Reverse Engineering Online Challenge 2022

Disassembling and Analyzing an AIWA HS-J36 Walkman

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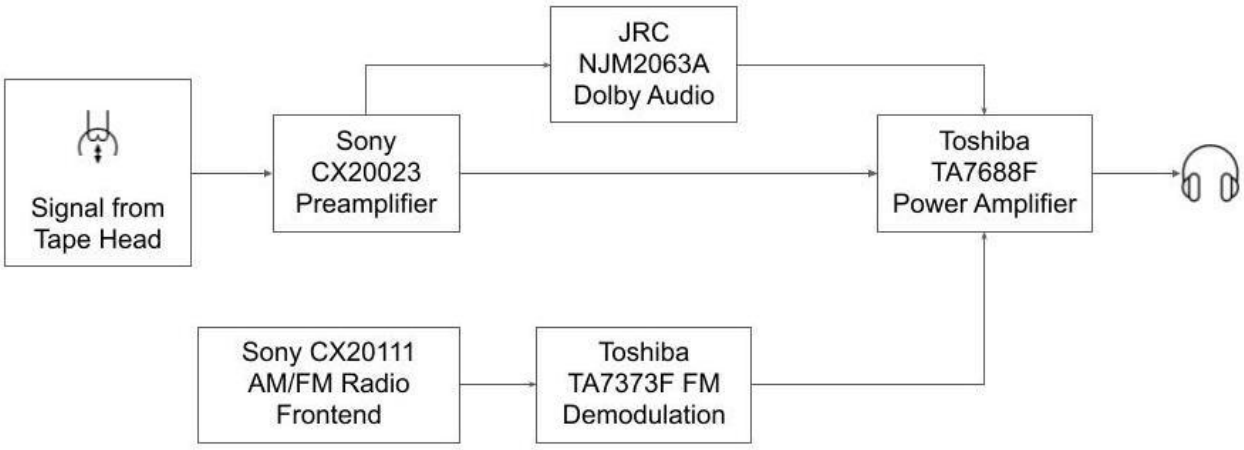
Summary Report

For this project, we chose to disassemble a cassette walkman. Walkman is a brand of portable audio players made by Sony. The original Walkman was a cassette player introduced by Sony in 1979. Walkman was popular in the 80s and 90s, and became a generic word that refers to all similar portable audio players. We decided to choose the AIWA HS-J36 walkman for this challenge because Ayden found it in his dad's workshop. Even though it stopped working, we were curious to see how a personal audio player played music 30 years ago. Ayden's dad happily agreed.

The walkman we have disassembled was made by AIWA, another top brand. At the time, model HS-J36 was one of the high end products because it not just played the audio from the tape, it could also play tape reverse, so the user did not need to take the tape out and manually flip it. It had AM/FM radio, Dolby audio noise reduction, and could record audio to tape.

We wore safety glasses and took precautions during the whole disassembling process, especially when some wires needed to be disconnected with soldering iron. A multimeter and magnifier was helpful to identify the surface mount components, since some of them looked very similar. We had identified components such as IC chips, capacitors, inductors, resistors, diodes, transistors, etc. Unfortunately, no TI chips were found. While researching, we learnt that typical electronic systems consist of input signal, output signal, and the process of the signal depends on the system's function. Despite its age, we were able to find datasheets for most of the IC chips, and figure out their functionality to develop the diagram below:



There were a fair amount of capacitors and inductors, which we think are because the device supported AM/FM radio and microphone for recording. Capacitors and inductors are widely used in tuning circuits of radios that isolate electromagnetic radiation of selected frequencies and reduce noises. Another interesting finding was that a separate Dolby audio circuit board was connected to the main board with wires. We wondered if it was badly designed, and cost more to make. After more research and discussion, we concluded that it was intentional. AIWA

could use the same PCB for different models without the Dolby audio feature, which would actually reduce the production cost.

What made the AIWA HS-J36 reversing engineering particularly interesting was its complex mechanical structure. With widely used SMD technology, the compact device could pack around 280 components in the palm-sized box. Nowadays, we can listen and watch digitized content streamed directly from the internet on phones and tablets. Because of this, we were fascinated by how fast technology is changing over the years. Before the challenge project, we were not even aware that to listen to music years ago, people needed to carry a heavy device with a tape and motor spinning inside. It'll be interesting to see what our next personal device will be, maybe everyone will wear a lens.

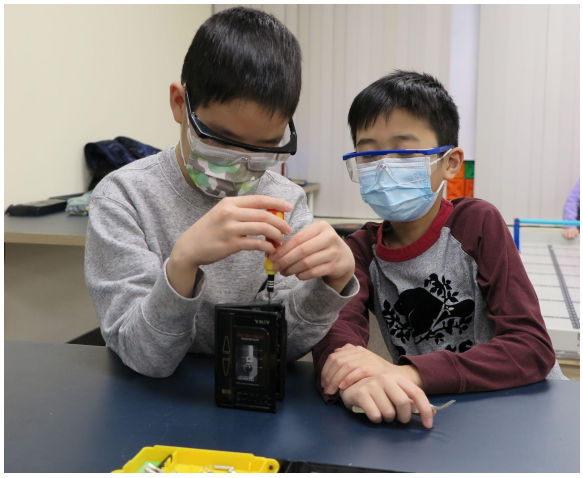
Word Count: 498

Disassembly Process

To disassemble the AIWA HS-J36 Walkman, first the battery door and the batteries needed to be removed. The front door could also be opened, but only for inserting the cassette tape (Figure 2.1).

Figure 2.1: Front Door

The majority of the side and back of the device were covered by the back cover, which were attached to the body with screws. The switches were still attached to the cover body. The functions of the switches were: Dolby Sound on/off, Pause, Tape Type Selector, and Radio on/off (Figure 2.2).



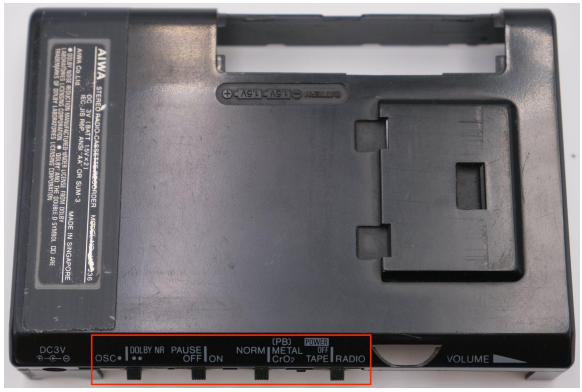


Figure 2.2: Back Cover and Switches

The back of the main circuit board was uncovered inside. On one side of the board there was the DC 3V external power socket, the four switches, and volume dial (Figure 2.3). On the other side there was the battery mount (Figure 2.4). 2 size AA batteries were needed to power the device.

