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Study and Analysis: MIDI, the use of Arduino in MIDI and Various Custom MIDI Controllers

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Abstract- Till date, there are numerous devices and tools developed based on electronics in music technology. Arduino, which is a common electronic module or a platform is designed to make electronics more accessible to various categories of people viz. artists, designers, musicians, studio professionals, hobbyists and anyone, who is interested in creating music related tools. It is seen that along with the musical instruments, the electronic devices or controllers used with the instruments for various applications viz. audio synthesizing, recording, mixing etc. comes out at high price, which is not often affordable for every common people. Also, in some cases, these devices are not available in the market with the desired requirements. This paper presents a study on MIDI, how Arduino is used in MIDI and how some common issues viz. cost and requirements etc can be sorted out by using an Arduino to build custom MIDI devices.

Keywords- Arduino; Controllers; MIDI (Musical Instrument Digital Interface); Audio synthesizing.

1. INTRODUCTION

Technology plays a very significant role in the world of music production. Since, the late 18th century, the use of electronic devices, electronics and digital instruments, computer hardware and software is increasing day by day. These are used in the performance, recording, composing, mixing, analysis and editing of music. The combined use of computers and synthesizer technology has brought a different way of making music.

The invention of MIDI (Musical Instrument Digital Interface) has transformed the world of music recording. It brought a rapid growth in the sales and production of electronic instruments and music software.

Even though there are various electronic instruments and applications developed in the area of music, there comes a matter of cost and availability of the exact requirements. This paper presents a study on MIDI, the use of Arduino in MIDI and building of various custom MIDI devices with the help of Arduino at much cheaper price than those available the market.

2. LITERATURE SURVEY

There have been a number of electronic musical devices and tools developed in the field of music technology. However, a very few studies focuses on the use of electronics, to makeit more accessible to the people in creating interactive environments. Below is a brief discussion of some related works on MIDI-

[1] The paper presents a series of open-source firmwares for the latest iteration of the popular Arduino microcontroller platform. The HIDUINO (a portmanteau of Human Interface Device and Arduino) project tackles a major problem in designing NIMEs: easily and reliably communicating with a host computer using standard MIDI over USB.
[2] system aimed at developing a synthesizer system to blend the techniques of modern electronic music equipment with the concept of the keyboard. To design high performance and a fully equipped digital synthesizer with all features using a low-cost system-on-a-chip (SoC) embedded system.
[3] develops an Arduino-based MIDI Controller for Detecting Minimal Movements in Severely Disabled Children. The device is developed in which electrical sensors is used as a way of creating sound. The sensors can be used to create specially crafted controllers and thus making it possible for children with different impairments to create music or sound.

3. MIDI

MIDI or Musical Instrument Digital Interface is the standard interface for the musical instrument industry which enables different electronic instruments and electronic music devices to interface with each other and with computers.

MIDI was standardized in 1983. It is a hardware and software specification which allows electronic musical instruments to communicate with each other. It is designed for recording and playing back music on digital synthesizers which is upheld by numerous makes of PC sound cards. Initially, it was just planned to control one keyboard from another.

The MIDI protocol was created so that different synthesizers could communicate with each other. It is a serial protocol which operates at 31,250 bits per

second. The board built-in serial port can send data at that rate. MIDI protocol explains what a MIDI message should contain and what different messages do. Each MIDI message is divided into two types: (i) the status and (ii) the data. The status byte indicates what type of information is being sent eg. the status byte can tell that there should be a note plying or there should be a pitch bending. The data portion of the message tells what values are associated with the status part.

A MIDI file contains instructions which describe the notes played in a performance and related information viz. notation, pitch, velocity, vibrato, panning, and clock signals. It doesn't contain any sound data.

4. ARDUINO

Arduino is an open-source electronics platform. It is based on easy-to-use hardware and software. Arduino boards are able to read inputs eg. light on a sensor, a finger on a button etc and turn it into an output eg. activating a motor, turning on an LED, and so on. In simple, Arduino connects physical environment into digital.

A variety of sensors can be connected in the Arduino and it can be programmed as per requirement. By connecting sensors in the output of the Arduino, one can control LEDs, motors, lights and so on. So, sensors can be used to outputs or sensors can be used to control something in the computer as digital / audio workstations. Computers can be used to control the outputs of the Arduino, as for instance, using MIDI from the computer to control LED lights or motors etc.

