WIBOTIC

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Description

WiBotic wireless power solutions enable autonomous wireless charging of aerial drones, mobile robots, and unmanned aquatic vehicles across a wide range of applications.

The WiBotic Development Kit is the first step towards autonomous deployments of entire robot fleets. In addition to fully automating the battery charging function, remote monitoring of battery parameters and configurable charging profiles can extend the life of every battery while ensuring every robot is ready to take on its next mission.

The Development Kit is the typical starting point for operators wishing to test and evaluate these capabilities. The kit is assembled from standard WiBotic components, selected to meet customer needs for size and capacity as well as to maximize charging flexibility. The WiBotic Software Graphical User Interface (GUI) is also supplied for system configuration and monitoring purposes.

Key Features

- ✓ **100% autonomous wireless battery charging**
  - Stand-by heartbeat mode with auto sensing for charge initiation
  - Auto tuning for wide transmit-receive coil range and alignment flexibility
  - Up to 8 amps/100 watts delivered to the battery for wireless operation
- ✓ **Constant current and constant voltage charging modes**
  - Supports many battery chemistries, including LiPo, $LiFePO_4$, and SLA
  - Fully programmable charging current/voltage
- ✓ **Optional wired battery charging**
  - Up to 10 amps/250 watts delivered to the battery when directly wired for non-wireless operation
- ✓ **Lightweight receiver system for weight-sensitive installations**
- ✓ **Three antenna sizes available to ensure the right fit for your robot**
- ✓ **Optional cell balancing, battery monitoring and battery protection**

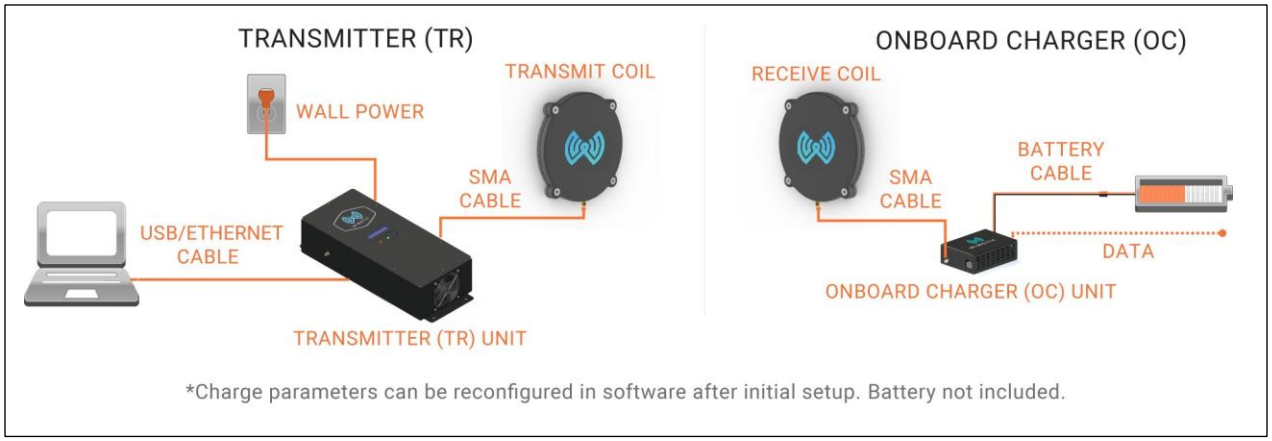
Development Kit System Specifications

PARAMETER	MIN	TYPICAL	MAX	UNITS
AC Input Voltage	90	110	264	V
DC Input Voltage*	36	48	55	V
Standby DC Current	-	20	84	mA
RF Output Power (into 50Ω load)	0.1	-	250	W
Operating Frequency	-	13.56±0.007		MHz
Communication Link Frequency	2.433	-	2.483	GHz
DC Output Voltage**	0	V_{BAT}**	33.6	V
DC Output Current**	0	I_{CHARGE}**	10.0	A
DC Power Output to Battery	0	-	125	W

*The standard WiBotic Development Kit comes complete with an AC/DC power supply built into the transmitter enclosure. If AC power is not available, a direct DC input to the transmitter can be accommodated. Contact WiBotic for details.
**DC Output Voltage and Current are configurable between min and max values via WiBotic software

Development Kit Components

The following diagrams show the operational configuration of the system as well as the individual components supplied with every WiBotic Development Kit:



Inside the Box

1. Ethernet (or USB) Cable
2. USB Adapter
3. Power Cable
4. Power Transmitter
5. Power Receiver
6. Receive Coil
7. Transmit Coil
8. SMA Cable (x2)
9. Battery/Load Connector

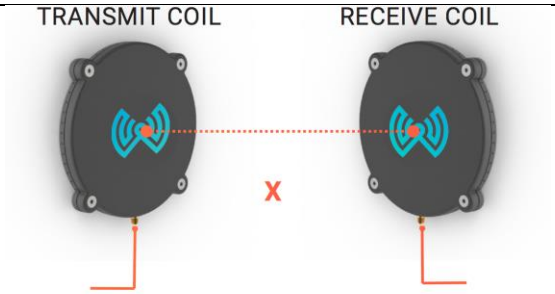
Initial Hardware Setup

With the following steps, it is quick to setup and evaluate the WiBotic wireless charging system either on a test bench or in your robot/drone. Follow these steps in order for quickest setup and best performance out of the box:

1. Connect one coaxial SMA cable between the Power Transmitter and the Transmit Coil. Make sure the connection is finger-tightened on both ends.
2. Connect the second coaxial SMA cable between the Power Receiver and the Receive Coil. Make sure the connection is finger-tightened on both ends.
3. Connect the Power Receiver to the target device to be powered (e.g. the battery) using the supplied battery connector cable. ***NOTE**: The development kit requires a direct connection to the battery for operation. The "heartbeat mode" algorithm is disabled if the Power Receiver does not receive power from the battery before wireless power is enabled.*

TRANSMITTER	RECEIVER
	

4. Using either stands to mount the coils or spacers to distance the coils, place the coils face-to-face with the WiBotic logo side of each coil facing towards the other. Coils should be positioned in-parallel and on-axis with each other for best performance and for initial testing. ***NOTE**: It is possible for the coils to be placed too close together, make sure to reference the diagram below for sufficient coil spacing depending on the coils provided.*

