# **Electronics Online Challenge**

Disassembly and Analysis of a Baofeng UV-5RTP Radio





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# Introduction

## What is the Baofeng UV-5RTP?

The Baofeng UV-5RTP is a VHF and UHF Dual Band Handheld Radio with the ability to transmit and receive between 136-174 MHz (2-meter band) and 400-480 MHz (70cm band). This radio operates within the Amateur Radio band, and thus requires an Amateur Radio License to be operated.

## **Schematic Diagram**

During our research, we found that a schematic diagram was available for a similar model radio from the same brand. Although there were many similarities between the UV-5RTP model we disassembled in this report, there were also many differences. We used this schematic diagram to aid in identifying the components on the PCB as well as determining the overall function of each component as an entire system.



Figure 1: Schematic Diagram of Similar BaoFeng Radio



# **Disassembly Process**

## **Procedure:**

**Step 1:** Safety precautions such as safety goggles and gloves were worn. The workspace was cleared and tools such as a screwdriver and prying tools were obtained.

**Step 2:** Removable components such as the antenna and battery were removed (Figure 2.1). The gold brackets holding the antenna connector and volume potentiometer were also removed using pliers (Figure 2.2)



Figure 2.1: Radio with battery and antenna removed.



Figure 2.2: Removing screwed socket

**Step 3:** Casing screws and brackets were removed from the radio (Figure 2.3). The back panel was then lifted off from the rest of the casing (Figure 2.4).



Figure 2.3: Removing screws and brackets holding the radio together



Figure 2.4: Removing the back panel of the radio



**Step 4:** The circuit board was lifted out of the main casing of the radio (Figure 2.5). Then a soldering iron was used to disconnect the speaker wires from the circuit board (Figure 2.6).



Figure 2.5: Removing the circuit board from the radio casing and the backplate.



Figure 2.6: Using the soldering iron to remove the speaker wire

**Step 5:** Using a hacksaw and vice stand, the plastic casing around the antenna was cut open to reveal the internal wiring (Figure 2.8).



*Figure 2.7 (Right): Antenna wiring removed from the plastic casing.* 



# **Device Component Analysis**

## **Circuit Overview:**

Radio Circuit Board



Figure 3.1: Front view of the radio circuit board.



Figure 3.1: Back view of the radio circuit board.



#### **Analysis Process**

We used various tools including a multimeter and a microscope to analyze the various components located on the circuit board. Based on our findings we used the internet to identify the component and analyze its function in this system. Below is a summary of the various components we were able to identify on the circuit board.

| Table of Components and Quantity |          |  |
|----------------------------------|----------|--|
| Component                        | Quantity |  |
| Capacitors                       | ~220     |  |
| Resistors                        | ~165     |  |
| Inductors                        | ~45      |  |
| Transistors                      | ~36      |  |
| Diodes                           | ~25      |  |
| LEDs                             | g        |  |
| IC                               | 7        |  |
| Potentiometer                    | 3        |  |

Note: The numbers are approximates based on our assumptions and findings.



## Components Found Inside BaoFeng UV-5RTP

Figure 3.3: Pie chart of the components found inside of our radio's circuit board



# Integrated Chips:

| Part and Description  | Image              | Location |
|---|--------------------|----------|
| Microcontroller Chip -<br>Fujitsu MB95F013K<br>From our understanding, it is<br>the microcontroller for the<br>radio. It may be a custom<br>manufactured chip making<br>information scarce.<br>Unable to find the datasheet.  |                    |          |
| Electrically Erasable and<br>Programmable Read-Only<br>Memory (EEPROM) -<br>Shanghai Belling<br>BL24C64A<br>The EEPROM allows the<br>user to modify the ROM<br>allowing for reprogramming.<br>This chip in particular stores<br>the programmed channels<br>and frequencies of the radio.<br>Datasheet | BL24C64A<br>6470DP |          |
| LT-ZY702 - Unidentified<br>(Voice IC)<br>Based on the schematic, we<br>can infer that it is most likely<br>the 'voice' chip potentially<br>used for the text-to-speech<br>included in the interface.<br>Unable to find the datasheet.   |                    |          |



