WhistleTronix – Frequency Detection and Processing of a Pressure Cooker Whistle Signal

Rashmi B, Riti Agarwal, Supriya Umashankar, Surabhi S, Yashaswini S, Veena S Murthy

Electronics and Communication Department
BNM Institute of technology
Bangalore, India

***Abstract*—Electronics is all about making human lives simpler. This paper would be one of the million efforts in that direction. Cooking is one of the most ancient parts of everyday activities and a pressure cooker has evolved to be an integral part of it. The main aim here is to eliminate confusions involved in keeping a count of the whistles. The heart of this design is the missing pulse detector, an application of 555 timers. This circuit detects the whistle frequency and gives a non-oscillating output and a decision is made considering this as the criterion for further processing.**

***Keywords*—Frequency detection, Missing pulse detector, Frequency to amplitude conversion**

I. INTRODUCTION

The pressure cooker whistles when the pressure increases due to steam formed inside as the food is being cooked. Designing a system that detects and counts the whistles of a cooker can be done through various inputs available, namely

- Displacement of the weight
- Sound waves
- Rise in air temperature
- Steam inside the cooker

Here, sound has been considered as the input due to the following reasons,

- Availability of cost efficient sound transducers
- High accuracy of detection
- Simplicity of processing sound signals

Firstly, the frequency of the whistle was determined. The most prominent frequency was found to be 6 kHz. Thus, the design involves detection of this peak frequency, counting these peaks and displaying the same.

The basic block diagram is as shown in Fig. 1. The three main stages are:

- Transducer stage
- Signal Processing and frequency detection
- Count and display

In stage 1, the input sound waves are converted into electrical signals using a condenser microphone. This signal is then amplified and fed to the frequency detector in stage 2. The frequency detector developed is a 555 timer used in monostable multivibrator mode, followed by an operational amplifier as a comparator. In stage 3, this signal is given to a BCD counter and count is displayed on a seven segment LCD display. The following sections describe each stage in detail.

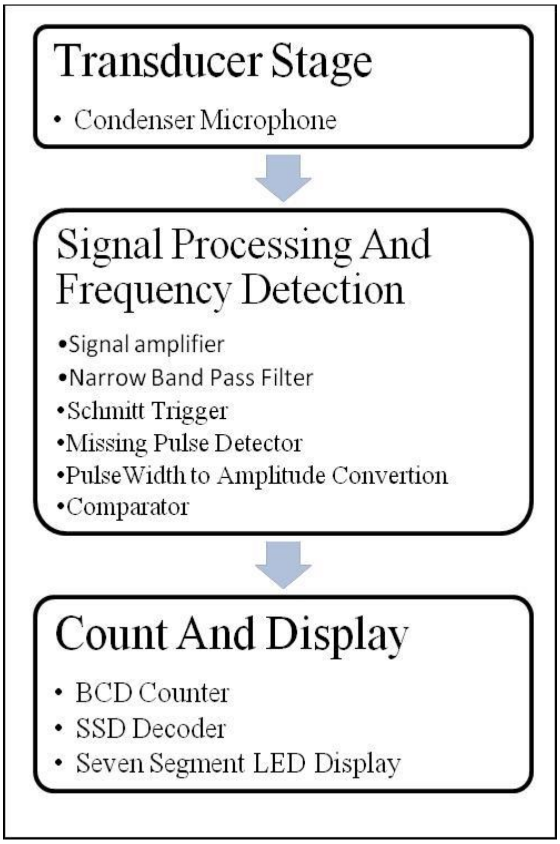

Fig. 1. Stages involved in whistle detection

II. Condenser Microphone

A Microphone is a transducer that converts sound energy into electrical energy. The Microphone used in this design is an electret condenser microphone (ECM) [1]. Fig. 2 shows the circuit for the microphone.

III. Signal Processing and Frequency Detection

A. Signal Amplifier

An Operational Amplifier is used to amplify the weak output signal of the condenser microphone, which is then fed to the filter.

B. Band pass Filter

A Multiple-Feedback 2nd-Order Narrow Band pass Filter [2] is used and is designed to have a cut-off frequency of 6 kHz. The circuit used is as shown in Fig. 3.