	See the “Certificate of Conformance” included in your shipping box for your system’s Optimal Charging Distance (X)

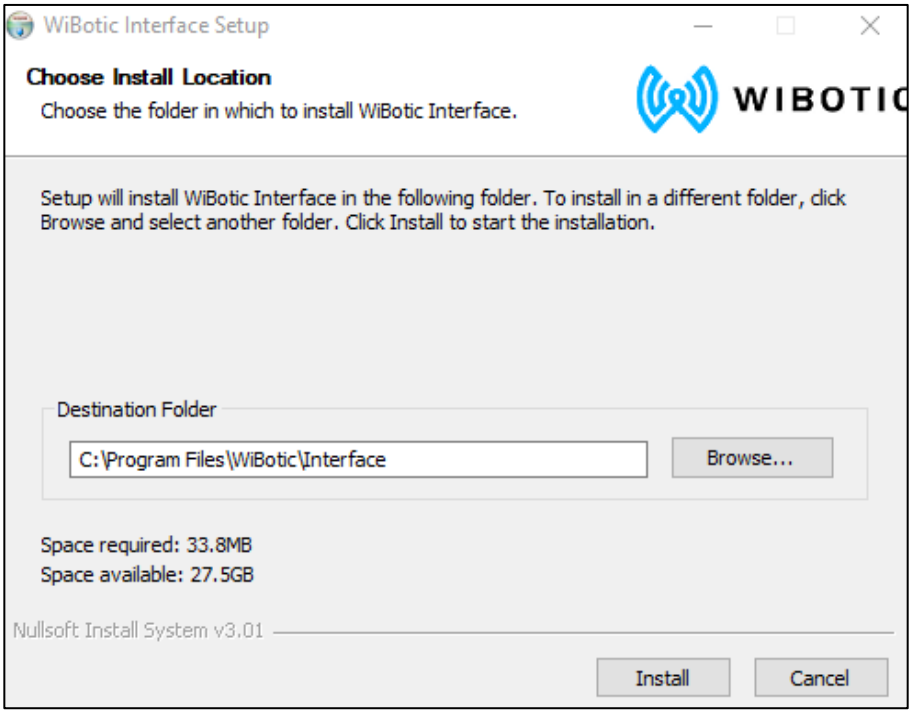
CAUTION: Do *not* place the Transmit Coil on a metallic surface, and make sure that all metal objects are at least 30cm away from the Transmit and Receive Coils during testing.

5. Be sure the coil faces with WiBotic logos are face-to-face. For optimal performance, position the coils concentrically at the “Optimal Distance” as specified on your Development Kit’s “Certificate of Conformance” (included in the package). *Note that the CoC provides the distance between plastic enclosure faces when both coils remain in their enclosure. The distance between bare coils is also provided if removed from their enclosures. These distances will be slightly different due to the thickness of the enclosure itself.*
6. Connect the Power Cable to the Power Transmitter (before plugging in the Power Cable to an electrical outlet).
7. Plug the other end of the power supply into a standard electrical outlet. The Green “READY” LED on the Power Transmitter will turn on once the system has been activated via the software GUI.
8. After installing the GUI on a Windows PC (see Software Setup instructions in the next Section), connect either the Ethernet Cable or USB Cable from the Power Transmitter to the computer. ***NOTE****: We strongly recommend the use of Ethernet if possible. If using the Ethernet Cable, either plug directly into the Ethernet port on the computer, or use the provided USB Adapter if the computer does not have an Ethernet port. Also if using the Ethernet Cable, there are additional steps required to configure the IPv4 settings on Windows. Refer to the Section on Configuring Ethernet Connectivity. If using the USB Cable, make sure to use the provided USB Cable which includes a ferrite bead on the cable, this is important for noise mitigation to reduce the chance of disrupting the communication link to the Power Transmitter. Refer to the Section on Configuring USB Connectivity.*

9. Once the GUI has been installed, all connections have been made and the coils are within the Ideal Operating Range, you're ready for wireless power! Press the "Transmitter Off" button to enable heartbeat mode. Assuming everything has been setup properly and coils are in range, the system will turn on and begin charging. ***NOTE**: As the default operating mode, the Power Transmitter will be disabled when initially powered. Therefore the GUI must be installed and the system must be manually turned on to enable charging. After the initial set-up, the default operating mode (enabled on power-up or disabled on power-up) can be configured using the GUI.*

Software Setup

To install the GUI, download the Windows executable from the link provided. This link is provided by WiBotic via e-mail. Follow the steps in the WiBotic Interface Setup.



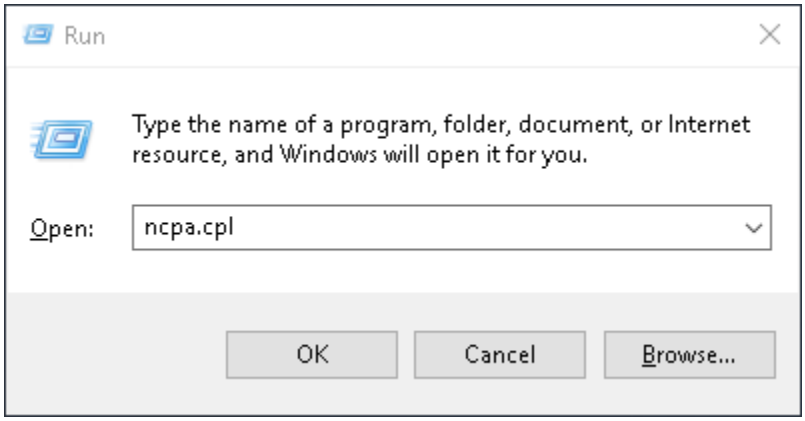
After successfully installing the GUI application, follow the steps in the subsequent section to complete the system configuration using either the Ethernet interface or the USB interface. ***NOTE**: WiBotic recommends that the Power Transmitter be connected via Ethernet for improved robustness to interference that may interrupt the communication link between the Power Transmitter and the computer.*

