RTK Network
869 MHz
About This Document

The RTK Network 869 MHz User Guide provides information about RTK.

Read the Operator’s Manual for the following information:

- RTK system
- Network setup
- Diagnostics

This User Guide is for reference only. Accuracy of information is not guaranteed as hardware, software, and operating conditions can change.

Please consult your local AMS PSS and/or Branch member to ensure proper RTK network planning and setup.

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Introduction

John Deere StarFire 869 MHz RTK utilizes a local, ground-based reference station that transmits high-accuracy corrections to a machine’s StarFire Receiver using RTK radios. Having the Base Station close to the machine, reduces GPS system errors (like drifts) and increases accuracy and repeatable. Increased accuracy and repeatability are important in applications where GPS drift is not tolerable, such as bedded and permanent row-crops. For the Base Station signal to reach the machine, a direct line-of-sight between the machine and Base Station is essential.

StarFire RTK network consists of:

- Base Station
- Machine components: StarFire Receiver with RTK Radio
- Repeater
  - 1 to 3 Multiple Repeater
  - 1 Standard Repeater

Dealer-Owned RTK Network

To achieve customer satisfaction with RTK, plan and set up RTK Network. The RTK Network owner is responsible for setup, maintenance, and repair. The best solution is a dealer-owned network. The dealership invests in the RTK infrastructure, and rents the RTK signal to customers.

Example of network:

NOTE: Coverage of an RTK Network (Base Station and Multiple Repeaters) depends on the surface, environment, and topography in an area.
RTK Network Components

StarFire Receiver
A StarFire Receiver with SF2-ready and RTK activation is needed for the Base Station and for each machine receiver in the network. Remove objects from the location of the Base Station that may affect the signal reception of the receiver, such as shading and multipathing.

RTK Radio
Use the 869 MHz RTK Radio for:

- Machine Rover (StarFire Receiver plus RTK Radio) to receive an RTK correction signal.
- Base Station (StarFire Receiver plus RTK Radio) to send out an RTK correction signal.
- Standard Repeater (RTK Radio) to repeat an RTK correction signal (not as multiple repeater).
To send correction data (Base Station and Repeater), RTK Radio converts the signal from the receiver, and transmits it at the harmonized 869 MHz frequency to all radios. Mount radio on machines that have a free line of sight to base station or repeater radio with the same settings.

**NOTE:** The 869 MHz frequency is public and can be used by various applications. It is not necessary to license the RTK radio through the government in approved countries. To avoid interference, watch for other 869 MHz radio applications in your area. Adjust system settings accordingly (see Section 4). John Deere RTK signal (received by machine’s RTK Radio) itself is encrypted, and can only be decoded by John Deere StarFire Receiver.

John Deere RTK Base Station does not send other RTK signal formats, such as RTCM and CMR.

Data sheet:

<table>
<thead>
<tr>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmitter</td>
</tr>
<tr>
<td>Output Power</td>
</tr>
<tr>
<td>Channels</td>
</tr>
<tr>
<td>Secured Network</td>
</tr>
</tbody>
</table>

**Technical Specifications - John Deere StarFire 869 MHz RTK Radio**

<table>
<thead>
<tr>
<th>Radio Transceiver</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency Range</td>
</tr>
<tr>
<td>Channel Spacing</td>
</tr>
<tr>
<td>Number of Channels</td>
</tr>
<tr>
<td>Frequency Stability</td>
</tr>
<tr>
<td>Type of Emission</td>
</tr>
<tr>
<td>Communication Mode</td>
</tr>
</tbody>
</table>
### Radio Transmitter

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carrier Power</td>
<td>10 mW ...500 mW/50</td>
</tr>
<tr>
<td>Carrier Power Stability</td>
<td>± 2 dB/-3 dB</td>
</tr>
</tbody>
</table>

### Radio Receiver

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>-108 dBm (BER &lt; 10 E-3)*</td>
</tr>
<tr>
<td>Common Channel Rejection</td>
<td>&gt; -12 dB</td>
</tr>
<tr>
<td>Adjacent Channel Selectivity</td>
<td>&gt; 60 dB</td>
</tr>
<tr>
<td>Intermodulation Attenuation</td>
<td>&gt; 60 dB</td>
</tr>
</tbody>
</table>

*NOTE: * Depends on receiver settings.

