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Locally Fabricated Electronic Drum Trigger-Module

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ABSTRACT

Different electronic gadgets and devices nowadays exist and develop rapidly with the latest trends and technology. Gadgets have specific functions based on people's interests or needs in communication, transportation, music, and entertainment. The electronic drum is one of these gadgets that music enthusiasts would surely want to have. The study aimed to fabricate or assemble an electronic drum using raw materials which is locally available. The study used the experimental and project method. It was accomplished by fabricating the edrum module based on the circuit design of Admir Salahovic. The processes include the use of the toner transfer method in making the Printed Circuit Board; programming the microcontroller; the construction of the different triggers with the use of locally available materials and testing the device's functionality. The study concludes that the locally fabricated electronic drum trigger-module found on the internet as a do-it-yourself project using locally available materials works; it answers the queries of how electronic musical instrument works and what it is made of. The researcher and students are capable to build complicated electronic devices with the theories and skills learned behind it. It is recommended to enhance some of the trigger pads for a professional-like electronic drum kit.

Keywords **–** Technology, electronic drum, fabrication, drum triggers, experimental and project method, Philippines

INTRODUCTION

Technology gives ease, comfort, security, entertainment, and other things that help people's day-to-day living. The term technology has multiple definitions. Some define technology as both material and immaterial entities created by mental and physical efforts to achieve value. This can also refer to machineries, tools, instruments used in communication, transportation and construction.

Meanwhile, Arthur (2009) describes technology as "means to fulfill a human purpose." The reproduction of sounds nowadays is developed from analog to digital signals. Music contains different sounds produced not by a traditional acoustic music instruments, but rather a digitally processed.

Digitization accomplishes many of the same things just like the gramophone: music storage and retrieval are greatly facilitated, though this time it is not simply music as sounds, but music as bits – the combinations of zeros and ones. These digits are more portable, more easily disseminated than ever before. However, it is not just storage and retrieval that have changed but the production as well. Anyone who recalls television programs from the 1970s or earlier might also remember that the soundtracks usually featured orchestral music, attributed to a composer in the program's credits. In those previous days, television, film, advertising, and all music were written by a person, perhaps, orchestrated by another; parts were copied and distributed to orchestral musicians, often employed by major television and film studios, and the music was recorded for each program and edited to fit the specific program. Now, however, music can be realized by a single person with a home studio consisting of a computer and few electronic musical instruments. No performance required; indeed, there is no "performance" in a conventional sense (Taylor, 2001).

The production of digitally processed music involves the conversion of acoustic instruments into electronic or electric. The musical telegraph is one of the first electric musical instruments existed in 1876. It was invented by Elisha Gray where steel reeds produce oscillations through electromagnets being transmitted over a telegraphy line. Other inventions of Gray, which also involved vibration and magnetic field to produce audible oscillations is a loudspeaker device (Chadabe, 2000).

In 1971, Luciano invented an electronic instrument for simulating the sound effects produced by a piano, comprising an electronic generator adapted to generate an electrical signal of constant or substantially constant amplitude, and electrical switching means connected to the generator and adapted (upon operation of a key associated therewith) to cause the signal from the generator to be applied to an output of the instrument. The amplitude of the signal at the output being representative of the time taken for the switching means to move from an inoperative to an operative condition.

Electronic musical instruments typically generate processed sound and could simulate virtually the musical instruments. Vibrations produced by striking an element will be translated into electric signal. Such instrument includes percussions and electronic drums which are increasingly becoming popular with the modern musical groups (Bozzio, 1987).

The electronic drum nowadays is popularly used in different musical events and recordings. Unfortunately, the cost of these electronic drums in the market is very high that an average musician or a beginner could not afford to have. The design, development and fabrication of this device requires an in depth knowledge and skills in the advance electronics technology.

To address this problem, the researcher attempted to come up with a locally fabricated electronic drum trigger and module with the use of his knowledge and skills in electronics technology.