Option 1: Configuring Ethernet Connectivity

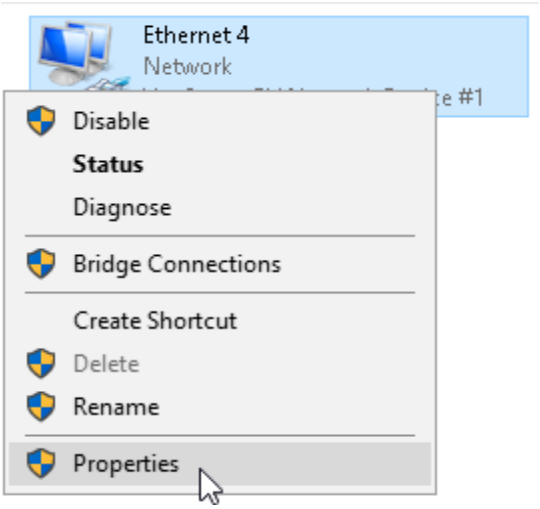
The following instructions allow for a point-to-point Ethernet connection. Please note that WiBotic currently supports only point-to-point Ethernet connections and users should not attempt to connect to the Power Transmitter over an Ethernet network/LAN.

1. With the Power Transmitter powered on, **connect the Ethernet Cable** to the Power Transmitter and either directly connect the Ethernet Cable to the computer or use the provided USB Adapter.

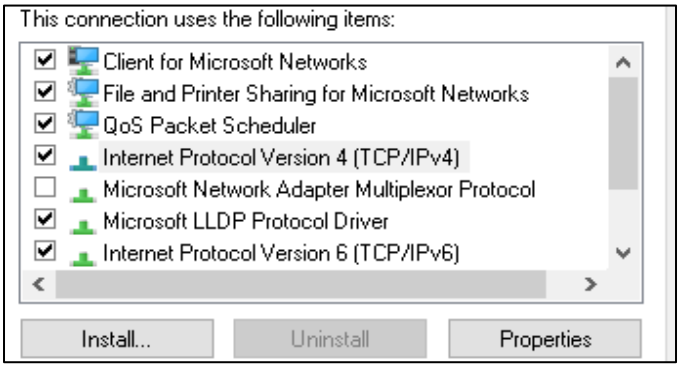
2. Open “Network Connections” by pressing **Windows Key + R**. Type in “ncpa.cpl”, and click OK:



3. Right click on the network adapter that is connected to the WiBotic Power Transmitter and select **Properties**:

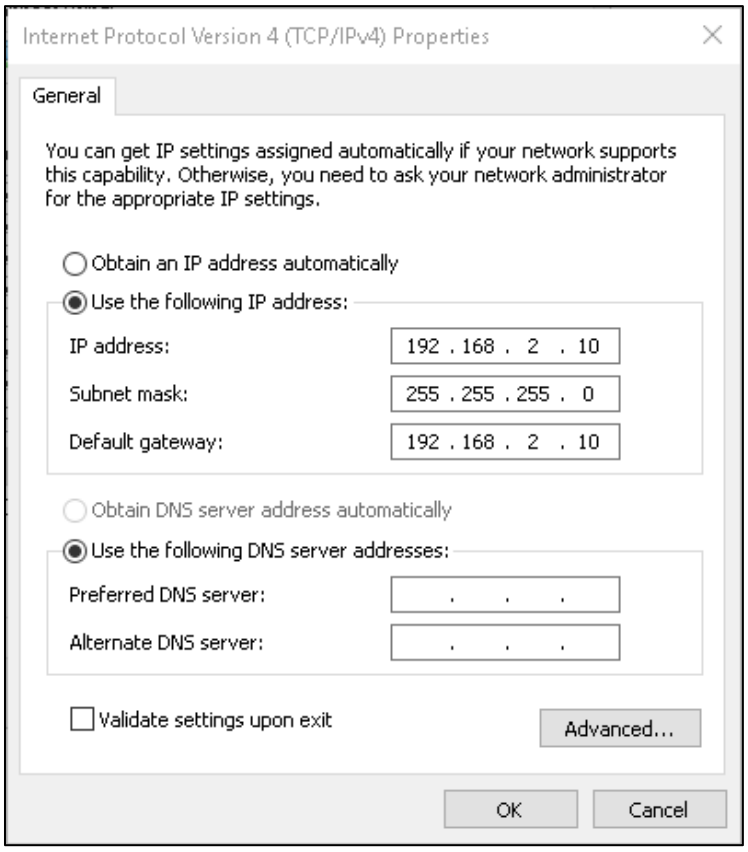


4. Select **Internet Protocol Version 4** (TCP/IPv4) and click the **Properties** button below it:



5. Click the **Use the following IP** address button and specify the following settings. The DNS section may be left black. Click OK:

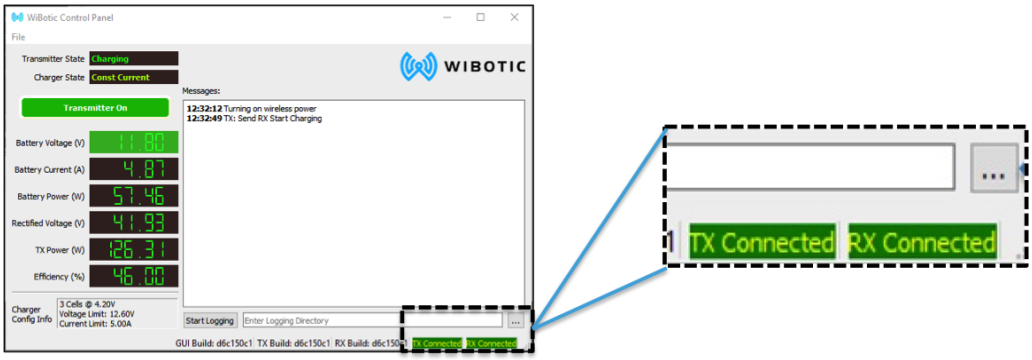
IP address:	192.168.2.10
Subnet mask:	255.255.255.0
Default gateway:	192.168.2.10



6. After the network settings have been configured, **open the WiBotic GUI Application.**

7. Click the **Network button** and enter the IP address followed by port number: **192.168.2.20:1234** then click OK. ***NOTE****: the IP Address is different than the IP address typed into the network settings from the previous step.*

8. Verify that the GUI displays **TX Connected** as indicated by the icon in the bottom right of the GUI. ***NOTE****: the GUI may or may not indicate RX Connected at this point, but so long as the GUI indicates TX Connected, the network settings have been configured properly.*



Note: All Ethernet connectivity instructions are intended for an ad-hoc point-to-point connection directly to the Development Kit. Changing the IP address, default gateway, and subnet mask of your default adapter may cause a loss of connectivity between your computer and your local network.