### Modem

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface</td>
<td>RS-232 or RS-485, RS-422</td>
</tr>
<tr>
<td>Interface Connector</td>
<td>D15, female</td>
</tr>
<tr>
<td>Data Speed of RS - Interface</td>
<td>300 - 38400 bps</td>
</tr>
<tr>
<td>Data Speed of Radio Interface</td>
<td>19200 bps (25 kHz channel)</td>
</tr>
<tr>
<td>Data Format</td>
<td>Asynchronous RS-232 or RS-422 or RS-485</td>
</tr>
</tbody>
</table>

### General

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Voltage</td>
<td>+9 ... +30 VDC</td>
</tr>
<tr>
<td>Power Consumption (Average)</td>
<td>1.7 VA (Receive)</td>
</tr>
<tr>
<td></td>
<td>4.0 VA (Transmit)</td>
</tr>
<tr>
<td></td>
<td>0.05 VA (in Standby Mode)</td>
</tr>
<tr>
<td>Operating Temperature Range</td>
<td>-25 °C...+55 °C</td>
</tr>
<tr>
<td>Antenna Connector</td>
<td>TNC, 50 Ω, female</td>
</tr>
</tbody>
</table>
Multiple Repeater Radio

Multiple Repeater Radio provides different settings on the radio for receiving and transmitting RTK correction signal. These settings enable the installation of up to three Multiple Repeater Radios per Base Station. Configure the Multiple Repeater Radio with the RTK Diagnostic and Configuration Tool. The software for this tool is available for download from www.StellarSupport.com. Order the configuration harness KJD10585 through SERVICEGARD.

The Multiple Repeater Radio is a standalone system. It does not need a StarFire Receiver to function.
To identify a regular RTK Radio and Multiple Repeater Radio, use the following labels on the Multiple Repeater Radios:

RTK Base Station Harness
For setup purposes, RTK Base Station Harness links the Base Station to power supply and a display. This harness is mounted permanently. An extension harness is available to mount the Base Station further from the ground; whereas, the Base Station harness is installed close to the ground to facilitate setup and upgrades. The Base Station harness is always required.

RTK Base Station Extension Harness (20 m [65.6 ft.])
This harness extends the base station harness. It is 20 m (65.6 ft.) long. A maximum of two harnesses (40 m [131.2 ft.]) can be hooked together. If the RTK Base Station Harness cannot reach the receiver, use an RTK Base Station Extension Harness. Use of the extension harness allows for easier access for upgrades or diagnostics.
Radio Extension Harness (5 m [16 ft.] - 10 m [32.8 ft.] - 20 m [65.6 ft.])

This harness transmits the correction signal from the StarFire Receiver to RTK radio. Use this harness between the Multiple Repeater Radio and the power harness. This harness is 5 m (16 ft.), 10 m (32.8 ft.), 20 m (65.6 ft.), allowing the RTK radio to be mounted away from the ground. The receiver can then be closer to the ground for easier maintenance, updates, and diagnostics.

*NOTE: The length of the Radio Extension Harness affects the maximum data transmission rate. The longer the cable, the lower the transmission rate.*
Power Source

Ensure a stable power source for operation. Power source components are not available from John Deere. When hooking up power to a Base Station or Repeater, connect it to a battery/Uninterruptable Power Source (UPS) in addition to a regular power source. A battery/UPS provides emergency power to the Base Station or Repeater when the input power source fails or fluctuations occur.

System requirements for power supply:

<table>
<thead>
<tr>
<th></th>
<th>Amperage</th>
<th>Voltage</th>
<th>kWh/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>StarFire Receiver</td>
<td>2 A</td>
<td>12 V</td>
<td>~ 210 kWh</td>
</tr>
<tr>
<td>With RTK Radio</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repeater</td>
<td>1 A</td>
<td>12 V</td>
<td>~ 105 kWh</td>
</tr>
</tbody>
</table>

*NOTE: To prevent injury and allow uninterrupted operation of the system (Base Station and Repeater), electrical installation and grounding must meet all applicable national standards and regulations. An authorized electrician should always be used to ensure the system is installed correctly and is compliant.*

Alternative Power for Multiple Repeaters Radios

In areas where power is not available or too expensive to install, alternative power sources is the next best option. Solar batteries have some advantages over regular 12 V batteries. Solar batteries hold 12 V until they are fully discharged. Solar batteries can be discharged to a low point, and recharged without being damaged. These features give solar batteries longer life and less maintenance.

A stable power source with a battery/UPS is recommended for a Base Station due to the higher power consumption as shown in the Power Source table.

*NOTE: To prevent injury and allow uninterrupted operation of the system (Base Station and Repeater), electrical installation and grounding must meet all applicable national standards and regulations. An authorized electrician should always be used to ensure the system is installed correctly and is compliant.*
Antenna

Antenna broadcasts the correction signal to all machines within a certain line of sight radius depending on environmental conditions.

The original John Deere antennas are recommended, as they send out correction data in all directions. No matter how you set up your RTK Network, mount an RTK Radio with the antenna as high as possible in an upright position to broadcast the correction signal to the machines. All other components, including the StarFire Receiver, can be mounted near the ground. Ensure Receiver has clear view to the sky.

John Deere 869 MHz Antenna

Omnidirectional Antenna

- 2 dBi gain
- 869.4 - 869.65 MHz
- 50
- TNC-Male Connector

High Gain Antenna

The John Deere StarFire 869 MHz RTK Radio Modem is designed to operate on frequency ranges, the exact use of which differs from one region and/or country to another. The operator of the radio modem takes care that the device is not operated without permission of the local authorities on frequencies other than those reserved and intended for use without a specific permit. The John Deere SF 869 MHz RTK Radio Modem is designed to operate in the countries listed in the operator’s manual on the license free frequency band of 869.400 – 869.650 MHz (not incorporating the band 869.300 – 869.400 MHz) according to
recommendation CEPT/ERC/REC 7003. This recommendation has been drawn up by the European Radio Communications Committee (ERC) under CEPT.

