COMPUTER-INTERFACING DESIGN FOR REAL TIME SIGNAL CLASSIFICATION USING FUZZY

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Abstract

It is aim to classify and display the real time signal in frequency through computer. The process involved the used of AI (Artificial Intelligence) technique. Software based on MATLAB Fuzzy Toolbox and MATLAB Simulink will be used to develop the fuzzy logic. The real time input signal based on the specify frequency generated by the signal generator will be insert to the fuzzy logic controller through the computer-interfacing system that will be built and designed based on RS-232 communication. The output will be displayed through the computer based on the classification of the frequency signal set in the membership function.

Keyword:
MATLAB Fuzzy Toolbox, MATLAB Simulink RS-232.

1.0 INTRODUCTION

Signal is an electric current or electromagnetic field used to convey data from one place to another. The two main types of signals are analog and digital. In short, the difference between them is that digital signals are discrete and quantized while analog signals possess neither property. Signals have a property called frequency and wavelength which is inversely proportional to the frequency.

This paper presents the work carried out in classifying the sound signal based on the frequency range. Ultrasound is sound with a frequency greater than the upper limit of human hearing, approximately 20 kilohertz. Some animals, such as dogs, dolphins, bats, and mice have an upper limit that is greater than that of the human ear and thus can hear ultrasound. In general, the range of the frequency is as shown in Table 1.1

Frequency Range (Hz)	Frequency Spectrum	Symbol
3k - 30k	Very Low Frequency	VLF
30k-300k	Low Frequency	LF
300k -3M	Medium Frequency	MF
3M -30M	High Frequency	HF
30M-300M	Very High Frequency	VHF
300M -3G	Ultra High Frequency	UHF
3G-30G	Super High Frequency	SHF
30G-300G	Extremely High Frequency	EHF

Table 1.1 General division of frequency spectrum

The specified frequency range was then classified using artificial intelligent (AI) technique and display onto a computer via computer-interfacing system.

2.0 METHODOLOGY

The overall process of this project is shown in Figure 2.1 which designing and building the computer-interfacing system based on RS-232 communication. The final result of the device is in real time signal.

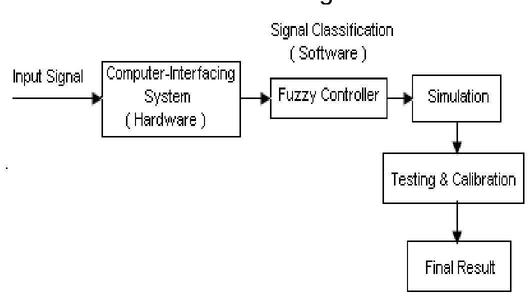


Figure 2.1: Block diagram of the overall process of the Project

3.0 COMPUTER-INTERFACING DESIGN

Figure 3.1 shows a block diagram of the acquiring the signal which consist of the overall design of computer-interfacing system.

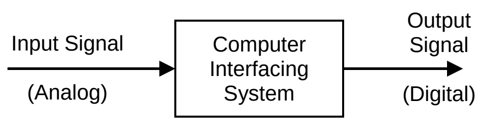


Figure 3.1: Block Diagram of acquiring the signal

The computer-interfacing system consists of three major parts that is Analog to Digital Conversion (ADC), Universal Asynchronous Receiver Transmitter (UART) and RS-232 Level Converter. The schematic diagram of the computer interfacing system is shown in Figure 3.2.

