



400 MHz Base Station Repeater User Guide

Part No. 875-0321-000 A1



This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

- (1) This device may not cause harmful interference, and
- (2) this device must accept any interference received, including interference that may cause undesired operation.

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Hemisphere GPS Precision GPS Applications

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The Outback S™ and S-Lite™ automated navigation and steering guide systems are covered by U.S. Patents No. 6,539,303 and No. 6,711,501. The Outback Hitch™ automated hitch control system is covered by U.S. Patent No. 6,631,916. The Outback eDriveTC™ GPS assisted steering system is covered by U.S. Patent No. 7,142,956. Hemisphere GPS products may be covered by one or more of the following U.S. Patents:

6,111,549	6,397,147	6,469,663	6,501,346	6,539,303
6,549,091	6,631,916	6,711,501	6,744,404	6,865,465
6,876,920	7,142,956	7,162,348	7,277,792	7,292,185
7,292,186	7,373,231	7,400,956	7,400,294	7,388,539
7,429,952	7,437,230	7,460,942		

Other U.S. and foreign patents pending.

Notice to Customers

Contact your local dealer for technical assistance. To find the authorized dealer near you:

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Hemisphere GPS is committed to the quality and continuous improvement of our products and services. We urge you to provide Hemisphere GPS with any feedback regarding this guide by writing to the following email address: docfeedback@hemispheregps.com.

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Chapter 1: Introduction

Repeater Overview

What's Included

Ports and LEDs

Obtaining Product Updates

Repeater Overview

Hemisphere GPS[®] 400 MHz repeater is a powerful tool that allows you to extend your RTK radio coverage with a compact and easy-to-deploy weatherproof radio repeater.

In conjunction with a Hemisphere GPS base station (Outback A321™/A221™ Smart Antenna) and rover (Outback A320™/A220™ Smart Antenna), the 400 MHz Repeater kit provides reliable RTK radio coverage for precision farming in the most challenging environments.

Base Station Antenna Height

A key factor in good RTK radio coverage is to ensure your base station external radio antenna is mounted as high above the ground as possible. Provided the terrain is relatively free of hills and trees, you can expect your base station radio to deliver RTK messages to mobile farm equipment (rover) with good reliability over distances of several miles.

With precision RTK you cannot afford to have dead spots of RTK radio coverage. When radio coverage is lost for approximately 5 to 10 seconds or more GPS precision degrades. Also, when operating farm equipment in valleys or behind patches of trees, the rover radio may not receive RTK messages from the base station. In this scenario using a repeater is key to ensuring continuous centimeter-level precision farming.

Which Kit is Right for Me?

A permanent (fixed location) repeater solution may be ideal if you have access to a location on the farm that:

- Is on the opposite edge of the property
- Can provide power
- Enables you to mount the repeater several feet off the ground (such as a silo or grain elevator)

If a permanent repeater solution is either not feasible or suitable for your location you can deploy a portable (battery-powered) repeater kit on your property on a day-to-day basis to provide the coverage you need for various sections of the farm that may be blocked from the base station (such as by hills or trees).

What's Included

There are two types of repeater kits: fixed and portable (battery-powered). The type of kit determines the parts included in your kit.

Fixed Kit Contents

The fixed kit includes the following:

- Weatherproof AC/DC power adapter/communications cable
- DB9 serial adapter cable
- External antenna and mounting hardware
- External RF cable
- USB flash drive with repeater configuration software

Portable Kit Contents

The portable kit includes the following:

- Power/communications cable with alligator power clips for battery
- DB9 serial adapter cable
- Portable tripod with telescoping mast and antenna
- External RF cable
- USB flash drive with repeater configuration software
- 12 V, 18 Ah deep cycle sealed lead acid battery
- Battery charger

Note: If your PC or laptop does not include a serial port you will need to provide a serial-to-USB cable to connect the repeater to your PC/laptop (see Chapter 3, "Connecting to Your Repeater"). Contact your dealer for assistance in obtaining this cable.

Table 1-1 provides part numbers, descriptions, and photos for the parts in your kit.

