## DEVELOPMENT OF REAL TIME AUDIO SIGNAL MEASURING INSTRUMENT AND SIGNAL CONDITIONING CIRCUIT.

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Abstract-This paper presents the development of real time audio signal measuring instrument and signal conditioning circuit. The design undergoes several processes and displayed using computer via interfacing system. The raw signal which is in term of frequency is detected by sensor and then purified through signal conditioning circuitry. The output signal from signal conditioning circuit is then injected to the interfacing system circuit. Those signals are then classified using fuzzy logic membership function.

### **1.0 INTRODUCTION**

Measurement is essential for observing and testing science and technological investigation. Measurement system is consisting of basic constituent element that is transducer or sensory devices, signal conditioning circuitry and display. Signal conditioning refers to changes or conversion process that is made to produce purified signal. The signal may be too small and have to be amplified, it may contain interference which must be remove, non-linear and required linearization, analog form and have to be made digital or vice versa and etc [4].

The mains part in this project is signal conditioning circuit, interfacing circuit and MATLAB simulation. In the signal conditioning circuit it is consist of amplification circuit, filtering circuit and converter circuit. Preamplifier is needed to ensure the signal acquired is more reliable. Since the raw signal is small, then the amplification circuit used to increase the gain. Filtering circuit is designed to eliminate or reduce the interference. Then the filtered signal is converted into suitable signal to be use further. Whereas, the interfacing circuit is contain of analog to digital conversion (ADC), parallel to serial data converter using Universal Asynchronous Receiver Transmitter (UART), Baud rate generator to support UART transmission, and RS-232 level converter. The interfacing circuit connected to computer using serial port. The last part is MATLAB simulation which is the design of Fuzzy Logic Controller and real time simulation.

### 2.0 DESIGN METHODOLOGY

#### 2.1 Signal Conditioning Circuit.

Figure 1a shows a block diagram of signal conditioning circuit which consists of preamplifier, amplification circuit, filtering circuit and converter circuit. The main role of signal conditioning circuit is to adjust the sensor's output signal span to match the ADC input range. Figure 1b shows the schematic diagram of the overall signal conditioning circuit.



Figure 1a: Block diagram of signal conditioning circuit



Figure 1b: Schematic diagram of overall signal conditioning circuit

## 2.1.0 Pre-amplifier circuit



Figure 2: Schematic diagram of pre-amplifier circuit.

In this circuit, a microphone is used as a sensor. It is based on a low noise, high gain two stage PNP and NPN transistor amplifier using DC negative feedback through R12 to stabilize the working condition precisely. Output level is attenuated by R13 but at the same time the stage gain lowered due to the increase R11, thus allowing to cope with wide range of input sources. The circuit is shown in Figure 2.

## 2.1.1 Amplification circuit



Figure 3: Schematic diagram of amplification circuit.

The amplification circuit as shown in Figure 3 is used to produce clearer signal sensed by the sensor. It can be done by increase the voltage gain. The main component is LM386 audio amplifier. The gain of this amplifier is depends on pins 1 and 8. The required gain value can be achieve by manipulate the resistor and capacitor value. The gain can be set to any value between 20 to 200. The output frequency can be tune by adjusting the R3 until the best output is obtained. By adjusting R3 also it can reduce noise at the output.

## 2.1.2 Filter Circuit



Figure 4: Schematic diagram of filter circuit.

The amplification circuit amplifies the audio signal and so do the noise. Since the noise will disturb the original signal, therefore a suitable filter is used to filter out all the unwanted signal. Filter are classifies according to the frequency ranges they transmit or reject. The most suitable filter to be use in this design is band-pass filter. The band-pass filter will permitted certain value of high frequency and low frequency. The frequency limitation is depending on capacitor C9 and C10 and R7 and R6. The integrated signal use in this circuit is UA741. Figure 4 shows the band-pass filter circuitry.

### 2.1.3 Converter Circuit



Figure 5: Schematic diagram of converter circuit.

The converter circuit as shown in Figure 5 is use AD650JN as converter component. Voltage to frequency converter is needed for interfacing system circuitry. The buffer is used to avoid current to flow back due to high input impedance [1].

### 2.2 Computer Interfacing Circuit

The overall circuit for computer interfacing using serial port is shown in Figure 6 and Figure 7. Interfacing circuit is use because computer or micro-processor bus system cannot connect directly to the peripheral devices. This is due to lack of compatibility in signal form and levels [4].



