Hanging out with hotspots

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Disclaimer: These are my personal notes and opinions based on my experience playing around with hotspots, as well as by learning from what others are sharing. I’m not affiliated with any hotspot projects, except as an enthusiastic user. If anything needs correcting, please let me know.

1) Overview

A personal, low-power hotspot is a combination of hardware, firmware, and software that enables an amateur radio enthusiast with internet connectivity to link directly to digital voice (DV) systems around the world. Hotspots can link to DMR, P25, and NXDN talkgroups; D-STAR reflectors; YSF rooms; and so on.

Basically, hotspots are your own personal digital voice repeater and gateway, which can be really fun. Here’s a simplified diagram of what it looks like when you connect via your hotspot to a BrandMeister-hosted multiprotocol talkgroup, which enables people using different modes to talk with each other:
Note: Some multi-mode hotspots are themselves capable of directly communicating to different modes.

HBlind (Home Brew Link) = An open-source, amateur radio networking protocol
OpenBridge = An open protocol to link DMR servers
NXDN and P25 work similar to YSF.

For someone like me who doesn’t live within range of a digital voice repeater, a hotspot goes beyond being fun to being a critical key to accessing digital voice systems, a gift that opens doors to the whole wide world.

Overall, this is an exciting area of amateur radio that is evolving and progressing rapidly with some excellent work being done by some very innovative hams (there's a shoutout to some of these folks at the end of this article).

1a) Background
This is an article about personal, low-power hotspots, also known as personal access points\(^1\), not repeaters. (For info about digital repeaters, see: How to make a MMDVM Digital Repeater by N5AMD and Repeater Builders.)

- Many personal, low-power hotspots are boards that mount on computers like the Raspberry Pi, one is an all-in-one board, and some others are thumb drives that plug into computers. There’s even one that’s a handheld radio that plugs into a Raspberry Pi via USB.

- Some can handle many digital modes, including DMR, D-STAR, YSF, P25, NXDN, various cross modes, and POCSAG; others are limited to only one or a few modes.

- Most require a digital voice-capable radio to work with them (these typically have stubby or onboard ceramic antennas for nearby connectivity). There’s also another type that has its own AMBE\(^\circledast\) Vocoder chip so you can operate it without the need for a digital radio, for example, by using a headset with a microphone that is connected to the computer the hotspot is plugged into.

  *Note:* A core component of a digital radio is an AMBE\(^\circledast\) chip, which compresses the digitized signal and adds error correction. If a hotspot has its own AMBE\(^\circledast\) chip, it doesn't need a digital radio. Alternatively, a hotspot can use an AMBE\(^\circledast\) chip for transcoding between modes, in which case, a digital radio is still needed.

I’ve been playing around with personal, low-power hotspots since 2016. During that time, I’ve tried a bunch of devices and apps including: a whole range of MMDVM-based hotspots running an app called Pi-Star (discussed in more detail in the Playing with Pi-Star article); three generations of SharkRF openSPOTs running their own software; the DVMEGA, first running DStar Commander, then Pi-Star; the BlueStack-Micro+ running BlueDV; the DV Access Point (DVAP); and a couple DV4 products. I discuss my experiences with all of these in this article.

1b) Digital ham radio nets

A great way to make use of hotspots is to join some of the many digital radio nets that are run every day by hams throughout the U.S. and around the world.
I particularly enjoy participating on the Colorado HD (Hotspot Discussion) net, a Colorado Digital Multiprotocol net held at 7:30p MTN each Tuesday:

- DMR/YSF/P25 talkgroup 31088
- D-STAR reflector DCS/XRF/XLX303 D
- YSF room 99256

They also have a Telegram group: Colorado Digital Multiprotocol.

**Additional Telegram groups**

There’s a good list of Amateur Radio Telegram groups that was compiled by Tom, W2XQ, which is posted on the Colorado Digital website’s Resources page: Ham Radio Telegram Channels. One that I really like is for finding DMR nets: Ham Radio DMR Nets. It has a quite comprehensive list of active DMR nets. Each net is displayed an hour before it goes live, making it easy to find out what’s currently on the air: https://t.me/HamRadioDMRNets

1c) Hotspot best practices

The regulations and best practices that apply to amateur radio—including use of frequencies, control of our stations, and on-air courtesy—also apply to our use of personal, low-power hotspots. It’s our responsibility to understand and adhere to these regulations and best practices.

My personal practice is that I power on my personal, low-power hotspots only when I’m monitoring and in control of them, adhere to my local band and frequency use plans, and leave adequate pauses between transmissions. For more about this, see Hotspot best practices.

2) The hotspots

Disclaimer: Again, these are my personal notes and opinions based on my experience playing around with hotspots, as well as by learning from what others are sharing. I’m not affiliated with any hotspot projects, except as an enthusiastic user. If anything needs correcting, please let me know.

These are the hotspots I use, have tried in the past, or have heard/read about, in mostly alphabetical order:

- My current personal favorites [★]
2a) My current personal favorite hotspots [★]

My current favorite personal, low-power hotspots among the available ones are the SharkRF openSPOT2 & 3, and the MMDVM-based ZUMspot and LoneStar. They all are dependable, high-quality products, and are versatile, supporting multiple modes including DMR, D-STAR, YSF, P25, NXDN, various cross modes, and POCSAG (for digital voice paging).

[★] Here are some additional reasons I like the SharkRF openSPOT2 & 3:

- They’re ultra-compact, the smallest hotspots I know of, made possible because all the components are integrated onto a single board.
- They’re easy and quick to get up and running initially.
- They’re simple to use and fast, and have a good web-based control panel.
- The openSPOT3 incorporates built-in hardware transcoding so that D-STAR cross modes are now possible, as well as a 3.7V 1200 mAh battery.
- The hardware is designed by Ákos, HG1MA, an engineer with experience as a team lead focusing on wireless hardware development.
- The software, which is being very actively developed, is created by Norbert, HA2NON, an engineer with experience as a team lead focusing on embedded software development.
- They support APRS messaging and location data forwarding.
- They’re well supported via the SharkRF community forums 🐟.

[★★] And here are some additional reasons I like the MMDVM-based devices:
- The ZUMspot is designed by Jim, KI6ZUM, who is one of the earliest participants in the MMDVM project.
- The LoneStar devices are designed by David, N5BOC, an electrical engineer with 35 years of experience, including designing micro hardware.
- They are made possible by the excellent foundational software (MMDVMHost, etc.) by Jonathan, G4KLX, who conceived the Multi-Mode Digital Voice Modem (MMDVM) project.
- They run the quite good, widely used Pi-Star dashboard by Andy, MW0MWZ. Although Pi-Star isn’t seeing much new development work recently, it still provides a solid hotspot experience.
- If you want to have some fun experimenting, you also can try the Pi-Star fork being developed by Daniel, F1RMB: GitHub: f1rmb/Pi-Star_DV_Dash 🐟.
- They use firmware by Andy, CA6JAU, who is another one of the earliest participants in the MMDVM project, and the firmware can be easily updated.
- They are compact, fitting and running well on a Raspberry Pi Zero W, though they will run faster on the larger RPi 3B, 3A+, 3B+, and 4B boards.
- They are widely adopted, so it’s easy to find online and on-air help.
- They have through-hole connectors right on the boards for directly wiring in either a Nextion or OLED display.
- They provide an excellent opportunity to learn about a wealth of subjects beyond hotspot usage itself, like Raspberry Pi computers and their Raspbian operating system (based on Debian, which is a Linux distribution), and the programmable Nextion displays, as well as practical skills like soldering.

A couple notes about the MMDVM project:
- The Multi-Mode Digital Voice Modem (MMDVM) project was conceived in early 2015 by Jonathan, G4KLX, and developed by Jonathan and Jim, KI6ZUM. Jonathan wrote all the software, Jim created the hardware (and, eventually, the ZUMspot), and both worked on the early firmware. Later, Andy,
CD6JAU, took over writing the firmware, as well as the software-based cross modes (DMR2YSF, DMR2NXDN, YSF2DMR, YSF2NXDN, YSF2P25).

- There's a good presentation from Pacificon 2017 with an introduction to digital voice and multimode by Jim, K6JM, and an MMDVM keynote by Jim, K16ZUM: MultiMode Digital Voice: The Exciting New Trend in DV (PDF).

All that said, there are other hotspots available and included in the following list that also are worth considering.

2b) Amateur Radio Toys

By Winters Huang, BI7JTA.

Huang is quite passionate about amateur radio and hotspots. He has designed a variety of boards. He also provides friendly support for his hotspots. A digital voice radio is required.

I run one ART simplex hotspot, the MMDVM_HS_HAT_RPiZW (a.k.a., ZW_SPOT HAT) by BI7JTA and VR2VYE. It has an RPi Zero W form factor, though I have it mounted on an RPi 3A+.

Because I’ve had good success with onboard antennas, I ordered a custom version with a RainSun onboard ceramic antenna.

The board also came with an SMA antenna mount, which I removed after taking this photo.

I also run a second ART simplex hotspot, the hotSPOT for RPi (a.k.a., RPi hotSPOT with Cool FAN) by BH7NJF and BI7JTA. I have it mounted on an RPi 3B+ in the "official" RPi 3 case. (As you can see, I had to tweak the case a bit to make everything fit. I also drilled an opening in the bottom of the case so I could mount a heat sink on the chip that’s on the bottom of the RPi 3B+.)
The RPi hotSPOT with Cool FAN has the form factor of an RPi 3A+, but this is a great board to run on an RPi 3B+ because of its very quiet but effective built-in fan, which helps keep the hot 3B+ running cooler. When I’m running the hotspot, I keep the case cover off; at other times, I keep it on to keep the dust out. Bonus: the RxOffset needed no adjustment!

I also previously tried the simplex Nano hotSPOT(BlueBox) for MMDVM. It’s very compact and works well, though it’s slow, presumably due to the specs of the NanoPi NEO computer it uses. Amazingly for its compact size, it has a built-in OLED display, a fan, and even full-sized ethernet and USB ports (the USB port can be used for a WiFi dongle).

