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WIRELESS POWER SYSTEM

USER GUIDE – REV 31.0

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Description

WiBotic wireless power solutions enable autonomous wireless charging of mobile robots, aerial drones, unmanned aquatic vehicles, and other industrial automation devices across a wide range of applications. For simplicity and consistency, we refer to all of these vehicles, drones, and devices as “robots” for the remainder of this User Guide.

The WiBotic system allows users to automate power delivery to robots or entire robot fleets. In addition to fully automating the battery charging function, configurable charging profiles can also extend the life of every battery. This configurability helps to ensure every robot is ready to take on its next mission while reducing battery replacement and downtime costs.

Each WiBotic system consists of standard components selected to meet customer needs for size, weight, and power as well as desired charging range. The WiBotic web-based “Control Panel” Graphical User Interface (GUI) and Application Programming Interfaces (APIs) are also provided at no extra cost for system configuration and monitoring purposes. This User Guide provides an overview of the hardware setup procedures and detailed instructions for the Control Panel GUI.

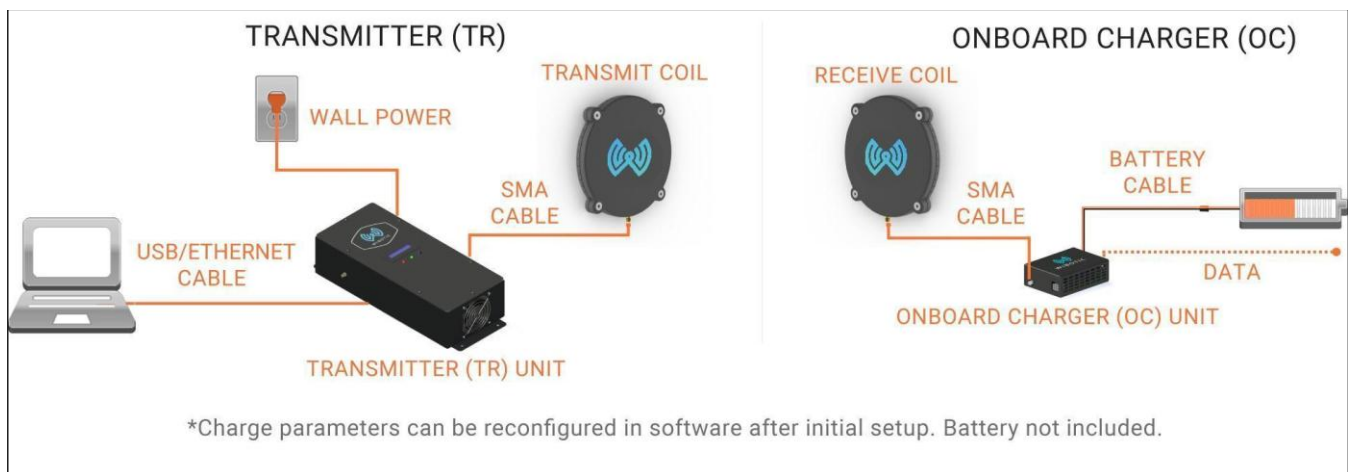
WiBotic also provides a free trial license of WiBotic Commander, the fleet energy management product, for a limited time. Commander is designed for any customer interested in gaining insights into power usage and battery health, whether for a single robot or entire fleets. For more information on Commander please visit www.wibotic.com/products/software/commander. To redeem your free Commander trial license, contact WiBotic Sales at sales@wibotic.com.

Key Features

- **100% autonomous wireless battery charging**
 - Automatically starts to charge when robot approaches transmitter
 - Wide transmit-receive coil range and alignment flexibility
 - Multiple configurations offering power levels from 50W to 1000W and the best combination of size, weight, and power for each application
- **Flexible charging modes**
 - Supports most common robot battery chemistries such as Lithium-Ion / LiPo, LiFePO₄, NiMH, and Lead Acid.
 - Constant Current/Constant Voltage charging modes for lithium chemistries with a user-programmable mode for non-standard batteries
 - Fully adjustable charging current and voltage via the Control Panel GUI or API
- **Optional wired battery charging**
 - Multiple options up to 3A/1000W delivered to the battery when used with a DC power supply for non-wireless operation
- **Lightweight Onboard Charger system for weight-sensitive installations**

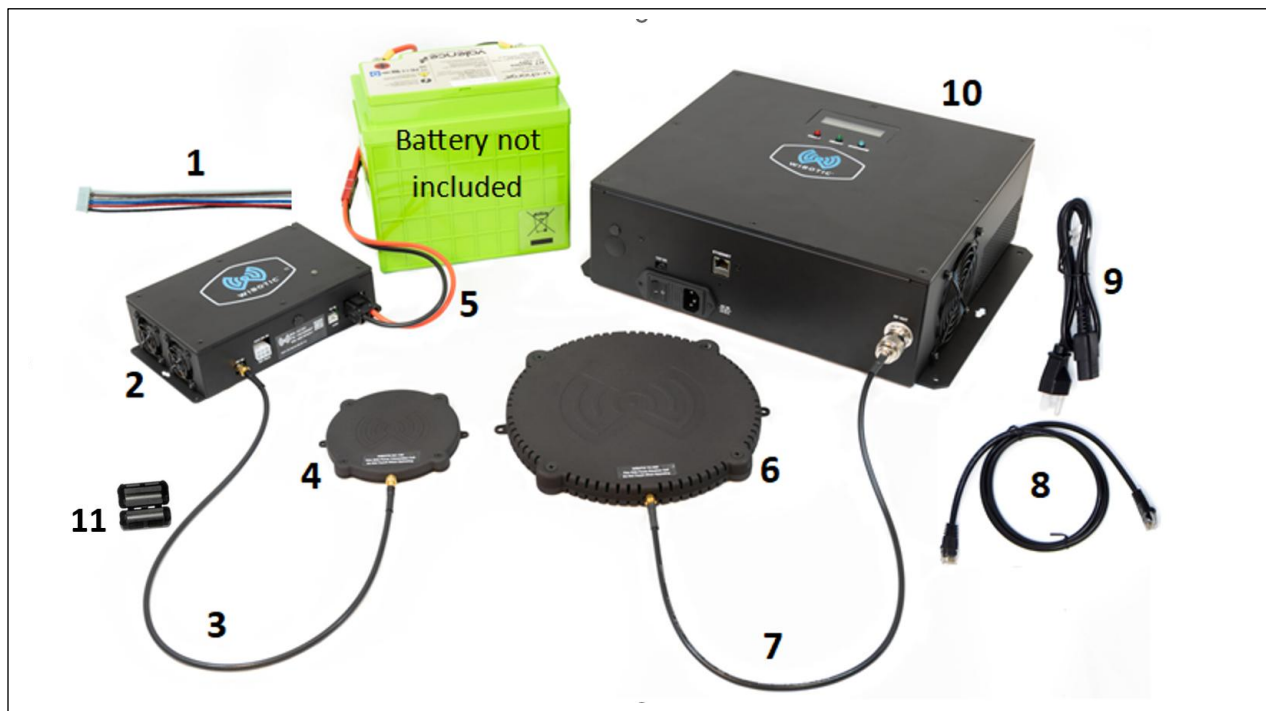
Wireless Power System Configuration

The following diagram shows the operational configuration of the system as well as the individual components supplied with every WiBotic system:



Inside the Box

- | | |
|---|--|
| 1. CANBus communication cable | 6. Transmitter Antenna Coil (TC) |
| 2. Onboard Charger (OC) | 7. Transmitter Antenna Cable (aka "SMA Cable") |
| 3. Receiver Antenna Cable (aka "SMA Cable") | 8. Ethernet Cable |
| 4. Receiver Antenna Coil (RC) | 9. AC Power Cord |
| 5. Battery Cable | 10. Transmitter |
| | 11. Ferrite Bead |

**Notes:**

*Individual models of the TR, OC, TC and RC may vary in appearance

*Ferrite Bead (#11) should be clipped to the Receiver Antenna Cable (#3) as close to the Onboard Charger (#2) as possible after the components are installed in their final locations for compliance purposes.

Specifications

All WiBotic wireless power systems share the following standard specifications:

PARAMETER	RANGE
Wireless Power Operating Frequency	6.78 ± 0.015 MHz
Communication Link Frequency	2.433 - 2.483 GHz
Ambient Operating Temperature (all but WiBotic Edge)**	-20° to 45° C
Ambient Operating Temperature (WiBotic Edge)**	-20° to 35° C (300W) -20° to 45° C (250W)
Transmitter AC Input Voltage*	90 - 264 VAC
Transmitter AC Input Frequency	50 – 60 Hz
Transmitter Data Port	Ethernet (RJ45)
Transmitter Data Communications	WiBotic API via WebSockets
Onboard Charger Auxiliary DC Input Voltage	22 - 50 VDC (48V preferred)
Onboard Charger Data Communications	WiBotic UAVCAN API over CANBus

*Standard WiBotic Transmitters include an internal AC/DC power supply. Direct DC input versions, also available, require a separate 48V nominal (42-54V) DC power supply. Contact WiBotic for details.

See the **Thermal Throttling and Derating section for more information on performance of specific models.

The table below shows the average power consumed by WiBotic Onboard Chargers (OC) when connected to a battery, and idle (not charging). These numbers can be used as a general guide for idle power consumption and do not represent min or max values:

Battery Voltage	12V		24V		36V		48V	
Onboard Charger	mA	mW	mA	mW	mA	mW	mA	mW
OC-150	17	204	9	204	6	230	5	250
OC-251	13	156	7	161	5	187	4	206
OC-262	13	150	7	156	5	169	4	182
OC-301	13	157	7	164	5	187	4	204
OC-1000	16	190	9.5	225	7.5	270	7	335

Power Level & Charge Speed

Power Level Specifications (Wattage vs. Current)

The WiBotic wireless power system is available in configurations that combine Transmitters and OCs to provide the best combination of size, weight, and power for each application. The following table shows the available combinations for each desired power level. Systems ≤300W utilize 200mm Transmitter and 100mm Receiver antenna coils. The 1000W system utilizes a 200mm Transmitter and 150mm Receiver antenna coil.

UP TO:	150W	250W	300W	1000W
Transmitter	TR-302	TR-302	TR-302	TR-1000
Onboard Charger	OC-150	OC-251	OC-262/OC-301*	OC-1000

*OC-262 is a passively cooled option for delivering up to 300W to the battery. The OC-301 is a high-current actively cooled model that also delivers 300W.

Onboard Chargers are paired with the correct Transmitter to achieve their maximum power level. Therefore, the OC ultimately determines the amount of power delivered to the battery. Each OC has a different maximum power level (watts), maximum current level (amps), and output voltage range as shown in the chart below:

ONBOARD CHARGERS	OUTPUT VOLTAGE (TO BATTERY)	MAX OUTPUT POWER	OUTPUT CURRENT
OC-150	10.0 - 58.4 VDC	150W	0.5 - 10A
OC-251	10.0 - 58.4 VDC	250W	0.5 - 12A
OC-262 ST (standard) & WP (waterproof) models	10.0 - 58.4 VDC	300W	0.5 - 12A
OC-301	10.0 - 58.4 VDC	300W	0.5 - 30A
OC-1000	12.0 - 58.4 VDC	1000W	0.5 - 36A

*DC Output voltage and current are configurable within the specified range via the WiBotic Control Panel or APIs.

The total amount of power delivered to the battery is determined by either the maximum power output or the maximum current output, based upon the voltage of the battery being charged. Since there is a straightforward equation that relates voltage, amperage, and wattage ($\text{volts} \times \text{amps} = \text{watts}$) simple calculations can establish which factor will ultimately determine your system's power level and charge speed:

Example:

The user wishes to configure the OC-251 to charge a 4S Lithium-Ion battery that reaches 16.8V when fully charged. In this case, the OC-251 will reach its 12A limit, outputting 201 (16.8V x 12A), before its overall wattage limit of 250W is reached.

$$12.6V \times 10A = 126W$$

A different user wishes to configure the same OC-251 to charge a 6S Lithium-Ion battery that reaches 25.2V when fully charged. In this case, the OC-251 will reach its maximum wattage output of 250W before it reaches its maximum current output of 12A. In this case, the output current will be limited to 9.9A.

$$250W / 25.2V = 9.9A$$

There is no risk in inadvertently setting the desired charge current above the maximum level. The system firmware will limit operation to the maximum power level that is safely achievable. Note that the above values are representative only. Other factors such as antenna position can also affect system efficiency and power delivery. After fully reading this User Guide, please contact WiBotic with questions about the maximum power level available with your system.

Battery Charging Speed

Operators often wonder how long it will take the WiBotic charger to charge a battery. The answer is that it will take the exact same amount of time as a “plug in” (or wired) charger with the same power specifications. A 300W wireless charger will charge the battery just as quickly as a 300W desktop charger.

To calculate the charge time, however, it is important to know a simple equation for how long it normally takes a battery to charge to an 80% level. For most common robot battery types, the formula is:

$$\text{Battery Capacity} / \text{Charger Output} = \text{Charge time to 80\% of Battery Capacity}$$

To perform the calculation, you will need to know your battery’s capacity in either Watt-hours or Amp-hours. Most batteries are labelled with at least one of these two specifications.

If you know the Watt-hour capacity of the battery, then divide that by the wattage of the charger to determine the number of hours. For example, a 600 Watt-hour battery will take two hours to charge to 80% with a 300W charger (i.e. $600Wh/300W = 2h$).

If you know the Amp-hour capacity of the battery, then divide it by the maximum amperage the WiBotic charger can output. For instance, an 18Ah battery will take 1.5 hours to charge to 80% if the WiBotic charger is outputting 12A (i.e. $18Ah/12A = 1.5h$).

Once the battery has reached 80%, it will normally take an additional 30-50% of the transpired charge time to reach a full 100% charge - but this can depend on external factors such as ambient temperature, the age of the battery, and the number of charge cycles the battery has already experienced.

Finally, remember to apply the rules in the section above to determine whether your charger is limited in the wattage or amperage it can deliver. For instance, when charging a 24Ah battery with a charge voltage of 25.2V, keep in mind that the OC-251 will charge at a maximum of 9.9A. If you are using Amp-hour calculation above, divide 24Ah by 9.9A to get a charge time of 2.42 hours (again, to 80% battery capacity).

Thermal Throttling and Derating

WiBotic products are typically rated for operation in ambient temperatures of up to 45°C (112°F). Please note that the following WiBotic products are derated to a lower sustainable power level when operating at the designated temperature limits.

MODEL	DESCRIPTION	MAX POWER AT 45C
TR-302-AC-EDG	TR-302 Edge Transmitter	250W
TR-302-AC-ST-JP	TR-302 Standard Transmitter – Japan Market	225W
TR-302-AC-EDG-JP	TR-302 Edge Transmitter – Japan Market	175W

As is typical of any battery charging system, WiBotic's Transmitter and Onboard Charger circuit boards produce additional heat during the charging process. Each circuit is designed to dissipate heat either through active cooling (fans) or passive cooling (heat sinks). This cooling process helps to maintain an acceptable board temperature during normal operations and helps ensure a long lifespan for critical components on the board.

During normal operations, the circuit board temperature will logically always be somewhat higher than the ambient temperature near the board. In a stable system, as the surrounding ambient temperature increases, it's also common to see the board temperature increase by a similar amount.

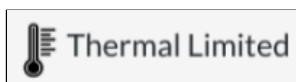
In unusual cases, however, the circuit board itself may approach damaging temperatures. In fan cooled units, this could be due to a lack of proper air movement across the circuit board. In passively cooled units, this could be because the heat sink is not properly mated to a surface that allows adequate heat transfer (see WiBotic installation instructions for passively cooled models). Other potential sources of excess heating include attempting to send power beyond the normal coil-to-coil operating distance or antenna detuning from nearby conductive materials.

To safeguard against these circumstances, WiBotic has implemented temperature sensors and firmware controls to limit system power levels when an over-temperature event occurs. This feature is known as Thermal Throttling. Thermal throttling is a staged process whereby the system will A) no longer increase power output if temperatures surpass Threshold 1, B) actively decrease power if temperatures surpass Threshold 2, and C) shut down completely if temperatures surpass Threshold 3 as shown in the table below. Each WiBotic Transmitter and Onboard Charger has specific circuit board temperature limits based upon rated power level, cooling method (active/passive), and the components chosen for the circuit assembly.

	THRESHOLD 1 (Power stops increasing)	THRESHOLD 2 (Power decreases until temperature stable)	THRESHOLD 3 (Charging stops until system cools)
Transmitters			
TR-302	70°C	75°C	80°C
TR-1000	75°C	80°C	85°C
Onboard Chargers			

OC-150; OC-251	85°C	90°C	95°C
OC-262-ST; OC-262-WP	60°C	65°C	70°C
OC-301	95°C	100°C	105°C
OC-1000	75°C	80°C	85°C

Once again, these temperatures represent the temperature thresholds of the circuit boards themselves and should not be confused with the maximum ambient operating temperature of 45°C. If thermal throttling occurs, the following indicator will appear next to the throttled transmitter or onboard charger on the Control Panel homepage. Once normal operating temperatures are reached, the “Thermal Limited” indicator will disappear, and normal operations will ensue.



It should also be noted that the passively cooled OC-262's power output is highly dependent upon its ability to dissipate heat into attached heat sinking materials. Special installation instructions are provided for the OC-262 later in this guide but, to achieve its full 300W rating, the OC-262's aluminum base must be mounted to an aluminum plate or robot body panel that will absorb sufficient amounts of heat from that base. If operated in a stand-alone mode, with no further heat sinking into other objects, the OC-262 will reach approximately 125W of output power at room temperature.

Initial Hardware Setup - Benchtop

For initial system familiarization, WiBotic highly recommends bench-top testing. This allows the system to be operated in open air and at various power levels and antenna positions – demonstrating the unique flexibility of WiBotic’s technology. However, if WiBotic has uniquely “tuned” your power transfer antenna coils (we will inform you if this is the case) operation in open air is not recommended.

Note that throughout this guide we refer to the power transfer antennas as the “antenna coils” or simply the “coils”.



NOTE: *WiBotic does not recommend immediate installation of the wireless power system on robots for testing purposes. Many robots consist of metallic frames or body parts that can temporarily de-tune wireless power antenna coils, resulting in degraded performance. To avoid de-tuning problems and to maximize system performance, contact WiBotic to understand if tuning is required for your particular robot.*

When customers order their first system, WiBotic typically provides a desktop coil stand for testing purposes. Shown below, the stand includes mounts for both the transmit and receive antenna coils as well as a “T” shaped base. Sliding and rotating the antenna coil brackets on the base allows power transfer to be tested at different distances (both face-to-face and side-to-side) and angularities.

To use the stand, install the two brackets on the “T” shaped base by loosening the thumbscrews and sliding the head of each thumb screw bolt into the T-Base slots.

Install the transmitter antenna coil in its bracket by rotating it until the coaxial cable connector is facing sideways and sliding it into the pocket on the bracket. Screws are provided for the corners of coil if more secure mounting is desired. When placing the coil in the bracket, be sure the side with the embossed or printed WiBotic logo is facing inward toward the receiver coil. If there is no logo (as with some early 1kW coils) place them as shown below with the vented sides of the coil facing each other.



Repeat the process for the receiver antenna coil with the WiBotic logo facing inward.

