

Smart Radio Troubleshooting Guide

Advanced MIMO Mesh Router for Resilient Private Wireless Networks

Introduction

This is a troubleshooting guide for all Smart Radio models. The Smart Radio runs Doodle Labs Mesh Rider® OS. This guide is organized in the following sections

- [System Overview](#)
- [Troubleshooting radio access](#)
- [Troubleshooting link quality](#)
- [UART and USB ports](#)
- [Crashes, reboots, etc](#)
- [Factory Resetting](#)
- [Connect with Technical Support](#)
- [References](#)

We recommend reading the System Overview section before jumping to any specific section of the guide.

System Overview

Fig. 1 shows the default network configuration of the Smart Radio. The radios are pre-configured so that the entire Mesh Rider network acts like one big distributed Ethernet switch. Therefore, devices plugged into Mesh Rider will automatically be able to communicate with one another if they are on the same subnet. Accessing the radios themselves requires them to be on the same subnet as the host machine.

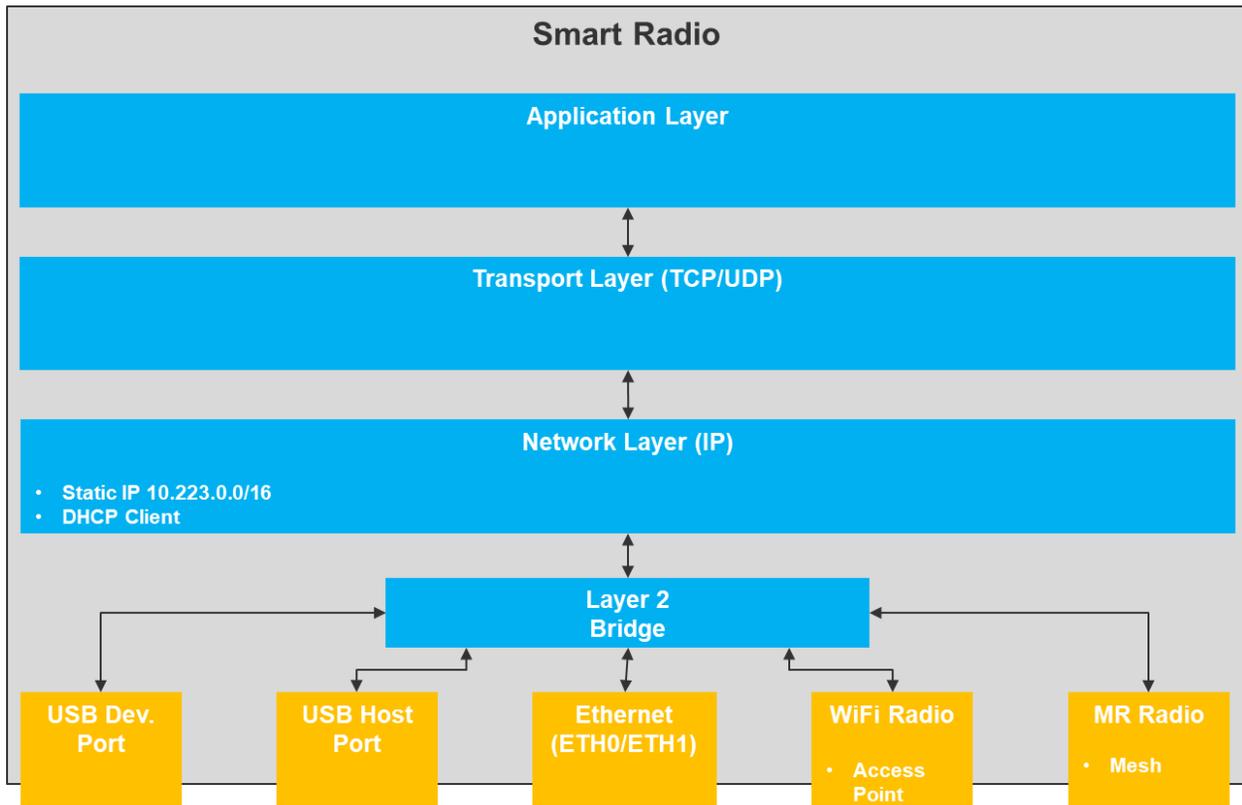


Fig. 1 Default Network Configuration

Available Interfaces

Table 1 shows the available interfaces for the different radio form factors.