5. MIDI CIRCUIT AND ARDUINO CONNECTION

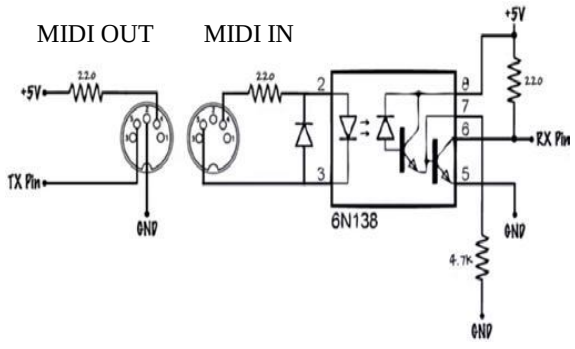

Fig.1. Schematic diagram of MIDI circuit

MIDI devices are connected with 5 pin cable and transmit information like note, pitch, velocity, pitch band and control messages. MIDI bytes vary from 0-5 volts. The majority of the circuit is made up of resistors and diodes and a 6N138 optocoupler.

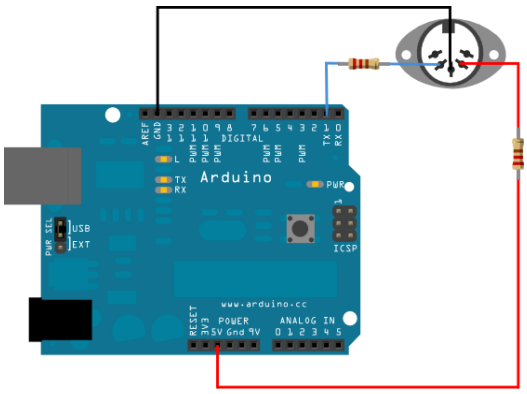

Fig.2.Arduino-MIDI circuit for MIDI output

Pin 5 of MIDI ouput jack is connected to pin 1 of Arduino board through a 220 ohms resistor.
Pin 2 of MIDI output jack is connected to GND pin of the Arduino board.
And Pin 4 of MIDI output jack is connected to +5V pin of the Arduino board through 220 ohms resistor.

6N138 optocoupler: 6N138 optocoupler is an 8 pin microchip that helps to protect the MIDI devices from anything that is plugged in. Optocoupler consists of LED light source and a phototransistor that behaves as a light detector and switch. The diode that is in left indicates the input LED whereas the right one indicates the phototransistor.

Fig.3(a)

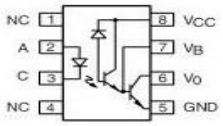

Fig.3(b)

Fig. 3(a) shows a picture of 6N138 optocoupler and fig. 2(b) shows the circuit diagram of the chip.

The whole circuit of MIDI (in fig.1) can be divided into two main parts: MIDI output circuit and MIDI input circuit. MIDI output and input circuit is a simple circuit consisting of MIDI Jack and 220 ohm resistor. The whole device is connected to transmitting instrument and not connected electrically with receiving instrument.

For high signal, Tx pin is high and 5V will appear through Tx pin. The voltage will travel to anode to signal diode and to the cathode of LED. The voltage source of 5V will also send voltage down to the line. Since, there will be no voltage difference across the diodes so both diodes will be OFF and no current will flow through the circuit.

For low MIDI signal, Tx pin will be low i.e 0V will appear (also referred as GND). It results to

voltage difference between anode and cathode for both diodes. The small signal diode has more voltage on its cathode than anode. So, it will not pass any current. On the other hand, current will start flowing through LED as soon as the LED turns ON. For a bad MIDI cable, where the wire is placed reversed, the small signal acts as a protective device.

Optocoupler phototransistors will turn ON when the optocoupler LED light is ON. Once the phototransistor is ON, it will allow current to flow through it and helps to connect the resistor to GND. The receiver pin (Rx pin) will be connected to Rx input of Arduino. When the phototransistor, Rx pin will be at GND and Arduino will set as digital low signal. When the photo transistor is turned OFF, no current will flow through it and +5V power supply will appear at Rx pin that results to digital high signal. So, basically we can conclude that low signal on Tx pin equals to low signal on Rx pin, and high signal at Tx pin equals to high signal at Rx pin.

6. MIDI DEVICES

MIDI devices are classified into two broad types-

1. Controllers
2. Synthesizers

A. MIDI controllers: These devices produce MIDI signals based on human actions. The musicians physically manipulate these devices to generate MIDI software messages. MIDI controllers can take the form of almost any acoustic or electronic instrument such as keyboards, guitars, drum sets, drum pads etc.

Fig.4.Guitar as MIDI controller

Fig.5.Drum set as MIDI controller

Fig.6.Keyboard having 61 keys as MIDI controller

MIDI controller does not synthesize or generate audible music or sounds. They generate MIDI software messages that are routed through one or more MIDI ports.

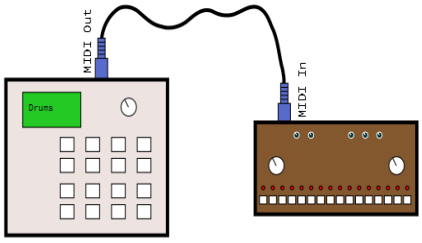

Fig.7. A MIDI controller connected with a MIDI synthesizer

MIDI controllers and synthesizers can be commonly integrated with each other, making it a single unit. The cost of such integrated product is less than of the combined cost of each device. The most typical integrated product is the MIDI keyboard controller and synthesizer packaged into a single unit.