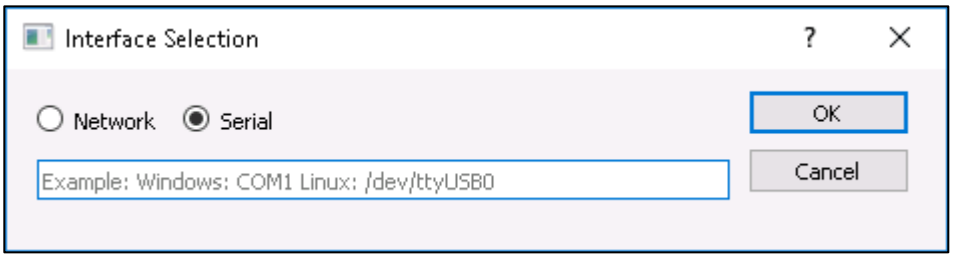
Note: Only connect the Power Transmitter to a local machine's internal Ethernet port or by using the USB-to-Ethernet adapter provided by WiBotic. The Power Transmitter should not be plugged into any network switchable interface.

Option 2: Configuring USB Connectivity

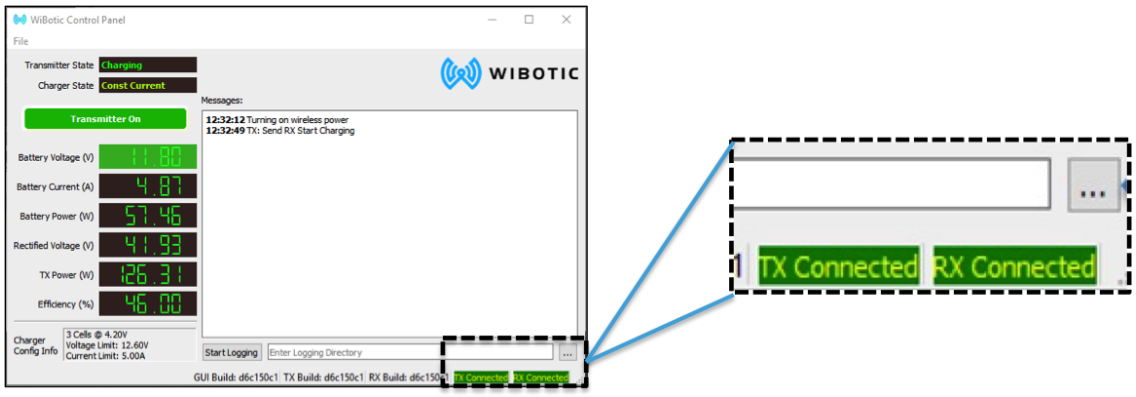
The following instructions allow for a direct USB connection to the Power Transmitter. Please note that WiBotic recommends using the Ethernet connectivity option. If USB connectivity is desired, be sure to use the provided USB Cable with a ferrite bead to reduce the chance of interference between the Power Transmitter and the computer.

1. Connect the USB cable between the computer and the Power Transmitter. ***NOTE**: make sure the USB cable is sufficiently plugged in to the Power Transmitter.*

2. Open the **WiBotic GUI Application**. Enter the serial port for the connected USB cable. This can be found within Device Manager. Enter the COM port using capital letters and no spaces (i.e. COM4) and then click OK.



3. Verify that the GUI displays **TX Connected** as indicated by the icon in the bottom right of the GUI. ***NOTE**: the GUI may or may not indicate RX Connected at this point, but so long as the GUI indicates TX Connected, the serial port settings have been configured properly.*



Using the System – Bench Testing

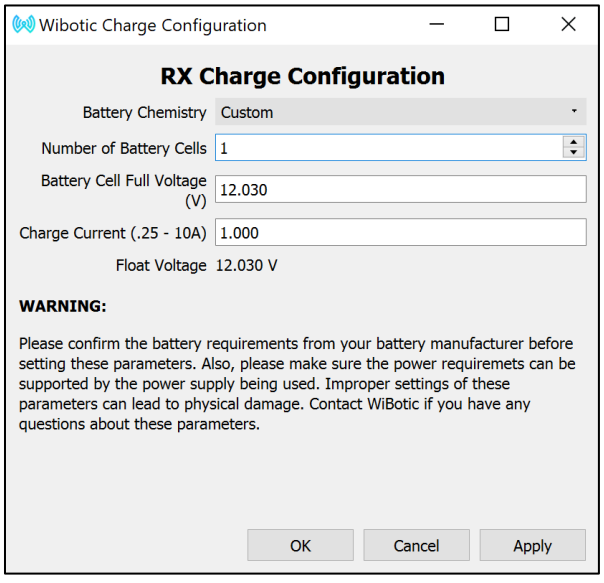
Before starting, please review this document to familiarize yourself with system operation and the GUI application.

Note: As with any wireless device, field testing of the Development Kit components in the end-use application is strongly recommended as numerous factors may impact system performance.