Additional products

Amateur Radio Toys also makes a Duplex hotspot board, a repeater board, and some other products, though I haven’t tried any of those.

The boards come in a variety of configurations: as bare boards or with various cases, and with optional Nextion or OLED displays.

Setup and ordering info

- Radio/Modem Type:
  
  STM32-DVM / MMDVM_HS – Raspberry Pi Hat (GPIO)

- Firmware – These use standard firmware by Andy, CA6JAU (juribeparada / MMDVM_HS). To update the firmware via Pi-Star:
  
sudo pistar-mmdvmhshatflash hs_hat
2c) D2RG – something new coming?

![D2RG Logo](image)

An MMDVM-HS-AMBE® hat with an onboard DVSI AMBE3003™ to make transcoding on the RPi possible. Back in May 2019, they announced that the board was in production, and in June 2019, they announced that they were shipping boards out to software developers. Since then, they’ve gone totally silent, so who knows if this will become a real product.

Additional info

*Website: Digital Radio Research Group*

*See also: [https://mmdvm.blogspot.com/](https://mmdvm.blogspot.com/)*

2d) DMRspot Premium

By 27Labs

If you’re looking for a preassembled MMDVM-based hotspot in a good custom case with an OLED display and a Raspberry Pi Zero W, then the DMRspot Premium Hotspot collection is a good one to consider.
The DMRspot Premium hotspots are based on the high-quality LoneStar MMDVM devices by David, N5BOC (it's well worth a few extra bucks to get these premium boards). They can be ordered in three variations: simplex with ceramic antenna, simplex with stubby antenna, or duplex. They offer a wide variety of case colors.

*Note:* Pre-assembled MMDVM hotspots take away from the ham what is, in my opinion, a fun aspect of hotspots: the ability to learn and explore by putting them together ourselves. Still, while I don't use these myself, I can certainly understand why they are attractive to so many. And at least these are good quality.

*Ordering info*

*Website:* DMRspot.com [🔗]
The DVMEGA comes in single-mode (UHF) and dual-mode (VHF/UHF) versions, both of which can be mounted on Raspberry Pi computers, and there are other models as well. The DVMEGA also can be mounted on a BlueStack board. A digital voice radio is required.

With firmware 3.07 and later, it can support D-STAR, DMR, and YSF. As far as I know, it doesn't support NXDN, P25, any cross modes, or POCSAG.

Works well with Pi-Star, and once you’ve soldered the firmware update jumper wire in place for Pi-Star, it’s easy to update the DVMEGA in-house firmware via Pi-Star’s command line. It’s also possible to update the firmware when it’s mounted on a BlueStack board connected to a PC, with the jumper wire soldered to different pins. For firmware info, see the note DVMEGA firmware update.

A note about the shape: The DVMEGA has an odd form factor. Its GPIO connector is sized for 10 pins (2 rows of 5 pins) and it has a standoff in an odd place on the opposite side from the pins, between the pins and the antenna mount. I’m guessing this may have matched some older RPi, but it’s a bit awkward on the current RPi 3B/3B+/3A+ boards. The standoff acts as a pivot point, so that if you touch the antenna, the GPIO connector can easily pull up off the pins.

To partially solve this, I took a full GPIO connector, cut off 5 rows, pulled the pins out of the rest, and mounted that on the remaining GPIO header on the RPi. That creates a bit of a base that gives the DVMEGA a bit more stability, though it still can pull up from the GPIO pins, just not as easily.
Additional products

- **DVstick30**
  [ Newer product, but still somewhat limited design ]
  USB stick with an AMBE-3000™ Vocoder chip. Plugs into a Windows PC (requires a sound card) and works without a radio. You can use the PC's microphone and speaker, or a headset. Works with the BlueDV app. As far as I know, it doesn't support NXDN, P25, any cross modes, or POCSAG.

- **DVMEGA Cast**
  [ Newer product, but still somewhat limited design ]
  An AMBE-3000™ based multi-mode IP radio for DMR, D-STAR, and YSF. Includes a built-in speaker
and a 2.4” touchscreen. Its host system is based on the NanoPi, and has Pi-Star pre-installed. As far as I know, it doesn’t support NXDN, P25, any cross modes, or POCSAG.

Support and ordering info

Website: DVMEGA.
Twitter: Guus van Dooren.

BlueStack-Micro+

[ For use with the DVMEGA ]

By Ruud Kerstens, PE1MSZ.

A companion board for the DVMEGA. The DVMEGA RPi board can be paired with the BlueStack-Micro+ instead of an RPi, which enables a bluetooth connection to an Android or iOS phone running BlueDV or a serial connection to a Windows computer running BlueDV.

When powered by a portable battery pack, the BlueStack + DVMEGA combo provides a mobile solution that can be used with D-STAR, DMR, and YSF radios:
I made a case for the BlueStack + DVMEGA duo out of some mahogany scraps.

For more about this mobile solution: Just can't wait to get on the road again.

The BlueStack board also can be used to facilitate a DVMEGA firmware update. For more info, see the note DVMEGA firmware update.

Ordering and additional info

Website: pe1msz.nl.
Supplier: Combitronics.

BlueDV apps

[ For use with the DVMEGA and DVstick30 ]

By David, PA7LIM.
David makes some really fun and innovative apps. He's continuously trying new things and pushing boundaries. BlueDV can be run on Android and Windows (experimental versions also available for iOS, Linux, and RPi), and is a good solution for a mobile hotspot using the BlueStack-Micro+ paired with a DVMEGA.

*Note from David's website:* "I am not a company! I just wrote the software for fun! (I have no commercial link with DVMEGA, Combitronics or others.) Hope you have a lot of fun with the software!"

**Download and additional info**

*Website:* BlueDV.

*Twitter:* David PA7LIM.

**Peanut**

[ Experimental standalone project ]

FYI, David also is working on an experimental project called Peanut, which makes it possible to use D-STAR and DMR via an Android device (no radio required). Peanut also can be used with a ZUM AMBE board.

2f) DVAP dongle

[ Older, intentionally limited design ]
By Robin Cutshaw, AA4RC, and Moe Wheatley, AE4JY, Internet Labs, Inc.

The DVAP was among the earliest personal hotspots available (my first hotspot was a DVAP). The DVAP was designed to be connected to a PC running Windows or a Mac, and to work with a D-STAR radio.

When running its own software, the DVAP works with only DPLUS (REF) reflectors, intentionally block access to XRF, DCS, and XLX reflectors, and doesn’t support DMR, YSF, or P25 modes. I’ve read that some people use Pi-Star instead, but I don’t have any experience with that.

Internet Labs also made the DV Dongle, which used a DVSI AMBE-2000™ chip, and later they released the DV3K dongle that used the newer DVSI AMBE-3000™ chip. But both of those appear to have been discontinued.

**DV Air** – At the 2017 Hamvention, they announced an upcoming "DV Air" product with built-in Bluetooth, WiFi, and ethernet. As of late 2019, I haven’t found any further info, so I suspect it never went into production.

**Additional info**

*Website: DVAP Dongle.[1]*

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2g) LoneStar MMDVM devices

[ ★ Personal favorites ]

By David, N5BOC; firmware by Andy, CA6JAU ([juribeparada / MMDVM_HS][2]).

These MMDVM-capable boards, designed in Texas, are well made of quality components, use good design techniques, and work with DMR, D-STAR, YSF, P25, NXDN, and POCSAG, as well as various DMR and YSF cross modes. A digital voice radio is required.

**LoneStar MMDVM Simplex**

[ ★ Personal favorite ]

This board is the same size as and works well mounted on a Raspberry Pi Zero W. It also can be mounted on the faster RPi 3B+, 3A+, or 4B, as well as most of the older RPi boards.

It’s a well-designed, four-layer board with a YAGEO 432 MHz ceramic antenna (as well as SMA through-holes), and a large ground plane sandwiched in the middle, which results in well-isolated signals.
Supports OLED and Nextion displays. From the website:

... this board has its own dedicated 3.3V regulator and does not pull voltage off of the noisy Raspberry Pi 3.3V line like all other simplex board do. This board is now a 4 layer board with LARGE ground planes for 3.3V and GND sandwiched in the middle. This acts as one very large decoupling cap the side of the entire board. Also this isolates signals between TOP side and BOTTOM side. Speaking of that all of the Analog RF signals are on the TOP side only and the high harmonic digital signals are all kept isolated on the BOTTOM side. Making this board much more stable.

The LoneStar MMDVM Simplex I received didn't require any RxOffset, and it stated that on the box, so it looks like he tests the individual boards before shipping them.

Setup, support, and ordering info

- **Radio/Modem Type:**
  
  MMDVM_HS_Hat (DB9MAT & DF2ET) for Pi (GPIO)

- **Firmware upgrade script:**
  
  `sudo pistor-mmdvmhshatflash hs_hat`

- **Order directly from David via his website:** [N5BOC store](#)

- **Documentation:** [N5BOC MMDVM Documentation](#)

- **Contact:** There's a contact form on the [N5BOC website](#)

*LoneStar MMDVM Duplex*

[ ★ Personal favorite ]
It’s obvious that David has done some clever work to make a duplex board with quality components and good design practices with a Raspberry Pi Zero W form factor, the first duplex board to accomplish this. Works very well. Quite an accomplishment! It also can be mounted on the faster RPi 3B+, 3A+, or 4B, as well as most of the older RPi boards.

I like it that the SMA antennas are a bit further apart then on some of the other duplex hotspots I’ve used or seen. Also supports both OLED and Nextion displays.

From the website:

This board was designed by myself and all boards are fully assembled here in the great state of Texas using only the highest quality components. This can make a big difference to you. For example this board uses an ECS brand TCXO purchased from Mouser in Mansfield Texas. ECS is known for their quality of oscillators and this one is no exception. They are consistently on frequency with a very low drift over temperature.

