Notice Regarding this Upgrade

Warning!

Although this upgrade has been tested and the techniques used will not directly cause harm to your Star Wars arcade game, if you do something wrong, you can very seriously damage the game electronics!

To perform this upgrade you should:

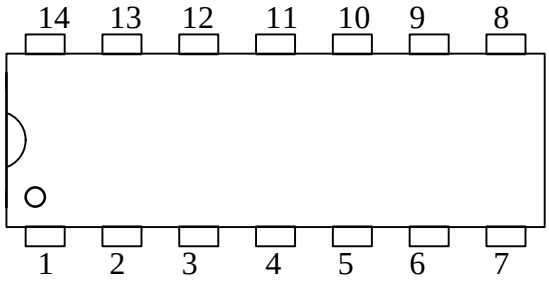
- Have a working understanding of electronics.
- Be familiar with safe handling procedures for electronic components.
- Have basic soldering and electronic assembly skills.
- Be able to follow directions.

Arcade games are rugged equipment, but anytime you start messing around with something (particularly something electronic) you accept a certain amount of risk that you may break something.

This kit carries with it no guaranty of compatibility to your particular game. Although all Star Wars PCB's (Printed Circuit Boards) are believed to be of the same layout and electrical characteristics there's a remote possibility that some of them are different. If you carefully follow these instructions, you'll do fine and everything will work. If this looks like it's above your confidence level please recruit someone locally to install the kit for you!

Please read these instructions completely through before starting. If at any point your PCB looks significantly different than what you see in here, please ask before trying something!

Since this is as good of place as any, this is how IC's are numbered (you start at the notch or dot and work you way around counter-clockwise):



Credits and Thanks:

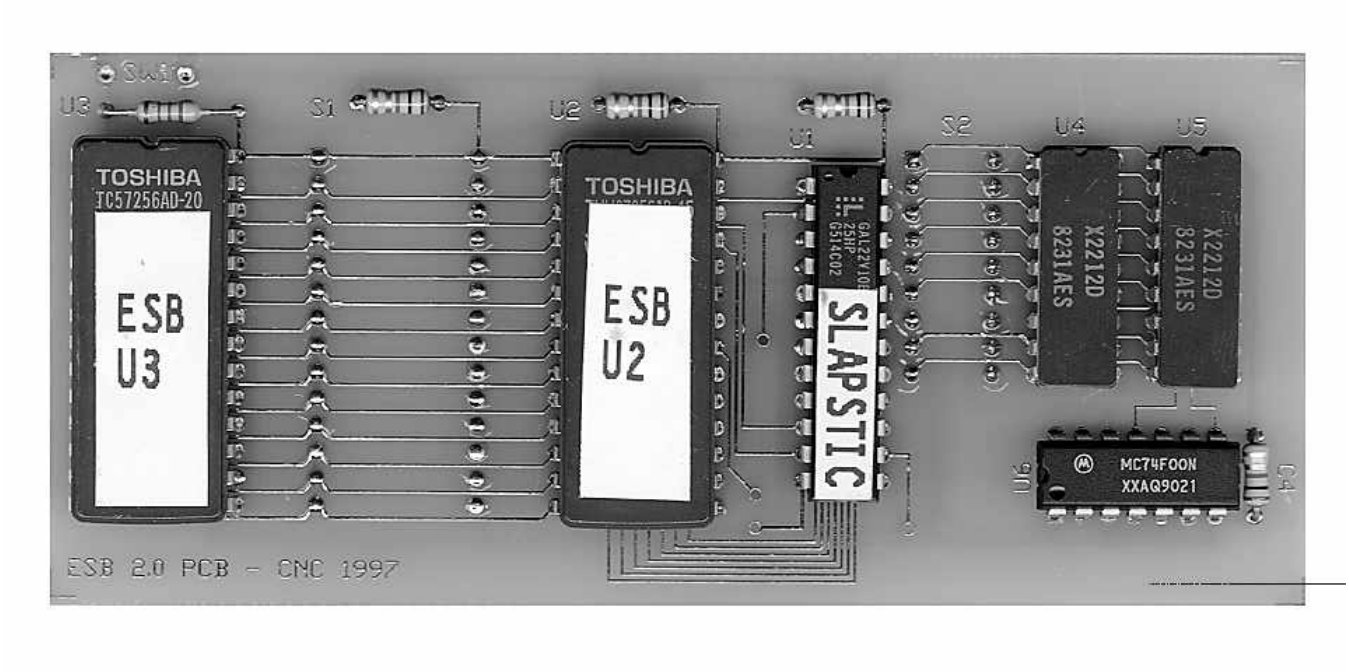
I wanted to take a little space with you, my now captive audience, and thank a few people that helped in various ways with this particular project.

Cliff Koch	Without Cliff's reverse engineering of the ESB plastic, this kit wouldn't be possible!
Rick Schieve	Rick provided known-good Mathbox PROMs when I had trouble with my copies. Rick also saves my butt with spare parts when I break things☹.
Werner Sharp	For generally prodding me on to do this and helping out with the startup costs.
Joel Rosenzweig	For the constant wishes of luck and support.
Dave Fish	For supplying me with a known-good set of PROMs to test with.
Doug Jefferys	For supplying me with another set of PROMs to compare with.
Jess Askey	For having the best Atari Vector Games page on the planet! (http://magenta.com/~jess)
Bill LaCovara	For sending me his original ESB Conversion manual which provided the raw material for the cool cover for this manual☺

I hope these instructions are adequate and helpful. I had hoped to do more, but I'm really worn out by all this writing and image-capturing, so these will have to do! This kit has been successfully installed many times, so stick with the instructions and you'll do fine.

Introduction:

The Empire Strikes Back kit is a printed circuit board and collection of chips that with some wire, a switch, and some time and a little soldering will allow you to convert your Star Wars arcade game board into a "switchable" Star Wars/Empire Strikes Back Game.