FRAMEWORK

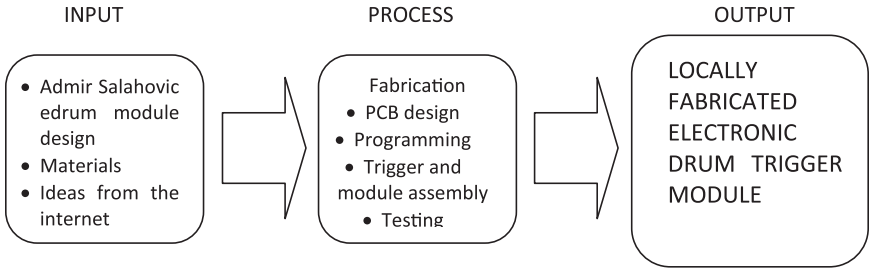


Figure 1. The Conceptual Framework

The input includes the main source of the e-drum module design (Admir Salahovic, 2009), and the materials needed in his website. The triggers were out of

available materials in the market and others were scrap based from the ideas of the researcher and from the different ideas on the internet. The processes involved the PCB design, where the researcher used the Toner Transfer Method, programming the PIC microcontroller, assembly of the module and the construction of the different triggers.

The History of the Electronic Drums

The first electronic drum is said to be created by a drummer of The Moody Blues, Graeme Edge together with a Professor at Sussex University, Brian Groves and was used in the song "Procession" in 1971.

Pollard Industries released the first commercial electronic drum, Pollard Syndrum, in 1976. It caught the attention of many drummers and percussionists, but it was a financial failure that led the company into a monetary loss.

The commercial electronic drum set production was continued by the Simmon's company in 1978 and its famous product SDS-5 was released in 1981. This electronic drum gained its prominence during the 80's where this was used by famous bands and artists in the pop/rock and synth-pop groups such as Duran Duran, Spandau Ballet and Shock.

Other companies, Roland and Yamaha, started selling their own electronic drum versions the following years. The drum pads used were rubber-coated the same as that of today's kits. It is velocity sensitive and with single multiple-layered sound samples.

The TD-10 model was introduced by Roland in 1997. The innovations made in this model are: 1) It provides a sound for the drums or pads to trigger themselves and not through instrument sound samples. Instead of rubber-coated pads, they used mesh-head pads made from double layer woven mesh fibers. Roland called their innovative electronic drum sets as V-drums (Rule & Fisher, 2015).

It was found in the study of Harvey (2002) that online search for information and navigations engages learners, creates more meaningful tasks and increases the intrinsic motivation of the students. Moreover, according to Elliott (2005), Do-It-Yourself (DIY) is chosen by people for the fun of creation, to learn and to get something that cannot be bought because it is too specialized. Making something on your own allows you to customize, and when it's done, the fun and pride of accomplishing it will always be there.

Doing it yourself is not exactly what others think as to save money. The use of available materials or junk materials, yes it could be, but the main reason why do-

it-yourself is to learn new skills or mastery that displays your talent or technical know-how.

OBJECTIVE OF THE STUDY

The study aimed to fabricate an electronic drum out of locally available materials.

MATERIALS AND METHODS

The study utilized the project and experimental method of research in assembling the Electronics Drum Trigger-Module**.**