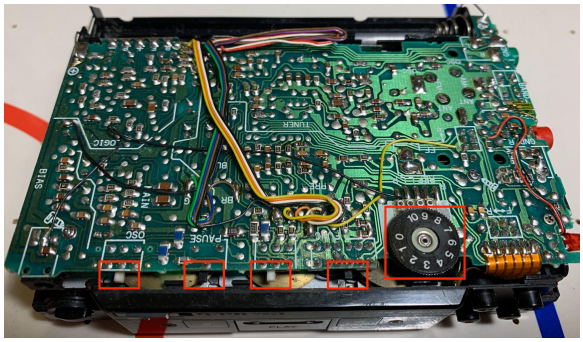


Figure 2.3: Main Circuit Board 1

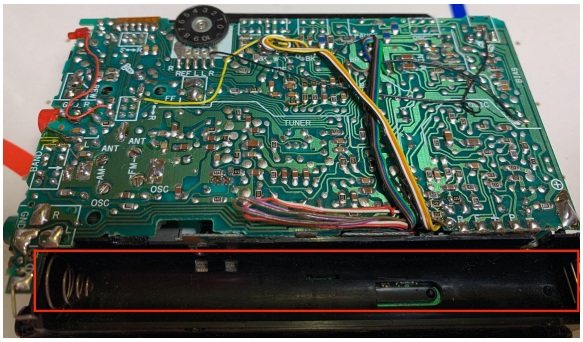


Figure 2.4: Main Circuit Board 2

On top of the circuit board from left to right there was a power LED light, internal microphone, 3.5mm audio socket for line-in microphone, radio antenna, AM/FM radio switch, and 3.5mm audio socket for headphones (Figure 2.5).

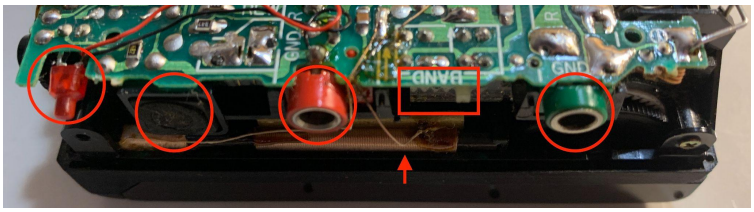


Figure 2.5: LED and Headphone socket

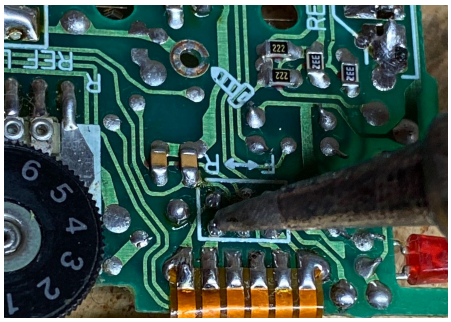


Figure 2.6: Using soldering iron to remove wires

The main circuit board was attached to the mechanical chassis with screws and there were wires that needed to be disconnected with soldering iron (Figure 2.6). Once flipped over, the front side of the board with all the electronic components could be seen (Figure 2.7).

We also found a worn-out rubber belt which explained why the walkman stopped working. The rubber belt was meant to connect the motor with all the wheels to create a pulley and drive the tape movement.

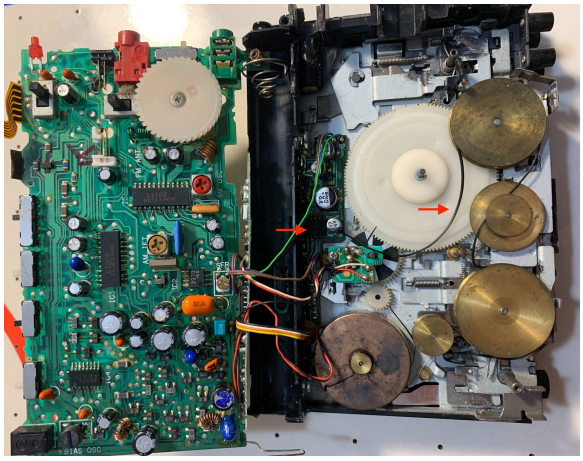



Figure 2.7: Main Circuit Board and Chassis

There was still a small circuit board connecting to the main board and screw mounted to the main chassis (Figure 2.7 and 2.8).

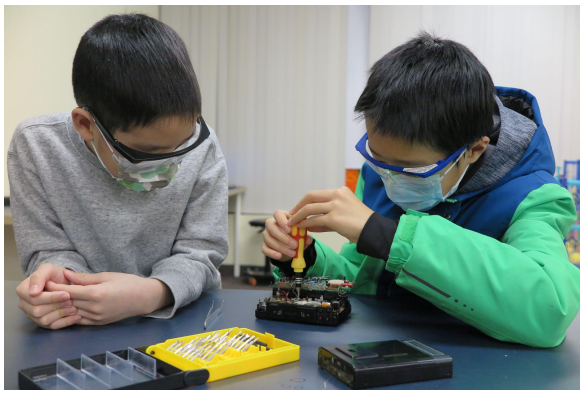
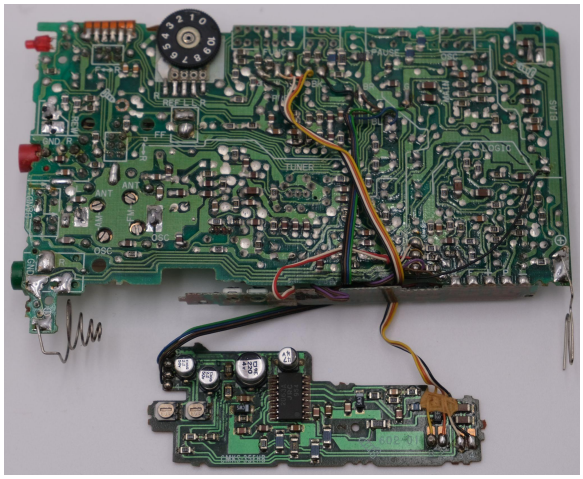



Figure 2.8: Detaching Circuit Board

What remained on the chassis were the side frame (Figure 2.9), the radio antenna chassis (Figure 2.10), the top panel (Figure 2.11), and the front door (Figure 2.12). All were again to be detached by removing screws.