C. Schmitt Trigger

The Schmitt Trigger is a comparator circuit having a high and a low input threshold voltage. When the voltage at the input exceeds the high threshold level, the comparator switches to state A. The Schmitt Trigger output will remain at state A until the voltage level at the input drops below the low threshold level. When that occurs, the output will switch to another voltage level, state B, and remain there until the high threshold level is exceeded once again. For example, if the input is a sine wave, whose amplitude triggers both thresholds, the output will be a square wave with the output frequency same as that of the input.

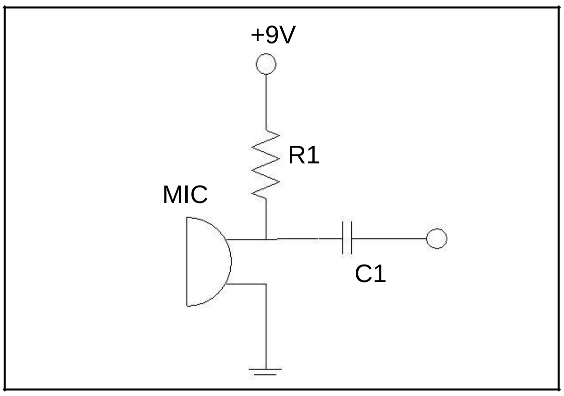

Fig. 2. Condenser Microphone

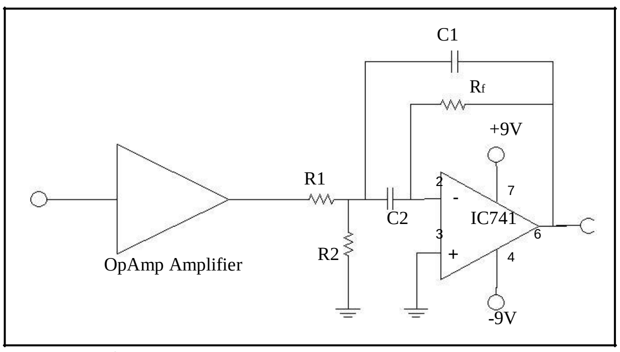

Fig. 3. Amplifier and Filter

D. Missing Pulse Detector

The output of the Schmitt trigger is fed to a 555 timer operating in monostable multivibrator mode, as a missing pulse detector to detect the frequency peak in the whistle. Fig. 4 gives the circuit connections.

A basic Monostable Multivibrator has only one stable state, and it enters the unstable state only when it is triggered externally. The output returns to its stable state after a period of time determined by the time constant of the RC network.

The external capacitor C1 is initially held discharged by a transistor inside the timer. Upon application of a negative trigger pulse whose magnitude is more than 1/3rd of VCC to pin 2, the internal flip-flop is set, which releases the short circuit across the capacitor and drives the output high. The voltage across the capacitor then increases exponentially with a period of

$$T = 1.1*R1*C1 \quad (1)$$

At the instance of the capacitor voltage becoming 2/3rd of VCC, the comparator resets the flip-flop, which in turn discharges the capacitor and drives the output to its low state. Thus the output of the 555 timer is high only for a fixed period of time. When the output is high, any further application of a trigger pulse will not affect the circuit.

Here we use Monostable Multivibrator as a missing pulse detector [3]. Whenever, trigger input is low, the emitter diode of the transistor Q is forward biased. The capacitor C1 gets clamped to few tenths of a volt and the output of the timer goes high. The circuit is designed so that the time period of the monostable circuit is slightly greater than that of the triggering pulses. As long as the pulse train keeps coming at pin 2, the output remains high i.e. for input frequencies more than 1/T. However, for lower frequencies the trigger input goes high and transistor Q is cut-off and the 555 timer enters into normal mode of monostable operation, i.e. the output goes low after time T of the monoshot.

