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REVERSE ENGINEERING ANALYSIS
SONY PLAYSTATION ONE CONTROLLER

❖ INTRODUCTION

Reverse engineering is a skill that can provide an engineer with a complete understanding of an artefact's functions, objectives and the manufacturing process. To achieve mastery of this skill, my team (Team Infinity) and I dissected a Sony Playstation One (commonly referred to as the PS1) controller to better understand how it was designed to be used to control movement on screen. The Playstation One controller acts as a communication device between the user and the main system. Its primary objective is to provide the user a layout of various easy-to-use buttons and joysticks so that, with a small learning curve, the user can communicate with the system almost instinctively. The team took a systematic approach to reverse engineering and scrutinized the artefact's many layers sequentially, starting with an examination of the external characteristics and then digging deep into the internal circuits and component layout.

Playstation One main system and a Dual Shock Controller

The objective of this report is to provide the audience with an understanding of our reverse engineering process for this specific artefact, and also to describe how the artefact functions. This will be achieved by presenting the reader with a detailed analysis of the product, its functionality description, and with a step-by-step dissection methodology.

❖ THE DESIGN

External

The Playstation One controller was designed to be held between the palms of two average sized human hands. When placed face-up on a flat surface, it is 15cm wide at its widest point and 13cm at its narrowest. It stands 6cm tall when measured from its lowest point to the highest (the top of the joysticks). Two grasping handles protrude down on either side, to be held between the palm and the lower fingers. The controller requires 5V to run, which are supplied to it via the main system.

A very elegant and ergonomic design

There are two types of Playstation One controllers found in the market, a standard controller and a Dual Shock controller. Our team dissected a Dual Shock controller which has 3 additional buttons and 2 joysticks, which are not present on the standard controller. 4 arrow-shaped plastic buttons are present on the Direction Pad (commonly known as the D-Pad), located under the left thumb. These buttons are all joined together to prevent the user from pressing 2 contradictory directions at the same time, but allowing the user to press 2 buttons at 90 degrees to one another. Another 4 plastic buttons are located under the right thumb and are known as function keys (also known as F-pad). These are labelled with 4 shapes (circle, triangle, square and X) in 4 different colours (Red, Green, Pink and Blue) for easy distinction. The F-pad keys are also spaced farther apart than the D-pad to prevent the user from accidentally pressing 2 or more buttons at the same time. 3 rubber-buttons, labelled start, select and analog, are located in the middle of the controller. The analog button turns on/off the analog feature and has a red LED light underneath for indication. The analog feature lets the user control a game using the 2 joysticks mounted just below the 2 key pads. The joysticks are mainly plastic, with a rubber top for better control, and can also be depressed down as buttons. On the shoulder of the controller are 4 additional buttons, labelled L1, L2, R1 and R2. These are controlled by the left and right forefinger, respectively. The functionality of each button on the controller depends on each game's configuration and set-up.

Etched information and screws on the back.

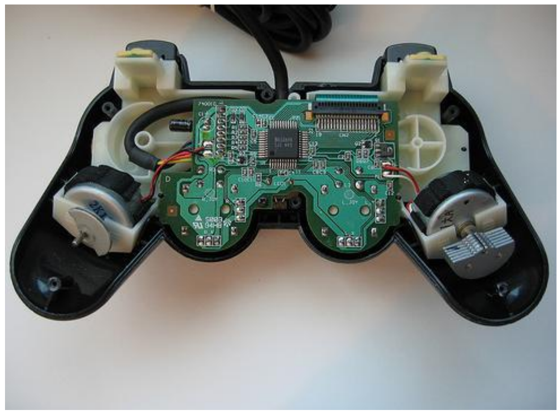
The overall external design of the controller is very smooth, with rounded edges on all buttons. The plastic used for the casing appears to be hard and very resistant. Playstation and Sony logos are printed on the front of the controller, and technical information about the device is etched on the back. Seven 7mm Philip treaded screws can be found embedded deep inside the back casing for easy opening. The chord extending out of the controller is 193cm long and is rated for 60 degrees C. The connection port at the end of the chord is stamped with a CE (European standard testing) symbol. The port has 9 male pins that are plugged into 9 female pins on the main system. The layout of the nine pins is:

1. DATA – Carries the information about a pressed button from the integrated circuit to the main system. It uses an 8-bit stream.
2. COMMAND – Carries signal from the main system to the controller, commanding it to perform certain tasks. It also uses an 8-bit stream.
3. Not used
4. GROUND
5. POWER – The main system provides the controller with 5V through this pin.
6. SELECT – Used to notify the controller of incoming signals.
7. CLOCK - Synchronizes the controller and the main system.
8. Not used

9. ACKNOWLEDGE – Acknowledges any signals received from the system immediately.

Internal

The inside of the controller consists of 4 main components, a main printed circuit board, a circuit foil and 2 motors with unbalanced weights on either handle. The main circuit board lies on top, and contains an integrated circuit and a connection for a 16-pin ribbon cable which connects the main circuit board to the inner circuit foil. 2 wires, red and black, extend from the main board to the 2 motors. A screw holds the outer circuit board firmly in place over the inner foil. The circuit foil has 2 lines of conductors drawn on it, which pass under each button. 2 rubber meshes with metallic bottoms are placed under the D-pad and the F-pad. The shoulder buttons are attached to 2 smaller foil circuits, which are then attached to the larger foil circuit. The top 2 shoulder buttons are attached to the top cover, however, their circuit foil stays in the lower cover with the other circuits and the lower shoulder buttons. The 2 joysticks each are connected directly to the main circuit board via their metallic cubic housing. The joysticks are held in place by a metal harness, and move 2 circular disks in each axis when moved. Since the joysticks also act as buttons, they are also attached to 2 tiny buttons in their metal housing. Each button in the controller has its own uniquely shaped slot which makes it extremely easy to reassemble.



