



Game Boy Save Immortalizer (by @obskyr!)

The save file in a Game Boy cartridge is kept alive by a battery. Fifteen years or so after manufacture, that battery dies, taking your save file with it. Compatible with both Game Boy and Game Boy Color games, this mod fixes that for good – with the magic of non-volatile memory!

This comes with the kit:

- FM1808 (or, if N64 compatibility is unneeded, FM1808B or FM18W08) FRAM chip
- FRAM signal swizzler daughter board

In addition, you'll need:

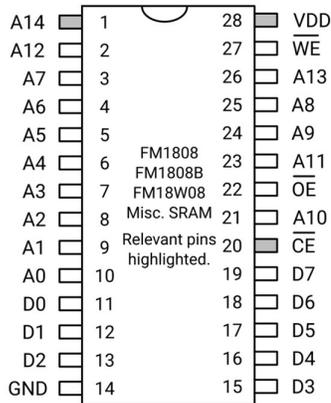
- A 3.8 mm line-drive (AKA "game bit") screwdriver
- Fine-gauge wire (e.g. wire wrap wire; around 0.05 mm² or AWG 30)
- Soldering iron
- Something that lets you desolder SMD ICs (e.g. a hot air station, ChipQuik™, etc.)
- Fine electronics tweezers
- A simple multimeter
- If you want to transfer an existing save file over, a ROM dumper (beware of third-party dumper compatibility issues; see step 10)

Not strictly necessary, but nice to have:

- Flux, e.g. a flux pen
- Polyimide (AKA Kapton™®) tape
- Solder wick
- IPA (that's isopropanol, not Indian pale ale)
- Cotton buds



Daughter board "pinout"



FRAM and SRAM pinout



Game Boy cartridge pinout

Instructions

There are two overarching steps: switching the memory chip, and installing the daughter board. But you get more detail than that! Ten steps may seem like a lot, but most of it is nitty-gritty specifics that you learn by heart as you go. You'll get it down pat before you know it!

- Most but not all games are compatible. To make sure that a game is compatible, check that the MBC chip on the cartridge's circuit board is marked "**MBC1**", "**MBC3**", or "**MBC5**".
 - If you want to keep an existing save file, **dump it using a ROM dumper** (e.g. BennVenn's Joey, a GB01, or a Retrode). If you have a way to write to FRAM chips directly (e.g. an F-Ramune; <https://github.com/obskyr/f-ramune>), you can at this point preemptively write the save to the FRAM chip you will use. If not, don't fret – it can be flashed back later.
1. Open the cartridge and locate its **SRAM chip**. This is typically the bottom left chip. Search for the chip number (e.g. "LH52256CN" or "W2465S") online to find its datasheet, and make note of the size of the memory: for example, a "32 × 8 bits" chip has a size of 32 KiB, and an "8 × 8 bits" chip has a size of 8 KiB. This information will be needed in step 8.
 2. **Desolder the SRAM chip** using your method of choice. My personal recommendation is:

1. For heat insulation, mask off the area around the chip using polyimide tape.
2. Flux the pins.
3. Grab the pins firmly but carefully on one side with a pair of tweezers.
4. Pre-heat the pins using the hot air nozzle from ~10 cm away for ~10 seconds.
5. While lightly (truly lightly – don't rip up any pads!) pulling on the tweezers, move the nozzle in close and back and forth along the pins until the chip comes loose.
6. Clean the pads with IPA on a cotton bud.



Switching out the SRAM chip.
See youtu.be/yuzGZnmYQLA for a video.

3. Find points to solder the wires to later. Cartridges' circuit boards vary from game to game, so you'll have to determine this yourself. The signals you will need to solder wires to are: the **cartridge's VDD**, also known as **5V** (pin 1 on the cartridge connector), the **cartridge's GND** (pin 32 on the cartridge), the **original -CE on the save chip** (wherever pin 20 of the SRAM was connected to), and **CLK** (pin 2 on the cartridge; often leads to the MBC). Good connection points for wires include:

- **Vias**. Insert the wire and solder it in as though the via were a through-hole.
- **Pins on the MBC**. Lay the wire on top of the pin and add a teeny-tiny bit of solder. This may take a bit to get the hang of – use flux and take care not to bridge any pins!
- If nothing else, the **pins on the cartridge connector** itself.

