

# Sync Digital Sound to Your 16mm Film Projector

by **zlp** on February 21, 2007

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## Intro: Sync Digital Sound to Your 16mm Film Projector

In this instructable I'll show you how to modify an Elmo 16-CL projector to output sync pulses. Those pulses are monitored by free software I made ("Film-O-Sync") which plays back a soundfile in sync with the projector.

Traditionally, 16mm filmmakers have to choose...

**Finish on film and make \$\$\$ prints with lo-fi sound...**

or...

**Finish on video and get lo-fi picture with great sound.**

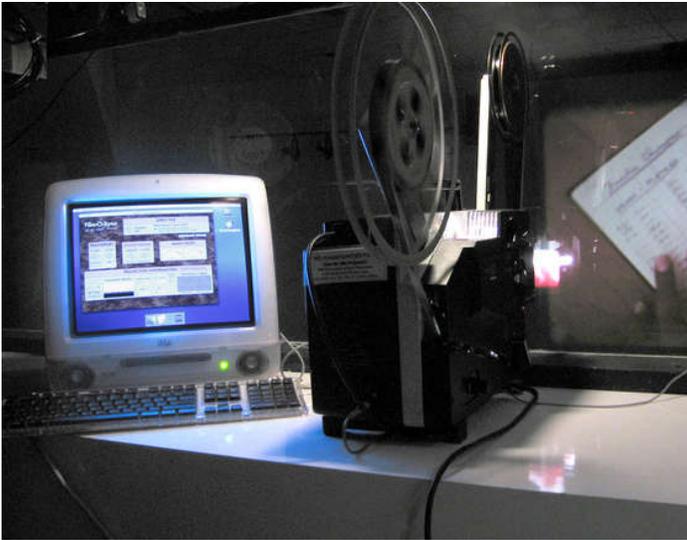
This technique provides the benefits of good sound *and* good picture and it can be done with generally cheap materials and very little reliance on expensive lab services.

**Keep in mind that this technique requires a certain workflow before you get to the projection stage.**

- 1.) Shoot on film.
- 2.) Edit on film and add an Academy Leader or other visual countdown.
- 3.) Transfer your film to video using a method that guarantees a constant speed of 24fps or 23.98fps. (That means a "sync" projector, a professional telecine, or perhaps a video recording of a well-maintained Steenbeck editor.)
- 4.) Edit your sound on a computer, using your video copy as a reference.
- 5.) Add beeps to your audio track, synced with reference frames on your leader.
- 6.) Export your sound as a single AIFF or WAVE file, with the sync beep as the first sound in the file.

I came up with this for students at Cooper Union Art School, where I work, so it's not a refined solution but it gets the job done and costs basically nothing. Most projectors have a similar mechanism, and you can probably come up with a design for the pulse-generator that fits whatever machine you have.

I wrote the software in MAX/MSP and tested it as a self-contained Mac OS X application. Windows is a possibility too, but I haven't tried it. Complete software info can be found in the download link provided in the last step. (including the source "MAX patch" which you are free to mangle, improve, etc.)



## step 1: Get Prepared

*This whole thing is an improvisation, but here are the basic things you will need...*

### Materials:

A **projector** (In my case an Elmo 16-CL)

A **computer** (in my case an iMac 400mHz. Anything slower will probably cause problems.)

My **Film-O-Sync** software (*link coming soon!*)

A **plastic pen or small dowel** (somewhere around 1cm diameter by 3cm long)

A **scrap of sheet aluminum or plastic** (about 10cm x 5cm)

Some **"magnet wire"** to make a coil ( I used the 30gauge from Radio shack part # 278-1345 )

A **panel-mount jack** (I used RCA)

2 tiny **neodymium magnets** (I used 1 pack of Radio Shack part # 64-1895 )

Some **shielded unbalanced cable** (like a standard RCA audio cable)

<http://www.instructables.com/id/Sync-Digital-Sound-to-Your-16mm-Film-Projector/>

A cable to connect your projector to the audio input of your computer. (I made an RCA->3.5mm cable from my scrap bin.)

