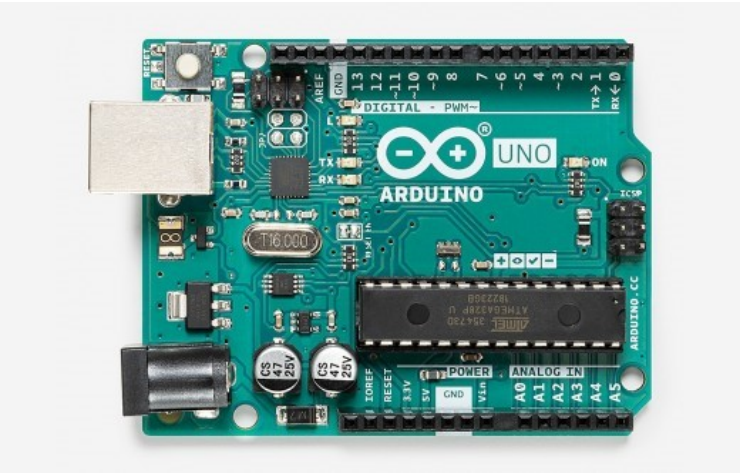
Tones, Notes and MIDI Out (WS001)

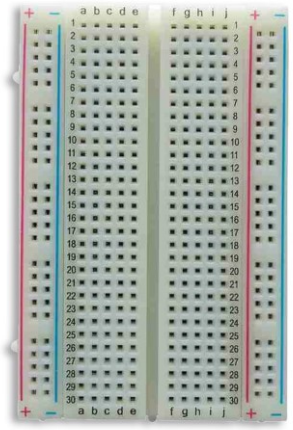
In this set of projects you will be creating variable tones, a simple "keyboard" and simple MIDI controllers. For the more adventurous among you, you could go on to create a simple two-note MIDI "pianola" using light sensors or a piezo-sensor MIDI "drum controller". You will need to refer to the online pages to complete most of these projects.

Kevin



Parts List – WS001

- Arduino Uno (USB lead and power)
- Solderless Breadboard(s)
- Jumper Wires
- 1x 180Ω resistor (brown-grey-brown)
- 8x 220Ω resistors (red-red-brown)
- 8x 10kΩ resistors (brown-black-orange)
- 5x 1MΩ resistors (brown-black-green)
- 2x 10k potentiometers
- 2x 10k "trim" style potentiometers
- 5x 1N4733A Zener diodes (5.1V)
- 2x light dependent resistors (LDRs)
- 1x white LED; 2x red LEDs
- 5x piezo disk sensors
- 5-pin DIN plug or socket
- 8x momentary SPST 6mm miniature push buttons pcb mounting
- 8Ω Loudspeaker or old headphone speaker



All projects in this worksheet can be made using the above parts, but the quantities listed assume that parts will be re-used between projects.

Introduction to Arduino

You'll need a computer running the Arduino software. Details of how to get up and running can be found here:

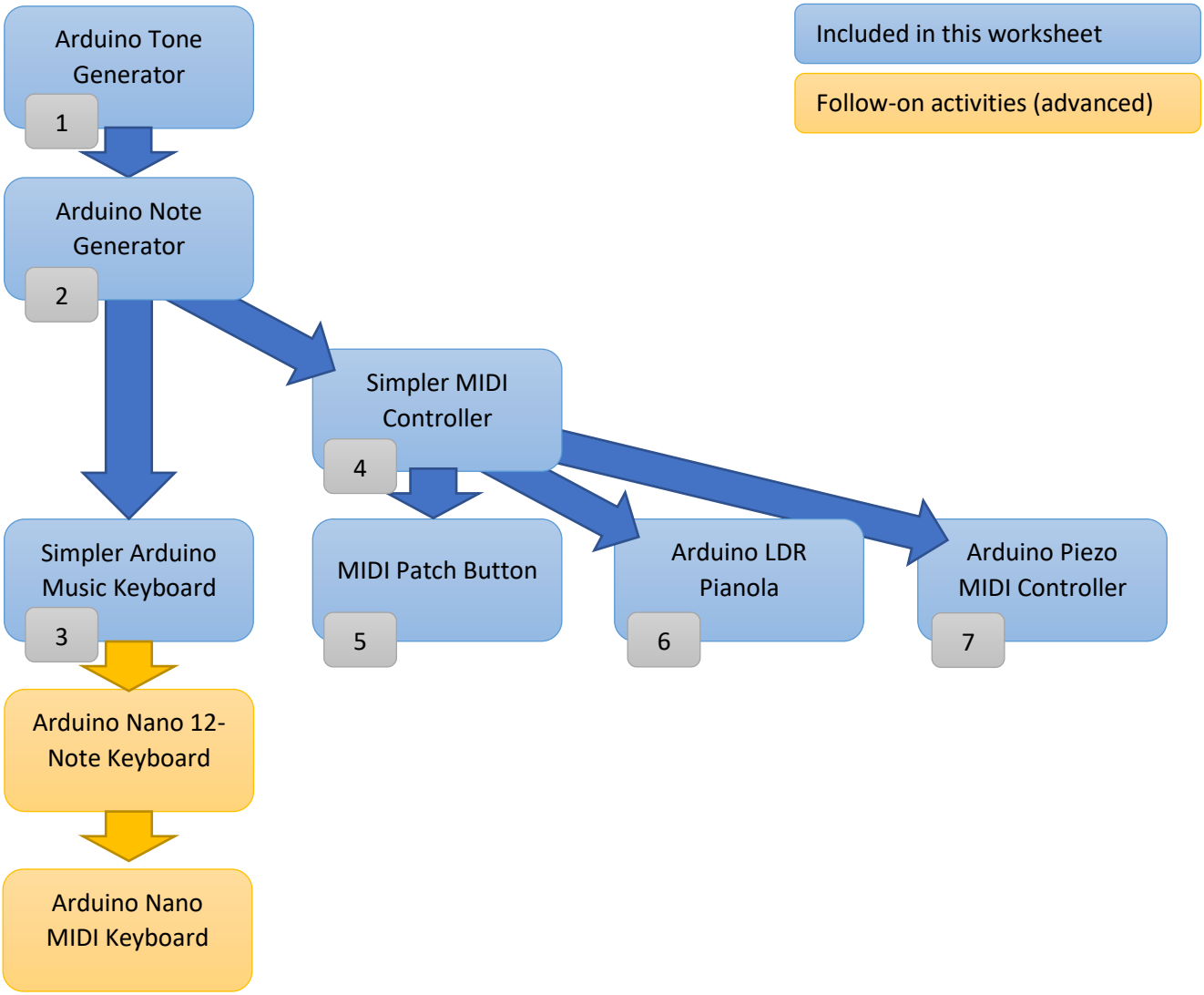
> Lady Ada's Learn Arduino - https://learn.adafruit.com/ladyadas-learn-arduino-lesson-number-0
> The official Arduino Getting Started pages - https://www.arduino.cc/en/Guide/HomePage

Caution!

1. NEVER let your home-made electronics anywhere near live mains.
2. I strongly recommend powering your Arduino using a separate power supply – NOT your computer or any expensive music equipment with a USB port.
3. Always double check your wiring. Ideally test for any short circuits, especially between 5V and GND, with a multi-meter.
4. I strongly recommend getting hold of a second hand, cheap (ideally "sacrificial") MIDI keyboard for your experiments.

WARNING: You undertake these projects at your own risk – I will not be held responsible for damage to expensive electronic, computer, music, or any other, equipment as a result of these experiments. Re-read point 4 above…

Suggested Project Sequence



The full technical details supporting all of these projects can be found on:

https://diyelectromusic.wordpress.com/

All the source code is available to download from GitHub on:

https://github.com/diyelectromusic/sdemp

There are many more projects to try on the above links too.