Default Charge Settings

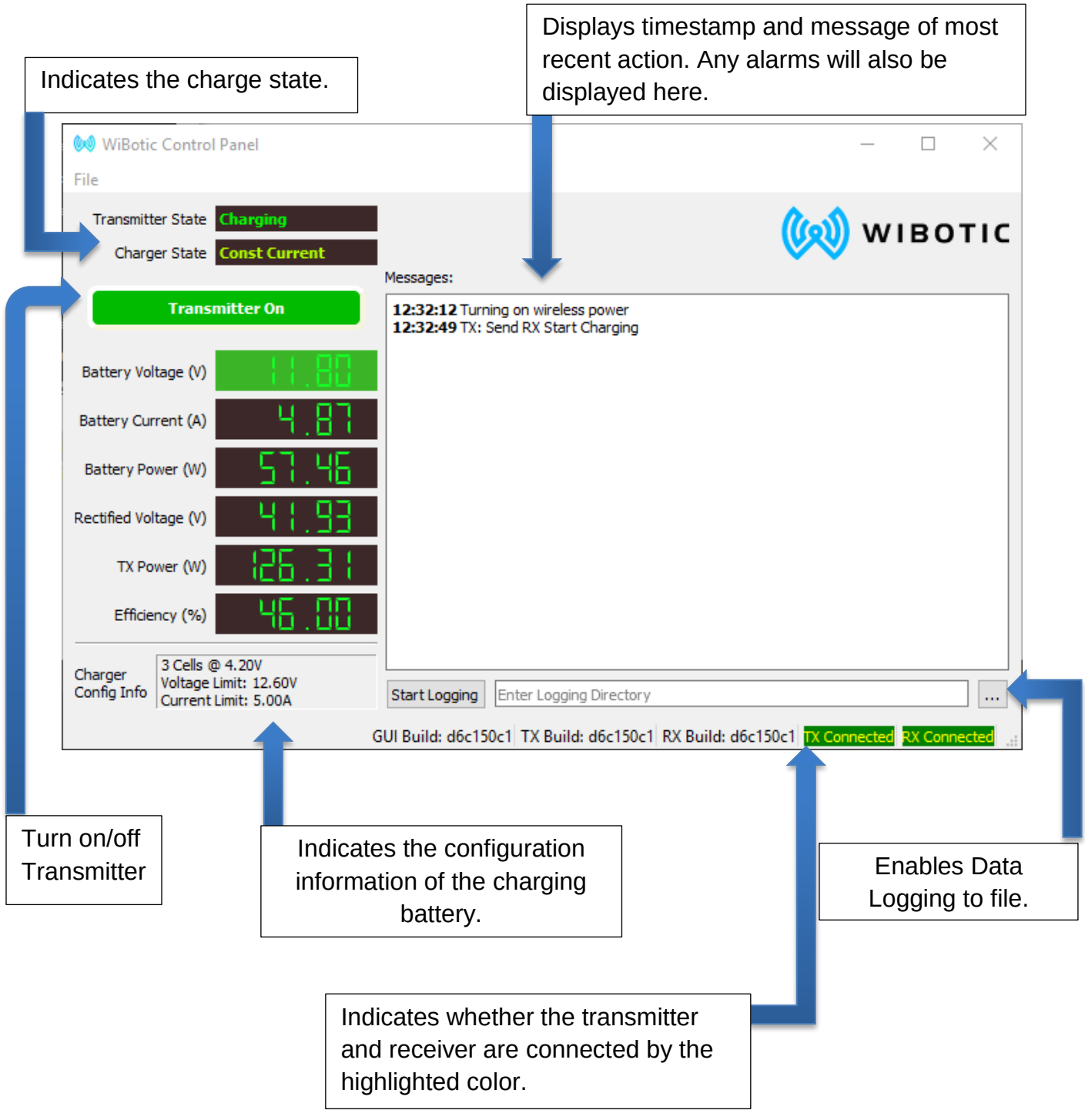
Prior to shipping the Development kit, WiBotic will pre-configure the proper charging voltage and amperage for the particular battery used in your application. These values may be changed within the GUI. However, WiBotic recommends the use of the preset values that were configured for your Development Kit.

If it is desirable to change these values, click on the “File” menu in the top left corner of the GUI and select “Charge Configuration”. A dialog is presented which permits the changing of battery chemistry, number of battery cells, battery cell full voltage, and charge current.



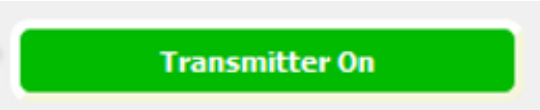
CAUTION: Please confirm the battery requirements to ensure the charge current and voltage are within permissible limits. Damage to the battery, charger or connected equipment may occur if incorrectly configured. A damaged battery could cause personal injury.

WiBotic GUI Overview



Starting Wireless Power Transmission

To begin testing, turn the Power Transmitter on by clicking the “Transmitter Off” button. The system will turn on in heartbeat mode and the button will change state and indicate “Transmitter On”.



In this mode, the Power Transmitter periodically turns on until it detects a Power Receiver. If the Transmit and Receive Coils are within the ideal operating range, wireless power transfer will begin automatically. Once wireless power transmission begins, the system will stop only if the “Transmitter On” button is clicked to turn off or if a shutdown event occurs. (See the Power Down Events section for details). WiBotic recommends disconnecting power to the development kit when not in use for an extended period of time.

Battery Charging Process

WiBotic Power Receivers are configured by default to act as Constant Current - Constant Voltage (CC/CV) battery chargers.

If the Power Transmitter is on and a Power Receiver is in range, the system will begin charging if the battery is not already considered fully charged. The charger regulates output voltage to the battery at a pre-defined voltage limit. The voltage limit is set by default at the WiBotic factory based upon the appropriate voltage limit for the customer’s battery. The default voltage limit is listed on the Certificate of Conformance and is also shown in the “Charger Config Info” box in the bottom left corner of the GUI. The voltage limit can be changed and will be remembered even if the Power Receiver is powered off.

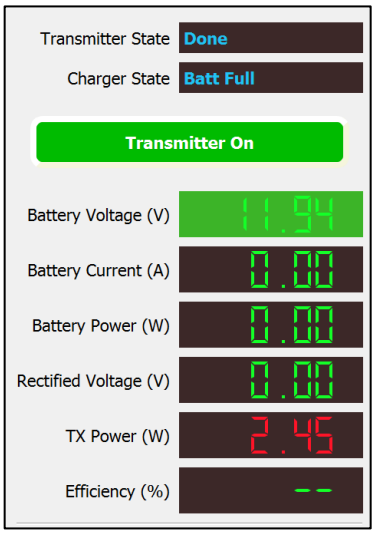
During startup, the charging current will ramp up to the maximum constant-current charge rate as configured in the WiBotic software. The Power Receiver will always try to ramp-up to the maximum charge current. However, in some cases, depending on either sub-optimal coil position, environmental conditions or high temperature of the electronics, the Power Receiver may not be able to achieve the maximum charge current. If unable to reach the maximum charge current, the Power Receiver will not increase beyond a charge current that the system can reliably and safely sustain.