The CEPT regulates effectively radiated power output (ERP) from the radio at 27 dBm (=500 mW). The usage of an antenna other than the one supplied might lead to violation of the above license free regulation.

The electrical installation and grounding meet all applicable national standards and regulations. Always use an authorized electrician to ensure the system is installed correctly and is compliant.

*NOTE: John Deere does not test and support High Gain Antennas.*

While using an additional Coax Cable as an extension, cable loss can occur. It is technically possible to compensate cable loss with a High Gain Antenna.

Calculation of coax cable loss:

- Total cable loss = cable attenuation per meter X cable length

Manufacturer provides the value of cable attenuation.

Gain antennas often have a *directional* signal path, this means, they do not provide the same signal strength in all directions.

Example:
Coax Cable (Optional)
When separating the radio and antenna, an additional coax cable can be used. It is essential to use a cable that causes low loss at the sending frequency.

Decreasing the loss of a cable result in an increase of thickness and loses flexibility.

The recommendation is to choose a cable with low attenuation.

Use special Connectors for the Coax cable, such as:

Mounting
The electrical installation and grounding meet all applicable national standards and regulations. Always use an authorized electrician to ensure the system is installed correctly and is compliant. Mount components far away from the ground. Components that are mounted far away from the ground need to be grounded and have lightning protection.

For more information on mounting locations for the base station, see "RTK Network Base Station Setup" in the operator’s manual.

**NOTE:** Ensure Base Station Receiver does not move or sway. Any motion of the base station receiver translates directly to the vehicle position. Repeater or Multiple Repeater can move and sway without influence to AB lines and boundaries, because they are "only" repeating the Base Station signal.
Planning an RTK Network

The first step of planning an RTK Network is to determine if there is customer potential for RTK.

The John Deere Regional Center in Mannheim analyzed the area conditions in Europe to identify potential locations for Radio RTK networks. The definition of outlined Radio RTK High Potential Area from John Deere is:

- Agricultural areas > 60%
- Agricultural areas with slopes < 3 Degrees in > 80% of the agricultural areas
- Root crops, Permanent crops, specialty crops > 15% of agriculturally used area in district or number of L/XL arable farms per 100 km² agriculturally used area is > 5

To learn more about identified RTK high potential areas for your dealer area, contact your Product Sales Specialist.

Best Practice

Buy a map of your dealership area to visualize the number of potential customers.

Mark on your map:

- Customers
  - Who is cultivating specialized crops?
    - Are there any specialty crops in your area that might require a higher level of guidance, accuracy, or repeatability?
    - Asparagus
    - Sugar beets
    - Seed corn
    - Vegetables (for example, potatoes and corn)
  - Are there any cropping practices that can be improved upon?
    - Strip Tillage - As input costs have increased in recent years, this practice is becoming widely used by producers.
    - Drip irrigation - Installation of irrigation lines without AutoTrac caused inconsistencies in width across
fields. To compensate for these inconsistencies, producers may have to set 50 or more A/B lines per field. RTK can set lines once and reference them the following years.

- Interested in RTK
- Who has a pioneering role (opinion leader)?
- Farming with competitive RTK system
- Who already works with a John Deere AutoTrac system?
  - How many SF1, SF2, and RTK customers do you have?
  - Where are these customers located?
  - Would they be willing to upgrade to RTK?
  - Would your current RTK customers be willing to sell back their RTK base station or turn it in to a vehicle kit?
  - What are the needs and requirements of each customer?
  - Where are the fields located?

**NOTE:** Mark the area that results from the above map. RTK Signal covers area, and is suited for a start in your RTK Network (for example, topographic aspects and customer fields).

- Figure out the potential locations for Base Stations and Repeater.
  - The higher the location the better (mill, grain dryer, silos, barn roof, wind mill - for Repeater only). This ensures a good radio horizon, resulting in signal reception.
  - Third-party tools and/or formulas that help to determine the radio horizon are available on the Internet.
  - Cellular towers can be an option, but usually with high rents.
  - Ensure accessibility to your Base Station.

- Competitive Pressure - Existing RTK Structures in the area.
  - To identify potential and risks, it is important to understand how competition uses RTK in your area. Competitors may include:
    - Trimble
    - Auto Farm
▪ Leica
▪ Beeline
▪ Agrocom/Claas
▪ Reichhardt

○ Where are the competitive Base Stations located?
○ What do they charge for their services?
○ What do their components cost?
○ What is the cost to access their RTK system?
○ How do their current customers like the RTK system?
○ How many base stations are there? Does it make sense to "compete" against them?
○ Do they have special frequencies?
○ How many customers do you have that use competitive RTK Auto Guidance systems?
○ Would they be willing to switch?
○ No competitor RTK system yet established:
  ▪ Are competitors interested in building up an RTK system?
  ▪ What are their arguments?
  ▪ What do their components cost?

