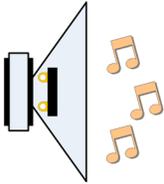# How-To #5: Make Arduino™ Tones Louder

The Arduino™ can generate what can be called a passable tone using the function `tone()`. This How-To shows how a few inexpensive parts can be used to make these tones dramatically louder than those heard when a speaker is connected directly to an Arduino™ output pin.

Background:

The Arduino™ can make sounds, but they aren/t loud.

Many Arduino™ tutorials, including those on our home site LearnCSE.com, have a lesson that uses the Arduino™ function `tone()` to generate a sound. Typically a speaker is connected to an Arduino™ pin, either by a coupling capacitor or a resistor.

While this connection works well for teaching the use of the function, it has the disadvantage of producing a low-volume tone. Many of us, particularly when we want to add sound effects to something we've made that is powered by an Arduino,™ want a much louder sound.

A linear audio amplifier can make them louder, but at the expense of several parts.

An audio amplifier, such as the ubiquitous LM386, can be added but at the cost of the integrated circuit and all its supporting components, including up to four capacitors, a resistor, and some sort of potentiometer if volume control is desired.

Arduino™ tones are square waves, providing a simple alternative.

But an Arduino™ tone is a square wave with a 50% duty cycle repeated at the desired frequency. It's not very musical, but it is simple. It doesn't need to be "amplified." To sound louder all that's needed is a way to increase current through the speaker. And this can be done by reducing the overall resistance of the speaker circuit.
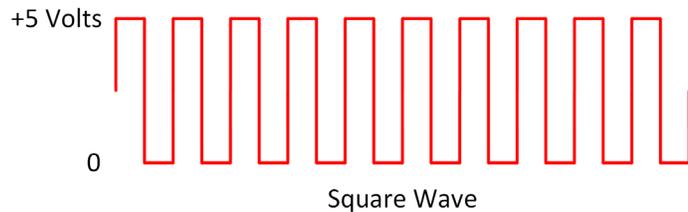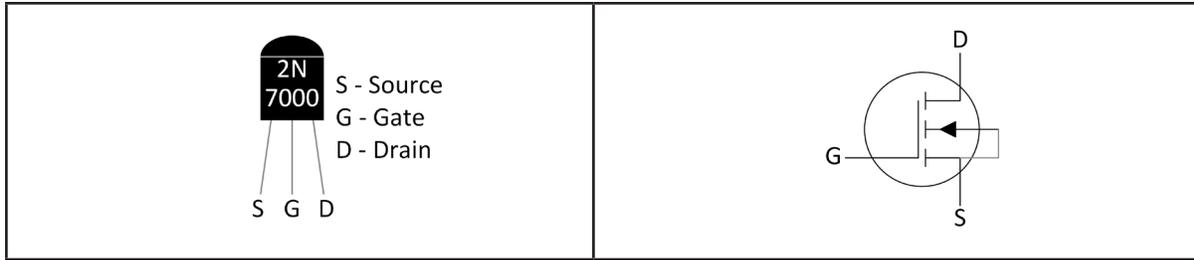

Figure HT5-1. Square wave

Figure HT5-2. Pictorial for FET

Figure HT5-3. Schematic for FET

To do this all we need is to connect the speaker directly to a source of electrical current, then switch this current on and off as the square wave goes to +5 volts and zero. The device that can do this is a *Field Effect Transistor (FET)*. There are many types of FETs; we will use a 2N7000, which is an *N-channel, Metal Oxide Semiconductor, Field Effect Transistor (MOSFET)*. As Figure HT5-2 shows, this device has three pins labeled Source (S), Gate (G), and Drain (D). The schematic symbol for this FET is shown in Figure HT5-3.

The feature of the FET that will be taken advantage of is that when the gate is positive relative to the source the resistance between the drain and source drops to nearly zero. This is the "switch." As the schematic Figure HT5-4 shows, the drain is connected to the Vin of the Arduino™ via the speaker. The source is connected to ground. And, finally, the gate, as the switch, is connected to the pin of the Arduino™ that is generating the square wave.
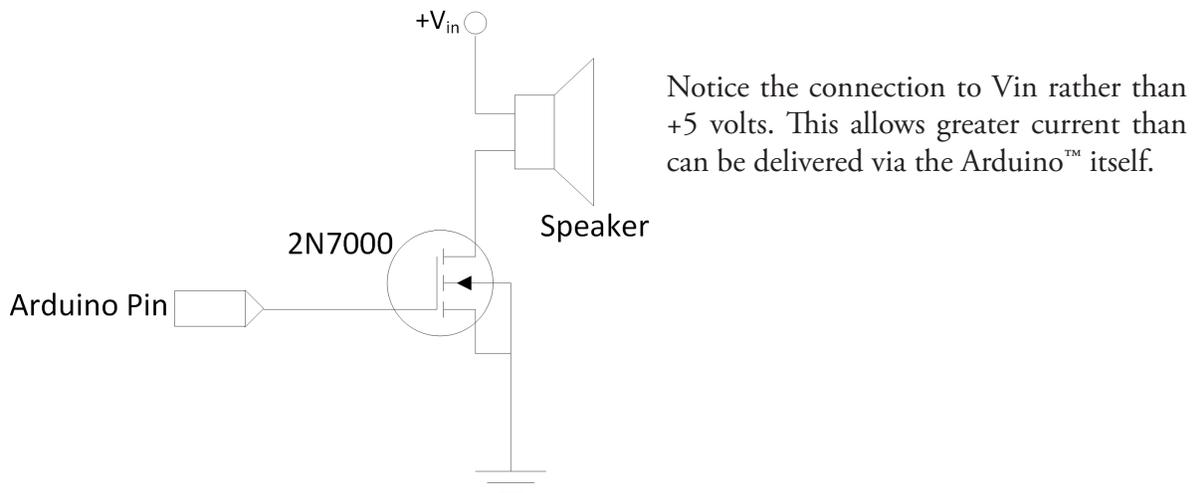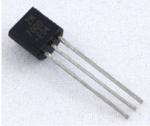

Notice the connection to Vin rather than +5 volts. This allows greater current than can be delivered via the Arduino™ itself.

Figure HT5-4. Schematic for using FET to amplify square wave generated by Arduino™

Procedure:

These instructions show how to prototype a MOSFET switch to drive audio-frequency square waves through a speaker. The resulting sound should be significantly louder than those heard when a speaker is connected directly to an Arduino™ pin.

Among the advantages of this approach is that just a few new, inexpensive parts are needed.

Materials:

Quan-tity	Part	Image	Notes	Catalog Number
1	Arduino™ Uno		Single-board computer.	3102
1	USB Cable		This is a standard USB adapter cable with a flat connector on one end and a square connector on the other.	2301
1	Computer with at least one USB port and access to the Arduino™ website, http://www.arduino.cc.	---	The operating system of this computer must be Windows, Macintosh OS/X, or Linux.	---
1	Field effect transistor (FET) 2N7000		N-channel, MOSFET.	1305
1	Magnetic speaker		4, 8, or 16 ohm.	3119

Steps

1. Assemble the parts shown in the Materials list.

2. Wire the parts as shown in the Figure HT5-5.

Figure HT5-5. Pictorial diagram for connecting Arduino™ to speaker

3. Connect the Arduino™ to the programming computer via a USB cable.

4. Enter then upload the test sketch from Lesson 10, `Lesson10SimpleTones.ino`.

The louder sounds should now be obvious.