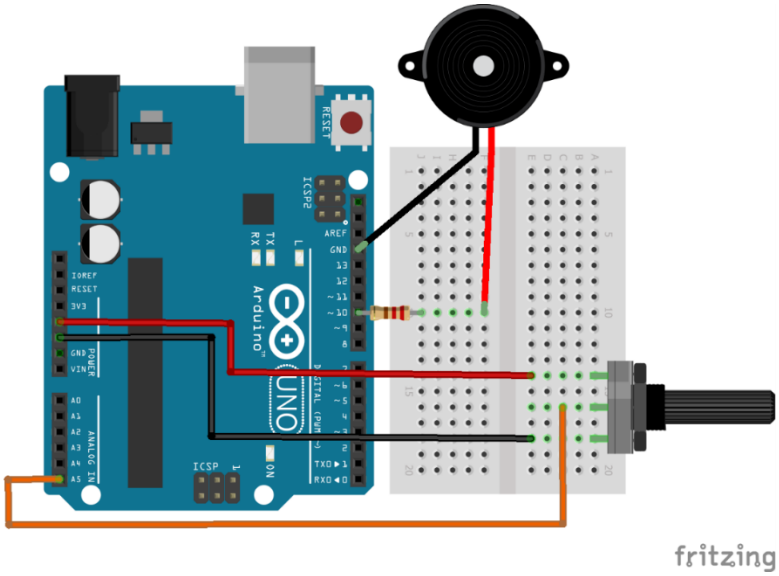
Arduino Tone Generator (Project 1)

Full details: https://diyelectromusic.wordpress.com/2020/06/01/arduino-tone-generator/
Code: https://github.com/diyelectromusic/sdemp/tree/master/src/SDEMP/ArduinoToneGenerator

Parts List

- Arduino Uno
- 8Ω loudspeaker or old headphone speaker
- 1x 220Ω resistor (red-red-brown)
- 1x 10kΩ potentiometer
- Breadboard and jumper wires

The Circuit



Basic Principles

This circuit uses a potentiometer connected to one of the Arduino analogue input pins to create a voltage between 0 and 5V depending on its position. This is used to select a frequency to feed into the Arduino tone() function. The tone() function generates a tone by alternating the output voltage between high (5V) and low (0V) at the required frequency on an Arduino digital output pin.

The output pin is connected to the loudspeaker via a resistor enabling you to hear the results without any further equipment required. The resistor limits the current flowing both through the loudspeaker and from the Arduino's output pin which have to be limited to no more than 40mA at its peak, and ideally around 20mA typical usage.

Further Reading

- Arduino Potentiometer – https://www.arduino.cc/en/Tutorial/Potentiometer
- Arduino Tone Pitch Follower - https://www.arduino.cc/en/Tutorial/TonePitchFollower

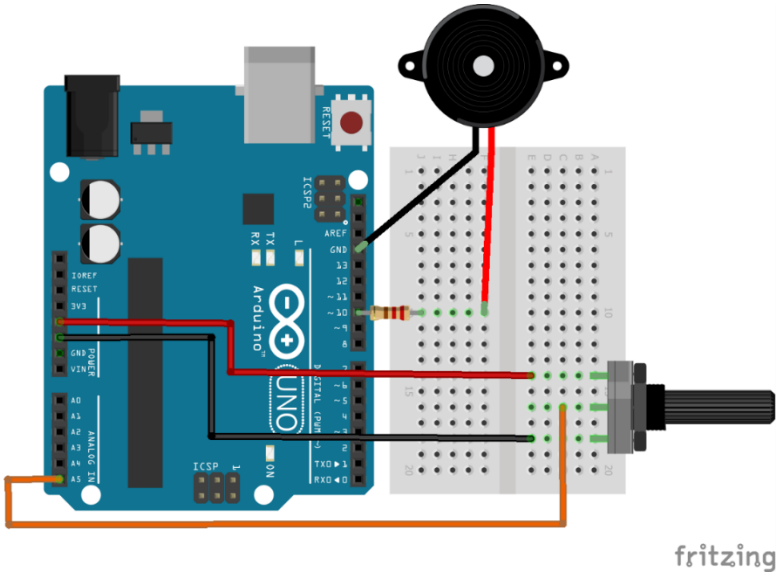
Arduino Note Generator (Project 2)