Device Fabrication

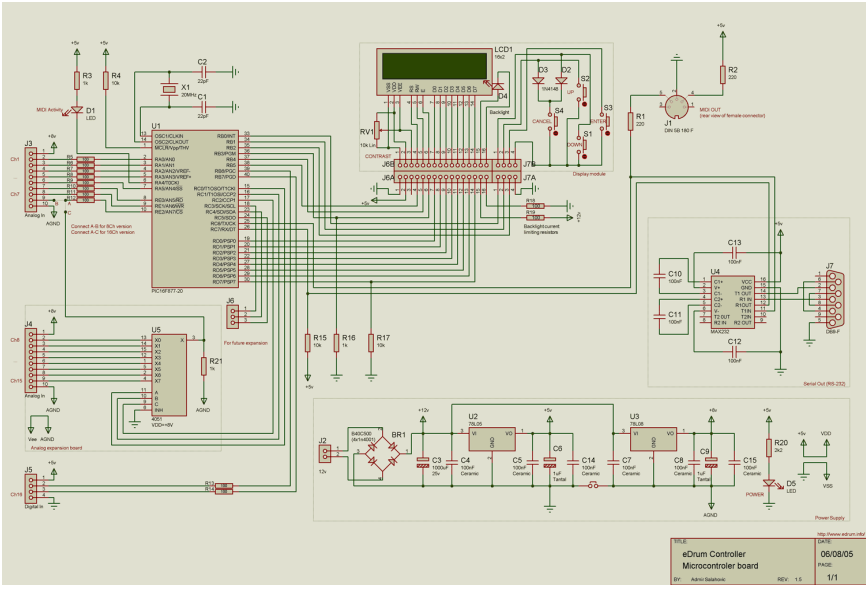
a. Materials

Bill Of Materials			ANALOG BOARD		
QTY	PART-REFS	VALUE	QTY	PART-REFS	VALUE
Resistors			Resistors		
2	R1,R2	220	8	R1,R11,R21,R31,R41,R51,R61,R71	47K
3	R3,R16,R21	1k	16	R2,R3,R12,R13,R22,R23,R32,R33,R43,R52,R53,R62,R63,R72,R73	100K
3	R4,R15,R17	10k	8	R4,R14,R24,R34,R44,R54,R64,R74	1K
12	R5-R14,R18,R19	100	Capacitors		
1	R20	2k2	16	C1,C2,C11,C12,C21,C22,C31,C32,C41,C42,C51,C52,C61,C62,C71, C72	100nF
Capacitors			2	C101,C102	1uF
2	C1, C2	22pF	IC		
1	C3	1000Uf	2	U1,U2	LM324
10	C4,C5,C7,C8,C10-C15	100nF	Diodes		
2	C6, C9		8	D1,D11,D21,D31,D41,D51,D61,D71	BAT85
IC			8	D2,D12,D22,D32,D42,D52,D62,D72	1N4148
1	U1	PIC16F877-20	Miscellaneous		
1	U2	78L05	8	P1,P2,P3,P4,P5,P6,P7,P8	100k
1	U3	78L08			
1	U4	MAX232			
1	U5	4051			
DIODES					
3	D1,D4,D5	LED			
2	D2,D3	1N4148			
Miscellaneous					
1	LCD1	16X2			
1	1	10K Lin			
4	S1 – S4	Pushbutton			
1	X1	20MHz			

Figure 2. Materials of the Electronic Drum Trigger-Module

There are two major parts of the trigger-module: 1) The digital board which is the Brain of the device, consists of the Programmable Interface Controller (PIC), Microcontroller, PIC16F877, 10-bit low power processor, analog-to-digital converter. This converts the signals from the analog board into a Musical Instrument Digital Interface (MIDI) signal through a programmed code. The same PIC microcontroller was used by Malhotra and Seethalakshmi (2013) in their “Automatic Meter Reading and Theft Control System by Using GSM” and Karnavas and Liagkos (2012), "Development of a Practical Low-Cost µC based Brushless DC Motor Controller using Proteus". Second is the analog board consists of the LM324 low power Quad Operational amplifier. This regulates the input signal coming from the piezo electric transducer and maintain the output voltage for the A/D converter.

The Circuit:



