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SCARAB: Research Document

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# Introduction

## Abstract

The SCARAB device and accompanying program are retro game preservation tools designed to check the health of retro game cartridges, and manage their save data. The device, built around a microcontroller, interfaces with the cartridges via cartridge port modules. These modules can be swapped in and out, allowing for a variety of cartridge types, and providing future expansion options. The SCARAB device can auto-detect the inserted modules, and can detect whether a cartridge is inserted. The SCARAB program provides a GUI for the user to interact with. It provides options to dump and restore save data, run a full diagnostic checkup on an inserted cartridge, and run individual tests. It also serves as a save browser, allowing the user to view the save files they have dumped from cartridges.

## Overview

# SCARAB PC Program

## 2.1 Languages

## 2.2 Libraries

## 2.3 Layout

# SCARAB Device

## Microcontrollers

To serve as an interface between the cartridge port modules and the SCARAB PC program, some kind of microcontroller was deemed necessary. Microcontrollers are small computers on a single chip. They contain a processor core, RAM, and EEPROM, for storing programs to run. The purpose of a microcontroller is to manage a specific set of tasks within an embedded system, without the need for a complex operating system [1]. This is perfect for the SCARAB, as there are only a handful of tasks necessary, and a dedicated machine or Raspberry Pi would be excessive. The brand of microcontroller I had settled on was Arduino.

### Why Arduino?

Among the reasons for choosing Arduino, the main one was the variety of development boards. Several families of boards exist, such as Nano, MKR, UNO, Classic, and Mega, sporting over 30 different boards between them [2]. Given the sheer number of boards, and all their different configurations, there is sure to be a board suitable for the SCARAB. In addition to this, Arduino is inexpensive, has cross-platform support, and the software and hardware are completely open source. Choosing Arduino is not all that needs to be chosen, however. The most suitable board needs to be chosen, and in this case, it’s the Arduino Mega 2560 Rev3.

### Arduino Mega 2560 Rev3

A green circuit board with black and white text

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(Fig 3.1.2.1 – Arduino Mega 2560 [4])

Based on the ATmega2560 microcontroller, the Arduino Mega 2560 Rev3 contains everything needed to support the ATMega2560, including 54 digital I/O pins, 16 analog inputs, 4 hardware serial ports, a 16MHz crystal oscillator, USB connection, and a power jack [3]. The Mega 2560 was the perfect choice for several reasons. Due to the sheer number of I/O pins required for some cartridges, only boards in the Mega family of Arduinos would be sufficient. Within the Mega family, the Arduino Mega 2560 Rev3 is the only one powered by 5V; the Due and GIGA use 3.3V. Seeing as most cartridges use 5V, this was the ideal choice.

## Languages

## Game Cartridges

The SCARAB is intended to interface with many different cartridges through its module boards. The architecture of these cartridges varies, so measures must be taken on a system-by-system basis.

### Nintendo Entertainment System (NES)

Released in 1983 in Japan as the Famicom, and later in Europe in 1986 [5], the NES single-handedly saved the gaming industry. The cartridges, known as Game Paks (a recurring name for Nintendo), have since become iconic.

INSERT PICTURE OF GAME PAK INSERT PICTURE OF GAME PAK BOARD

Earlier games, such as Super Mario Bros, were simple to read and write to, as they contained 2 important chips: one containing 32KB of Program ROM, and the other containing 8KB of Character ROM. These were part of a board revision known as NROM-256 [6]. The problem with reading later cartridges comes from the introduction of “Mapper Chips”. These chips allowed the NES to bypass its 16-bit address bus limit, by swapping the currently accessible ROM data on the cartridge, allowing for much bigger games [7]. All but 20 games are covered by the Action 53, MMC1, and MMC3 families, so implementing the 256 registered mappers is not a goal of this project.

A screenshot of a computer program

AI-generated content may be incorrect.Figure 3.3.1.3 shows the pinout of the NES cartridge connector. Most of the important pins for this project come in the format “XXX YZ”, where XXX is either CPU (leading to Program ROM), or PPU (leading to Character ROM), Y is either A for address line or D for data line, and Z is the number for the line. Other important pins include the 5V and GND lines, M2 for the mapper chips, /ROMSEL, CPU R/W, PPU /RD, and CIC +RST (Reset).