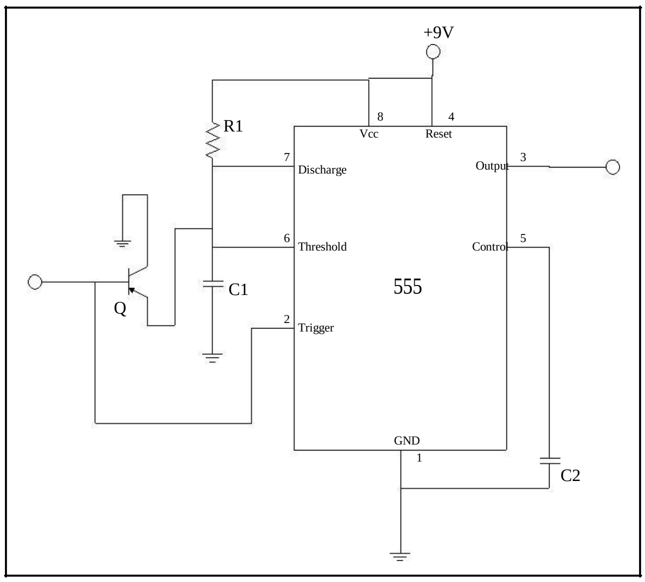

Fig. 4. Missing Pulse Detector

Thus for frequencies greater than 6 kHz (i.e. 1/T = 6 kHz) the output goes to unstable state and stays there as long as the cooker whistle exists. This is shown in Fig. 5.

E. Pulse Width to Amplitude Conversion and Comparator

The pulse width to amplitude convertor gives an output voltage proportional to its input pulse width.

The circuit is as shown in Fig. 6. It consists of a capacitor C that charges when input voltage is high and discharges through the transistor Q as soon as the input goes low. The voltage across the capacitor is proportional to the input pulse width.

An Op-amp comparator is used to check for a predetermined value of the capacitor voltage which is one of its inputs. The other input to the comparator is the reference voltage Vref that is adjusted according to the time period of the cooker whistle. Thus, output of the comparator is high (+Vcc) during the whistle and low (-Vcc) otherwise.

IV. COUNT AND DISPLAY

A. BCD Counter

The IC7490 BCD counter [4] is used to count the number of falling edges in the output of the comparator. Fig. 7 shows the circuit of the BCD Counter.

IC7490 is a divide-by 10 counter using 4 Master-Slave JK Flip-flops. It contains divide-by 2 and divide-by 5 counters, which when cascaded give a divide-by 10 counter. A simple switch is used to reset the counter.

B. Seven Segment Display Decoder

The SSD Decoder IC7447 [5] converts the 4-bit binary into SSD codes. Fig. 8 shows the SSD Decoder.

C. Seven Segment LED Display

A Seven Segment LED display as shown in Fig. 9 is used to display the count.

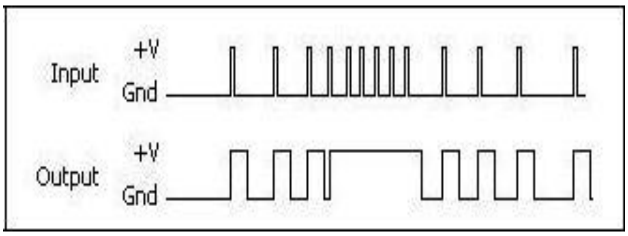

Fig. 5. Missing Pulse Detector – Circuit Response [3]