Figure 6: Block diagram of element in computer interfacing circuit.



Figure 7: Schematic diagram of overall computer interfacing circuit.

## 2.2.0 Analog-to-Digital converter

The incoming signal from the signal conditioning circuit is in analog form. Therefore, to deals with the computer system, this analog signal must be converted to digital form. In this case, the ADC 0804 CMOS is used as in Figure 7. This ADC is CMOS 8-bits successive approximation A/D converters that use a differential potentiometric ladder and it is operated at dc voltages 5 volts.

# 2.2.1 Universal Asynchronous Receiver Transmitter (UART)

This computer interfacing circuit is based on RS-232 serial communication. Since the output from ADC is in parallel data format, therefore it is require the converter to convert parallel data to serial data format. The UART HD-6402-9 is used in this interfacing circuit. Figure 7 shows the overall schematic diagram of the interfacing circuit. The receiver converts serial start, data, parity and stop bits. The transmitter converts parallel data into serial form and automatically adds start, parity and stop bits. Parity can be odd or even.

### 2.2.2 RS-232 Level Converter

Data is sent as time series of bit in RS232. RS-232 devices may be classified as Data Terminal Equipment (DTE) or Data Circuit termination Equipment (DCE), this defines at each device which wires will be sending and receiving each signal. Valid signal is between  $\pm 3$  to  $\pm 15$  volts with correspond to logical 1 and logical 0. In this connection, the voltage supply selected is 5 volts which signify logic 1 and zero volts for logic 0. This connection can be refers to pin 2 and 6 in Figure 7 at component Max 232.

### 2.3 Fuzzy Classification

Fuzzy logic is a branch of the mathematics that allows a computer to model the real world the same way that people do. Fuzzy allows representation of human decision and evaluation processes in algorithmic form [7]. The signal classification is depending on the certain ranges of frequency given as input. Figure 8 shows the block diagram of signal classification using fuzzy logic.



Figure 8: Fuzzy Logic block diagram

The input and output variable is real time frequency and it is defined by the membership function. Figure 9 and Figure 10 shows the graphical representation of the input and output membership function. Table 1 show the fuzzy classification for membership function and fuzzy output.







Figure 10: Output membership function.

Frequency	Membership	Fuzzy output
range	function	classification
3kHz-30kHz	VLF	0.125
30kHz-300kHz	LF	0.375
300kHz-3MHz	MF	0.625
3MHz-30MHz	HF	0.825

Table 1: Frequency classification.

Fuzzy logic output is base on set of fuzzy rules. Fuzzy inference using if-then rules is commonly use. Figure 11 show the rules involve in this project. The rules are developed in such a way that if the fuzzy input recognized the signal then it would give the appropriate frequency 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.



Figure 11: Rules of membership input/output function

### 2.4 Simulation Model

The MATLAB Simulink is use to design the real time simulation model. The simulation model consists of two main parts. First part is the design of fuzzy logic controller model and another part is the design of read real time signal from interfacing circuit by using RS232 block. Figure 12 below represent the overall design.



Figure 12: Real time simulation model

In the first part, the fuzzy logic controller model 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 a period of one second.

The second part consists of the RS232 setup block that use to initialize and closed the serial communication. The setting of port, baud rate, data bit, stop bits and parity of serial communication are selectable. RS232 read is to read from serial port input and send to STRfromBin block as string object. This block is then convert vector of binary to vector of number.

## 3.0 RESULTS AND DISCUSSION

The output signal from signal conditioning circuit was examined and injected to the interfacing circuit system in order to display via fuzzy Ruleviewer. Figure 13a, Figure 13b and Figure 13c shows the output signal from signal conditioning circuit. Figure 14a, Figure 14b and Figure 14c shows the fuzzy Ruleviewer for the signal in Figure 13a, Figure 13b and Figure 13c respectively.



Figure 13a: Input and output at 3.1kHz.



Figure 13b: Input and output at 31kHz







Figure 14a: Fuzzy output at frequency 3.1kHz

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Figure 14b: Fuzzy output at frequency 31kHz



Figure 14c: Fuzzy output at frequency 135kHz

### **4.0 CONCLUSION**

The development of real time audio signal measuring instrument and signal conditioning circuit are successfully presented. The fuzzy logic membership function is able to classify the output signal of signal conditioning circuit.

## 5.0 FUTURE DEVELOPMENT

The design can be improved by applying MATLAB Graphical User Interface (GUI) to display the output in term of Hz or rad/sec.

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