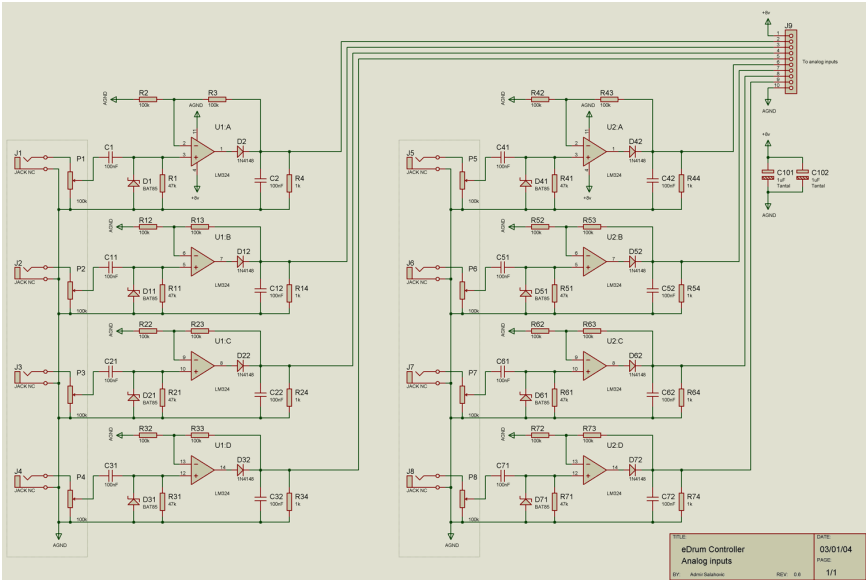


Figure 3. Schematic diagram of the module

The schematic diagram shows circuit connections of the different electronic components used in the module. This allows further understanding on how the module works. This also serves as a guide in the fabrication and troubleshooting.

The analog circuit used operational amplifier circuit that regulates and controls the signal input coming from the piezo electric transducers. The output of this circuit will then be fed to the input of the digital circuit consisted of the brain of the device, the PIC16F877 IC. The microcontroller then translates the signal into MIDI signals, a signal that is accepted by a sound device (i.e. musical keyboard) or a software in a personal computer (i.e. addictive drums). The settings, parameters, vu meters can be viewed through a 16x2 LCD connected to the output of the microcontroller.

PCB fabrication:

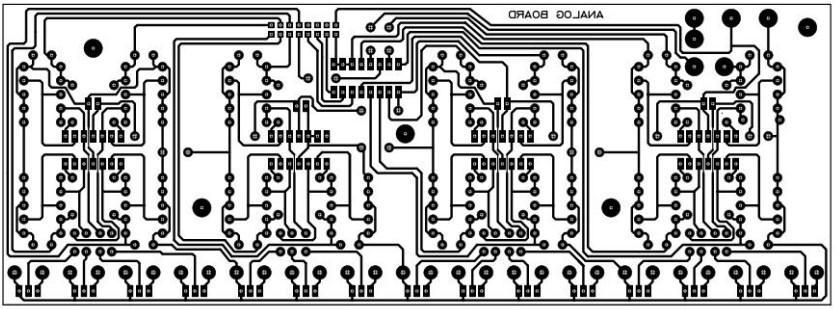


Figure 4. Analog Printed Circuit Board

This figure shows the design of the printed circuit board of the analog circuitry used in the study.

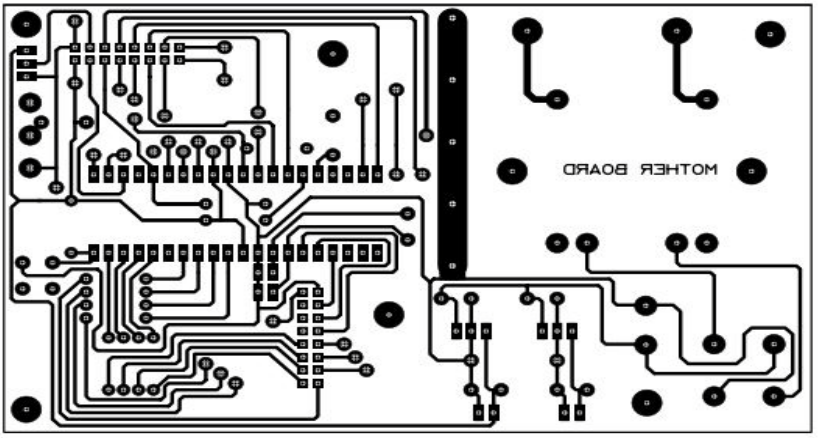


Figure 5. Motherboard Printed Circuit Board

The figure shows the design of the Printed Circuit Board of the motherboard or the digital board used in the study.

The PCB designs were downloaded from the website of Admir Salahovic. Toner transfer technique was utilized in the fabrication. The PCB designs were printed in a photo paper using a laser jet printer and then transferred to the Copper Clad Board (CCB) by heating with pressure through a flat iron.