Table 1: Available Interfaces for Smart Radios

Interface	Embedded (-H)	Embedded (-J)	External	Wearable	Helix
Mesh Rider Radio	Yes	Yes	Yes	Yes	Yes
Ethernet (ETH0)	Yes	Yes	Yes	No	No
Ethernet (ETH1)	Yes	Yes	Yes	Yes	Yes
USB Device Port	No	No	No	Yes	Yes
USB Host Port	-U only	Yes	Yes	Yes	Yes
WiFi Radio	No	No	No	Yes	No
UART	-S only	Yes ^a	Yes ^a	Yes ^a	Yes ^b

^a up to 1 Mbps

^b up to 115,200 bps

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Mesh Rider Interface

The Mesh Rider interface is the main wireless interface and is available on all Smart Radio products. Because it uses a proprietary wireless protocol, it is only accessible from other Mesh Rider devices. The Mesh Rider wireless interface can be configured in Mesh or WDS AP/Client modes. The WDS AP/Client mode is a star network configuration where all traffic passes through the AP. Clients may not directly communicate with one another except through the AP. APs may not directly communicate with one another except over a wired backbone. In Mesh mode, all devices are equal and communicate with each other or through other devices.

ETH0 and ETH1 Interface

ETH0 and ETH1 are standard Ethernet interfaces and are bridged to the Mesh Rider Interface. You may use the ETH0/ETH1 interface for communications between different devices in the network and also to directly access the radio itself (for device configuration for example).

USB Device Port

The USB Device port is a Ethernet over USB interface and can be connected to USB host ports like those found on PCs, or USB OTG ports like those on Smart Devices. It is bridged to the Mesh Rider interface. USB Devices can only communicate with USB Hosts and not with other USB Devices.

USB Host Port

The USB Host port is setup as an Ethernet over USB interface and can be connected to USB device ports or USB OTG ports like those found on Smart Devices. It is bridged to the Mesh Rider interface. Its functionality can be extended by installing additional USB drivers on the Smart Radio, like USB HID drivers. USB Hosts cannot communicate with other USB Hosts, only with USB Devices.

WiFi Radio

The WiFi radio is bridged to the Mesh Rider Interface and provides standard WiFi connectivity to devices such as PCs and Smart Devices. The default SSID is DoodleLabsWiFi and the password is DoodleSmartRadio.

UART

The UART interface is not part of the IP network, however, it can be bridged to the IP network using software built into the Smart Radio. The UART interface on the Helix Smart Radios supports up to 115200 bps while other radios support up to 1 Mbps.

Configuration Recommendations

We suggest that for initial bench evaluations, start with the default configuration (Mesh). Just power up the radios and they should establish the wireless link

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When changing the configuration of your radio, we always recommend starting with the Simple Configuration menu available in the web GUI by navigating to `Network Configuration` → `Simple Configuration`. While configuring your device, take regular back-ups of the configuration so that in the event that you need to factory reset the device, you can always recover your good configuration.

Accessing the CLI using SSH

You can access the CLI of the Smart Radio using SSH. Windows 10 and many Linux distributions come with a built-in SSH client. SSH into the radio using

```
user@host-pc:~$ ssh root@<IP ADDRESS>
```

You may need to update your ssh known hosts file with

```
user@host-pc:~$ ssh-keygen -R <IP ADDRESS>
```

Troubleshooting Radio Access

This section deals with problems accessing the radios. As explained in the System Overview section, in order to access the radios themselves, host machines do need to be on the same subnet as the Smart Radios.