These instructions describe how to install the ESB PCB into a Star Wars boardset without having to make any cuts on the Star Wars PCB. A second section briefly references how to perform the "cut" based conversion based on Cliff's original article.

So before we get started, grab your favorite beverage, maybe something to snack on, and find a quiet place to read this manual so you fully understand what to do before you start tinkering around with your precious Star Wars boards!

Getting Started:

First, let's cover what you'll need in some detail. We'll start with the base ESB Kit which includes the following:

- ESB 2.0 Printed Circuit Board (1)

The "Mathbox" PROMs (82S137's):

- PROM "7H" (Atari part number 136031-110, PROM_7H.BIN)
- PROM "7J" (Atari part number 136031-109, PROM_7J.BIN)
- PROM "7K" (Atari part number 136031-108, PROM_7K.BIN)
- PROM "7L" (Atari part number 136031-107, PROM_7L.BIN)

A set of EPROMs programmed with both the Star Wars and Empire Strikes Back game code. There are 6 27C256 type EPROMs and 1 27C64 type (28 pin DIP packages):

- EPROM "CPU 1F" (CPU_1F.BIN)
- EPROM "CPU 1J/K" (CPU_1JK.BIN)
- EPROM "CPU 1K/L" (CPU_1KL.BIN)
- EPROM "CPU 1M" (CPU_1M.BIN)
- EPROM "SND 1H" (SND_1H.BIN)
- EPROM "SND 1J/K" (SND_1JK.BIN)
- EPROM "AVG 1L" (AVG_1L.BIN) (this is the 27C64 EPROM)

In addition, you'll also want to have the following handy:

- Wire (30ga wire-wrap wire is fine for the PCB work)
- A soldering iron (15-30 watts with a small tip. The blue $8 Radio Shack iron is great.)
- Wire cutters
- Wire strippers
- Something to remove socketed chips (I like a small standard screwdriver—use what you're comfortable with.)
- A single-pole single throw switch (for switching between games)

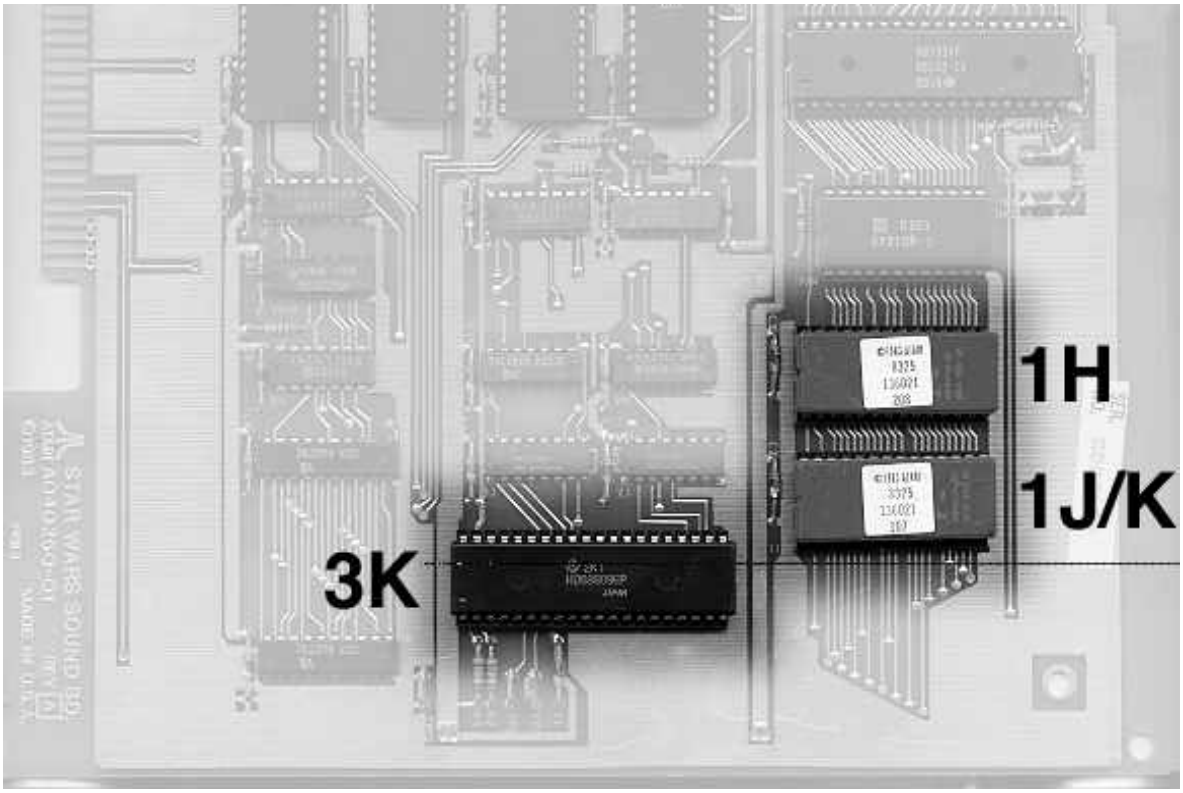
Gather your parts and tools and prepare a clean workspace that you can hack at for a while…

Get to know your Star Wars boards:

Star Wars consists of three different Printed Circuit Boards (PCB's) connected by a small "interconnect" board. We'll start with a brief explanation of each board and show which parts you'll be working on.