Table 1-1: 400 MHz repeater kit parts list (fixed and portable kits)

Base Kit	Port Kit	Part No.	Description	Qty	Photo
X		050-0033-001	Antenna cable TNC male to N male, 8 m	1	

Table 1-1: 400 MHz repeater kit parts list (fixed and portable kits) (continued)

Base Kit	Port Kit	Part No.	Description	Qty	Photo
	X	050-0071-000#	Antenna cable TNC male to TNC male, 3 m	1	
X	X	051-0343-000#	Serial adapter cable 3-pin circular male to DB9 female	1	
	X	054-0154-000#	Power/data cable 18-pin circular female to 3-pin circular female, 3 m (with clamps, for portable base setup)	1	
X		054-0155-000#	Power/data cable 18-pin circular female to 3-pin circular female, 3 m (with AC adapter, for fixed base setup)	1	
	X	150-0008-000	Antenna 450 MHz, 30 in	1	

Table 1-1: 400 MHz repeater kit parts list (fixed and portable kits) (continued)

Base Kit	Port Kit	Part No.	Description	Qty	Photo
X		150-0024-000#	Antenna 450 MHz, omnidirectional	1	
	X	427-0048-000	Battery Power-Sonic, 12 V, 18 A	1	
	X	427-0050-000	Battery charger 12 V, 4 A	1	No photo
	X	054-0095-000#	Battery charger cable	1	No photo
	X	601-1245-000#	Tripod mounting plate for rover	1	
	X	676-0033-000#	Antenna adapter TNC female to NMO, 5/8-11 thread	1	
X	X	710-0124-000	USB flash drive, 2 GB (loaded with Hemisphere GPS Radio Configuration Tool software)	1	
	X	750-0050-000	Tripod base, black	1	

Table 1-1: 400 MHz repeater kit parts list (fixed and portable kits) (continued)

Base Kit	Port Kit	Part No.	Description	Qty	Photo
	X	750-0144-000	Mast, tripod mounted, telescoping, 2.3 m	1	
X	X	802-1069-000#	Repeater (Microhard L400 rover radio, 400 MHz)	1	
X	X	875-0321-000	400 MHz Base Station Repeater User Guide	1	<i>No photo</i>

Ports and LEDs

Figure 1-1 shows the ports of the repeater.



Figure 1-1: Repeater ports

Figure 1-2 shows the LEDs on the side of the repeater.



Figure 1-2: LEDs on repeater

Obtaining Product Updates

Contact your Outback Guidance dealer or Outback Guidance Customer Service to obtain product updates for your receiver, repeater, software (such as the Hemisphere GPS Radio Configuration Tool), and GPS applications.



Chapter 2: Deployment Options

Deployment Overview

Configuration 1 – Two Permanent Repeaters

Configuration 2 – One Permanent Repeater and One Portable Repeater

Configuration 3 – One Permanent Repeater

Configuration 4 – One Portable Repeater

Deployment Overview

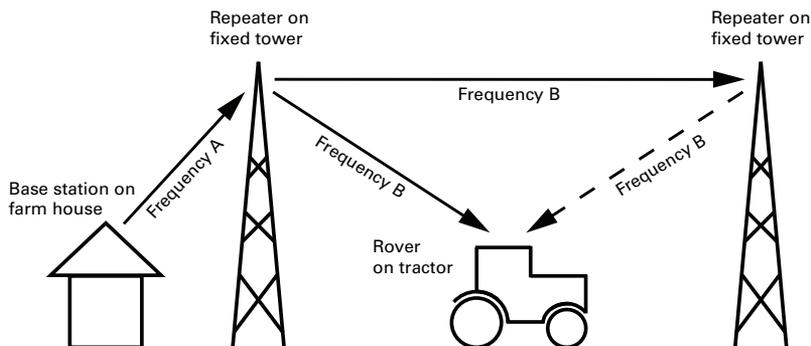
Base station installation is critical for good GNSS performance and RTK coverage. You must install the base station clear of all obstacles—it must have a clear, 360° view of the sky without obstructions. If a radio tower or other obstacle blocks the view of the sky, your RTK performance may be compromised. Balancing this requirement with that of ensuring the radio antenna is as high off the ground as possible can be challenging.