“I have never been able to access the radios”

If you have never been able to access the radios, then the likely causes are:

1. Most likely there is an IP conflict on your host machine.
2. There may be problem with the physical connection between the host machine and the Smart Radio.

IP Conflict Issues

1. Turn off any other networking interfaces on your host machine, for example WiFi. Although this is not strictly necessary, it could be that your other network uses the same IP subnet as the Smart Radios.
2. Make sure that your host machine has an IP address in the 10.223.0.0/16 subnet.
 - a. If you are using a Windows 10 machine, open up a cmd prompt and type `ipconfig` to see the IP address of your host machine.
 - b. In Linux, open up a terminal and type `ifconfig` to see the IP address of your host machine.
3. Disable the firewall on your host machine.

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Problems with the Physical Connection

1. If your host machine is a Linux machine, type `dmesg | tail` after plugging in the Ethernet port and see if there is a message indicating that an Ethernet device was plugged in.
2. If your host machine is a Windows 10 machine, check your network adapter settings to see that an Ethernet adapter is enabled and connected.

“I can no longer access the Smart Radio”

If you previously were able to access the Smart Radio and can no longer do so, first do a sanity check on the items in the section above. Assuming your IP configuration is fine and the devices are connected, you can proceed with the recommendations below.

1. Try the 192.168.153.1 fallback IP address.
2. Try IPV6 instead.
3. Factory reset the Smart Radio. This topic is discussed the the section [Factory Resetting](#).

Using the fallback IP address

Make sure to power down any other Smart Radios in the network and only have the local Smart Radio powered. Change the IP configuration of your host machine and add a new IP address in the 192.168.153.0/24 subnet. Attempt to access the Smart Radio at 192.168.153.1.

IPV6 Login

1. First bring down any unnecessary interfaces like WiFi.
2. Power down the other Smart Radios in the network to that you are sure you are accessing the correct radio.
3. First find out the index number of the interface connected to the Smart Radio. Open up a cmd prompt and type (ignore the \$ sign)

```
$ netsh interface ipv6 show interfaces
Idx      Met      MTU      State      Name
-----
1        75      4294967295  connected  Loopback Pseudo-Interface 1
16       35      1500     connected  Ethernet
```

4. In this case, the index is 16. Next, run

```
$ ping -6 fe80::%16
Pinging fe80::%16 with 32 bytes of data:
Reply from fe80::%16: time=413ms
Reply from fe80::%16: time<1ms
Reply from fe80::%16: time=2ms
Reply from fe80::%16: time=1ms
```

5. Assuming the ping worked, we can check the ipv6 address of the Smart Radio with

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```
$ netsh interface ipv6 show neighbors
Interface 16: Ethernet
Internet Address                               Physical Address   Type
-----
fe80::230:1aff:fe4e:aabc                       00-30-1a-4e-aa-bc  Stale
(Router)
```

- a. From here, we can see the ipv6 address (in bold). Note that the corresponding physical address starts with 00-30-1a which is true for all Doodle Labs products. So you can try logging in with

```
ssh root@fe80::230:1aff:fe4e:aabc%16
```

6. Once you are logged into the CLI, you can check the ipv4 address of the `br-wan` interface

