DIY SEGA Game Gear 512Kb Flash Cartridge.

Please Read through this entire document before you commence soldering.

Use the accompanying Instructional Videos I have made, along with this PDF Document for the best chances of success. My YouTube Channel link is shown below:

http://www.youtube.com/user/NLEproGUY

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SEGA Game Gear D.I.Y. 512Kb Flash Cartridge

Step by Step Guide

By

Gerry O'Brien

Revision 1.3

October 2010

IMPORTANT NOTE: *Electronics education and hands on experience varies from user to user. Be advised that this Step by Step guide is targeted to those individuals that may need a little help along the way.*

The provided PCB layout is a single sided design and was only intended to be used during the research & development stages of this project. It was merely a prototype design. With this in mind I designed the board with both the trace lines and components on one side, while having the wire bridges on the other. I also intentionally made the PCB layout much larger . All of this was put in place to make troubleshooting less of a burden. Obviously a large sized PCB is a downfall if you plan on using this for regular Game play. The prototype PCB is almost as large as the Game Gear itself. If you intend to etch your own board, I highly recommend that you use the provided schematic file and create a double sided PCB layout of your own.

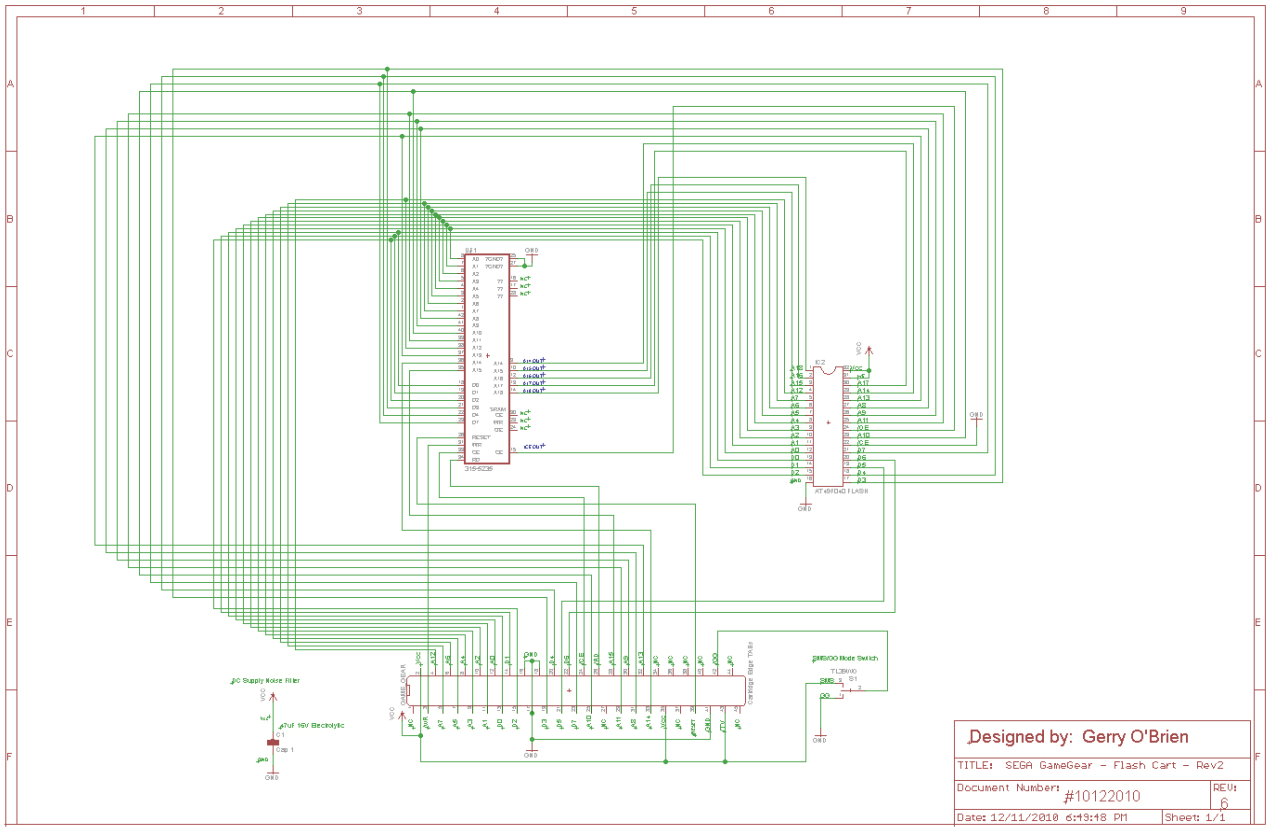
You can download my Eagle schematic & Prototype Layout at the link below:

http://www.digital-circuitry.com/FILES/Electronics/SEGA/GameGear/SEGA_GameGear_Flash_Cart_Schematic_Pack.zip

Introduction:

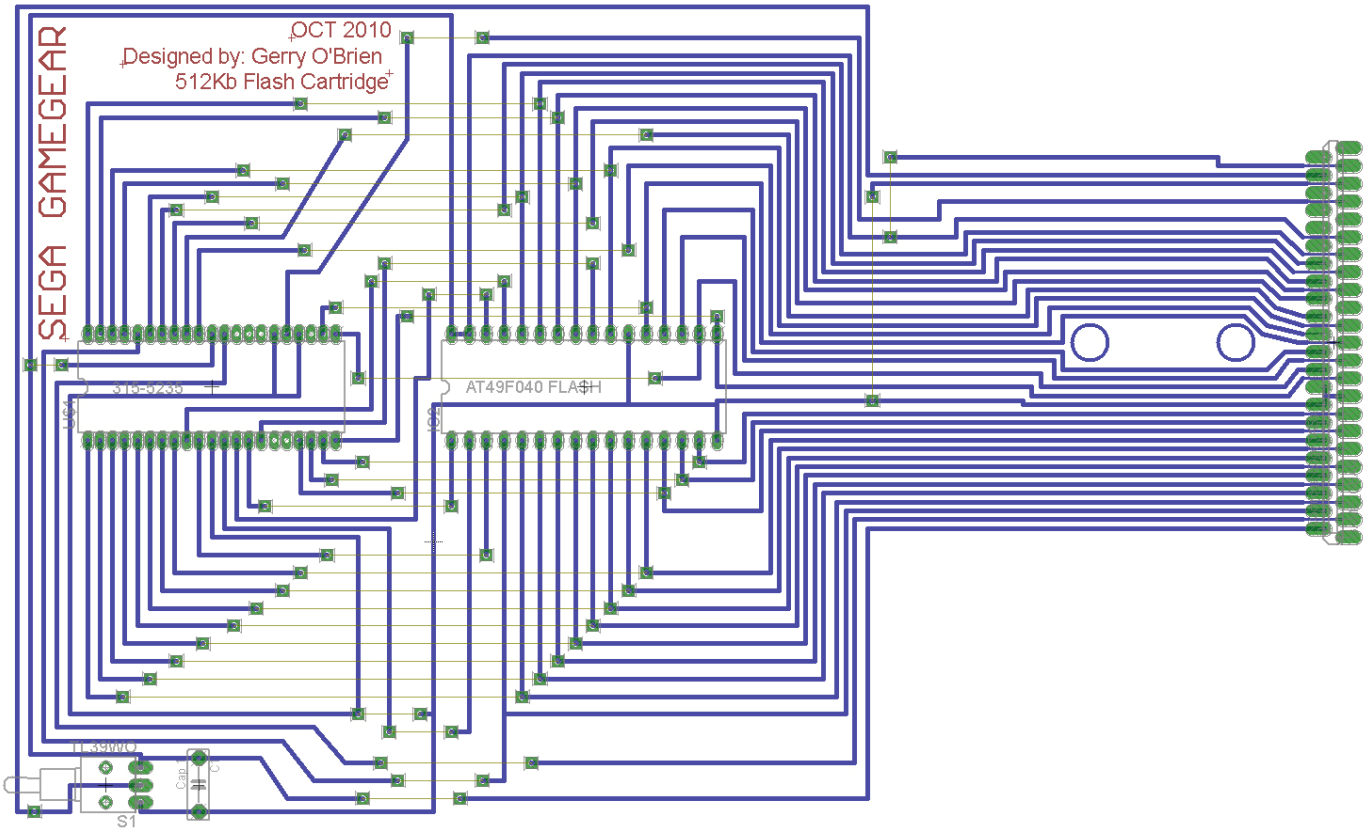
For a little over a year now, I have been working on developing a SEGA Game Gear Flash Cartridge for the avid Electronics Hobbyist. I am still working on completing my 1 Mbyte + version. However, for the time being I have completed a circuit design that permits us to interface a generic 512Kb Flash chip.

My schematic design is shown below:



The Schematic incorporates a SEGA 315-5235 Mapper chip and a 4Mbit Flash chip. I have included my Prototype PCB design as part of the Eagle schematic download. My PCB layout is single sided and was merely designed as a prototype. With this in mind I made the PCB much larger to make troubleshooting less of a burden. This is a downfall if you plan on using this layout design for regular game use. The PCB is almost as large as the Game Gear itself.

See the Image on the following page.



I was not going to include the Prototype PCB but I figured some of you may enjoy etching a board of your own. This board was designed with trace lines and components on the Top side and wire bridges on the Bottom. Feel free to make your own modifications to the layout, or you can make you own Layout design by using the provided Schematic. Some of you may want to attempt designing a double sided PCB. This would reduce the overall size immensely. If you plan on etching the board above, make sure to use 1/32" thickness boards. The Game gear Cartridge slot will only accommodate a PCB of this thickness when used with a standard cartridge enclosure. You can also interface this PCB to a GG cartridge via a 34 wire Ribbon cable.

