We had tried out all these designs. We have chosen the Colpitts oscillator for the device because:

1.) The output is a sine wave (which is not exactly so for the Hartley oscillator) that we require detection.

2.) The output is stable in frequency.

***Difficulties faced*:**

Since the frequency of operation is around 70 KHz we should take care to use a high frequency transistor. We have used a transistor. The results with a BF and BC low frequency transistor were not good.

1.2 Coil Design

We have used a frequency of 70 KHz. The ideal frequency of operation for this metal detector is 70 KHz. This is because of

1.) The IC used (NE 567) which has the best performance characteristics in the range upto 100KHz

2.)The value of the parasitic capacitances and inductances becomes appreciable at high Frequencies

$$L_{rect} \approx N^2 \frac{\mu_0 \mu_r}{\pi}\left[-2(w+h)+2\sqrt{h^2+W^2}-h\ln\left(\frac{h+\sqrt{h^2+W^2}}{W}\right)-W\ln\left(\frac{W+\sqrt{h^2+W^2}}{h}\right)+h\ln\left(\frac{2W}{a}\right)+W\ln\left(\frac{2h}{a}\right)\right]$$

Formula 1[2]

	Capacitance (pF)	Inductance (mH)	Area(A)	No of turns
1.	50	102	130.5 sq.in	239
2.	185	26.16	130.5 sq.in	120
3.	340	15	130.5 sq.in	91
4.	**500**	**10.2**	130.5 sq.in	**76**
5.	750	6.8	130.5 sq.in	62

Table 1[2]

Wire Gauge Used = 30 SWG , Dimensions of the coil = 14.5 in X 9 in X 1 in

Using this table we have used a coil of Inductance 9.1 mH and Capacitors C1 and C2 of values 560 pF . The frequency of oscillation obtained is around 71 KHz.

1.3 Frequency Detection Circuit (NE 567)

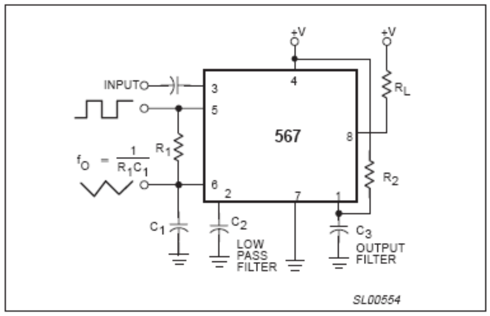

Figure 3[3]

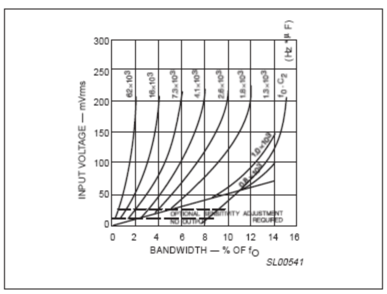

Figure 4[3]

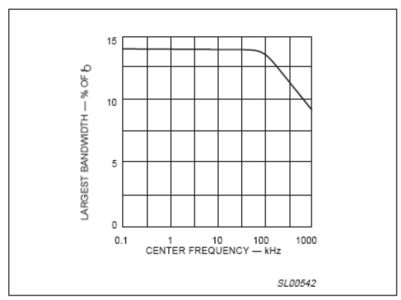

Figure 5[3]

$$f_o \approx \frac{1}{1.1R_1 C_1}$$

$$BW \approx 1070 \sqrt{\frac{V_I}{f_o C_2}} \text{ in \% of } f_o$$

$$V_I \leq 200mV_{RMS}$$

Where

V_I = Input voltage (V_{RMS})

C_2 = Low-pass filter capacitor (µF)

The bandwidth is the frequency range centered around fo within which an input signal above the threshold voltage (typically 20mV rms) will cause a logical zero on the output.

Passive Element Values

- To select R1 and C1 for the central frequency R1 should be between 2 KΩ and 20 KΩ. We have chosen R1 as 5.6 KΩ. Now from the relation for central frequency C1 = 2.2nF for a central frequency of 72 KHz
- In *Constant Bandwidth Operation* (**CBO**) for V_{in} above 200mVrms, the

bandwidth is controlled solely by the fo. C2 product (fo (Hz), C2 (μF)). In all our operations we are working in the **CBO**. The corresponding value of the fo.C2 product according to our frequency of operation can be obtained from Fig 2.
For fo = 70 KHz

Bandwidth	fo.C2 (fo (KHz), C2 (μF))	C2
8%	4.1	0.058 μF
4%	16	0.2 μF
2%	62	0.88 μF

Table 2

- The values of C3 is generally non critical but it should not be too large or too small. A typical minimum value of C3 and the one used is here is around 2C2.
- The value of R2 is typically around 130 KΩ which is used to ensure the tested limit of 10Vrms

- The value of C2 we have chosen is 0.2 μF which gives a B/W of around 4% and the value of C3 is 0.4 μF.