```
root@smartradio:~# ip a show dev br-wan
6: br-wan: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP
group default qlen 1000
    link/ether 00:30:1a:4e:aa:26 brd ff:ff:ff:ff:ff:ff
    inet 10.223.187.38/16 brd 10.223.255.255 scope global br-wan
        valid_lft forever preferred_lft forever
    inet 192.168.153.1/24 brd 192.168.153.255 scope global br-wan
        valid_lft forever preferred_lft forever
    inet6 fe80::230:1aff:fe4e:aa26/64 scope link
        valid_lft forever preferred_lft forever
```

Troubleshooting Link Quality

This section covers troubleshooting problems with the link quality. If you are looking for information on optimizing the link quality, please read the guide, “Optimizing the RF Link”, in our technical library [\[1\]](#). This section is broken down into three sub-sections which cover

1. No wireless link
2. Poor throughput at close range
3. Poor long-range performance

“The radios are not connected to each other at all”

Make sure you can access the radios before troubleshooting the wireless link. If the radios are not connected to each other at all, then the most likely causes are:

1. The radios have been configured in different modes
2. The antennas are not connected properly

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3. Power supply issues

The radios are configured in different modes

This could happen if you have inadvertently configured one radio in WDS AP/Client mode and another in Mesh mode or both radios as WDS AP for example. Navigate to the wireless configuration in the web GUI and check whether the mode is “station”, “master”, or “mesh point”. Make sure the two radios are in compatible modes. We suggest using the Simple Configuration menu to configure your radios.

The antennas are not connected properly

Make sure that the connectors on the antennas are compatible with the connectors used on the cables. RP-SMA (reverse polarity SMA) is not compatible with SMA.

Power Supply Issues

Make sure to follow the power supply recommendations of the particular model which you have ordered. The power supply must be of the correct voltage and have sufficient current sourcing capability to power the radio.

“The throughput is poor even at close range”

As the radios are optimized for long range, they do not work well when they are within a close range of each other. At close range, the radios are likely to saturate the RF front-end, resulting in poor performance. For bench evaluation, please use RF attenuators supplied in the Eval kit. You should also reduce the output power of the radios and not use high gain antennas. , It is further possible to enable Transmit-Power Control (TPC). Note that TPC is only recommended for point-to-point networks.

If the radios are more than 5-10 meters apart and the throughput is still poor, then it could be an interference or power supply issue. Please see the advice in the next section.

“The radios are connected, but the range is poor”

This could be a rather wide topic. The datasheets provide typical performance over distance assuming a reasonable fade margin (10-15 dB). The fade margin accounts for variations in the link quality due to things like antenna misalignment or environmental noise. The most common reasons for poor range are:

1. Not adhering to recommended Fresnel Zone clearance requirements
2. Noise and Interference
3. Power Supply Issues
4. Overheating

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5. Poor choice of antennas
6. Antenna cable loss

We will only briefly discuss these topics. Before covering these topics, if your radios are linked, then you can use the “sysutils checklink” program to perform a quick link check. Setup the two radios 10m apart from each other and point the antennas straight upwards. Then SSH into one of the radios and run

```
root@smartradio:~# sysutils checklink -d 10 -h 10.223.216.116 -g 3
```

Note that `-d 10` means 10m distance, and `-g 3` means 3-dB total antenna gain (this is the combined antenna gain for both radios, e.g. 2 dBi on radio 1 and 1 dBi on radio 2). The program takes about 1 minute to run, and will perform link test between each antenna. At the end of the test, a log file will be saved at `/tmp/results.json`. The results report the expected RSSI and measured RSSI, as well as the link throughput per antenna. An example is shown below