▪ Dealer qualification and experiences
  ○ RTK is a premium AMS product, so it is crucial to make a fair assessment of your dealership. Evaluate your business setup for successful and sustainable RTK sales.
    ▪ Do you have experiences with guidance technologies/maybe in RTK?
    ▪ Do you have an AMS-specialist?
    ▪ Are your salesmen or AMS specialists following the trainings paths from JDU for mainstreaming and specialization?
    ▪ Is guidance a business you are focusing on?
    ▪ Are you set up to include RTK in your demonstrations or dealer events to show the benefits of a steering solution (for example, demo-kits)?
Does it make sense to join an existing RTK system from a neighbor (another dealer) and help to expand? Are you set up to support after establishing a system?

- Number of customers per Base Station and Multiple Repeater
  - When considering establishing or marketing your own RTK Network, it is important to know how many customers or machines will be accessing the network. Forecasting your user potential is important information.
  - Marketing different pricing structures to different customers is something to consider when you have customers with ten or more vehicles accessing the network versus a customer with one to two machines.

Investment Costs for John Deere RTK Equipment

- Number of Base Stations needed to cover a certain area and all the customers.
- Number of vehicle kits needed if business model allows it (dealer is owner of the vehicle kits and rent them out to the customers).
- Number of Multiple Repeaters needed.
- More John Deere equipment (for example, extension harnesses for power supply, and brackets).

Non-John Deere RTK Equipment

Includes power sources, extension cables, and mounting materials.

Existing Structures

Using existing structures can reduce your initial investment cost. For more information on existing structures, see "RTK Network Base Station Setup" in the operator’s manual.

New Structures

If no structure exists, a new tower needs to be set up. Careful planning and consideration of various aspects is a solid base to ensure the tower is placed in the optimum location. The topics below will help you determine this location:

- Power - Is power available at the location you are looking at? If power is not available, consider alternative power sources like batteries or solar panels. Running power from the nearest source can increase initial investment costs due to the expense of installation.
• Topography - Placing a tower on a high elevation leads to a better coverage than placing a tower on a lower elevation due to less interference from hills, trees, and buildings. The height of a Base Station or Repeater has the strongest influence on RTK coverage. Screening your RTK potential area for the highest elevation or potential locations is the first step to take. Evaluating feasibility and simulate coverage are second.

• Simulate RTK coverage - After narrowing down the possible locations, check this specific location on expected RTK coverage. This is a good indicator to decide with combination of locations does cover your area the most effective. Software available on the Internet that allows you to simulate line-of-sight broadcast signal from a specific location and height. Ask your Product Sales Specialist for details.

For more information, see "Specific Tower Setup Information" in the operator’s manual.

Base Station and Repeater Location

The basic prerequisite for installing an RTK Network is to find an optimum location for installation that takes into account the installation requirements of GPS and radio telecommunication link.

Requirements for placement of GPS antenna:

• Clear view of the sky.
• No shadowing from structures such as buildings or trees.
• No multipath effects from structures such as reflective buildings or other materials.
• No vibration and swaying of the GPS antenna.
• No interference.
• Power supply.

Requirements for placement of radio antennas:

• As high as possible to get a long range coverage - radio horizon.
• No interference.
• Power supply.
• Free line of sight to machine.
• Free line of sight to Base Station if used as Repeater.
• The electrical installation and grounding meet all applicable national standards and regulations. Always use an authorized electrician to ensure the system is installed correctly and is compliant.

### Constructing an RTK Network

Proper planning is key to a successful RTK Network and helps to avoid many problems in the future. There are several options for planning and installing an RTK Network. For example, you can manage the overall project or hire a consultant to manage the entire project.

In general an RTK Network consists of one Base Station and a maximum of nine Multiple Repeaters. All Multiple Repeaters use one of the ten available frequencies. Maximum range of Base Station is 40 km (24.9 mi.) (see also Section 3.4-Using Multiple Repeaters). John Deere recommends not to exceed a 25 km (15.5 mi.) range from the base station.

Example of an RTK Network:

![Example of an RTK Network](image)

**NOTE:** Range of a Base Station or Multiple Repeater depends on terrain structure, topography, and any obstacles in the line of sight between Base Station or Multiple Repeater and machine.

869 MHz band width is a public radio frequency. Other RTK Networks or Radio systems are operating in your neighborhood or also in your Network area.
Ensure RTK Network does not interfere with other systems by testing signal strength and quality (see Section 5-RTK Network Diagnostics) or agree with your neighborhood on a non-interfering setup in the overlaid area, if possible.

If other RTK systems in the same area are interfering with the network and causing decreased Base Station communication, Time Slot can be changed.