You can download my Eagle Schematic and Prototype layout design at the link below:

http://www.digital-circuitry.com/FILES/Electronics/SEGA/GameGear/SEGA_GameGear_Flash_Cart_Schematic_Pack.zip

Now for those of you who do not have the equipment to etch your own PCB's, I have an alternative option. Now, this option has a major advantage over the **"Etch your own board"** method shown above. The advantage is that your final product is much smaller in size. It involves some soldering work, and a lot of patience. Then again, most of us doing these kinds of projects would have to have a lot of patience otherwise, we would probably go insane.

So, based on the fact that my design uses an SMS 315-5235 Mapper chip and a 32 pin memory chip, we can use a Sega Master system Game Cartridge PCB. Now it doesn't matter how you interface the PCB to the Game Gear. Some of you may wish to modify various adapters or interface your flash chip directly inside the Game Gear. Regardless how you proceed, know that the method I have laid out here is probably the best way to minimize the overall size of your Flash cartridge. As long as you match your end design with my schematic, you'll be good to go.

I have taken the liberty of putting together a Full set of procedures for you to follow. I have incorporated several Photographs to provide as much detail as possible to help you along the way.

So by following this PDF document and watching my YouTube Instructional videos for this project, I'm sure you will be victorious in building your very own 512Kb SEGA Game Gear Flash Cartridge.

Cheers! And good luck to you.

Kind Regards,
Gerry O'Brien

PROCEDURES:

STEP #1:

The first step is to de-solder the original ROM chip from a 4Mbit SMS game Cartridge PCB and also de-solder the Integrated ROM/Mapper chip from a Game Gear Cartridge PCB.

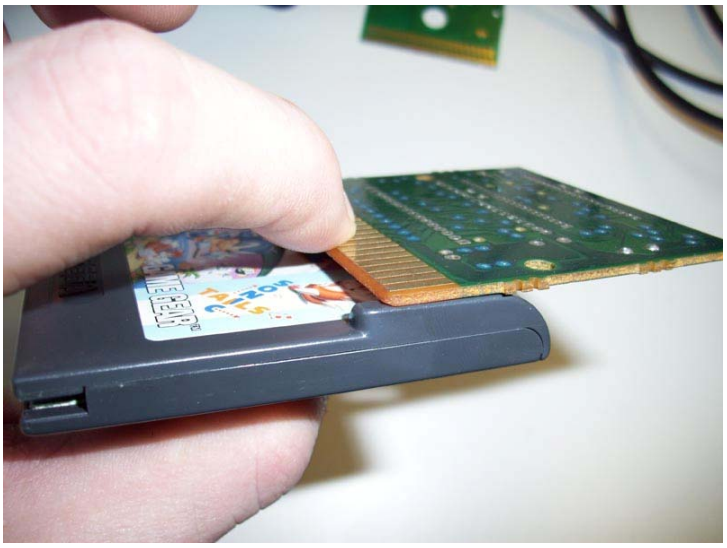
A Game Gear ROM chip is actually a ROM & Mapper /Memory Bank controller, integrated into one. As compared to an SMS cartridge, the chips are separate. Based on the fact that the SMS and the Game Gear are essentially the same system, we can use SMS Mapper chips with the Game Gear. Mapper chips such as the **315-5235** model are found in most 4Mbit SMS cartridges. The SMS "AFTERBURNER" game cartridge is an example and is the cartridge recommended for this project. The 315-5235 Mapper will accommodate a 512Kb Flash chip and is the main reason why I have selected it for this project. I also recommend using The ATMEL 4Mbit Flash chip **"AT49F040"**.

Not all of your backup ROM images will run using the 315-5235 Mapper chip (Codemasters games) but most do. This Mapper chip should also suffice when running your own custom code.

"Sonic 2" Game Gear cartridge PCB

"Afterburner" SMS Cartridge PCB (ROM -bottom chip)

By using the **“AFTER BURNER”** cartridge PCB, your final Flash Cart will be only slightly larger than a standard Game Gear cartridge.



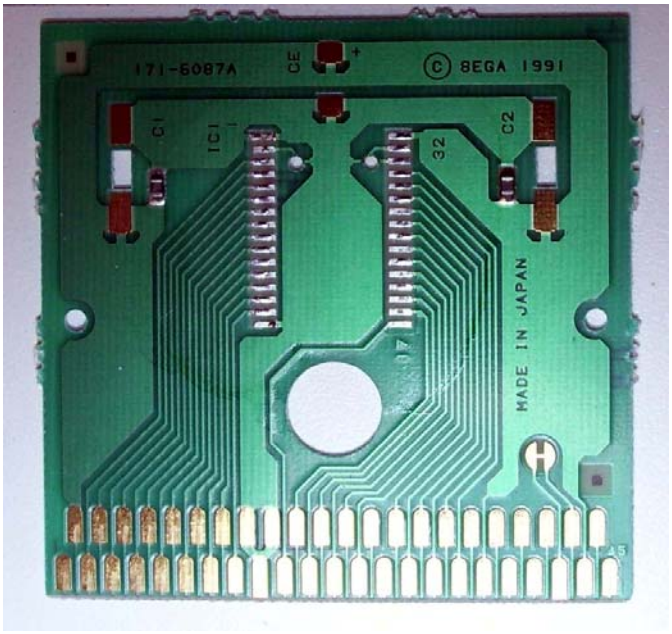
If you plan on running your own code on the GG (Game Gear) and you wish to have RAM support, you can also use the SMS cartridge PCB **“PHANTASY STAR”** which has integrated RAM and also a battery backup. Although, keep in mind that your Final cartridge will be larger in size.

Now, if you don't have access to a Special De-soldering Iron, the best way to remove the existing solder from the ROM pins is to use Rosin FLUX solution and copper Wire Solder wick. This is available at almost any Electronics Component store or even Radio Shack.

Coat the Copper Wire wick with Rosin Flux solution. When this wick then comes into contact with heated molten solder, it will chemically bond the solder to the Copper Wire wick. Just like metal to a magnet, it will attract the Solder away from the IC's PINs.

Some people call this ***“The wicking effect”***.

Once the de-soldering is complete, your cartridge PCB's should look similar to the images below.

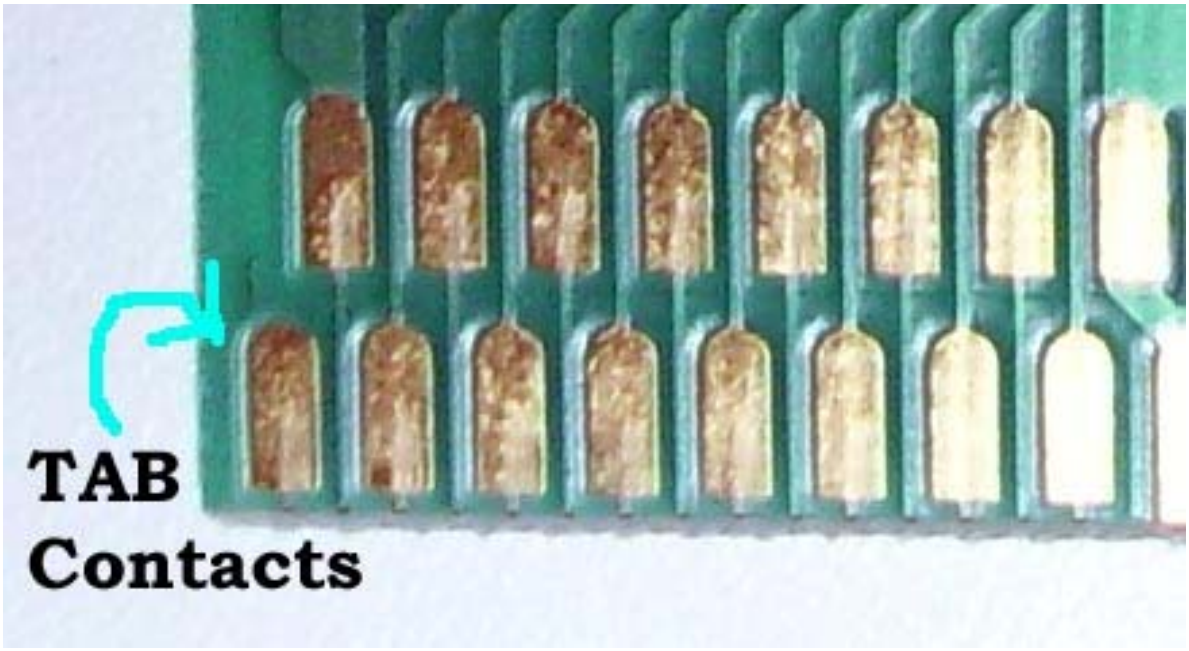


This PCB shown above is from the "Sonic the Hedgehog" Game Gear game Cartridge.