```
{
  "distance": "10",
  "total_antenna_gain": "3",
  "frequency_band": "2442",
  "expected_RSSI": "-37",
  "RSSI1": "-42",
  "RSSI2": "-58",
  "throughput1": "23987123",
  "throughput2": "24518300"
}
```

The peak single-antenna throughput is approximately 40-45 Mbps per 20-MHz channel bandwidth per antenna. In the case above, we are getting around 24 Mbps in a 15-MHz bandwidth due to interference. The expected RSSI was -37 dBm, but the measured RSSI was significantly lower (-58) on the second antenna because of misalignment.

Fresnel Zone Clearance

The required Fresnel Zone clearance is the radius around the line-of-sight path which must be clear of obstacles. The Fresnel Zone clearance is frequency dependent, so we recommend using an RF calculator to calculate the required clearance for your application. Drone applications typically do not need to worry about Fresnel Zone clearance, but it is critical for unmanned ground vehicles (UGV).

Noise and Interference

Background noise and interference has a direct effect on the achievable range. The 2.4-GHz ISM band may be the most crowded frequency band in the world due to the ubiquity of 2.4-GHz WiFi. Therefore, the achievable range in urbanized areas is notably poorer for the 2.4-GHz band than other bands. Aside from the 2.4-GHz band, the 915-MHz band and the 5-GHz bands are also license-free and may be highly congested depending on where the radios are being

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deployed. You can measure the level of the background noise picked up by the radio using the built-in spectrum analyzer on the wireless configuration page. This is only accessible in the Advanced Settings. The figure below shows the wireless page with Advanced Settings enabled, and a Spectrum Scan button available for the radio0 interface. The spectrum scanner is only available for 10 MHz channel bandwidth or greater.

Smart Radio model: RM-2450-2I-X

Wireless Overview

Generic MAC80211 802.11bgn (radio0)
Channel: 7 (2.442000000 GHz) | Bitrate: 130 Mbit/s

100% SSID: simpleconfig | Mode: Mesh Point
BSSID: 00:30:1A:4E:BB:02 | Encryption: WPA3 SAE (CCMP)

Spectrum Scan Add Disable Edit Remove

Associated Stations

	SSID	MAC-Address	Host	Signal / Noise	RX Rate / TX Rate
wlan0	simpleconfig	00:30:1A:4E:BB:01	?	-40 / -95 dBm	58.5 Mbit/s, 15MHz, MCS 12 97.5 Mbit/s, 15MHz, MCS 15

Fig. 2 – Wireless page with Spectrum Scan available

If you perform a spectrum scan, the radio will scan all channels. We recommend narrowing in on the desired operating channel to check the noise performance as it will be faster and more accurate. Note that the thermal noise floor is approximately -116 dBm per FFT bin in a 20-MHz bandwidth. The operating range is reduced by 2x for every 6 dB increase in the measured noise above the thermal noise floor.

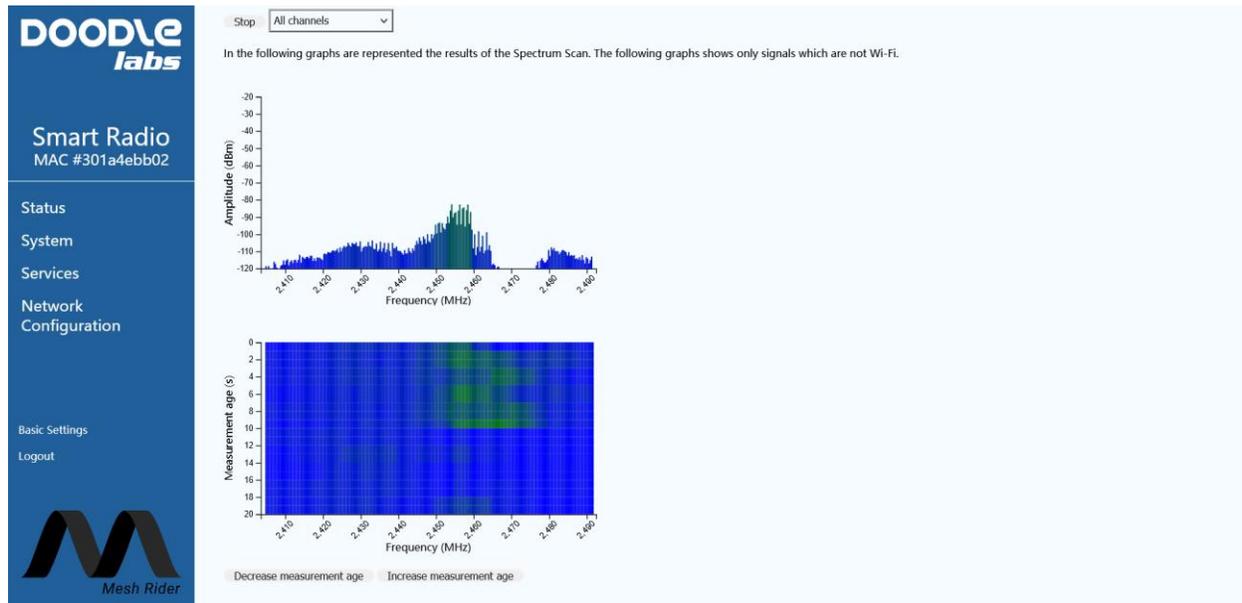


Fig. 3 – Spectrum Scanner results

Power Supply Issues

Please make sure to follow the power supply requirements mentioned in your product’s datasheet. The Smart Radios have voltage and power requirements. Most AC/DC regulators specify an output voltage, and the maximum current they can supply. The maximum power they can supply is simply the voltage multiplied by the current (in amperes). So a 9-V, 2-A adapter can supply 18-W of power. Additionally, for best performance, power supply lines should

1. be short to minimize the IR drop
2. be twisted (ground and supply) to minimize their inductance
 - a. if they cannot be twisted, keep them as close together as possible
3. be routed in a star topology. The power lines should never be daisy-chained
 - a. the center of the star should be as close to the power supply as possible

Some power supplies are noisier than others. Devices such as powerful motors create supply noise when they pull current from the source. The Smart Radios have power supply isolation built in, but their effectiveness depends on how noisy the supply really is. If you are unsure whether your supply is causing a problem, power the Smart radio from a separate battery.