Examples of mounted Base Station/Multiple Repeater:

- Area or fields with RTK signal coverage
- Area or fields without RTK signal coverage

**NOTE:** RTK Extend helps cover small areas where no RTK signal is provided due to obstacles. Place a Base Station or Multiple Repeater in a way that most of the potential area is covered with an RTK signal. Keep areas without signal as small as possible.

**NOTE:** Vehicle needs a free line-of-sight to the Base Station or repeater to receive RTK signal.

Example 1:
Example 2:

NOTE: The highest position is not always the best. This position depends on the area that is to be covered. See Example 4.

Example 3:

Example 4:
**RTK Network - Antenna Height**

To maintain a good RTK Radio link, mount antenna high enough to get the best possible coverage. As shown in the picture below, obstacles can block the signal from the Base Station or Repeater. If Base Station radio antenna is mounted too low, the broadcasting range is reduced.

**Using Additional Repeater**

RTK Radio setup is configured as a Repeater. It is possible to install one Base Station and one additional Repeater. The Repeater repeats the Base Station signal. A Repeater allows better coverage behind obstructions. Every Base Station needs free line of sight to the Repeater. To see the special settings, see the diagram.
Using Multiple Repeaters

The drawing shown is a good example of how "StarFire Multiple Repeaters" per Base Station can be set up: Base Station transmits its correction data on setting A. Multiple Repeaters 1, 2, 3, and 5 receive the correction signal from Base Station, since they are set up to receive setting A. Each Multiple Repeater broadcasts correction data on a new setting (like settings B,C,D, and F in the drawing) to avoid interferences.

Also set up Multiple Repeaters, as in the example with Multiple Repeater 3 and 4 (look at the orange arrow in the diagram). The Multiple Repeater technology provides the necessary flexibility to get the RTK correction signal around obstacles.

A maximum of nine Multiple Repeaters can be set up for a Base Station, and defined by the 10 different frequencies within the John Deere 869 MHz RTK system. The maximum range between Machine and Base Station using Multiple Repeaters is 40 km (24.9 mi.). The Base Station operates with different satellites compared to the Rover. This results in less accuracy (SF2 signal quality). If all nine frequencies are available, John Deere recommends the usage of additional Base Stations to ensure good signal quality and coverage, not exceeding a 25 km (15.5 mi.) radius.

NOTE: The signal quality between Multiple Repeater to Multiple Repeater decreases drastically if no line of sight and 100 % signal reception (% Received) is guaranteed.
John Deere recommends a maximum distance of 10 km (6.2 mi.) line of sight between Base Station to Multiple Repeater or Multiple Repeater to Multiple Repeater. Do not exceed a 25 km (15.5 mi.) signal range from the Base Station. Set up additional Base Station, if necessary.
RTK Network Setup Examples

The following symbols are used in the setup examples:

- **Network I**
- **Network II**

- **Interferences**
- **Proper Network Setup**

- **Direct Network Link**
- **Link Other Network**

**Receiving Channel**

**Transmitting Channel**

### Proper RTK Network Setup

- **Base I**
  - Frequency T1
  - Time Slot 1
  - Network ID 1

- **Multiple Repeater Base III**
  - Frequency R 3/T 5
  - Network ID 3

- **Machine I**
  - Frequency R 2
  - Time Slot 1
  - Network ID 1

- **Base II**
  - Frequency T 3
  - Time Slot 1
  - Network ID 3

- **Multiple Repeater Base II/II**
  - Frequency R 5/T 4
  - Network ID 3

- **Machine II**
  - Frequency R 4
  - Time Slot 1
  - Network ID 3
Poor RTK Network Setups

Example 1

Example 2
Example 3

Worst RTK Network Setup

Interferences between Network Base I and Network Base II causes line jumps.
Mounting Possibilities (Base Station/Multiple Repeater)

1. StarFire Receiver and RTK radio in one housing.

- Advantages:
  - Only one unit.
  - Only few components needed.
  - Less mounting material required.
  - Easy installation.
  - Lower investment cost.
• Disadvantages:
  ○ Restricts mounting possibilities.
  ○ Requires rigid mount (for example, a shaking building).
  ○ Restricts height due to weight of the receiver. It is easier to mount only the radio on a high mast.
  ○ Ensures good access to structures.

2. StarFire Receiver and RTK radio mounted separately.

• Advantages
  ○ Facilitates maintenance and upgrades of StarFire Receiver (mounted on the ground) when RTK radio and antenna are mounted on top of a structure.
- Uses best location for the StarFire Receiver and radio and antenna.

- Disadvantages
  - Requires additional mounting material.
  - Takes more time to install Base Station.
  - Prevents easy access to RTK radio for diagnostics because RTK radio is mounted on top of a structure.
  - Access may be needed for a separate building.
  - Decreases data transmission rate with use of a long radio harness.
  - Ensures good access to structures.