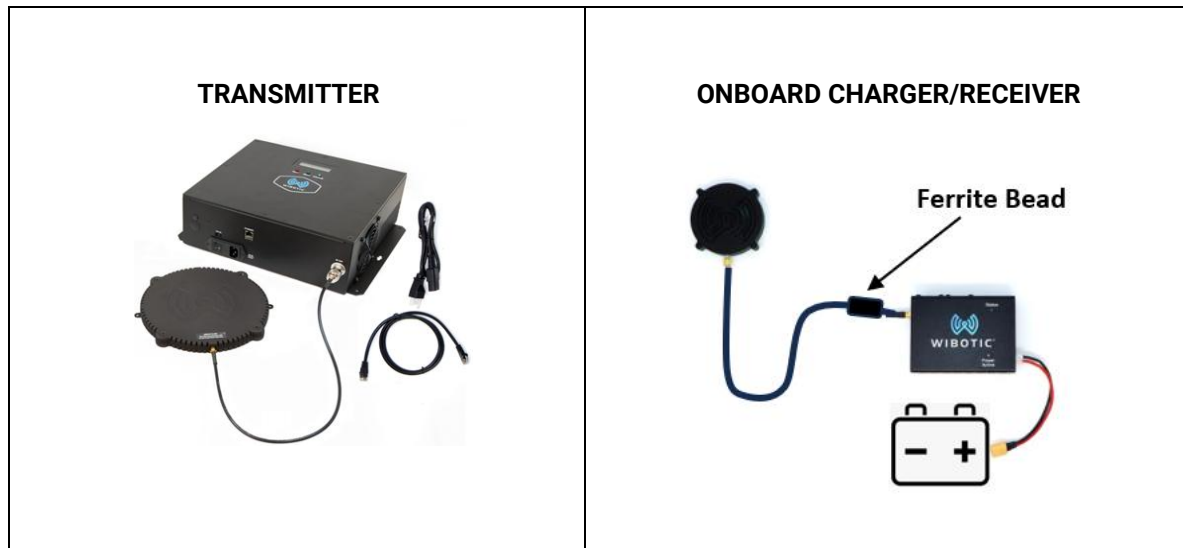
To move the antenna coils relative to one another during testing, simply loosen the thumbscrews and slide or angle both coils within the T-Base channels.

Connecting the Components



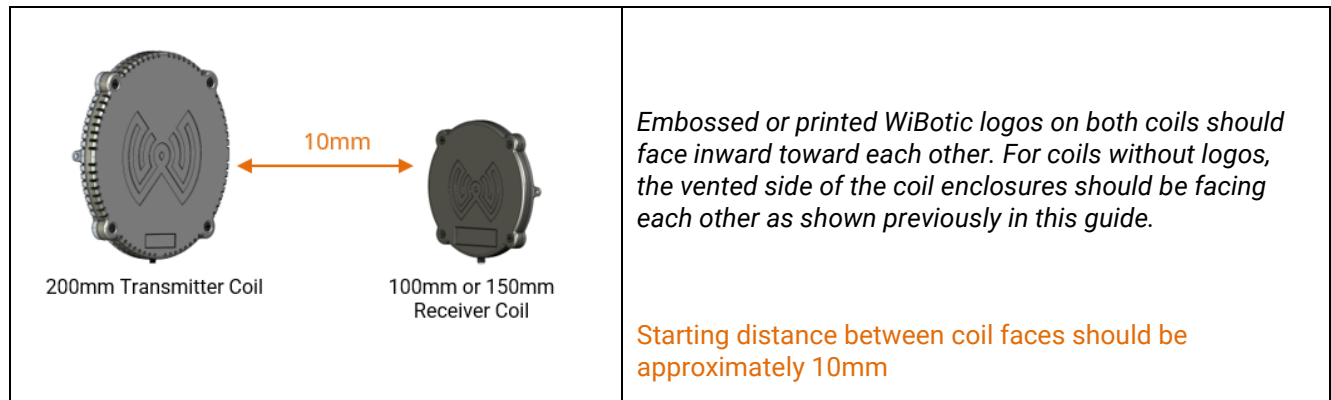
NOTE: Be sure the Transmitter is turned off, or is unplugged, before connecting either end of the coaxial cable to the Transmitter or TC antenna coil.

1. Connect one coaxial SMA cable between the Transmitter and the Transmit Coil (TC).
 - a. Make sure the TC end of the cable is tightened to 5 inch-lbs.
 - b. For TR-302s, connect the three-position black Molex connector end of the cable to the transmitter until it snaps into place.
 - c. For TR-1000s, hand tighten the type “N” connector to the transmitter.
2. Connect the second coaxial SMA cable between the Onboard Charger and the Receive coil (RC). Make sure the connectors is tightened to 5 inch-lbs. on both ends.
3. Clip the ferrite bead around the receiver antenna cable as close to the OC as possible.
4. Connect the OC to the target device to be powered (e.g. the battery) using the supplied battery connector cable.



CAUTION: If using a battery power cable other than the one supplied by WiBotic, be sure to follow the pin-out instructions in this guide.

5. With the antenna coils mounted on the antenna stand, loosen the thumbscrews and adjust their position so they are concentric and approximately 10mm apart. This will be the starting position for testing, but you may then move the coils in and out and side to side. You may also rotate one or both antenna coils to experience power transfer when they are at an angle to one another.



CAUTION: Removing the antenna coils from their plastic enclosures is not recommended without guidance from WiBotic. High voltage exists on antenna coil components during charging. **DO NOT touch or place any body part within 60cm of the antenna coil during charging.**



CAUTION: Do not place the Transmit Coil on a metallic surface or a surface (such as a table top) that may have metal behind it. All metal objects should be at least 12cm from the Transmit & Receive antennas during testing.

6. Connect the Power Cable to the Transmitter (before plugging in the Power Cable to an electrical outlet or other power source).
7. Plug the other end into a standard electrical outlet and turn the Transmitter power switch on. The LCD screen on the front of the transmitter (only equipped on the TR-302) should become active at this point, but none of the three LEDs will turn on. The Green "READY" LED will illuminate only after the system has been activated via the software GUI (see later steps).
8. Connect the Ethernet cable from the Transmitter to a computer. Either plug directly into the Ethernet port on the computer (if available) or connect through a network. There are additional steps required to configure the IPv4 settings on Windows. Refer to the section on "Communicating with the Transmitter" below to properly configure the Ethernet connection before using the system.

The hardware setup for benchtop testing is now complete. Please proceed to the "Communicating with the Transmitter" section to enable the WiBotic Control Panel to begin charging.

Initial Hardware Setup – Field Applications

WiBotic Antenna Mounting Guidelines

WiBotic systems transfer power through magnetic resonance between coupled antenna coils. Unlike other wireless power systems, where maximum power transfer is achieved at a single relative antenna position, WiBotic systems are designed to provide more range in antenna position while maintaining maximum power - allowing robots more overall navigational

flexibility and ensuring rapid battery charging even when antennas are somewhat misaligned. Additionally, unlike inductive power systems, WiBotic antennas do not create the safety risk of heating nearby conductive materials.

However, nearby conductive materials can interfere with the magnetic fields created by WiBotic antennas, causing a “de-tuning” effect. This can lead to overall system instability and/or lower power levels. For this reason, it is very important to mount the antennas in a location where such materials won’t have an impact. If this is not possible due to the robot design, please consult with WiBotic before the antenna coils are first mounted and testing commences. We can typically suggest ways to counteract interference so performance is maintained even if the following guidelines cannot be followed.

Materials to Avoid

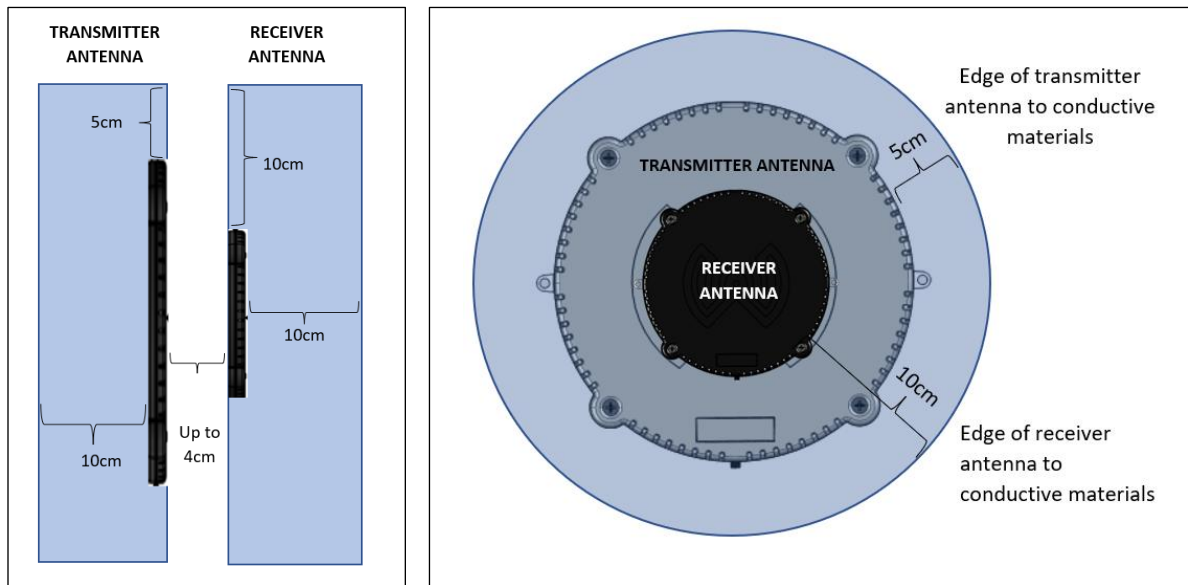
For most applications, the primary concern is large flat planes of metal (or other conductive materials), located either immediately behind or to the side of the WiBotic antennas. Any broad sheet of metal, stainless steel, aluminum, carbon fiber, and even certain fiberglass materials can create interference. Plastic materials typically will NOT cause interference and are highly preferred.

The magnetic field will normally extend around smaller rods or tubes made from conductive materials, such as aluminum or carbon fiber, so these elements are typically NOT a problem. Similarly, small conductive objects such as metal screws and clips are normally not large enough to create a negative effect.

Antenna offsets for best performance

The transmitting antenna is most sensitive to de-tuning effects. However, care should be given to the placement of the receiving antenna onboard the robot, since any conductive material near the receiving antenna will also be near the transmitting antenna when the robot is docked and charging.

The following diagram provides an overview of the suggested clearances (areas indicated by the blue shading) for coil mounting. At these distances the detuning effect of metal sheets or objects is slight and will not impact performance.



Blue shaded areas represent preferred clearance between antenna and nearby conductive material

Again, we realize these recommendations may be difficult to follow for some applications. In those cases, we offer antenna tuning services which allow the antennas to be located closer to conductive materials after the tuning process is complete.

During custom tuning, we test the performance of the antennas in their desired location relative to conductive materials in both the charging station and the robot. For this process, it is best for WiBotic to have a sample of the robot chassis at our facility for testing. We then compensate for interference by changing the physical characteristics (resonant frequency) of the antenna for your application.

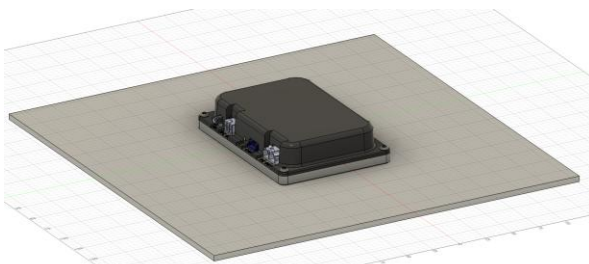
Custom tuning is a one-time effort. If the robot and charging station remain unchanged, all future antennas ordered for that model will be shipped from WiBotic, pre-tuned for maximum performance. Again, if you have any questions regarding antenna placement, please contact your WiBotic representative or info@wibotic.com for assistance.

OC-262 Installation Instructions

The OC-262-ST and OC-262-WP are WiBotic's passively cooled onboard chargers, capable of providing up to 300W of power. Both products in the OC-262 series are equipped with an aluminum baseplate that conducts heat away from the internal electronics during operation.

To provide full power, the OC-262 series must be installed in a way that allows for proper heat dissipation from its base. We recommend either mounting OC-262s to an aluminum plate or adding a finned heat sink with forced air cooling. Mounting the OC-262 directly to a metal body panel of the robot/device may also be an option depending upon the panel material and size.

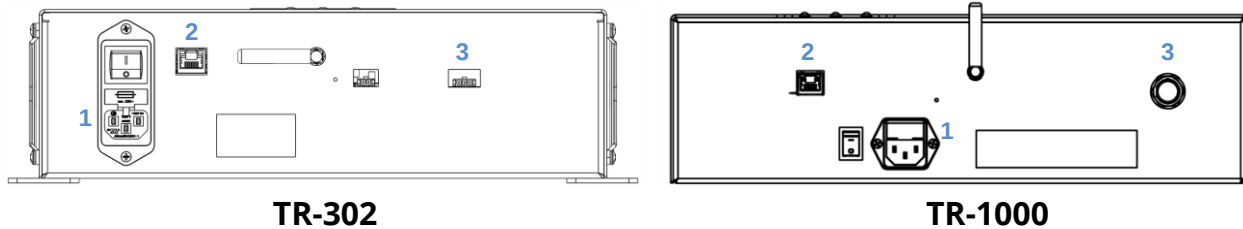
When using an aluminum plate, we recommend a plate that is 450mm (L) x 450mm (W) x 3mm (H). For optimizing thermal performance, the interface between the heat sink or aluminum plate and the OC should be coated with thermal grease or another appropriate thermal interface material, and the OC-262 must be firmly mounted at the center of the plate as shown here.



Connectors

The following section provides information on the cables and connectors used by WiBotic in case customization is required after initial system testing.

Standard Transmitter Connectors:



AC Input

AC power is connected to WiBotic transmitters through either an AC inlet with integrated power switch (TR-302) or a stand-alone AC inlet with separate switch (TR-1000). An AC power cord of the proper wire gauge is supplied with the Transmitter. Be sure to always use the supplied power cord of one with the same wire gauge shown in the table below.

Ethernet

As described in the following section, the WiBotic Control Panel software interface and the Network API are accessible over the transmitters Ethernet port. A standard RJ45 Ethernet jack is provided on every TR model.

TC Coil

Due to differing power levels, the TR-302 and TR-1000 use different connectors for the TC antenna coil. The TR-302's cable has a 3-pin Molex connector on the transmitter end, which the TR-1000 uses an N-Type female connector. The TC cable itself is supplied with each TR. Other cables should not be used unless approved by WiBotic.

12V DC Output

WiBotic transmitters are equipped with a 12V DC auxiliary output. The 12V output can source up to 250mA continuously. This output is designed as a status signal output and should not be considered a 12V power supply for high current loads. The port will source 12V when unloaded but because of the protection network, the output voltage will be a minimum of 7.5V at 250mA. For this reason, the 12V output is typically used to drive light loads such as relays, LEDs, or a small 12V fan. If overdriven or in a short circuit condition, the upstream resettable fuse (PTC) will trip.

Control Radio Antenna

WiBotic systems use a 2.4GHz wireless control radio for communication between the Transmitter and Onboard Charger. The antenna for this radio is connected to an RPSMA connector located near the center of the back panel on both the TR-302 and TR-1000.

The following chart provides the connector types (including mating connectors) on each TR model

TR MODEL	TR CONNECTOR	MATING CONNECTOR
TR-302		
AC Input	IEC320-C14	IEC320-C13
Ethernet	RJ45 Female	RJ45 Male
TC Coil	Molex 043650-0301	Molex 043645-0300
12V DC output	Molex 043650-0202	Molex 043645-0208
Control Radio Antenna	RPSMA Male	RSPMA Female
TR-1000		
AC Input	IEC320-C14	IEC320-C13
Ethernet	RJ45 Female	RJ45 Male
TC Coil	N-Type Female	N-Type Male
12V DC output	Molex 043650-0202	Molex 043645-0208
Control Radio Antenna	RPSMA Male	RSPMA Female

Edge Transmitter Connectors

WiBotic offers alternative transmitters for use outdoors or in otherwise dusty or water-prone environments. These transmitters are called “Edge” transmitters and consist of WiBotic’s standard IP-20 rated transmitters and transmitter coils packaged inside a larger weather resistant polycarbonate enclosure. Due to the use of special connectors and filtered fan openings, these products have an ingress protection rating of IP54.



TR-302 Edge Exterior



TR-302 Edge Interior

Please note that WiBotic ships the Edge units with a standard, non-IP rated Power Cable and Ethernet Cable. These cables are for indoor use and are for initial configuration and programming only.

When installing the Edge units outdoors or in difficult environmental conditions, local electrical codes should be referenced and the appropriate cables used. To facilitate the use of such cables, the table below provides the brand and part number for both connectors used on the Edge as well as commercially available mating cables that will provide the full rated IP protection of the connector itself.

Edge Bulkhead Connector			Connector Image	Mating Cable			
Description	Brand	Part Number		Cable Brand	Cable Part Number	IP Rating w/cable	Cable Connector Image
Ethernet Connector	L-Com	WPBHC5E		L-Com	TRD815WP	IP67	
AC Power Cable	Schurter	DG12-CBDWM100C0-000-C6135-720-1880-00		Schurter	SC54C13KS	IP54	
				Note: Other cable brands using the same "V-Lock" connector type may be substituted			

Note that the Schurter AC Inlet module on the Edge has a blue rubber gasket located at the base of the male AC plug receptacle. Be sure this gasket is properly seated prior to plugging in the cable.

The Edge transmitters fan vents also contain a filter material to keep dust and other debris from entering the polycarbonate enclosure. The filter material provided with new Edge units can be washed and reused. If replacement materials is required however, we recommend filter material with the following characteristics to maintain proper overall operation of the Edge units.

WiBotic Edge Fan Filter Material:

Material	Polyurethan Foam
Pores Per Inch	45
Thickness	.25" (6mm)
Specifications Met	UL 900

Onboard Charger Connectors

Battery Cable Connectors

The battery output connectors and cables on WiBotic's Onboard Chargers are sized for the OC's maximum rated current. If not using WiBotic's battery cable, use the information below to select the proper connectors, crimps, and wire gauge to properly mate with the connector on the OC. Terminal pin-outs are also provided for reference.