This technique is similar to the US patent "Electro (stato) Graphic Method using Reactive Toners" by Uyttendaele, De Beeck, Leenders and Tavernier (1996) where they fixed the toner particles in the final substrate by heat or by heat and pressure.

Component placement and soldering

The different components or parts were carefully placed and soldered into the printed circuit boards following the schematic diagram and the lay-out.

PIC programming using PICpgm software and JDM programmer

The Peripheral Interface Controller, PIC16F877A, is a 10-bit, 8-channel analog to digital converter enhanced flash microcontroller. This is the brain of the device. It converts the analog signal from the hit of the pads containing the piezo electric transducer into a Musical Instrument Digital Interface (MIDI) signal that triggers the MIDI notes of an electronic musical sound device or instrument.

The microcontroller's function can be set by a program code that is designed by a programmer. The author of the module, Admir Salahovic, provided his code on his website that was transferred or programmed into the microcontroller using a PICpgm software available in the internet. A programming device or instrument, JDM programmer, was also fabricated for this purpose. It serves as the device that links the microcontroller to the computer for programming the code.

Final Assembly of the Trigger module

Figure 6. Trigger Module

The figure shows the final assembly of the module. All the necessary parts and components were wired and encased in a scrapped VCD case. The researcher as much as possible made use of scrap materials available to reduce the cost of the project.

B. Hi-hat pedal construction using optical device

Figure 7. Hi-Hat Trigger Pedal

A Hi-hat is a pair of cymbals that clashes using a hi-hat pedal. It produces high frequency note or pitch. The hi-hat pedal is a drum device that shifts the "HI-HAT" cymbals. This shifts the operation of the cymbal from close-open or vice versa operated by foot.

The Hi Hat trigger pedal as shown in Figure 7, was improvised from a plywood designed to mimic the real one. A circuitry that involves the production of the trigger signal for hi-hat operation includes a Light dependent resistor (LDR) and a Light Emitting Diode (LED). When the pedal is pressed, the light from the LED will be blocked causing the LDR to change its resistance value.
In 1997, Robert Weil invented a foot operated signal controller with lighted visual reference. It is a typical rocker pedal linked to a variable resistor which controls the LEDs and audio signal.

Kick drum pedal assembly

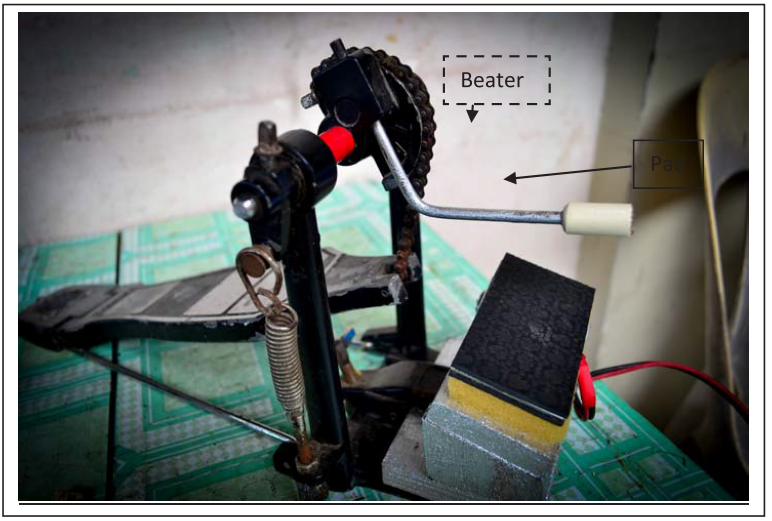


Figure 8. Kick drum trigger pad

A Bass Drum is a low note or low pitch frequency-producing drum. It is usually paddled by a beater by hand or foot. The kick drum, therefore, is a bass drum paddled by foot using a pedal.

The Kick drum pedal in the study is a real Kick drum pedal only with an improvised beater and the trigger pad. The pad is made of rubber and foam placed in a designed plywood casing. The piezo electric transducer is sandwich

between the foam and the rubber. The beater was an improvised bent metal rod.