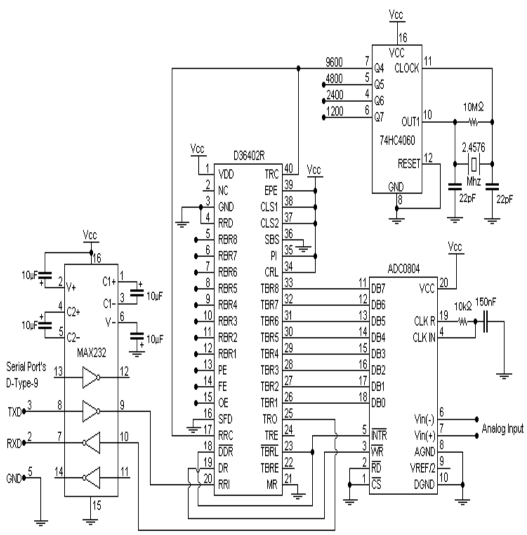


Figure 3.2: Schematic diagram of the computer interfacing system

3.1 Analog to Digital Conversion

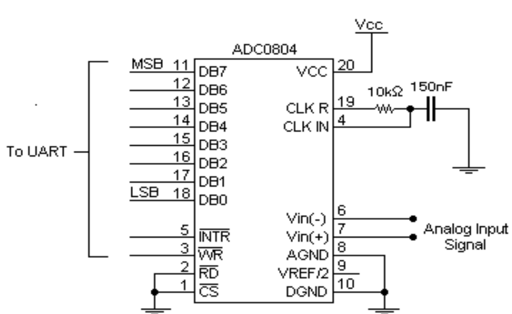


Figure 3.3: The schematic diagram of ADC circuit

The incoming signal that generated from signal generated is in analog form. So to deals with computer system, this analog signal must be converting to digital form. Therefore the analog to digital conversion is used in this project. Figure 3.3 shows the analog to digital conversion circuit that used ADC0804 to convert analog signal to digital form. The ADC0804 is CMOS 8-bit successive approximation A/D converters that use a differential potentiometric ladder. This device operates with any dc supply voltage range from 5V to 6.5V.

3.2 Universal Asynchronous Receiver Transmitter (UART)

The computer-interfacing design is based on RS-232 communication which means that data is send to computer using the 8N1 (8 Data bits, No Parity and 1 Stop bit) serial data format. The output from ADC is in parallel data format, so it needs the device to convert it in serial data format. That is the reason why the UART is used in computer interfacing design. The UART HD3-6402R-9 is chosen to be used in this project. The Figure 3.4 shows the UART HD3-6402R-9 pin out

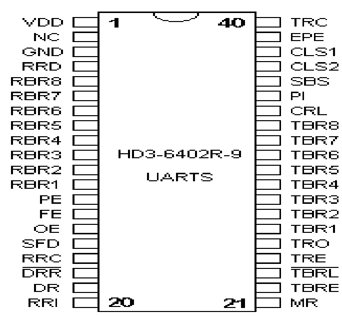


Figure 3.4: HD3-6402R-9 pin out

This UART is the brains of operation and performs the conversion of Parallel data to Serial format for transmission. It has the separate Receive and Transmit data buses and can be configured by connecting certain pins to various logic levels. However one disadvantage of this chip is it has no inbuilt Programmable Baud Rate Generator, and no facility to connect a crystal directly to it [3]. Therefore the Baud Rate Generator using a 74HC4060 14-bit Binary Counter and Oscillator is used in this project. The 74HC4060 as shown in Figure 3.5 being a 14-bit binary counter/divider only has outputs for some of its stages. Only Q4 to Q14 is available for use as they have external connections.

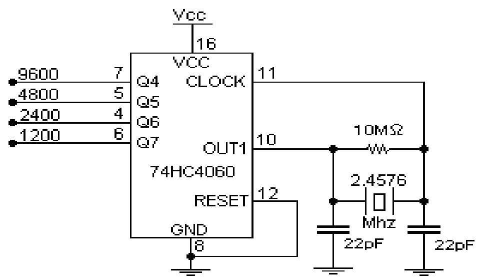


Figure 3.5: Baud Rate Generator using a 74HC4060

3.3 RS-232 Level Converters

RS-232 logic levels uses +3 to +25 volts to signify a “Space” (logic 0) and -3 to-25 volts for a “Mark” (logic 1). Any voltage in between these regions (between +3 to -3 volts) is undefined. The TTL or CMOS logic levels use +5 volt to signify a logic 1 and 0 volt for logic 0. Therefore the first step to connecting a device to the RS-232 port is to transform the RS-232 levels back into 0 and 5 volts. Figure 3.6 shows the RS-232 Level Converters using MAX232 that have transmit and receive data lines in same package.