Much care was taken during the design and layout of this board. This board is built on a 4 layer Gold Plated PCB which is 1.6mm thick. The gold plating give the best solder adhesion (no pesky cold solder joints) and makes the board more resistant to oxidation for the absolute highest possible reliability. The inner layers are solid POWER and GROUND planes. This is important because it makes the receiver more immune to noise and therefore more sensitive. This also allows every component on the board to have a very low impedance path to either the +3.3V rail or GND which also improves the noise immunity. Lastly the plane layers being the inner layers act as one VERY LARGE decoupling capacitor which makes this board much more immune to voltage glitches on the power supply.
Setup, support, and ordering info

- Setup PDF: De N5BOC MMDVM Duplex Setup Instructions

- Radio/Modem Type:
  MMDVM_HS_Dual_Hat (DB9MAT, DF2ET & D07EN) for Pi (GPIO)

- Radio Frequency RX and TX offset: 5 MHz

- Firmware upgrade script:
  sudo pistar-mmdvmhshatflash hs_dual_hat

- PDF of the LED layout on the bottom of the board: Dual board LEDs

- C4Labs case designed specifically for this board: DRZ-1S. The case has enough space inside for an optional OLED display.

- Order directly from David via his website: N5BOC store.

- Documentation: N5BOC MMDVM Documentation

- Contact: There's a contact form on the N5BOC website

A final note about LoneStar hotspots

These are beautiful boards, crispy laid out, with a lustrous deep blue finish. While that isn't an essential element of a radio/modem board, it is nice, and I appreciate the craftsmanship, care, and sense of aesthetics that went into designing and making these boards.

Configuring Pi-Star for a duplex hotspot

The duplex boards have one immediate advantage over the simplex hotspots, which is that you can transmit even when your radio is in the middle of receiving. This means that you can easily unlink from a busy talkgroup even when the hams using the TG don't leave gaps between their transmissions.

Another advantage of the duplex boards is that you can use both time slots, for example, you can use two DMR radios, one linked via TS1 and the other linked via TS2, to listen to both linked talkgroups simultaneously.

There are a couple things that are different when configuring Pi-Star for a duplex hotspot compared to a simplex one:
In the Control Software section, select Controller Mode = Duplex Repeater, and then click Apply Changes.

Once the Duplex Repeater option has been enabled, in the General Configuration section, you'll see two Radio Frequency options: RX and TX (these are the hotspot frequencies, the opposite of those used by your radio).

<table>
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<th>Setting</th>
<th>Value</th>
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<tr>
<td>Hostname:</td>
<td>pi-star-d</td>
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<td>Node Callsign:</td>
<td>KE0FHS</td>
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<td>CCS7/DMR ID:</td>
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<tr>
<td>Radio Frequency RX:</td>
<td>440.300.000 MHz</td>
</tr>
<tr>
<td>Radio Frequency TX:</td>
<td>445.300.000 MHz</td>
</tr>
</tbody>
</table>

**Important!** Avoid frequencies used for other purposes, for example, 435.0 - 438.0 and 145.8 - 146.0, used internationally for satellite communication, which can be disrupted by even low power hotspot transmissions.

**Pi-Star reminder:** Beginning with dashboard v20181216, when you change a frequency, the frequency field displays red when it is within the satellite range and green when it is safely outside that range. Pi-Star itself doesn't enforce frequency ranges; however, hotspots running firmware ZUMspot/MMDVM_HS v1.4.12 or later won't work on satellite frequencies.

**Band plan:** See your country's band plan and your local frequency use plan. For example, for the U.S., see: U.S. Band Plan [ ]. For the U.S. State of Colorado, see: Colorado Frequency Use Plans [ ]. For other U.S. States, see Amateur Radio: Repeater Coordinators [ ], a list by Thomas, W2XQ. See also the info posted by Ron, VE1AIC: Digital Voice frequencies [ ].

*Note:* There is a known DMR timing synchronization issue with some duplex hotspots and radio combinations. Bud, W0RMT, has a good post on the Pi-Star User Forum about adjustments that can be tried to address the issue [ ].

**Good article about setting up a duplex hotspot**

There's a detailed article "focused on the MMDVM board with dual (duplex) radios and the DMR protocol, operating on the Brandmeister network," which includes sections on using pistar-mmdvmcal for calibration, and on performance tuning, by COMMS Working Group [ ].
2h) MMDVM_HS_Hat

[ Available in Germany only ]

The high quality MMDVM_HS_Hat line of boards from Germany is based on work by Jonathan, G4KLX, and Jim, KI6ZUM, and uses firmware by Andy, CA6JAU.

These boards handle D-STAR, DMR, YSF, P25, and NXDN, as well as the YSF and DMR cross modes, and POCSAG (Florian and Mathis were very active in POCSAG-related development). A digital-voice capable radio is required.

The designs were openly published on GitHub under a Creative Commons Attribution-NonCommercial-ShareAlike 3.0 license. Unfortunately, the designs were used in a way that is explicitly forbidden by the license as the basis for the unauthorized, lower-quality, commercial clones known as JumboSPOT or J-Hat.

*MMDVM_HS_Hat Simplex*

[ Available in Germany only ]

By Florian, DF2ET, and Mathis, DB9MAT.

The newer versions of this board (1.6 and later) use a 12.288 MHz TCXO chip, while the older versions used a 14.7456 MHz chip. You also can see which TCXO chip your board has in the Radio Info module of the Pi-Star dashboard.

**Support and ordering info**

- *Radio/Modem Type:*
  
  MMDVM_HS_Hat (DB9MAT & DF2ET) for Pi (GPIO)

- *Firmware upgrade script:*

  - MMDVM_HS_Hat board with 14.7456 MHz TCXO¹ connected to GPIO:

    `sudo pistar-mmdvmhshatflash hs_hat`
- MMDVM_HS_Hat board with 12.288 MHz TCXO connected to GPIO:
  
  ```bash
  sudo pistar-mmdvmhshatflash hs_hat-12mhz
  ```

- **MMDVM_HS_Hat on GitHub**: mathisschmieder / MMDVM_HS_Hat [🔗].

- Pre-configured Mouser cart: MMDVM_HS_Hat v1.6 [🔗].

- Available in Germany only: Funk24.net in Aachen [🔗].

**MMDMV_HS_Dual_Hat**

[ Available in Germany only ]

By Florian, DF2ET, Mathis, DB9MAT, and Andreas, DO7EN.

The newer duplex board uses a 12.288 MHz TCXO chip.

**Support and ordering info**

- **Radio/Modem Type**:
  
  MMDVM_HS_Dual_Hat (DB9MAT, DF2ET & DO7EN) for Pi (GPIO)

- **Firmware upgrade script**:

  - MMDVM_HS_DUAL_Hat board with 14.7456 MHz TCXO conn to GPIO:

    ```bash
    sudo pistar-mmdvmmhatflash hs_dual_hat
    ```

  - MMDVM_HS_DUAL_Hat board with 12.288 MHz TCXO conn to GPIO:

    ```bash
    sudo pistar-mmdvmmhatflash hs_dual_hat-12mhz
    ```

- **MMDVM_HS_Dual_Hat on GitHub**: phl0 / MMDVM_HS_Dual_Hat [🔗].

- Available in Germany only: Funk24.net in Aachen [🔗].
Contact info

- Email: mmdvm@df2et.de.
- Twitter: Flo (DF2ET) and Mathis Schmieder.

2i) Nano-Spot

[ MAR 2020: Micro-Node has gone out of business ]

By Mark Guidbord, K7IZA.

Per a note posted on his website:
"Mark has decided to retire so Micro-Node will no longer be providing new product sales. Micro-Node will continue to honor and support current customers and products that are under warranty."

For more information, see Mark’s website: http://micro-node.com/

The Nano-Spot is a plug-n-play device. It includes built-in WiFi, RF and WiFi antennas, and an OLED display, all in a durable extruded aluminum case. Runs Pi-Star. Supports D-STAR, DMR, YSF, and P25.

Requires a digital radio.

I haven’t personally tried this hotspot. One thing to be aware of is that it uses custom firmware and it may also use a custom version of the Pi-Star software, so you are dependent on Mark for new versions, and may even need his assistance for some of the updating.

Website: Micro-Node.

2j) OpenGD77

[ Experimental project ]

This is a bit of an oddity, but a fun one! Roger, VK3KYY, of Melbourne, Australia, is creating experimental firmware for the relatively inexpensive Radioddity GD-77, which enables it to be turned into a mid-power hotspot by plugging into a Raspberry Pi running Pi-Star via USB.
This project is attracting a lot of attention among digital radio enthusiasts and a good number of people are experimenting with it and experiencing good results. I personally don’t have a use case for a higher-power hotspot device like this, but I love it when people are pushing the boundaries with experiments like this!

**Download and additional info**

For more info and firmware, see [RogerClark.net](http://RogerClark.net)

**Additional info**

- **GD77 original CPS:** [Radioddity Download](http://Radioddity Download)
- OpenGD77 User Guide ([FAQ](http://FAQ))
- OpenGD77 forum
- Upgrade to OpenGD77 by VK3TBS
- Radioddity GD-77 User Guide Informative Links
- *Talkgroup supporting the OpenGD77 project:* BrandMeister TG98977

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**2k) SharkRF openSPOT2 & 3**

[ ★ Personal favorites ]

By Ákos Marton, HG1MA, and Norbert Varga, HA2NON.

There are a few observations that apply to both the openSPOT2 & 3:

- It's quick and easy to get an openSPOT up and running initially, and they're very fast in use.
- Even though the basics are quick and easy to use, the openSPOTs are sophisticated and capable, with many advanced options and features.
They have their own very good and easy-to-use browser-based control panel that works well when viewed on a desktop monitor, a tablet, or a cell phone. It includes a status dashboard, regular and advanced configuration options, and a Quick Setup button for easy mode changes.

Since all the components are on a single board, they’re slim and compact, smaller than any other hotspots I know about. They include both WiFi and RF antennas inside their cases.

The openSPOT firmware and web-based control panel are being actively developed with regular releases adding new features and fixes. The firmware upgrade process happens automatically in the background while the openSPOT is running.