The base station has an external 400 MHz cable connector, which you typically connect to a lengthy cable and that runs up to your elevated 400 MHz antenna. If this cable is too long it may weaken the radio performance. Ideally, you should keep the RF cable lengths to a minimum, while still ensuring the base station is not blocked by radio towers or other obstacles.

The following sections describe the recommended configuration options for various installations.

Configuration 1 – Two Permanent Repeaters

Farm Type:	Large farm (up to 15 miles coverage) with tree or hill blockage
Infrastructure Requirements:	Farm house or other structure with base station mounting-access and power on the roof Two towers or tall permanent structures with access to power; preferably located at opposite ends of the farm from one another
Ideal For:	Very challenging farms that may contain significant rolling hills or groves of trees interspersed throughout the property

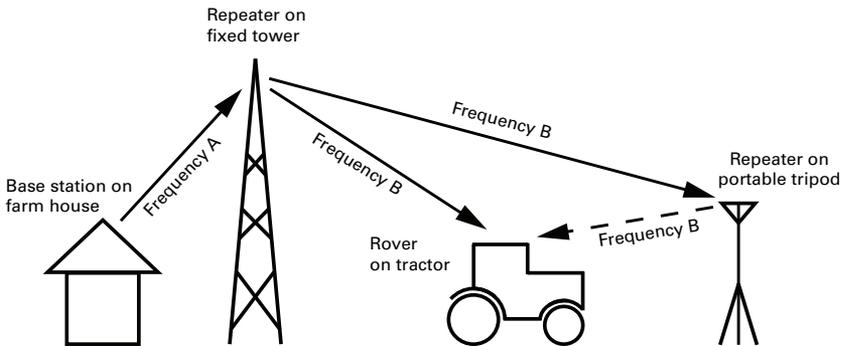


Above ground antenna height is critical for good radio coverage. Having access to tall structures with power (preferably at opposite ends of the property) ensures that if the signal to the rover from one repeater is blocked the rover still has coverage from the second repeater. The rover may receive the message from both repeaters; if this occurs the rover automatically discards the duplicate message.

The base station transmits the RTK message to the first repeater on Frequency A; the first repeater then re-transmits the message on Frequency B to both the second repeater and the rover. The second repeater receives and transmits the message on Frequency B.

Configuration 2 – One Permanent Repeater and One Portable Repeater

Farm Type:	Large farm (up to 15 miles coverage) with tree or hill blockage
Infrastructure Requirements:	Farm house or other structure with base station mounting-access and power on the roof Two towers or tall permanent structures with access to power; preferably located at opposite ends of the farm from one another
Ideal For:	Very challenging farms that may contain significant rolling hills or groves of trees interspersed throughout the property



Note: Configuration 2 differs from Configuration 1 in that the second repeater is portable as opposed to being mounted on a tall permanent structure.

The first repeater is mounted on a tall structure or tower and provides the primary radio coverage of the farm property. The portable repeater is tripod-mounted and designed for quick deployment at various locations around the property.

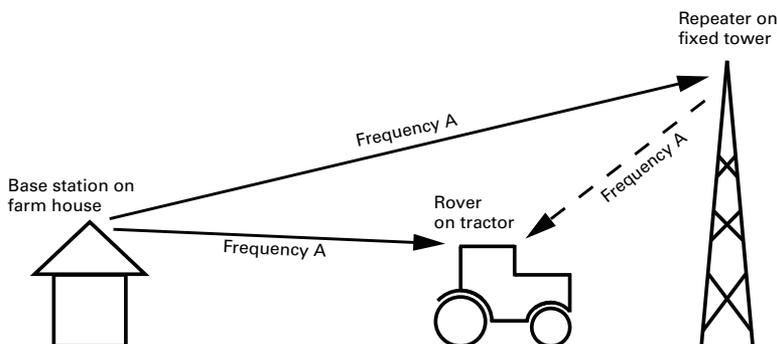
When farming behind trees or in valleys where the radio signals are too weak to be received by the rover directly from the permanent repeater, simply deploy the portable repeater on a nearby hilltop. The portable repeater will receive the RTK message from the permanent repeater and forward it to the rover.

It is possible the rover may receive the message from both repeaters. In this case, it will automatically discard the duplicate message.

The portable repeater kit takes only a few minutes to set up and is equipped with a sealed lead acid battery that provides up to approximately 18 hours of operation on a single charge.