Finding the points involves following traces with your eyes, or using a multimeter in continuity mode (in which case you'll need to desolder the battery temporarily – continuity mode doesn't like the circuit being powered). Be mindful that the area immediately right of the save chip will be covered by the daughter board, so wires can't be soldered right there.

Selecting these points may not be trivial – see **page 4** for some illustrative examples! Make note of where the points you have chosen are.

4. **Solder in the FRAM chip** included in the kit. The video above details this step as well. My favored method is:
 1. Apply solder to the tip of a soldering iron and drag it across the pads to re-coat them.
 2. Flux the pads on the board and pins on the FRAM chip.
 3. Place the FRAM chip on the pads, taking care to orient it correctly (pin 1 is typically in the top left, pointed to by a little bare metal arrow on the circuit board).
 4. Once more, pre-heat the pins using from ~10 cm away for about 10 seconds.
 5. Move the nozzle in close and back and forth along the pins until the chip settles into place. It may help to set the hot air station to an air flow level high enough to effectively melt the solder, yet low enough not to displace the chip.
If all else fails, the chip can be taped down with polyimide tape.
 6. Flux the pins.
 7. Apply solder to the tip of the soldering iron once again, and drag it over both rows of pins to securely drag-solder them in place.
 8. Clean any flux mess you may have made around the pins using IPA on a cotton bud.
5. **Lift pins 20 and 28** of the FRAM chip (see pinout on page 1). This is easiest done by inserting the tip of one prong of a pair of tweezers underneath the pin, and lightly (once again, truly lightly!) levering it upward while heating the pad using a soldering iron.
6. **Remove the protective film from the double-sided tape** on the bottom of the daughter board included in the kit, and carefully slide it in under the lifted pins so that they line up with the VDD and -CE pads. Press down on the board to **stick it in place**.
7. **Lower the lifted pins** onto the daughter board and **solder them in place**.
8. If the SRAM size you sleuthed out in step 1 was 32 KiB, skip to the next step. **If the SRAM size was 8 or 16 KiB**, however, pin 1 is unconnected, which the FM1808 family is unequipped to handle. To avoid unreliability, chaos, and anguish, lift pin 1, slide a tiny piece of polyimide tape onto the pad, and **connect the lifted pin 1 to GND** with fine-gauge wire.
9. Solder 4 pieces of fine-gauge wire between the **free pads on the daughter board** and the **connection points you chose** in step 3. The examples on **page 4** may again help here! Afterward, clean the soldered areas well using IPA on a cotton bud if you should like.
10. If you want to keep an existing save, and didn't transfer it directly to the FRAM chip earlier, **use your ROM dumper to transfer it back**. Some ROM dumpers are buggy and won't play nice with the mod, but depending on the specific dumper, there may be a workaround (confirmed to work with the Retrode): if you desolder the CLK wire and temporarily put it on -CS (pin 5 on the cartridge connector), you may be able to transfer the save. Return it to CLK afterward, as -CS causes compatibility issues with genuine hardware in certain cases.
 - If the game uses a real-time clock, the battery needs to stay connected, but otherwise you can remove it completely (or, to preserve the aesthetics of translucent cartridges, desolder one side's tab and put some polyimide tape underneath).
 - If you soldered a wire to the cartridge connector, the cartridge may not close properly due to the bottom plastic wall of the top shell. Use a precision knife to cut out a small notch in the plastic that accommodates that wire.

And with that, you're done, and your game's save files are safe! Congratulations, and thank you for doing your part to make retro games more historically sustainable!

If you have any questions about any of the steps (or about anything, really) ask me anytime at @obskyr on Twitter, or send an e-mail to obskyr@obskyr.io. Enjoy!

Signals

Here are two examples of how the traces may be laid out. “-RAMCS” is synonymous with -CE. GND is pin 32 on the cartridge (the pin furthest to the right), and leads to a ground plane: connection points for GND may easiest be found by visually following the large islands of copper.



Installation Examples

For your convenience, here are a few examples of the mod in situ!



English Pokémon Crystal
MBC3, DMG-KGDU-10 board



Japanese Pokémon Gold
MBC3, DMG-KFDN-10 board



Japanese Pokémon Red
MBC1, DMG-DEDN-10 board