Sound board:

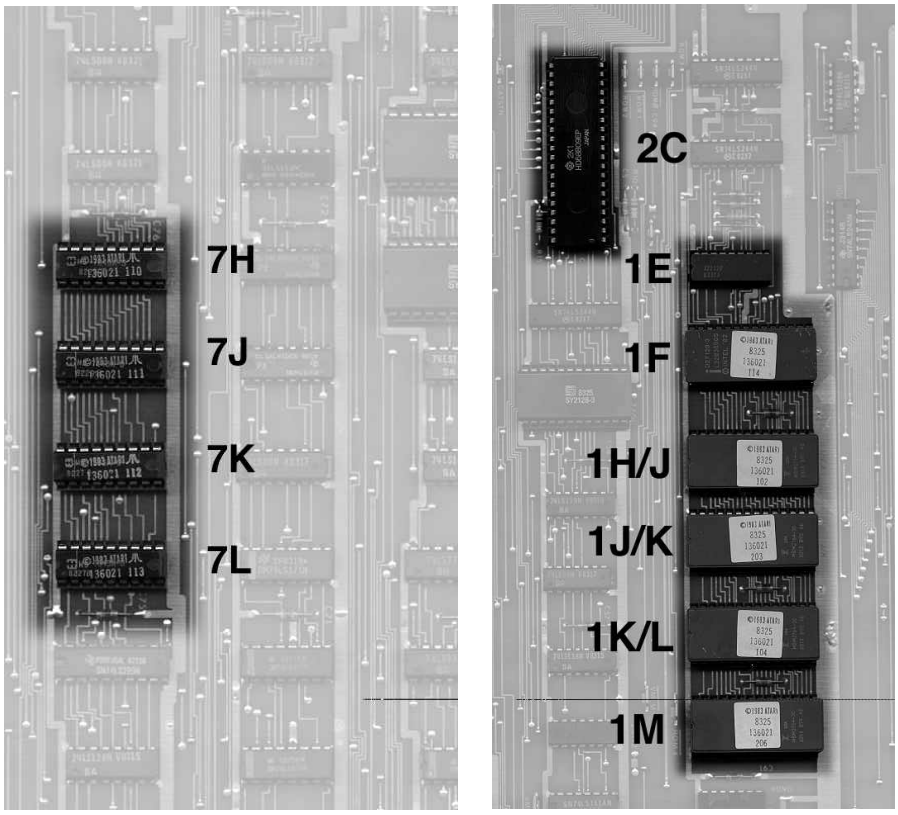
The sound board is usually the first PCB in the stack of Star Wars boards. It's the smaller board with lots of "foil" on the top. You'll note that it's labeled "STAR WARS SOUND BD.". Holding the board so the larger edge connector is on the left, you'll see something like this:



Later on you'll be soldering a wire to one of the pins of the 6809 at location "3K' and replacing the ROMs at locations "1H" and "1J/K".

CPU board:

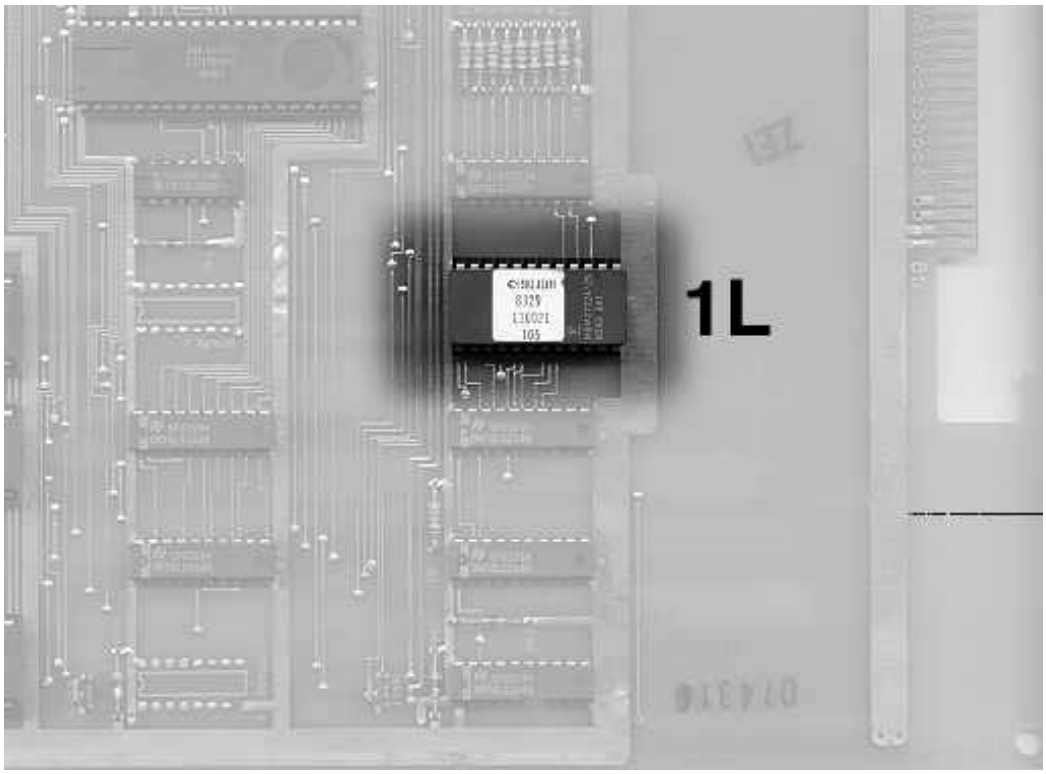
The CPU board is the brains of your Star Wars. This time hold the board so that the large edge connector is on your right. (The writing on the chips will be "right side up" this way.) On the right hand side of the board and in the center of the board you'll see something like this:



You'll be replacing the PROMs (on the left, 7H-7L); replacing the EPROMs (on the right, 1F-1M); removing the NOVRAM at 1E; as well as soldering on a wire to the 6809 in location 2C and placing the daughtercard in the socket at 1H/J and 1E.

Analog Vector Generator Board:

The AVG is responsible for drawing all those snazzy vectors you see during the game. Holding the AVG so that the large edge connector is on your right you should see something like this in the lower right hand corner:



You'll be replacing the EPROM at location 1L with a larger EPROM to hold data for both Star Wars and Empire Strikes Back.