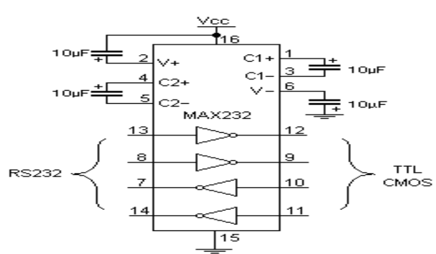


Figure 3.6: RS-232 Level Converters using MAX 232

4.0 CLASSIFICATION DESIGN

The design actually based on the human way of logic thinking. The signal classification is depending on the certain ranges of frequency given as an input [2]. Figure 4.1 shows the block diagram of signal classification using fuzzy logic that was build in FIS Editor in Fuzzy Logic Toolbox

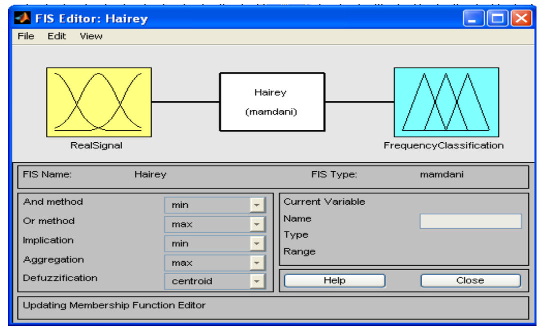


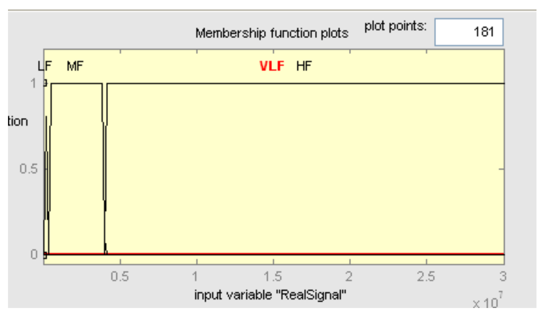
Figure 4.1: Fuzzy Logic block diagram

The signal classification consists of one input and one output block where each block there are four membership functions. Table 4.1 shows the input fuzzy variable for classification of frequency signal.

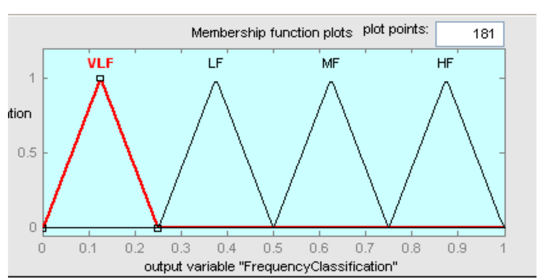
Frequency (Membership Range)	Name of membership Function
3kHz-30kHz	VLF
30kHz-300kHz	LF
300kHz-3MHz	MF
3MHz-30MHz	HF

Table 4.1: Input Fuzzy Variable for signal

The graphical representation of input and output membership function is presented in Figure 4.2.



a) Input membership function



b) Output membership function

Figure 4.2: Input and Output membership function

In the development of fuzzy logic controller the similar rules of human thinking were used. This can be shown in Figure 4.3.

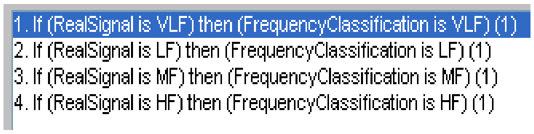


Figure 4.3: Rules of membership input\output function

The rules are developed in such a way that if the fuzzy inputs recognize the signal then it would give the appropriate frequency classification. There are four rules all together and each of them is dedicate to each signal classification.

In the fuzzy logic controller once the appropriate rules are fired, the degree of output membership function is determined by encoding the antecedent fuzzy subset [1].

5.0 DESIGN OF SIMULATION MODEL

The simulation design models were developed many times until the fuzzy controller able to pick up the frequency generated by the signal generator and thus giving the decision on type of frequency. The design is divided into two part where the design to read real time data from computer interfacing system through RS-232 port and design of fuzzy logic controller. Figure 5.1 shows the model design to read data from computer-interfacing system through serial port.

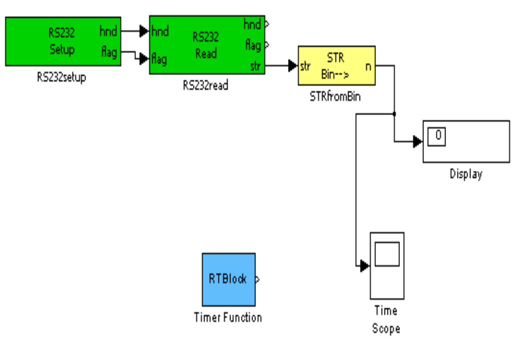


Figure 5.1: RS232 Read Signal Simulation model

The purposes of RS232 setup block are initialized and close the serial communication. The settings of port, baud rate, data bit, stop bits and parity of serial communication are selectable. The RS232 setup block is connected to RS232 read where this block reads from serial port all bytes in input and sends it to the block port as string object. The next block is STRfomBin block used to converts a vector of binary string into a vector of number. The data type UINT8 is be used. The display and time scope will display the data read from RS-232 port.