Configuration 3 – One Permanent Repeater

Farm Type:	Small to medium size farm (up to 10 miles coverage) with minimal tree or hill blockage Smaller farm (up to 5 miles coverage) with some tree or hill blockage
Infrastructure Requirements:	Farm house or other structure with base station mounting-access and power on the roof One tower or tall permanent structure with access to power
Ideal For:	Small to medium sized farms (up to about ten miles of radio coverage), which feature generally flat terrain and have minimal tree blockage Also recommended for smaller farms (up to about five miles of radio coverage), with some hilly areas or tree groves



The distance of coverage is limited by the following factors:

- Height of the repeater structure above ground
- Severity of the hills
- Height and density of tree blockage

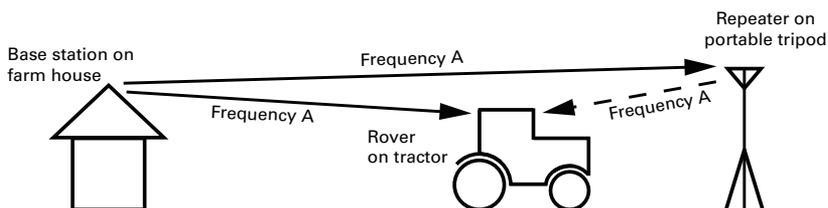
After installing the repeater on the fixed structure you should verify the radio signal strength on the rover to ensure you have good coverage in the most challenging locations of the property. If there are still issues you can resolve them by reverting to Configuration 2.

In Configuration 3 the repeater provides the primary radio coverage for the rover; however, the rover is still capable of receiving the RTK message directly from the base station if it is in range.

It is possible the rover may receive the message from both the base station and the repeater. In this case, it will automatically discard the duplicate message.

Configuration 4 – One Portable Repeater

Farm Type:	Small to medium size farm (up to 10 miles coverage) with minimal tree or hill blockage Smaller farm (up to 8 miles coverage) with some tree or hill blockage
Infrastructure Requirements:	Farm house or other structure with base station mounting-access and power on the roof
Ideal For:	Small to medium sized farms (up to about ten miles of radio coverage), which feature generally flat terrain and have minimal tree blockage Also recommended for smaller farms (up to about eight miles of radio coverage), with some hilly areas or tree groves



The distance of coverage is limited by the following factors:

- Access to convenient hilltop locations for deploying the portable repeater
- Severity of the hills
- Height and density of tree blockage

This configuration provides a great deal of flexibility; however, you must occasionally redeploy the portable repeater to provide adequate radio coverage for the area of the property that is currently being farmed.

Depending on the severity of the hills or tree blockage, the portable repeater can provide full property coverage from a single location. As hill or tree blockage and property size increases you may need to move the repeater around the property to several different locations to maintain good radio coverage.

When deploying the portable repeater, always ensure good received signal strength from the base station (see “Verifying Received Signal Strength” on page 14).

In Configuration 4, it is possible the rover may receive the message from both the base station and the repeater. In this case, it will automatically discard the duplicate message.

Verifying Received Signal Strength

After you deploy your repeater in the desired configuration (1,2, 3 or 4), you should verify the repeater is successfully receiving RTK messages from either from the base station or the first repeater. The easiest way to do this is to monitor the signal LED (to the left of the power LED) on the repeater enclosure, as shown in Figure 2-1.



Figure 2-1: Signal LED on repeater

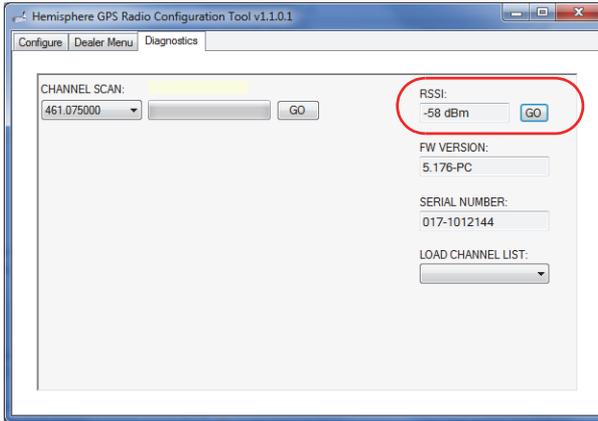
Table 2-1 describes each signal LED state.