General Comment on the Upgrade:

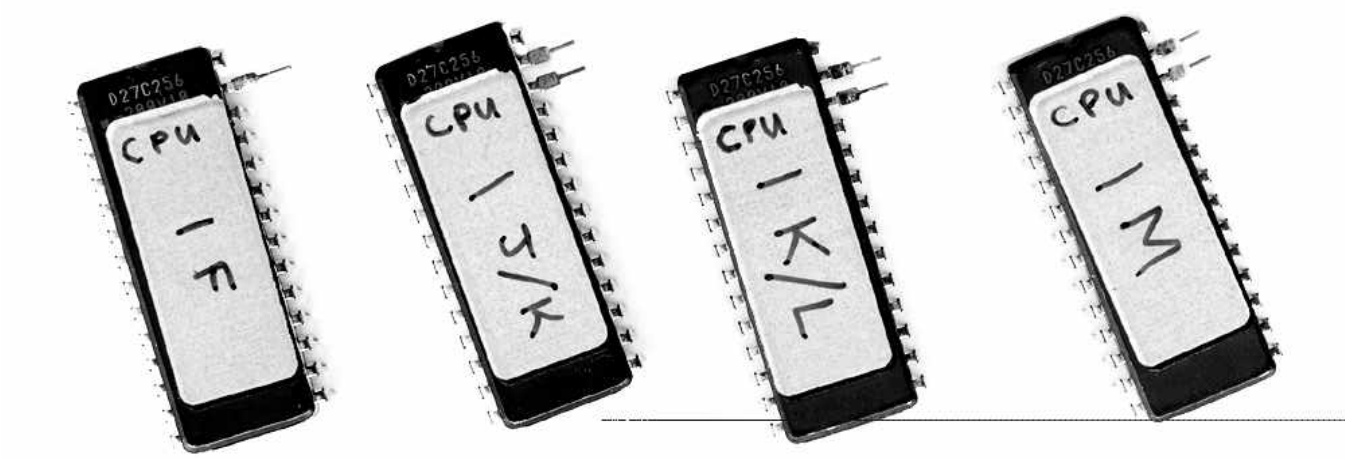
The following procedures are pretty simple once you know what we're trying to accomplish. All you'll be doing is replacing all the EPROM memory on the boards with devices that are twice as large as the originals to store both the Empire Strikes Back and Star Wars programs. We'll be wiring all the highest address lines on all the EPROMs together and connecting them to a switch that goes to the daughtercard. The switch will toggle the highest address line to either a "1" or a "0" state. Depending on what the state of the high address line is, the game's processors will either address Star Wars or Empire Strikes Back data on the EPROMs.

In addition to the "bank switching", Empire Strikes Back actually uses more than twice as much program space as Star Wars. (The Empire Strikes Back kits originally used 16K EPROMs where Star Wars used 8K parts.) To give some more space (and to discourage the pirates of the day) Atari devised a memory expansion daughterboard. The PCB in this kit is the functional equivalent of the original daughtercard, just as Cliff Koch's 22V10 is the functional equivalent of the original Slapstic that Atari used as a memory switcher/protection scheme.

Let's Get To Work:

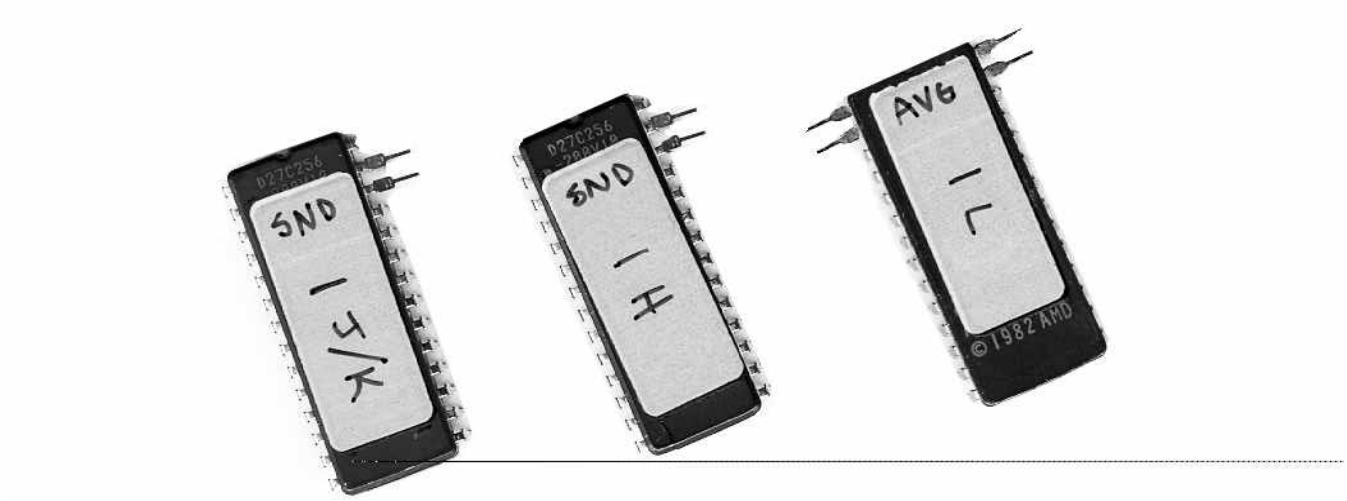
Locate the four "CPU"EPROMs numbered "1F", "1J/K", "1K/L", and "1M". We'll be bending some of the pins out from the EPROM so that they will not go into the EPROM sockets (this is the alternative to cutting the actual traces on the back of the PCB). The idea is not to bend the pins out straight (this will tend to interfere with the chip next to it), but rather to bend them out at about a 45 degree angle.

- On "1J/K", "1K/L" and "1M" bend out pins 27 and 26.
- On "1F" only bend out pin 27.



Now locate your "SND"EPROMs and the "AVG" EPROM. This will be the same drill as before, bend the correct pins out, but not straight out…

- On "SND 1 J/K" and "SND 1H" bend out pins 27 and 26.
- On "AVG 1L" bend out pins 1, 2, 27 and 28.



Modify the Sound Board:

It's time to modify the sound board. We'll be soldering wires onto the bent-out "SND" EPROM pins and onto a pin on the 6809.