Full details: https://diyelectromusic.wordpress.com/2020/06/01/arduino-note-generator/
Code: https://github.com/diyelectromusic/sdemp/tree/master/src/SDEMP/ArduinoNoteGenerator

Parts List

- Arduino Uno
- 8Ω loudspeaker or old headphone speaker
- 1x 220Ω resistor (red-red-brown)
- 1x 10kΩ potentiometer
- Breadboard and jumper wires

The Circuit



Basic Principles

Like the previous project this circuit uses a potentiometer to provide a reading on one of the Arduino's analogue input pins. But in this case the reading is used to choose between a set of discrete notes to play rather than a continuous tone.

The frequencies are taken from the Arduino Tone Medley tutorial and correspond to the traditional notes of the musical scale. So for example "concert A" ("A4") is 440Hz. You might notice that when the frequency doubles, it plays a note an octave higher and when halves, an octave lower. So "A3" is 220Hz and "A5" is 880Hz. However working out the frequencies for all notes in between is a little more complicated as it involves finding a mathematically consistent frequency for each note (not to mention the "twelfth root of 2" – look up the "equal temperament" tuning for the gory details!) Thankfully the values in Tone Medley have already been worked out for us.

Future Reading

- Arduino Potentiometer - https://www.arduino.cc/en/Tutorial/Potentiometer
- Arduino Tone Medley - https://www.arduino.cc/en/Tutorial/ToneMelody

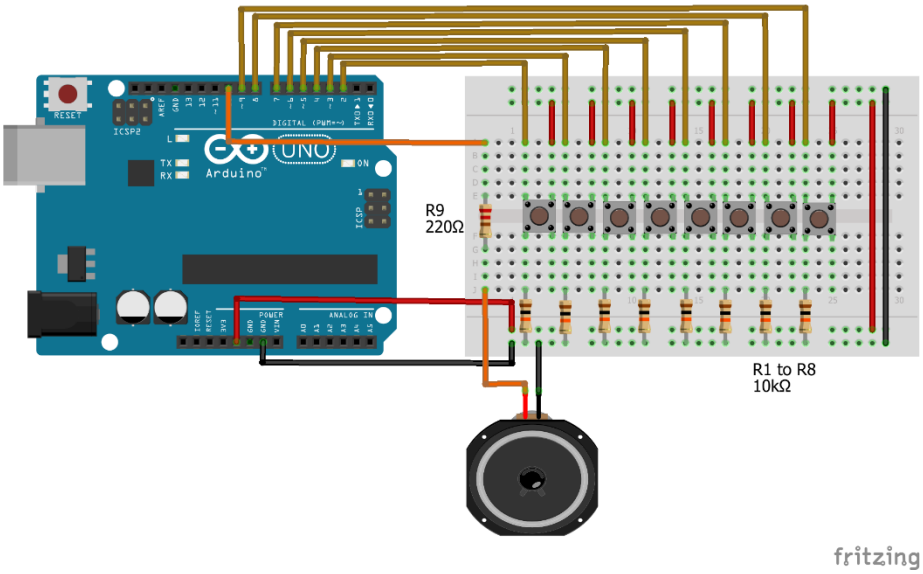
Simple Arduino Music Keyboard (Project 3)

Full details: https://diyelectromusic.wordpress.com/2020/06/01/simple-arduino-music-keyboard/
Code: https://github.com/diyelectromusic/sdemp/tree/master/src/SDEMP/ArduinoMusicKeyboard

Parts List

- Arduino Uno
- 8Ω loudspeaker or old headphone speaker
- 1x 220Ω resistor (red-red-brown)
- 8x 10kΩ resistors (brown-black-orange)
- 8x momentary SPST 6mm miniature push buttons pcb mounting
- Breadboard and jumper wires

The Circuit



Basic Principles

The Arduino will generate a different tone() depending on which button is being pressed. Each button is connected up to the Arduino's digital input pins which will detect a LOW (0V) signal if the button isn't pressed and a HIGH (5V) signal if it is pressed. The resistors ensure that when the button isn't pressed there is a clear LOW signal on the input pin. This is called "pulled low". Pressing the button connects the pin to the 5V voltage line making it temporarily HIGH.

