Universal Remote Antenna Tuner
Rich Holoch, KY6R
KY6R - Background

- First licensed as WN2QHN in Newton, NJ – 1973
- Off air from 1977 – 2001
- Earned DXCC Honor Roll in 11 years – 2013
- 2 away from Top of Honor Roll after 16 years of DX-ing
- 36 years in IT – Staff Data Architect and Data Engineer at Credit Karma in San Francisco
VK0EK – Heard Island Co-Organizer
u.RAT – Ham Meets Maker
The Elecraft KPOD

- Tune the Remote Antenna Tuner Knobs Using Stepper Motors
- The Rocker Switch Can Switch Between 3 Front Panel Controls (that have knobs that turn)
- Change Antenna Tuner Switch Positions or Store Previous Tunings in Memory for Automatic Recall
The Palstar BT1500A
Mod-Bob Low Band Antenna
Mod Bob Plots
Arduino or Raspberry Pi?
Elecraft KPOD Driver Decided For Me!

• KPOD driver written (by Paul, N6HZ) in C required Linux to compile
• Raspberry Pi is a Debian Linux based computer (“Raspbian”)
Raspberry Pi Zero W Plus Adafruit OLED
The Completed u.RAT
Where Would I Install The u.RAT?

In The Shack:
- Elecraft KPOD
- Raspberry Pi Zero W

At The Antenna:
- TB6600 Drivers
- Steppers on BT1500A

USB Connect

12 and 5V
4 Driver lines

Steppers Plugged Into Drivers
Maker Projects – Its All About Creativity

• The best Maker – Ham projects seem to design themselves
• Ask yourself “I wonder if” or “What if I put A together with B”
• In my case, the problem I had to solve evolved after I purchased an Expert SPE 1.3K FA solid state amplifier
• My goal was to use the Mod Bob antenna on all low bands – and the Mod Bob is resonant on 160M
Solid State Amplifiers Need Low SWR

SPE Expert 1.3 – FK Solid State Linear Amplifier – has ATU but range is small
What Would Be The Best Antenna Coupler?

The answer was easy, the Palstar BT-1500A fit like a glove.
BT1500A is a Balanced Antenna Tuner
BT1500A Can Switch to Match Hi and Low Z

• The BT1500 can switch the variable capacitor as input to the inductors or on their output
• The inductors are synchronized on the same shaft – control
• The Mod Bob is an open wire balanced “Double Inverted L” antenna – a weird variant on the Bobtail Curtain with far less loss, but which requires exactly the flexibility that the BT1500A offers impedance wise
The BT1500A Only Requires Two Steppers

• While playing with my KPOD tuning my K3, I saw that the controls were perfect for tuning an antenna
  • The knob has a great feel – even better than the mechanical knobs on the tuner itself
  • The rocker switch could switch up to three stepper motors that could turn any kind of manual antenna tuner meaning any old antenna tuner could be retrofitted and now become a new “digitally controlled” remote antenna tuner
  • If you did not want to spend the money on a KPOD – a simple rotary encoder and set of switches could be used (requiring different and greatly simplified code though)
The “Universal” Aspect of the u.RAT

- Turning any old manual antenna tuner into an automatic remotely controlled “digital” tuner is what turned this project into an “Open Source” idea (than just solving my own backyard antenna problem)
- A quick email to Elecraft resulted in a collaboration with Paul, N6HZ
- Since the code was C and it required Linux to compile, Raspberry Pi was the only way to go
- Once I started – all of the decisions that I worried about at first just answered themselves – it was like magic!
Decision Steps (For KPOD + BT1500A)

1. Which processor - Arduino or Raspberry Pi => Raspberry Pi
2. Which Stepper Library => WiringPi
3. Which Stepper Motors and Drivers => Nema 23 and TB6600
4. Which Raspberry Pi => Raspberry Pi Zero W
5. Which display => Adafruit Pi-OLED
6. Which Pi-OLED Library => OLED96
Things I Tried But Didn’t Decide to Do