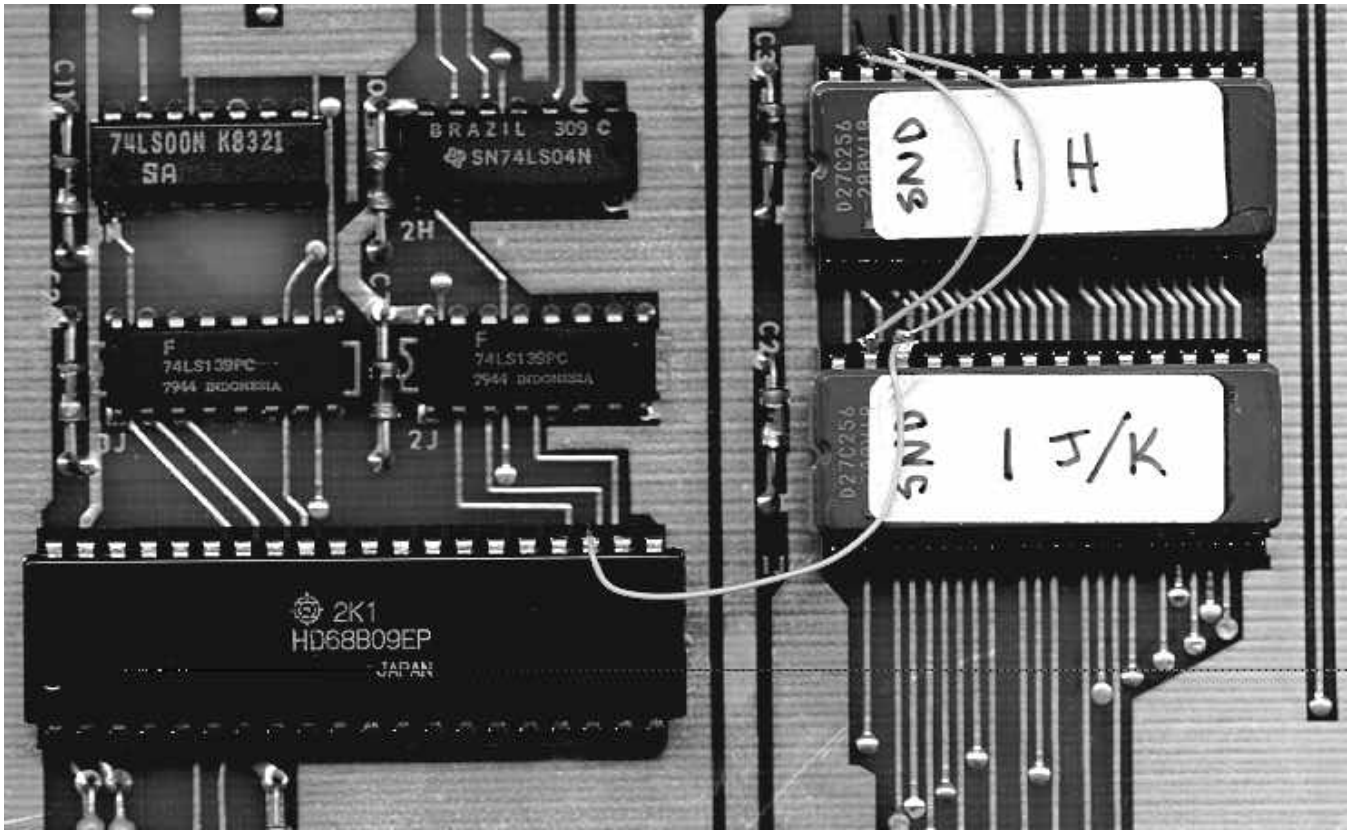
Remove the EPROMs at location "1H" and "1 J/K". Keep them—maybe you'll want to switch back or save another Star Wars someday. Install your replacement "1H" and "1 J/K" EPROMs (with pins 26 and 27 bent out) into the "1H" and "1 J/K" sockets, respectively.

Solder a wire from Pin 23 of the 6809 at position "3K" to Pin 26 of the EPROM at "1 J/K".

Solder a wire from Pin 26 of "1 J/K" to Pin 26 of "1H". (You just connected an extra address line to the EPROMs to allow for more sampled voice that Empire Strikes Back uses.)

Solder a wire from Pin 27 of "1 J/K" to Pin 27 of "1H". (Later on we'll be connecting pin 27 of these chips to the other replacement chips.)

Your finished Sound board should look roughly like this:



Modify the AVG Board:

The AVG board modifications are easy, so let's get that one out of the way.