Overheating

The Smart Radios are rated to operate at a case temperature of up to 85 C. At 85 C there will be some degradation in the output power (model dependent, but typically up to 2-3 dB) which will result in reduced operating range. If your application allows it, we recommend good heat sinking.

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Poor Choice of Antennas

Antenna selection is a very broad topic, so we will only provide a few important reminders.

1. Make sure to choose an antenna which is designed for the operating frequency of the Smart Radio. Wideband and dual-band antennas which are designed to work over many bands generally don't perform as well as narrowband antennas a single particular band of interest.
2. $\frac{1}{4}$ -wave antennas normally need to be mounted to a $\frac{1}{4}$ -wave radius ground plane. For example, at 915-MHz, the $\frac{1}{4}$ wavelength is 82 mm in air. Therefore, a $\frac{1}{4}$ -wave antenna would need to be mounted to a metal plane of at least 82-mm radius.
3. $\frac{1}{2}$ -wave dipole antennas normally do not need to be mounted to a ground-plane.
4. Chip antennas normally need to be mounted on a PCB which serves as a ground plane. These are not recommended unless you are familiar with antenna design.
5. High gain antennas are directional. That means that the antenna will only have high gain when they are pointed in a particular direction. Look up the radiation chart if you are unsure.
6. Antennas have a polarization (horizontal, vertical, R/L handed circular). Polarizing TX and RX antennas differently can lead to significant loss.
7. In general, cheap antennas should not be trusted unless you have tested them.

Antenna Cable loss

When choosing an antenna cable, keep the following in mind.

1. Make sure to use 50-ohm coaxial cable (not 75-ohm cable)
2. Coaxial cables have different loss per unit length depending on the type and frequency. Use a calculator like this one https://www.qsl.net/co8tw/Coax_Calculator.htm [2], or look up the loss specifications from the coaxial cable's datasheet.
3. Every 3-dB coaxial cable loss results in 3-dB loss in the TX power and 3-dB loss in the RX signal which results in 2x reduction in the operating range.

UART and USB ports

This section covers common pitfalls encountered when using the USB and UART ports. Please note that for -H hardware, the auxiliary port is either USB or UART, but not both (See Table 1).

UART Troubleshooting

The UART port is described in more detail in the "Serial Interface Guide" available for download in the Doodle Labs Technical Library [1]. The guide includes information about how to manually

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configure the UART port over the CLI. Troubleshooting the serial interface generally requires the user to be able to [SSH](#) into the radio.

The general steps to debug the UART port are

1. Make sure you can get data from a PC to the UART port. You can SSH into the Smart Radio and run the application `picocom` as described in the “Serial Interface Guide”. Make sure you disable `socat` before running `picocom`.
 - a. In order to eliminate the user’s host machine as the source of the problem, you can connect the UART port in loop-back mode but directly wiring the UART TX to the RX. Any message you type in `picocom` should be echoed back to you.
 - b. Assuming loop-back works, then the problem could be a mismatch in the signalling levels, or UART settings (baudrate, parity etc).
2. Assuming that serial data can be sent and received over the UART interface you can debug the networking side. Close `picocom` and re-enable and re-start the serial interface bridge using the GUI. Then in the Smart Radio CLI, you can
 - a. Check that `socat` and `ser2net` are running (they will both be running)