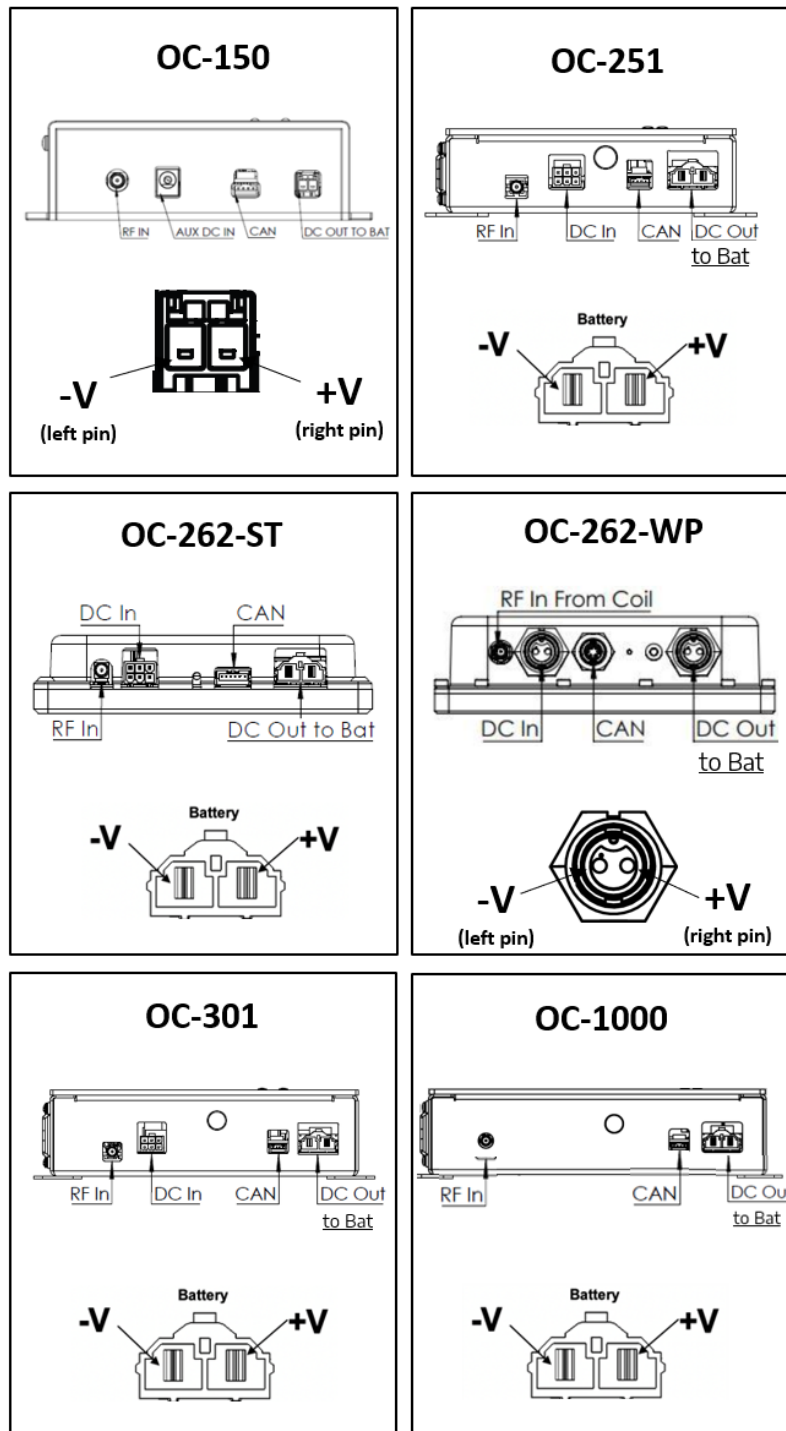
Use the following connectors on battery cables

OC MODEL	CONNECTOR BRAND	HOUSING PART #	CRIMP PART #	WIRE GAUGE
OC-150	TE Connectivity	176271-1	175152-1	16AWG
OC-251	Molex	42816-0212	42815-0114	10 AWG (24A max)
OC-262-ST	Molex	42816-0212	42815-0114	10 AWG (24A max)
OC-262-WP (IP67 rated)	Switchcraft	6382-2SG-3DC	Solder Cup	16 AWG (12A max)
OC-301	Molex	42816-0212	42815-0114	10 AWG (24A max)
OC-1000	Molex	42816-0212	42815-0114	8-10 AWG (36A max)

* If using your own cables, take care to select wire with appropriate temperature and insulation ratings when charging at > 30A

The following diagrams show the connectors on each OC and the pin-out of each battery output connector. Use these diagrams to properly wire the corresponding connectors.

PIN-OUTS FOR DC OUTPUT TO BATTERY



Auxiliary DC Power Input for Onboard Charger (i.e “Wall Power”)

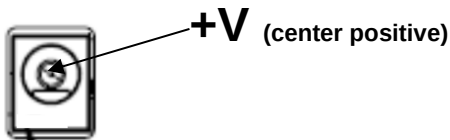
WiBotic Onboard Chargers are primarily designed as wireless power receivers. However, there may be times when it is desirable to use the OC as a wired (i.e. “wall power”) charger. For example, if a battery dies when the robot is away from the transmitter, it may be easier to charge the robot in place rather than manually pushing it back to the transmitter station.

Also, for some customers, the WiBotic Onboard Charger may be used as a programmable plug-in charger at first and then upgraded to wireless charging in the future by adding a receiver antenna and transmitter station. For these reasons, the WiBotic OC-150, OC-251, OC-262s and OC-301s have an auxiliary DC power input port. To power the OC using the auxiliary input, you may connect any 22-50V DC power supply rated for at least 150% of the power level (watts) you require as output from the OC.

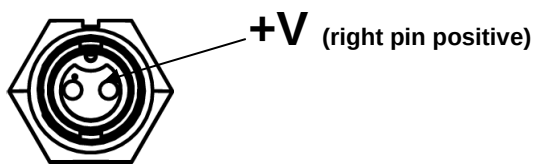


CAUTION: For safest operation, connect the DC power supply's output cable to the Onboard Charger before plugging the DC power into an AC outlet or other AC source.

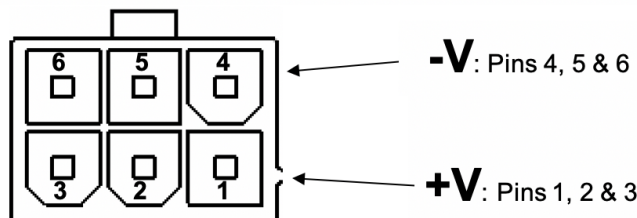
WiBotic uses a range of DC Input connectors depending upon the OC's size and configuration. The pin-out for the connector on each OC is shown below.

DC Power Input Connectors on the OCs**OC-150**

The matching connector for the OC-150 is part number EP501B from Memory Protection Devices. Note that the OC-150's input is current-limited 7A.

OC-262-WP

The matching female connector for the DC power supply cable is the SwitchCraft 6382-2SG-3DC. Optional waterproof DC input cables may be purchased from WiBotic. Note that the OC-262-WP's input is current-limited 12.5A.

OC-251, OC-262-ST and OC-301

The matching female connector for the DC power Supply is Molex Part No: 0039012060. Note that this input is current-limited at 10A for the OC 251, 12.5 A for the OC-262-ST, and 24A for the OC-301

*The OC-1000 is not equipped with a DC input

It is important to note that the current limits on the Aux DC input (listed above) may restrict overall OC power delivery when lower voltage DC power supplies are used. For this reason, we recommend using 48V supplies when possible. Also, many WiBotic Onboard Chargers can sense when they are being powered via the wireless power antenna or an auxiliary power supply. If the aux power supply is detected, a “Plug” icon will appear next to the OC within the Control Panel GUI.

CANBus Communications Connectors

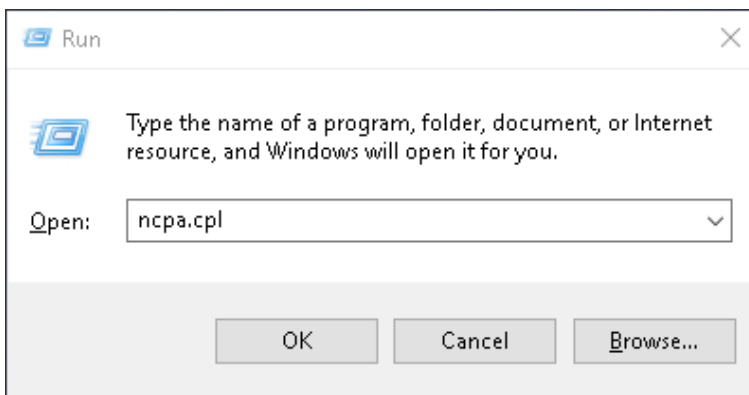
Please see Appendix C for all information related to the UAVCAN CANBus API and related connectors.

Communicating with the Transmitter

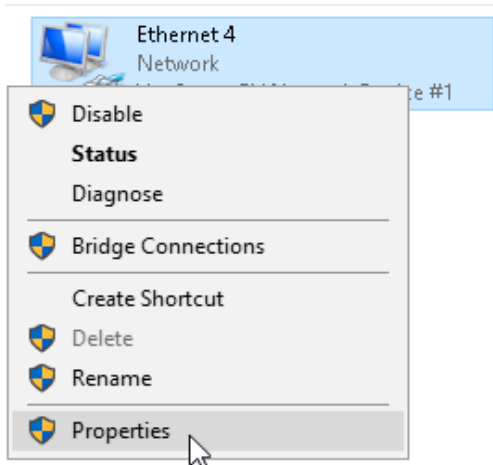
The WiBotic Control Panel allows users to control the WiBotic system, view its status, and make changes to settings without having to install separate software. The interface is accessible via modern versions of Firefox, Chrome, Edge, and Safari. A direct point-to-point Ethernet connection is recommended for initial setup although networking is possible through the Network Setting menu. The Power Transmitter serves the WiBotic Control Panel web-based software interface on a specific IP address configured on HTTP port 80.

Windows

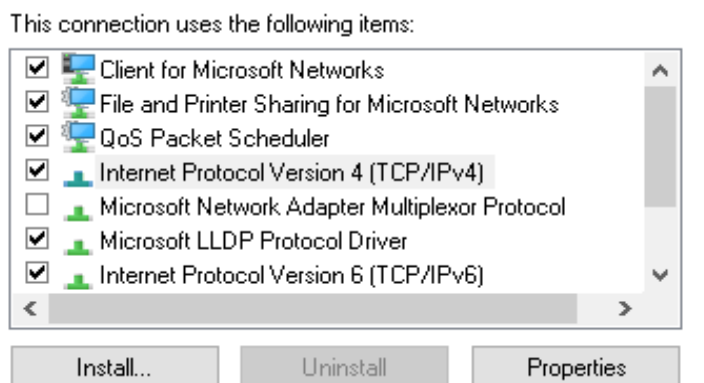
1. With the Power Transmitter powered on, confirm that the Ethernet Cable is connected to the computer either directly, or via the provided USB Adapter.
2. Open “Network Connections” by pressing **Windows Key + R**. Type in “ncpa.cpl”, and click OK:



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

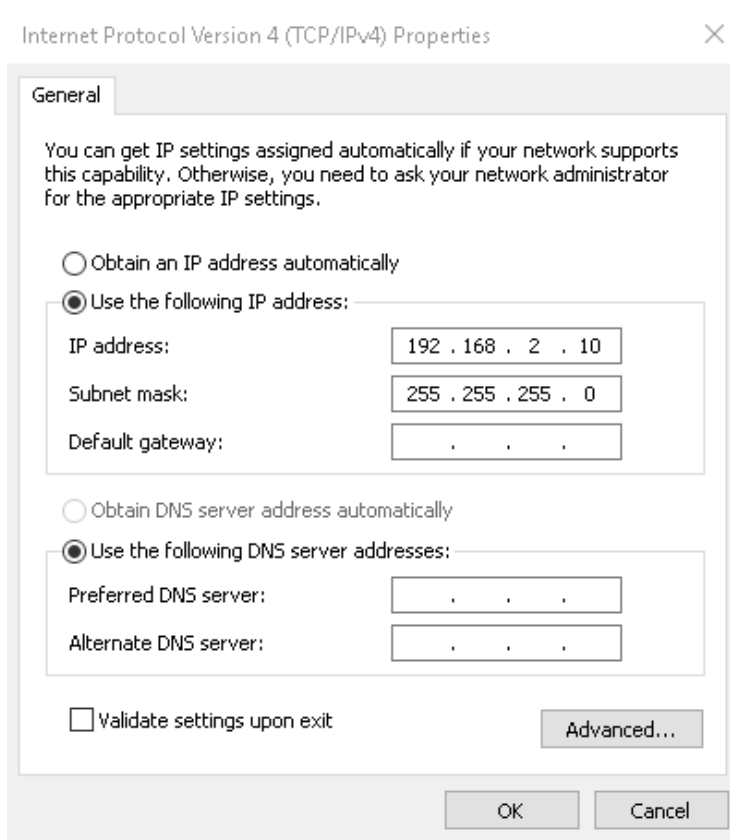


4. Select **Internet Protocol Version 4** (TCP/IPv4) and click the **Properties** button below it:

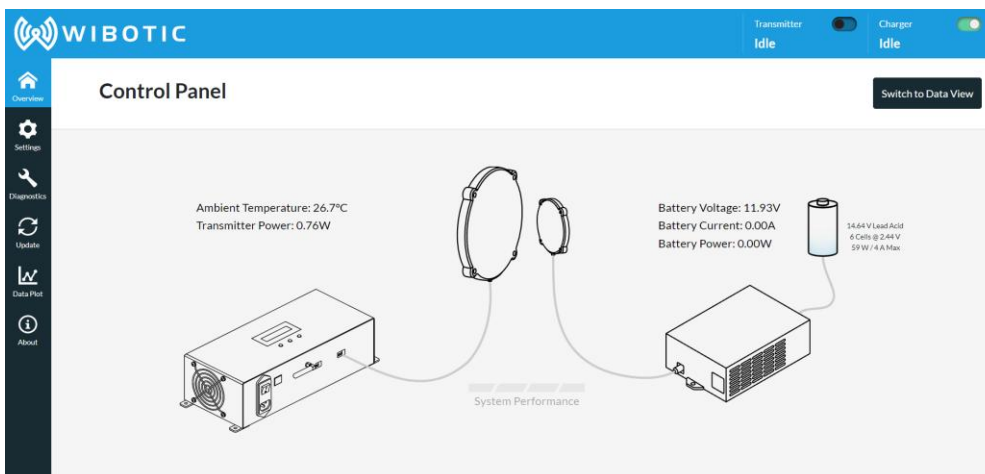


5. Click the **Use the following IP** address button and specify the following settings. The DNS section may be left blank. Click OK:

IP ADDRESS:	192.168.2.10
SUBNET MASK:	255.255.255.0
DEFAULT GATEWAY:	Leave Blank



6. After the network settings have been configured, **open a Web Browser** (Firefox, Chrome, or Edge) and go to the following URL: **<http://192.168.2.20>**
7. Verify that the web application loaded and that the Transmitter status at the top of the screen shows "Idle".



Linux (Temporary Connection)

1. Open a terminal window (many desktop environments have a keyboard shortcut CTRL+ALT+T to do this).
2. Type "ip address" to list all network interfaces on your computer and their respective IP addresses.
3. Locate the name of the network interface connected to the WiBotic system. This interface is usually near the bottom if using a USB dongle. It should be something like `enx0012345678`, `eno1`, or `eth0`.
4. Type "sudo ip addr add 192.168.2.10/24 dev `enx0012345678`" assuming you're running a system that uses sudo to elevate permissions. Replace `enx0012345678` with the name of the network interface identified above.
5. Visit <http://192.168.2.20> in a web browser (Firefox, Chrome).
6. Verify that the web application (shown above) loaded and that the Transmitter status at the top of the screen shows "Idle".

Linux (Permanent Connection) or Another OS

Please refer to the network setup guide for your operating system. You will need the following information:

Static IP (for the computer you are setting up):	192.168.2.10
Static IP (for the WiBotic transmitter):	192.168.2.20
Subnet Mask:	255.255.255.224 (/27) or larger

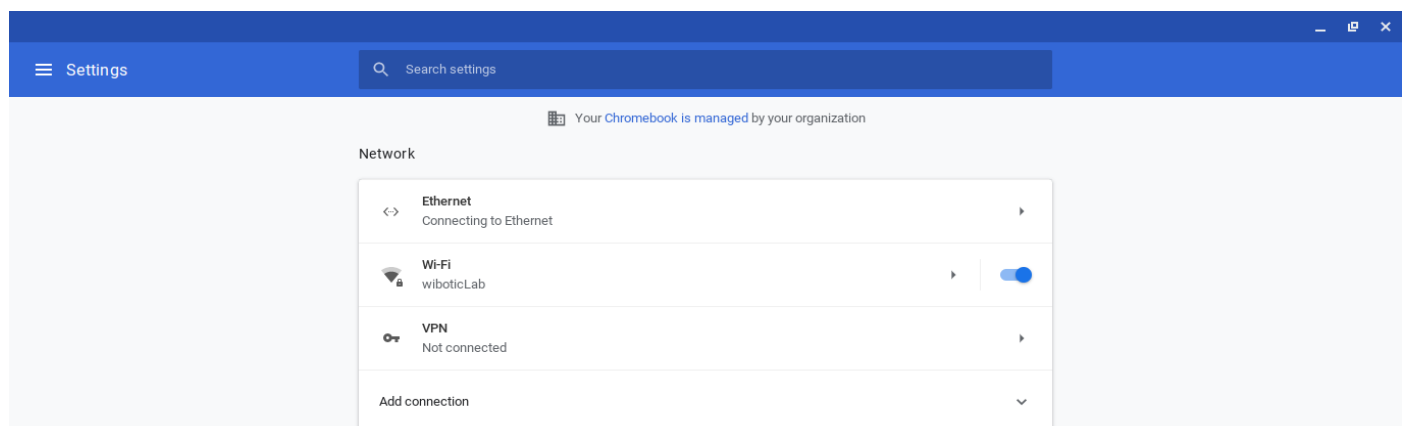
Additionally, if your OS has an option like "Use network only for resources on its own network", this option should be checked for the network connection used for a direct Ethernet connection to the WiBotic hardware.



Note: All Ethernet connectivity instructions are intended for an ad-hoc point-to-point connection directly to the WiBotic system. 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.

Chromebook

1. Plug in the Ethernet cable from the WiBotic transmitter.
2. Go to Settings and click "Ethernet".



3. In the following screen, de-select the “Configure IP address automatically” toggle switch, and enter in the IP address, Routing prefix, and Gateway as shown below.

Configure IP address automatically ☐

IP address
192.168.2.10

Routing prefix
255.255.255.0

Gateway

IPv6 address
Loading...

Name servers

☒ Automatic name servers

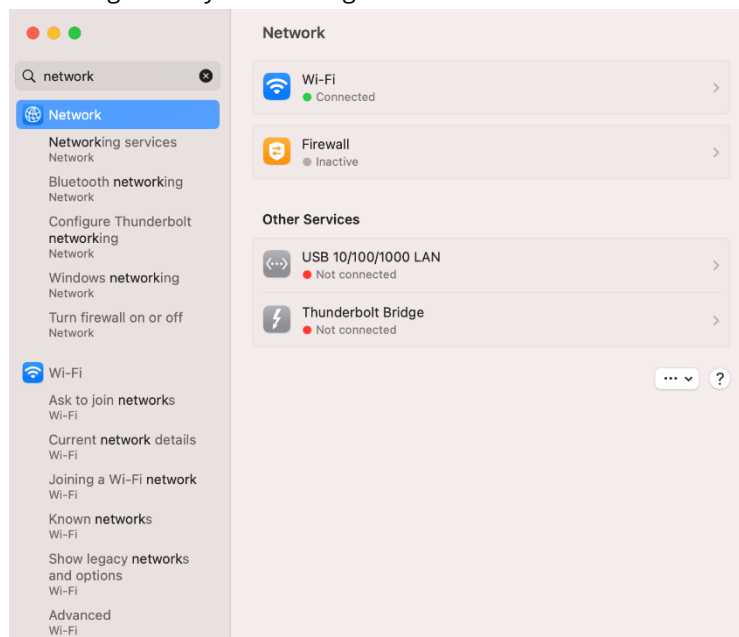
☐ Google name servers [Learn more](#)

☐ Custom name servers

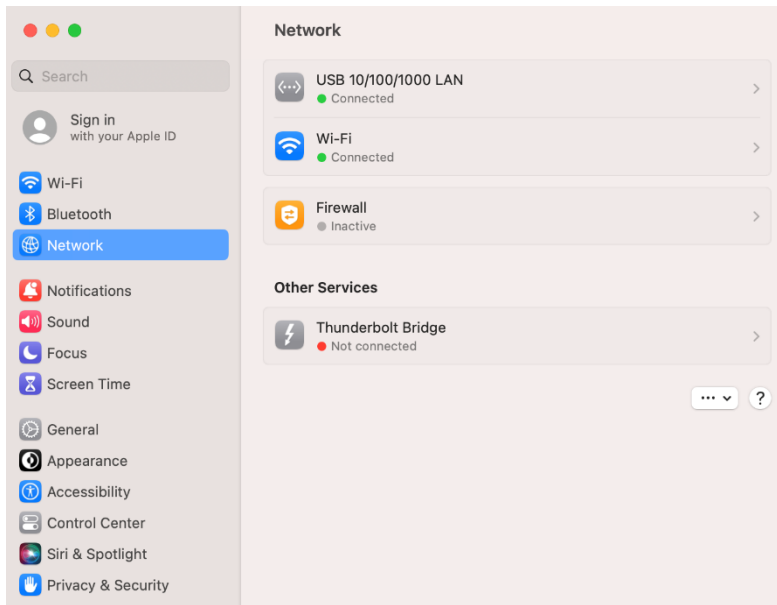
4. Open a browser (Chrome) and navigate to <http://192.168.2.20> to access the WiBotic GUI.