The second part is designing the fuzzy logic controller model. Figure 5.2 shows the fuzzy logic controller model that consists of counter and fuzzy logic Controller with Ruleviewer block. In this model the counter will act like a sensor which will count number of falling edge signal in period of one second.

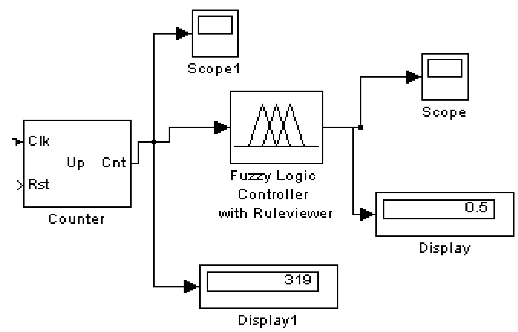


Figure 5.2: Fuzzy Logic Controller Model

The two models has to equip with data type conversion block where the data type of UINT8 will converted to double that needed to input the Fuzzy Logic Controller. Figure 5.3 shows the full design of real time simulation model.

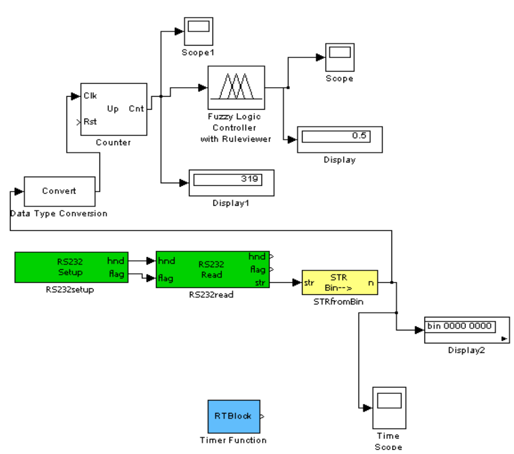


Figure 5.3: Real Time Simulation Model

6.0 RESULT

The output of fuzzy logic controller for real time simulation can be evaluated by comparing the output value from fuzzy rule viewer which the output is acquired when the frequency is set in FIS editor. The output value of fuzzy rule viewer is used as a reference. Table 6.1 the reference value.

Reference	
Frequency (Input)	**Fuzzy output**
3.1kHz (VLF)	0.125
13.5kHz (VLF)	0.125
28kHz (VLF)	0.125
31kHz (LF)	0.375
135kHz (LF)	0.375
290kHz (LF)	0.375
301kHz (MF)	0.625
1.35MHz (MF)	0.625
2.9MHz (MF)	0.625
3.1MHz (HF)	0.875
13.5MHz (HF)	0.875
29MHz (HF)	0.875

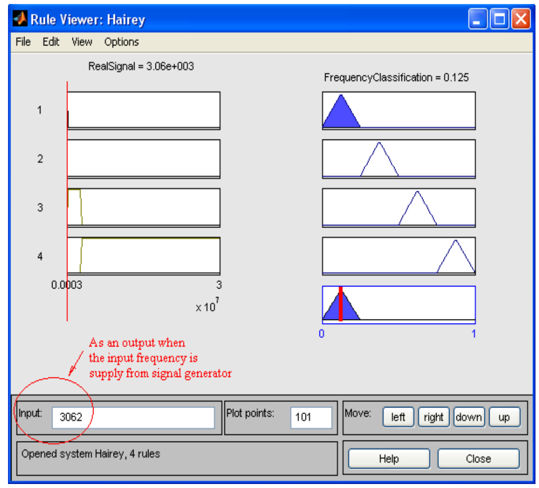
Table 6.1: Reference value

Table 6.2 shows the output value from real time simulation which the real signal is supply from signal generator to computer-interfacing circuit with the input frequency is varied based on the reference frequency.