- Advantages
  - Facilitates maintenance and diagnostics of StarFire Receiver and RTK Radio mounted on ground; antenna is mounted on top of a structure.
  - Uses coax cable to mount antenna on top of a building; radio is close to the ground.
  - Uses best location for the StarFire 3000, RTK radio, and antenna.
  - Ensures good access to structures.
• Disadvantages
  ○ Requires additional mounting material.
  ○ Takes more time to install Base Station.
  ○ Access may be needed for a separate building.
  ○ Requires additional components, such as a coax cable.
Configuration

After setting up Base Station and Multiple Repeater:

- Submit RTK activation.
- Configure RTK radio.
- Complete an absolute Base Survey (24-hr. measurement) to set up the RTK Network properly.

RTK Radio Configuration

- Whenever configuring Base Station, ensure components are linked correctly. The Display links to the StarFire Receiver for configuration only.
- To ensure configuration, verify GPS Receiver has clear view to the sky.
- Reception of GPS signal is required before starting RTK Radio configuration.
• After receiving GPS signal, look at the diagnostics page if radio is connected to the receiver. Radio firmware and serial number shows up.

Ensure the following settings are the same for Base Station, Vehicle, and Repeater used in the same system:

• Frequency - The radio transmits and receives signals in range of 869,4125 to 869,6375 MHz. This range is divided into 10 channels, which can be used for setup. Ensure every frequency is transmitted only once in a network. Multiple usages of the same frequencies in a network can cause signal interferences and non-functional RTK on machines.

• Time Slot - The Base Station transmits RTK correction signal every 4 seconds. The Time Slots divide these 4 seconds into 10 parts of 400 ms (10 Time Slots). Operators can decide the exact time the transmission of the RTK signal starts.

• Network ID - Setting of the network ID machines are assigned to certain Base Stations. Machine receiver and Multiple Repeater filter signals received from other RTK networks. Only signals from the assigned Base Station are accepted.

NOTE: Changing Network ID cannot fix interference issues.
Change Frequency and/or Time Slot if radio signal interference is an issue. If signal from another Base Station is received, change Network ID to the correct Base Station.

To configure:

- The frequency, press Configure.
- The base or rover radio, press START Configure RTK Radio.
- The repeater radio, press START Configure Repeater Radio.
NOTE: Make sure you have chosen a frequency, Time Slot, and Network ID that is unique for your Base Station (and Repeater, if used) to avoid interferences with other Base Stations.

NOTE: Detailed information is available in the operator's manual.

Base Station Configuration

When configuring a Base Station, there may be a difference between Absolute, or Permanent, Base and a Quick Survey Base. Since permanent locations are the focus, use Absolute Base setup.
1. Go to StarFire softkey, and press RTK softkey.

2. Press "Configure" button. Ensure operating mode is set to Absolute Base Station.
Absolute Base Station Survey

1. Press the "Start" button below "Edit stored RTK Base".
2. Press the "Start" button on the right side of the screen to start the 24-hr. survey.
3. If position data is already available, enter the position of the Base Station on the left side of the screen.
4. Select storage location number and start the 24-hr. survey.

- 1. Select storage location
- 2. Position StarFire Receiver
- 3. Press start survey button below
- 4. Wait 24 hours (display can be disconnected)
- 5. Base station location will be saved automatically at the end of 24 hr survey

Start 24 hr Survey

5. It is possible to disconnect the display. Ensure power for the StarFire Receiver stays on for the 24-hr. measurement.
Recording Absolute Base Station Coordinates

After the 24-hr. Absolute Base measurement is done:
1. Record latitude and longitude values in case Receiver is replaced (for example, Base Station fails or is stolen).
2. Enter recorded values. A new 24-hr. measurement can be skipped.
3. Enter location to prevent AB lines and boundaries from shifting.

NOTE: Do NOT record position on the INFO page for the Absolute Base location.
To protect an RTK Network from unauthorized access:

1. Go to RTK main page, and choose a Network ID from 4001 to 4090. This Network ID causes the security feature to appear as button "I" on the right side on the screen.
2. Press the "Access List" button to enter the Machine (rover) number and the StarFire Receiver serial number from the respective machines.
3. Use the "Toggle" button to set the RTK Network to secure or public mode. In public mode, any machine with the same settings (Frequency, Network ID, and Time Slot) has access to the RTK Network.

RTK Radio Diagnostics

How can I see if RTK Radio works properly?

- RTK Radio of a Base Station (Quick Survey or Absolute Base Station):
  - Ensure Base Station configuration has been done correctly.
    Record Time Slot, Network ID and Frequency.

- Configure machine according to Base Station settings (Time Slot, Network ID, and Frequency).
- Refer to the RTK main screen of the machine:
  - Quick Survey: Ensure Base Station data field shows status OK, satellite corrections more than 7, and distance to vehicle location has a reliable value.
○ Absolute Base: Ensure Base Station data field shows status Survey. Under location, find the name of the Absolute Base Station chosen before.

Press the button to refresh "Radio Data".

The "% Received" increases 10% every 4 seconds until value is stable (100% maximum). Observe value for at least 15 minutes.

If the value is constantly between 80% and 100%, the position is good.