The tone() is provided via a digital output pin which is connected via a resistor to the speaker as in the previous projects.

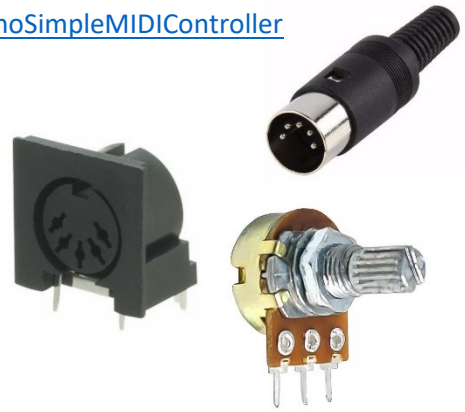
Future Reading

- Arduino Button - https://www.arduino.cc/en/Tutorial/Button
- Arduino Tone Medley - https://www.arduino.cc/en/Tutorial/ToneMelody

Simple MIDI Controller (Project 4)

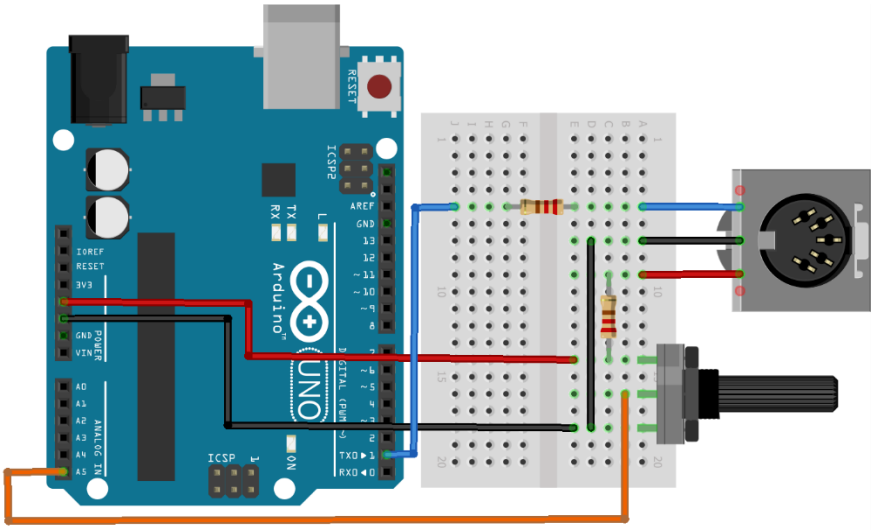
Full details: https://diyelectromusic.wordpress.com/2020/06/04/arduino-simple-midi-controller/
Code: https://github.com/diyelectromusic/sdemp/tree/master/src/SDEMP/ArduinoSimpleMIDIController

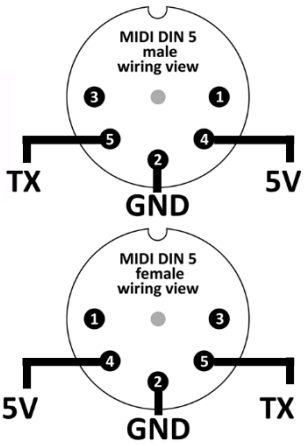
Parts List



- Arduino Uno
- 2x 220Ω resistors (red-red-brown)
- 1x 10kΩ potentiometer
- 5-pin DIN plug or socket
- Breadboard and jumper wires

The Circuit





Basic Principles

A simple MIDI "out" circuit can be made from two resistors and a MIDI socket or plug and connected to the Arduino's built-in serial port transmit pin, marked as "TX". Rather than using a MIDI socket on a breadboard it is possible to solder the two resistors directly within a MIDI plug making for a simple self-contained "MIDI out" unit that can be used with other projects too. Some circuits you'll find on the Internet only have one resistor on the 5V connection. Pin 4 of the MIDI plug/socket needs to be connected to 5V and pin 5 to the TX pin.