```
root@smartradio:/# ps | grep -E "socat|ser2net" | grep -v "socat|ser2net"
3133 root      1012 S    /usr/sbin/ser2net -c /var/run/ser2net.conf
3370 root      1072 S    /usr/bin/socat tcp:127.0.0.1:65534 UDP4-LISTEN:2000
```

- b. Make sure that the firewall is open if you are using server mode

```
root@smartradio:/# iptables -L | grep 2000
ACCEPT      udp  --  anywhere             anywhere             udp dpt:2000
/* !fw3: Allow-Socat */
ACCEPT      tcp  --  anywhere             anywhere             tcp dpt:2000
/* !fw3: Allow-Socat */
```

- c. Check the status of the socket. In TCP mode, the socket should be either in a `LISTEN` state or an `ESTABLISHED` state. In UDP mode, the state will be either `empty` or `ESTABLISHED`

```
root@smartradio:/# netstat -tuapn | grep 2000
tcp        0      0 0.0.0.0:2000          0.0.0.0:*             LISTEN
20711/socat
```

- d. If the connection state is not `ESTABLISHED`, then it means that the application trying to connect to the Smart Radio is unable to connect. This is normally a problem with the configuration. For example, the IP address, network port or firewall could be configured wrongly.

USB Troubleshooting

Different hardware variants have different types of USB ports. Please see the first section for details. USB uses a master-slave communications protocol where a single host can support up to 128 slaves. In general, a USB port is either a USB device or a USB host; USB devices cannot communicate with other USB devices and USB hosts cannot communicate with other hosts. Please check what type of USB port your hardware has before proceeding.

Some devices have USB OTG ports which can switch between host and device mode. Typically they use the 5-V VBUS line as an indicator for which mode they should be in. If an OTG port detects power on the VBUS line, then it will switch to device mode.

Smart Radio USB Device Ports

The USB Device port is the main data interface on the Wearable and Hex-Band models. It only supports IP networking over USB and does not support any other USB protocol such as HID. This port can be directly plugged into a laptop, or certain Smart Devices (typically tablets and not phones). Please see the note on Android below.

Smart Radio USB Host Ports

The USB Host port is setup by default to support IP networking over USB. It can be made to support certain USB devices, depending on the type of driver required. It cannot be connected directly with a laptop, but it can be connected to certain Smart Devices (typically phones). See the note on Android below.

Android

Android phones and tablets usually have USB OTG ports, and may support USB tethering or USB reverse tethering.

- USB Tethering is when the Android device is sharing its internet connection with another device. The Android device's OTG port switches to device mode (it needs a 5-V input to do so). The Android device also starts a DHCP server and routes traffic from the connected device to its internet connection. Only one such Android device can be on the subnet. USB Tethering is normally supported on Android phones as they are expected to have a dedicated internet connection. This mode works with the Smart Radio's USB Host port.
- USB Reverse Tethering is when the Android device gets its internet connection from another device. The Android device's OTG port switches to host mode and it raises the VBUS line to 5-V. The Android device switches to DHCP client mode by default, but it can also be setup with a static IP address. Many of such devices can be on the same subnet. USB Reverse Tethering may be supported on Android tablets as they do not have a

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dedicated internet connection. This mode works with the Smart Radio's USB Device port (Wearable, Hex-Band).

Signal Integrity and Power

USB lines run at high speed and are very sensitive to both differential and common-mode disturbances. Make sure that all four lines (VBUS, USB+, USB-, GND) are tightly twisted together. Ideally the lines should be kept short for best signal integrity.

Some Smart Radio models supply a 5-V output with the USB. This output is rated to a maximum of 1-A. If the connected device is power hungry, then you should supply the power externally.

Debugging

You can check the connectivity of the USB port if you [SSH](#) into the Smart Radio. If you are using the USB Host port, unplug and then plug in the USB device, and then run