If the value is below 80%:
  • Check for other 869 MHz radio applications in area and adjust system settings (Frequency, Network ID, Time Slot) to avoid interference.
  • Select Different Base Station or Multiple Repeater as signal source (if available).
  • Select another Multiple Repeater location or position:
    ○ John Deere recommends a maximum distance of 10 km (6.2 mi.) line of sight between Base Station to Multiple Repeater or Multiple Repeater to Multiple Repeater.
    ○ If the status “OKrtk” is shown, look at the Satellite page.

Additional Diagnostics Information

Signal Level

Signal (Noise) level is the signal strength of the received correction signal sent by the Base Station or Repeater. If you have not install a repeater and you received a signal level, then you have an interfering transmitter.

The signal level decreases while increasing the distance to the reference station. John Deere recommends setting up more Base Stations instead of exceeding the signal with Repeater chains. The accuracy decreases to SF2 level if exhausting the 40 km (24.9 mi.) absolute maximum range from the Base Station (with the RTK correction signal, not the Repeater location).

To get an RTK signal, it is mandatory to have a minimum signal level of 20%. Below this level, the correction data cannot be received complete. Use a signal level higher than 60% to operate with RTK signal.
**Data Received**

The base station transmits one data package (correction signal) every 4 seconds. If RTK receives data every four seconds, "data received" value shows 100%. If one or more packages cannot be received at rover site, the value drops.

**Corrections Age**

The corrections age shown in the satellite page gives information about the age of the last received correction data package. The Base Station transmits one package every four seconds. In this case, the corrections age counts from one to four and then start again at one. If packages cannot be received at rover site, the correction age increases to 8 (1 package missing) or 12 (2 packages missing). If more than two packages are not received, the rover receiver changes to RTK-extend mode until corrections are available again.
RTK Network Diagnostics

RTK Configuration and Diagnostic Tool

For setup purposes of the Multiple Repeater radio, a StarFire Receiver or GreenStar Display is not required. The configuration uses a Computer and RTK configuration harness. Download the software on www.StellarSupport.com in the Dealer Corner - Radio RTK section. The configuration harness KJD10585 is available through SERVICEGARD.

NOTE: The setup and configuration of a Multiple Repeater has to be done by the dealer. The customer is not allowed to set up the system alone. Also, read the operating manuals carefully. The configuration software is installed on a dealer's laptop computer only.

Configuration and Diagnostic Tool

Configuration software allows the dealer to set up:

- Frequency for the Multiple Repeater on which it receives RTK correction data.
- Frequency for the Multiple Repeater on which it transmits RTK correction data.

The diagnostic screen shows the signal strength of the incoming signal. The color of this bar changes depending on the strength.
Also view the:

- Software version of radio.
- Serial number of radio.
- Base station coordinates.

**NOTE:** It is possible to attach a "traditional" Repeater radio. In this case, a setup for Repeater functionality for this radio is possible. It is not possible to attach a traditional RTK radio to configure it as a machine, Base Station, or Multiple Repeater.
For further information, read the Configuration and Diagnostic Tool manual.

After Multiple Repeater setup is complete, check if you received a signal from the correct Base Station and Signal Strength is higher than 50%. Signal strength is not the only quality indicator for RTK signal. Also, check the Signal Quality with a GreenStar Display and StarFire RTK Receiver.

**RTK Network Diagnostics with StarFire Receiver**

Signal strength is not the only quality indicator for RTK signal. It is important to check the Signal Quality with a GreenStar Display and a StarFire RTK Receiver.

Measure Signal Quality:
1. Power up a machine Receiver (StarFire 3000 or newer with RTK Radio and Display) at a potential Multiple Repeater location.

*NOTE: For most accurate measurement, ensure the Receiver RTK Radio is mounted on the exact same position as the future location of the Multiple Repeater Radio.*

2. Navigate to SF3000 RTK page (G), press the configure button and chose "Vehicle" as operating mode.
3. Set up Time Slot and Network ID according to the Base Station.
4. Select Frequency (Radio Channel 1-10) according to the incoming signal you would like to repeat (Base Station or other Multiple Repeater).

Example 1: Repeat Signal from Base Station

- Base Station settings: Channel 1, Time Slot 1, Network ID 4004
- Set Machine Receiver to: Channel 1, Time Slot 1, Network ID 4004

Example 2: Repeat Signal from Multiple Repeater

- Base Station settings: Channel 1, Time Slot 1, Network ID 4004
- Multiple Repeater: Received Channel 1, Send Channel 2, Network ID 4004
- Set Machine Receiver to: Channel 2, Time Slot 1, Network ID 4004

1. Start a measurement with the appropriate setup and the Base Station or Multiple Repeater shut off to ensure no interference with other radio systems occurs.
2. If there is no reception of any signal from a foreign RTK Network or radio system, turn Base Station or Multiple Repeater on. Proceed with a measurement of your Base Station or Multiple Repeater signal availability.

Start test equipment and the appropriate parts of your RTK Network (Base Station or Multiple Repeaters). Wait for the Base Status to change to “OK”. The "% Received" increases 10% every 4 seconds until value is stable (100% maximum). Observe the value for at least 15 minutes.