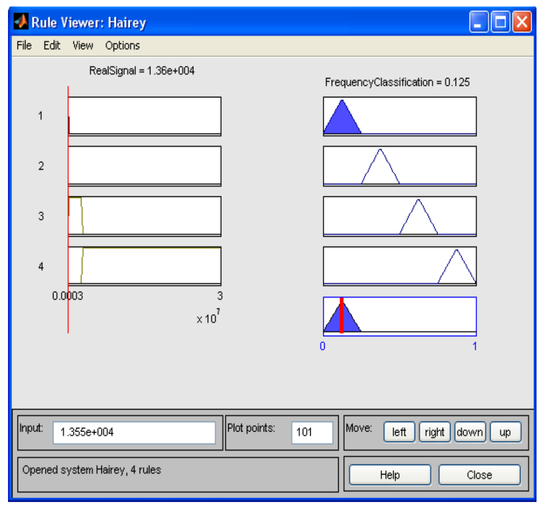
Results			
Input Frequency (Signal Generator)	**Output Frequency (Rule Viewer)**	**Fuzzy Output (Rule Viewer)**	**Period**
3.1kHz (VLF)	3.062 kHz	0.125	3 min 20 sec
13.5kHz (VLF)	13.55 kHz	0.125	10 min 40 sec
28kHz (VLF)	27.7 kHz	0.125	22 min 15 sec
31kHz (LF)	31.5 kHz	0.375	30 min 01 sec
135kHz (LF)	134.6 kHz	0.375	45 min 54 sec
290kHz (LF)	289.7 kHz	0.375	1 hour 15 min
301kHz (MF)	305 kHz	0.625	1 hour 20 min

Table 6.2: Result from real time simulation

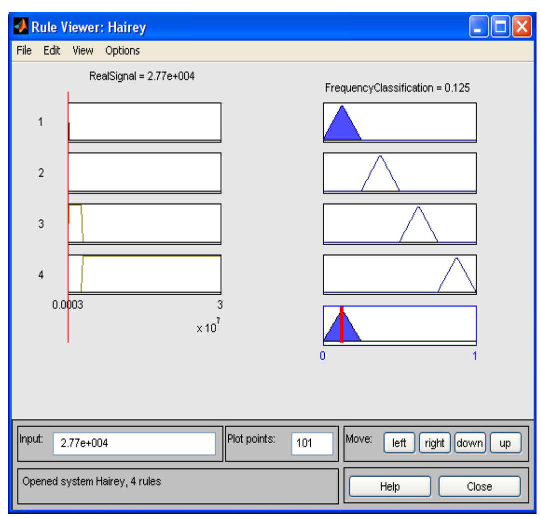
The output from real time simulation also can be shown in Fuzzy Rule viewer as in Figure 6.1.



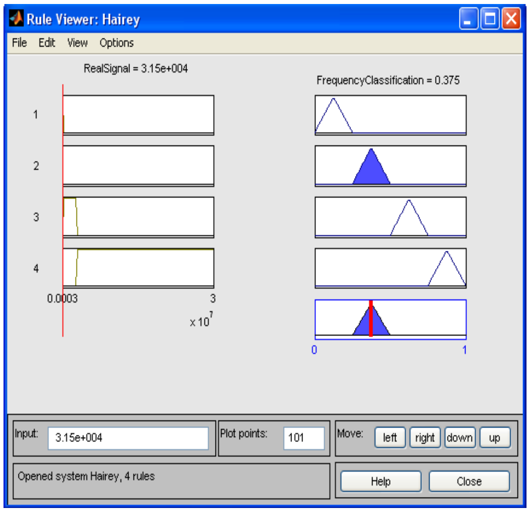
a) Fuzzy output value when input freq 3.1kHz



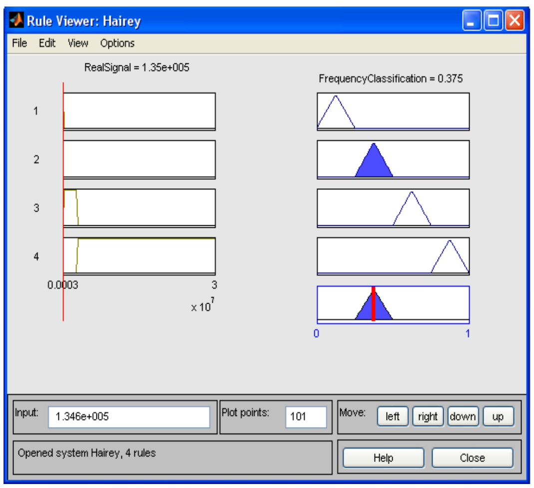
b) Fuzzy output when input frequency 13.5 kHz