• Just build a very simple rotary encoder and rocker switch controller of my own – instead of using the $250 KPOD
• Just use a simple L tuner based on components I already had in the junk box
• Use an Arduino that I had on hand collecting dust
Stepper Motors, Drivers, etc
Raspberry Pi Development Environment

Raspberry Pi Zero W and full sized Raspberry Pi

WiringPi Utility “GPIO”

Raspberry Pi Breakout Board (“Cobbler”)
# Raspberry Pi GPIO Pinout

<table>
<thead>
<tr>
<th>HY-DIV268N-5A</th>
<th>Connects to:</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIR-</td>
<td>RPi GPIO GND</td>
</tr>
<tr>
<td>DIR+</td>
<td>RPi GPIO #18</td>
</tr>
<tr>
<td>PUL-</td>
<td>RPi GPIO GND</td>
</tr>
<tr>
<td>PUL+</td>
<td>RPi GPIO #23</td>
</tr>
<tr>
<td>EN-</td>
<td>RPi GPIO GND</td>
</tr>
<tr>
<td>EN+</td>
<td>RPi GPIO #4 or GND</td>
</tr>
<tr>
<td>A+</td>
<td>stepper green wire</td>
</tr>
<tr>
<td>A-</td>
<td>stepper gray wire</td>
</tr>
<tr>
<td>B+</td>
<td>stepper red wire</td>
</tr>
<tr>
<td>B-</td>
<td>stepper yellow wire</td>
</tr>
<tr>
<td>DC-</td>
<td>GND (black on PC power supply)</td>
</tr>
<tr>
<td>DC+</td>
<td>+12v (yellow on PC power supply)</td>
</tr>
</tbody>
</table>

![Raspberry Pi Pinout Diagram](image-url)
Github is Your Best Friend
The Code

- **Elecraft KPOD device driver** – written in C (Kernighan and Ritchie)
  - HID RAW USB device
- **Wiring Pi** – emulates an Arduino wiring scheme but written in C and runs on Raspberry Pi
- **Oled96** – library for the Adafruit OLED

```c
#include <stdint.h>
#include <unistd.h>
#include <stdio.h>
#include <stdlib.h>
#include <fcntl.h>
#include <time.h>
#include <errno.h>
#include <string.h>
#include <sys/ioctl.h>
#include <ctype.h>
#include <linux/types.h>
#include <linux/hidraw.h>
#include <wiringPi.h>
#include "oled96.h"
```
• Took it one step at a time
  • Got the KPOD to be seen by the Raspberry Pi
  • Got the steppers to move when I turned the KPOD knob and used its rocker switch
  • Switched from the regular Raspberry Pi 3 to the Zero W and then got the OLED to work
Documenting Your Project

Fritzing – generate schematics and PC boards from drawings

Eagle by AutoCad

CircuitLab
Key Learnings

• The Raspberry Pi Zero W and its uses, plus “headless” operation
• Controlling Stepper motors with the Raspberry Pi, the GPIO and WiringPi – that emulates the Arduino
• Embedded devices and the Internet of Things (IOT)
• Ham Shack Remote control – wired or wireless
• Antenna tuners and when you need a balanced antenna tuner
• Arduino vs. Raspberry Pi
• C and Python as Maker languages
• USB device drivers and HID vs. HIDRAW
• OLED devices on the Raspberry Pi Zero W
• Github and Open Sourcing a project
• How antenna tuners work – and the different circuits employed (esp. Balanced Tuners)
• Antenna impedance matching and solid state amplifiers and what they “need” . . .
How Can This Project Be Extended?

• Someone could easily add a third stepper for a 3 control tuner
• Someone could use a tuner that has a fixed switchable inductor
• Someone could remote the entire project and use WiFi
• Someone could make tuning automatic for any band by tapping into the SWR circuit on their tuner
• Someone could add the ability to save band settings as KPOD button memory locations
• Someone could also add a remote wireless antenna switch so that it follows the u.RAT switching
Resources

• My blog – Top Band Chordal Hopper (Google it)
• Adafruit
• Hackaday
• Github
• Amazon
• Youtube - https://youtu.be/Dc16mKFA7Fo
  • Google stepper, etc