Figure 2.9: Side Frame

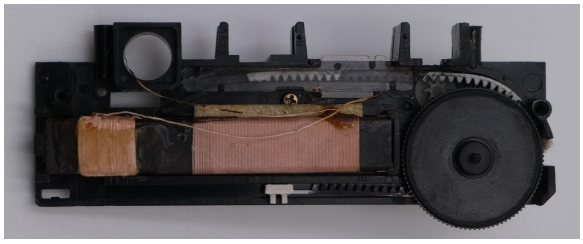


Figure 2.10: Radio Antenna Chassis

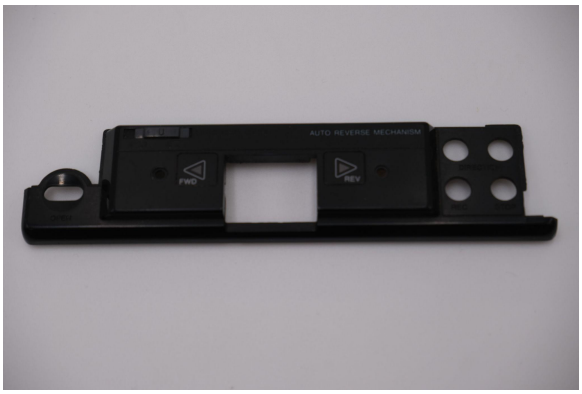


Figure 2.11: Top Panel

Figure 2.12: Front Door

Riveted to the main chassis there were the motor, gears and metal bars and wheels, which were not removable without being destructive.

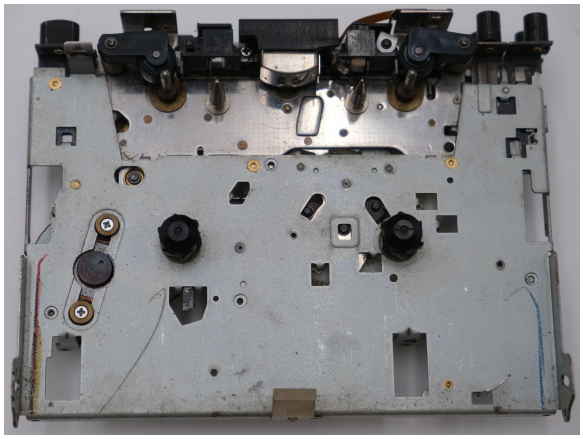


Figure 2.13: Main Chassis

At this point we decided to stop disassembling the device and start analyzing the components.

Component Analysis

Mechanical Analysis

We could not find an actual tape to play with, however we could still find a picture from Wikipedia (Figure 2.1.1). With the PLAY button pressed, the device should be on and the tape pulley starts to pull tape from left to right side of the tape head (Figure 2.1.2). While the tape is moving under the tape head, audio signals stored on the tape are read. [Reference [2]]

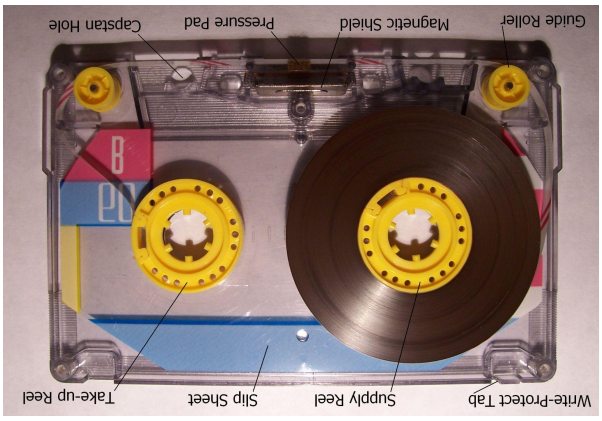


Figure 2.1.1 Internal of an Compact Cassette
[Reference [3]]

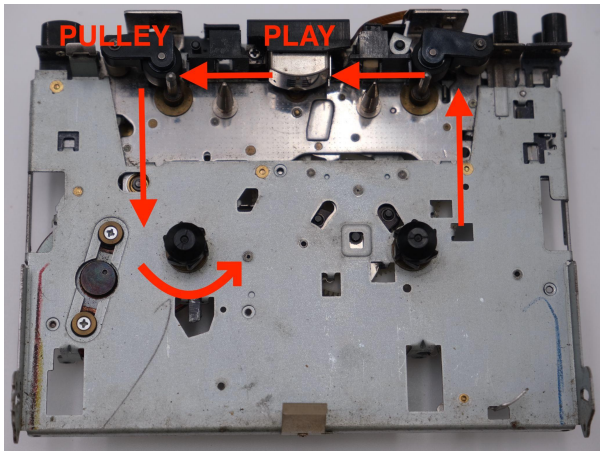


Figure 2.1.2: Tape Movement (Forward)

In a Compact Cassette, the audio signal is stored on the half width of the tape. The cassette needs to be flipped and played to get the full length of the tape.

Figure 2.1.3:

Regular Tape Head reads half of the tape when tape moving forward direction

[Reference [4]]

Figure 2.1.4:

AIWA HS-J36
Tape Head reads tape moving both directions

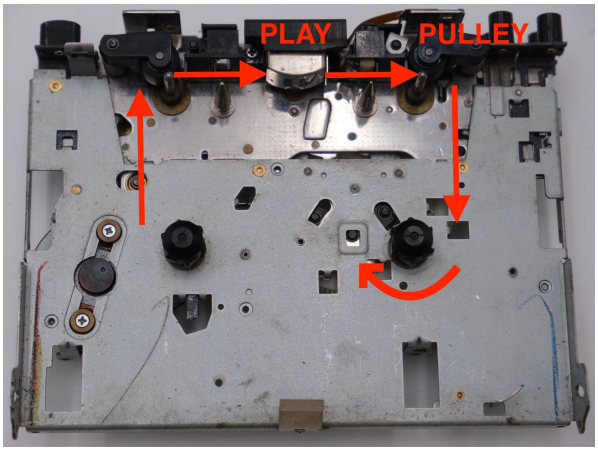


Figure 2.1.5: Tape Movement (Reverse)

The tape movement direction could be triggered by the Fast Forward and Reverse buttons. When the tape is playing forward, pressing the Reverse button will make the tape play reverse, and pressing Forward will make the tape play forward again (Figure 2.1.6).