They work with D-STAR, DMR, YSF, P25, and NXDN radios, include cross-mode functionality, handle POCSAG, and support APRS messaging and location data forwarding. They require a digital radio.

SharkRF provides a comprehensive online user manual for each model, as well as a robust community forum for support.

**SharkRF openSPOT2**

[ ★ Personal favorite ]

The openSPOT2 was released Oct 2018.

Since it combines the radio/modem and computer onto a single board (2-7/8”×1-1/2”) that is only slightly bigger than a Raspberry Pi Zero (2-9/16”×1-3/16”), it’s the most compact hotspot I know of. Here it is compared to a Lonestar MMDVM Simplex with a ceramic antenna mounted on an RPi Zero W:
The only thing I didn't like about the openSPOT2 out of the box is the bright, multi-colored LED light. While it's helpful (the different colors and blinking patterns convey a wealth of information about the functioning of the device) I simply don't like bright, pulsing LEDs. No problem, though, you can adjust the brightness in the control panel. Nice! Sure wish my MMDVM-based hotspots had that option.

I don't think I can sum it up any better than David, KK4MHI, does in his comment in the SharkRF Community Forum: "It just works. Period. Bottom-line – if you [want] rock-solid reliability and don't feel like learning Linux or playing with Raspberry Pi images … go with the OpenSPOT."

How much do I like the openSPOT2? Once I had played around with it enough to know how good it is, I went ahead and ordered a second one so that I can operate DMR and D-STAR simultaneously (on different frequencies). Life is good!

Setup and ordering info

- SharkRF openSPOT2
- SharkRF openSPOT2 online user manual
- SharkRF openSPOT2 firmware changelog
- SharkRF openSPOT2 Community Forum
SharkRF openSPOT3

[ ★ Personal favorite ]

The openSPOT3 was released Jan 2020.

For me, the most Interesting upgrade of the Shark RF openSPOT3 is that it incorporates an onboard AMBE® chip for hardware transcoding so that D-STAR cross modes are now possible in a personal hotspot.

So far, only D-STAR to DMR and DMR to D-STAR are supported, but soon (Feb 2020) there will be a firmware upgrade to also support D-STAR to NXDNReflector, NXDN to D-STAR REF/XRF and DCS/XLX, and D-STAR gateway usage with C4FM transceivers.

The openSPOT3 also includes a built-in 3.7V 1200 mAh battery with a claimed 10-hour life. The battery has a plug, so it theoretically should be replaceable. The hotspot now chirps and beeps, and the sounds have a nice character and their volume can be adjusted. For those of you who like to take a walk on the dark side, there's now a dark mode available for the control panel.

It has "range extended" antennas: a Freedom FXP72 WiFi patch antenna and a helical RF antenna, perhaps something like the Pulse Electronics CW3127. So far, my subjective results with the performance of the antennas has been good.
Setup and ordering info

- SharkRF openSPOT3
- SharkRF openSPOT3 online user manual
- SharkRF openSPOT3 firmware changelog
- SharkRF openSPOT3 Community Forum

Using the openSPOT3 D-STAR cross mode

The v7 firmware (beta; should be available as a regular firmware update on Feb 10, 2020) adds support for changing to BrandMeister, YSFReflector and NXDNReflector servers using a D-STAR transceiver:

- To change to BrandMeister server 2162, set the URCALL to BM2162 and start a short call
- To change to YSFReflector server 89804, set the URCALL to YS89804 and start a short call
To change to NXDNReflector server 28299, set the URCALL to NX28299 and start a short call

(Don’t forget to set the URCALL back to CQCQCQ after the short call used to change the server)

*Homebrew/MMDVM® connector > Cross modes usage*

*Source:* openSPOT3 online user manual.

**D-STAR® notes**

You can update the Route cross mode calls to ID with a D-STAR® radio using two methods:

- Set the ID and call type in the D-STAR® radio's URCALL, then start a short call. After the short call, set back the URCALL to CQCQCQ. Examples:
  - 2161005P – private call to 2161005
  - 216G – group call to 216
  - 216 – group call to 216 (if there’s no G character then the call type is set to group call)
- DTMF codes: you can start a short private call to an ID by entering † followed by the destination ID in DTMF code. You can start a short group call to an ID by entering # followed by the destination ID in DTMF code. Examples:
  - #3100 - group call to 3100
  - † 4770 - private call to 4770

See also:

- [Cross modes using a D-STAR® transceiver](#).
- [Switching reflectors/gateways using your radio](#).

**Some final notes about the openSPOT2 & 3**

The openSPOT3 is bigger than the openSPOT2, but still slim and portable. They both slip easily into the front pocket of my jeans.

- openSPOT2: 3-1/4” × 1-7/8” × 5/8”; 32 grams
- openSPOT3: 3-7/8” × 2-1/4” × 3/4”; 77 grams
There are three additional things that warrant mentioning:

1. They don’t support add-on displays like a Nextion or OLED. As I discuss further below (see 3i) Components > Displays, I enjoy playing around with Nextion displays, but don’t think a display is a necessary component for a hotspot, and agree with what Norbert, HA2NON, says in his answer in the SharkRF Community Forum: “We think you already have a display on your radio where you can see what’s going on in more detail. If that’s not enough, you may still have your phone or computer around where you can open the web interface for real time monitoring.” That said, if you want a display, you’ll need to look at some other hotspot.

2. They are WiFi only. For me, that’s totally fine; I personally prefer to use a WiFi connection over a wired Ethernet connection (the original openSPOT was wired only, and while it was a quite capable hotspot, I didn’t like it that it didn’t support WiFi out of the box and ended up using a travel router with it). But I know some people prefer to have their hotspots connected via a wired Ethernet connection, so it’s important to be aware of this.

3. The software is proprietary. Unlike the MMDVM and Pi-Star projects, you won’t find the code in a repository like GitHub where you can look it over and even contribute to the project or customize it to your own liking. It’s easier for me to read Martian than code, so this doesn’t matter much to me, but I know some people like to dig into the code, and you can’t do that with openSPOTs.
2l) ThumbDV

[ Older, limited design ]

By Bryan Hoyer, K7UDR, Basil Gunn, N7NIX, John Hays, K7VE, and Dennis Rosenauer, AC7FT.

The ThumbDV is a USB device with a built-in AMBE3000™ chip, so it can be plugged into a computer that has a microphone and speaker, and doesn’t require a digital radio. I haven’t tried this hotspot so can’t share much about it. Apparently it can support D-STAR, DMR, and YSF, depending on the hotspot software used. I even heard someone on a net who had the ThumbDV plugged directly into his Android phone (I’m guessing using BlueDV software). Sounded just fine.

While there is still stock of this board as of early 2020, they appear to be more focused on other projects now.

Ordering and additional info

Website: NW Digital Radio ThumbDV

2m) ZUM Radio ZUMspot

[ ★ Personal favorite ]

Designed by Jim Mclaughlin, KI6ZUM, based on the MMDVM work by Jonathan Naylor, G4KLX (g4klx / MMDVM), and others; firmware by Andy, CA6JAU (juribeparada / MMDVM_HS).

The ZUMspot-RPi Board is the same size as and works well mounted on a Raspberry Pi Zero W. It also can be mounted on the faster RPi 3B+, 3A+, or 4B, as well as most of the older RPi boards. Requires a digital radio.

It’s a Multi-Mode Digital Voice Modem that works with DMR, D-STAR, YSF, P25, NXDN, various cross modes, and POCSAG.

The ZUMspot-RPi Board 3 v0.6 includes a pre-installed Nextion display header connection, as well as these updates:

- EMI (ElectroMagnetic Interference) improvements.
• The I2C connector moved to make it easier to mount 0.96” and 1.3” OLED displays.

• The SDA/SCL pins for OLED now connected to the GPIO pins (previously to the STM32 pins).

• The voltage supplied to the Nextion port changed from 3.3V to 5V.

• Two new LEDs added: NDXN and MODE (other).

Availability

U.S. – In the U.S., the ZUMspot is available from Ham Radio Outlet in a couple configurations:

• ZUMspot-RPi Board 3 v0.6, which is a bare board that includes a built-in Nextion display header connection.

• ZUMspot-RPi v0.6 with attached 1.3” OLED display kit, which includes an RPi Zero WH and a microSD card preloaded with Pi-Star.

U.K. – In the U.K., the ZUMspot-RPi v0.6 is available from ML&S (Martin Lynch & Sons). ML&S also carries a variety of other ZUM Radio boards.

Additional and new ZUM Radio products

HRO also carries a variety of other ZUM Radio boards and accessories including a ZUMspot Dual Band Kit, a ZUMspot Duplex Kit, a ZUMspot USB Module Hotspot, the ZUM Radio Nucleo, which is for repeater and high power hotspot applications, and an AMBE® Server for cross-mode transcoding (ZUM AMBE board). To find these products, just do a search at HRO on “ZUM Radio.”

Cases

There also are a variety of C4Labs cases designed specifically for the ZUMspot board, for use with RPi Zero W or RPi 3B/3B+ computers, and optionally with OLED or Nextion displays.

Setup and support info

• Radio/Modem Type:

  sudo pistar-zumspotflash rpi

• Firmware upgrade script:

  sudo pistar-zumspotflash rpi

• Support: You can find support for ZUM Radio products in a few places:

  • You can try contacting the store where you purchased them.
- If you use Facebook, you can try the [Official ZUMspot and ZUM Radio Products Group](https://www.facebook.com) on Facebook.

- You can try the [ZUMspot section of the Pi-Star User Forum](https://www.pi-star.info). I don't think the ZUM Radio team monitors that much, if at all, but other ZUMspot users may be able to help you.

- If all else fails, you can try sending an email to support@zumradio.com.

- A good video: [ZUMspot setup with Pi-Star for the Kenwood TH-D74](https://www.youtube.com) by Don, W6GPS. In the first half of his video, Don explains the general initial configuration of a ZUMspot using Pi-Star. In the second half, he explains setting up the Kenwood TH-D74A for use with a hotspot.