MacOS:

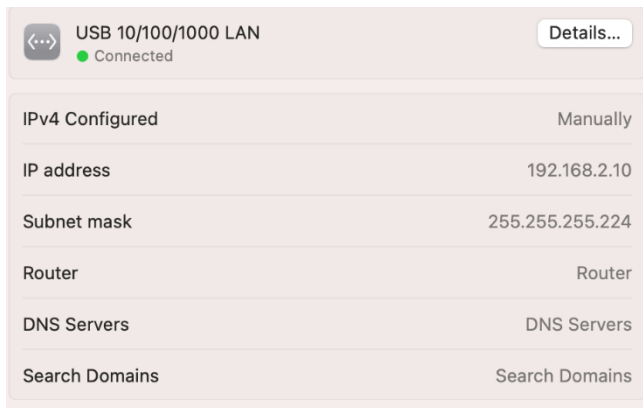
1. Power up the WiBotic transmitter.
2. Navigate to System Settings > Network.



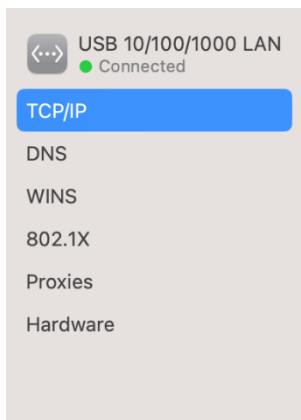
3. Connect the provided ethernet cable to the WiBotic transmitter and the Mac device.
4. An additional network should be detected, denoted with a green “Connected” icon within 30 seconds as shown below:



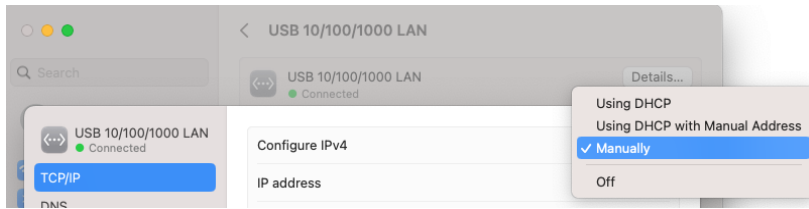
5. Click on the new network and click “Details”.



6. Click TCP/IP on the left sidebar.

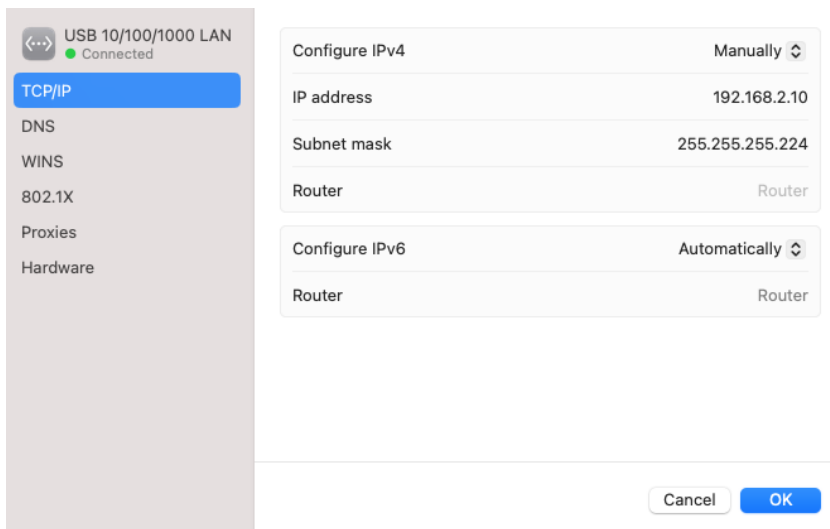


7. Click the dropdown near Configure IPv4 and select "Manually."



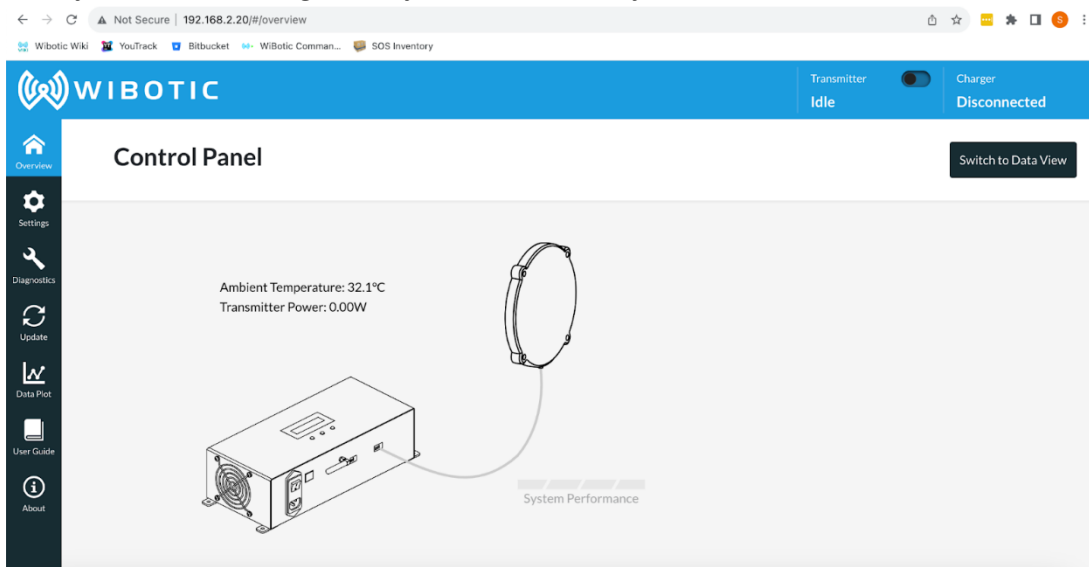
8. Enter/select the following:

- a. IP address: 192.168.2.10
- b. Subnet mask: 255.255.255.224
- c. Router: Leave blank
- d. Configure IPv6: Automatically
- e. Router Leave blank



9. Enter the following in a browser window: <http://192.168.2.20>

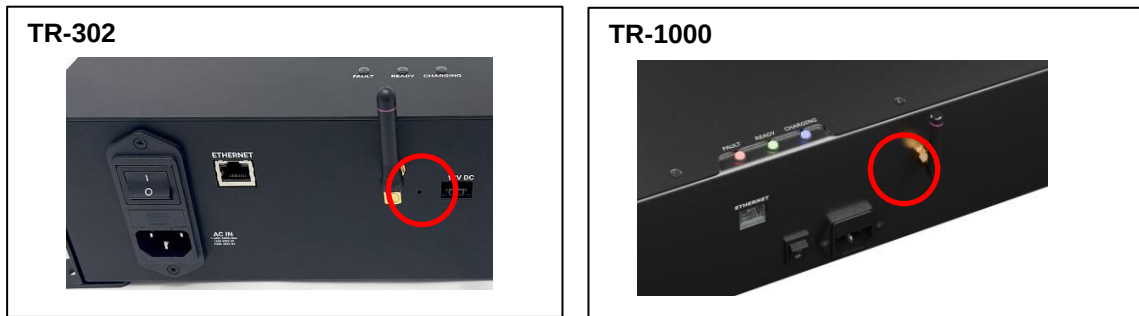
10. If you see the following screen, you have successfully connected to the WiBotic transmitter! Success!



Ethernet Configuration Reset

If the WiBotic system does not respond at the default IP address, you can reset the Ethernet configuration to the default factory settings as follows.

1. Locate a thin rigid object such as a small hex key or an unfolded paperclip.
2. Gently insert the object into the hole on the face of the transmitter shown below.



3. Upon inserting the thin rigid object, you should feel a button that depresses about 1mm. Hold the object on the button for more than 5 seconds.
4. Upon releasing the button, the LCD screen (if equipped) on the front of the transmitter will turn magenta and display "Ethernet Config Reset". If no screen is provided, turn the TR power off and back on and continue the configuration.



For TR-302 Edge outdoor transmitters, remove the polycarbonate enclosure lid to access the TR-302 inside.



Note: If the LCD only turns white and displays network configuration settings after being released, the button did not detect a continuous 5 second press and the Ethernet settings have not been reset. Try again.

Power cycle the transmitter for the new network settings to take effect.

Transmitter Displays

The primary means of monitoring system status is via the Control Panel user interface. However, the TR-302 Transmitter is also equipped with an LCD screen and indicator LED lights to provide basic status information. The TR-1000 has indicator LEDs but does not have the LCD screen.

LCD Display

Below is an image of the LCD display located on the front of the TR-302 Transmitter:



When no receiver antenna is in range, the display will not illuminate and will simply read “No Rx Coil in Range”. When a robot approaches the transmitter and the transmitter antenna recognizes the receiver antenna, a process called “Coil Checking”, the screen will momentarily illuminate with a green backlight and “Rx Coil in Range” will be displayed. After a brief “handshake” between transmitter and onboard charger, the screen will illuminate with a blue backlight and two lines of text will appear.

- The upper line of text displays the current battery and charging conditions. For instance, the battery connected to the OC in the above example currently has a voltage of 11.2V and charging has not yet started (current to the battery is 0.0A).
- The bottom line of text shows the pre-programmed power settings for the connected onboard charger. In the above example, the charge voltage for this OC is set to 14.6V and the maximum charge rate is set to 2.0A.

If the antenna range is suitable for charging, and charging is enabled, wireless power transfer will begin. At that time, the current (amps) shown in the upper line of text will reflect that actual current being delivered to the battery.

Two other symbols also help to indicate systems status. The Ethernet connector symbol at the end of the top line of text indicates that the transmitter is connected to an active laptop or network switch via its Ethernet port. The antenna symbol at the end of the bottom line of text indicates the transmitter and onboard charger are actively communicating over the system’s 2.4GHz control radio link.

The LCD display will also indicate other charging status messages such as “Battery Full” and any important error messages or alarms that may occur.

LED Indicator Lights

All WiBotic transmitters also provide Red, Green, and Blue LED lights that provide system status at a glance. Below is an overview of LED combinations and what they indicate:



No LEDs: System is powered off



Green LED slowly cycling on and off (not shown): System is powered-on but charging has not been enabled (see “Starting Wireless Power” section in this guide)



Green LED only: System is enabled and ready to charge when an Onboard Charger arrives

Green and Blue LEDs: System is enabled *and* is actively sending wireless power



Red LED: System is in an alarm condition

Note that the Red LED flashes momentarily when charging is manually stopped via the Control Panel GUI or as robots drive away from the transmitter. This is normal and the system will return to the “Ready” status after a few seconds.

TR-302 Edge - LED Indicator Light

The WiBotic TR-302 Edge for outdoor applications has only a single LED indicator on the front panel. For this TR model, the indicator will flash a specific pattern that indicates the current operating state:

Operating State	LED Pattern
Idle	3 second blink ON/OFF
Charging	1 second blink ON/OFF
Charging Complete	ON solid
Fault	3 Long flashes followed by 3 short flashes (SOS pattern)



WiBotic Control Panel Functions

Once the network connection has been established, all system cables have been connected, and the antenna coils are within the ideal operating range, you're ready to open the Control Panel to begin experiencing WiBotic wireless power!



Important Note: Once again, testing the system on a benchtop is highly recommended as a first step. This will ensure the system is operating correctly at the expected coil range and power level. Because nearby conductive materials (like metal robot chassis panels) can de-tune the system, it is not recommended that you test the system on your robot without first determining reference performance through benchtop testing.

At this time, open the Web-GUI using the following IP address typed directly into your web browser: <http://192.168.2.20>

As the default operating mode, wireless power will be disabled (OFF) when the Transmitter is initially powered up. Therefore, the GUI must be opened, and the system must be manually turned ON to begin charging. Later, the default operating mode can be changed to have the system automatically turn ON whenever a robot is in range. See the "System Settings" menu section later in this document for details.

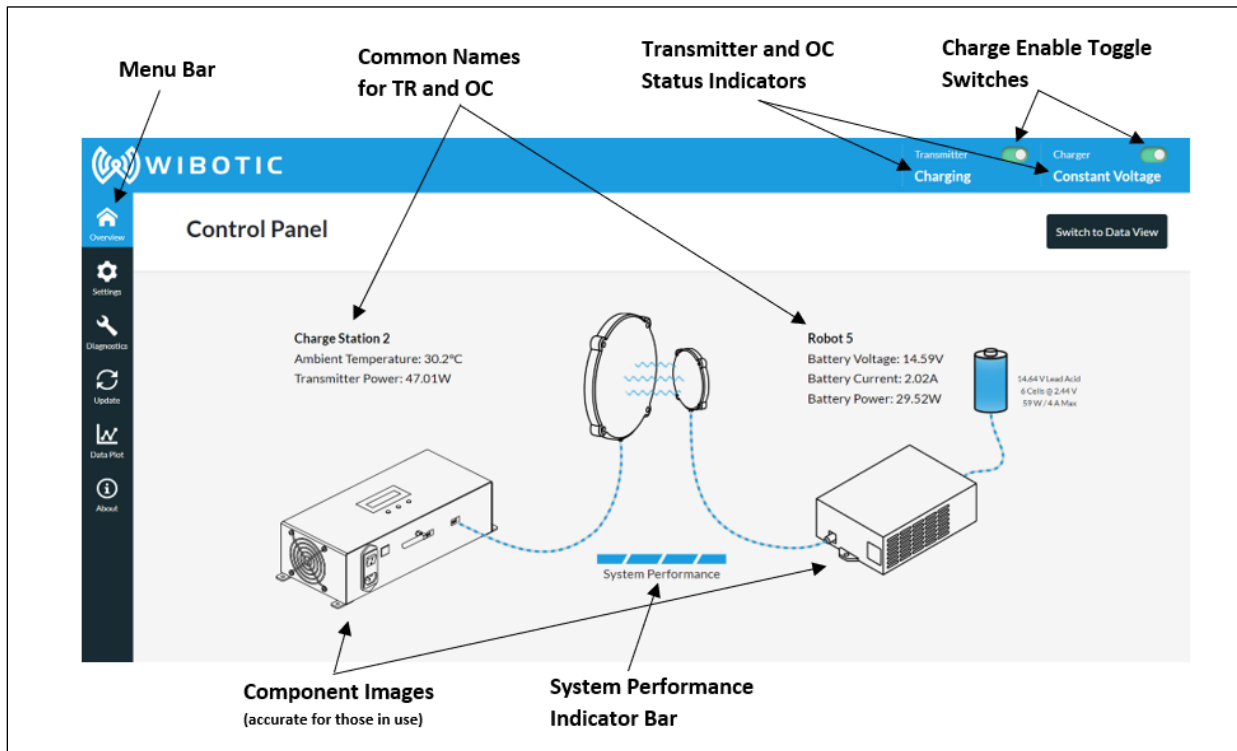
Before starting, please review the rest of this document to familiarize yourself with the Control Panel application and overall system operation.

Homepage

The image below shows the primary Control Panel Homepage within the WiBotic Control Panel. This display provides a graphical representation of the Transmitter and Onboard Charger (if in range) and their current operational status. If no Onboard Charger is within range, "Disconnected" will appear as the "Charger Status" and the onboard charger and battery icon will not appear in the display. To see if there are Onboard Chargers within radio range of the Transmitter (typically 30-

50ft), and to remotely connect to them if desired, a separate mode called Distance Connect Mode can be used (see the DCM section later in this document).

The Transmitter and Onboard Charger images in the center of the screen represent the specific models in use. If the GUI is used to log into a different Transmitter model, or if different Onboard Charger models approach the same transmitter, the images will change accordingly. Once again, the Onboard Charger image will only appear when the robot is within charging range and an antenna “handshake” has occurred to confirm it is ready for charging.



When power transmission begins, the antenna wires and wireless “waves” between the components and antennas will animate. After further system checks, the cable between the OC and battery will also become active – signalling that charging has begun.

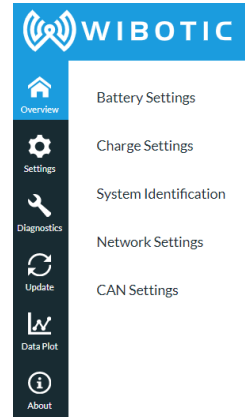
Live data related to each component is displayed on the Control Panel, and battery settings are shown just to the right of the battery image. A more detailed view of all parameters is accessible via the “Switch to Data View” button in the upper right corner of the main display.

The homepage also contains a feature called the **System Performance Indicator (SPI)**. This feature is designed to provide the user with a rough representation of how the system is performing compared to desired performance. It uses the instantaneous current being delivered to the battery and compares it to the max output current programmed by the user on the Battery Settings page. When properly configured, the system should operate with three or four bars. If the SPI is constantly operating with only one or two bars highlighted, the user should consider whether nearby metal may be detuning the antenna coils, or if the distance between the coils should be adjusted.

Settings Menu

The Settings menu provides five sub-menus that allow for customized system operation:

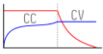
1. **Battery Settings:** supports a wide range of battery chemistries, voltages, and current levels and determines the type of charge cycle/algorithm used to charge the battery
2. **Charge Settings:** allows for deeper configuration of autonomous functions.
3. **System Identification:** Displays the MAC address for the transmitter and OC and allows common names to be assigned to each component
4. **Network Settings:** allows for configuration of network connections to transmitters over Ethernet.
5. **CAN Settings:** Provides CAN-bus communications settings for the Onboard Charger's optional CAN interface.



Battery Settings

Battery Chemistry:

Different battery chemistries (Lead Acid, Lithium Iron Phosphate, Lithium Polymer, etc.) require different charging procedures to maximize power storage and longevity. These procedures influence the voltage and current to the battery during a charge cycle. Batteries are also made up of multiple cells that are combined in different ways (series, parallel, or a combination) to provide the overall capacity (Amp-hours) and voltage the application requires. To begin configuration, open the "Battery Settings" sub-menu within the main "Settings" menu to display the following screen.