The MIDI out from this circuit will need to be connected to the MIDI in of your music equipment. Recall the warning about connecting your circuits to expensive equipment at your own risk.

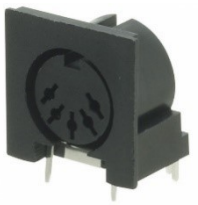
MIDI has the concept of "controllers" which can set things like volume, level of modulation (vibrato), pitch modulation and so on. The potentiometer is connected to an Arduino analogue input pin as before and is used to determine the value to send over MIDI for the controller. The sample code turns the Arduino into a Modulation Wheel as found on many digital synthesizers.

Future Reading

- Arduino Potentiometer – https://www.arduino.cc/en/Tutorial/Potentiometer
- Arduino MIDI Library - https://github.com/FortySevenEffects/arduino_midi_library

MIDI Patch Button (Project 5)

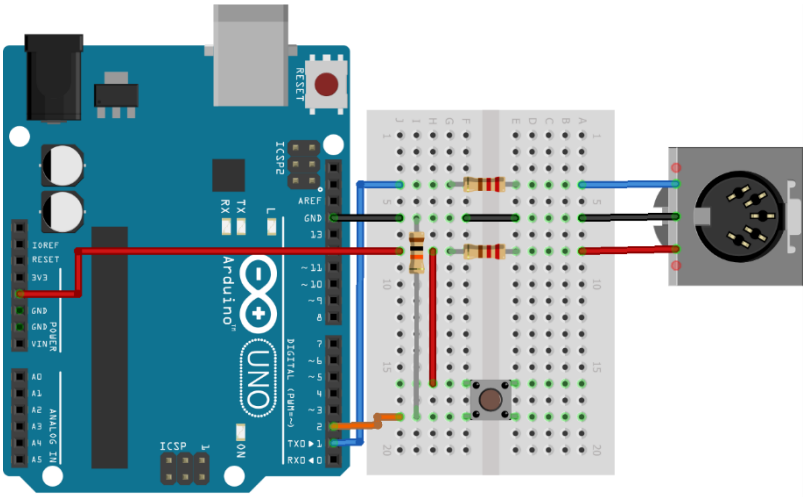
Full details: https://diyelectromusic.wordpress.com/2020/06/05/midi-patch-button/
Code: https://github.com/diyelectromusic/sdemp/tree/master/src/SDEMP/ArduinoPatchButton

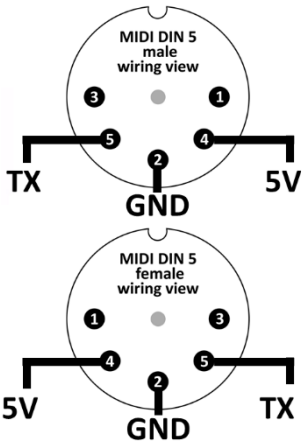


Parts List

- Arduino Uno
- 2x 220Ω resistors (red-red-brown)
- 1x 10kΩ resistor (brown-black-orange)
- 1x momentary SPST 6mm miniature push buttons pcb mounting
- 5-pin DIN plug or socket
- Breadboard and jumper wires

The Circuit





Basic Principles

Once again, this circuit and code creates MIDI messages in response to an input device managed by the Arduino. In this the input is a button and the MIDI message is a "patch change" message. In the code you can pre-set the patch number to send to your instrument, making this a patch change shortcut button.

Some instruments won't respond to a patch change message for the built-in keyboard, but only for the MIDI controlled voices, so it isn't universal. Also, some instruments have several banks of patches so the code would need to be modified to send a "bank change" as well as a "patch change" message.

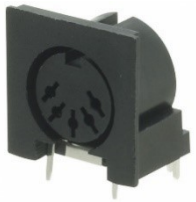
As usual, the warning about connecting home made circuits to expensive instruments applies.