### 2n) Others

There are other hotspots available that I've seen or heard about (and likely still others that I haven't). Here are a few:

- **Jumbospots (a.k.a., J-HATS)** – These are unauthorized clones of the original MMDVM_HS_Hat board made by Florian, DF2ET, and Mathis, DB9MAT. Unlike the high-quality originals, the quality of the components used in these clone boards can vary (especially, for some reason, the quality of the TCXO chips, which can lead to issues with high BER, the need for high TX offsets, and offset instability), it's unclear who manufactures them, and getting support for defective units is sometimes challenging.

- **Pre-assembled devices** – There are some other hotspots that are pre-assembled from readily available components; unfortunately, many of these I've seen are quite expensive for what they are, especially when they're based on the lower-quality Jumbospot clones. They also take away from the ham what is, in my opinion, a fun aspect of hotspots: the ability to learn and explore by putting them together ourselves.

- **DV4 devices by Uli, AG0X/DH6SAB, and Torsten, DG1HT** – These are older and somewhat limited in design. Probably discontinued (their website is offline, all their products are out of stock, and their social media activity ceased in Jan 2018). The DV4mini was a USB stick that could be plugged into a PC running Windows or Linux, or a Raspberry Pi. The DV4home, released later, was a standalone digital voice device that had two AMBE® chips as well as its own screen, microphone, and speaker. While I know people who have used and liked the DV4 devices, I personally found both the DV4mini and the DV4home V1 clunky to use when I tried them in 2016/2017. The DV4home's rotary knob was particularly poorly implemented—I found it almost unusable—and I've heard similar feedback from someone using V2. I also didn't like its bias for the DMR+ network. Too bad, because I had high
hopes for using the DV4home as my digital base station, but it didn't work out. Website: Wireless Holdings.

- **Older devices** – In addition, there are a couple earlier personal, low-power hotspots that I've read about, DUTCH*Star (no longer online) and DVRPTR, but they were discontinued already by the time I started exploring hotspots.

### Stay safe

I recommend staying away from apps that aren't being actively maintained, updated, and supported. Hotspots connect your personal network to the internet, and given the state of (in)security on the internet these days, it's really helpful if the apps they use are being kept current by actively involved developers.

Probably the most important and basic thing you can do to protect yourself is to update the software you use to its newest version. That means using an updated version of whatever operating system you’re using, and updating all your apps and software. It also means updating the firmware on your router, connected devices, and any other gadgets you use that can connect to the internet.

– The Motherboard Guide to Not Getting Hacked

Also, wherever possible, use unique, difficult-to-guess passwords!

### 3) The components

A personal, low-power hotspot is like your own personal repeater and gateway computer. Similar to a repeater, it’s capable of receiving and transmitting RF, though at a very low power level, typically, 10mW or 0.01 watts. Like a gateway, it’s also capable of connecting to the internet to send and receive data.

A typical personal, low-power hotspot is made up of some kind of radio/modem board with an antenna together with a small computer like a Raspberry Pi (the functionality of these two components also can
be combined into a single board). The hardware typically includes built-in WiFi and/or an ethernet port, and in some cases, various other ports (USB, HDMI, etc.) and pins or through-holes that enable connecting peripherals like displays.

The radio/modem board component typically has firmware controlling its core functions, while the entire hotspot has software controlling its overall operation. Usually, both the firmware and software can be upgraded by the end user, enabling the hotspots to incorporate feature updates and fixes.

Here's a closer look at some key personal, low-power hotspot topics:

- **Radio/modem board**
- **Processing and connectivity**
- **Firmware**
- **Software**
- **LEDs**
- **Buttons**
- **Through-holes**
- **Cases & cooling fans**
- **Displays**

3a) Radio/modem board

I'm most familiar with MMDVM-based hotspots, so I'll focus on them for this explanation. I had the good fortune to meet Dave, KC6N, via email, and he shared insights with me about how they work. What he pointed out made me appreciate these little boards even more.

Here's what I understood: the MMDVM-based personal, low-power hotspots have a radio/modem board with two primary chips (shown here on a ZUMspot), and the radio and modem functions are distributed between those two chips.

One of those primary chips is an Analog Devices ADF7021 Integrated Chip, a low-power 2FSK/3FSK/4FSK* transceiver. The ADF7021 generates RF signals and handles audio tones used by our digital radios to represent 1s and 0s.

The other primary chip is a microcontroller, a small computer on a single integrated circuit. It does the digital work, builds the packet frames, and programs and controls the ADF7021.
Thanks, Dave, for taking the time to share your knowledge and patiently explain this to me; it’s at times like these that I appreciate the amateur radio community the most. If you’d like to dive into all of us this a bit more deeply, Dave created a good presentation about all of this: Digital Voice for Amateur Radio (PDF).

*Hint:* A common issue with some new hotspots, especially the ones that use the clone boards like the Jumbospot, is high Bit Error Rate (BER > 1%). If you experience this when transmitting, see Fine tuning to reduce high BER.

[*] FSK = Frequency Shift Keying; 2FSK is used for D-STAR, and 4FSK is used for DMR, YSF, P25, and NXDN, which explains why software-based cross-mode transcoding is possible between the latter four, but not so easily with D-STAR. However, at least one new hotspot, the SharkRF openSPOT3, is incorporating an AMBE® chip in order to add hardware transcoding that works with D-STAR.

3b) Processing and connectivity

With the MMDVM hotspots, the radio/modem board handles the tasks related to the radio signals, and a small computer handles the rest of the processing tasks, as well as the internet connectivity tasks, and the hotspot’s power processing.

A primary hotspot component handled by the computer is the Gateway, which communicates with the internet. For an MMDVM-based hotspot, that’s handled by a computer like a Raspberry Pi, which the radio/modem board is mounted on.

The MMDVM-based radio/modem boards can be mounted on and work well with a variety of Raspberry Pi models, most commonly the compact Zero W and the faster and more powerful 3B, 3B+, 3A+, and 4B. They’ll also work on most of the older models that have a 40-pin GPIO connector. Some MMDVM-based radio/modem boards are designed to work with other small computers like the NanoPi Neo, but those aren’t as common. As I mentioned earlier, some hotspots incorporate both the radio/modem and computing components onto a custom single board.
My current favorite Raspberry Pi is the 3A+ because of its nice balance between form factor size and performance. It’s much faster than the Zero W, more compact than the 3B+/4B, and also runs much cooler than the 3B+/4B, while not much warmer than the Zero W. You do give up some ports with the 3A+ compared to the 3B+/4B: there’s only one USB port vs. four on the 3B+/4B, and most importantly, there’s no ethernet port, but that's fine for me as I primarily use WiFi for my hotspots. The RPi 3B is also a good board.

Bud, W0RMT, posted a good article comparing the RPi 3A+, 3B+, 4B, and Zero W: [Choosing a Pi for your Pi-Star hotspot](https://zbwձmedical.åm/index.php?title=Choosing_a_Pi_for_your_Pi-Star_hotspot).

### 3c) Firmware

The radio/modem’s firmware controls its key functions. Most MMDVM-based modems use the firmware developed by Andy, CA6JAU ([GitHub: juribeparada / MMDVM_HS](https://github.com/juribeparada/MMDVM_HS)). You can find the latest releases and release notes at [ZUMspot/MMDVM_HS firmware](https://github.com/juribeparada/MMDVM_HS). Other hotspots, such as the openSPOT and the DVMEGA, use their own firmware.

It’s a good practice to keep the firmware up to date, as the updates include fixes, updated features, and changes to ensure they work with the latest hardware.

The ZUMspot/MMDVM_HS firmware can be updated easily via Pi-Star (see [Performing firmware updates via Pi-Star](https://zbwձmedical.åm/index.php?title=Performing_firmware_updates_via_Pi-Star)). To use Pi-Star’s firmware updating script, you need to know the exact firmware update command to use, which you can learn from the manufacturer or vendor of your MMDVM-based hotspot.

### 3d) Software

Most of the MMDVM-based hotspots work well with the Pi-Star app, and setup is relatively easy, especially because many of them can use Pi-Star’s Auto AP feature for wireless network configuration (requires a recent RPi like the Zero W, 3B, 3B+, 3A+, or 4B).

At least one hotspot, the openSPOT, uses its own software, and a couple use derivatives of Pi-Star, which you can learn more about from the manufacturer or vendors of those hotspots.

### 3e) LEDs
You need to view the LEDs from the perspective of the hotspot:

- **PTT (Push-to-Talk)** – Lights up when the hotspot has received data from the internet and is transmitting (Tx) it out via RF. When this is happening, your digital radio will be receiving.

- **COS (Carrier Operated Switch)** – Lights up when the hotspot’s receiver squelch is open and an RF signal is being received (Rx). This happens when you press your digital radio’s PTT in order to transmit.

- **Modes (D-STAR, DMR, YSF, P25, NXDN, OTHER)** – These light up when the hotspot is in a specific mode. If you have multiple modes active and there is no activity, the hotspot will scan those modes looking for activity, so their LEDs will flash in succession. When there is activity, the current mode’s LED will be lit, and it will remain lit after the activity finishes for the amount of time the hotspot continues listening on that mode (see the Pi-Star configuration Hangtime setting).

- **Multi-mode LED** – The SharkRF openSPOT has a unique multi-mode, multi-colored LED that displays a variety of states via the colors being displayed and the pattern with which they are being displayed. Here’s a visual overview of the openSPOT2 LED states.

### 3f) Buttons

Sometimes, there are one or more push buttons on an MMDVM-based radio/modem board, for example, on the ZUMspot-RPi v0.4, you’ll see:

- **RST** – The reset button forces a reset of the STM32 chip.

- **BOOT0** – When BOOT0 is pressed, the STM32 chip starts in bootloader mode and will wait for a firmware update.

  *Note 1:* If you run a firmware update via SSH using the easy built-in Pi-Star command for the ZUMspot, the script automatically toggles the BOOT0 and RST pins. For more info, see [Performing firmware updates via Pi-Star](#).