Battery Chemistry	LiFePO4
Charge Cycle voltage and current	
Number of Cells in series	14
Volts per Cell	Set Max 3.65 V
Charge Voltage	51.1 V
Restart Threshold	47.25 V
Maximum Battery Charge Current	22 A
Maximum System Output that can be delivered wirelessly	1,000 W
Charge Termination Ratio in terms of max battery current to stop charging. 0.1 x Maximum Charge Current is usually reasonable if not specified.	0.1 I Max
Enable Recovery Charge Charge slowly during undervolt conditions. Ensure battery support before enabling.	☐
Enable High Temperature Charging Allow charging in high temperature conditions. It is not recommended to charge most batteries at or above 45°C	☒
Enable Low Temperature Charging Allow charging in low temperature conditions. It is not recommended to charge most batteries at or below 0°C	☐
Save	

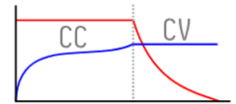
First, select the correct Battery Chemistry for the battery you are using. If you are unsure of the chemistry, review the battery's label or datasheet, or contact the robot or battery maker for more information.



CAUTION: Charge Cycles within the WiBotic system are labelled for specific battery chemistries. Always determine your battery's chemistry before charging is started and NEVER use a charge cycle that is not specifically identified for your battery's chemistry.

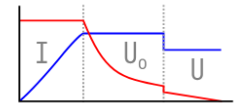
Once the chemistry is selected, the WiBotic Onboard Charger will automatically display a pre-programmed industry-standard charge cycle graph for the chosen type. For instance, most lithium batteries use a "Constant Current/Constant Voltage (CC/CV)" cycle as indicated by the title and graph that appear just below the Battery Chemistry drop-down menu:

Charge Cycle voltage and current



Lead Acid batteries can be charged using a number of different charge cycles. Four options are listed (IU, IUoU Float, IUI ΔV , and IUI Pulse). The image below provides a graph depicting the "IUoU Float" charge cycle, where an additional "float" period is used at the end of the cycle to complete the charging process.

Charge Cycle voltage and current



All four cycles can be used with any Lead Acid battery, but they should never be used with lithium or other non-Lead Acid batteries. Please see your Lead Acid battery manufacturer's recommendations when choosing the charge cycle for your specific battery and application.

Finally, a "Custom" battery chemistry option is also available. For this option, the typical CC/CV charge cycle is used, but users can manually enter any cell voltage and number of cells to establish the charge voltage for the entire battery pack.

An overview of all WiBotic charge cycles is available in **Appendix D**.

Number of Cells:

After selecting battery chemistry, the next step is to input the number of cells your battery contains. This information can typically be found on the battery's label or in the datasheet. Once the number of cells is entered, the overall "Charge Voltage" for the entire battery pack will be calculated and displayed. For instance, a LiFePO₄ battery pack with 8 cells and 3.65V/cell will be charged to 29.2V. For most charge cycles, charging will continue until the battery reaches this value and the current flowing to the battery decreases to a level determined by the charge cycle and the Charge Termination value (described below).

Volts Per Cell:

Selecting the Battery Chemistry also sets a pre-programmed industry standard Volts per Cell. For instance, the charging voltage for Lithium Iron Phosphate (LiFePO₄) batteries is 3.65V/cell, whereas many Lead Acid batteries charge to 2.4V/cell.

While the industry standard value is automatically displayed, users can override this value at any time by simply typing a new value into the Volts Per Cell box. Hitting "Set Max" will switch the value back to the default maximum value for the selected

battery chemistry. Setting a lower per cell voltage than the maximum industry standard may be desirable for some users since studies have shown that operating batteries between 80% and 20% of their rated capacity will generally result in longer battery lifespan. Note that this voltage is typically different than the nominal voltage displayed on the battery. Many datasheets will describe this voltage as the “Charge Voltage” or “Maximum Voltage”.

Charge Voltage:

Once the Number of Cells and the Volts Per Cell have been set, the system will calculate the Charge Voltage for the entire battery pack. This value is displayed for reference only just below the Volts Per Cell.

Restart Threshold:

It is normal for battery voltage to sag immediately after charging stops, and it would be impractical for the system to immediately resume charging to again reach the float voltage. Therefore, a default Restart Threshold is built into the system based upon known characteristics for various battery chemistries. If the Onboard Charger is still docked at the Transmitter and battery voltage drops to this restart threshold (typically due to an active load on the battery or self-discharge) the WiBotic system will automatically resume charging until the float voltage is reached once again. The default Restart Threshold can be overridden if necessary, using the available input box, but we recommend maintaining the default value unless you are extremely familiar with your battery's performance characteristics.

Maximum Battery Charge Current:

The Maximum Battery Charge Current value is an important user-adjustable parameter since it controls the “speed” at which a battery will be charged. This value can be set anywhere within the output wattage and current range of the connected Onboard Charger.

For instance, the WiBotic OC-251 Onboard Charger has a maximum power rating of 250W and a maximum current output of 12A. If the OC is configured to charge a battery with a relatively low float voltage of 14.6V, then a charge current of 17.1A would be needed to output the full 250W power capacity of the OC-251:

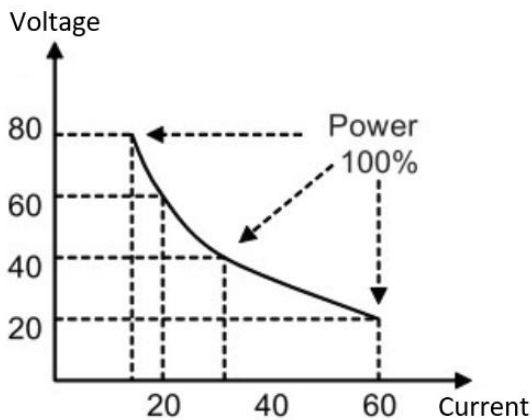
$$250\text{W} / 14.6\text{V} = 17.1\text{A}.$$

Since the OC-251 has a max output of 12A, however, the wattage output will be limited to 175.2W as voltage approaches 14.6V at the end of the cycle:

$$14.6\text{V} \times 12\text{A} = 175.2\text{W}.$$

Earlier in the charge cycle when battery voltage is lower, the overall power output (in watts) of the OC-251 may be further restricted by the 12A maximum.

WiBotic OCs are programmed to deliver the max amount of current possible based upon the measured battery voltage at every point throughout the charge cycle. As voltage rises, the charge current will automatically be reduced, while overall power delivered to the battery (in watts) remains as close to OC's rated maximum as possible.



The number of cells and how they are wired (in series or parallel) determines the overall voltage and capacity of the battery pack. Different battery chemistries accept different levels of current per cell. As a result, the battery manufacturer will recommend a maximum charge current based upon both the chemistry and capacity of the battery pack.



When setting the charge current, battery manufacturer recommendations must be followed.

Also note that a *lower* battery current can be specified at any time for better management of battery lifespan. With many lithium chemistries, charging batteries at the maximum allowable rate can significantly decrease the total number of available charge cycles. Therefore, this setting can be used to slow down battery charging when fast charging isn't needed. Charge speed can then be increased again when the robot needs to quickly return to service. Using the WiBotic API to programmatically make these adjustments based upon the robot's duty schedule lets users truly maximize the lifespan of entire fleets of batteries.

Maximum System Output:

To help users understand the relationship between wattage and current, and the connected OC's specifications, the Maximum System Output field on the Battery Settings page displays the maximum wattage the user can expect from the system after the voltage and current values have been set.

Charge Termination:

As mentioned above, when a charging method such as Constant Current/Constant Voltage is used for lithium batteries, the battery is considered "full" when current flowing into the battery is reduced to a specific value. This value is identified as a ratio of the Maximum Battery Charge Current entered by the user. Most non-programmable battery chargers use a fixed ratio such as 1/10th of their max charge current (or 0.10) for this value. This means that a system that has a maximum charge rate of 10A will consider the battery full, and stop charging, when the current flowing into the battery drops to 1A.

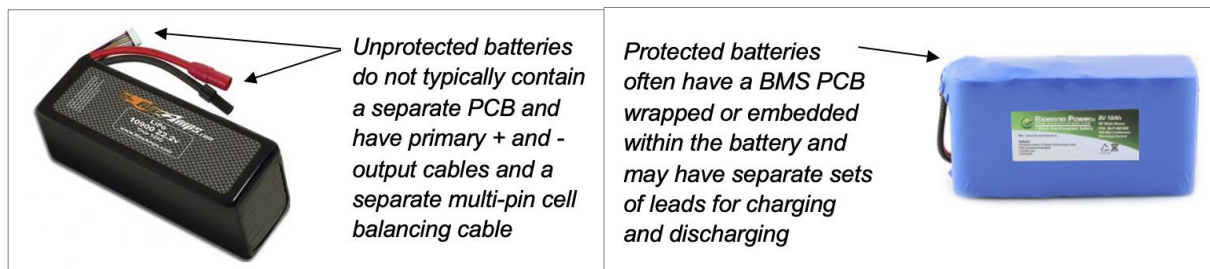
WiBotic understands that some batteries may respond favorably to a higher or lower ratio. Therefore, the Charge Termination input field allows operators to select the percentage of the programmed maximum current at which the charger will display "Battery Full" and cease charging. If you are unsure of the value you prefer for the Charge Termination, we recommend using 0.1 (10%) as a starting point.

Float or Final Voltage Per Cell

This parameter is only available for the IUoU Float, IUI ΔV , and IUI Pulse cycles for lead acid batteries. It provides a second voltage-per-cell value that allows the charging cycle algorithms to determine the proper point of charge termination. See **Appendix D** for more information on charge cycle inputs.

Enable Recovery Charge:

Some batteries have built-in Battery Management System (BMS) circuits that protect the battery from damage due to over-charging, over-discharging, or a lack of balance between cells.



Unprotected Lithium batteries, however, have no onboard circuitry to avoid these conditions. This can be very dangerous if not properly managed. The WiBotic Onboard Charger inherently provides overcharge protection since voltage during charging will not exceed the Charge Voltage as set by the user. The OC constantly monitors battery voltage and will automatically stop charging once the Charge Voltage is reached and the current being delivered to the battery drops to the Charge Termination threshold.

However, the WiBotic charger cannot control battery discharging. It is possible that overuse of the robot or drone could lead to a dangerous undervoltage condition when unprotected batteries are used. During undervoltage conditions the battery cells may become unstable. In this condition, charging the battery at full current could lead to further damage or catastrophic battery failure. The WiBotic OC is designed to avoid that possibility. By default, the OC will not attempt to charge a battery that reads below its minimum safe voltage.

Protected batteries, however, operate differently. Their internal BMS circuits automatically stop charging or discharging when overvoltage or undervoltage thresholds are met. This protects the battery cells, avoiding potentially dangerous failures and extending overall battery life. In these cases, since permanent damage to the cells has been prevented, it is acceptable to “wake up” the battery so full-speed charging can resume. This mode of operation is allowed by activating the Enable Recovery Charge (ERC) toggle switch on the Battery Settings page.

Enable Recovery Charge

Charge slowly during undervolt conditions. Ensure battery support before enabling.



By enabling this feature, you are signalling to the WiBotic charger that it is acceptable to send a low-level of current to the battery even when it senses no (or very low) voltage. This effectively resets the BMS circuitry and allows the battery voltage to slowly and safely climb to the minimum threshold. Once the minimum voltage threshold is reached, full-current charging will resume.

If you choose to enable the ERC switch, however, two important concepts must be understood:

- 1) You must only enable this feature if you are sure that your battery can support a low-level charge when in protected mode. This feature is NOT designed for recovering unprotected batteries. If an unprotected battery is over-discharged, attempting to recover it in this way may lead to permanent battery failure or even battery fire.
- 2) When the WiBotic OC is powered only by the battery itself, which is the most common case, then it will likely lose power completely when the protection circuitry engages. This is because the 2.4GHz control radio onboard the OC will not be powered and communication with the transmitter will not be possible - even if the robot/drone is manually brought within range of an active transmitter. To enable charging in this situation, a secondary source of power for the OC is required. This can be supplied by a DC power supply connected via the six-pin Auxiliary Power input on most OCs (see Hardware Setup Section). Or, in certain robots and drones, a 5V USB connection may also be connected to the OC to provide power to the control radio. If no other source of power is available, please contact WiBotic for a third possible option called "Power Unpowered" mode.

Due to the somewhat complex nature of protected vs. unprotected batteries, we recommend consulting with WiBotic before the ERC function is used.

Enable Low/High Temperature Charging:

Finally, most battery manufacturers do not recommend charging batteries below 0C or above 45C. WiBotic Onboard Chargers do not measure battery temperature directly, but there is a thermistor on the OC that measures ambient temperature on the circuit when a charge cycle first begins. As a safeguard, the WiBotic system will not allow charging if that temperature is below 0°C or exceeds 45°C.

We realize the battery itself is not always in the same location as the OC, however. It may be located in a warmer or cooler environment. For this reason, we provide operators with an Enable High Temperature Charging and Enable Low Temperature Charging feature. When selected, the temperature limits are disabled.



WARNING: Before moving on, please reconfirm battery settings to ensure the charge current and voltage are within permissible limits for your battery. Damage to the battery, charger, or connected equipment may occur if incorrectly configured. A damaged battery could cause fire or personal injury.

Charge Settings

The Charge Settings sub-menu allows users to configure the system for fully autonomous operation. It also provides control over the transmitter fans for quieter operation, provides "Charge Cycle" and "Top-off Period" time limits, and allows the system to be configured as a current-limited constant-voltage power supply.

Autonomous Operation:



WARNING: Never disconnect the battery from the Onboard Charger when actively charging. This may damage the OC circuit. Instead, use the Control Panel software toggle switches or separate the transmitter and receiver antennas to manually stop charging before disconnecting the battery from the OC.

In the previous section, we described how to start the charging process by manually clicking on the Transmitter and Onboard Charger software toggle switches in the upper right corner of the GUI. However, using the GUI to start charging may not be

possible in all cases, or you may want the system to run fully autonomously without the need for a human to monitor and control it over the Ethernet connection. This capability is built into the system and is easy to enable.

To configure the system to start charging automatically when a robot approaches (and the battery is not already full), first navigate to the Charge Settings page and note the status of the Transmitter Enabled and Charger Enabled toggle switches.

The screenshot displays two sections of a settings page: 'Transmitter Settings' and 'Charger Settings'. In the 'Transmitter Settings' section, the 'Transmitter Enabled' toggle switch is in the 'Off' position (grey), while 'Startup Behavior' is set to 'Save default state as OFF' and 'Temperature Controlled Fans' is 'On' (green). In the 'Charger Settings' section, the 'Charger Enabled' toggle switch is in the 'On' position (green), 'Startup Behavior' is set to 'Save default state as ON', and 'Maximum Total Charge Time' and 'Maximum Top-Off Charge Time' are both set to 10800 seconds. The 'Act as Power Supply' toggle is 'Off'. A callout box on the right, titled 'Note "Enabled" toggle switch position for Transmitter', has two arrows pointing to the 'Transmitter Enabled' and 'Charger Enabled' toggle switches.

Transmitter Settings

Transmitter Enabled ☐

Startup Behavior
Use the current state as the default when the system is first turned on **Save default state as OFF**

Temperature Controlled Fans
Transmitter fan speed reacts to temperature at all times. If disabled, fans operate at fixed speed only during power transfer. ☒

Save

Charger Settings

Charger Enabled ☒

Startup Behavior
Use the current state as the default when the system is first turned on **Save default state as ON**

Maximum Total Charge Time 10800 sec

Maximum Top-Off Charge Time 10800 sec

Act as Power Supply ☐
Act like a Current Limited Constant Voltage Supply. Ensure battery and powered device support before enabling.

Save

Note "Enabled" toggle switch position for Transmitter

In the above image, the transmitter is disabled/off. This means users will need to manually click on the toggle switch in the upper right corner of the Control Panel to restart charging after the TR has lost power. However, if fully automatic operation is desired, simply toggle both the transmitter and OC switches to the "On" position on the above page and then click the black "Change default state from OFF to ON" button. Click "Save" to store this new setting to memory.

Transmitter Settings

Transmitter Enabled ☒

Startup Behavior
Use the current state as the default when the system is first turned on Change default state from OFF to ON

Temperature Controlled Fans
Transmitter fan speed reacts to temperature at all times. If disabled, fans operate at fixed speed only during power transfer. ☒

Save

Charger Settings

Charger Enabled ☒

Startup Behavior
Use the current state as the default when the system is first turned on Default state is ON

Maximum Total Charge Time sec

Maximum Top-Off Charge Time sec

Act as Power Supply
Act like a Current Limited Constant Voltage Supply. Ensure battery and powered device support before enabling. ☐

Save

An alert will appear in the taskbar confirming the change of settings. From this point forward, the transmitter and onboard charger will automatically turn ON and start charging a robot/drone as soon as it approaches a charging station.

To disable this feature, simply toggle the Transmitter and Charger buttons back to the “OFF” position and click “Change default state from ON to OFF” and click Save.

Transmitter Settings

Transmitter Enabled ☐

Startup Behavior
Use the current state as the default when the system is first turned on Change default state from ON to OFF

Temperature Controlled Fans
Transmitter fan speed reacts to temperature at all times. If disabled, fans operate at fixed speed only during power transfer. ☒

Save

Charger Settings

Charger Enabled ☒

Startup Behavior
Use the current state as the default when the system is first turned on Default state is ON

Maximum Total Charge Time sec

Maximum Top-Off Charge Time sec

Act as Power Supply
Act like a Current Limited Constant Voltage Supply. Ensure battery and powered device support before enabling. ☐

Save

Maximum Total Charge Time:

In some cases, it may be preferable to limit the total duration of a charge cycle so the system does not continue to transmit energy if the battery does not reach a “Battery Full” state. The Max Charge Time is set to 3hrs (10800s) by default, but users can adjust this value by entering a new value in the input box and clicking the “Save” button. The charge-time clock starts when the WiBotic transmitter first starts wireless charging and it will automatically turn off once the end of the time cycle is reached. If the battery is not fully charged after the system turns off, it will automatically turn back on and the timer will be reset.

Maximum Top-Off Charge Time:

The “Maximum Top Off Charge Time” is also a user-adjustable variable. This setting determines how long the charger will remain in “Constant Voltage” mode at the end of a charge cycle. Normally, current slowly drops during CV mode until it reaches 1/10th (C/10) of the Maximum Charge Current value. The charger then turns off and waits for battery voltage to drop to the “Restart Threshold” before starting to charge again.

In some cases, the robot’s own load (if it remains powered on) may not allow the WiBotic system to reach the C/10 level where the battery is considered “full”. This may be desirable if keeping the robot powered at all times is a key goal. However, if you do not want the WiBotic system to continue sending power indefinitely, you can limit the amount of time it will spend in CV mode. To do this, simply adjust the Maximum Top-off Charge Time level to the desired time (in seconds) and click “Save”.

When the system turns off at the end of this period, it will remain off as usual until the Restart Threshold voltage is met.

Act as Power Supply Mode:

While the WiBotic OC is a fully programmable battery charger, we understand there may be situations when a battery charger already exists onboard the robot or where the delivery of a current-limited constant-voltage power supply is required. If this is the case, you may place the system into the Act as Power Supply Mode by toggling the “Act as Power Supply” switch to the on position.

Charger Settings

Charger Enabled ☒

Startup Behavior
Use the current state as the default when the system is first turned on **Save default state as ON**

Maximum Total Charge Time 10800 sec
Power Supply mode is enabled. This setting will not have an effect.