Fig.8.An integrated MIDI controller and synthesizer

B. MIDI synthesizers: These devices produce musical tones and percussion based on the input of MIDI software messages. The MIDI synthesizer generates music based on MIDI software messages but it doesn't need to be integrated with a controller eg. Rack-mounted MIDI synthesizers, MIDI-enabled computer sound cards, drum machine etc.

Fig.9.A rack-mounted MIDI synthesizer

Fig.10.MIDI Drum machine

A synthesizer and computer can be connected for making communication using the MIDI protocol, and start recording. MIDI synthesizers include samplers and sequencers.
The MIDI sequencer is an electronic device incorporating both MIDI software and hardware, which is used for storing and replaying MIDI software message sequences. It records MIDI software message sequences, replays the sequences using the appropriate timing, provides some sort of editing capabilities.

7. WHY MIDI?

MIDI is an old protocol. It is widely used in this present time, though it has been more than three decades of its standardization. Advantages of using MIDI are in comparison to none.

- o The MIDI audio files are relatively smaller or compact size than that of digital audio files.
- o MIDI format files are easily editable. The removal or addition of any specific instrument from a song can be done just by selecting it. Also, various effects can be applied to individual instruments.
- o High quality output. i.e better than digital audio files.

MIDI is vastly used in computer programming. There are different types of software which use MIDI specifications viz. Sequencers, Digital Audio with MIDI sequencers, Music Notations, MIDI in Multimedia Applications, Music Notation, Object-Oriented Programming and so on.

8. BUILDING A SIMPLE MIDI CONTROLLER USING ARDUINO

The proposed device is a simple custom MIDI controller which can control various effects, clippings etc in a DAW (*Digital Audio Workstation*). The components required for building the controller are-

The hardware components used-

1) Arduino Uno
2) Jumper wires
3) Push Buttons
4) 10K Potentiometer

The software components used-

1) Arduino IDE
2) Hairless-MIDIserial
3) DAW or Digital Audio Workstation software (Here, *Ableton Live* is used)

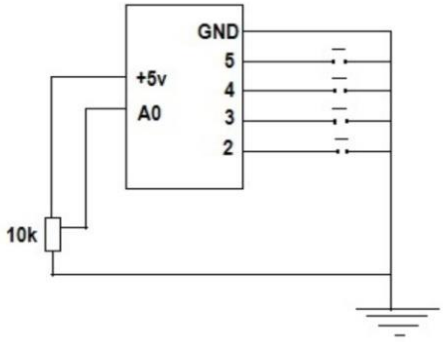

Fig.11.Circuit diagram of the controller

Four push buttons and a potentiometer are connected with the pins of Arduino Uno as shown in fig.11.

After the connections is done, the code is uploaded into the Arduino Uno board.

There are two ways to communicate via MIDI, either by using physical MIDI port or using the USB. Here communication is done through USB.

The Ardunio uses serial protocol which is not compatible for MIDI. A software named *"Hairless-MIDIserial"* is used to convert serial protocol into the MIDI protocol. Debug MIDI messages and then the notes come from the controller when any button is pushed.

Next, the MIDI has to be configured in the operating system and create a virtual MIDI port.

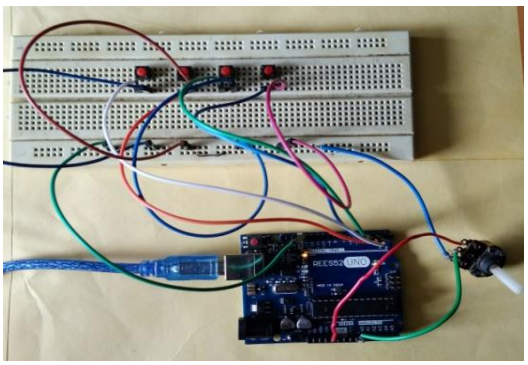

Fig.12.Hardware setup

Thus, the serial data coming from the Arduino through the USB are converted to MIDI on *Hairless-MIDIserial* and it is sent to the virtual MIDI port.

After this, the controller is ready to use with a DAW (*Digital Audio Workstation*). The potentiometer is used to control the effects and clipping when the music is being played.

Hence, the built controller is a simple example of how MIDI devices viz. controllers, synthesizers etc. can be build with Arduino at a low budget. So, depending on the requirements, various such custom devices can be build in a simple way.

9. SUMMARY

Thus, the paper presents a study on MIDI, various MIDI devices and a custom MIDI controller, built using Arduino. This may be helpful for artists, designers, musicians, hobbyists and anyone for understanding MIDI, the various MIDI devices and the use of Arduino in building custom devices or controller at cheaper price than those available in the stores.

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