



# So You Want to Build an Emergency Repeater?

At one time or another it occurs to most members of ARCA and CERT that it would be fun to build a widget that you could toss into a tree and use as an emergency repeater. With the advent of inexpensive Chinese hand held transceivers, it is now easy to try this.

On the practical side, it would be reassuring to have a backup for your regular repeater – something that would save the day in the case of damage to your group's primary equipment. How practical is this?

Let's take a look at what is involved in building a very basic, working repeater.

## Portrait of a Repeater

Most repeaters consist of six functional parts working together to provide service (Fig. 1).

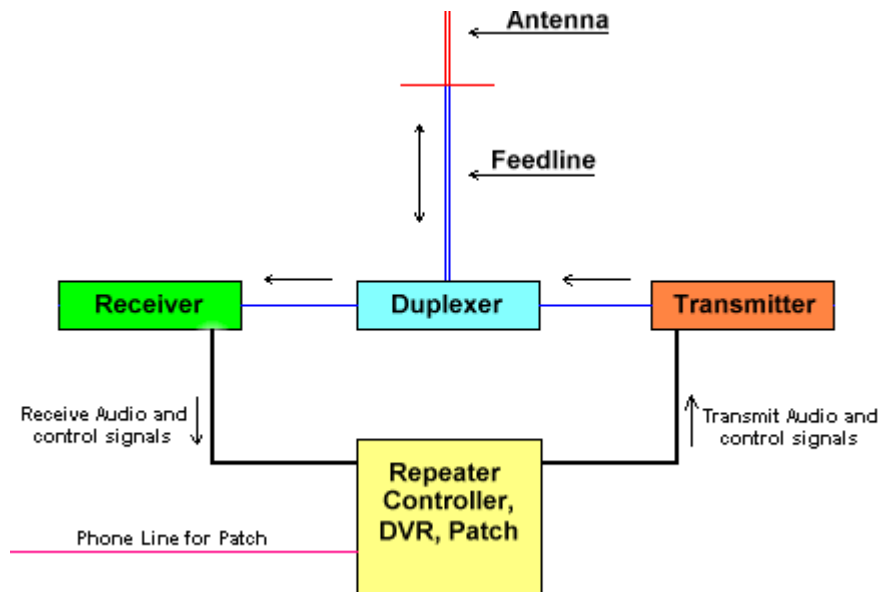


Figure 1: Six typical repeater components.

All repeaters have a **transmitter** tuned to the primary frequency – the one that users program into their radios. And all repeaters have a **receiver**, listening on an offset frequency and forwarding voice signals to the transmitter radio. Often a **repeater controller** manages this process and periodically sends it's call sign to insure that FCC regulations are met.

Many repeaters have a **duplexer**, which allows both the transmitter and receiver to share the same **feedline** and **antenna** by using special filters. The duplexer simplifies the antenna setup by preventing the transmitter's RF signal from overwhelming the receiver.

## How Low Can You Go?

Do you need all of these components? Well, the answer is “yes” and “no.” To have something that you can hang up in a tree to communicate over short distances for a brief period, the answer is “no.” You can get by with very little, albeit with many limitations. If you want a more serious backup for your regular repeater and need to handle appreciable traffic, you are likely to need something more substantial.

Let's put together the simplest repeater possible and see how well it works (Fig. 2).



Figure 2: The “Baby Baofeng” repeater.

The “Baby Baofeng” repeater requires only two Baofeng UV-5R HT transceivers, the antennas that come with them, and a cable connecting the speaker jack at the receiver with the microphone jack at the transmitter.

The cable providing the connection is the **RPT-2D** by **SainSonic**, a special repeater cable designed for the Baofeng (Fig. 3).



Figure 3. SainSonic RPT-2D Two-way Radio Repeater Box for two transceivers.

The RPT-2D provides for two way communications between two Baofeng radios enabling a variety of repeater configurations. In fact, the “Baby Baofeng” only requires a one way connection. Nevertheless, the RPT-2D is key to building the “Baby Baofeng” repeater because it matches impedances between the speaker and microphone jacks of the radios. It costs under \$30 at Amazon.

The RPT-2D setup is straightforward. Just plug each end of the cable into a Baofengs. Your hardware setup is complete! (Fig. 4)



Figure 4: Setup with the SainSonic RPT-2D.

The radio configuration is also simple. To pick a familiar example, we will use the K6QLF repeater frequencies. Be sure to check that no traffic is on the repeater. Also be sure to announce that the K6QLF frequencies are being used for testing.

The K6QLF repeater is on 444.575 MHz with a positive offset of 5 MHz. Transmissions are on 444.575 MHz. Reception is on 449.575 MHz. K6QLF has a PL of 88.5 Hz, but we will not use PL tones with the Baby Baofeng, so test transmissions will not directly echo on K6QLF. Do note that K6QLF users may hear the Baby Baofeng transmitter via simplex if they are close enough and on the K6QLF frequency.