Table 2-1: Signal LED states

LED State	Description
Off	Repeater is offline (currently in configuration mode), such as when you are connected to the Hemisphere GPS Radio Configuration Tool.
Slow blink	Repeater is online, but is out of range from the transmitter. Repeater is not successfully receiving RTK messages.
On solid	Repeater is successfully receiving RTK messages from a downstream repeater or base station with good signal strength.
Fast blink	Repeater is successfully receiving RTK messages from a downstream repeater or base station with weak signal strength. Try raising the antenna or moving the repeater to a different location to receive a stronger signal.

Received signal strength indicator (RSSI) is the actual power in a received radio signal. The Diagnostics tab of the Hemisphere GPS Radio Configuration Tool provides an RSSI value in dBm.

Note: See Chapter 3, “Connecting to Your Repeater” for instructions on connecting the repeater to your PC, powering the repeater, and starting the Hemisphere GPS Radio Configuration Tool.



To check the current RSSI value:

- On the *Diagnostics* tab click **GO** next to the RSSI field (see photo above). “Please wait” appears in the RSSI field followed by the RSSI value.

RSSI values are interpreted as follows:

- -120 dBm: No Signal
- -60 dBm or greater: Extremely good signal
- -100 dBm: Approximate signal strength threshold for reliably receiving 100% of RTK messages. This value may vary depending on if there are other interfering transmitters in the vicinity.



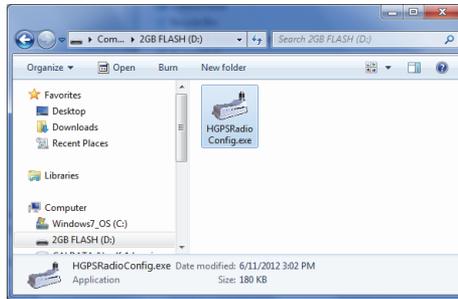
Chapter 3: Connecting to Your Repeater

After you determine the optimum configuration for your location (see Chapter 2, “Deployment Options”) you need to connect to your repeater. Review the parts in your kit (see Table 1-1 on page 3) before performing the following steps.

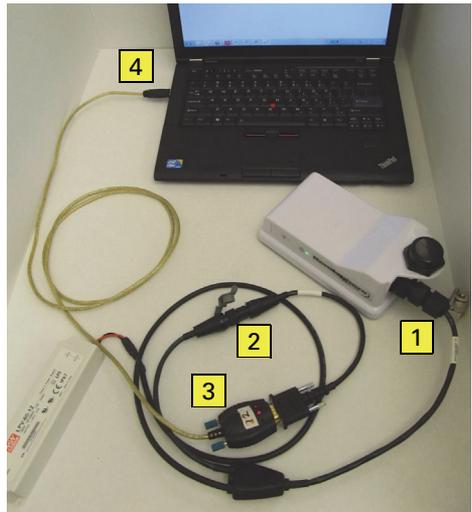
Note: The following steps assume you have a serial-to-USB cable.

To connect to your repeater:

1. Copy the HGPSRadioConfig.exe file from the USB flash drive (shown below) to your computer (preferably to your desktop).

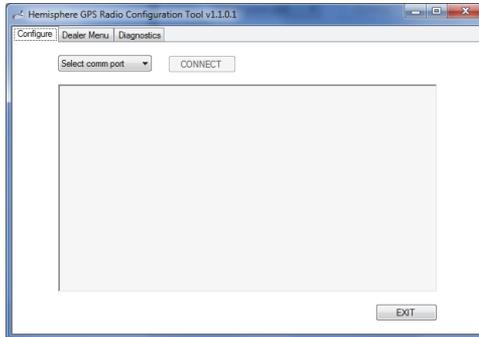


2. Connect the 18-pin connector of the power/data cable to the repeater (#1 in photo) and connect the 3-pin connector of the power/data cable to the serial adapter cable (#2 in photo).
3. Connect the serial end of a serial-to-USB cable to the serial adapter cable (#3 in photo) and connect the other (USB) end to an available USB port on your computer (#4 in photo).
4. Power up your repeater.
 - For the fixed kit, plug the power cable into a power outlet.
 - For the portable kit, connect the power cable alligator clips to the battery.