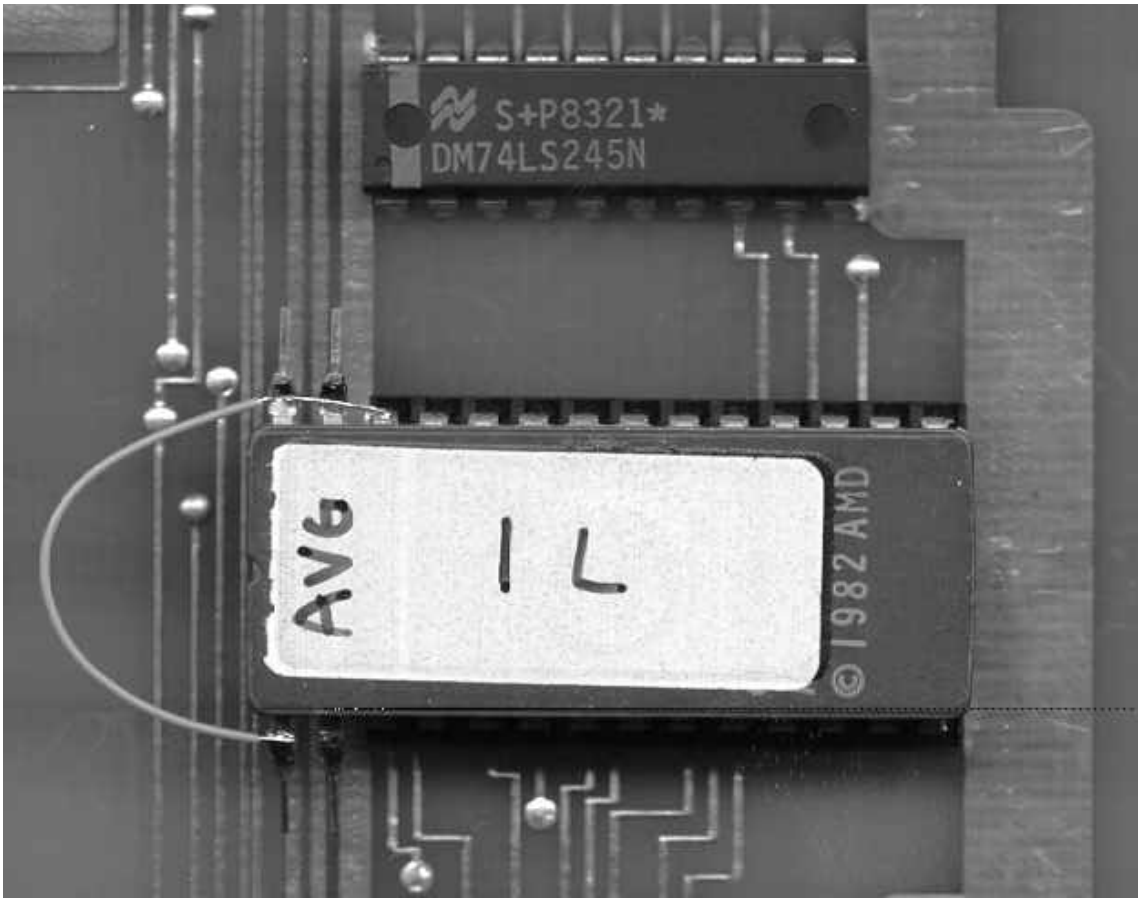
Remove the EPROM at location "1L". Keep it with the rest for a rainy day☺

Install your replacement "1L" EPROM. You'll notice that the socket is only 24 pins, but the chip is 28. (Hmmmm…) So place it in the socket so that the four pins that you bent out earlier are hanging off the edge closest to the big chips on the left side of the board.

Solder a wire to Pin 26 of the EPROM (it's the last pin that's IN the socket on the top-left of the picture below) and connect the same wire to Pin 27, Pin 28, and Pin 1 of the chip. (Pins 27,28, and 1 are all hanging off the end of the socket out in thin air…) You've just connected the +5V power supply line from pin 26 (pin 24 of the 24 pin socket) out to the replacement chip. Good job.

Pin 2 will be left disconnected for now, but we'll be connecting the other replacement chips to it later.

You should have something looking like this now:



You can put the AVG board aside for now. We're basically done with it.

CPU Board:

Time for the main board! By this time hopefully you've worked out your technique for soldering on the little wires. ☺ We'll be repeating the process that we used on the other PCB's with the main CPU board.

Remove the Star WarsEPROMs from locations "1F", "1H/J", "1J/K", "1K/L" and "1M". Stash them with the rest of your Star WarsEPROMs.

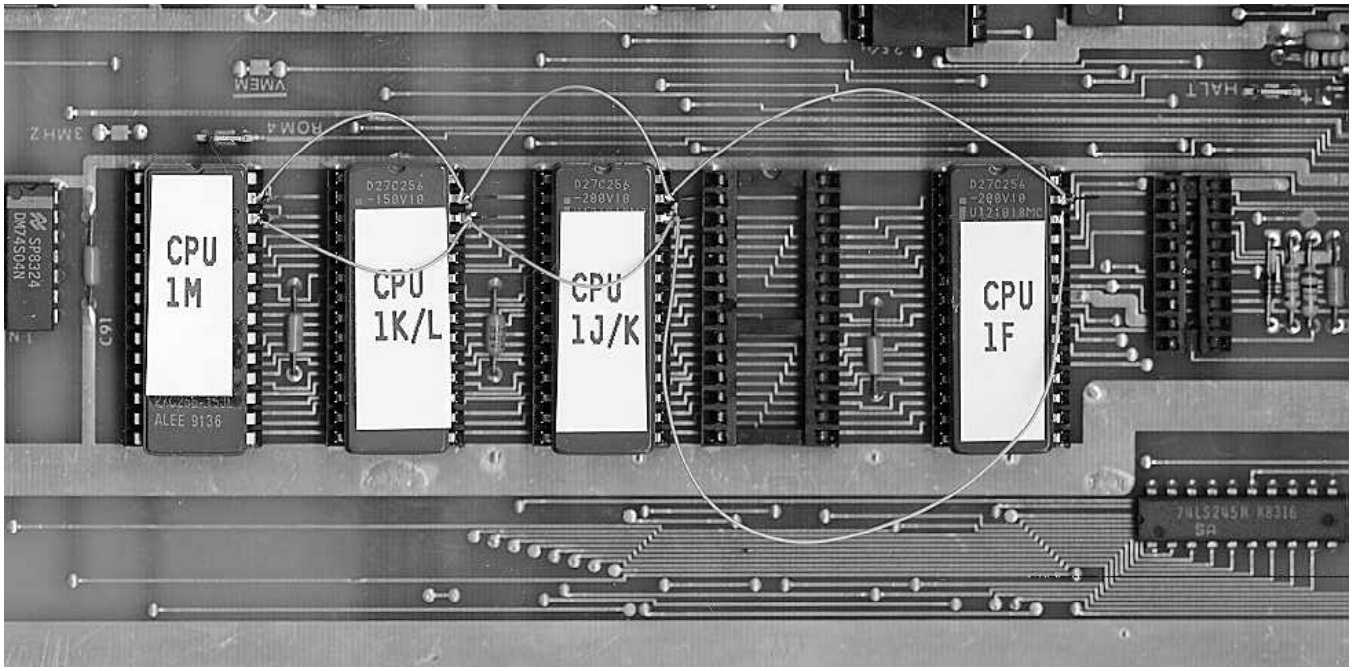
Remove the NOVRAM at 1E and place it in the Daughtercard at location U6. Solder it in place. Your daughtercard should now look like the one pictured at the beginning of this manual.