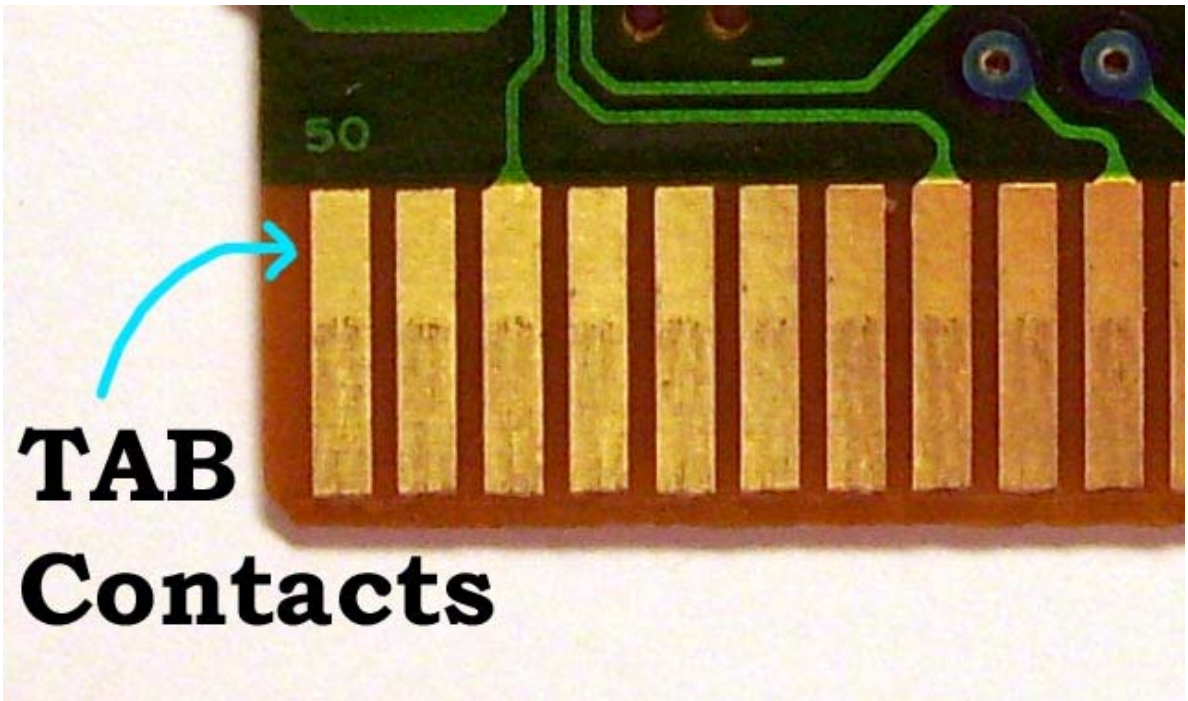
The PCB shown here is from the **"AFTER BURNER"** SMS game Cartridge with the 315-5235 Mapper chip. The standard filter Capacitors are not shown in the image above. There are usually two **10nF ceramic** capacitors and a single **47uF 16Volt electrolytic** capacitor (See Page 6). Replace the electrolytic capacitor with a new replacement. These capacitors serve to rid any voltage spikes or **"Noise"** that may occur on the data or address bus. These spikes can sometimes cause the loaded game to freeze. It is good practice to have a Filter capacitor connected between the **Vcc** and **Gnd** of your IC's pins and in close proximity.

Now for short, I refer to the contacts on the game cartridge PCB's as a "**TAB" a**nd I will refer to these contacts as such throughout this PDF guide.

SEGA Game Gear (GG) Cartridge PCB shown below:



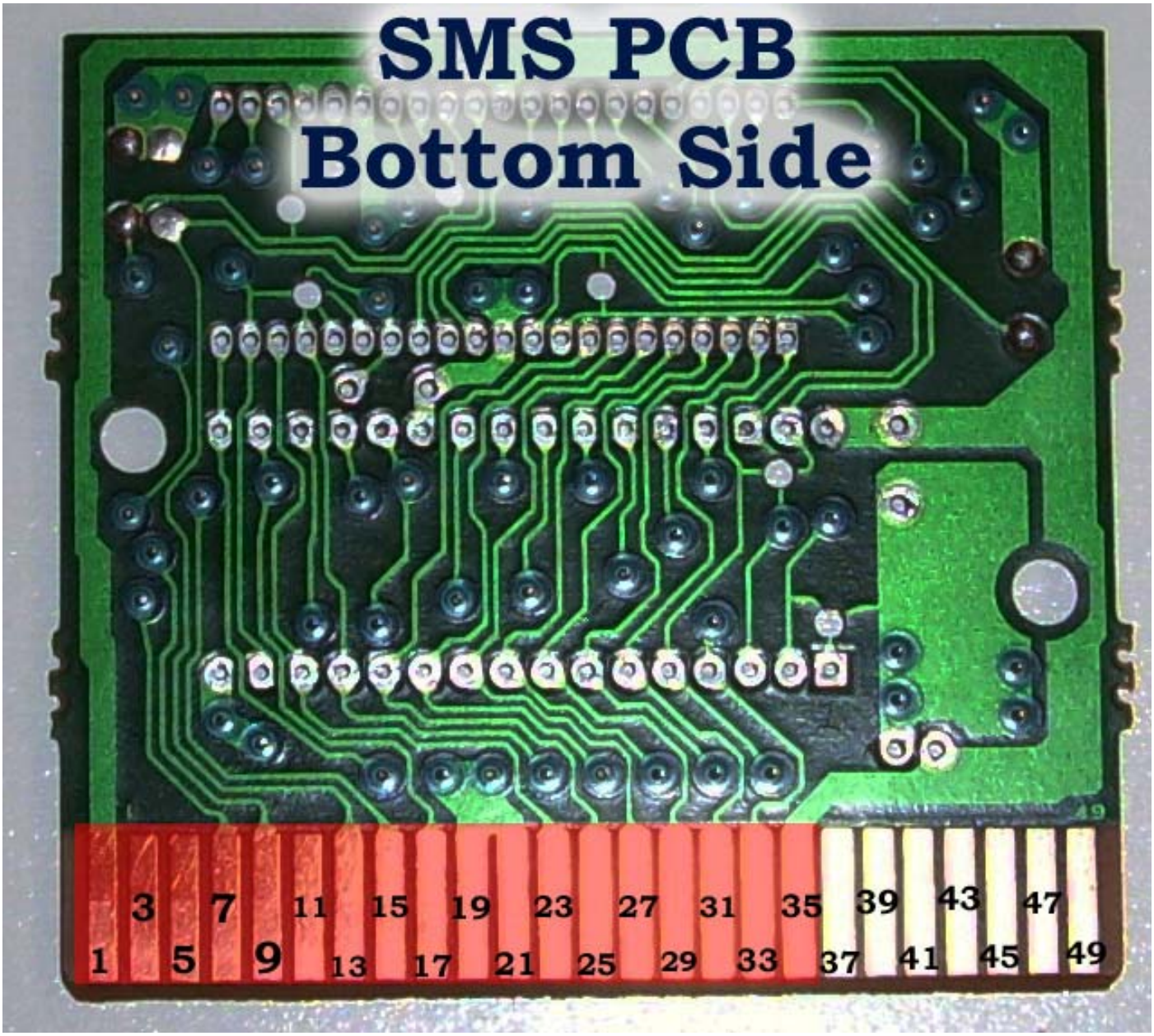
SEGA Master System (SMS) Cartridge PCB Shown below:

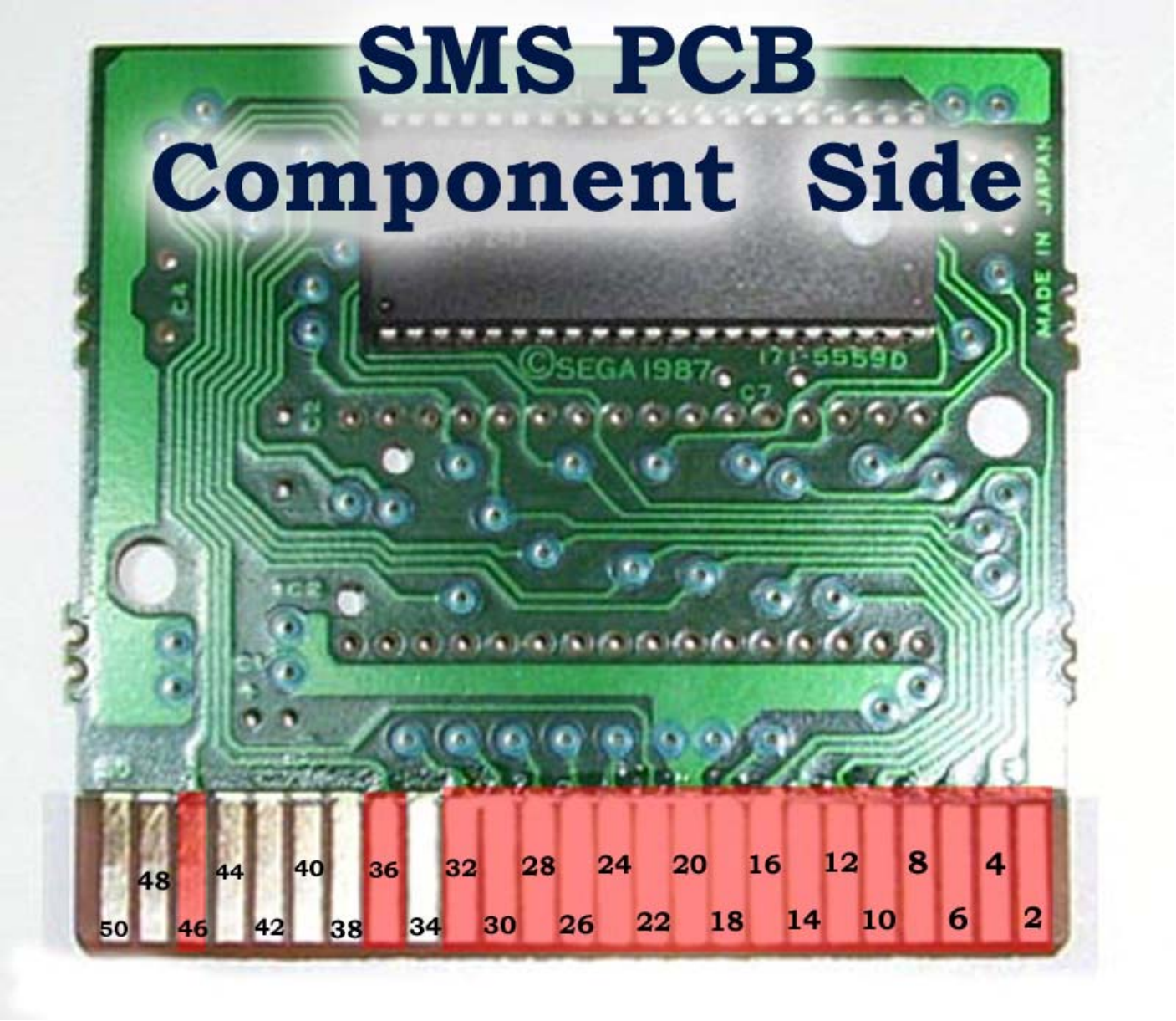


STEP #2:

Now we do not use all of the TAB contacts on the cartridges. You can pre-tin the SMS cartridge edge contacts (TABs) & the Game Gear ROM contacts which have all been highlighted in RED or by a RED square to show single solder points. ***See the Images below.***

Certain TAB contacts on the SMS cartridge PCB do not have any trace lines connected to them at all. Therefore we can omit soldering to these. Pre-coat all of the TAB contacts Highlighted in RED, with Flux and then apply enough solder to make a firm connection with the **"30 AWG"** size wire that we will be soldering to each of these TABs.