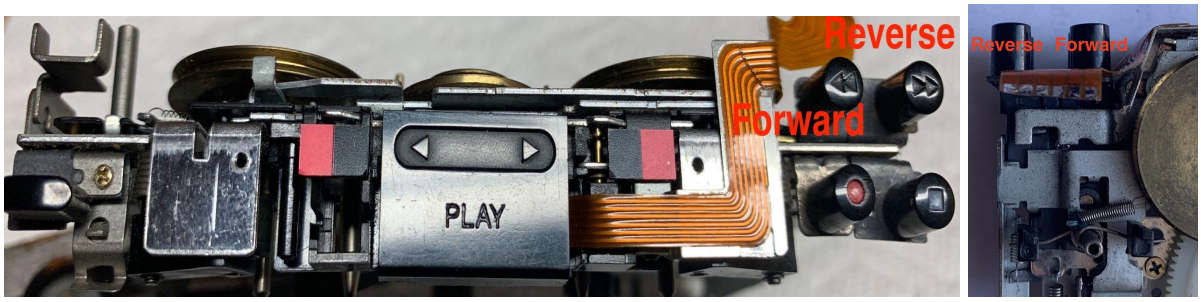


Figure 2.1.6 Forward and Reverse Button

With the Forward (Figure 2.1.7) or Reverse (Figure 2.1.8) button pressed, it pushes the standoffs to press the leaf switch on the circuit board and trigger the tape movement mode.

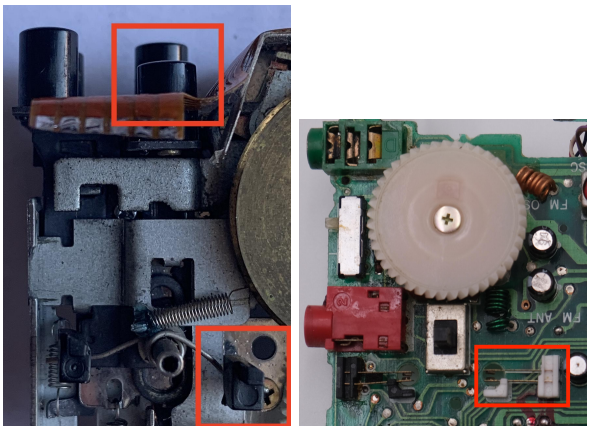


Figure 2.1.7 Forward Button Pressed

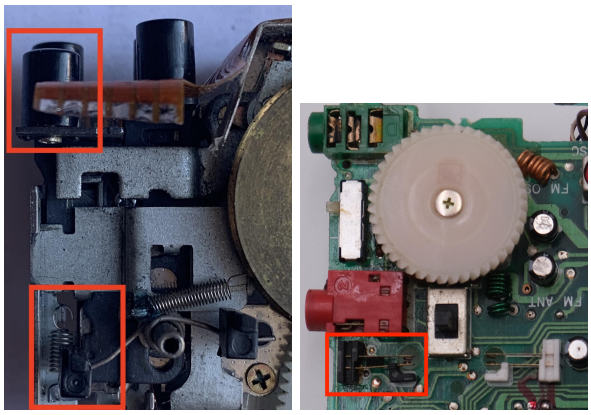


Figure 2.1.8 Reverse Button Pressed

Electrical Components

Schematic Diagram

We found a scanned copy of a schematic diagram (Figure 3.1) of an AIWA device with similar functionality. We used it as reference during our electrical component analysis.