  *Note 2:* To initiate a manual firmware update on the ZUMspot, you either can press BOOT0 while powering on the board, or press BOOT0 and RST simultaneously when the board is powered on. For more info, see the manual firmware update process outlined on the [ZUMspot/MMDVM_HS GitHub page](#).

- **Multi-mode button** – The SharkRF openSPOT2 has a button that can be used to toggle the Access Point mode with a short push, or a full reset with a longer push.

### 3g) Through-holes
Radio/modem boards also have various sets of plated through-holes you can use to connect a variety of peripherals, for example, you might solder in a 4x1 straight or right-angle pin header connector that you can use to connect the cable from a display. A couple of the sets of through-holes you might see:

- **I2C (Inter-Integrated Circuit)** – Can be used for an OLED display.
  
  On the ZUMspot v0.4 board, this set is connected to the clock (SCL) and data (SDA) pins on the STM32 chip. On the ZUMspot v0.6 board, the SDA/SCL pins are connected to the GPIO pins.

- **Serial** – Can be used for a Nextion display. Used as part of the serial passthrough in MMDMVMHost, and also can be used as a debug port.

  **Note 1:** TX on the Nextion display connects to the RX through-hole, and RX on the display connects to the TX through-hole.

  **Note 2:** My 3.5” Nextion Basic NX4832T035 and 3.2” Nextion Enhanced NX4024K032 displays run fine using the 3V3 (3.3 volt) connection on the ZUMspot v0.4 board. I’ve tested this with both the RPi 3B and Zero W using a quality 2.5A power supply. I’ve heard others have needed to connect to a 5-volt GPIO pin. On the ZUMspot v0.6 board, it’s now a 5V connection.

  **Note 3:** On a ZUMspot, this is connected to the Universal asynchronous receiver/transmitter (UART) on the STM32 chip.

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### 3h) Cases & cooling fans

Technically, you don't need a case for an MMDVM-based hotspot; I've used some of mine with just the bare boards, connected together with standoffs, and with some short standoffs beneath to provide feet. But it's really nice to put them in a proper case. Here are some examples of handmade and manufactured cases.

- **Handmade hotspot cases**
- **Cooling fans**
- **Other manufactured hotspot cases**

#### Handmade hotspot cases

I'm a woodworker, so for fun I decided to make a few hotspot cases out of some thinwood I had left over from my woodworking projects, as well as a few other scraps. I ended up building several cases as I experimented with different combinations of RPi boards, batteries, displays, and shapes, before I settled on one design for my shack, a second for the desk where I do a lot of my research and writing, and a third and fourth for mobile use.

#### Shack hotspot

The initial setup for my shack hotspot was a ZUMspot mounted on an RPi 3B with an [Alchemy Power Pi-UpTimeUPS](https://www.alchemypower.com/pitimesup), which uses type 18650 3.7V batteries for uninterrupted power. Since our mountain power
is a bit unreliable, I figured that would be helpful, but in most cases I don’t think it’s necessary.

Note 1: From the Pi-UpTimeUPS product page [🔗]: “Pi-UpTimeUPS protects the Raspberry Pi from brown-outs as well as power failures preventing unwanted downtime. Pi-UpTimeUPS accepts power input from an external power source and charges its batteries at the same time it provides clean uninterrupted power to Raspberry Pi.”

Note 2: Adafruit has a good battery tutorial [🔗].

Note 3: A work in progress: after I upgraded this hotspot to Pi-Star 4 in Mar 2019, I swapped in an RPi 3A+ to take advantage of its cooler operating temperatures. Then in Oct 2019, I swapped in an RPi 4B to test how that board works, added a fan and vents to keep it cooler, and disconnected the micro USB-based Pi-UpTimeUPS since the RPi 4B uses USB-C and draws more power.

Since Pi-Star can run headless, the hotspot really doesn’t need any external ports other than one for power in. Basically, it can be a black (or mahogany) box, optionally with an on/off switches between an external power port and the RPi, and maybe a display screen. For this case, I made a simple box: 4.5” wide × 4.7” deep × 3.5” high (mm: 114 W × 119 D × 89 H).
The height of the case was determined by the stack of boards, which has a plexiglass base. The stack slides into the case, with the plexiglass base sliding under a rectangle of wood to secure the stack in place.
The display fits into the opening in front of the stack of boards. To reduce the footprint of the display, I soldered wires directly to its back rather than using the connector that plugs into its side (on a subsequent Nextion, I actually removed the connector altogether and soldered directly to the board, which was easier).

Since I'm using those same soldered wires to connect the display directly to my PC for programming via a USB to TTL UART CH340 Serial Converter, I also didn’t need to leave space or cut a slot for inserting a microSD card into the display. That means I can fit a 3.5” display into a space that's nearly the same size as the width and height of the stack of boards.
For the on/off switches, I used the LoveRPi Power Switch, which includes a green status LED showing when it's on (important in a black box scenario). It also includes three rubber caps for the switch (green, red, and black). I used one switch as an external power port, with the other end connecting to the UPS, and a second switch between the UPS and the RPi.

A good alternative switch is the CanaKit PiSwitch (Micro USB).
The cables and switches, which I attached to the case with hot glue, determined the depth of the case. Here you can see them crammed into the remaining space. (It’s amazing how as electronic components keep getting smaller and smaller, the plugs and cables have become some of the bigger and bulkier components!) The case piece with the glued-on switches fits into the case's back opening.

The power switches and the power input port are located on the back of the case. The cable with the black switch controls power between the power input and the UPS. The cable with the green switch controls power between the UPS and RPi. When I switched to the new RPi 4B, I added another switch (not shown in the following photo), the CanaKit PiSwitch (USB-C), with its plug end acting as the power port, and the other end connecting directly to the RPi 4B, bypassing the micro USB-based UPS, which I’m no longer using. The two micro USB switches are now unused, but standing by just in case I ever switch back to an older RPi board.
Theoretically, I could leave the UPS powered on all the time, but ever since we had a (fortunately relatively small) fire in our home several years ago that was caused by an electrical short sparked by some poorly done wiring by a previous owner, I’ve been a bit paranoid about leaving things on when I’m not using them.

Writing desk hotspot

I keep another hotspot on my writing desk so I can test things out as I’m researching new features.
One thing I realized is that I have no problem using my hotspots when I'm in another room with a thick wall in between, which means I really don't need to have the antenna sticking out of the box. So my goal was to make something clean looking with the screen at an angle for easier viewing when I'm typing.

This case includes a 3.2” Nextion enhanced display. Initially, it had a ZUMspot mounted on a RPi 3B+ inside. Later, I upgraded to an RPi 4B (a board that I think is generally overpowered for a hotspot, but I wanted to experiment with it). Therefore, I changed the case to incorporate a USB-C power connector, mounted a CanaKit PiSwitch (USB-C) on the back, and added a fan and some more ventilation holes to compensate for the extra heat the RPi 4B generates. The updated design works well.
**Mobile hotspots**

The design for my mobile hotspots was influenced by two goals: a desire for compact simplicity and a hunger for operating time. I decided on a minimalist design: just an MMDVM-based radio/modem board mounted on an RPi Zero W in a box for protection and powered by a rugged external RAVPower 10050 mAh portable charger, which gives me a full day's capacity.

I added a right-angled micro-USB adapter inside the box to make plugging in easier (the plugin port aligns better with the port on the portable charger), as well as to reduce wear and tear on the RPi's micro USB port. The mahogany case fits nicely on top of the battery, attached with Soft Touch Velour cinch straps.

**Jan 2019 update**

Once Pi-Star 4, which supports the Raspberry Pi 3A+, became available, I upgraded my mobile hotspot to a combination of an RPi 3A+ and an MMDVM simplex board with a ceramic onboard antenna. I chose the RPi 3A+ because it’s more compact and runs cooler than an RPi 3B+, while being a lot faster than an
RPi Zero W. I ended up with a case that's not much bigger, and has the advantage of no awkward antenna sticking out.

A good radio/modem board that use ceramic antennas is the Lonestar MMDVM Simplex. The SharkRF openSPOT v2 also uses a ceramic antenna.

*Bonus:* For my new mobile hotspot, I also left the RPi 3A+ USB port accessible so I can plug in an external Nextion display if I want.

(For my two Nextion test units, I simply made cases out of their boxes.)
Size comparison

<table>
<thead>
<tr>
<th></th>
<th>Width</th>
<th>Depth</th>
<th>Height</th>
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</thead>
<tbody>
<tr>
<td>Shack hotspot:</td>
<td>4.50” × 4.70”</td>
<td>× 3.50”</td>
<td></td>
</tr>
<tr>
<td>Mobile hotspot:</td>
<td>3.37” × 2.50”</td>
<td>× 1.75”</td>
<td></td>
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<tr>
<td>New mobile hotspot:</td>
<td>3.00” × 2.90”</td>
<td>× 1.75”</td>
<td></td>
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<tr>
<td>External battery:</td>
<td>4.60” × 2.80”</td>
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<td></td>
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<tr>
<td>Deck of cards:</td>
<td>3.60” × 2.60”</td>
<td>× 0.70”</td>
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Cooling fans

When I started experimenting with the Pi-Star 4.0 Release Candidate running on the new (at that time) RPi 3B+, I noticed that my hotspots started heating up a bit more than normal. Then I read some early reviews about the RPi 4B, which I knew I’d want to try out, and noted that it has a heat signature that makes even the 3B+ look like a snowball on an iceberg. So I decided to add fans to a couple of my hotspots running those warmer boards. I've tried a bunch of different fans. Here are some of the better ones I've found.

First: Is the RPi 4B a good board for a hotspot?

In my opinion, no.

One of the aspects I enjoy most about playing around with hotspots is that there’s often new stuff to try. When the Raspberry Pi 4B was released in June 2019, I began testing it in a couple hotspots, and also made a new shop computer based on the 4 GB model.