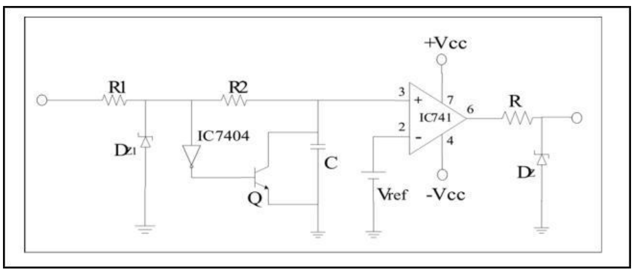

Fig. 6. Pulse Width to Amplitude Conversion

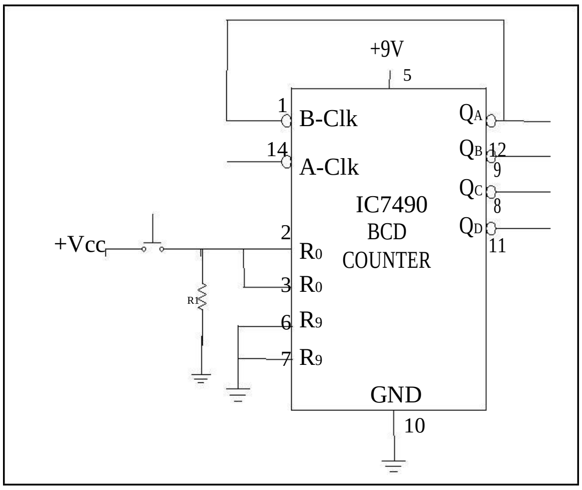

Fig. 7. BCD Counter

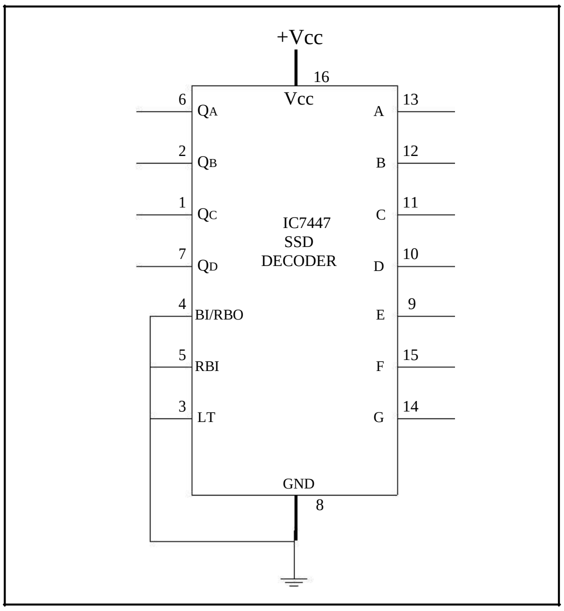

Fig. 8. SSD Decoder

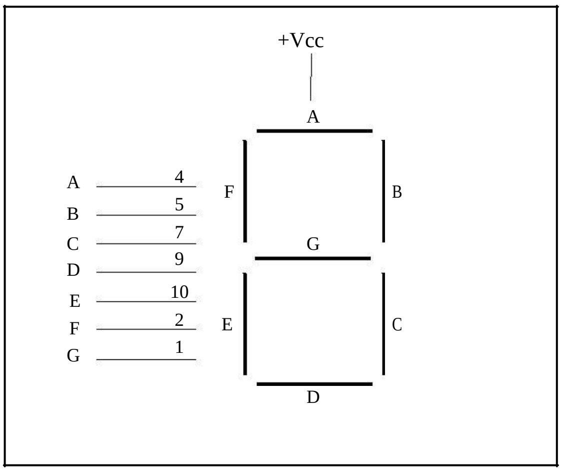

Fig. 9. Seven Segment LED Display

V. Specifications

- Power Supply : +/- 9V
- Position : Wall-Mounted
- Distance : 0.3m from the cooker
- Direction Of Feasibility : All
- Capacity Of Cooker : 0.25 to 1 litre
- Display : SSD on the circuit board
- Controls: ON/OFF Switch & RESET Button.

VI. Results

The frequency of the pressure cooker whistle was found to be centered around 6 kHz using the android application "Audio Analyzer"[6]. Fig. 10 shows the frequency spectrum of the whistle.

VII. Conclusions

Using 555 timer as a missing pulse detector, the peak in the frequency during the whistle is detected. This detected peak in frequency is successfully used to trigger the counter. Hence, the aim of eliminating the confusions involved in the manual way of remembering the count has been successfully implemented.

VIII. Future Work

Keeping in mind the Indian market conditions the design of this whistle counter is made in such a way so as to minimize the cost and keep the circuit simple.

Future improvements in the filter design can further enhance the efficiency and accuracy of WhistleTronix counter.

WhistleTronix can be further upgraded by making the display wireless. Also, a microcontroller can be used to add additional features.

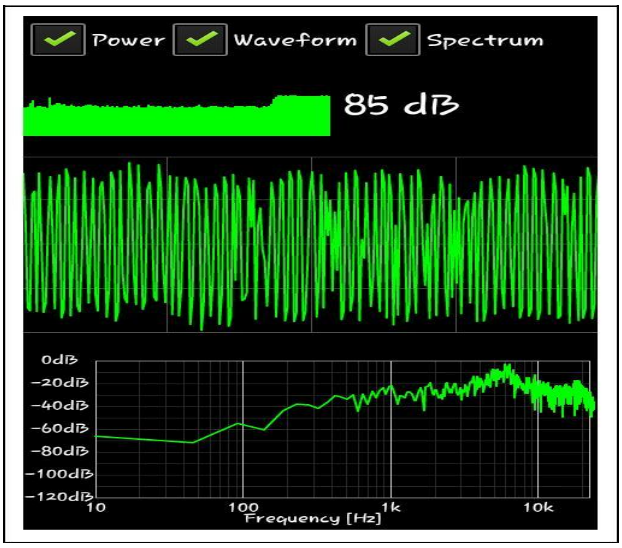

Fig. 10. Output of Condensor Microphone

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