The manual setup for the radios is below (assuming all are Baofengs):

## Basic “Baby Baofeng” Radio Setup

### Set receiver radio frequency

1. Press “VFO/MR” [enter frequency mode]
2. Key “449575” [enter 449.575 MHz]
3. Press “Exit”

### Set transmitter radio frequency and VOX Settings

1. Press "VFO/MR" [enter frequency mode]
2. Key "444575" [enter 444.575 MHz]
3. Press "Menu" [confirm]
4. Key "4" [select VOX mode]
5. Press "Menu" [enter edit VOX threshold]
6. Key "10" [enter VOX threshold]
7. Press "Menu" [confirm]
8. Press "Exit"

### Set up frequency and offset on the user radios (Baofeng directions)

1. Press "VFO/MR" [enter frequency mode]
2. Key "444575" [enter 444.575 MHz]
3. Press "Menu" [confirm]
4. Key "26" [select offset mode]
5. Press "Menu" [enter edit offset]
6. Key "005000" [enter 5.0 MHz offset]
7. Press "Menu" [confirm]
8. Scroll to "SFT-D" [select Shift Direction]
9. Press "Menu" [enter edit Shift Direction]
10. Scroll down to "+" [select positive shift direction]
11. Press "Menu" [confirm]
12. Press "Exit"

The setup works because it takes advantage of the VOX feature ("Voice Operated Transmission") on the repeater transmitter. VOX mode enables transmitting when a strong signal is detected on the microphone jack cabled to the receiving radio's audio.

Two adjustments to the repeater receiver may be needed to tweak performance. The squelch may need adjusting using Menu 0. Similarly the volume may need adjustment in order to have sufficient amplitude to open the VOX circuit on the receiver transmitter when the voice signals appear.

For an example of this kind of setup, see [Set up a Baofeng UV-5R repeater](#) on YouTube.

### What Can you Add to the Basic Configuration?

One useful feature that you can add to the Baby Baofeng is **CTCSS**. Adding a PL tone to transmissions will insure that users wanting to hit K6QLF do not hit your repeater as well. K6QLF has a PL tone of 88.5 Hz, so you could enable a PL tone of say, 77.0 Hz. Use Menu 11. You will also need to set your user radios to transmit a PL of 77.0 Hz (use Menu 13, if

they are Baofengs).

A second useful feature is a **Roger tone**. A Roger tone is added at the end of a transmission so that users know that the previous speaker is finished. You can enable Roger tones by using Menu 39 on the transmitter.

## How to Improve Performance

We will see on Shop Night how well the Baby Baofeng repeater performs. Based on others' experience we would expect it to work when set up as a table top demo. It should work on low power (i.e. the Baofeng's 4 watts) and it should work with low gain rubber ducky or whip antennas. And we might expect it to work when there is considerable separation between the listening and transmitting frequencies, for example, cross band or on a band like 440 MHz where the repeater offset is large.

However, whenever there is more power in any of the radios, the antennas have more gain or the offsets are smaller, problems arise. The primary villain is receiver desensitization ("desense"). Strong signals near in frequency or near in location to the receiver swamp its circuits.

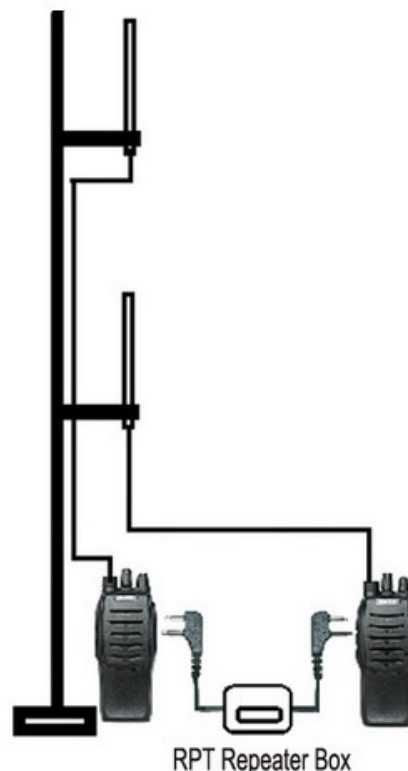


Figure 5: Providing vertical or horizontal separation to avoid "desense."

The simplest solution is to move the transmitting radio antenna and the receiving radio antenna as far apart as possible, either vertically or horizontally. At the 4 watts put out by the Baby Baofeng, two antennas, one 15' above the other, will probably work (Fig. 5). At higher wattages, the horizontal or vertical separation required can be quite substantial.

Another solution is to use a duplexer. Cavity duplexers are the traditional way to isolate the transmitted signals from the receiver. In fact duplexers work well enough that repeaters can use the same transmission line and antenna for both transmitting and receiving. The side attached to the receiver passes the frequencies that the repeater expects from users and blocks all others. The side attached to the transmitter passes the signal it creates and blocks those that it does not need. This two way filtering effectively separates the transmitter from the receiver (Fig. 6)

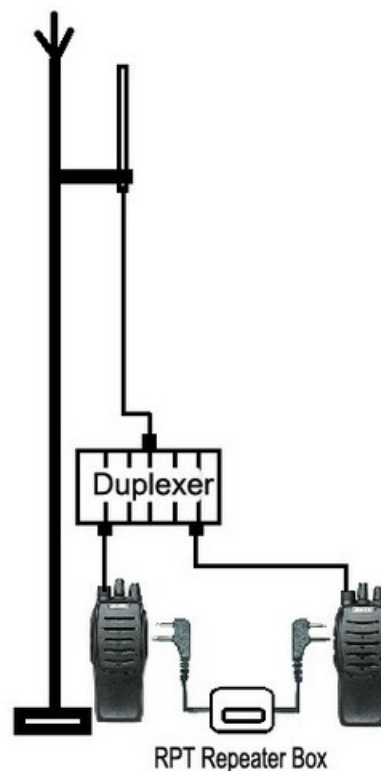


Figure 6: Adding a duplexer.