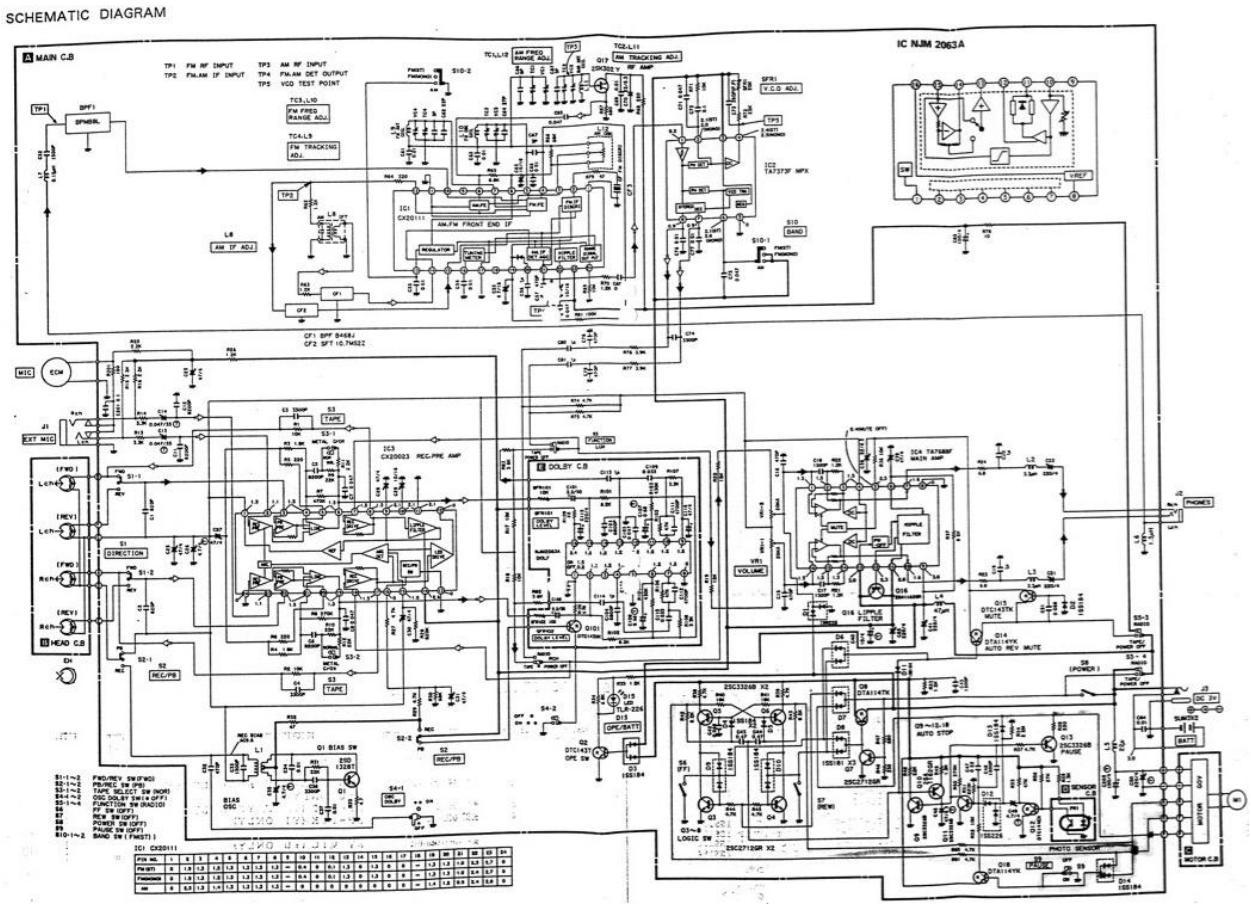


Figure 3.2.1: Schematic Diagram

Circuit Board Overview

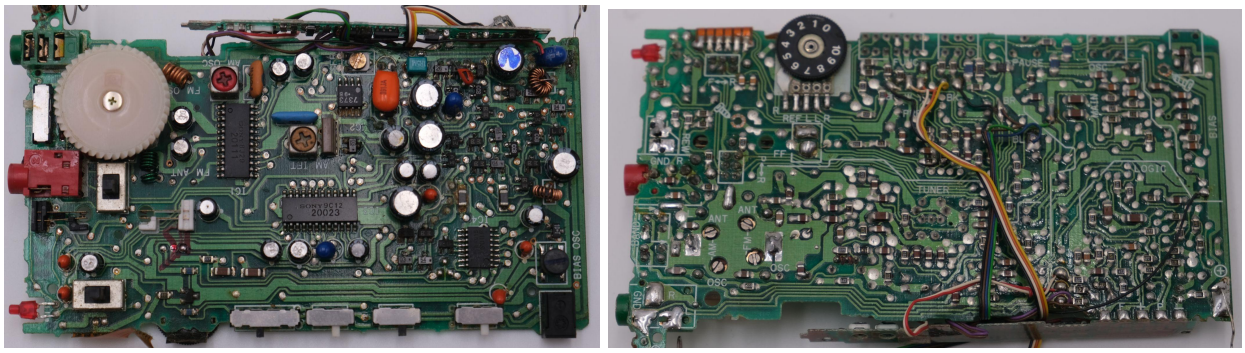


Figure 3.2.2: Main Circuit Board Both Sides

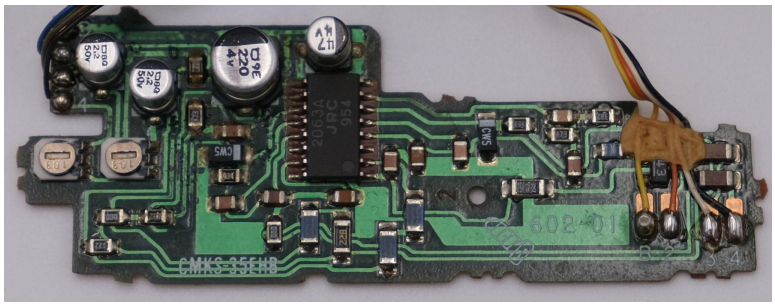


Figure 3.2.3: Dolby Circuit Board

Component Research

We used a multimeter and magnifier and researched on the internet to help us identify the electronic components on the circuit board and determine the functionality. Below is a summary of the various components we were able to identify.

Components and Quantity Table:

Component	Quantity
IC Chips	5
Transistors	11
Capacitors	~120
Resistors	~85
Inductors	12
Diodes	15
Switches	10
LED	1

Note: The numbers are approximates based on research and findings.

Components and Quantity Chart:

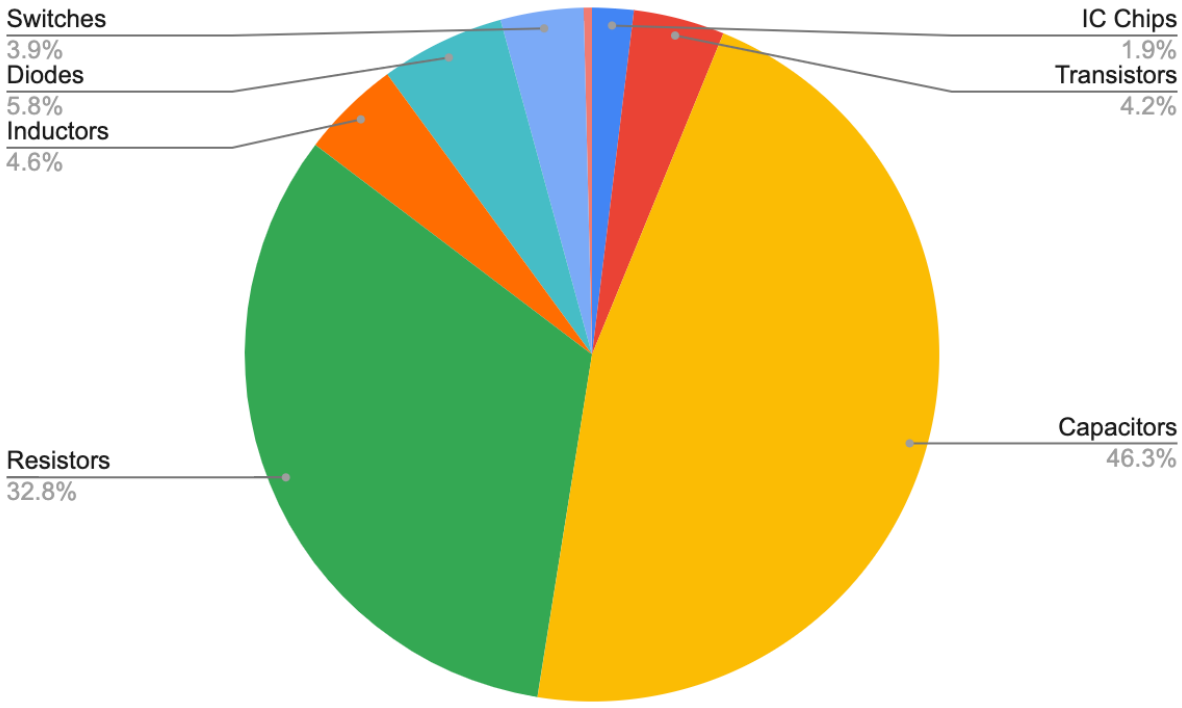
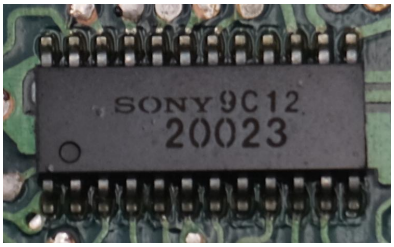
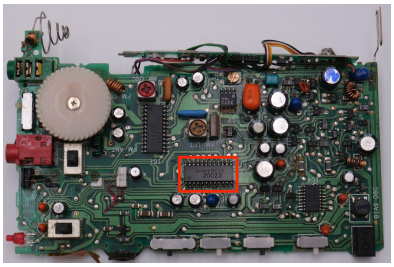
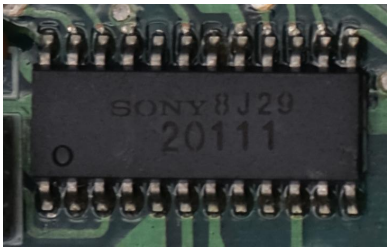
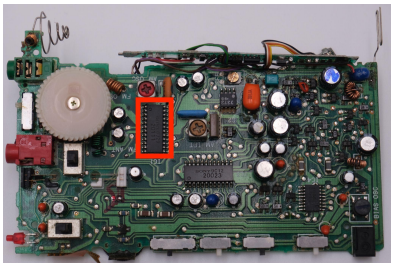
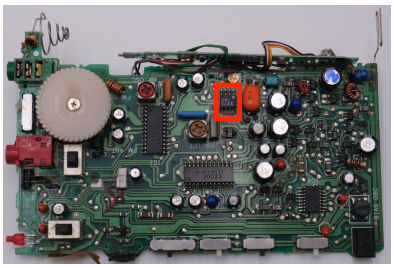
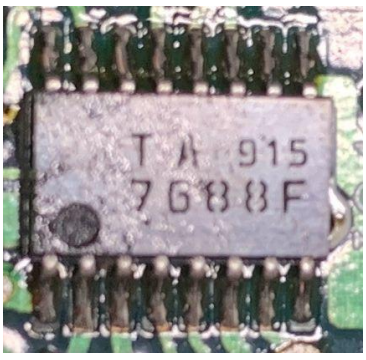
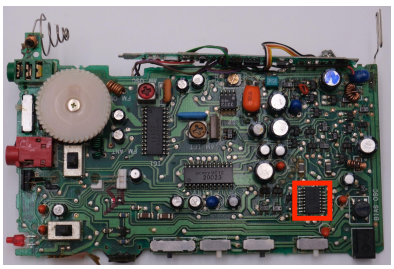
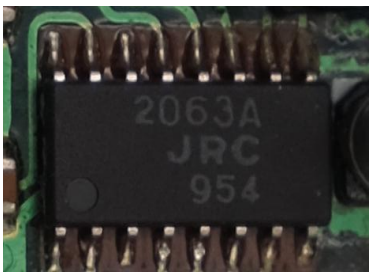
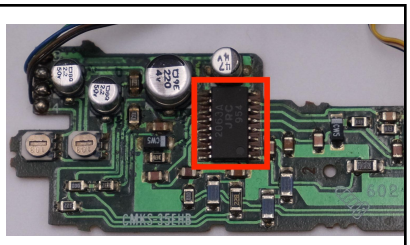


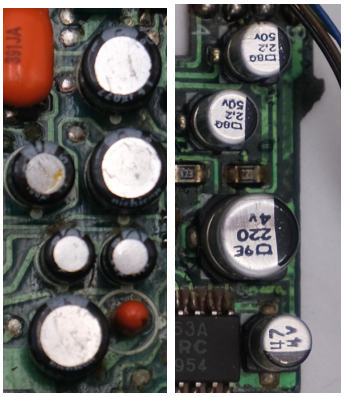
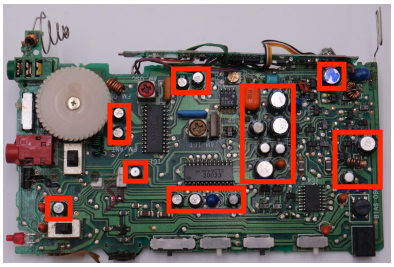
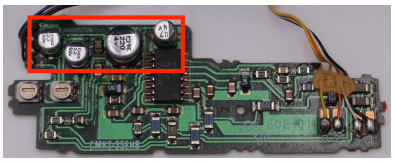
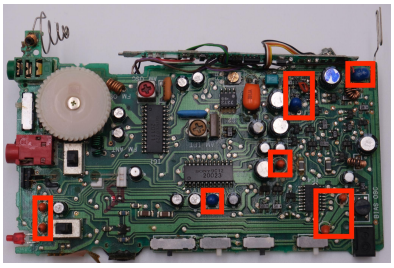
Figure 3.2.4: Pie Chart of Component Count

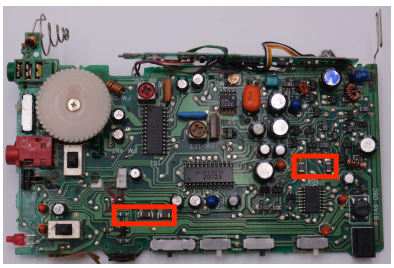
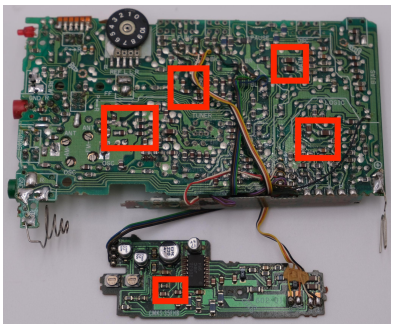
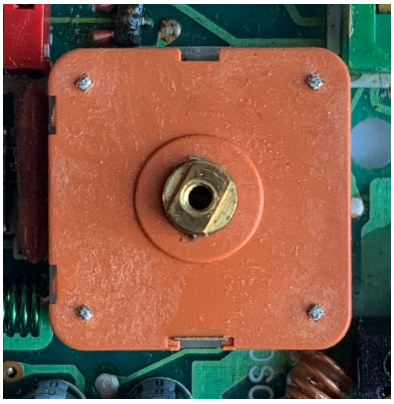
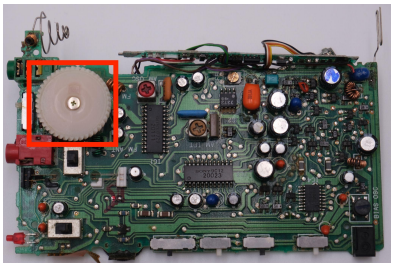
Integrated Chip