Nylon wire ties , Super glue , Epoxy , Electrical Tape

**Tools:**

Soldering Iron

Exact-o knife

Wire-cutters / Strippers

Tin-snips or some other way to cut sheet metal/plastic.

Power Drill

Screwdrivers - (A long-shaft phillips one makes the 16-CL much easier to work on.)

**step 2: Take it Apart**

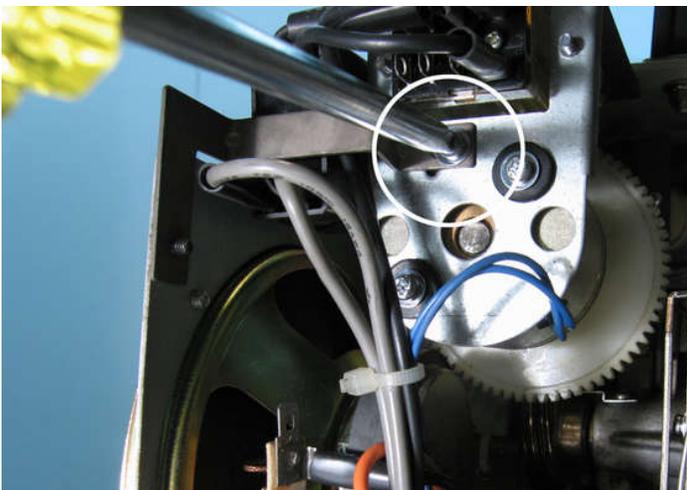
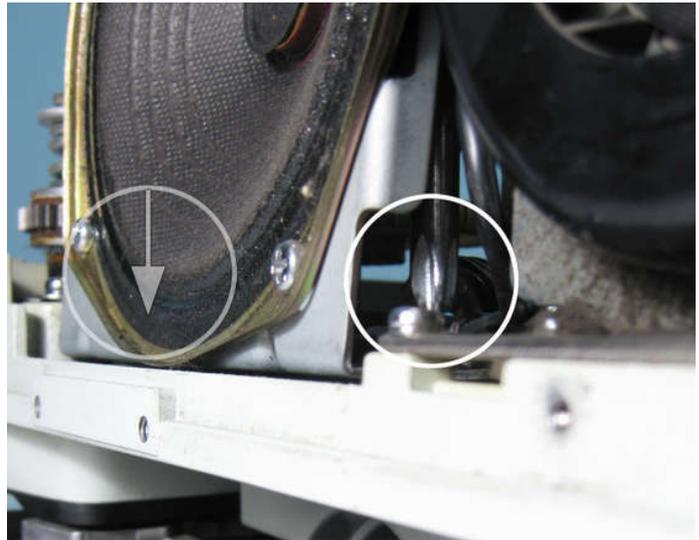
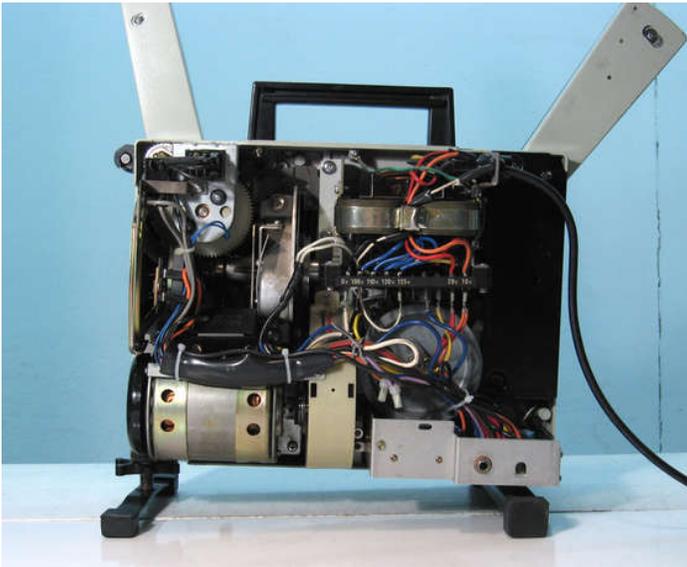
The first thing to do is get the projector apart so we can add the pulse-generator.