Future Reading

- Arduino Button - https://www.arduino.cc/en/Tutorial/Button
- Arduino MIDI Library - https://github.com/FortySevenEffects/arduino_midi_library

Arduino LDR Pianola (Project 6)

Full details: https://diyelectromusic.wordpress.com/2020/06/06/arduino-ldr-pianola/
Code: https://github.com/diyelectromusic/sdemp/tree/master/src/SDEMP/ArduinoLDRPianola

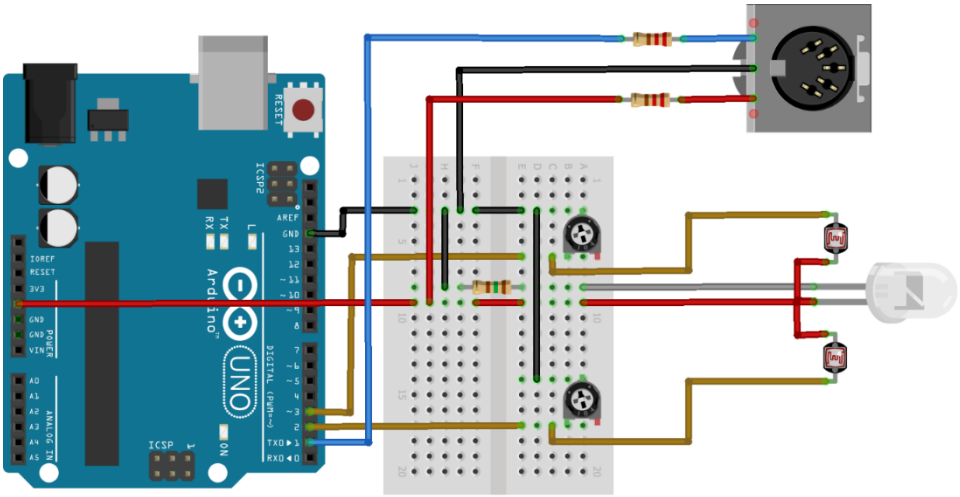






Parts List

- Arduino Uno
- 1x 180Ω resistor (brown-grey-brown)
- 4x 220Ω resistors (red-red-brown)
- 2x 10k "trim" style potentiometers
- 2x light dependent resistors (LDRs)
- 1x white LED; 2x red LEDs
- 5-pin DIN plug or socket
- Breadboard and jumper wires

The Circuit



fritzing (Fritzing)

Basic Principles

The MIDI side of the circuit is as per previous projects, but this time it is creating a message to play a note. Which note is played, and when to play it, is determined by detecting the signal from a light dependent resistor (LDR). In this way if a piece of paper is passed under the LDR any black coloured in sections will turn the note on and any blank, white sections will turn it off. These principles can be used to construct a simple pianola type device which in this case can play up to two notes.

There is quite a bit more to this project to construct suitable housing for the LDRs and to design a "transport" section for a strip of paper. I used Lego for mine. See the full description for some examples.

This is also quite fiddly to get working as the sensitivity of the LDRs needs to be adjusted using the "trim" potentiometers. The setting will depend on a range of factors – ambient light, design of our housing, density of "black" on the paper and so on. Again notes on performing the calibration, and adding two optional (in this case red) LEDs to help, can be found in the full description.

Future Reading

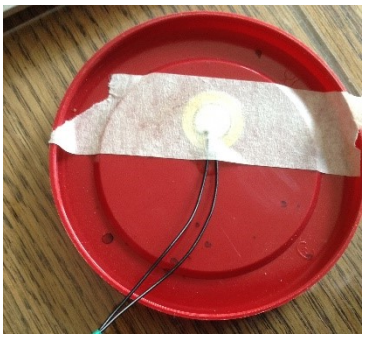
- Arduino LDR Input - https://www.tweaking4all.com/hardware/arduino/arduino-light-sensitive-resistor/
- Arduino MIDI Library - https://github.com/FortySevenEffects/arduino_midi_library