If the value is constantly between 80% and 100%, the position is good.

If value is below 80%, evaluate:

- Watch for other 869 MHz radio applications in your area and adjust system settings (Frequency, Network ID, Time Slot) to avoid interference.

- Use a Different Base Station or Multiple Repeater as signal source (if available).

- Use another Multiple Repeater location or position
  - John Deere recommends a maximum distance of 10 km (6.2 mi.) line of sight between Base Station to Multiple Repeater or Multiple Repeater to Multiple Repeater.
  - Look at the Satellite page if the status “OKrtk” is shown.

John Deere recommends a maximum distance of 10 km (6.2 mi.) line of sight between Base Station to Multiple Repeater or Multiple Repeater to Multiple Repeater.
Troubleshooting

Symptoms:

- AB line moved or drifted
- Field boundaries moved or drifted
- Markers moved or drifted

**NOTE: When the term AB line is used, it also encompasses Circle track and Curve track lines.**

Solution:

RTK is designed to provide repeatability pass to pass and from season to season.

The repeatability is a function of the Base Station location and its correlation to a field specific AB line.

AB lines, boundaries, and field operations are linked to the Base Station they were originally created with. Every AB line and boundary in the field is created that utilizes a specific RTK Base Station. Every pass or boundary in a field utilizes the same original base station that was used to create specific AB lines and boundaries.

Changing Base Station or the Base Station location results in offset and drift of AB lines, markers, and boundaries.

**RTK Base Station Quality Indicator (BSQI)**

Diagnostic addresses 140-142 indicate the average drift in centimeters of the Base Station position over the previous 24 hours. It is an indicator of the quality of the Base Station location a Diagnostic Trouble Code (DTC) is thrown. The following is an example of the information that appears in a DTC:

- SPN Number: 516198
- SPN Name: Base Station Quality Indication (BSQI)
- FMI Address: 16
- FMI Name: Data Valid but Above Normal Operating Range - Moderately Several Level
- DM1 Lamp Status: Protect Lamp
• Engineering Code Description: Any of the position standard deviations received from the base exceed the high threshold.

• Level 1 Text: Base position average.

• Level 2 Text: Bad base position. Check for obstructions or presence of interfering signal around base receiver.

<table>
<thead>
<tr>
<th>Diagnostic Address</th>
<th>140</th>
<th>141</th>
<th>142</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>&lt;5</td>
<td>&lt;5</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Bad</td>
<td>&gt;5</td>
<td>&gt;5</td>
<td>&gt;10</td>
</tr>
</tbody>
</table>

- 140: 24 hr. survey position standard deviation, east (in cm)
- 141: 24 hr. survey position standard deviation, north (in cm)
- 142: 24 hr. survey position standard deviation, elevation
Values indicate if the base station receiver is experiencing shading, multipathing, or movement.

NOTE: Diagnostic address values are not correlating with the accuracy in the field. It needs 25 hr. of continuous power before BSQI populates (24 hr. Absolute Base Station survey plus 1 hr. for adequate pull-in time to ensure Base Station has a good positioning).

**Shading**

Many structures can cause shading, such as buildings, towers, poles, and grain legs. These structures can prevent a StarFire from transmitting data.

The receiver is located on top of the building, which is circled in red. It could be affected by multipathing (discussed in the next section) and shading. The grain legs in the picture will shade the receiver, causing poor satellite reception.
In the picture above, both receivers are experiencing shading. The tower is shading the receiver on the left, and the pole is shading the receiver on the right. The receiver on the right has more shading issues than the receiver on the left because the pole is against the receiver, shading a large portion of the sky. The receiver on the left has been moved further away from the tower to prevent shading issues.

**Multipathening**

Each satellite sends time-coded messages for any receiver to pick up. If a receiver sees multiple time-coded messages from the same satellite, it
tries to determine if there is a problem with the satellite. The receiver discontinues using that satellite until it corrects the problem. The correction could take a few minutes.

Reflection causes doubling of the signal. The receiver receives the direct signal before the reflected signal is received. For the receiver algorithm, it is difficult to determine the correct signal. In some cases, the receiver uses the affected satellite in its solution calculation.

Causes of multipathing include:

- Metal roofs
- Center pivots
- Water towers
- Cars and trucks
- Grain bins
- Water surfaces
- Forest
- Any type of reflecting material

The picture was taken after the Base Station was elevated 2 m (6.6 ft.) from the top of the tower. Raising the receiver greatly reduced
the multipath effects observed on this RTK system.

To avoid multipathing and shading, elevate Base Station Receiver above any structure that it is mounted on. For best results, 2 m (6.6 ft.) from the highest point of the structure is recommended. The higher the better, but also ensure the Base Station Receiver is mounted securely to prevent movement of the receiver. Any motion of the Base Station Receiver translates directly to the vehicle position.

When setting up a Base Station on a tower, ensure receiver is at least 20 m (65.6 ft.) away from the tower to protect your system from multipathing.