**UNPLUG IT FIRST!**

Avoid any circuit boards, especially ones with large capacitors (big metal or plastic cylinders). There can be painful/lethal voltages here, EVEN WHEN UNPLUGGED. If you are not comfy dealing with these sorts of things, stop here. You have been warned.

On the 16-CL the back comes off with a few screws, revealing the guts. Perhaps the voltage indications on the transformer will remind you to unplug it. Did I mention that already?

Now turn the projector face down and remove the 2 screws that hold the speaker-bracket onto the main chassis. The circles in my photos show the location of the 2 screws. The 3rd photo shows how to reach in with your long phillips driver to get at the buried one.



### step 3: The Worm Gear

Most projectors have a worm-gear that interlocks the shutter/ claw to the 2 sprocketed rollers that pull the film through the machine. The 16-CL has a brass worm-gear on the main drive shaft that performs this function. This is convenient because we know that once the projector gets rolling, the spinning of this gear has an unbreakable 1:1 relationship to the spinning of the shutter and the advancement of the film (until your splice breaks, of course).

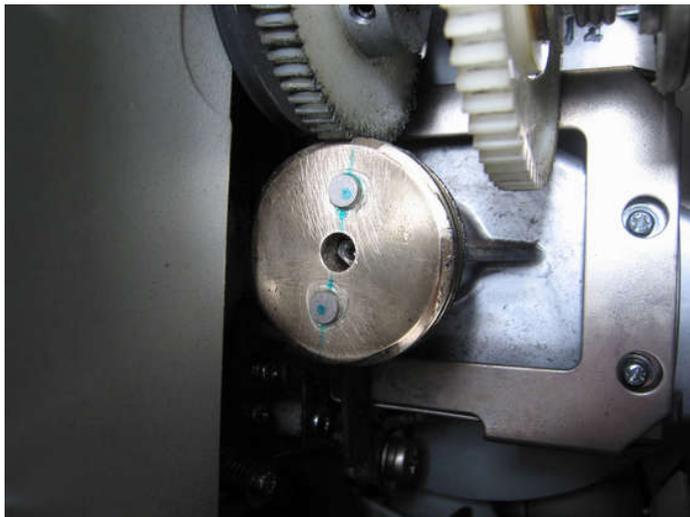
So, get out your little magnets and **epoxy** them to the gear:

You want them to be directly opposite each-other...

AND opposite polarity (one should be "north-up", one should be "north-down")

(Use **epoxy** for this because Super glue is brittle and this part vibrates a lot. Clean the parts with alcohol first to get rid of grease and oil.)

*I chose this method for measuring speed because it was easy. It would be more accurate to introduce an extra sprocketed roller to the film path. That way, as the film moves through the projector you would know exactly what was going on. (With my method, the sound keeps playing if the film breaks, and sync is lost during stopping/starting as the clutch engages the transport.) For all of its benefits, a sprocketed roller introduces issues of complexity, reliability, and possible film-scratching. Feel free to come up with your own solutions and modify the software accordingly.*



### step 4: Make and Mount the Sensor Coil

The sensor coil is where the pulses are generated. As the "north-up" magnet passes the coil we get some electricity flowing in the "+" direction, then a transition to the opposite when the "north-down" magnet passes. So, we end up with a cycle of + and - oscillations at the speed of the spinning gear.

Cut a short section of the plastic pen or dowel. Wrap the magnet wire around it in a few layers to make a coil. You want your wrapping to be fairly orderly, so the first layer covers the bare cylinder before the next layer covers the first. I didn't count when I made mine, but expect a few hundred turns.