SMS PCB
Component Side
©SEGA 1987
MADE IN JAPAN
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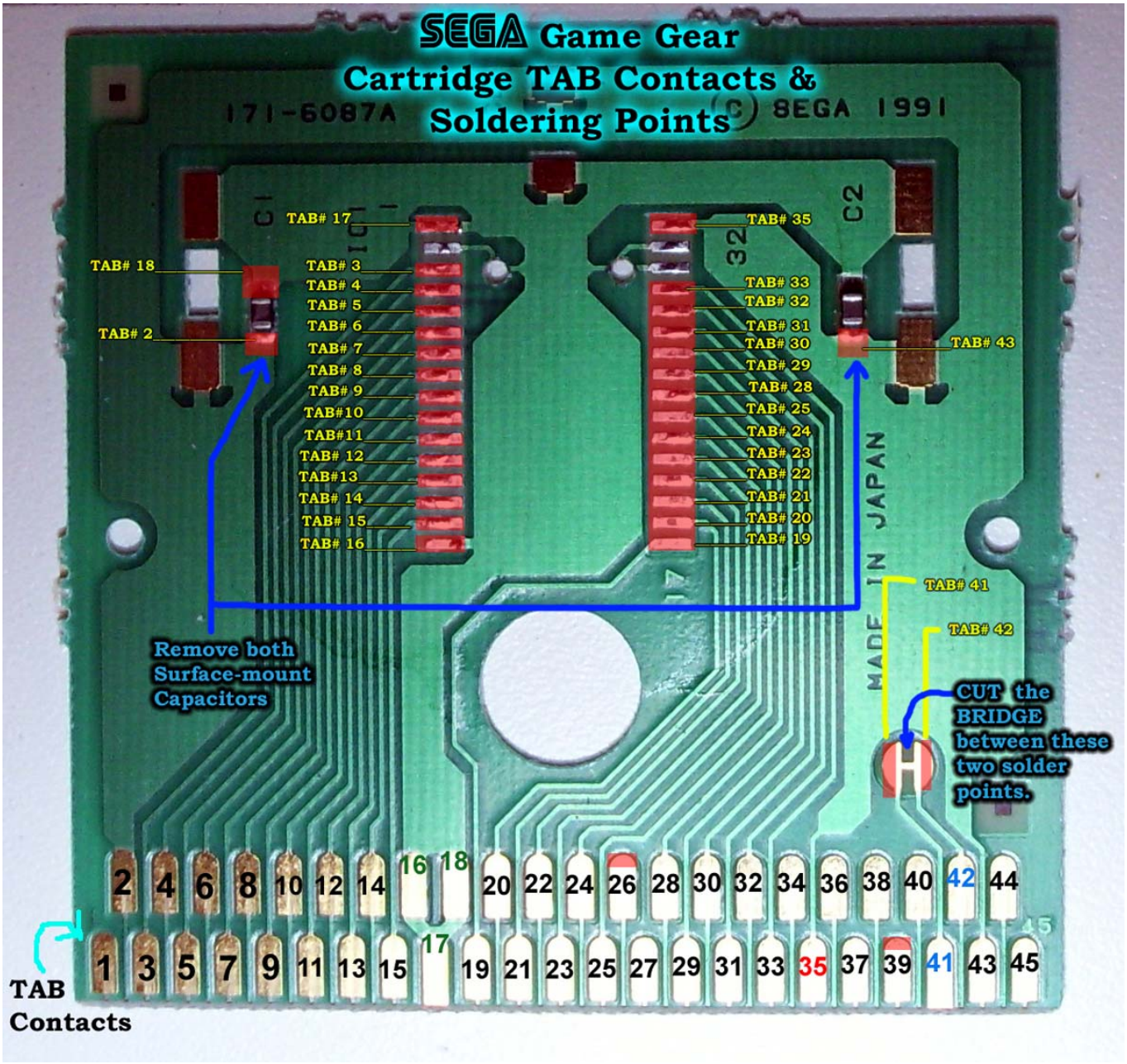


There are 33 wire connections in total that will be going from the SMS cartridge PCB, to the Game Gear PCB. You can use **"30 AWG"** wire or a ribbon cable if you wish. These connections form the Interface Bus between the two cartridge boards. Make sure to Pre-Tin or at least apply flux to the striped ends of your 33 sections of wire before soldering the interface Bus together. This is time consuming but worth it in the end. Performing this step will result in a clean and perfect soldering connection as opposed to those that skip this step. Trust me it's worth your while.

The next step is on the GG cartridge PCB; make sure to **cut** the trace bridge between the two contacts for TAB# 41 & 42 highlighted in the image above.

Also de-solder the two surface-mount ceramic capacitors labeled as C1 & C2. These are noise filter capacitors. We already have noise filter capacitors in place on the SMS cartridge PCB, so these are not required and should be removed.

To Strip the 30 AWG wire, use a wrap/strip tool similar to this one shown below by OK Industries. You can find these on eBay or at various Electronics component stores. EBay sells these for about $25.00 with free shipping within North America. See eBay Store http://stores.ebay.com/Goodtronic

Make sure your 33 sections of wire are about 3 Inches in length.

Step #3:

Now we can begin soldering the cartridge interface Bus. For this step, we need to match up the TAB contact numbers between the two cartridge PCBs according to the **"Cartridge Interface Bus"** wiring table shown on the following page.

Just to clarify, in reference to the TAB contacts on the Game Gear PCB, there are only two TAB contacts that we actually solder to **(TAB # 26 & 39).** The reason for this is because these TABs do not have any trace lines connected to them and there is no other point for us to make a soldering connection to them. All of the Game Gear TABs plug into the Game Gear cartridge Slot, so we don't want to clutter them up with too many wires and solder. We solder most of our interface wires to the equivalent ROM contacts which connect to the TABs via PCB trace lines.

Use the provided **"Game Gear cartridge TAB contacts & Soldering Points"** diagram on the previous page. I have labeled the ROM contact with their equivalent TAB # numbers.

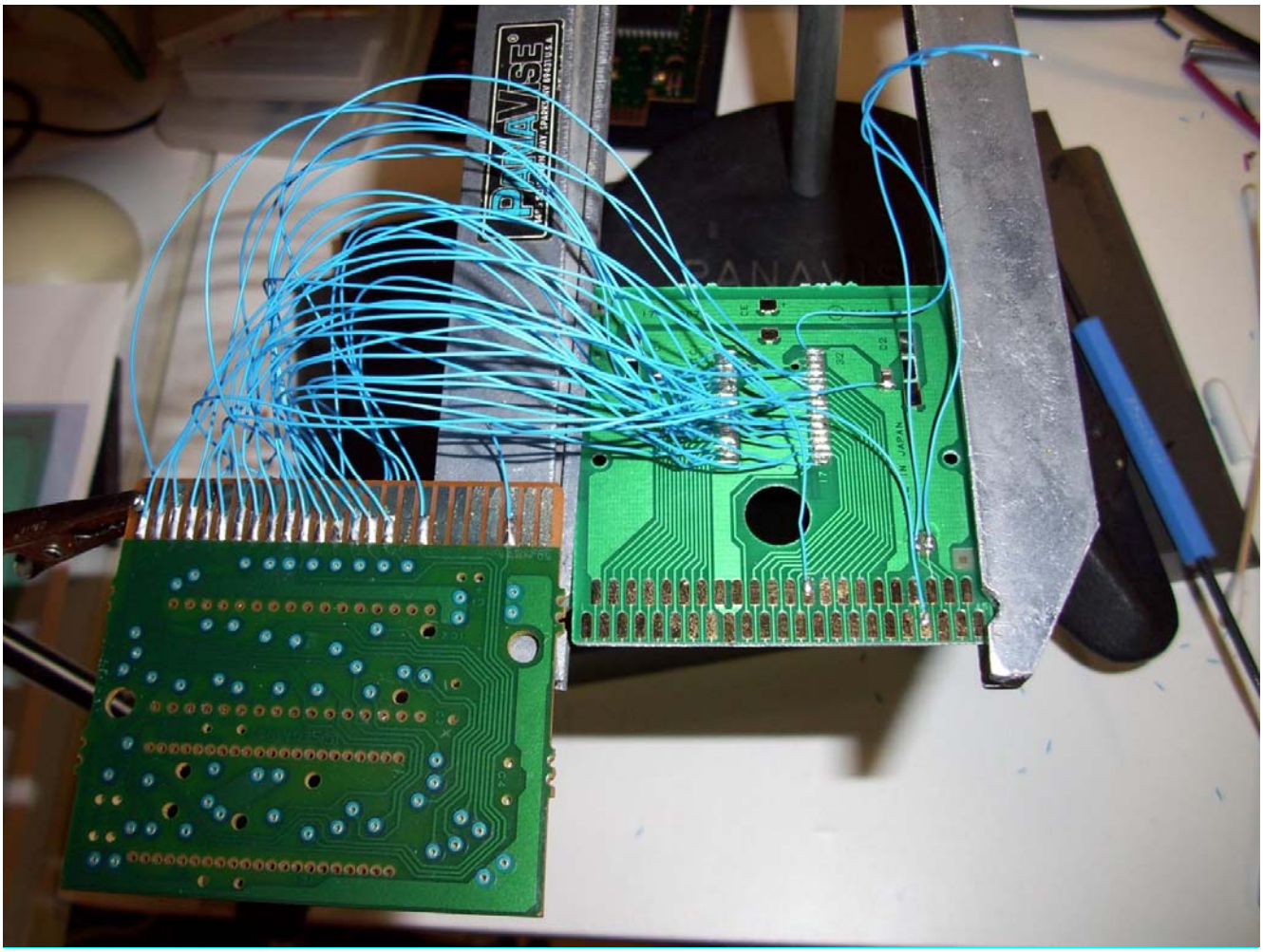
SMS to Game Gear
Cartridge Interface Bus