| Digital Signal Processor -<br>AT1846SConverts a radio signal to<br>voice, and voice to a radio<br>signal. Uses the I²C protocol<br>to communicate with the<br>microcontroller chip and other<br>components.Basic datasheetSimilar chip, more detailed<br>Datasheet | 13465<br>02995708                     |  |
|--|---------------------------------------|--|
| Audio Amplifier - UTC TDA<br>2882G<br>Considering the proximity to<br>the microphone input speaker<br>output jacks, this chip is used<br>to amplify the audio signal for<br>the external speaker and<br>microphone.  | UTC ILIO<br>TDA2822G<br>O BT<br>DOBID |  |
| Unidentified - 04S 7114<br>(Audio Amplifier)<br>Since this chip is near the<br>onboard microphone of the<br>radio, we believe this is an<br>audio amplifier used to<br>amplify the electret<br>microphone signal.  | 04S<br>7114                           |  |



| N653 N715 - Unidentified<br>We believe this is the FM<br>receiver used to playback FM<br>radio. Schematic included a<br>separate IC for FM playback<br>not found on our device.<br>Unable to find the datasheet |  |
|---|--|
| LCD Controller<br>This is the LCD controller<br>which allows for data and<br>information to be displayed<br>as part of the user interface<br>of the radio.  |  |



## **Electronic Components:**

#### **Transistors:**

Transistors are semiconductors that can be used as a switch based on the bias or can be used to amplify power and signals such as audio. Some variants we found on our device are listed below with their datasheets if available.

| Variant  | Image    | Location |
|--|----------|----------|
| 2SC3356 - NPN RF Low<br>Noise Amplifier Transistor<br>Amplification transistor<br>specifically used for radio<br>signals. Based on the<br>position and schematic, we<br>believe this transistor helps<br>amplify the VHF and UHF<br>signals. | R25      |          |
| 2SC1623-L6 - NPN<br>Transistor<br>Based on the location of the<br>transistor, we believe it may<br>be involved in amplifying the<br>output audio to the external<br>speaker.<br>Datasheet:   | <u> </u> |          |







#### Inductors:

Inductors create a magnetic field in order to filter signals and power to tune the circuit to correct values. In our particular radio device, many of the inductors are more robust to allow higher frequency radio signals to pass through.

| Variant   | Image | Location |
|---|-------|----------|
| <b>SMD Inductor (Multilayer)</b><br>Coils printed on sheets which<br>are then stacked in the SMD<br>package. High performance<br>despite its compact nature.    |       |          |
| SMD Wire Wound Type<br>Inductor<br>Typically have low resistance<br>for large currents and high<br>inductance.  |       |          |
| Air-Core Inductor<br>The core being air allows for<br>lower inductance and usage<br>in high-frequency circuits.<br>Used in the low pass filter of<br>the radio. |       |          |



## Capacitors

Capacitors store energy in an electrostatic field until it releases it into the rest of the circuit. They can help stabilize the flow of electricity and remove noise from the power line.

| Variant  | Image   | Location |
|--|---|----------|
| Tantalum Electrolytic<br>Capacitor<br>These capacitors tend to<br>have higher capacity and<br>longer-term reliability. They<br>also have low leakage<br>current. | A 107 /A<br>6 0 6 /A 1  |          |
| SMD Capacitors:<br>Surface mount variants of the<br>capacitors allow for smaller<br>circuit boards and easier<br>manufacturing by machines.                      | (Note: There were too many to individually identify in the image to the right.) |          |



### Resistors

Resistors help regulate the amount of current that is able to flow in the circuit. It can also control the amount of voltage that flows in the circuit.

| Variant  | Image | Location |
|--|-------|----------|
| Zero Ohm Resistors have<br>nearly zero resistance and<br>are often used as place<br>holders when the same circuit<br>board is used in multiple<br>products. Can also act as<br>jumpers between points. |       |          |
| SMD Resistor<br>Surface mount variants of<br>resistors for smaller size and<br>ease of manufacturing.  |       |          |