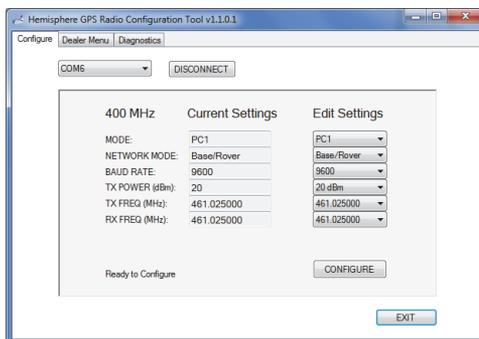
The repeater’s power LED illuminates and the repeater’s signal LED blinks.

5. Double-click the HGPSRadioConfig.exe icon on your desktop (or where you copied the .exe file in step 1). The Hemisphere GPS Radio Configuration Tool starts and appears as below:



6. Click **Select comm port**, select the desired port, and then click **CONNECT**. Several comm ports may appear in the Select comm port drop-down. If you are not sure which one is correct, try the following:
 - a. Write down a list of the comm ports available in the drop-down.
 - b. Unplug the serial-to-USB cable from your computer.
 - c. Close and then restart the application.
 - d. Review the list of comm ports in the drop-down, making note of the comm port that no longer appears in the list.
 - e. Close and then restart the application.
 - f. Plug the serial-to-USB cable into the computer and restart the application. The comm port that has again become available is the one being used by your repeater.

Once successfully connected the application should appear similar to below. You are now ready to configure your repeater.





Chapter 4: Configuring Your Repeater

Configuration Overview

Configuring the Repeater Mode

Configuring NETWORK MODE

Configuring TX POWER (dBm)

Configuring TX FREQ and RX FREQ (MHz)

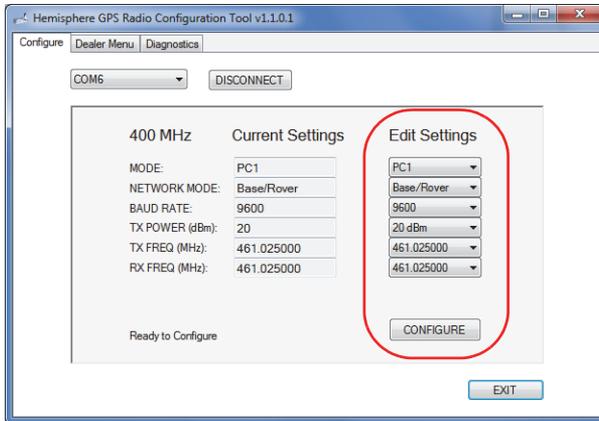
Configuration Overview

The repeater comes pre-configured with a list of frequencies (TX FREQ and RX FREQ) typically made available by government license in your jurisdiction.

WARNING: You must apply for and receive a radio license before operating this product. For more information on licensing for Canada, USA, and Australia refer to the *User Guide Addendum for L400 Radio (PN 875-0285-000)*, which is available from the Outback Guidance website (go to www.outbackguidance.com and navigate to Support > Precision > Technical Documentation).

The list of frequencies may not be complete or accurately reflect the license that has been made available to you. If additional frequencies have been granted to you, contact Outback Guidance Customer Service or your dealer for instructions on how to add these frequencies to the list.

Configure your setup using the Configure tab of the Hemisphere GPS Radio Configuration Tool.



The Configure tab contains the following options:

- MODE
- NETWORK MODE
- BAUD RATE
- TX POWER
- TX FREQ
- RX FREQ

Configure each option by selecting the desired value from the corresponding drop-down under Edit Settings (circled in screenshot above).

Configuring the Repeater Mode

Using Table 4-1 as a guide select your repeater mode. The mode depends the following:

- Base Station type (A221 or A321)
- Configuration type (see Chapter 2, “Deployment Options”)

Note: You must configure the mode of your A220/A221/A320/A321 to match that of the repeaters.