Place the replacementEPROMs (with the appropriate pins bent out) in their respective locations. (EPROM "1F" goes into socket "1F", "1J/K" goes into socket "1J/K" etc.) Socket "1H/J" is where the daughtercard plugs in so it will be empty for now.

Solder a wire from pin 26 (which is in the socket) of "1F" to pin 26 of "1J/K", "1K/L" and "1M". You can "daisy chain" the wires from one chip to the next (see picture). You just connected another address line to all the chips forESB's larger program. (Actually it's the MPAGE, line but close enough…)

Solder a wire from pin 27 (which is bent out) of "1F" to pin 27 of "1J/K", "1K/L", and "1M". Once again, you can "daisy chain" this from chip to chip. We'll be connecting pin 27 of these chips to the EPROMs on the Sound Board and AVG board later.

Be sure to use enough wire so that the wires from "1F" can go around the socket at "1H/J" so the daughtercard will plug in easily. You should have something like this:



At this point, we need to do something that won't show up very well on the scanner, so you'll have to follow carefully in this text…

Attach the Daughtercard:

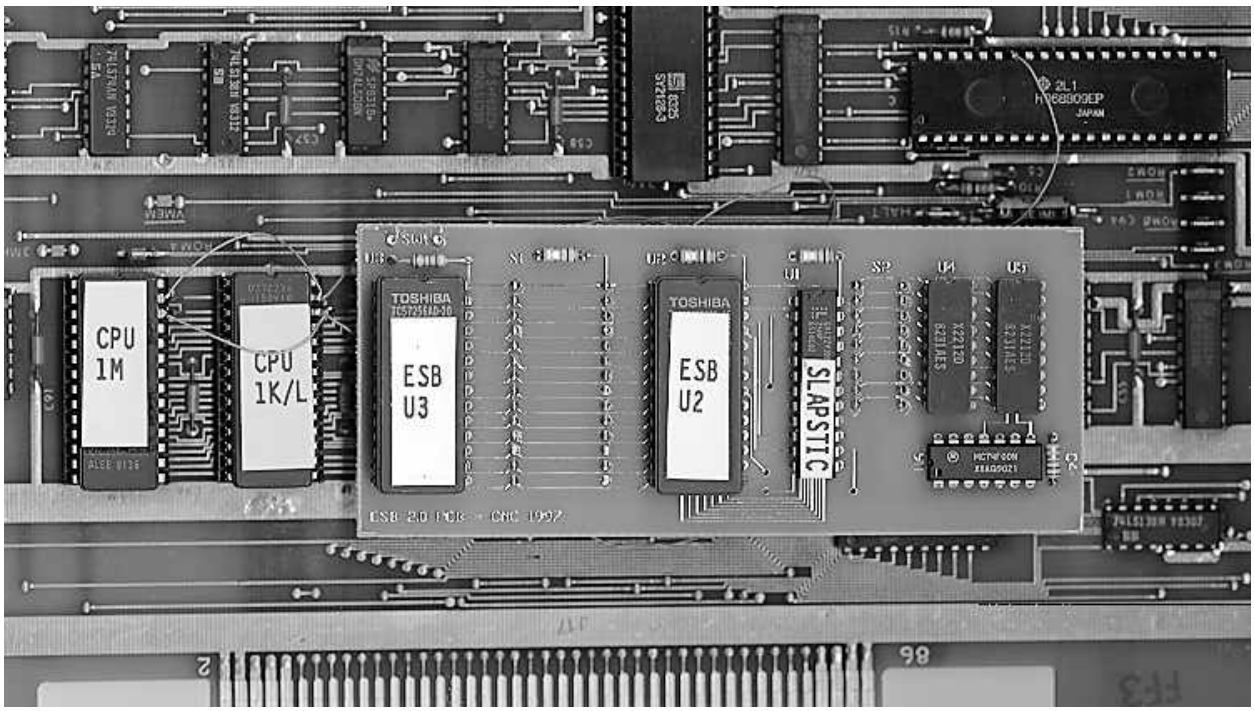
Get your ESB Daughtercard. It should be fully assembled and ready to go at this point.

Solder the short wire (blue) (from pin 27 of the dual-SIP header "S1" on the daughtercard) to pin 27 of "1K/L". (Any of the "bent out" pin 27's on the EPROMs will work since they're all connected together. "1K/L" just seems close and convenient.)

Solder the longer wire (yellow) (from pin 22 of the dual-SIP header "S1" on the daughtercard) to pin 34 of the 6809 at location "2C".

Take the daughtercard and orient it so that the EPROMs are facing the same direction as the EPROMs on the CPU board. Make sure that the wires for pin 27 (shorter wire—blue) and pin 22 (longer wire—yellow) are out of the way of the sockets at "1H/J" and "1E". Carefully line up the pins on the daughtercard and press it firmly into place in the socket. It should make a little "er-chunk" noise as it seats into place. Be careful when aligning the card and make sure that it meets both the socket that the NOVRAM ("1E") was in as well as the socket for the EPROM ("1H/J").

If all goes well (which it will :-), you should have something that looks like this:



Remove the Mathbox PROMs at locations "7H-7L" on the CPU board. Store these with your Star Wars EPROMs.

Replace the Mathbox PROMs with you new set. Each part goes into the socket of the same name—PROM "7H" goes into socket "7H", PROM "7J" into socket "7J" etc. Be sure to keep the chips oriented the same way on the PCB! (There's really not much to see here, so I'll omit the picture.)

Hang on! We're almost done! Just a small matter of a switch to hook up…

Finishing touches:

Time to connect that "gameswitcher" switch. Most any switch will work. All you need is a Single Pole, Single Throw switch which you can get at Radio Shack, mail-order, or a hardware store. Make sure it's NOT a momentary switch. You just need a plain-old "on-off" type switch. Mounting the switch somewhere is up to you—I leave my coin-doors unlocked so I put my switch in there with the test switch, but if you've got a sit-down cabinet maybe you want to put in under the dash or something?

