MACCHIATO
S.T.E.M. Pack
MINI DIGITAL SYNTHESIZER

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INTRODUCTION

The Macchiato Mini-Synth is an 8-bit digital synthesizer that can be built from scratch in just a few hours. Students will take home a real musical instrument that they made themselves. Each STEM pack consists of 6 Macchiato Mini-Synth kits, one “Soldering Is Easy” booklet, and this guide. The synth kit includes a template for making a cabinet from a cereal box. You may also have chosen to purchase some accessories: a pack of colored cardstock for your cabinets; plastic cabinet kits; or 9V DC power supplies.

The detailed assembly instruction manual is on our web site. Print it, view it on a laptop or tablet, or cast it to your fancy digital chalkboard. The website also contains the Quick-Start Guide and Reference Manual (a much-expanded version of this document), plus videos and links to other teaching resources.

DESCRIPTION

The Macchiato Mini-Synth is a versatile 8-bit digital synthesizer. It can create a vast array of unique and complex sounds, yet it is easy enough to use that you can start making music instantly! It has a built-in 13-note capacitive touch keyboard with 2-note polyphony – it can sound up to two notes simultaneously. The nine control knobs (pictured below) give you tremendous creative flexibility. These knobs and their functions are described in detail below. In brief, you can choose from four different basic sounds; shift through four octaves; adjust how fast the note fades in and out (attack & release); and then shape your sound with a Low Frequency Oscillator (LFO). You can choose from four LFO shapes, and adjust its rate, cutoff frequency, and depth. The volume knob controls the on-board speaker and the volume of the line-out jack. You can plug the Macchiato into speakers, headphones, or into your computer for recording. There is even a MIDI IN jack, so you can control the Macchiato from another keyboard.

![Macchiato Mini-Synth](image)
HOW IT WORKS

The music begins with the capacitive touch keyboard, built right in to the printed circuit board (PCB). The synth recognizes your fingers as one side of a capacitor: it can tell when you touch one of the keys. Each key is connected directly to a pin on the little chip that makes the Macchiato work. This chip is called a microcontroller. A microcontroller is like a tiny computer that can be programmed to do just about anything: run the air conditioner, swindle banks, rule the world.

We wrote the Macchiato software using the Arduino Integrated Development Environment (IDE). Arduino is an open-source platform that uses easy programming language to run the microcontroller. Although quite versatile, microcontrollers are not very good at handling audio. Typically, Arduino programs are only capable of making simple beeps like you hear from your microwave oven; but recently, Tim Barass, through very clever programming, developed an open-source software add-on he calls “Mozzi” that expands Arduino’s music-making capabilities. Using wave-table and pulse-width modulation (PWM) technologies, Mozzi gives Arduino the ability to create all kinds of unique and interesting sounds.

The Macchiato software reads the voltage coming from all the potentiometers (knobs); checks which keys are pressed; checks if a MIDI message has arrived lately; checks what time it is; and then constructs the waveform and outputs it to the speaker or headphones. It performs some of these tasks 64 times a second; others at 41,000 times a second!

You can download the Macchiato source code from www.Github.com/zeppelindesignlabs, study and change it. Feel free to edit and tweak the code any way you like, and then re-program your synth using the ISP header on the PCB. The Macchiato is the perfect platform for exploring the sounds that Mozzi offers. You will find detailed instructions for doing this in the Github Macchiato repository mentioned above.
QUICK START GUIDE


1. POWER UP Use a 9V DC power supply or a battery.
   - 9V DC power supply (“wall wart”, strongly recommended): Must be rated for 200mA minimum, with center-negative polarity. Look for this graphic on the power supply. Your synth won’t work with a center-positive power supply. Simply plug the cable into the back of your synth under the “9V” label.
   - 9V battery: Use a high-quality alkaline battery, like Energizer. (Don’t waste your money on cheap batteries!) Open your cabinet; insert the battery into its holder; snap the contacts into place; and then push down to snap the battery into the holder.

2. PLUG IN A LISTENING DEVICE Plug in headphones or powered desktop speakers into the AUDIO OUT jack on the back of the synth; or run a cable to the LINE IN on your computer, or the AUX IN on your stereo. In a pinch, you can monitor the synth with the little on-board speaker, but this will gobble up batteries a lot faster and will not sound as good.

3. TURN ALL THE KNOBS TO THE LEFT except OCTAVE and CUTOFF. Turn these all the way to the right.

4. TURN IT ON Press the red power button on the back of the synth. If you built a cardboard case, be careful how you squeeze your synth; you don’t want to crush the cabinet.

5. TURN IT UP Tap some keys while you slowly turn up the VOLUME Knob #9 at the far right. CAUTION: ALWAYS TURN THE VOLUME DOWN BEFORE YOU PLUG IN HEADPHONES! The signal may be louder than you expect and could hurt your ears or damage your headphones.

6. SHAPE YOUR SOUND The first four controls on the left affect the basic sound of the synth:
   - WAVE SHAPE Turn to choose between Sine, Triangle, Saw and Square.
   - OCTAVE Turn to move up through four octaves, from high (4) to low (1) and back.
   - ATTACK Turn slowly while tapping the keys to increase the time it takes for a note to fade in.
   - RELEASE Turn slowly while tapping the keys to increase the time it takes for a note to fade out.

7. SHAPE YOUR FILTER The next four controls affect the LOW FREQUENCY OSCILLATOR (LFO), which affects the LOW PASS FILTER (LPF), which in turn applies all sorts of effects to your note.
   - Turn CUTOFF left and right while playing. It acts like a tone control. Full left cuts off more of the high frequencies for a soft, warm, muffled sound. Full right gives a bright, crisp sound. This effect is most noticeable when playing a Square Wave, and least noticeable with a Sine wave.
   - Turn RATE and DEPTH up halfway. Your synth now has a distinct “wawawawawah” sound.
   - Slowly turn RATE back and forth to control the rate at which the LFO oscillates. At full left, the speed is zero, and the LFO effect freezes.
   - Turn DEPTH right to increase the effect of the LFO, and left to decrease it down to no effect at all.
   - LFO SHAPE Turn to choose between Sine, Saw, Ramp (which is a backwards Saw) and Square. Note the distinct effect each shape produces.