Table 4-1: MODE selection guide

Base Station	Configuration	MODE
A221	TYPE 1: Two permanent repeaters	PC3
A221	TYPE 2: One permanent repeater and one portable repeater	PC3
A221	TYPE 3: One permanent repeater	PC1
A221	TYPE 4: One portable repeater	PC1
A321	TYPE 1: Two permanent repeaters	HGPS
A321	TYPE 2: One permanent repeater and one portable repeater	HGPS
A321	TYPE 3: One permanent repeater	HGPS
A321	TYPE 4: One portable repeater	HGPS

To configure the repeater mode:

- On the Configure tab of the Hemisphere GPS Radio Configuration Tool select the desired mode from the MODE drop-down under Edit Settings.

Configuring NETWORK MODE

Make sure the network mode is set to Repeater. This forces the baud rate to 9600, as this is optimal for operation.

To configure the repeater mode:

- On the Configure tab of the Hemisphere GPS Radio Configuration Tool select the desired network mode from the NETWORK MODE drop-down under Edit Settings.

Configuring TX POWER (dBm)

You must set the transmit power of your repeater to a maximum level that complies with your operating license. Set the power to the maximum level allowable by your license.

Table 4-2 provides a conversion between power in dBm and power in Watts.

Table 4-2: Power conversion (dBm vs. Watts)

dBm	Watts
20	0.1
27	0.5
30	1.0
33	2.0
35	3.0
37	5.0

To configure the TX (transmit) power:

- On the Configure tab of the Hemisphere GPS Radio Configuration Tool select the desired transmit power from the TX POWER drop-down under Edit Settings.

Configuring TX FREQ and RX FREQ (MHz)

When setting the transmit (TX) and receive (RX) frequencies of your repeater, consider the following questions:

- Which frequencies do you have a license for?
- Which configuration option are you deploying (1, 2, 3 or 4)?
- If you are deploying your network with configuration option 1 or 2, are you configuring the first repeater or the second repeater?
- Are the frequencies you want to configure already used by others?

To configure the TX and RX frequencies:

- On the Configure tab of the Hemisphere GPS Radio Configuration Tool select the desired transmit frequency from the TX FREQ drop-down and select the desired receive frequency from the RX FREQ drop-down under Edit Settings.

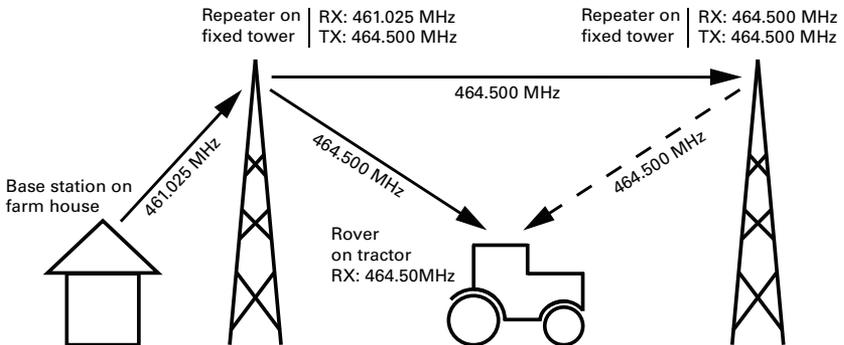
Configuration Options 1 and 2 – Two Repeaters

Configuration options 1 and 2 call for two repeaters where the first repeater receives RTK messages directly from the base station and forwards them to the second repeater and to the rover. Therefore, you must set the first repeater's RX FREQ to match the base station (Frequency A), and set the first repeater's TX FREQ to a different frequency (Frequency B)—refer to Chapter 2, "Deployment Options" for more information on Frequency A and Frequency B.

For example, if the base station is set up to transmit at a frequency of 461.025 MHz then:

1. You must configure the first repeater's RX FREQ to 461.025 MHz.
2. You must configure the first repeater's TX FREQ differently—to 464.500 MHz in this example.
3. You must configure the second repeater to both receive and transmit on frequency 464.500 MHz:

You are now set up for your rover to receive RTK messages from both the first and second repeaters on frequency 464.500 MHz. Verify the rover's frequency is set to 464.500 MHz. This example is illustrated below:



⚠ WARNING: Make sure you configure your base station and repeater TX frequencies and power that comply with your license as well as scan the selected frequencies before transmitting (see Chapter 5, "Scanning for Usable Frequencies").