After the constant current portion of the charge cycle is complete, the Power Receiver will enter constant-voltage charging mode. During constant-voltage charging mode, the charge current decreases gradually as the voltage of the battery approaches the charge termination voltage.

There are two ways for the system to terminate charging in constant-voltage mode:

1. **CV Mode Timeout:** Once charging has started, a configurable timeout period begins, with a default of three hours. Even if the battery is not fully charged after this timeout, the charge cycle will terminate and the Power Transmitter will return to standby.
2. **CV Mode C/10 Charge Complete:** If the charge current drops below one-tenth of the maximum charge current rate (C/10), then charging is complete and the Power Transmitter will return to standby.

The GUI will indicate that the battery is fully charged by highlighting the battery voltage background in green, as illustrated in the image below.



Once the battery has been fully charged and to avoid repeatedly topping-off the battery, there is a threshold in the WiBotic software that requires the battery to drop below a certain voltage before charging will resume. The threshold depends on the battery chemistry and voltage, but typically equates to roughly 90% of full charge. This threshold can be inferred visually via the background of the battery voltage reading on the GUI: if the background is green, the battery is considered fully charged. If the background is black, the battery can be charged. If the Power Transmitter is left on, this functionality will occur autonomously.

As an example, if the vehicle finishes a task and comes back to the Power Transmitter for charging, the battery will autonomously charge up. Once the battery is fully charged, the vehicle might have other electronics that consume power from the battery. When the battery drops below the voltage threshold defined by WiBotic software, it will autonomously charge back up to full.

Power-Down Events

There are several different mechanisms that can cause the Power Transmitter to power-down during charging:

COMMUNICATION ERROR: The Power Transmitter and Power Receiver communicate over a low-power radio link. If the Power Receiver is out of range, or is in a particularly electrically noisy environment, then the GUI will display “RX Disconnected”. The Power Transmitter will power-down until the low-power radio link is restored.

GUI INFORMATIONAL MESSAGES: There are informational messages that appear on the log of the GUI. These messages indicate either a status update or an alert. If an alert has been triggered, the message will provide a recommendation to hopefully solve the problem. If the GUI application stops responding, it may be necessary to force close the program and restart. If the problem persists, contact WiBotic for support. See the section on GUI Alert Messages for more details.

GUI Status Indicators

The table below enumerates the charge status indicator name and descriptions.

Table 1: GUI Status Indicators

STATUS NAME	STATUS DESCRIPTION
Off	The Power Transmitter is off.
Heartbeat	The Power Transmitter will periodically turn on until the receive coil is detected.
Ramp Up	Wireless power is enabled and power is ramping up to target levels.
Constant Current	The battery is being charged in constant-current mode.
Constant Voltage	The battery is being charged in constant-voltage mode.
Batt Full	The battery has completed charging.
TX/X Disconnected	The Power Transmitter and/or Power Receiver is not connected. ***NOTE****: the Power Receiver and Receiver Coil needs to be within the Ideal Operating Range before RX Connected will appear.*

GUI Alert Messages and Troubleshooting

The following events will cause the Transmitter to shut down temporarily, and then automatically re-enter heartbeat mode.

Table 2: GUI Alert Messages

ALERT NAME	ALERT DESCRIPTION
TX Alarm: Power Supply Over Current	If the power supply exceeds the maximum permitted current, this alarm will occur. The system will restart and enter heartbeat mode. If the problem persists, disconnect the transmitter power cable and contact WiBotic before continuing.
TX Alarm: Power Supply Over Power	If the power supply exceeds the maximum power limit, this alarm will occur. The system will restart and enter heartbeat mode. If the problem persists, disconnect the transmitter power cable and contact WiBotic before continuing.
TX Info: Radio Communication Lost	If the radio link is not maintained between the transmitter and receiver, the transmitter will turn off. Try moving the transmitter and receiver closer to each other. The system will shut down and enter heartbeat mode.
TX Info: Received power low	This usually occurs when the coils are positioned too far apart or in a non-optimal orientation. Transmitter will immediately shut down. Try repositioning the coils if this alert persists.
TX Info: Coil position not optimal	The transmitter cannot transition out of heartbeat mode, and will retry in 10 seconds. Make sure the coils are placed within the Ideal Operating Range. If the message persists, the transmitter will remain in heartbeat mode.
TX Info: Internal communication error	An internal error might occur that will cause the system to restart. The system will restart and enter heartbeat mode. Contact WiBotic if this problem persists.
TX Alarm: RX is in alarm state	The receiver has encountered a problem. The system will attempt to restart and resume operation.
TX Alarm: Power transfer too inefficient. Try moving coils apart.	Wireless power transfer is presently too inefficient. Try moving coils farther apart to resolve issue.
RX Alarm: Battery voltage incorrect	The battery parameters (number of cells, chemistry, volts per cell) are inconsistent with the current battery voltage detected by the charger. Correct the battery parameters or change batteries and try again.
RX Alarm: Rectified voltage crashed	The input voltage seen by the receiver has changed abruptly. This may be due to poor coil position or other hardware error. If this problem is not resolved by repositioning coils, contact WiBotic.
RX Alarm: Charger shorted	The battery charger on the Power Receiver has detected a short circuit on the battery output. Try disconnecting the battery to power cycle the Power Receiver and see if the problem persists. If this problem is not resolved, contact WiBotic as there may be a hardware issue with the Power Receiver.
RX Alarm: Internal event alarm	The receiver has had an internal error and has attempted recovery. Try disconnecting the battery to power cycle the Power Receiver and see if the problem persists. If this problem is not resolved, contact WiBotic.
RX Alarm: Low battery current	Something is limiting the amount of current that can be used to charge the battery. This caused charging to stop. Allow the system to resume, but if the problem persists across multiple charging attempts, contact WiBotic.