Component Description	Close-Up Image	Location
Sony CX20023 is a recording / playback dual preamplifier system IC for low voltage cassette tape recorders. It is used in both the playback preamplifier and recording amplifier circuit. Datasheet: Reference [5]		
Sony CX20111 is an integrated chip used for FM/AM radios. It integrates all necessary functions from the front end detector stage of a radio. Datasheet: Reference [6]		
Toshiba TA7373F is an integrated chip for FM radio stereo demodulation. Datasheet could not be found for the chip. In general an FM stereo demodulator circuit takes in frequency modulated RF signals and takes the modulation from the signal to output only the modulation that had been applied at the transmitter. Reference [7]		
Toshiba TA7688F is a stereo headphone power amplifier integrated chip commonly used in cassette tape players. Datasheet: Reference [8]		

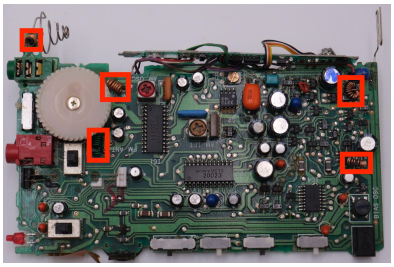
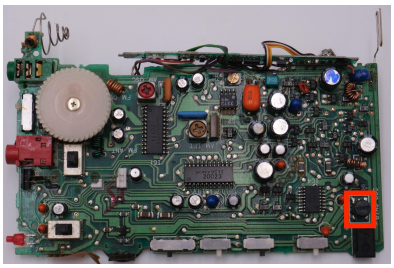
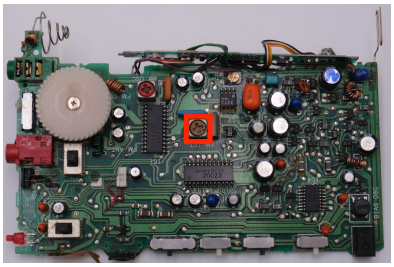
JRC NJM2063A on the Dolby circuit board is a low-voltage operating Dolby noise reduction processor IC manufactured by Japan Radio Co. ltd. It operates as encoding or decoding mode commonly used in cassette tape players. Datasheet: Reference [9]		

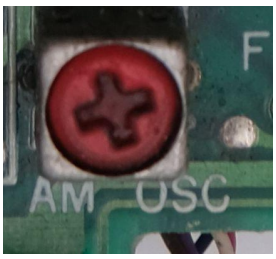
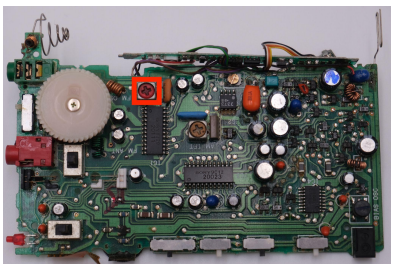
Capacitor

Component Description	Close-Up Image	Location
Electrolytic capacitors are particularly suitable for passing or bypassing low-frequency signals, storing energy and releasing later to stabilize the flow of electricity and remove noise. Reference [13]		 
		

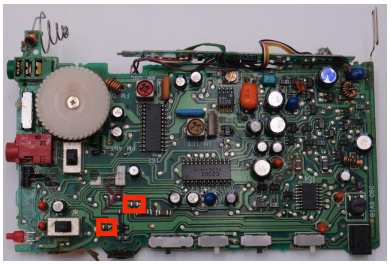
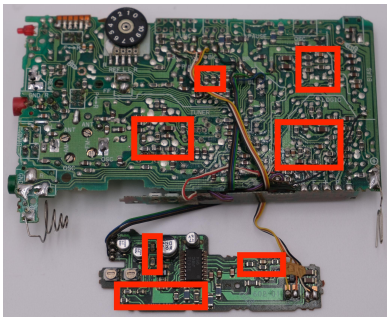
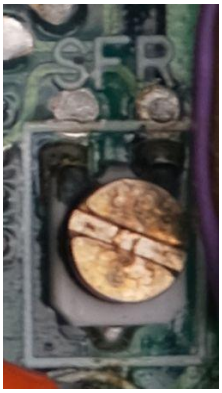
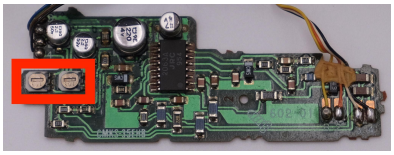
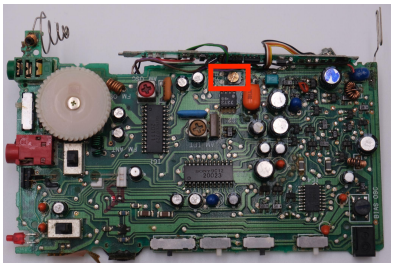
SMD / SMT surface mount capacitors are the most used form of the device. Being small, leadless and easy to place on the printed circuit board, they are ideal for high volume manufacture. Reference [14]		 
A **Tuning Capacitor** is a variable capacitor used in an electronic circuit of a radio. It's connected in parallel to the loop AM/FM antenna of the radio circuit. While the capacitance is adjusting, the circuit would then be tuned for a particular radio station frequency signal. Reference [21]		

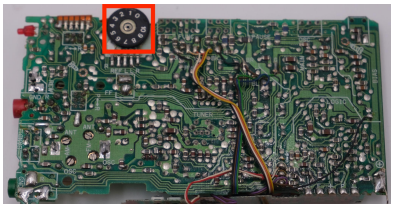
Inductor

Component Description	Close-Up Image	Location
Inductors are designed to produce a magnetic field or to provide electrical resistance or inductance. Reference [11]		
The **Bias Oscillator** circuit is used in the tape recorder to reduce the noise during the reproduction of the recorded signal. We think it reduces the noise while recording from the internal or line-in microphone. Reference [25]		
In communications and electronic engineering, an intermediate frequency is a frequency to which a carrier wave is shifted as an intermediate step in transmission or reception. This **AM radio IFT** (Intermediate Frequency Transformer) is a variable frequency oscillator that can be tuned to a certain frequency. Reference [12]		