Maximum Top-Off Charge Time 10800 sec
Power Supply mode is enabled. This setting will not have an effect.

Act as Power Supply ☒
Act like a Current Limited Constant Voltage Supply. Ensure battery and powered device support before enabling.

Once toggled, the system will disable features that are specific to battery charging – such as the charge timers described above and the “Restart Threshold” and “Battery Recovery Mode” features on the Battery Settings page. The power supply

voltage is set using the “Number of Cells” and “Volts per Cell” settings on the battery settings page. Most users will set Number of Cells to “1” and the Volts per Cell to the desired power supply voltage.



WARNING: Do not use the Power Supply Mode when charging batteries unless the batteries are otherwise protected from over-charging.

System Identification

All WiBotic transmitters and OCs can be identified by their Media Access Control (MAC) addresses, which are unique identifiers assigned to any device that may be added to a network. However, MAC addresses can be difficult to remember and don't provide any reference as to how or where a device might be used. For this reason, WiBotic allows transmitters and OCs to be given common names. Since the OC is typically permanently installed on a particular robot, this allows you to use an existing robot name to identify it within the WiBotic GUI and within WiBotic Commander, our Fleet Energy Management software package. New names may also be created for otherwise unnamed OCs/robots.

The System Identification page shows the MAC address of the Transmitter to which you are currently connected, as well as the Onboard Charger that is currently connected to that Transmitter.

Transmitter Settings

MAC Address
34:d9:54:00:02:d9

Name

Save

Charger Settings

MAC Address
34:d9:54:00:02:61

Name

Save

As different Onboard Chargers approach the same transmitter, the Charger Settings MAC address will change. Any time you are connected to the Transmitter or a specific Onboard Charger, however, you can assign it a common name by simply typing that name into the “Name” field and clicking “Save”. Once created, common names will appear throughout the GUI in any location where the MAC address had previously appeared – allowing you to more quickly identify which transmitter you are connected to, and which OC (and therefore robot) is currently connected to that transmitter.

Note that the common name is associated with the Onboard Charger, so if the OC is moved to a new robot you may wish to update the OC's name to match.

Network Settings

The Network Settings sub-menu provides configuration parameters for adding the WiBotic transmitter to a Local Area Network. The options available via this menu should be familiar to networking/IT professionals, but please contact WiBotic if questions arise.

Network Settings

Network settings will be applied the next time the WiBotic transmitter is power cycled.
If the system becomes inaccessible due to incorrect network configuration, press and hold the ethernet reset button for 5 seconds as described in the WiBotic user guide.

MAC Address	34 d9 54 00 01 2e
IP Address	192.168.2.20
Subnet Mask	255.255.255.0
Gateway	192.168.2.10
DNS	8.8.8.8
MTU	1500
Connection Options	☐

Save

CAN Settings

The CAN Settings sub-menu provides configuration parameters for CAN-bus communications between the Onboard Charger and the robot/drone controller. See Appendix C for a complete discussion of WiBotic’s Onboard API and related CAN-bus setup and functionality.

Diagnostics Menu

The WiBotic system is intentionally configured for in-air operation using the supplied antenna coil mounting brackets. As you test various coil positions and power levels, and particularly if you move the coils to your robot or another location where de-tuning may occur, you may experience an increase in alerts or other system messages. Apart from appearing on the main overview page, these events can be tracked and logged using the Diagnostics menu.

Live Logs

The Live Log is a running list of system events that have occurred since the Control Panel was opened and connected to the Transmitter. The most recent event is listed at the bottom of the log file, so some scrolling may be required.

Events that appear in **black** text are normal and for informational purposes only. No operator action is required. Events that occur in **orange** text are alerts that generally represent a change in system condition. These may or may not require operator intervention (see Alert message list below). Events shown in **red** text are typically more severe and are unusual. If a red error message occurs and the system does not automatically return to normal operation after powering down and repowering, contact WiBotic for assistance.

Table 1: 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.

ALERT NAME	ALERT DESCRIPTION
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 Onboard Charger, the transmitter will turn off. Try moving the transmitter and/or Onboard Charger closer to each other. The system will shut down and enter heartbeat mode.
TX Alarm: Power transfer too 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. The system will attempt to restart and resume operation.
TX Alarm: RX is in alarm state	The Onboard Charger has encountered a problem.
TX Alarm: System over temperature. Restarting when cooled.	The transmitter has detected an unsafe operating temperature. This could be due to sub-optimal coil positioning or de-tuning of the coils
TX Alarm: Hardware Protection	An environmental factor is causing coil detuning or another hardware issue
TX Alarm: Coil Check Over Current	An environmental factor is causing coil detuning and excess current during coil check procedure
TX Alarm: Unexpected Power Usage	An environmental factor is causing a larger unexpected increase in the amount of power being drawn from the transmitter.
TX Alarm: Received voltage too low	The receiver did not see enough voltage to begin charging the battery. Check coil position and potential detuning.
TX Alarm: Ramp conditions unable to be met	The system was unable to get the OC to ramp after trying for 45 seconds. This could be due to sub-optimal coil positioning or de-tuning of the coils.
TX Info: output power limited due to temperature	The transmitter has detected that it is too hot and will limit output power to try to regulate its temperature. Check transmitter ventilation.
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 crash	The input voltage seen by the Onboard Charger 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.

ALERT NAME	ALERT DESCRIPTION
RX Alarm: Charger shorted	The battery charger on the Onboard Charger has detected a short circuit on the battery output. Try disconnecting the battery to power cycle the Onboard Charger and see if the problem persists. If this problem is not resolved, contact WiBotic as there may be a hardware issue with the Onboard Charger.
RX Alarm: Internal event alarm	The Onboard Charger has had an internal error and has attempted recovery. Try disconnecting the battery to power cycle the Onboard Charger 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.
RX Alarm: OC temperature exceeds 45C	The "Enable High Temperature Charging" setting is turned off and the system would begin battery charging, but the OC temperature exceeds 45°C which means that it's likely the battery is too hot to charge.
RX Alarm: System Too Cold	The OC detects a temperature below 0°C and is refusing to charge for battery safety reasons.
RX Alarm: OC Thermal Limits Exceeded	The OC is outside of the operating temperature it is designed to work in and has shut down to prevent damage. This usually means that thermal throttling was not able to counteract a rapid rise in temperature. Check airflow or heatsinking capabilities.
Charge Timeout Elapsed	The configured charge timeout has elapsed and the system will terminate charging
Fatal: Battery did not recover	Recovery mode attempted to recover the battery, but the battery did not show any signs of recovering and charging was stopped for safety. You must manually power cycle the charger to continue operation.

Version Information

The Version Information section contains the code number for the Control Panel and firmware versions that are currently installed on the system. MAC addresses and the currently selected radio channel are also supplied.

Log Messages

The Log Messages section allows users to select and view individual log files for the Transmitter and Onboard Charger – typically for troubleshooting with assistance from WiBotic. The "System Log" file contains a chronological record of all system events since the Transmitter was last powered on. It is like the Live Log above, but the System Log file is not date/time stamped and is not affected by closing the browser. The most recent event is listed at the bottom of the log file.

The numbered log files relate to each charging session for the Transmitter and Onboard Charger. There is currently a limit of 100 (0-100 with one missing) individually recorded cycles with numbering starting at 0 again after the 100th record is saved. The newest log file is determined by looking for the log file index that is one less than where a gap in the log file indexes is. Therefore the "Log 0" file may not be the most current set of system data. The most current logs are shown at the top of the list. If detailed analysis of the log files is required, all of the available logs can be downloaded at once using the "Download All Log Files" link.

Distance Connect Mode (DCM)

When there are no Onboard Chargers within charging range of the Transmitter, it is still possible to determine which, if any, OCs are within radio range. This may be helpful when monitoring various aspects of a fleet of robots, or for updating firmware across a fleet without asking each robot to approach the charging station.

Instructions for using Distance Connect Mode (DCM)

- 1) Confirm that all OCs in the fleet are connected to a battery and powered up.
- 2) Make sure there is no Onboard Charger antenna within charging range of the transmitter antenna. Usually, a separation of 12in is sufficient. If the two antenna coils are allowed to pair, then the transmitter will only be able to “see” the paired Onboard Charger.
- 3) Open the WiBotic GUI.
- 4) Go to the “Diagnostics” page
- 5) Expand the Distance Connect Mode box. This will provide a list of all of the Onboard Chargers within radio range of the Transmitter (roughly 30ft)

Distance Connect Mode

DCM allows you to remotely connect to an onboard charger when it is not docked at a transmitter station. It is used for diagnostic and system configuration only. Wireless charging cannot occur in this mode.



- 6) If only one OC is connected to a battery, then only one will appear. However, if you have a fleet of OCs that are active on robots, you will see a list of all of them within radio range.
- 7) To connect to a particular OC, click on its MAC address and select “Connect”.

Distance Connect Mode

DCM allows you to remotely connect to an onboard charger when it is not docked at a transmitter station. It is used for diagnostic and system configuration only. Wireless charging cannot occur in this mode. ▼

Searching for chargers in range 📶

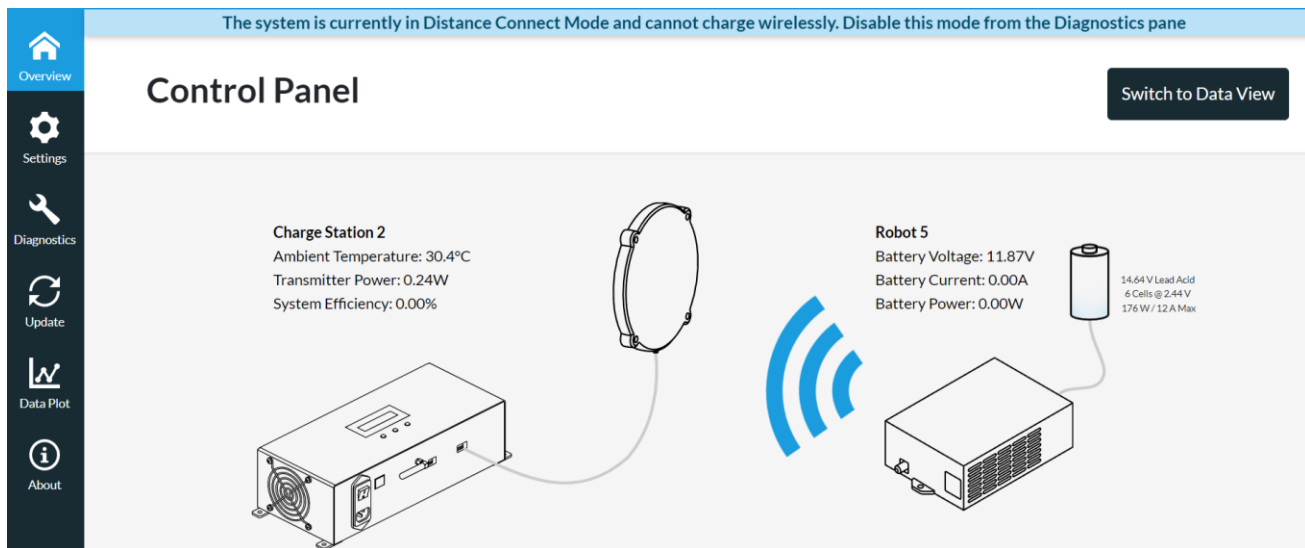
34:d9:54:00:00:f6 📶

1

Connect

2

- 8) After a few seconds, the Transmitter radio will connect to the OC and you will see a different animation on the Overview page showing a radio connection between the two devices instead of a wireless power connection (see below). A message at the top of the page will also indicate that the system is in DCM.



- 9) Once connected, you can proceed with monitoring of the remote system or with firmware updates following the normal update procedure. Note that the transmitter can only be connected to one Onboard Charger at a time, so if you're Distance Connected to an OC, the Transmitter will not connect to another OC even if it is brought within antenna coil range. You will first need to manually disconnect the transmitter from the first OC by clicking the "Disconnect" button.
- 10) To disconnect an OC from DCM, simply click on the "Disconnect" button in the DCM section of the Diagnostics page.

Update Menu

WiBotic will occasionally release new firmware for the Transmitter or Onboard Charger to improve system performance. To see if new firmware is available, simply click the "Check for Updates" button near the top of the Update page.

Check for Updates

Choose Files

No file chosen

Upload

Upload WiBotic firmware files here. Accepted file types are: .zip, .bin, .rfs

A new browser window will open with the left side showing the firmware revision (Rev) currently installed on your system. If new versions are available, the right side of the page will show those versions. If there is a direct upgrade path to the most current version, you are encouraged to install it directly. You will be informed if you must step through the installation of more than one version, and notes will be provided advising you of the proper sequence.

Downloading the Firmware Files

WiBotic Firmware Update Download

Download Transmitter Firmware, Web Firmware, and Charger Firmware from a single firmware version and upload them to the WiBotic transmitter that generated the link to this page.

Current Firmware

Rev15

↓ [API Files](#)

Upgrade Options

Rev16

Recommended

↓ [Firmware Bundle](#)
↓ [API Files](#)

Under the heading for each firmware Rev are two file download links 1) Firmware Bundle and 2) API Files.

The first link will download the Firmware .zip file with a filename similar to the following: *Revxx_WiBotic_Firmware.zip*. The .zip file contains three separate files as follows, but there is no need to unzip/extract the files at this time:

- **WEB.RFS** – the Control Panel update that is loaded onto the Transmitter
- **rx-m4-ota.bin** – the “rx” indicates this is the firmware file for the Onboard Charger/Receiver
- **tx-m7-ota.bin** – the “tx” indicates this is the firmware file for the Transmitter

After downloading the Firmware Bundle .zip file, you will then upload it to the Transmitter’s SD Card. This process updates the Control Panel GUI and stages the software for installation onto the transmitter and onboard charger microprocessors.

The second link downloads a separate .zip file that contains CAN API files, sample python scripts, and ROS drivers that are further explained in the API sections in the Appendices to this document.

Uploading the Files to the Transmitter

To upload these files to the transmitter, use the Choose Files button and browse to the Downloads folder on your local drive (or wherever you chose to store the .zip file).

Choose Files

No file chosen

Upload

Upload WiBotic firmware files here. Accepted file types are: .zip, .bin, .rfs

You may select the .zip file by itself and then click “Upload” to upload all three files at once. Alternatively, you may unzip the folder first and then select each of the three files to upload individually. Once the upload begins, you will see a status bar like the one below showing the progress for each file.

Uploading File 3 of 3...

As the files are being uploaded to the transmitter, you will notice a slight flash and reload of the Control Panel GUI. This is expected and indicates that the new WEB.RFS file has been successfully uploaded. You are now using the latest version of the Control Panel web application as indicated in the “Current Web Version” section in the center of the Update page.

As shown below, the “Current” and “Uploaded” versions for the Transmitter and Onboard Charger are also shown.

Web

Current Web Version:
Rev 16.0 (3c25460e)

Transmitter

Current Firmware Version:
Rev 15.0 (96ea0394)

Uploaded Firmware Version:
Rev 16.0 (3c25460e)

[Update](#)

Charger

Current Firmware Version:
96ea0394

Uploaded Firmware Version:
Rev 16.0 (3c25460e)

[Update](#)

At this point, the “Current” Transmitter and Onboard Charger firmware versions no longer match the Current Web Version. This is to be expected since the firmware running on the two components has not yet been installed. The system will provide an error message to alert you to the mismatch:

The system firmware is mismatched and may impact performance. See Update page for details.

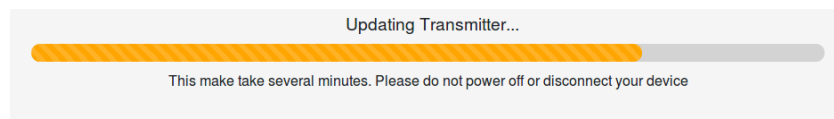


A more prominent notification will also appear instructing you to proceed with the firmware update/installation.

Updated Transmitter Firmware has been uploaded. Click Update below to fix.

Updating/Installing the Firmware

Continue by first selecting the black “Update” button for the Transmitter. This will begin the file installation process and a status bar will be presented.



After the update is complete, the Update web page will refresh on its own and the “Current” firmware version will now match the “Uploaded” firmware version as shown below. Both should reflect the latest Rev number that was available to you on the “Check for Updates” page. The multi-digit code in parentheses is the build hash code for the firmware and should also match.

Transmitter

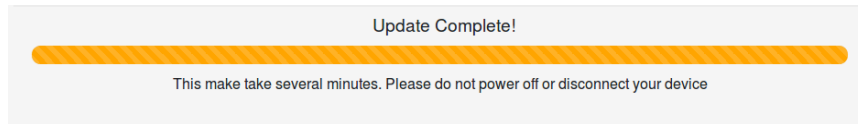
Current Firmware Version:
Rev 28.0 (3c25460e)

Uploaded Firmware Version:
Rev 28.0 (3c25460e)

If the system takes more than 5 minutes to update or the page does not automatically refresh, try manually refreshing the web page to see if the firmware versions will update. If it appears that the transmitter still hasn’t been updated, power cycle the transmitter and try again.

Next, ensure that the Onboard Charger you want to update is connected to the transmitter. If it is not, the Onboard Charger section of this page will show “Not Connected”. If this is the case, be sure the OC has power, is connected to its antenna coil, and that the antenna coils have been moved together until the OC shows up in the Control Panel.

Follow the same procedure for the Onboard Charger by clicking on the black “Update” button. Once again, the status bar will show installation progress. Because the Onboard Charger is being updated over a radio link, it typically takes slightly longer than the transmitter to complete this update. The status bar will eventually signal completion as shown below.



After the update is complete, the “Current” and “Uploaded” firmware versions for the Onboard Charger should also match. Note that it may take several seconds for the web page to update after the status bar indicates “Update Complete”. If it fails to do so, manually refresh the page. If unable to manually refresh or the system otherwise becomes unresponsive, it may be necessary to restart both the Onboard Charger and the Transmitter and try again.

After completing this step, your firmware will be fully updated on this transmitter and the connected Onboard Charger. Repeat the process for other Onboard Chargers after connecting to each individually. Or, contact WiBotic to learn how **WiBotic Commander**, our Fleet Energy Management software product, can automate firmware updates for large fleets of robots.

Onboard Charger Update Recovery

If you are unable to finish the firmware update after restarting both devices, and your Onboard Charger appears to be “stuck” in a non-functional mode, a recovery process is available. Use the area at the bottom of the update page to enter the last six digits of the MAC Address found on the OC’s label and press “Finish Update”. This will reset the OC and should allow completion of the firmware update process. Contact WiBotic if you are still unsuccessful.

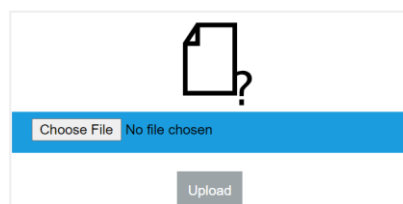
Continue Interrupted Update

If a charger was disconnected in the middle of an update and does not reconnect normally, enter the last six hexadecimal digits of its MAC address (check [system log](#)) below and press finish update.