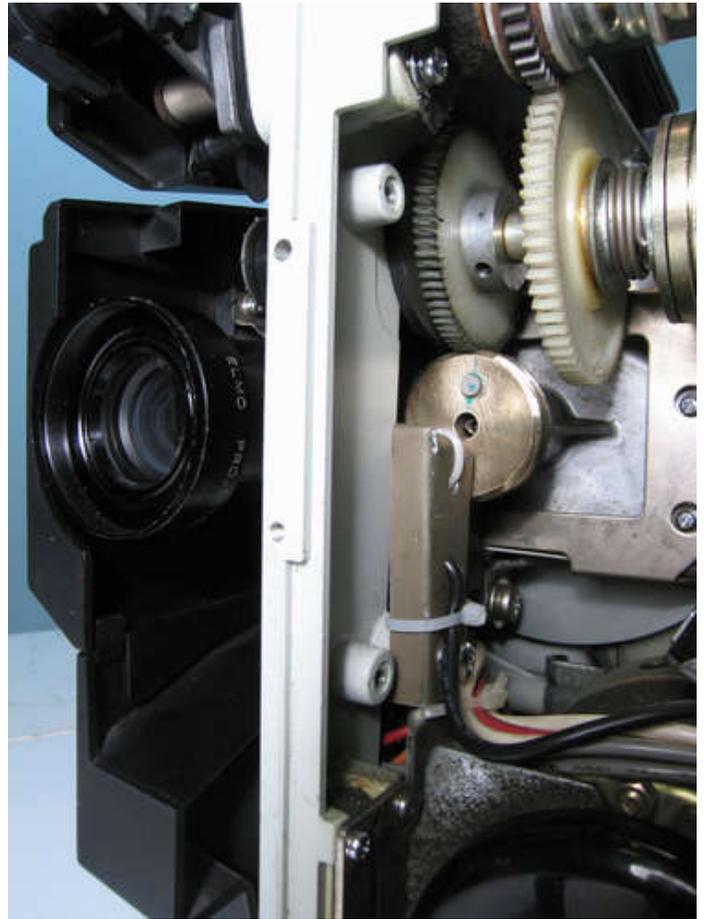
Use the Super glue to seal the coil so you can let go of it without the whole thing coming undone. (Tape helps here too.)

Now start thinking of how to shape your sheet metal/plastic into a bracket to hold the sensor. You want to suspend it close to the spinning magnets, so it hovers a few mm away. It must be **secure**, because you don't want any crashes here! I bent my aluminum into an L along its long side, so it would mount on a nearby motor-mount post.

Now drill 3 holes in the bracket:

- 1) A mounting hole to bolt the bracket to the motor-mount
- 2) A smaller hole on the other end where the coil lives. A wire-tie loops through this hole and cinches the coil to the bracket. (Note lack of glue, because we might have screwed-up the coil and it's no fun to un-gluce things later!)
- 3) A hole in the middle so your cable can pass through the bracket.

Solder the wires from the coil onto the end of your unbalanced cable. This cable will carry the signal from the coil through the inside of the projector to the jack, which will be added to the rear panel. You will need to strip the painted insulation off of the ends of the magnet wire. Use a match to burn it off, or some fine sandpaper to lightly scratch it away. Remember to insulate it with electrical tape or tiny heat-shrink tubing.



### step 5: Get Jacked

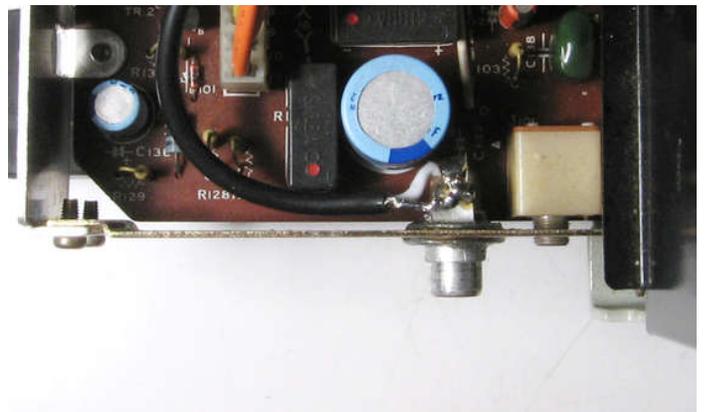
Now that the pulse-generator is installed, run the cable along with the others in the main wire-loom that flows through the projector.