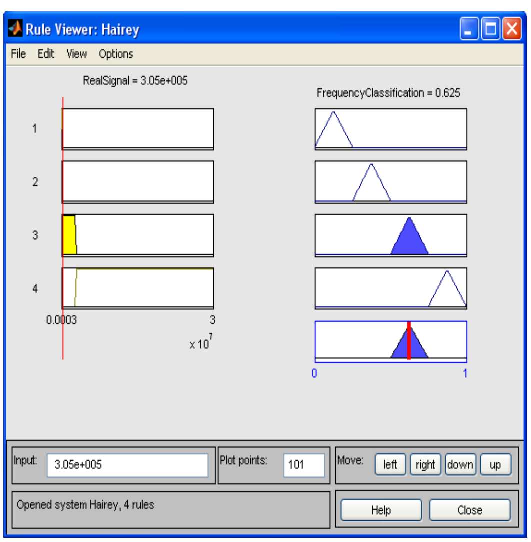
C) Fuzzy output when input frequency 28 kHz



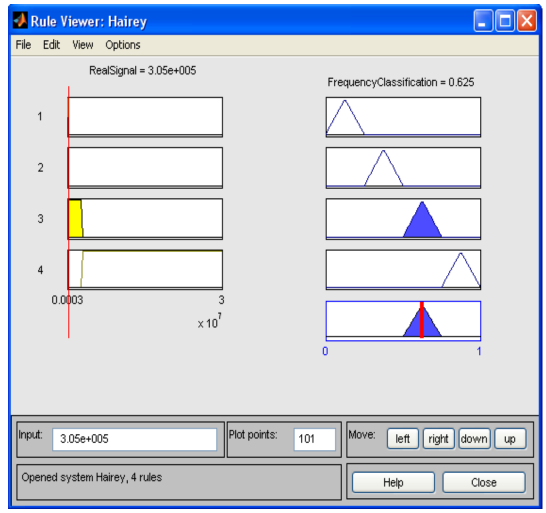
d) Fuzzy output when input frequency 31 kHz



e) Fuzzy output when input frequency 135 kHz



f) Fuzzy output when input frequency 290 kHz



g) Fuzzy output when input frequency 301 kHz

Figure 6.1: Fuzzy Rule Viewer output

7.0 DISCUSSION & CONCLUSION

Some blocks of RS232 read signal models are not provided in MATLAB simulink browser that from MATLAB installation CD which is RS232 setup, RS232 read and STRfroBin blocks. These blocks are getting from MATLAB File Exchange that can be downloading from MathWorks Web site [4].

From the results shown in Table 6.2, it has some error for the output frequency which acquired from fuzzy rule viewer. It is due to instability frequency of output signal from computer interfacing system but fuzzy logic controller still can recognize the frequency value of real time signal and give the classification of frequency. The performance of signal classification can be done by comparing the fuzzy output from Table 6.2 with reference value at Table 6.1 The result shows that fuzzy output that acquired from fuzzy rule viewer is same with reference value based on input frequency.

Due to long period of simulation time, the results have been limited up to 301 kHz input frequency. The amount of time takes to run a simulation depends on many factors, including the model complexity, the solvers step size, baud rate of computer-interfacing system and also computer's speed.

From this project, it can be conclude that the objectives of this project were achieved. The computer-interfacing design for real time signal using fuzzy is success which mean that the Fuzzy Logic can recognize and classify the frequency in the real time signal.

8.0 FUTURE DEVELOPMENT

In the future, the developments of this project can be continued by adding the design of a signal conditioning circuitry system specifically for sound measurement. The design will replace the input signal from signal generator that use in this project. The signal conditioning circuit provides the necessary operations to transform the incoming sound signal which is sensed using microphone as a sensor. The input from signal conditioning system will input the computer-interfacing system and then give the classification of sound signal detected by microphone using fuzzy controller that has been designed.

This project also can be proceed for future development by adding the Graphical User Interface (GUI) that can display the value of frequency in Hz and rad/sec which can be design and create using MATLAB Graphical User Interface (GUI).

9.0 ACKNOWLEDGEMENT

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10. REFERENCES

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