Charger MAC

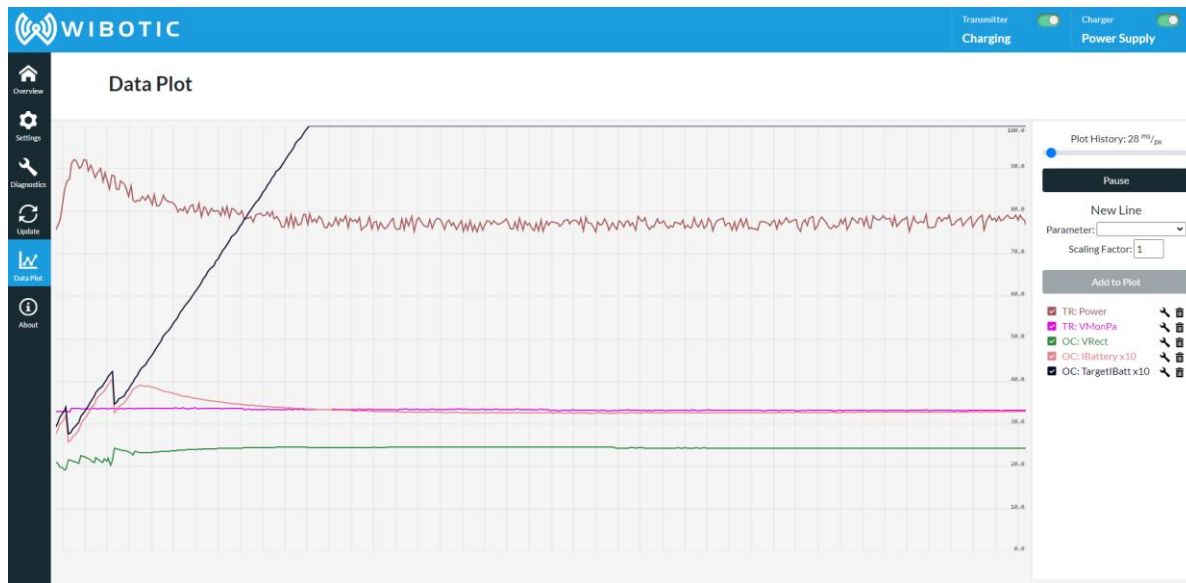
Control Panel Update Recovery

Finally, if the update has failed and the Control Panel is no longer responding at all, you can reinstall the Control Panel using a different procedure. Since you will not have access to the regular “Update” page, type the following URL instead: <http://192.168.2.20/update>. (Note that you should use the correct IP address for the transmitter if no longer using the default). You will then be presented with a basic web page where you can upload the WEB.RFS file directly.



Note that for this step you will need to unzip the Firmware Bundle .zip file to access the individual WEB.RFS file.

Data Plots Menu



Plot
Plot History: 22 ms/px
Pause

New Line
Parameter:
Scaling Factor: 1
Add to Plot

Advanced
Developer Names
Alternate ADC Stream
Sync OC Time
Plot to CSV

Lines
TR
Power
Power Amplifier Voltage
OC
Rectified Voltage
10x Battery Current
10x Target Battery Current

The Data Plots menu provides a graphical representation of various system parameters over time. To choose the displayed parameters, click on the Parameter pull-down menu on the right side of the screen. You may also reset the default scale for that parameter by typing a new value in the Scaling Factor box immediately below. Click "Add to Graph" to add the parameter to the list of displayed parameters. It will now appear on the plot.

To momentarily de-select a parameter from the plot, simply click on the check box. Click again to re-display the parameter.

To eliminate the parameter from the list of current options, click on the “Trash” icon. Parameters can always be added again using the directions above.

To extend the time range shown in the plot, slide the “Plot History” bar to the right.

There is also an “Advanced” drop down menu with a few additional options for viewing and exporting data. When the advanced menu is selected the following options appear:

- Developer Names Toggle Switch: Enabling this switch will cause the plot to show the ADC names for each parameter (ex: “VRect”) instead of the descriptive name (ex: Rectified Voltage)
- Alternate ADC Stream: When selected, this option allows the Control Panel to display OC data that is being streamed directly from the OC via CANBus as opposed to through the control radio between the TR and OC.
- Sync OC Time: This option allows a re-syncing of data if the above Alternate ADC Stream causes the timer in the TR and OC to become out of sync.
- Plot to CSV: Clicking this button will convert and export all selected and visible data in the plot via a CSV file. Note that this is not a complete historical log and only displays data that was currently shown in the plot.

About Menu

The About menu provides WiBotic contact information as well as detailed information on the software and firmware licenses used within the WiBotic platform.

Wireless Power Transmission

Before You Start

For safety purposes, always follow these guidelines before starting wireless power transmission, or any time a WiBotic system is in use:

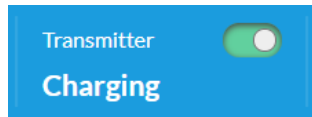


1. Double check all cable connectors to ensure they are properly connected and tightened.
2. Keep body parts at least 60cm away from the power transmission coils during operation. WiBotic products have passed all relevant international standards related to product safety, including human exposure to electromagnetic energy. Nonetheless, it is best practice not to touch or keep body parts within 60cm of the power transmission coils when the system is actively sending power.
3. After power transmission has stopped, allow a minimum of 3 minutes before touching or disconnecting any cables within the system. This will allow for the proper discharge of any built-up static energy and for components within the system to cool.
4. Never open the TR, OC, TC or RC component enclosures when the system is plugged into wall power or connected to a battery.
5. Never remove the component circuit boards from their enclosures or otherwise attempt to modify the product.

Getting Started

To begin testing wireless power, first confirm that the Onboard Charger toggle switch in the upper right corner of the Control Panel is in the “On” position and the Transmitter toggle switch is in the default “Off” position.

Next, turn the Transmitter on by clicking the Transmitter toggle switch. If there is an Onboard Charger ready to accept power, and it is within range of the transmit coil, the system will now enter its charging sequence. In a few seconds, charging will begin and the graphical indicators on the center of the screen will show active charging.



Once wireless power transmission begins, the system will stop only if the Transmitter toggle is clicked again to turn it off, if the battery is fully charged, or if a shutdown event occurs. (See the “Power Down Events” section for details). WiBotic recommends disconnecting power to both the Transmitter and Onboard Charger when not in use for extended periods.

The table below lists the transmitter and charger status indicators that will appear in the upper right portion of the GUI as the system is operating.

Table 2: GUI Status Indicators

STATUS NAME	STATUS DESCRIPTION
Idle	The Power Transmitter will periodically check for Onboard Chargers when they are in range of the 2.4GHz low power radio if enabled. The system is not transferring power.
Stabilizing / Ramp Up	Wireless power is enabled, and power is ramping up to pre-set target levels.
Charging	The transmitter is sending power to the OC for battery charging.
Constant Current	The OC is charging the battery in constant-current mode.
Constant Voltage	The OC is charging the battery in constant-voltage mode.
Battery Full / Done	The battery float voltage has been reached and charge current has dropped to C/10, so the system has completed charging.
Alarm	An unexpected event occurred. See log message for details. The system should restart once conditions return to normal.
Fatal	An unexpected event occurred. The system will not restart until it is power cycled manually.
Recovery	The OC is charging the battery at a reduced rate while checking to see if the voltage has come back into an acceptable range
Power Supply	The OC is configured as if it was a power supply with limited safeguards for battery charging.
Negative ΔV	The system is charging a NiMH or NiCD battery near the end of the charge cycle and is looking for the battery voltage to drop to determine when to terminate charging.

About the Battery Charging Process

WiBotic Onboard Chargers are configured by default to act as Constant Current/Constant Voltage (CC/CV) battery chargers. If the Transmitter is physically powered, the Transmitter toggle switch is turned on, and an Onboard Charger 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 the pre-defined voltage limit in the “Battery Settings” menu. The voltage limit can be changed by the user and is stored in Non-Volatile Memory (NVM). This setting, and others for the Onboard Charger, will therefore be retained even if the OC is powered off or disconnected from the battery.

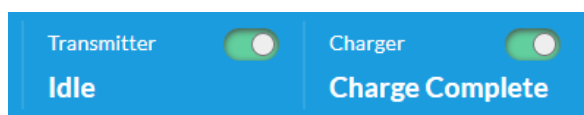
During start-up, the charging current will ramp up to the maximum constant-current charge rate as configured in the WiBotic software. The Onboard Charger will always try to ramp-up to the maximum charge current. However, in some cases, depending on either sub-optimal coil position, environmental conditions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

After the constant current (CC) portion of the charge cycle is complete, the Onboard Charger will enter constant-voltage (CV) charging mode. During CV 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 once it is in constant-voltage mode:

1. **CV Mode Timeout:** Once CV Mode has started, the “Maximum Top-Off Charge Time” period begins. Even if the battery is not fully charged at the end of this period, the charge cycle will terminate, and the Power Transmitter will momentarily return to standby. If the system senses battery voltage is below the Restart Threshold, the system will resume charging.
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 considered complete, and the Power Transmitter will return to standby.

The GUI will indicate that the battery is fully charged by displaying “Charge Complete” as the charger’s status.



Power-Down Events

Several mechanisms can cause the Transmitter to power-down during charging:

COMMUNICATION ERROR / RX TIMEOUT: The Transmitter and Onboard Charger communicate over a low-power 2.4GHz radio link. If the Onboard Charger is out of range, obstructed by metal, or is in a particularly electrically noisy environment, the GUI may display “RX Disconnected”. The Transmitter will power-down until the radio link is restored. If the radio link is restored when the battery’s voltage is above the restart threshold voltage, then the system will not turn back on until the restart threshold is met.

GUI INFORMATIONAL MESSAGES: There are informational messages that appear in the log of the GUI. These messages indicate either a status update or an alert – some of which may cause a precautionary shut down. If an alert has been triggered and power transfer stops, the message will provide a recommendation to ideally solve the problem. If the GUI application itself stops responding, it may be necessary to try refreshing the web page. If these problems persist, contact WiBotic for support. See the section on GUI Alert Messages for more details on the specific messages.

Troubleshooting Connectivity

If the Transmitter is powered on and connected to the computer via Ethernet, but the web app is inaccessible, proceed through the following steps:

1. Make sure you have setup the IPv4 settings as outlined in the “Communicating with the Transmitter” section.
2. Try resetting the Ethernet Connection settings as outlined in the Ethernet Configuration Reset section as in the previous section.
3. If you still cannot connect to the GUI, contact WiBotic at info@wibotic.com for assistance. It is helpful if you include the results of pinging the device with the command “ping 192.168.2.20” in a terminal or command prompt window. If able, running a packet capture tool such as Wireshark on the interface where the WiBotic system is plugged in, and sending the capture to WiBotic, may also help us assist you in getting the system up and running.

Suppliers Declaration of Conformity (SDoC)

The devices described in this User Guide and listed below comply with Part 18 of the FCC Rules.

The devices described in this User Guide and listed below comply 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.

Changes or modifications not expressly approved by WiBotic Inc could void the user's authority to operate the equipment.

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Name and address of the US Responsible Party

COMPANY NAME:	WiBotic Inc.	TELEPHONE NUMBER:	1-206-580-0900
CONTACT NAME:	Benjamin Waters	FACSIMILE NO:	N/A
CONTACT TITLE:	CEO	EMAIL ADDRESS:	Info@wibotic.com
COMPANY ADDRESS:	9706 4 th Ave NE Suite 403 Seattle, WA 98115	WEB ADDRESS:	www.wibotic.com

Identification of Equipment

PRODUCT NAMES:	Wireless Power System
MODEL NUMBERS:	TR-302-AC-ST, TR-1000-AC-ST, OC-150-10-ST, OC-251-12-ST, OC-262-12-ST, OC-262-12-WP, OC-301-30-ST, OC-1000-36-ST.

Note to robot manufacturers:

If a WiBotic Transmitter or Onboard Charger is installed inside a docking station or robot, or where the FCC approval label cannot otherwise be seen, a separate label must be affixed to the outside of the product. The label should read as follows depending upon the OC model used:

TR-1000-AC-ST: "Contains FCC ID 2AVQUTR1000ACST"

OC-1000-36-ST: "Contains FCC ID: 2AVQUOC100036ST"

OC-262-12-ST: "Contains FCC ID 2AVQUOC26212ST"

OC-251-12-ST: "Contains FCC ID: 2AVQUOC25112ST"

TR-302-AC-ST: "Contains FCC ID 2AVQUTR302ACST"

OC-301-30-ST: "Contains FCC ID: 2AVQUOC30130ST"

OC-262-12-WP: "Contains FCC ID 2AVQUOC26212ST"

OC-150-10-ST: "Contains FCC ID 2AVQUOC15010ST"

Product Warranty

MANUFACTURERS LIMITED WARRANTY: (a) WiBotic warrants to Customer that each hardware Product will be free from defects in materials and workmanship for a period of one year from the date of Product shipment. If any such Product proves defective in materials or workmanship during the warranty period, WiBotic will repair or replace the defective Product. Extended Warranty periods may also be purchased. The Extended Warranty shall have the same provisions for WiBotic repair or replacement of the defective products over the extended period identified. (b) WiBotic warrants that it shall perform the Services using personnel of required skill, experience, and qualifications and in a professional and workmanlike manner in accordance with generally recognized industry standards for similar services and shall devote adequate resources to meet its obligations under this Agreement. (c) The warranties set forth in this Section are subject to normal wear and tear and normal maintenance. They do not cover defects which WiBotic determines are due to accident, alteration, modification, negligence, misuse, abuse, failure to perform adequate maintenance, or service by any party other than WiBotic, (d) WiBotic shall not be liable for a breach of the warranties set forth in this Section unless Customer gives written notice without undue delay of the defective Products or Services, as the case may be, reasonably described, to WiBotic when Buyer discovers or ought to have discovered the defect.

DISCLAIMER WARRANTIES: THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED. WIBOTIC, ITS AFFILIATES AND ITS VENDORS, DISCLAIM ANY IMPLIED WARRANTIES, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF NON-INFRINGEMENT, SATISFACTORY QUALITY, MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR THEIR EQUIVALENTS IN ANY JURISDICTION.

EXCLUSIVE REMEDY: Customer's sole and exclusive remedy for any breach of the original manufacturer's limited warranty, if any, is set forth in this Section and Section 19. During any applicable warranty period, WiBotic will use commercially reasonable efforts to transport the defective Products from and to the Location (if necessary) at its expense and, at its sole option, repair or replace or provide a refund of the price paid for the Products within thirty (30) days following WiBotic's receipt thereof from Customer in accordance with WiBotic's RMA process. Customer shall bear all expenses of removal and reinstallation of defective Products, if any. WiBotic shall bear all transport, insurance, and all risk of loss in transporting the defective Products to and from the Location. If WiBotic determines that any returned Product is not defective or is not eligible for warranty service or replacement, the Product will be returned to Customer and Customer shall pay all costs of handling, inspecting, testing and transporting such Product to and from the Location.

LIMITATION OF LIABILITY: WIBOTIC'S SOLE LIABILITY UNDER ANY PURCHASE ORDER OR SOW EXECUTED HEREUNDER SHALL BE FOR THE PURCHASE PRICE PAID TO WIBOTIC FOR PRODUCTS THAT ARE RETURNED AND DETERMINED TO BE NON-CONFORMING. WIBOTIC SHALL HAVE NO OTHER LIABILITY UNDER THIS QUOTATION, ACKNOWLEDGEMENT, PRO FORMA OR INVOICE FOR THE PRODUCT FOR DAMAGES OF ANY KIND, INCLUDING WITHOUT LIMITATION FOR PUNITIVE OR EXEMPLARY DAMAGES OR ANY DIRECT, CONSEQUENTIAL, INCIDENTAL, INDIRECT, OR SPECIAL DAMAGES (INCLUDING WITHOUT LIMITATION DAMAGES FOR LOSS OF USE, PROFITS, REVENUE OR BUSINESS). THIS LIMITATION SHALL APPLY NOTWITHSTANDING ANY FAILURE OF ESSENTIAL PURPOSE OF ANY LIMITED REMEDY HEREIN AND REGARDLESS OF WHETHER SUCH DAMAGES ARE SOUGHT BASED ON BREACH OF CONTRACT, BREACH OR WARRANTY, NEGLIGENCE, STRICT LIABILITY IN TORT, OR ANY OTHER LEGAL OR EQUITABLE THEORY.

For Warranty Service and Support, please contact WiBotic Customer Support at support@wibotic.com or 206-580-0900 (Option 2).

Appendices:

A: Network API

Appendix A: Network API

The WiBotic Network API allows users to programmatically access the WiBotic Transmitter over an Ethernet network for system monitoring and control. All functionality available via the WiBotic Web GUI is also programmable via this interface. The following pages provide an overview of the API functionality. WiBotic also provides a Python library and sample code to help users get started. To access these files, navigate to the “Update” menu in the Control Panel GUI and select the “Check for Updates” button at the top of the page. You will be presented with the following screen

WiBotic Firmware Update Download

Current Firmware

Rev18

↓ [Documentation](#)
↓ [API Files](#)



Upgrade Options

System Up to Date

Click on the “API Files” link to download a .zip file with the sample code. If you cannot access the files in this way, please contact sales@wibotic.com for access.

Getting Started

The WiBotic Network API is accessible over a WebSocket at the address `ws://192.168.2.20/ws` (where 192.168.2.20 is the IP address of the WiBotic Transmitter) using the “*wibotic*” WebSocket subprotocol. You can use any language or environment that can communicate over WebSockets to send and receive API data to the WiBotic system.

A helper library and demo application are available in Python to assist in development (see Appendix B).

NOTE: The WebSocket server does not currently incorporate authentication. Do not connect the WiBotic system to a public network without considering the security implications. It could be susceptible to an attack where a malicious webpage opens a socket and sends data to the WiBotic system in another isolated network segment. This will be addressed in future versions of the system.

General Packet Format

The WiBotic Network API uses binary WebSocket frames. The frames begin with a byte that indicates the frame type (see Response Packet Types and Request Packet Types below). This byte determines how the rest of the frame should be interpreted.

Additionally, note that not every WiBotic system uses or reports every parameter or ADC value.

“C Types” (such as `uint16_t`) are typically little endian encoded. Larger blobs are typically in network order (big endian).



Tip: When porting the WiBotic binary websocket protocol to another language, it can be helpful to look at the `packettools.py` and `wiboticsocket.py` files available in `Wibotic API.zip`

Request Packet Types

NAME	CODE	DESCRIPTION
Read Parameter	0x01	Request a parameter to be read
Write Parameter	0x03	Request a parameter to be written
Stage Parameter	0x04	Request a parameter to be staged
Commit Parameter	0x05	Commit all staged parameter to non-volatile memory
Request Connected Devices	0x06	Requests an updated set of currently connected devices
Subscribe Request	0x11	Subscribe to topics containing periodic information
Unsubscribe Request	0x12	Unsubscribe from topics containing periodic information
Extended Parameter Write Request	0x20	Request data to be written to an extended parameter
Extended Parameter Read Request	0x21	Request an extended parameter to be read

Response Packet Types

NAME	CODE	DESCRIPTION
Parameter Response	0x80	A parameter was updated
Parameter Set Response	0x81	Response to a request for data from a parameter
ADC Update	0x82	New real-time ADC packet
Stage Parameter Response	0x83	Response to a request to stage a parameter for commit
Commit Parameters Response	0x84	Response to committing staged parameters

Connected Devices	0x85	What devices are currently connected to the system
Message	0x86	Log messages in ASCII format with severity level
Charger Association	0x87	A charger is in radio range and is checking to see if it's in coil range
OTA Status	0x88	Status of an in-progress update
Extended Parameter Response	0x91	Response to a request for data from an extended parameter
Extended Parameter Set Response	0x92	Response to a request to write to an extended parameter

API Requests

The following diagrams illustrate the position of the bytes that should make up the binary WebSocket frames that contain the API requests and responses. Multiple successive bytes with the same name indicate that the value is to be split over those bytes. The bytes illustrated continue to the next line if there are too many bytes to show on one line.