Toshinori Yamashita (1988) invented an electronic bass drum with integral supports where he properly reinforced the pedal for different type of drummers that could withstand the force of a beater.

Trigger Pads assembly/fabrication

Figure 9. Trigger Pads

A drum set is composed basically of a snare, high tom, mid tom, floor tom, bell, and cymbals. Electronic drums use trigger pads for each operation of the drums.

The trigger pads were designed by the researcher based on the different concepts found on the internet and the availability of the materials.

The snare and toms trigger pads used in the study were made out of a 10-inch pvc pipe, aluminum flat bar, mesh screen, sponge foam and the piezoelectric transducers. The hi-hat and bell pad were made out of a plastic chopping board with a foam cover as a cushion to prevent excessive noise when hit. The cymbals were out of screen cover of pots with the piezo element located beneath it.

Electronic drum pads include a vibration responsive plate mounted on a cushion with a thin buffer pad on its upper surface to provide the player the feel of natural drumhead. The supporting structure or frame also provides insulation of unnecessary vibrations to the vibration plate (Hoshino, 1984).

Operation and Testing

The device was tested functional with all the features and operations. The presence of the signal triggering the sound module/pc when striking the drum pads is a manifestation that the device is working. When the trigger pads are struck, the piezoelectric transducers embedded to the pads will produce small electrical signal proportional to the hitting strength. The signal is then fed to the e-drum module that translates the signal into digital codes that correspond to the MIDI notes in the sound module (electronic keyboard or personal computer).

Piezoelectric pickups are provided to each drum pad and the output of which is connected to an envelope-extracting circuit where the extracted signal will be converted by an Analog-to-Digital converter into which is fed to a Computer Processing Unit that feeds a tone designation signal to a tone generator. Together with a parameter data, it produces the corresponding drum sound (Uchiyama, Nakamura & Tsutsumi, 1988).

Bozzio (1987) stated that the electronic drum can also be used as an entirely different type of percussion instrument than a drum. It can also simulate cymbal that produces cymbal bell note, ping or ride note and crash.

The generated signals correspond to a MIDI note. When translated by a drum sound producing module, MIDI note C corresponds to a Bass Drum sound, D for snare drum and so on as indicated in figure 10 MIDI key assignments.

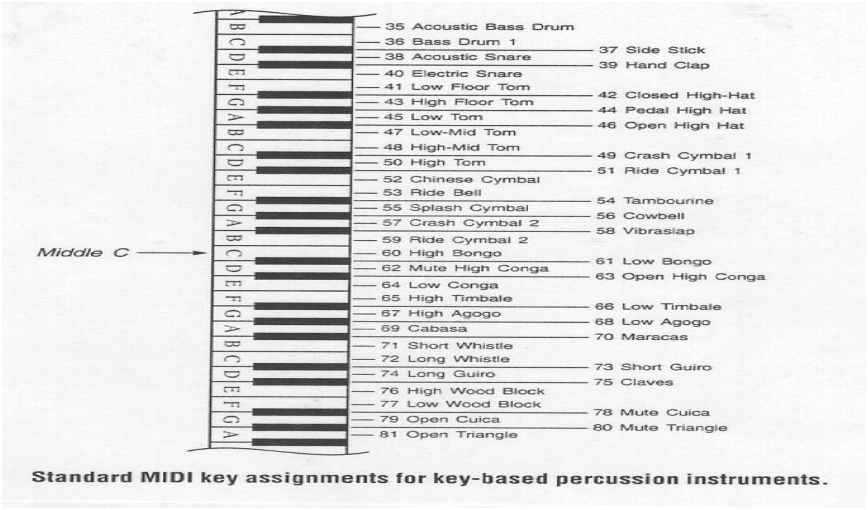


Figure 10. MIDI Key Assignments

The device's LCD worked as it displays necessary information, operations, parameters, VU meter for each channel, etc. as calibrated using the control buttons.

Startup screen

When opening the device, a message or characters will be displayed in the LCD called the startup screen. It should display the programmer/inventor's name and then the version of the firmware used.