```
root@smartradio:/# dmesg | tail
```

This prints out the latest kernel messages and you should see some notifications about activity on the USB port. You can also type `ifconfig usb0` to make sure that the USB port is up and bridged to the network.

If you are using the USB Device port, you should check for connectivity information on the host machine itself rather than the Smart Radio (for example, notifications that a new USB device was attached). From the Smart Radio, you can attempt to directly ping the host machine, and should resolve and IP conflicts (see [Troubleshooting Radio Access](#) section of this guide).

Crashes, Reboots, etc

The Smart Radios are designed to take a beating. That said, no system is perfect and if you find that the radios are misbehaving, consider the points below.

Unexpected wireless down time

If the Smart Radio is under heavy network load for hours or days on end, the watchdog monitor may kick in if the radio's transmit queues get stuck. This will result in around 30 seconds of down time.

Reboots and crashes

The Smart Radio is not expected to reboot. If it does, first check that your power supply is sufficient, and that the radio is not overheating. If you are able to save the state of the system before a crash or a reboot, please do so. You will need to [SSH](#) into the radio. After that, you can print the kernel messages and system logs with

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```
root@smartradio:/# dmesg
root@smartradio:/# cat /var/log/messages
```

The Smart Radio also includes a utility to do a comprehensive save of the system state

```
root@smartradio:/# sysutils savelog
```

The results will be stored in `/tmp/savelogs.tar.gz`. You can copy this file to your host your host machine by running

```
user@host-pc:~$ scp root@<IP ADDRESS>:/tmp/savelogs.tar.gz ./
```

Send this file along with your technical support request.

Factory Resetting

Configuration backup, restoration and factory resetting can be performed by navigating to the `page system → backup/flash firmware`. If you have modified your network configuration such that you can no longer access it, you can also factory reset the radio without network access. Factory reset differs from radio to radio.

In general, the factory reset pin should be pressed or pulled to ground for between 5 and 30 seconds (no more than 30 seconds and no less than 5 seconds). Factory reset only works after the device has fully booted up. Power up the device and wait for assurance, wait for 3 minutes for the radio to fully boot. The location of the factory reset switch is described below.

Note that if the device cannot be restored to it's factory reset state using this method, then it is possible that the device needs to be repaired by Doodle Labs. Contact tech_support@doodlelabs.com.

Embedded Radio (-2H)

The -2H radio includes a reset wire on the main connector which should be pulled to ground following the recommended timing.

Embedded Radio (-2J-*M)

Look for a pin hole on the front side of the unit. Insert a pin through the hole and press the tactile switch following the recommended timing.

External Radio (-2J-*E)

The External radio includes a reset pin inside the box which should be pressed following the recommended timing.

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Wearable Radio (-2K)

Unplug the Wearable Radio. Hold down the power button and then power the radio. Hold the power button down for between 10 and 20 seconds and then let it go. Wait for the radio to factory reset.

Helix Radio (-2L)

The -2L Helix Radio includes a reset wire on the main connector which should be pulled to ground following the recommended timing.

Connect with Tech Support

Before connecting with Tech Support, please read the troubleshooting information in this guide.

Otherwise, please feel free to contact us (<https://www.doodlelabs.com/about-us/tech-support/tech-support-request-form/>). Please describe your problem in as much detail as possible, and include photos of the setup if possible.

References

- [1] Doodle Labs Technical Library, [Technical Library For Mobile Industrial Mesh Radios | Doodle Labs](#), September 2021
- [2] Coax Calculator, https://www.gsl.net/co8tw/Coax_Calculator.htm, September 2021