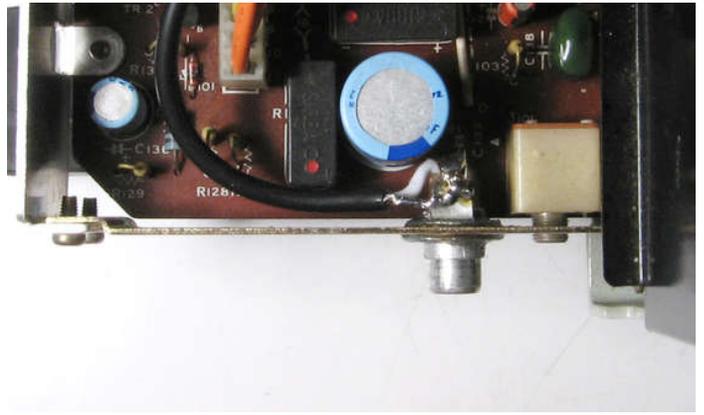
Take a look at the amp board with the speaker and mic jacks. This is where you will add your new output. On my projector there was already a hole here. All I had to do was build it up with a washer to make up for some size problems and screw in my RCA jack.

Make sure the polarity is right, and solder your cable to the jack.

Now is a good time to test things out. Connect your jack to the line-in of your computer and make a test-recording. You should hear a low pitched tone. The software filters out high frequencies so a little noise is OK, but if you hear lots of buzzing then check your wiring. You might need better shielding on your cables, or you might need to insulate your RCA jack from the projector chassis to avoid ground loops. (Mine was fine, but your mileage may vary.)

If everything works, put the speaker bracket back on.





**step 6: Hack the Case**

To make room for the new jack, we need to get rid of some plastic.

Extend the mic jack cutout with an exacto or a dremel, so it reveals your new jack.

Put the cover back on and you're done with the hardware end of things!



## step 7: Film-O-Sync

Download the software (beta version 0.5) at [www.zachpoff.com](http://www.zachpoff.com)

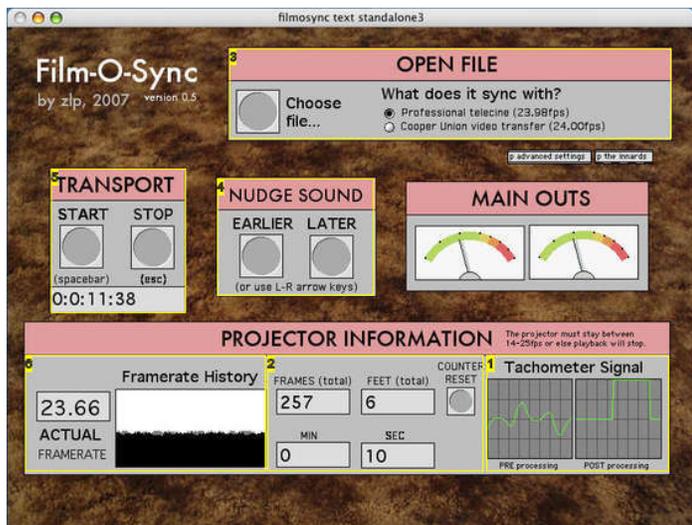
I'll avoid going into details because it comes with documentation, but...

### In a nutshell:

Once everything is connected, you will need an AIFF or WAVE file with your sound in it. You tell the software what the file syncs with (23.98fps or 24.00 fps) and you are ready to trigger the playback. As the projector changes speed, so will your file, and things should stay more-or-less frame accurate.

NOTE: The triggering is manual, so YOU will be telling Film-O-Sync when to play. (It's pretty easy, just watch the academy leader and hit the spacebar when your sync-mark arrives.) There is no facility to detect a start-mark automatically. That would take still more projector-modification, but maybe someday!

Enjoy!



### Image Notes

1. These oscilloscopes show the waveform from the pulse-generator, and the filtered and squared version that is used for the calculations. If there's nothing here then you should check your OS sound settings.
2. These counters are based on the projector analysis. They reset when you play your file.
3. Choose your file and tell the software what framerate to sync it with.
4. During playback you can nudge your sound earlier and later. This helps if you were a little late when you triggered playback.
5. Click here to start your sound when you see your sync mark. The counter shows elapsed time in your soundfile.
6. This is the live framerate reading from the projector, along with a few seconds of recent history.