VU-meters

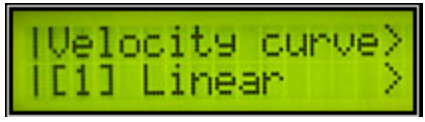
After the startup screen, VU meter display will appear. This shows input signal level for each channel when the pads are hit. VU meters is the same as signal level meters. It measures or display the strength of the signal.

Parameters

Pushing the buttons will take the device into the setting mode or the parameters. The parameter settings include:

1. Velocity curve

This sets the ratio of the striking force and the volume output. This is set to linear wherein the force of the hit or striking the pad corresponds to the volume of the sound. Meaning, it is just like hitting an acoustic drum that, when the strike is soft, it produces also a soft sound but when the hit or strike is hard, the sound is loud.



2. Threshold

This sets the level of the input signal where the e-drum starts to respond. This is the onset level where the module detects that a pad is hit. This is the setting for the sensitivity of the trigger pads.

3. Retrigger

The setting determines how fast e-drum consider or respond to another hit. This sets the electronic drum to simulate drum rolls. Every hit counts or being responded by the module no matter how fast the drummer hits the pad just like the acoustic drums.

4. Crosstalk

This parameter will be set to prevent false triggering from the vibrations caused by the rack or in between pads. The piezo elements are vibration triggered. They produce an output by vibrations. The sensitivity of these piezos may cause them to trigger easily. To avoid unnecessary trigger or sound, crosstalk function will do the job. It prevents cross triggering, or triggering nearby pads.

5. Note assign

A setting which designates a MIDI note to a specific channel. The output of the device is a MIDI signal that triggers a specific note in an electronic musical instrument such as the electronic keyboard. Each channel or pad can be assigned to a note preferred. The key assignments is presented in Figure 10.

The snare dual piezo triggering feature where it contains two piezoelectric transducers in one drum pad splits into two zones. One note will be triggered when the specific zone is hit. The device functioned well with the feature. Hi-hat pedal was made of optical sensor, a light emitting diode (LED) and a light dependent resistor (LDR). This triggers the hi-hat cymbals. The kick drum pedal is an original pedal, but a beater was fabricated along with the pad. The different parameter of the signal attenuation and operation was controllable. The overall functionality of the device was excellent and was proven to be operational.

Uchiyama, Nakamura and Tsutsumi (1988) claimed that an electronic musical instrument is a means of converting analog to digital signal where vibrations detected will be converted to a digital code that triggers a tone generating module. The electric signal produced by a member producing signal when struck (piezoelectric transducers) is being controlled with an operational amplifier that is fed to an analog to digital converter. The analog to digital converter includes a microcomputer that processes the signal with certain parameters and generates a tone as an output.

The device was tested by students, experts in the field of electronics technology and musicians. The device was used by musicians in a live band performance and works well with it. The acceptability was very high assessed with good performance, the great possibility of use in band performances, and the marketability.

CONCLUSIONS

The study showed the functionality of a do-it-yourself project found on the internet. All the parameters of the device works or functions as designed. The acceptability of the device's performance is very high and positive marketability. However, selling the device is strictly prohibited by the developer who quoted in the forum "eDrum project is for personal use ONLY. You cannot make a profit, or sell it".

The researcher gained a lot of information and skills in fabricating the device, such as how the device works where most of us who sees such device wonder how, how it is built, and the theories behind it. This also encourages students who are

also electronics and music enthusiasts to build their own gadget. It also serves as a sample project in analog to digital conversion and microcontroller programming.

TRANSLATIONAL RESEARCH

The device can be used as an instructional material in electronics technology as it dealt with the application of analog and digital devices, and microcontroller programming. The processes undertaken during the construction or fabrication will serve as a guide for the students to follow the techniques in the fabrication of the printed circuit board, programming and construction of a complicated electronic device. The device can also be used in entertainment as a working drum set and a trigger to electronic musical instruments. It can also be used in exhibits as a locally fabricated device that will serve as a motivation for researchers and enthusiasts to develop or fabricate their own device.

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