Configuration Options 3 and 4 – One Repeater

Configuration options 3 and 4 call for one repeater. These options are simpler than options 1 and 2, since all base station, repeater, and rover frequencies are the same.

Simply configure the repeater's TX FREQ and RX FREQ to match that of the base station and rover.



Chapter 5: Scanning for Usable Frequencies

When using the 400 MHz repeater for RTK applications you must comply with governmental regulations. Typically in the United States and in Canada only a small set of frequencies in the 400 MHz range are set aside for this type of GNSS application.

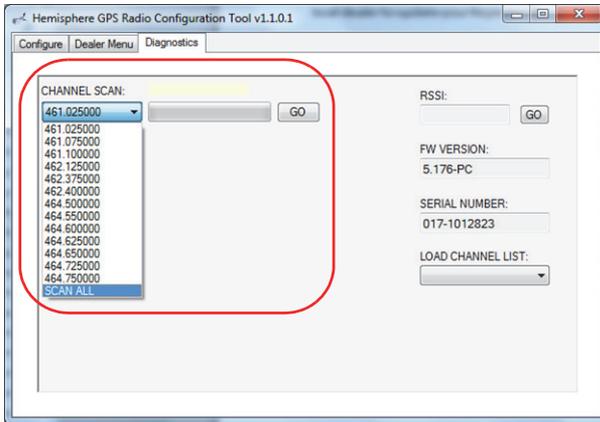
The Hemisphere GPS Radio Configuration Tool includes a Diagnostics tab that allows you to view a list of available factory pre-configured frequencies. After you apply for and receive a radio operating license, the frequencies you have been granted to use will typically be those that appear in the Hemisphere GPS Radio Configuration Tool.

If you have been granted a license for additional frequencies, contact Hemisphere GPS Customer Service or your local dealer to update your repeater.

Before deploying your 400 MHz radio network, at each location you will be deploying the system you must scan the frequencies you intend to use. Not only does this ensure successful radio coverage for you, but it also ensures you are not illegally broadcasting on a frequency already being used by someone else in the vicinity.

To scan/find the optimum 400 MHz frequency:

1. After setting up your base station and external 400 MHz antenna, temporarily remove the base station's external RF cable and connect it to your 400 MHz repeater.
2. Start the Hemisphere GPS Radio Configuration Tool and wait for a connection. The repeater will assist you in finding the best frequency that you are licensed to use as the base station's primary transmission frequency.
3. On the Diagnostics tab click the CHANNEL SCAN drop-down and select **SCAN ALL**, and then click **GO**.

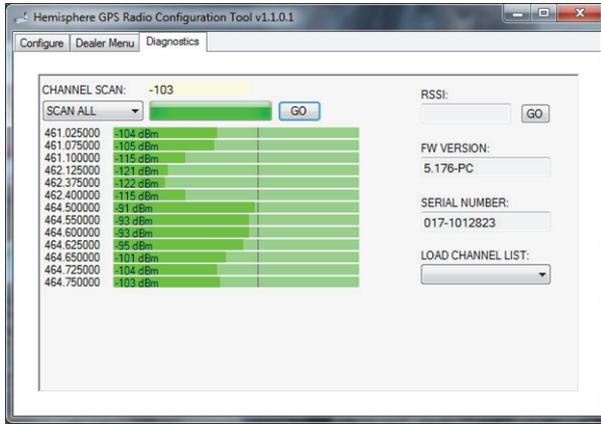


The scan should complete in approximately two minutes.

4. Review the results and look for the channel that has the lowest value (smallest bright green bar).

Note: Verify you have a license for any channel you want to use.

In the example below the best channel available is 462.375 MHz, which detected very low RF activity (-122 dBm), while the worst channel is 464.500 MHz at -91 dBm.



If the noise on the channel surpasses the black line, the bar will turn red, indicating that there is someone in your vicinity already using the channel, and you may not use it. The threshold of this line is -90 dBm.

- Repeat this process for your repeater sites to find the best secondary repeater frequency ("Frequency B") that you are licensed to use.

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