Game Gear Cartridge PCB TAB#		SMS Cartridge PCB TAB#
	Example: GG TAB #2 connects to SMS TAB #1	
Vcc	#2	#1
/WR	#3	#2
A12	#4	#33
A7	#5	#32
A6	#6	#31
A5	#7	#30
A4	#8	#29
A3	#9	#28
A2	#10	#27
A1	#11	#26
A0	#12	#25
D0	#13	#24
D1	#14	#23
D2	#15	#22
GND	#16	#21
GND	#17	#20
GND	#18	#19
D3	#19	#18
D4	#20	#17
D5	#21	#16
D6	#22	#15
D7	#23	#14
/CE	#24	#13
A10	#25	#12
/RD	#26	#4
A15	#28	#36
A11	#29	#10
A9	#30	#9
A8	#31	#8
A13	#32	#7
A14	#33	#6
Vcc	#35....Switch Vcc.....	
/RESET	#39	#46
GND	#41....Switch GND.....	
/GG	#42....Switch CENTER..	
/TV	#43	#35

GG N.C. TABs
1,27,34,36,37,38
40,

SMS N.C. TABs
3,5,11,34,37,38,39
,40,41,42,43,44,45
,47,48,49,50

Once you have completed soldering the PCB interface BUS together, your PCB's should look similar to the image below.



You'll notice on the GG cartridge PCB on the right hand side, there are three extra wires that have been left unconnected. These are for the toggle switch that will distinguish whether or not you are running the Game Gear in SMS mode or in GG Mode.

These three added wires give you a total of 36 wires soldered to your GG cartridge PCB.

The wire for **GG TAB #42** is connected to either **Vcc or GND** to determine the mode of operation. When **TAB #42** is connected to **GND** the Game Gear is in **GG mode**, and when connected to **Vcc** it is in **SMS mode**. So you can play both SMS & GG backup ROMs with this setup.

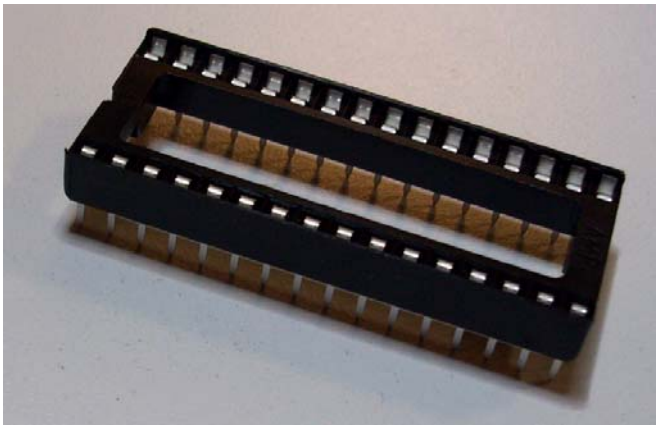
Use a permanent marker and place a ***single hash-mark*** on the end of the wire for ***GG TAB #42***. Then apply ***two hash-marks for Vcc*** and ***Three for GND***. We will need to identify these wires later when we connect the Toggle switch.

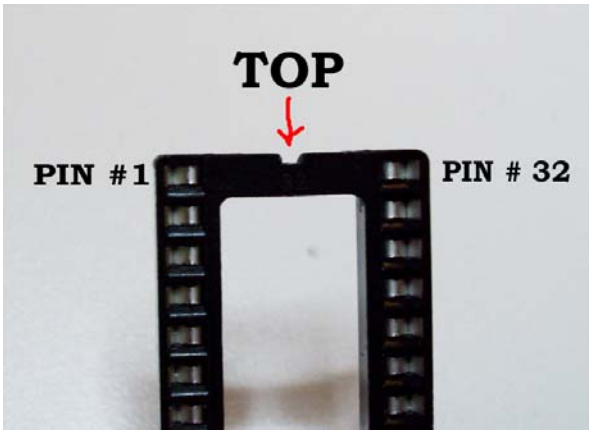
Step # 4:

Next, cut an opening on the top of a GG cartridge enclosure to allow the interface wires to pass through. I used a pair of cutters which did not cut very well. I would suggest using a Dremel Tool or a fine tooth saw. Using a pair of cutters is not as clean of a cut. As you can see in the images below, the plastic can crack and does not have a smooth edge. So keep that in mind when cutting the enclosure.

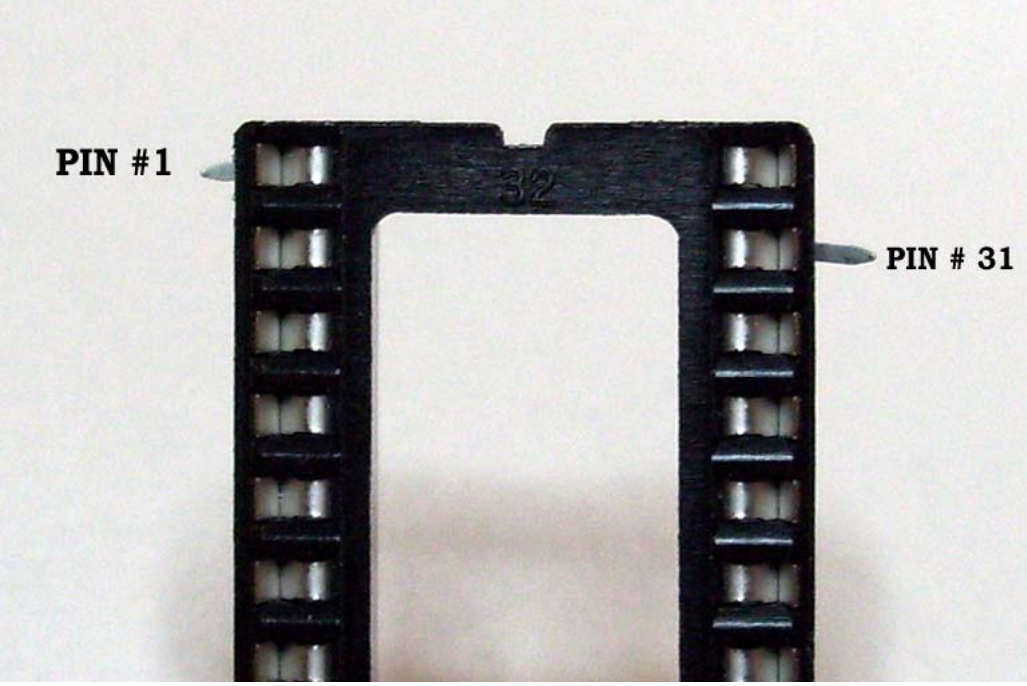
Step # 5:

The next step is to attach a 32 Pin Leaf socket to accommodate our ZIF socket which we will be using for attaching our flash chip after programming. The images below shows a standard 32 pin leaf socket, and you'll notice the indentation at the Top edge. This is present for proper Pin identification.