Cavity duplexers are simple to set up, but they require a technician to tune them to the exact frequencies needed by the repeater to transmit and receive signals. This is typically done by the manufacturer at the time of purchase. Note that doubly shielded coax should be used between the repeater radios and the duplexer to insure that the signal does not bleed onto the lines.

Duplexers are traditionally quite expensive, but a new generation of Chinese manufactured duplexers bring the costs down to where they are much more affordable. These use simple notch filters on the input and output sides. But from all reports they appear to work reasonably well. Early tests suggest that the manufacturers accurately tune them to the requested frequencies, and that the devices at least approximate the published specifications. They are available on eBay for around \$100 including shipping. Be sure to look at each device's specification sheet to insure that it is rated for the offset you plan to use. (Fig 7).



Figure 7: \$100 Chinese cavity duplexer for 380-485 MHz from eBay

## Other Enhancements

So far our emergency repeater appears to be a portable, temporary solution capable of several hours of light duty use. Note that the Baofeng radios are not rated for the heavy use they would receive if there was substantial traffic on a repeater. And their batteries will only last a short while.

A solution which can handle the heavy load likely in an emergency will require a more robust radio. In general radios for Amateur use are not rated for the kind of frequent and extended transmitting that can be expected on a busy repeater. Running them this way may cause overheating and shorten their life. However, ordinary transceivers that are run well below their maximum rated power will do better.



While many new and used radios can do the trick, an inexpensive example is the **Leixen VV-808S**. It is a compact, \$100, single-band mobile radio running 400-470 MHz. It is hardly bigger than a Baofeng HT. The frame has a solid cover with a hefty heat sink. Full power is 10 watts, but it can be run at 4-5 watts at low power to minimize overheating. It supports a Roger beep and CTCSS filtering. And it can hook up to a standard lead acid battery in the same way as any mobile (Fig. 8).



Figure 8: \$100 Leixen VV-808S 400-470 MHz mobile radio.

The last enhancement that should be considered is a simple, basic controller. A common example of the genre is HamGadgets' **ID-O-Matic IV Kit**. Originally featured in the ARRL Handbook, it provides automatic Morse code station ID, "Hang" time settings, Roger beep and other capabilities which improve the useability of the repeater. Voice station identification is an option, and everything is configurable by USB. Cost as a kit is about \$40 (Fig. 9).

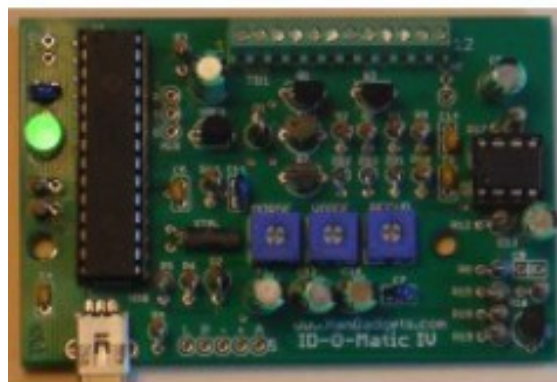


Figure 9: \$40 HamGadgets' ID-O-Matic IV repeater controller kit.

## Reality Check – Does the Baby Baofeng Work?

In Monday's ARCA Shop Night we will put together the “Baby Baofeng” Emergency Repeater – an absolutely bare bones setup that covers the minimal requirements for about \$85. Playing with it, we should get a good idea of what it can actually do.

Preliminary testing has had some surprises. Setting up a simple patch cable between the receiver radio and transmitting radio, as some have done, does result in the Baby Baofeng hearing users and triggering repeater transmissions. However, the radio continues to transmit even when there is no voice, and it does not stop until the built-in timeout kicks in. Note that this is true regardless of the value assigned to VOX. I do not recommend using a patch cable.

Using the SainSonic RPT-2D cable results in a much better behaved connection. The VOX in the transmitter works as expected. I would definitely use the RPT-2D.

## Future Areas of Exploration

We have seen that the Baby Baofeng may be enhanced with Roger beep and CTCSS filtering. And we have seen how it may be improved with higher gain antennas or a duplexer/antenna combination.

We have also outlined the possibility of building out a more capable emergency repeater with all new components – better radios, a duplexer and a basic controller for about \$365 (not including battery/power supply, feedline or antenna). This would be a reasonable backup to a club repeater that is down for repairs or has been damaged in an emergency – food for thought.

See you Monday night!