(Fig 3.3.1.3 NES cartridge pinout [8])

### Super Nintendo Entertainment System (SNES)

### Nintendo 64 (N64)

### Game Boy (GB)

### Game Boy Color (GBC)

### Game Boy Advance (GBA)

## Electronic Components

### Bus Transceiver

As the GBA and N64 cartridges utilise 3.3V logic, as opposed to the Arduino’s 5V logic, some form of voltage lowering was required. The method of choice was the SN74LVC245AN Octal Bus Transceiver. The bus transceiver allows for bi-directional voltage modulation, converting 5V to 3.3V on one side, and 3.3V to 5V on the other. This feature lets the device function as a translator in mixed 3.3V and 5V environments [9]. These transceivers will allow the Arduino’s 5V logic to interface with the 3.3V logic of the GBA and N64 cartridges.

### Buck Converter

Not only do the GBA and N64 cartridges use 3.3V logic, but they utilise 3.3V VCC too. The transceivers would not work for the level of amps required, so a new solution was needed. This is where buck converters are introduced. Buck converters convert a DC voltage to a lower DC voltage, such as 5V to 3.3V in this case [10].

### USB-C Input Module

While the Arduino Mega 2560 has enough pins to interface with the cartridge, it doesn’t support the Amps necessary to also power the cartridge. Using a USB-C cable, the SCARAB could draw the power necessary from a USB port on the PC. While this will require 2 USB cables to be connected between the SCARAB and the PC, it’s preferable to the alternative of batteries.

### Cartridge Ports

The Arduino has many I/O pins, but cartridges can’t be inserted directly into pins. Cartridge ports are widely available, mostly known by their pin count. For example, the NES port is known as a 72-pin connector. These ports have pins which can be slotted into pin connectors, or directly into PCBs, which will be the case for the cartridge port modules.

### Resistors

Resistors are passive devices used to control the flow of current in a circuit. In addition to this, they can divide the voltage of a circuit [11]. Both are useful for this project. Controlling current flow helps to prevent damage to fragile components. The voltage division, however, will allow for the detection of the currently inserted cartridge port module. By using different resistor combinations on each module, the output of the voltage divider can be measured against a table of existing modules to determine the currently inserted one.

# Similar Products

# Conclusion

# Appendix

# Glossary

SCARAB – Save and Cartridge Aid Requiring Adapter Boards

GUI – Graphical User Interface

RAM – Random Access Memory

EEPROM – Electrically Erasable Programmable Read-Only Memory

I/O – Input/Output

ROM – Read Only Memory

# Bibliography

[1] Schneider, J. and Smalley, I. (2024). *What is a microcontroller? | IBM*. [online] www.ibm.com. Available at: https://www.ibm.com/think/topics/microcontroller [Accessed 10 Sep. 2025].

[2] Arduino (2022). *Arduino Hardware*. [online] www.arduino.cc. Available at: https://www.arduino.cc/en/hardware [Accessed 9 Oct. 2025].

[3] Arduino® MEGA 2560 Rev3. (n.d.). [online] Arduino. Available at: https://docs.arduino.cc/resources/datasheets/A000067-datasheet.pdf [Accessed 10 Oct. 2025].

[4] Arduino (n.d.). *Arduino Mega 2560*. Available at: https://store-usa.arduino.cc/cdn/shop/files/A000067\_00.front\_1000x750.jpg?v=1727102662 [Accessed 11 Oct. 2025].

[5] Nintendo (2016). *Nintendo History*. [online] Nintendo of Europe AG. Available at: https://www.nintendo.com/en-gb/Hardware/Nintendo-History/Nintendo-History-625945.html [Accessed 11 Oct. 2025].

[6] NESdev Wiki. (2024). *NROM*. [online] Available at: https://www.nesdev.org/wiki/NROM [Accessed 11 Oct. 2025].

[7] NESdev Wiki. (2023). *Mapper*. [online] Available at: https://www.nesdev.org/wiki/Mapper [Accessed 11 Oct. 2025].

[8] NESdev Wiki. (2023). *Cartridge connector*. [online] Available at: https://www.nesdev.org/wiki/Cartridge\_connector [Accessed 11 Oct. 2025].

[9] Texas Instruments (2015). *SN74LVC245A Octal Bus Transceiver With 3-State Outputs*. [online] *Texas Instruments*. Available at: www.ti.com/lit/ds/symlink/sn74lvc245a.pdf [Accessed 11 Oct. 2025].

[10] Yates, J. (2024). *Understanding Buck and Boost Converters and the Capacitors Behind Them*. [online] blog.knowlescapacitors.com. Available at: https://blog.knowlescapacitors.com/blog/understanding-buck-and-boost-converters-and-the-capacitors-behind-them [Accessed 11 Oct. 2025].

[11] Dahl, Ø.N. (2023). *What Is A Resistor And What Does It Do?* [online] Build Electronic Circuits. Available at: https://www.build-electronic-circuits.com/what-is-a-resistor [Accessed 11 Oct. 2025].