Troubleshooting GUI Connectivity

If the Power Transmitter is powered on and connected to the computer via the Ethernet or USB cable but the “Interface Selection” window continues to appear and does not open the GUI, proceed through the following steps:

1. If using the **USB interface**, open Device Manager to verify the Power Transmitter exposes a COM port. You can verify you have identified the correct COM port by unplugging the USB cable and observing which COM port disconnects. Then reconnect the USB cable and make sure the same COM port reappears.
2. If the COM port does not appear, disconnect the USB cable from the computer.
3. Make sure you have properly installed the correct Virtual COM Port Drivers which can be downloaded from this website: http://www.ftdichip.com/Drivers/VCP.htm
4. Close and re-open the GUI.
5. Reconnect the USB cable to the computer.
6. If the Interface Selection window still appears, disconnect the power cable from the Power Transmitter. Then, repeat Steps 1-5.

Note: The first time the Power Transmitter is connected via USB, it may take several minutes to auto-install the necessary FTDI Virtual COM Port drivers.

7. If using the **Ethernet interface**, make sure you have setup the IPv4 settings as outlined in the Configuring Ethernet Connectivity Section above.

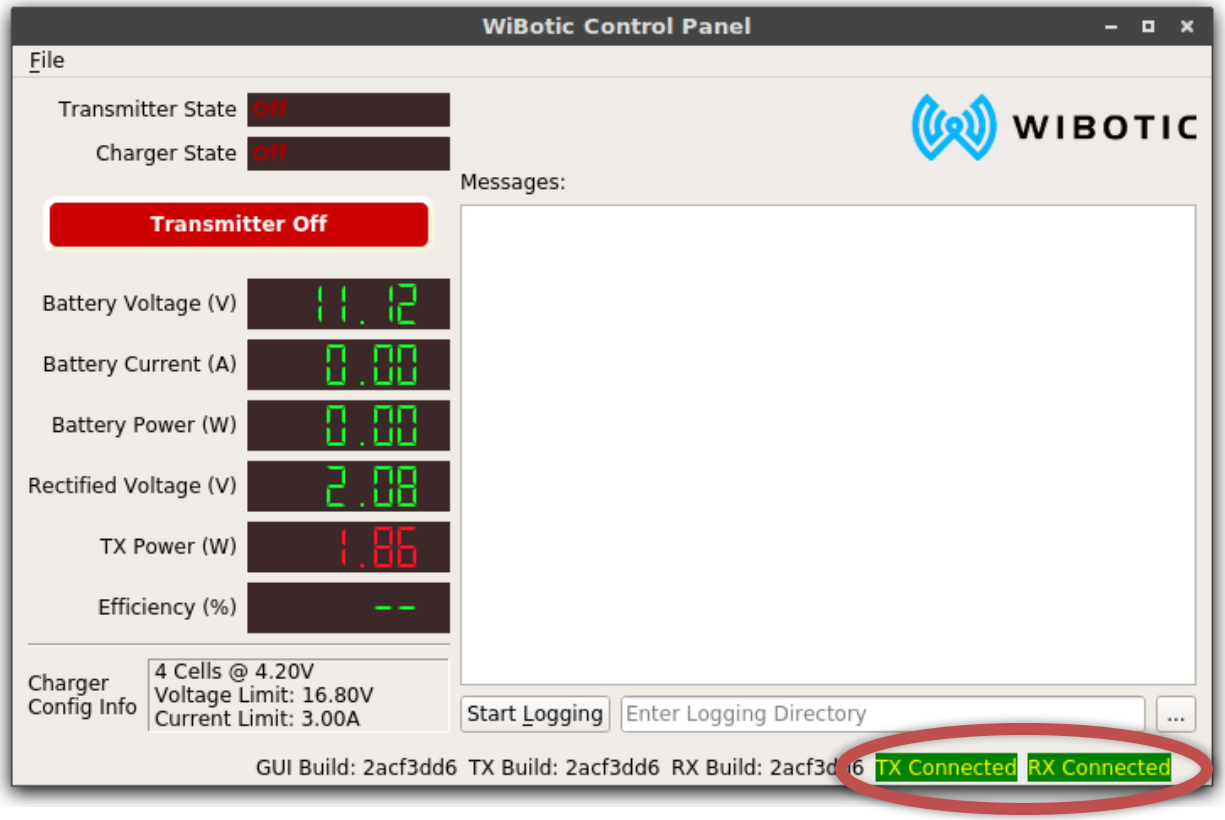
8. If you still cannot connect to the GUI, contact WiBotic at info@wibotic.com for assistance.

Updating Firmware

When updating firmware on either the transmitter (Tx) or Onboard Charger (Rx), please use the version of the WiBotic GUI that corresponds to the updated version of the firmware unless instructed otherwise. This may cause erroneous readings to appear which should return to normal after the update. We recommend updating the Onboard Charger firmware before the Transmitter firmware for best results. When downloading the firmware files, note that the file beginning with “tx-” is for the transmitter and the file beginning with “rx-” is for the Onboard Charger.

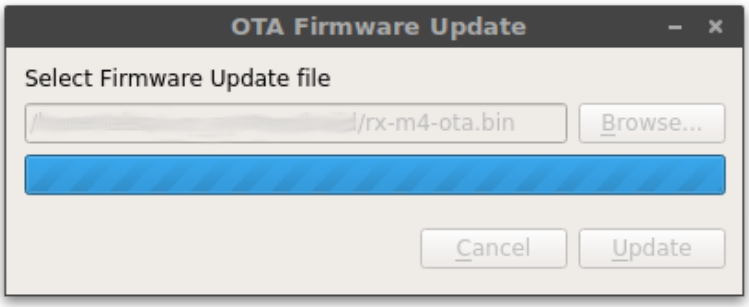
Onboard Charger (Rx) Updates

Before you begin, ensure that the Onboard Charger (Rx) is connected to the Transmitter (Tx) and the transmitter can communicate with a computer before proceeding with the firmware update. This is indicated on the WiBotic GUI by two green indicators in the bottom right section of the interface.



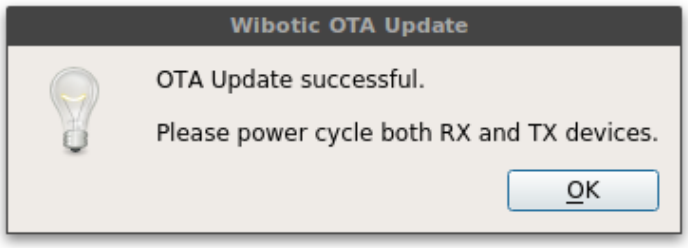
From the File menu, select “Firmware Update” and browse to the update file for the receiver (usually named something similar to **rx**-m4-ota.bin).