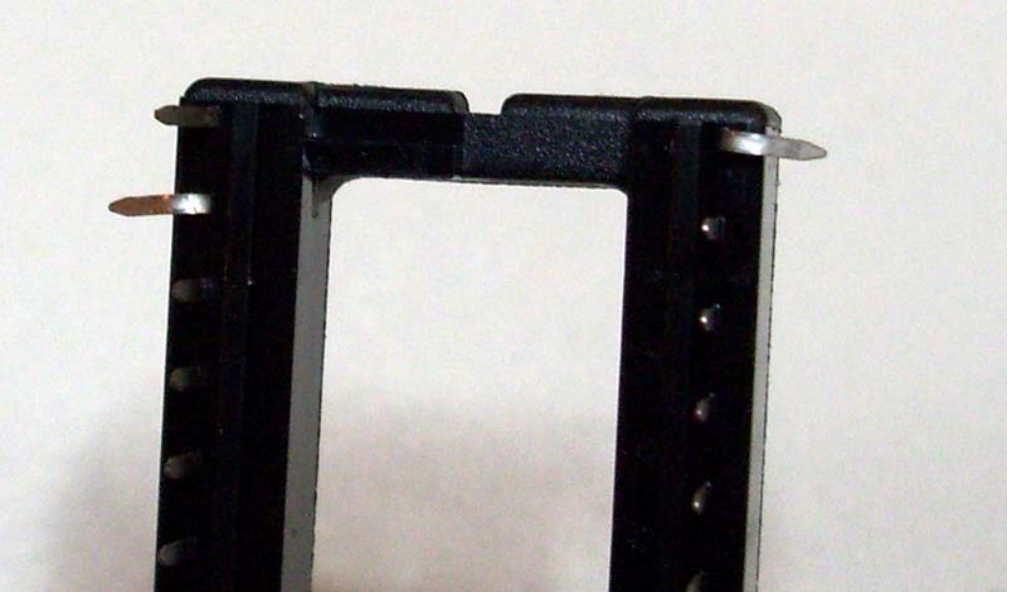




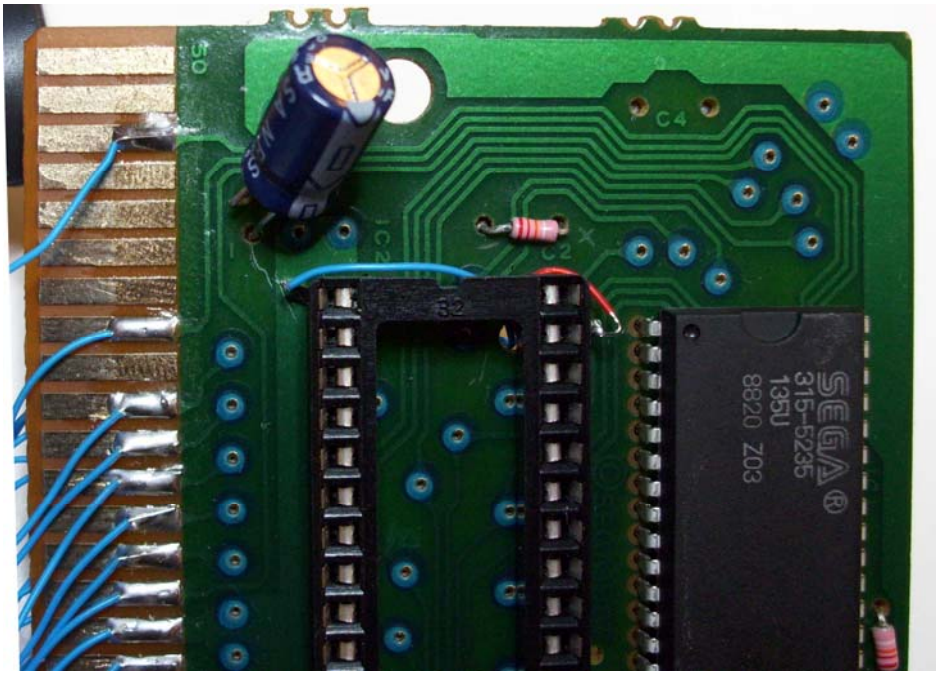
First bend the indicated pins on the leaf socket out to the sides as shown in the images below.
(ONLY Bend Pin Numbers 1 & 31)



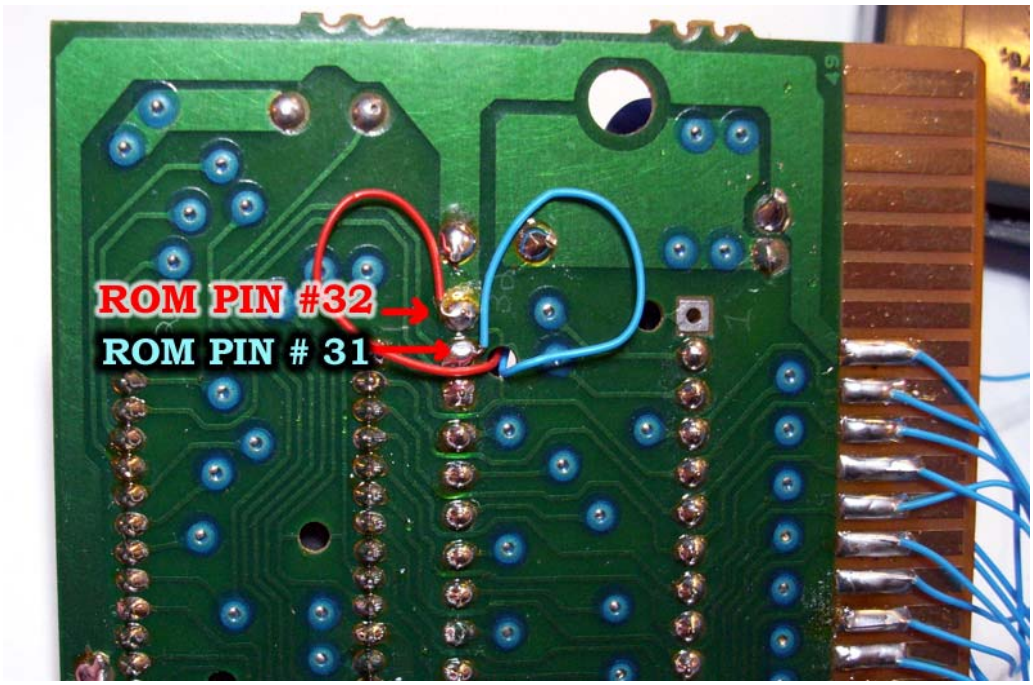
Back Side shown below:



Solder a Blue wire to PIN #1 & a RED wire to PIN #31. Push the Leaf socket onto the SMS PCB in place of the removed ROM chip as shown in the image on the following page. Make sure it is snug and is placed as close as possible to the PCB surface.



Just beside PIN# 31 of the leaf socket, there is a small hole in the SMS PCB. Loop both RED & BLUE wires around and under the leaf socket. Pass both wires through the hole so the wires come through to the solder side of the PCB as shown in the image below.

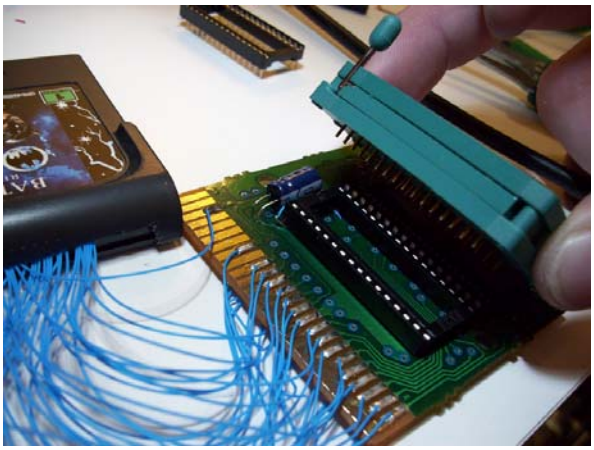


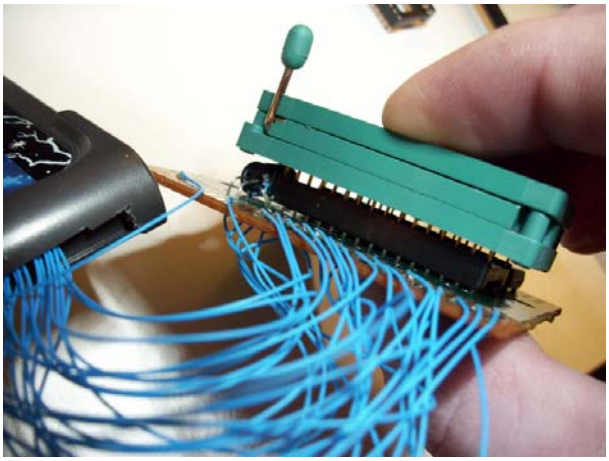
Next, solder the leaf socket in place and also solder the RED & BLUE wires connected to the Leaf Socket, to the ***"SMS PCB"*** ROM Pinholes #32 and #31 accordingly.

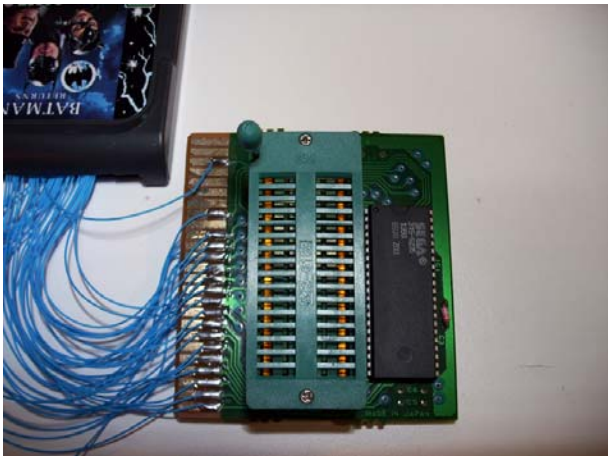
RED wire = PCB ROM Pinhole #32 Blue wire= PCB ROM Pinhole #31

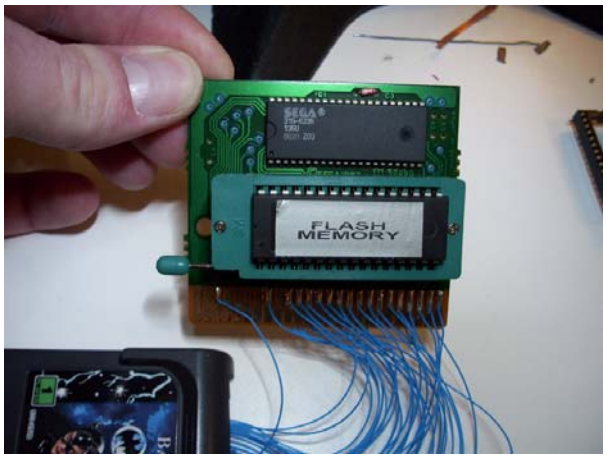
Step #6:

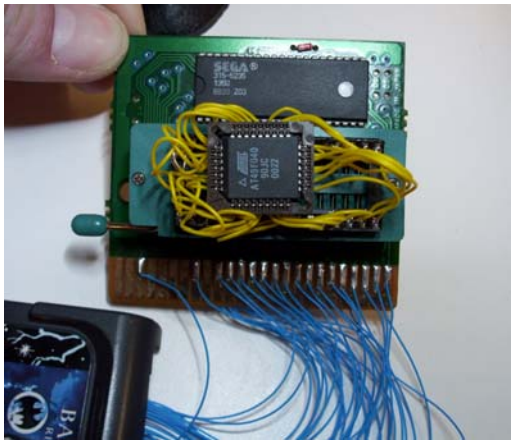
Now we must plug the 32 PIN ZIF into our modified leaf socket. Simply plug it in by pressing down firmly. Be sure your Leaf socket has been soldered as close as possible to the PCB. If not, you could damage the ROM Pinholes on the PCB when you are applying pressure. See the images below:







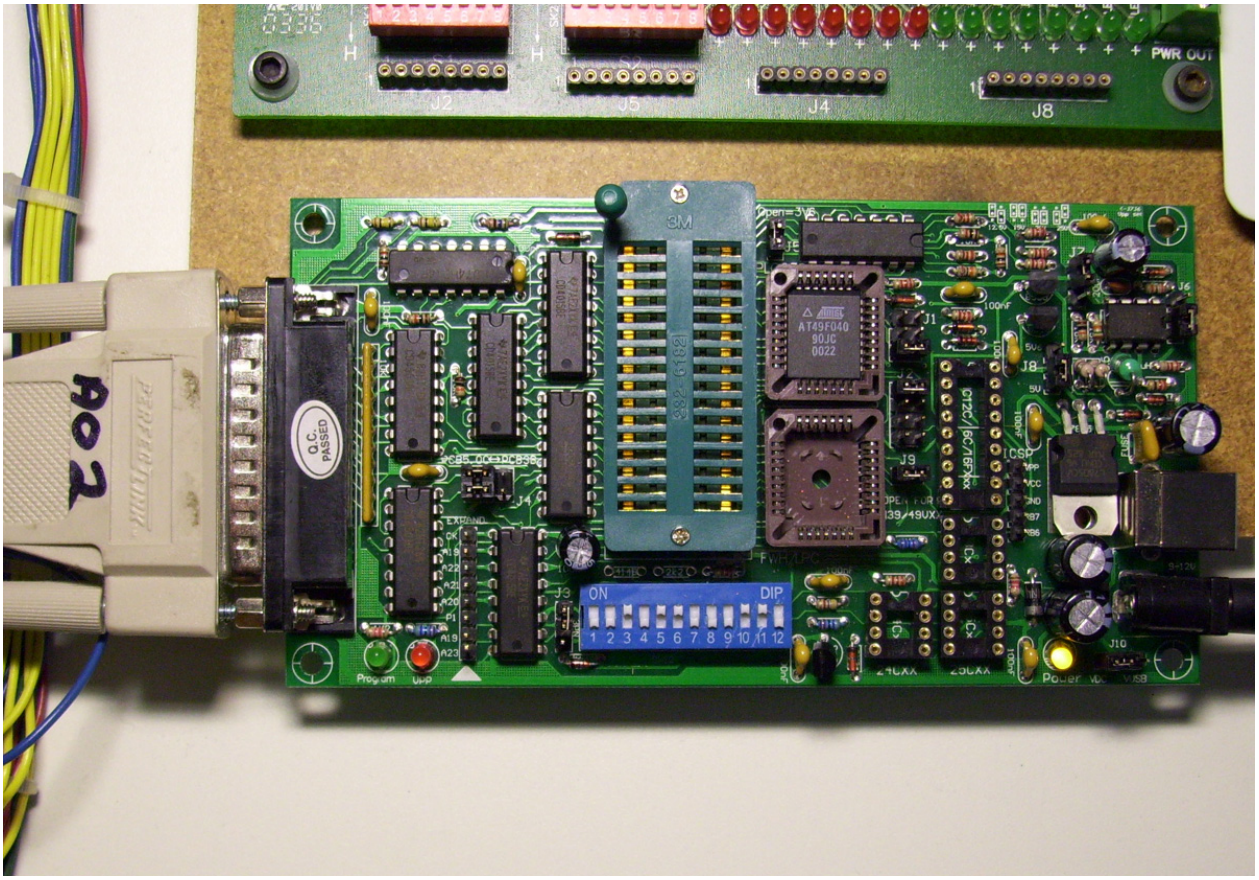




You can also use a "PLCC to DIP" adapter if all you have are PLCC-32 package chips.

STEP # 7:

It is best to test the Flash cartridge before we permanently attach the SMS PCB to the Game Gear Cartridge enclosure. To program our ***ATMEL AT49F040*** flash Chip, we must use a Universal Programmer such as the **"Willem Universal Programmer"** shown below. You can purchase the Willem programmer on eBay. The price varies between $30.00 and $50.00 Dollars depending on the seller.



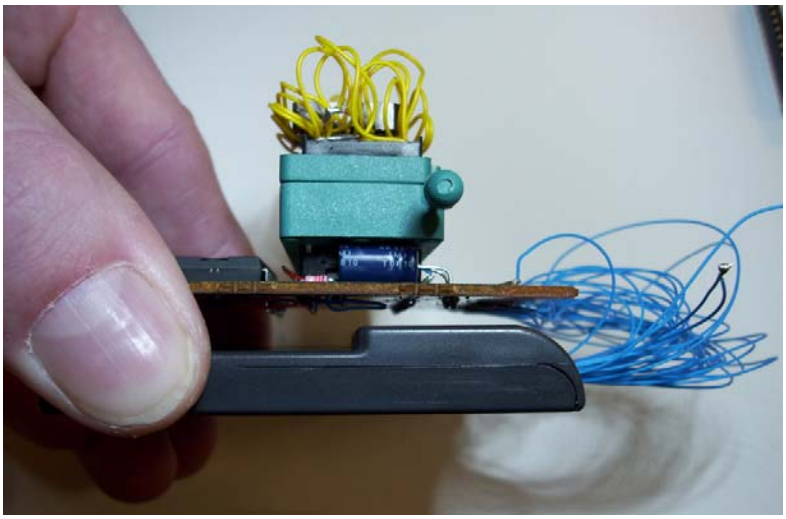
For Steps on Programming your ATMEL Flash chip refer to my accompanying YouTube Video at the Link below:

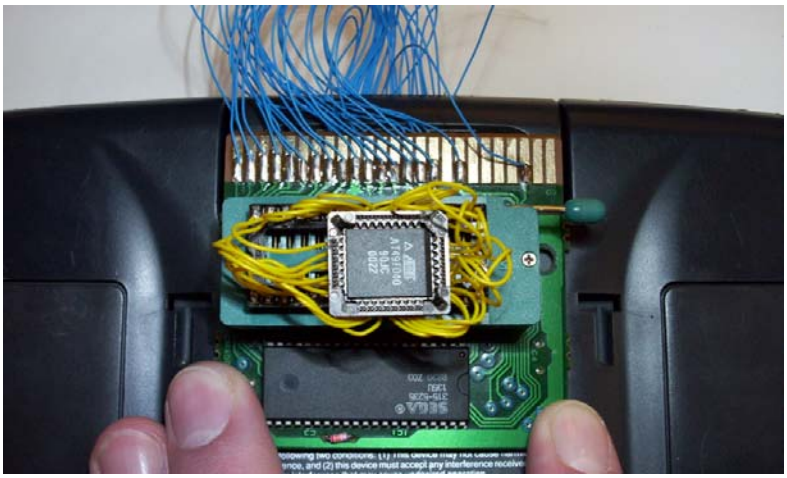
http://www.youtube.com/user/NLEproGUY#p/u/0/TNukYjpRieM

The video link above is Video Clip Part #5 of my Game boy Flash cart instructional video. The same Flash chip is used in both of these flash cart projects. ***(ATMEL AT49F040)***

STEP #8:

Once your Flash chip has been successfully programmed, lock it into your Flash Cart ZIF socket. Place the SMS Cartridge PCB overtop of the Game Gear Cartridge as shown in the image below. Proceed to plug the GG cartridge into the Game Gear console allowing the SMS PCB to rest on the backside of the GG enclosure while testing. Make sure you temporarily connect GG TAB # 42 & 41 together while testing a Game Gear backup ROM image.

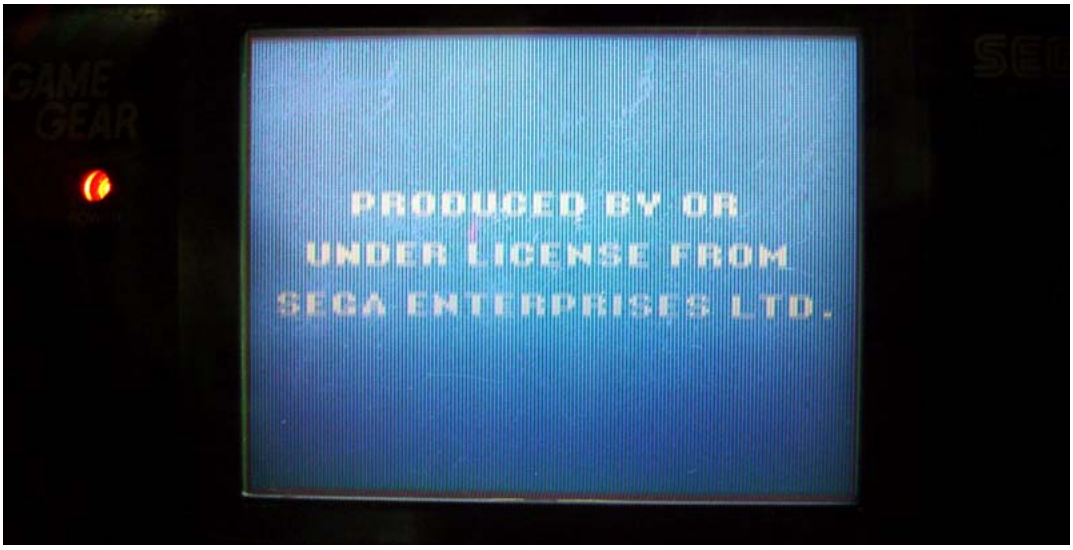




If by chance, you turn on the Game Gear and all you get is a Blank screen, try flashing your chip with a different ROM image. Remember, not all backup ROMs work with the 315-5235 Mapper chip. If you still have problems getting your data to load, chances are there is a short somewhere along the Interface Bus or possibly an intermittent soldering connection. In this case, I would suggest using a continuity tester or Multi-Meter and checking each wire on the interface Bus to confirm there are no shorts present. Also verify that your GG Cartridge TAB contacts are free of any dried Flux solution. This may prevent a solid connection between the TAB contacts, and the GG Cartridge Slot contacts. Use a contact cleaner solution, Flux remover or Isopropyl Alcohol to clean your TAB contacts if need be.