#### Diodes

Diodes are special semiconductors that only allow current flow in one direction. Often used in power circuits to prevent reverse flow, and surges during overvoltage. LEDs are a type of diode.

| Variant  | Image | Location |
|--|-------|----------|
| SMD Diodes<br>We believe these diodes may<br>be a rectifier diode due to<br>their high power applications. |       |          |
|  |       |          |

### Antenna

The antenna is important in propagating the radio signal from the transmitter on this device to another antenna at the receiving end.

| Image | Description  |
|-------|--|
|       | VHF/UHF radios typically require antennas<br>around 2 meters in length. The coils in the<br>antenna create an effective inductor allowing<br>for the overall length to be shorter. These<br>rubber ducky antennas have poor gain and<br>higher losses. |



## **Other Components**

| Part  | Image              | Location |
|---|--------------------|----------|
| Oscillator (26 MHz)<br>The oscillator creates the<br>necessary clock signals for<br>the digital signal processing<br>chip (DSP).                        | P26 00<br>0 G6ii C |          |
| Potentiometer<br>A potentiometer is a variable<br>resistor. The dial changes<br>resistance and is often used<br>to control volume and light<br>dimming. | <image/>           |          |



# Ports, Connectors, Interface

| Part  | Image    | Location |
|---|----------|----------|
| SMD LED<br>Surface mount variant of<br>LEDs are significantly smaller<br>making it ideal when creating<br>handheld devices.                   | A REPORT |          |
| Audio Jacks (2.5mm,<br>3.5mm)<br>The audio jacks are used to<br>connect the external speaker<br>and microphone to be used<br>with this radio. |          |          |
| LCD<br>Liquid Crystal Display used to<br>display the user interface of<br>the radio. Displays<br>frequencies and channels<br>programmed.      |          |          |







# **Final Summary Report**

As many of our team members are licensed Amateur Radio operators, our team decided to disassemble a BaoFeng UV-5RTP radio because of its budget price point considering its ability to transmit both in the 2-meter band (144 MHz) and 70 cm band (433 MHz).

The circuit board contained many integrated circuit chips including a proprietary microcontroller, a digital signal processor, Electrically Erasable and Programmable Read-Only Memory, and various amplifier ICs. From these components, we were able to conclude that this radio was software-defined in which the software performs the modulation/demodulation of the radio signals. The software is also able to change the capabilities of this radio. We were also able to identify a few different amplifier transistors with distinct purposes. Unfortunately, we were not able to locate any TI chips on the circuit board.

Based on our observation and research on software-defined radios, we were able to develop a simplified block diagram of the various components in this radio.



Aside from the integrated circuit chips, we also identified various electronic components. One interesting observation we made that is there was the most number of capacitors on this circuit board, followed by resistors and inductors. We believe this may be because capacitors are able to tune radio signals to set frequencies and also remove noise from signals and power transmissions. These things are particularly important in radio in which unwanted or inaccurate frequency transmissions can cause interference with other devices. Through research, we also found that inductors are particularly important in radios because it has the ability to cancel signals outside of the desired frequency. These tuning characteristics help pick the correct frequency and allow for clearer outputs sent to the speaker. This also explained why we found many of these components near the antennas of the radio where the radio signals would be coming in and out.

During this challenge, our team realized the significance of integrated circuit chips has on electronics, but most especially in radios. In the past, radio required special and advanced technology which limited the manufacturers of radios and also increased cost. Now with the development of integrated circuits such as the DSP, a singular chip with a few basic components can create a functional radio. The tuning can be completed through the chip and software, and the reduced number of components reduce failure points and cost. Even in the case of our BaoFeng UV-5RTP, looking at the datasheet revealed that the DSP chip in our



device has the capabilities to transmit in the 1.25-meter band (220 MHz), and can potentially be unlocked through software and slight hardware modifications.

We also learned about the challenges related to radio transmission. The number of capacitors and inductors despite the simplified nature of this radio through integrated circuits, made us realize how important it was for radio signals to be transmitted without error or noise. While radio seems to become distant technology, it was a reminder that even WiFi and Bluetooth are based on the same principles.

Word Count: 500



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