Click “Update”



NOTE: it is normal to see the "connected" indicator at the bottom of the GUI change to disconnected during a firmware update.

The system will update and will show an "OTA Update successful" message when complete.

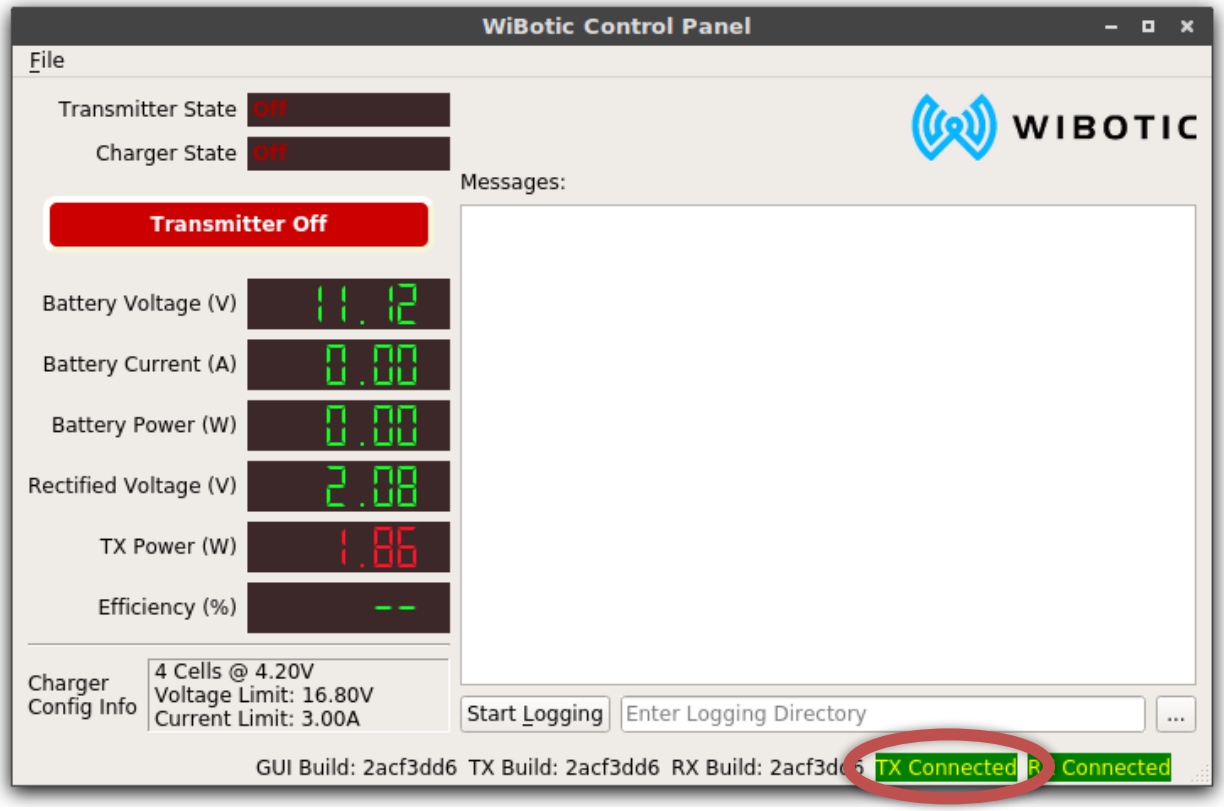


If the system encounters an error during the update, power cycle both the Transmitter and Onboard Charger and try the firmware update again even if the Onboard Charger (Rx) appears to be disconnected. The firmware update application will attempt to determine where the update left off and resume updating.

Transmitter Updates (Tx)

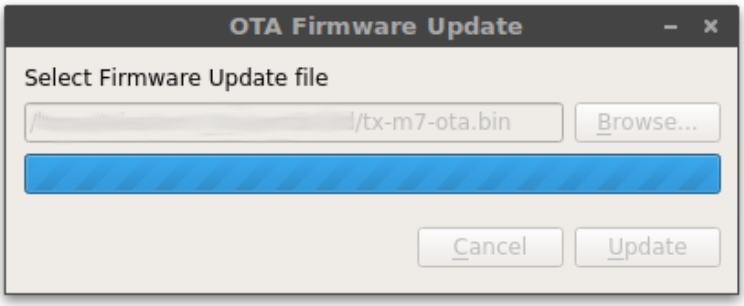
Option #1: Updating over USB Serial

Ensure that the Transmitter is connected to the WiBotic GUI via the USB Serial Port option and a green "TX Connected" indicator is present at the bottom of the GUI.



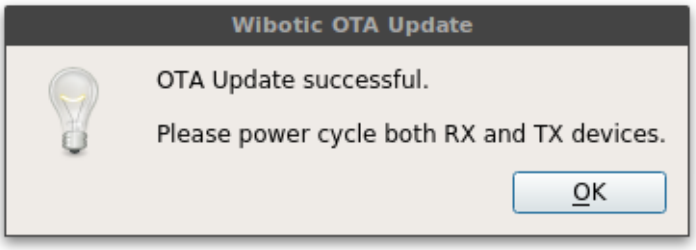
From the File menu, select “Firmware Update” and browse to the update file for the transmitter (usually named something similar to **tx**-m7-ota.bin).

Click “Update”



NOTE: it is normal to see the “connected” indicator at the bottom of the GUI change to disconnected during a firmware update.

The system will update and will show an “OTA Update successful” message when complete.



If the system encounters an error during the update, power cycle the transmitter and try the firmware update again. The firmware update application will attempt to determine where the update left off and resume updating.

Option #2: Updating over Ethernet

Proceed as if you were doing an update over a USB Serial connection. However, note that the update will appear to fail partway through the update. ***This is expected at this time and will be corrected in a future version of WiBotic's software.*** Continue the firmware update by restarting the WiBotic GUI, connecting to the transmitter, and selecting the firmware update again. This process is expected to happen twice. An "OTA Update successful" message will not be displayed after the system has updated, but you can verify that the update has taken place by ensuring the build hash at the bottom of the control panel is consistent with what the updated build's hash is.

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