Take some more wire and connect pin 27 of the EPROMs on the CPU board to pin 27 of the EPROMs on the sound board and pin 2 of the EPROM on the AVG board. Remember to consider how this whole thing is going to slide into the RFI cage (if you're using one) and run your wires so as not to get in the way. By doing this, the top-most address line of all the EPROMs are connected together. By putting either +5Vdc or 0Vdc on these pins we can select either the Star Wars program or the Empire Strikes Back program.

I ran wire from pin 2 of the AVG board EPROM ("1L") around the back of boardset (where the three-board connector goes) up to the sound board (pin 27 of either "1H" or "1J/K"). Then I ran a wire from the sound board EPROMs down to the CPU board (pin 27 of "1M" was convenient).

Once the boards are connected together you can re-assemble them into the "backplane" connector that hooks them all together.

Decide where to place your gameswitcher switch. You'll need two more pieces of wire long enough to reach from the "back" of the card cage (closest to the coin door) to where-ever you're putting your switch. It's helpful if you have the wires as a "pair" (like thin speaker wire, although two separate pieces work fine too). I find that the solid-core "alarm" wire from Radio Shack works well. Solder one end of each lead to the "SW1" holes on the daughtercard. When you slide the boardset back into the cardcage, you can just push the wire up through the air vents and run it wherever you want. Then solder the switch to the other ends of the wire and mount it however you like.

Final Test:

If you've done everything right you should now have a working switchable Star Wars/Empire Strikes Back game!

If possible, use an ohm meter to check the resistance between power and ground on the Star Wars/ESB boardset. If you read 0 ohms (or anything much under a hundred) you probably have a power short! Go check your work before trying anything!

When you first try the game, do **not** hook up the monitor! If something isn't right the board set will often just "draw" a line at maximum deflection and hold it there—tends to pop fuses on the deflection board! Start the game in "test" (the switch behind the coin door) mode with everything connected but the monitor. You should hear a series of 16 high-pitched "beeps" in sequence. If you hear any "boops" (low pitched beeps) you have an error of some sort—go double check your wiring and make sure all the EPROMs are socketed properly and there are no pins **unintentionally** bent out of the sockets. ☺

Unfortunately, Atari had some cheap sockets in some Star Wars games, and changing the EPROMs can result in pins breaking off internally to the socket and will give you ROM errors! There isn't much to do in this case except remove the sockets and replace them. This is not a job for the in-experienced! Get help if you haven't done it before…

If you have problems, listen to the "audio error codes" in self test mode and go by the following codes and tips:

A "beep" means the component tested OK. A "boop" means the component failed the test.

There are 16 beeps followed by a pause. After the pause the pattern repeats.

Star Wars/Empire Strikes Back Audio Error Codes:

Beep #	Description
1	RAM 2F/H on the CPU board (a 2Kx8 for the CPU)
2	RAM 5F on the CPU board (a 2Kx8 for the Matrix processor)
3	RAM 5H on the CPU board (a 2Kx8 for the Matrix processor)
4	RAM 3L on the AVG board (a 2Kx8 for vector RAM) ***
5	RAM 3M on the AVG board (a 2Kx8 for vector RAM)
6	RAM 4P on the AVG board (a 2Kx8 for vector RAM)
7	RAM 4L on the AVG board (a 2Kx8 for vector RAM)
8	RAM 4M on the AVG board (a 2Kx8 for vector RAM)
9	RAM 4P on the AVG board (a 2Kx8 for vector RAM)
10	NOVRAM 1E on the CPU board (a 2212 Xicor 256x4 NOVRAM)
11	EPROM 1F or 1M on the CPU board +++
12	EPROM 1 J/K on the CPU board
13	EPROM 1 K/L on the CPU board
14	EPROM 1F or 1M on the CPU board +++
15	EPROM 1 H/J on the CPU board (The daughtercard for ESB)
16	EPROM 1 L on the AVG board ***

*** The video display will not work properly in test mode if either of these are corrupt.
+++ The self test won't run at all if either of these are too corrupted.
(The 2Kx8 RAMs are "2016's" if you need to replace any. "6116's" and "9128's" should work too.)

Other Troubleshooting Information:

- Empire Strikes Back will start in game mode without the daughtercard. It won't play though.
- If either of the Sound ROMs are "dead" you will get no sound (or just grinding noises from insane POKEYs).
- If you run ESB with a Star Wars vector ROM, the "display" will be a maximum deflection +-20V signal that will probably pop fuses if left on for very long.
- If any of the program ROMs are in the wrong sockets, you can also get the "max deflection" effect with the same results as the bad vector ROM...
- If your Sound ROMs are swapped, you'll get weird grinding noise as it tries to make "beep" and "boop" sounds.
- When switching games, some machines require that the power be turned off BEFORE you switch or else they won't save the high score and settings information to the NOVRAM. It seems to vary from machine to machine, so experiment on yours. (It's technically "safer" to switch with the power off anyway, since it's less likely to damage your monitor if the CPU doesn't reset properly. Your Mileage May Vary. If in doubt, turn the game off before switching.)

About the "Cuts" conversion:

If you'd rather do the original "cut on the PCB" version of the upgrade, go ahead and follow Cliff's original instructions, just using the daughtercard and parts in this kit.

Conclusion:

I hope this works out for you all—feel free to ask questions if you have problems. You shouldn't be able to damage anything by performing the upgrade if you're careful doing it, so if it doesn't work you can always remove the kit, replace the Star Wars PROMs and EPROMs and see if the board still works. If not—check those sockets!

There have been LOTS of people that have installed the kit without problems, so they definitely work. If you have problems and can't find the fix yourself, feel free to contact me.

Good luck, have fun, and of course… May the Force be with you! *grin*

-Clay
clay@supra.com