Arduino Piezo MIDI Controller (Project 7)

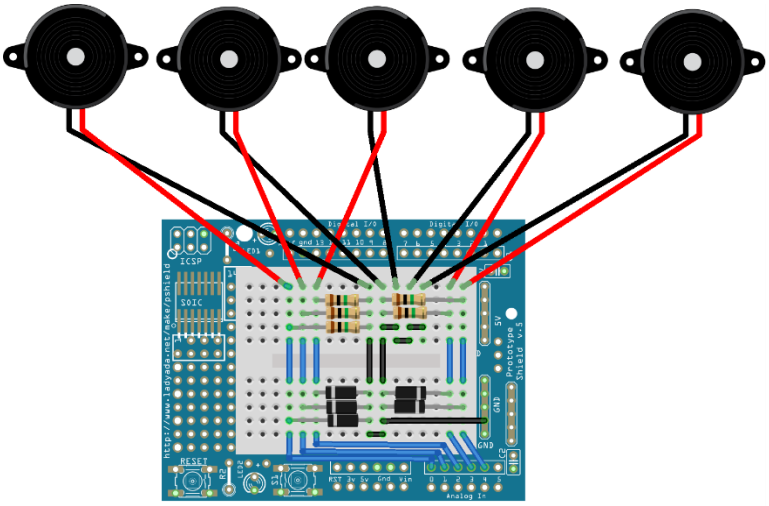
Full details: https://diyelectromusic.wordpress.com/2020/07/19/arduino-piezo-midi-controller/
Code: https://github.com/diyelectromusic/sdemp/tree/master/src/SDEMP/ArduinoPiezoMIDIController

Parts List

- Arduino Uno
- 5x 1MΩ resistors (brown-black-green)
- 5x 1N4733A Zener diodes (5.1V)
- 5x piezo disk sensors and "drum pads" (plastic lids)
- 5-pin DIN plug or socket
- Breadboard and jumper wires



The Circuit



Basic Principles

This project is a little more complex and will require a proper reading of the full description. The basic idea is that the Arduino is watching five piezo sensors. These sensors will generate a voltage if tapped or hit so they make a great basis for an electronic drumkit. In fact these are exactly the type of sensors you'll find in the types of drumkits available for playing games. Depending on which sensor is hit the Arduino will send out a MIDI note message on channel 10, which for any typical "general MIDI" setup is the percussion channel.

The diagram above made this on a "proto shield" – an Arduino shield designed to take a breadboard and let you easily connect it to the Arduino's pins without extra wires. It can be made just as easily using a normal breadboard too.

The MIDI "out" circuitry isn't shown, but it can use the same "two resistors in a DIN plug" MIDI out circuitry we've used several times already.

Use is fiddly again, with a calibration stage required to get the sensitivity of the sensors right. And once again that sensitivity is dependant on the physical design of your sensors. For a really good example of a quality set of home-made drum sensors, I recommend "Marco's DIY kit mentioned below.

Future Reading

- Arduino Knock - https://www.arduino.cc/en/Tutorial/Knock
- Marco's DIY Kit – https://arduinoplusplus.wordpress.com/2020/05/06/diy-midi-percussion-kit-part-1/

The Back Page

If you've found this useful there are plenty more projects to take a look at on my site:

https://diyelectromusic.wordpress.com/

Any feedback, thoughts, comments or ideas are welcome.

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If you like what you see, then please considering buying me a Ko-fi:

https://ko-fi.com/diyelectromusic

Everything you see has been built on the "shoulders" of those who share their tools, techniques, know-how, code and expertise openly via the Internet.

In particular, this wouldn't be possible without the Arduino ecosystem. You can support this ecosystem directly with financial support here:

https://www.arduino.cc/en/Main/Contribute

ARDUINO
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Official distributors for Arduino boards and kits in the UK include, among others:

https://shop.pimoroni.com/

https://thepihut.com/

https://hobbytronics.co.uk/

Thanks for playing along.

Kevin