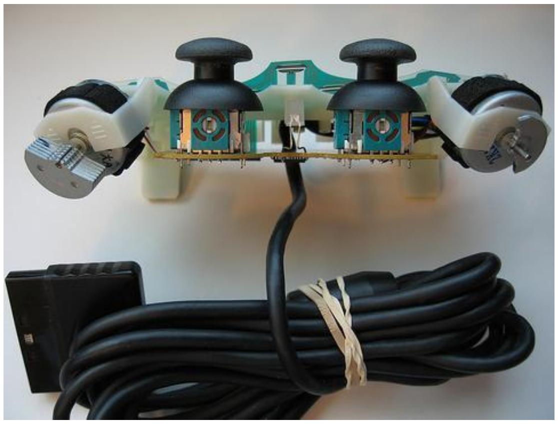
The Printed Circuit Board with an Integrated Circuit, 16-pin ribbon connection and motors

❖ FUNCTIONALITY

The Playstation One controller makes use of some basic electrical circuits to provide the user with various ways to interact with the main machine. All the buttons on the controller take advantage of some basic principles of electricity.

When the user presses a button, he/she forces the mesh under it to come into contact with the conductive lines on the circuit film. This bridges the gap between the 2 strips and provides a conductive path for current to flow through. The integrated circuit quickly records this change in electricity in the circuit and converts it to a language the main system can understand (8-bit serial streams). The main system sends out sample signals to the controller 60 times a second via the second pin on the connector. When the sample signals reach the integrated circuit, it acknowledges the command by

The Printed Circuit Foil, Joysticks and motors sending a signal via the ninth pin back to the system and sends the information about the changes in circuit current back to the main system via the first pin on the connector.



Joysticks, variable resistors and motors

The analog joysticks work in a much different way. They take advantage of variable resistors (more specifically, potentiometers) to detect changes made by the user. Electric current is always flowing through the variable resistors. When the user pushes the joystick in any direction, the variable resistors alter their resistance, affecting the amount of current flow. The Integrated circuit, once again, detects these changes, converts them into a language the main system can understand, and sends the information.

One major objective of Dual Shock controllers is accomplished by making use of some very simple design ideas. To create a rumbling effect, Dual Shock controllers make use of 2 motors mounted tightly into each arm of the controller. These motors have unbalanced weights attached to one side. When the integrated circuit receives a signal from the main system to cause a rumbling effect (once again via the second pin), the integrated circuits opens the gates to let current flow through the motors. As the motors turn, they cause the weights at their ends to rotate as well. Since the weights are unbalanced, and since the motors and weights are securely connected on the inside, the controller is jerked in various directions, creating a rumbling effect.

- **DISSECTION METHODOLOGY**

The dissection of the artefact was done according to an initial systematic plan. The first step was to analyze, in as much detail as possible, the external design of the controller. The button layout, connection plug and chord, materials and the design were all analyzed and described. Once satisfied with the depth of the external analysis, the team proceeded to open the controller. 7 screws were unscrewed from the back cover and the controller was opened. The next step was to examine the internal layout and identify as many immediately apparent design details as possible. Once this had been done, we proceeded to look more carefully at the main printed circuit board, where an integrated circuit and a 16-pin ribbon connection were immediately identified. After scrutinizing the main board for several minutes, the team proceeded to unscrew the only screw on the inside of the controller and look under the main board at the printed

All the internal components connected.

circuit foil. The printed foil was studied and drawn, and its functionality was debated for a few minutes, after which the team proceeded to take a closer look at the analog joysticks and the motors. The joysticks were extremely difficult to analyze because of their protective metal housing and harness, however, after much research and debate, its functionality was derived. The motors were, comparatively, much simpler, and their functionality was apparent instantaneously. The last step was to study the button layout from the inside, and all the buttons were removed from their slots and compared according to size, shape and material used.

After the artefact had been satisfactorily dissected, described and explained, the team proceeded to put it back together to ensure no parts had been missed in our analysis.

❖ **PARTS LIST**

- **Joysticks** – Plastic body, Rubber tops.
- **Buttons -** 3 rubber, 12 plastic.
- **Circuits** - Circuit foil film, Printed board plastic, rubber.
- **Motors -** Metal, metallic weights, foam covering.
- **Meshing -** 3 rubber meshes, metallic bottoms.
- **Casing** – Hard, resistive plastic, metal treaded screws.
- **Chord & Connector Plug** - Rubber, plastic.
- An LED.
- A 9-wire connector.
- A 16-pin ribbon connector.
- At least 9 capacitors with at least one 22uF Capacitor @ 6.3V.
- At least 10 resistors.
- At least 4 variable resistors with at least 2 matching pairs.
- A 44-pin Integrated Circuit
- At least 3 separate single logic gates.

Buttons [Front]

Buttons [Back]