While the new shop computer is great and well worth the upgrade, I don’t think the RPi 4B is a good board for a personal, low-power hotspot. When it comes to running Pi-Star, the RPi 4B doesn’t provide a noticeable speed or performance advantage over a 3B+ or 3A+, and it simply runs way too hot without a fan (even after the firmware upgrade that reduced the temperature a bit).

There are good alternative RPi boards available for hotspots. The Zero W and 3B are perfectly adequate, and the 3A+ provides a nice speed and performance upgrade without being so hot as to need a fan.
The Pimoroni Fan SHIM is a good cooling solution. Certainly, it’s the easiest, because there’s no need for soldering connectors to the RPi. However, it’s not effective when used with a radio/modem hat because there’s not enough room between the hat and the RPi for adequate air flow. (That said, I did figure out a way to make use of just the Fan SHIM’s shim, which I describe in a note further below.)

As the name suggests, it’s a shim that slides onto the GPIO header, positioning the fan directly over the main chip on the Raspberry Pi and slightly over the RAM chip (which means you can’t use heat sinks on those chips).

It’s quieter than 40 or 50 mm fans, though of course it doesn’t move as much air: the Noctua 40 mm fan (discussed next) mounted in a case typically keeps an RPi 4B CPU temp below 40°C, while the Pimoroni Fan SHIM keeps the CPU temp in the 45° – 50°C range, which is still totally fine (without a fan, the 4B runs 60°+ C).
Using the Pimoroni Fan SHIM as just a shim

As you can tell from my description above, I did try using the Fan SHIM on an RPi 4B with a radio/modem hat, but found it to be not very effective: the CPU temp quickly shot up into the mid-orange range (above 60°C). I’m guessing that’s because there’s too little room between the RPi and the hat for adequate air flow.

That got me thinking, though: I wondered whether I could use the Fan SHIM as just a shim to run another fan mounted in the case (I used a Noctua, discussed next). The reason that’s attractive is that it eliminates the need to solder wires to the RPi 4B’s GPIO pins in order to power the fan. Any time I can reduce the amount of soldering I need to do, I’m a happy camper!

So I snipped off the Fan SHIM’s arms that hold the fan, and removed those arms and the fan. Then I snipped the wires off the fan, connected their cut end to the case-mounted fan’s wires, and plugged the other end, as designed, into the SHIM. The SHIM is mounted, again as designed, on the RPi’s GPIO pins, sandwiched beneath the radio/modem hat’s connector.

Result: Works great! With the fan and arms removed, there’s room to mount heat sinks on all the 4B chips, and the SHIM powers the Noctua fan just fine, keeping the CPU Temp below 40°C. Life is cool!
Noctua fans

After reading reviews about how some of the cheap 5V fans that are available for RPi boards wear out quickly and either get much noisier as their bearings degrade, or fail completely, I looked around for a better quality fan. I found a quite good one that is well designed, quite effective, reasonably quiet (though definitely noisier than the standard fans because they're moving more air), and engineered for longevity (they have a six-year warranty!): the Noctua NF-A4x10 5V.

Initially, for use with a hotspot that is a radio/modem hat mounted on an RPi, I soldered connectors to the RPi GPIO pins 4 5V and 6 GND (for a good diagram, see: Raspberry Pi Pinout). Subsequently, I started using the Fan SHIM hack discussed above.

Although these fans are only 10 mm in height, they are a bit wider and deeper (40 mm x 40 mm) than a standard RPi fan. That's not a problem if you're making your own custom case, but if you're using a case designed for a typical RPi fan, these Noctua fans won't fit.

Note: The "10" in NF-A4x10 5V represents the 10 mm depth or thickness of the fan. They also make a heftier 20 mm thick version: Noctua NF-A4x20 5V.

C4Labs Zebra Bagel case

C4Labs has a case that works with 40 mm wide fans, so it will fit the Noctua (though it comes with a different fan).
C4Labs Zebra Bagel case

C4Labs Paramount 3 case

C4Labs also makes a new version of their Paramount case that incorporates a 50 mm wide fan and has plenty of room for cables, especially if you're hooking up a couple of monitors.

C4Labs Paramount 3 case

A note of caution: While I haven't tried this version of the Paramount case, I did try a 50 mm fan in one of my homemade cases; it moves a lot of air, so while it does perform effective cooling, it's also quite noisy.
It ended up being too noisy for me.

Other manufactured hotspot cases

Even though I like making some of my own cases, I also use some manufactured cases for test hotspots. For hotspots based on the RPi Zero W, 3B, and 3B+, I've used the really nice MMDVM cases made by C4Labs in Tacoma, Washington.

C4Labs case for a simplex hotspot with the RPi Zero W form factor
C4Labs case for a simplex hotspot with the RPi 3B/3B+ form factor

For the RPi 3A+, I use the very reasonably priced Adafruit Pi Model A+ Case Base and Lid, which are available in a variety of colors. The case has plenty of room inside for an MMDVM-based radio/modem board. If needed, I drill a hole in the lid for the antenna, and a larger hole in the base so I can add a heat sink to the chip that's on the bottom of the RPi 3A+. 
Here’s a case that I modified for a dual hotspot. All I had to do was snip a couple openings out of the sides. I always use the smoked tops because the LEDs on many of the radio/modem boards are way too bright for me.
Hint: I also found that it helps to sand the catch at the back of these cases (on the GPIO header side) to make it easier to snap the 3A+ in place.

In July 2019, I noticed that Adafruit also has a similar case that fits the Model B+, again very reasonably priced. It also fits the RPi 2, 3B, and 3B+.
As with the A+ case, this case has plenty of room inside for an MMDVM-based radio/modem board. Again, I drill a hole in the lid for the antenna, and a larger hole in the base (before I snap the RPi 3B+ board in place) so I can add a heat sink to the chip that's on the bottom of the 3B+. This case also is available in a variety of base and lid colors, though once again, I prefer the smoked tops because the LEDs on many of the radio/modem boards are too bright for me.

3i) Displays

MMDVM-based hotspots can run various displays. The most common are Nextion displays in a variety of sizes and the smaller OLED displays.

I personally prefer the Nextion displays. The design of my Nextion display screens is a customization of the Nextion_ON7LDS screens. My goal was to be able to look at the display from anywhere in my shop and tell at glance what’s being received, so I made the screens for the different modes look quite different from one another, with colors related to their logos. I also like simple, calm screens, so the different text fields are displayed in various subtle colors, and there are no other eye candy embellishments, just the mode logo and the essential data.
Thanks to Rob van Rheenen, PD0DIB, the Dutch ham and digital voice enthusiast who moderates the Nextion Ham-Radio Screens Facebook group, and who generously provides excellent tutorials and mentoring. Thanks also to the hams who are sharing inspiring designs and support in that group.

**Conclusion:** While I enjoyed learning how to program the Nextion displays, in the end I don’t think a display is a necessary component for a hotspot running Pi-Star (the one exception is that I appreciate being able to easily see the hotspot’s IP address). That said, I find it worth it to add Nextion displays to some of my hotspots simply because doing so broadens my knowledge about both hotspots and electronics. **Bottom line:** Nextion displays are optional, fun, and instructional.
Notes:

- **To connect the Nextion to a PC for programming:** I use a USB to TTL UART CH340G Serial Converter (this one is by RobotDyn), along with some breadboard jumper wires. I also used breadboard jumper wires for soldering onto the display.

  ![USB to TTL UART CH340G Serial Converter](image)

  I also use these converters to temporarily connect my test Nextion units to the USB ports of some of my hotspots.

- **Nextion Editor:** Can be downloaded from Itead: [Nextion Editor](https://www.itead.cc/en/nextion-editor/).

  Note: When I started playing around with the Nextion displays, I used the Ver 0.53 Nextion Editor. In mid-2019, Itead released **Nextion Editor Ver 0.58 (now Ver 0.59)**. It introduces new features and updated fonts, but it's not backward compatible with projects built in older editors. There is a Long-Term Support alternative, **Nextion Editor LTS** that does provide backward compatibility for projects created with older editors. In addition, there is a Pi-Star User Forum post by Jason, KE7FNS, explaining how to fix unreadable/corrupted fonts if you upgrade to Ver 0.58.

- **Installing the ON7LDS driver:** If you decide to upgrade to the ON7LDS driver, make sure it gets installed to the correct directory.

  Per Dave, WB6DTB, in the [Pi-Star User Forum](https://www.pi-star.net): Sometimes when installing the ON7LDS Nextion Driver, the driver file doesn't get installed into the "/dev" folder. Go back and follow the installation instructions again and download the driver file again into the "/tmp" folder and then run the 'check_installation' script and it will tell you if the Nextion driver is installed. If it is installed it will tell you the folder where the Nextion driver file is located (probably at "/usr/local/bin"). If so, goto that folder and copy and rename the Nextion driver file to the "/dev" folder, using this command when in the folder where the driver is located currently: `sudo cp NextionDriver /dev/ttyNextionDriver`. Go back to the Pi-Star Configuration page and you should see the Nextion Driver now in the Port field drop down list as 'ttyNextionDriver'. Select the Nextion driver then apply changes, then reboot Pi-Star.

- **Nextion screen layouts:**
- For a basic selection as well as the more detailed readme explanations of the differences between the layouts, see the Nextion subfolders of the g4klx/MMDVMHost GitHub page.

- Rob, PD0DIB, also shares his screens via GitHub: PD0DIB/Nextion_HAM-radio-screens.

- Ryan, WA6HXG, also shares nice screens and good explanations on his GitHub project page: WA6HXG/MMDVM-Nextion-Screen-Layouts.

- **Tech tip from Rob, PD0DIB**: You can control the active and idle screen brightness via Pi-Star's MMDVMHost Expert Editor, which should help preserve battery life for a mobile hotspot. For more info, see: Brightness settings for Nextion Screen.

- **A note about the connector**:
  - **Serial port**: 4 Pin 2.54mm
  - **Cable plug**: JST XH2.54

- **Wikipedia**: JST connectors; **Warning from the article**: Some 2.50 mm parts are incorrectly sold on the internet as 2.54 mm (0.100 in)....