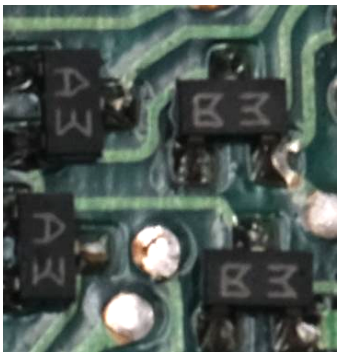
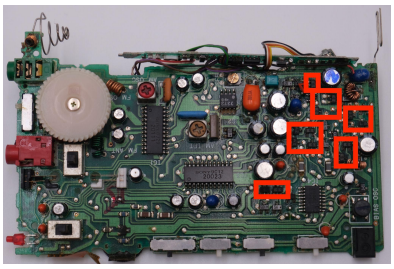
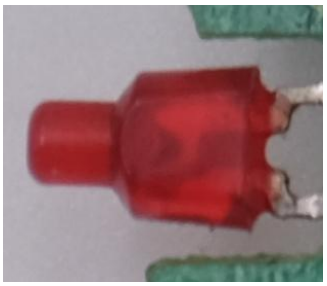
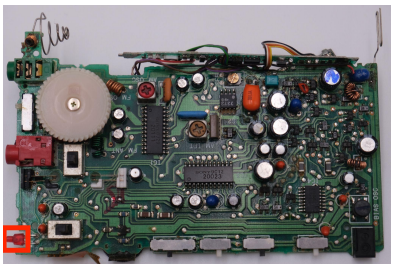
An AM radio transmitter uses an oscillator to create the carrier wave for the station. The radio receiver uses the variable **AM oscillator** called a resonator to tune to a particular frequency and get amplified, and all of the other frequencies will be ignored. Reference [20]		

Resistor

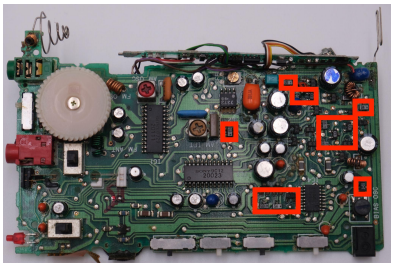
Component Description	Close-Up Image	Location
An **SMD surface mount resistor** is a tiny rectangular ceramic body with silver conductive edges on either end. An SMD resistor offers advantages in saving space on the circuit board. They have the resistance value code printed onto it, where there is space. Reference [17]		 
From the printed text on the PCB there are 3 **SFR (Standard Film Resistor) resistors**. Since there is a slot on the component and can be turned by a flat head screwdriver, we think this is a variable resistor. Reference [16]		 

A **variable resistor** is a resistor that can have its electric resistance value adjusted. It is used on the volume dial. Reference [26]		

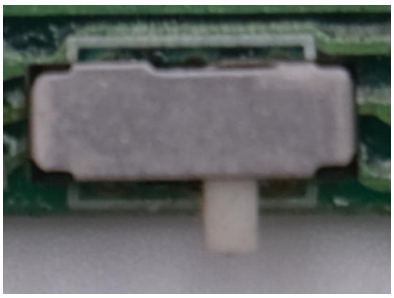
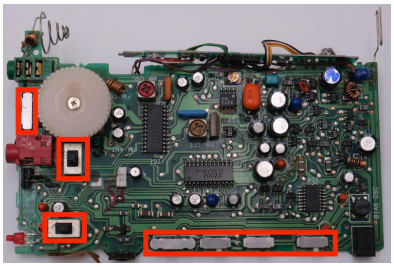
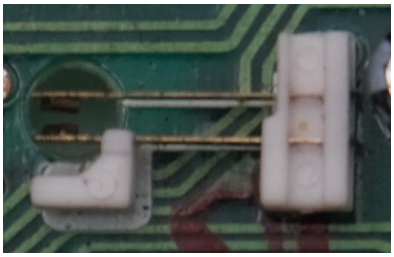
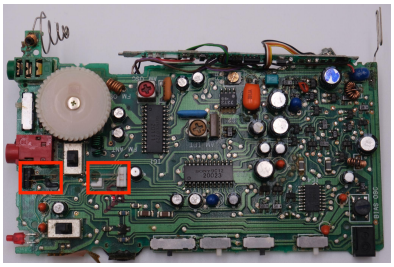
Diode

Component Description	Close-Up Image	Location
The **Diode** essentially acts as a one-way switch for current. It allows current to flow easily in one direction, but severely restricts current from flowing in the opposite direction. We've identified almost all diodes used in the device are surface mounted. Reference [18]		
LED is a special type of diode that emits light. This red LED will light up when the device is on.		

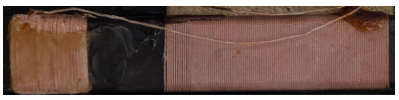
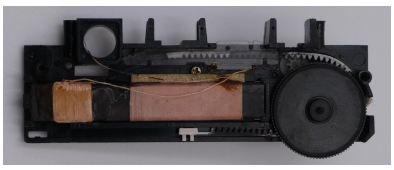
Transistor

Component Description	Close-Up Image	Location
A **transistor** is a miniature electronic component that can do two different jobs. It can work either as an amplifier or a switch. SMD transistors can be identified by the first two Alphabets on the body of its SMD. Reference [22]		

Switch

Component Description	Close-Up Image	Location
A **slide switch** is a switch in which the button handle has a contact, and the position of the sliding point is used to make the movable contact piece contact with two sets of static contact pieces to switch the circuit. In the device it is used for power on/off, AM/FM radio, Dolby on/off, etc. Reference [24]	 	
The **leaf switch** works similarly as a push button switch. It makes the circuit connected when pressed and breaks when released. It is used with the Fast Forward or Reverse button.		

Radio Antenna

Component Description	Close-Up Image	Location
Ferrite loop antenna is widely used in AM/FM radio receivers. It is made by winding fine wire around a ferrite rod. Reference [23]		

Unidentified Components

There were unidentified components but from the printed text we tried to guess their functionality.

Component Description	Close-Up Image	Location
From the shape and color of the component we think it's a capacitor.		
We think this could be an inductor used in the radio circuit.		

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