You can also try removing and reinserting the GG Cartridge two or three times. You will know that the ROM Data has been successfully loaded to the Game Gear when the screen displays the text **"PRODUCED BY OR UNDER LICENSE FROM SEGA ENTERPRISES LTD."**. This text is then followed by a **"SEGA"** Logo graphic as shown in the Image below:

First display:



Second display:

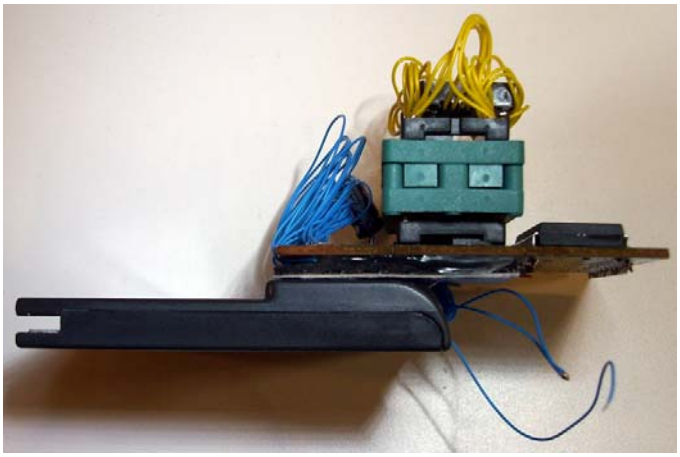
The SEGA logo may vary depending on the backup ROM being loaded. Once these screens appear, this is a sure sign of VICTORY! Your Cartridge is now working. All that remains is to secure the SMS PCB to the back of the GG cartridge enclosure and connect your Toggle switch to the appropriate wires. Some of you may wish to attach the SMS PCB to the Back side of your Game Gear permanently. Regardless, I will show you how I attached the SMS PCB to a standard GG cartridge enclosure.

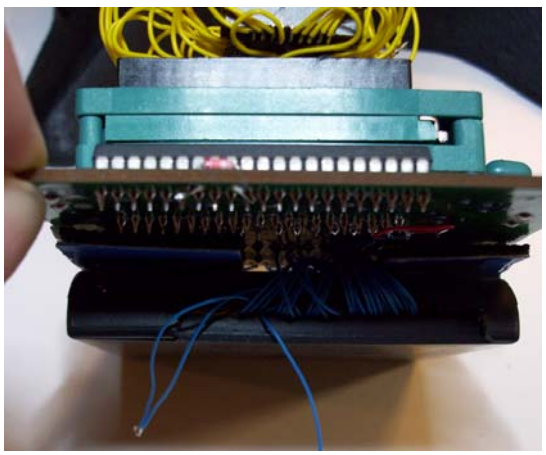
STEP #9:

Glue two strips of rubber padding to the top section of a Game Gear Cartridge enclosure. Using an old Mouse Pad is sufficient for this step. The gap between the two Rubber strips will provide room for the Interface wires to pass through. See the image below:

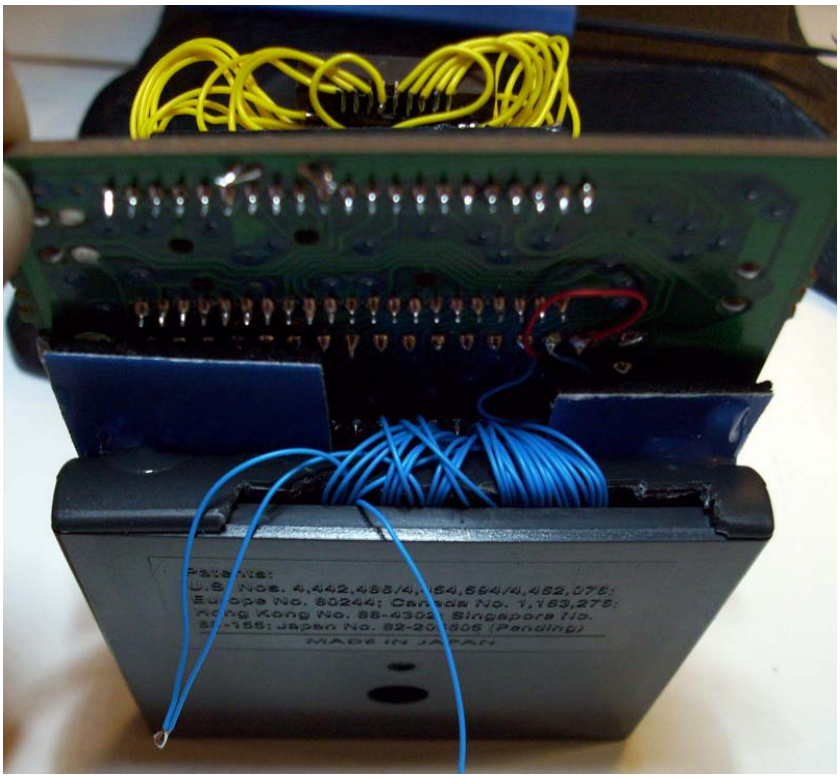
I recommend using a standard white glue gun for attaching the rubber pieces. **NOTE:** You could also cut the Rubber into a **"U"** shape which would then cover the entire solder side of the SMS PCB.

Once the glue has cooled, you can encase the GG PCB into its Enclosure. Lay the GG cartridge and SMS PCB down on the table with their components side facing up. Take the SMS PCB lift it up and place it on top of the two strips of Rubber allowing the Interface wires to pass between them. The Interface bus is now underneath the SMS PCB as shown in the images below.



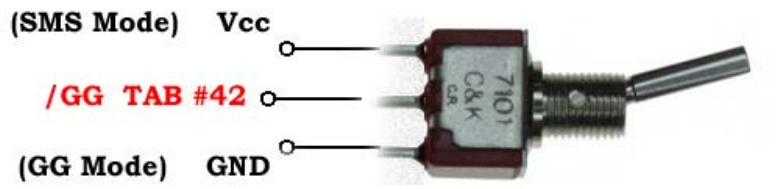


You can use a small amount of white glue to hold the SMS PCB in place, just make sure you don't glue any of the interface wires. This would be a disaster if you ever needed to fix a short.

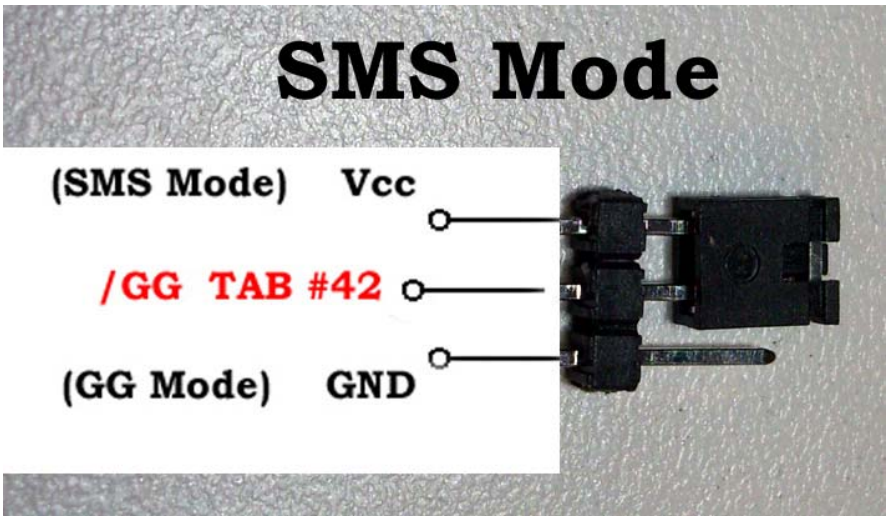


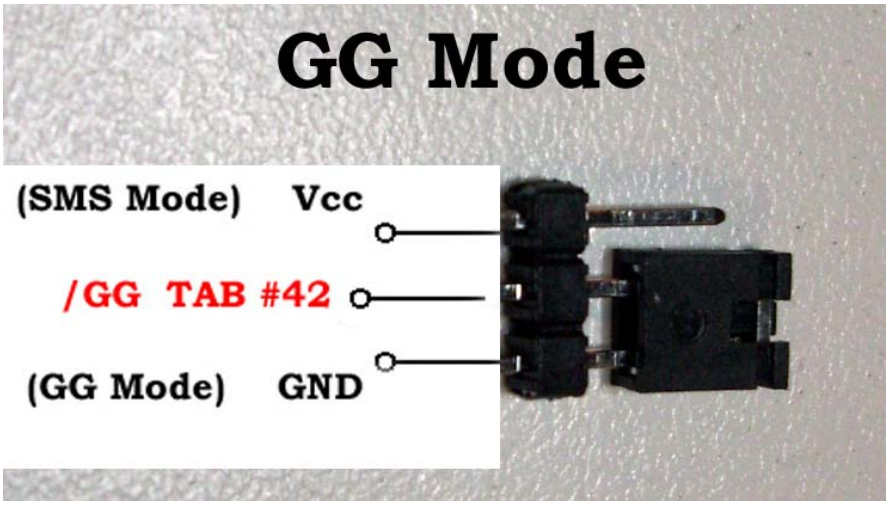
STEP #10:

The next step is to solder the Toggle switch to the three unconnected wires coming from the GG cartridge PCB. Solder the wire you marked earlier with the marker **(GG TAB #42)** to the center pole of your three pole Toggle switch. Next connect **Vcc** & **Gnd** to the top and bottom poles as shown in the image below:



You can also use Jumper pins as an alternative to the Toggle Switch.





STEP #11:

The last step is to simply attach the toggle switch to your Cartridge and then print off a Decal graphic for your GG Enclosure. An example image shown below:

So that's it folks! I wish you all the best in building your own SEGA Game Gear Flash Cartridges.

Kind Regards
Gerry O'Brien