PART 2 :

- Power control- 10% to 100%
- Cooking time setting
- End time beeper

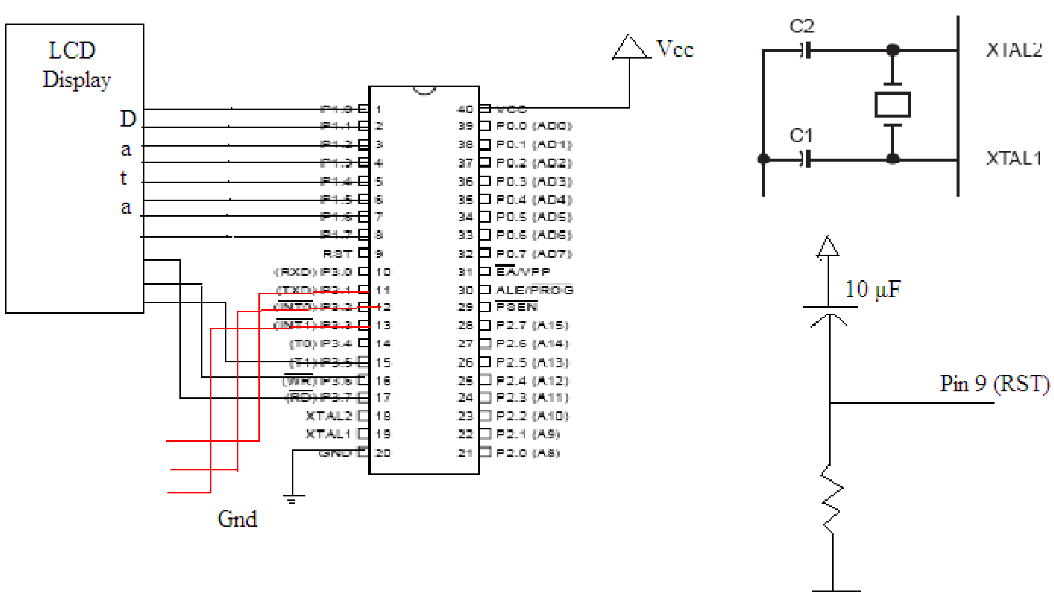

Figure 6[4]

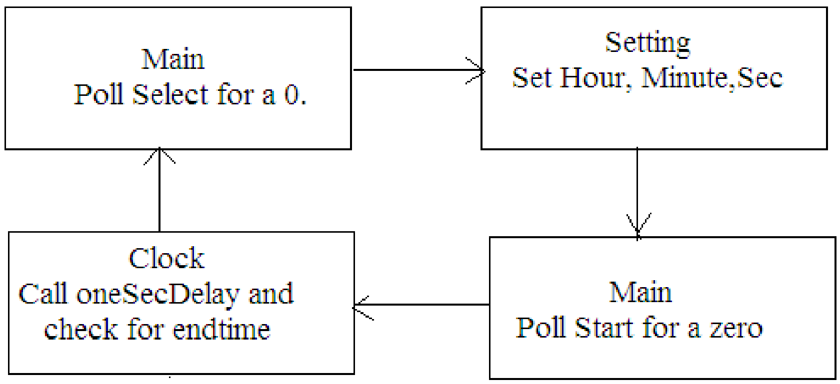

Figure 7

1.) Short Explanation of the Circuit Diagram

Data on Port 1
Select on Pin
Increment on Pin
Start on Pin

Crystal Used = 11.0592 MHz

Microprocessor used = AT89C51

2. Short Explanation of the code

The code starts and polls the select bit. Once we press the select button the bit becomes zero and the code moves to the subroutine SETTING. Here using the INCREMENT pin we can set the hours minutes and seconds in intervals of 10 seconds upto 6 Hrs.After the time is set and the display routine shows the cooking time , the MAIN polls for the START bit. On pressing the START bit the CLOCK subroutine starts. This subroutine calls the ONESECDELAY function and decrements the seconds counter . At each step each it checks the present hours , minutes and seconds. When this becomes zero the cooking time is reached and the ON bit is set. This can be used to sound a beeper.

2.) **Issues**

2.1 **Size of the metal**

For small metal objects the change in the frequency of the detection circuit is very less to be detected. The minimum change in frequency that can be detected using this detector is around 2% of the central frequency (70 KHz) which is the limitation reached by the IC used (567N). For a better detection of frequency change, we can use a frequency mixer.

2.2) Power Control

With minor modifications in the code for the time setting the power of the oven can be varied. This is done by PWM so that less power is consumed but there is uniform cooking.

Conclusion

The damger of introducing metal objects in a microwave oven calls for a device that can detect the metals at the entry stage and warn the users of its presence. The design suggested can be used for this purpose. The design is simple , low cost and can be easily introduced in new and existing ovens. The design can be made better by using flexible primers for the coil that can be easily attatched to frames.

Acknowledgements

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References

[1] Wikipedia.com
[2] www.technick.net/
[3] Data sheet for NE567
[4] Data Sheet for AT89C51