- **Nextion data sheets**:
  - 2.4”**: Basic NX3224T024
    Enhanced NX3224K024
  - 3.2**: Basic NX4024T032
    Enhanced NX4024K032
  - 3.5**: Basic NX4024T035
    Enhanced NX4024K035

4) **Shout out to the innovators and enablers**

In general, hotspots really put the amateur into amateur radio. For the most part, the creative innovation driving this branch of amateur radio forward is being done by passionate hams around the world with day jobs and families who are pouring their energy into these various projects in their spare time.

The upside is that we get this really innovative playground to play around in; the downside—or, depending on how you look at it, another upside—is that this really is an amateur endeavor: things don't always work; there are some rough edges; updates sometimes break stuff; it can take a while for new features that many people want to get implemented; sometimes the only way to make something work is with a soldering iron, a bit of cussing, and a lot of stubbornness; and some features aren't fully
documented so it can take a lot of trial and error to figure them out. In other words … lots of fun to be had for an adventurous amateur!

A hearty thanks to all the innovators, tinkerers, mentors, and enablers for making it possible for the rest of us to enjoy the rich variety of systems and features that are now available in the digital voice playground! Here are some of the hams driving all of this forward:

4a) The tinkerers

There are tinkerers in countries all around the world who are designing boards and wielding soldering irons faster than any of the legendary six-shooter gunslingers of the Old West.

Jim McLaughlin, KI6ZUM

Jim is one of these genius tinkerers. He worked closely with Jonathan and Andy on the original MMDVM project, and is the guiding hand behind the ZUM Radio products. Here’s a video of one of Jim’s talks: Multimode Digital Voice Modem, Pacifcon 2018.

Ákos Marton, HG1MA; Guus van Dooren, PE1PLM; David Dennis, N5BOC

Ákos, of SharkRF, Guus, of DVMEGA, and Dave, of LoneStar, are a few more of these geniuses. They have created their own uniquely innovative solutions for bridging digital radio and the internet.

And others …

There are a few others listed in The Hotspots section above. There are more who I’ve read about (try searching Twitter for MMDVM!), and I’m sure there are even more I haven’t heard about yet.

For someone like me who thinks it’s a pretty amazing accomplishment when I manage to solder on a GPIO header without melting the whole board … well, let's just say I’m impressed!

4b) The coders

There also are keyboard jockeys in countries all around the world who are writing solutions to create bridges between our digital radios, hotspots, and the internet that enable the rest of us to enjoy this fun playground.

Jonathan Naylor, G4KLX

Jonathan operates in a technical stratosphere. He has been creating important digital voice-related solutions for years, which he makes freely available to the hams who are innovating in the digital playground and helping to make amateur digital voice radio so exciting.
The fact that he does this as a side project is truly amazing. (In a video of a talk he gave about MMDVM, he mentioned how at one point his job took him away from home during the week for a period of time to a place that had few disturbances. This, he said with a somewhat mischievous grin, made it possible for him to spend his evening doing something useful … which turned out to be MMDVM!)

Jonathan is particularly passionate about opening things up so hams can participate fully in the hobby, not just as end users of systems and hardware. From his talk at Pacificon 2018: “A closed system in the face of an equivalent open system will never win.”

Here’s what Pi-Star’s Andy Taylor says about this:

> There are some more special people who we all owe a debt of gratitude for their willingness to release their software for free. Jonathan Naylor (G4KLX) for his most excellent DStarRepeater, ircDDBGateway suite, and more recently MMDVMHost and DMRGateway. These applications form the core of what makes Pi-Star what it is, and without these excellent applications Digital Voice for Amateurs would be an entirely different and barren landscape.

Here are a couple videos of Jonathan's talks: MMDVM, 2017; The Road to the MMDVM, Pacificon 2018. See also: GitHub g4klx.

**Andrew Taylor, MWØMWZ**

Andy’s work has made a huge difference to the thousands of us around the world who use MMDVM-based hotspots and repeaters by creating Pi-Star and making it freely available. Andy does this as a side project and somehow still manages to find time for his full-time job, his family, and his studies.

Website: www.pistar.uk; Github: Andy Taylor.

**José Uribe (Andy), CA6JAU**

Andy makes the firmware that powers many ZUMspot and MMDVM_HS-based boards, as well as some of the cross-mode gateways. If you ever hear a rumor about some awesome new feature or functionality, check out his GitHub page; chances are he’ll already have a release ready with it.

GitHub: juribeparada/MMDVM_HS.

**Norbert Varga, HA2NON**

Norbert, of SharkRF, creates the elegant software that powers the openSPOT, cranking out a steady stream of updates that include improvements and new features. He also does a wonderful job of helping their international community of users in their forum.

4c) The mentors and all the other enablers
There are a bunch of hams hanging out in forums and groups around the internet answering question, solving problems, and giving guidance for all the various aspects of digital voice and hotspots. For the Pi-Star project, this includes Craig, W1MSG, who also produces tutorial videos [1], and Andrew, M1DNS, as well as many others. Thanks to all the hams who are helping out in this way; I really appreciate the opportunity to learn by reading your posts!

Finally, a shoutout to all the clubs and individuals who are putting up repeaters, reflectors, servers, gateways, bridges, and other equipment, as well as providing trainings for how to use it all.

And a special thanks to a team here in my home state led by Bud, W0RMT, who created the Colorado Digital Multiprotocol group [2] and the associated Colorado HD (Hotspot Discussion) talkgroup, 31088. They’ve built a multiprotocol reflector project to interconnect various digital modes.

So far, they’ve brought together DMR, D-STAR, NXDN, YSF, P25, and Allstar. Exciting! For more info, see Colorado Digital Multiprotocol Reflector Gateway [2].

Their multiprotocol Colorado HD net—which is a really great net that is open to and attended by hams worldwide—is held at 7:30p MTN each Tuesday:

- DMR/YSF/P25 talkgroup 31088
- D-STAR reflector DCS/XRF/XLX303 D
- YSF room 99256

They also have a Telegram group: Colorado Digital Multiprotocol [2]. Recordings of the net are available at Colorado HD Net Recordings [3], thanks to Vladimir, AC2F.

5) Final notes and footnotes

Part of the fun of playing with hotspots is learning so much.

a. How I gain experience for writing these notes

b. Hotspots: an opportunity to learn
5a) How I gain experience for writing these notes

I use more than a dozen hotspots configured in various ways to test things like updating and upgrading, different options, as well as routine use. My current radio/modem boards include:

- The SharkRF openSPOT2 and openSPOT3 by HG1MA and HA2NON
- Several ZUMspots (v0.4 and v0.6) by KI6ZUM in different configurations
- LoneStar MMDVM Simplex (1V8) and Duplex (1V2) by N5BOC
- MMDVM_HS_Hat (v1.6) by DF2ET & DB9MAT
- MMDVM_HS_Dual_Hat (v1.3) by DF2ET, DB9MAT, & DO7EN
- ZW_SPOT HAT (v1) by BI7JTA & VR2VYE, Amateur Radio Toys
- RPi hotSPOT with Cool FAN (v4) by BH7NJF & BI7JTA, Amateur Radio Toys
- DVMEGA DUAL (v1) by PE1PLM
Note: I also previously used and learned from, but no longer use, the BlueStack-Micro+, openSPOT v1, Nano hotSPOT blueBOX, DVAP, and a couple of the DV4 products.

Most of my hotspots are based on the Raspberry Pi 3A+, 3B+, and 4B. While I like how small the RPi Zero W is and still have a hotspot based on it that I test with, I'm spoiled by the speed of the RPi 3A+/3B+/4B boards. The two hotspots I use the most, at my desk and in my shop, are currently based on the RPi 4B, both of which have custom cases with fans.

I run several Nextion displays (3.2” and 3.5”), which I enjoy even if I don't find them necessary. I also tried a couple OLED units, though I didn't like them much.

In addition to experimenting with my various hotspots, I read lots of online information related to hotspots, including tons of forum posts. As much as is practicable, I test what I write about, and I try to always note it when I mention something that I haven’t personally tested.

5b) Hotspots: an opportunity to learn

Before I started using hotspots, I didn’t know much of anything about digital voice (D-STAR and DMR were confusing concepts to me, and I hadn’t heard of YSF, P25, or NXDN), didn’t know the difference between a vocoder and a modulator or a reflector and a gateway, didn’t really know how to solder, didn’t know what a TCXO* chip is, had only heard about but had not tried the Raspberry Pi computer and its Linux-based Raspbian operating system, didn’t know what SSH is, and didn’t know the difference between a pub and a GitHub.

Now I’m happily playing around with a couple different digital voice modes on a variety of Raspberry Pi models, soldering pin headers onto boards (my joints won’t win any prizes, but hey, they work!), SSH’ing into the Pi-Star image and editing files with the Nano editor, figuring out what it means when a TCXO chip is bad, visiting GitHub regularly for a pint … um, I mean to read release notes, and learning more new stuff all the time.

In the grand scheme of things I’m still a novice, but it’s so great to be able to play around with something that offers so many opportunities to learn about so many different things!

[*] Temperature-compensated Crystal Oscillator

5c) Footnotes

[1] Hotspots vs Personal Access Points – When I first started playing around with hotspots a few years ago, there tended to be more of a distinction between "hotspots" and "personal access points" (see the article Hotspots vs Access Points? by Jim, K6JM [2]). While both perform a similar function—bridging radio and the internet to extend a local digital voice setup—hotspots tended to refer to higher-power devices, while access points referred to lower-power (~10 milliwatts) devices meant primarily for
As the growth of the lower-power devices exploded over the past couple years, the term personal access point has pretty much disappeared, and now the term hotspot is commonly used to refer to the lower-power devices, too.

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4. A shout out to the innovators and enablers

5. Final notes and footnotes
   a. How I gain experience for writing these notes
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Questions or comments?
Please let me know

Amateur radio notes by Toshen, KE0FHS:
CQ · Base · D-STAR · DMR · Hotspots · Pi-Star

This work by KE0FHS