Building API Requests

Read Parameter

0x01	Device ID	Parameter ID	Parameter ID	Parameter ID	Parameter ID
------	-----------	--------------	--------------	--------------	--------------

Write Parameter

0x03	Device ID	Parameter ID	Parameter ID	Parameter ID	Parameter ID
New Data	New Data	New Data	New Data		

Stage Parameter

0x04	Device ID	Parameter ID	Parameter ID	Parameter ID	Parameter ID
------	-----------	--------------	--------------	--------------	--------------

Commit Parameters

0x05	Device ID
------	-----------

Request Connected Devices

0x06

Subscribe Request

0x11	Topic ID
------	----------

Unsubscribe Request

0x12	Topic ID
------	----------

Extended Parameter Write Request

0x20	Device ID	Ext Param ID	Ext Param ID	New data □
------	-----------	--------------	--------------	------------

Extended Parameter Read Request

0x21	Topic ID	Ext Param ID	Ext Param ID
------	----------	--------------	--------------

Parsing API Responses**Parameter Response**

0x80	Device ID	Parameter ID	Parameter ID	Parameter ID	Parameter ID
Param Data	Param Data	Param Data	Param Data	Status	

Parameter Set Response

0x81	Device ID	Parameter ID	Parameter ID	Parameter ID	Parameter ID
Status					

ADC Update

0x82	Device ID	ADC ID 1	ADC ID 1	ADC Data 1	ADC Data 1
ADC ID 2	ADC ID 2	ADC Data 2	ADC Data 2	...	ADC ID <i>n</i>
ADC ID <i>n</i>	ADC Data <i>n</i>	ADC Data <i>n</i>			

The number of ADC values in a packet can be determined by the following equation:

$$\frac{(NumberOfBytes) - 2}{6}$$

Stage Parameter Response

0x83	Device ID	Parameter ID	Parameter ID	Parameter ID	Parameter ID
Status					

Commit Parameters Response

0x84	Device ID	Status
------	-----------	--------

Connected Devices

0x85	Device Flags	Device Flags
------	--------------	--------------

Bit 1: Transmitter Connected

Bit 2: Charger Connected

Message

0x86	Device ID	Level	ASCII String	ASCII String	ASCII String
ASCII String	ASCII String	ASCII String	...		

Charger Association

0x87	Device ID	RSSI	Charger MAC	Charger MAC	Charger MAC
Charger MAC	Charger MAC	Charger MAC			

Extended Parameter Response

0x91	Device ID	Ext Param ID	Ext Param ID	New data □
------	-----------	--------------	--------------	------------

Extended Parameter Set Response

0x92	Device ID	Ext Param ID	Ext Param ID	Status
------	-----------	--------------	--------------	--------

Parameters

NAME	ID	DESCRIPTION	READ	WRITE	TR/OC AVAILABILITY
Address	3	Address of the device on the internal point to point wireless link	Yes	No	Both
RadioChannel	4	Current device radio channel	Yes	No	Both
TargetCtrl	7	Acts on the command byte that is written to this parameter.	Yes	Yes	Both
HardwareCommand	14	Commands that manage hardware operations that are common across systems	Yes	Yes	Both
TargetVrect	24	Received rectified voltage target that the system will use along with power tracking (mV)	Yes	No	RX
DigitalBoardVersion	26	Version of the digital board that is running the system	Yes	No	Both
BatteryCurrentMax	34	Maximum current that the battery can handle	Yes	Yes	RX
ChargerCurrentLimit	35	Current limit that the system has decided can be delivered to the battery in milliamps	Yes	No	RX
MobileRxVoltageLimit	36	Calculated maximum battery voltage (mV) based on chemistry, number of cells, and voltage per cell	Yes	No	RX
RxBatteryVoltageMin	37	Calculated minimum battery voltage (mV) based on chemistry, number of cells, and voltage per cell	Yes	No	RX
BuildHash	38	Version hash of the firmware that is loaded on the device	Yes	No	Both
TargetFirmwareId	39	Type of firmware image that is running on the device	Yes	No	Both
OtaMode	41	Current firmware update state	Yes	Yes	Both

NAME	ID	DESCRIPTION	READ	WRITE	TR/OC AVAILABILITY
RxBatteryVoltage	42	Last seen value of the battery's voltage (millivolts)	Yes	No	RX
RxBatteryCurrent	43	Last seen value of the battery's current (milliamps)	Yes	No	RX
RxTemperature	44	Last seen value of the power board's temperature (celsius)	Yes	No	RX
EthIPAddr	45	Network Static IP Address if no DHCP	Yes	Yes	TX
EthNetMask	46	Network Subnet Mask if no DHCP	Yes	Yes	TX
EthGateway	47	Network Gateway if no DHCP	Yes	Yes	TX
EthDNS	48	Network DNS Server	Yes	Yes	TX
EthUseDHCP	49	Device should use DHCP on the network	Yes	Yes	TX
EthUseLLA	50	Device should fallback to Link-Local Addressing if DHCP fails	Yes	Yes	TX
DevMACOUI	51	MAC Address Organizationally Unique Identifier	Yes	No	Both
DevMACSpecific	52	MAC Address Specific Identifier	Yes	No	Both
EthMTU	54	Ethernet MTU	Yes	Yes	TX
EthTCPTTL	56	TCP Time to Live	Yes	Yes	TX
EthUDPTTL	57	UDP Time to Live	Yes	Yes	TX
EthUseDNS	58	Use DNS	Yes	Yes	TX
EthTCPKeepAlive	59	Keep TCP Connections Alive	Yes	Yes	TX
ChargeEnable	60	Enable or disable the ability for this device to transfer power or charge a battery	Yes	Yes	Both
RxBatteryNumCells	62	Number of cells in the battery this charger is configured to charge	Yes	Yes	RX
RxBatterymVPerCell	63	Voltage of a battery cell (in millivolts) that this charger is configured to charge	Yes	Yes	RX
MaxChargeTime	66	Maximum amount of time to charge a battery until timeout in seconds	Yes	Yes	RX
LogEnable	67	Enable logging battery charge data	Yes	Yes	TX
RxBatteryChemistry	68	Chemistry of the attached battery	Yes	Yes	RX
IgnoreBatteryCondition	70	Ignore battery condition when charging. Potentially Dangerous.	Yes	Yes	RX
PowerBoardVersion	71	Version of the power board that is running the system	Yes	No	Both
UpdaterMode	75	Mode for updating another device	Yes	Yes	TX
AccessLevel	78	Current level of access that external entities have to the system.	Yes	Yes	Both
ConnectedDevices	79	Bitset of devices connected to this device	Yes	No	TX

NAME	ID	DESCRIPTION	READ	WRITE	TR/OC AVAILABILITY
LcdVersion	80	Version of the LCD Display being used	Yes	No	TX
RadioConnectionRequest	81	Partial MAC of a device to request a connection to via radio. Uses DevMACOUI for OUI portion of MAC address. 0 to disable.	Yes	Yes	TX
CANMessageConfig	82	Configuration for what type of format to send over CAN	Yes	Yes	RX
CANID	83	Configuration for CAN bus id (requires reboot)	Yes	Yes	RX
OtaCtrl	84	Command parameter to control the firmware update process	Yes	Yes	TX
CoilCheckBaseStation	85	Partial MAC of the device that is connected to when in coil range	Yes	No	RX
RecoveryChargeEnable	86	Allow slow charging of a battery that has been over discharged	Yes	Yes	RX
CANBitRate	87	Bit rate of the CAN device (kbit/s)	Yes	Yes	RX
BatteryRestartPerCell	88	Number of millivolts per cell to allow the battery to drop before initiating charge.	Yes	Yes	RX
MaxCVChargeTime	89	Maximum charge time in seconds while battery is in constant voltage mode	Yes	Yes	RX
ThermalFans	90	Enable temperature based PWM on applicable fans	Yes	Yes	TX
PowerUnpowered	91	Periodically transmit low amounts of power to initiate charging	Yes	Yes	TX
ActiveTempAlarms	93	Bitset specifying which temperature alarms are currently active	Yes	Yes	RX
SystemMaxPowerWireless	95	Maximum amount of power that can charge the battery under wireless power (mW)	Yes	No	RX
SystemMaxCurrentWireless	96	Maximum amount of current that can charge the battery under wireless power (mA)	Yes	No	RX
SystemMaxPowerWall	97	Maximum amount of power that can charge the battery under wall power (mW)	Yes	No	RX
SystemMaxCurrentWall	98	Maximum amount of current that can charge the battery under wall power (mA)	Yes	No	RX
OnlyWallPower	99	Limit System to only charging on wall power	Yes	Yes	RX
ComputedCurrentLimit	10 0	Maximum amount of current that a battery or load will be charged with using the current power source	Yes	No	RX
DigitalOnly	10 1	Use only the digital hardware. Superseded if valid power board is detected	Yes	No	TX
StayRecovery	10 2	Stay in recovery mode for 10 minutes regardless of what the battery voltage does. Can prevent erroneous battery full detection with certain batteries.	Yes	Yes	RX
SystemMaxVoltage	10 3	Maximum amount of voltage that can charge the battery (mV)	Yes	No	RX

NAME	ID	DESCRIPTION	READ	WRITE	TR/OC AVAILABILITY
BootCount	10 4	Number of times the device has booted up	Yes	No	Both
RadioPowerLevel	10 5	Transmit power level for 2.4GHz radio	Yes	No	Both
BootloaderVersion	10 6	Current bootloader version on the device	Yes	No	Both
BaseUAVCANV1SubjectID	10 7	Starting ID for UAVCAN V1 WiBotic Subject Identifiers. Must be in range of 0 to 6143 inclusive.	Yes	Yes	RX
IMin	11 0	Minimum Battery current setpoint	Yes	Yes	RX
InputPowerSupplyLimit	11 2	Maximum amount of power that can be drawn from the 48V DC power supply	Yes	Yes	TX
BaseUAVCANV1ServiceID	11 3	Starting ID for UAVCAN V1 WiBotic Service Identifiers. Must be in range of 0 to 255 inclusive.	Yes	Yes	RX
PowerUnpoweredOnTime	11 4	Amount of time in seconds to keep a power unpowered pulse on	Yes	Yes	TX
PowerUnpoweredOffTime	11 5	Amount of time in seconds to keep a power unpowered pulse off after timeout or problem	Yes	Yes	TX
RadioMode	11 7	Spectrum Usage Schemes bitset. 0x1 disables channel scanning and uses the fixed channel. 0x2 only sends beacons when charging is enabled. 0x4 enables radio filters.	Yes	Yes	TX
RadioChannelRestrictLow	11 8	Minimum radio channel limit (inclusive) to search or set. Setting on Onboard Charger is only necessary for increased scan speed at the expense of not seeing some Transmitters.	Yes	Yes	Both
RadioChannelRestrictHigh	11 9	Maximum radio channel limit (inclusive) to search or set. Setting on Onboard Charger is only necessary for increased scan speed at the expense of not seeing some Transmitters.	Yes	Yes	Both
RadioFilter1	12 0	Slot 1 of last 3 octets of MAC address of radio to allow connection to. Setting to zero matches nothing. Top byte reserved 0.	Yes	Yes	TX
RadioFilter2	12 1	Slot 2 of last 3 octets of MAC address of radio to allow connection to. Setting to zero matches nothing. Top byte reserved 0.	Yes	Yes	TX

Parameter Response Status Codes

NAME	CODE	DESCRIPTION
Failure	0	The parameter was not set due to a general failure
Hardware Failure	1	Some hardware did not respond as expected. The parameter was not set.

NAME	CODE	DESCRIPTION
Invalid Input	2	The data that was to be written to the parameter was not valid for the parameter.
Non-critical Fail	3	The data was not written to the parameter, but this should be anticipated for the given parameter
Read only	4	The parameter is currently in a read only state and should only be read
Success	5	The data to be written to the parameter was written successfully
Not Authorized	6	The current session was not authorized to change the selected parameter
Pending	7	The parameter is being processed
Clamped	8	The parameter was set, but it was limited in value

Real-time ADC Packets

NAME	ID	DATA TYPE	DESCRIPTION
PacketCount	0	uint16_t	Packet identifier within second of time
Timestamp	1	uint32_t	Timestamp of the packet in seconds
ChargeState	2	uint8_t	Current state of system
Flags	3	uint16_t	Flags
PowerLevel	4	uint16_t	Output power level (mV)
VMon3v3	5	float	3.3v voltage (volts)
VMon5v	6	float	5v voltage (volts)
IMon5v	7	float	5v current (amps)
VMon12v	8	float	12v voltage (volts)
IMon12v	9	float	12v current (amps)
VMonGateDriver	10	float	Gate Driver voltage (volts)
IMonGateDriver	11	float	Gate Driver current (amps)
VMonPa	12	float	Power Amplifier voltage (volts)
IMonPa	13	float	Power Amplifier current (amps)

NAME	ID	DATA TYPE	DESCRIPTION
TMonPa	14	float	Power Amplifier temperature (Celsius)
VMonBatt	15	float	Battery Voltage (volts)
VMonBattProg	16	float	Charger Voltage (volts)
VRect	17	float	Rectified Voltage (volts)
TBoard	18	float	Board Temperature (Celsius)
ICharger	19	float	Charger current (amps) (may not exist on all OCs)
IBattery	20	float	Battery current (amps)
TargetIBatt	21	float	Target battery current (amps)
ISingleCharger1	22	float	Charger 1 current (amps)
ISingleCharger2	23	float	Charger 2 current (amps) (may not exist on all OCs)
ISingleCharger3	24	float	Charger 3 current (amps) (may not exist on all OCs)
RfSense	25	float	Reserved
Vmon48v	26	float	48v input voltage (volts)
Imon48v	27	float	48v input current (amps)
TmonAmb	28	float	Ambient Temperature (Celsius)
RadioRSSI	29	uint8_t	Radio Signal Strength (subtract 256 from the value to obtain estimated RSSI)
RadioQuality	30	uint8_t	Radio Signal Quality (arbitrary)
TCharger	31	Float	Charger temperature (Celsius)

Device ID

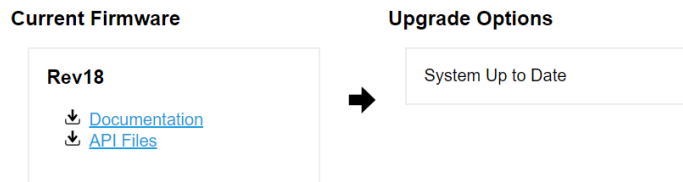
DEVICE	ADDRESS
Transmitter	1
Charger	2

APPENDIX B: PYTHON LIBRARIES

Introduction

A Python helper library and sample code is provided to help the user integrate faster with the WiBotic system and to demonstrate usage patterns. To access these files, navigate to the “Update” menu in the Control Panel GUI and select the “Check for Updates” button at the top of the page. You will be presented with the following screen (your screen may look slightly different)

WiBotic Firmware Update Download



Click on the “API Files” link to download a .zip file with the sample code. If you cannot access the files in this way, please contact sales@wibotic.com for access.

Both a lower-level interface and higher-level interface are provided.

Setup

The libraries and sample code require Python 3.8 (or greater) to be installed and the sample code was developed to run on Windows or Linux, though may run on macOS with small modifications. Beyond the basic installation of Python, an additional library will be required: websockets.

- Install Python 3.8 (or greater). <https://www.python.org/downloads/>
- [Ensure Python is correctly configured in your PATH environment variable for ease of access.](#)
- Install the websockets package. Note that the *pip* tool referenced is included with Python 3.6. <https://websockets.readthedocs.io/en/stable/intro.html> If not familiar with asyncio or Python coroutines, it is recommended that the user briefly read the following information. <http://cheat.readthedocs.io/en/latest/python/asyncio.html>

If not already done, the user should install the WiBotic UI as included and documented elsewhere in this User Guide and ensure that the Windows laptop is correctly configured to communicate with the transmitter via an Ethernet connection. If the WiBotic UI is not able to communicate with the transmitter, the Python scripts will also fail to operate.

Verify Sample Code Operation

At a command prompt window, navigate to the directory that contains all the Wibotic sample code and other python files and execute the following: `python wibotic_highlevel_sample.py`

You should see output similar to the following:

```

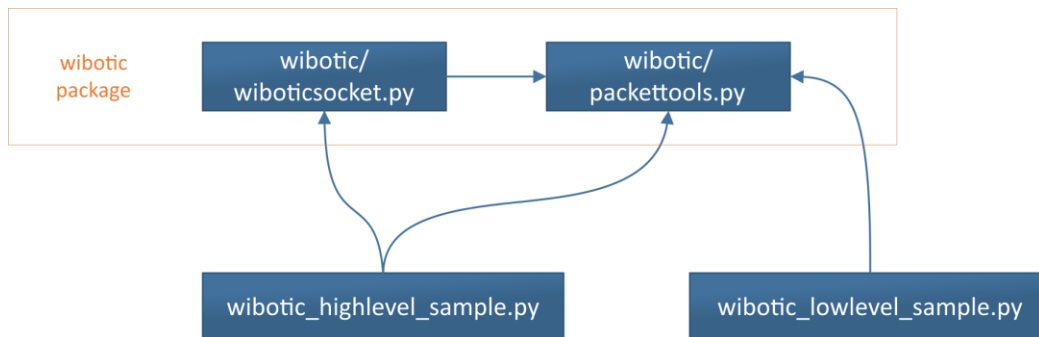
Transmitter is now enabled
=====
Transmitter
State:      RAMP_UP
Timestamp:  1 day, 1:34:16.093000
Set Power Level: 64000
PA Temperature: 28.0
=====
Charger
State:      IDLE
Timestamp:  0:16:33.045000
Battery Voltage: 12.43
Battery Current: 0.0
Temperature: 24.3
=====
Transmitter
State:      RAMP_UP
Timestamp:  1 day, 1:34:16.194000
Set Power Level: 50725
PA Temperature: 28.0

```

If you do not see this output, it is possible that either your TCP/IP settings are not configured correctly (is the WiBotic UI working?) or that the Transmitter is not configured to be at the default IP address of 192.168.2.20. In the latter case, you can modify `wibotic_highlevel_sample.py` to change the IP address to the address you have configured.

Python Development

The following diagram shows the dependency relationships between the various Python files.



Provided Code

- *wibotic/packettools.py*: low level library code to help create and parse packets used in communication with the Transmitter over the websocket interface.
- *wibotic/wiboticsocket.py*: higher level code to interact with the WiBotic system in a simpler blocking manner without having to consider asynchronous operations.

- *wibotic_lowlevel_sample.py*: Example code showing how to open the transmitter websocket directly, and communicate to the transmitter over that socket, using the low level packettools library to parse and create data packets. Because this sample connects directly to the asynchronous websocket interface it is the method of choice when requiring high frequency (10Hz) ADC data packets to be received from the Transmitter and any connected Onboard Charger/Receiver.
- *wibotic_highlevel_sample.py*: Example code showing how to use the higher level library code referenced above and implements some example commands. It sets the ChargeEnable setting to True, then it enters a loop to show the most recently received Transmitter and Onboard Charger/Receiver ADC packets.

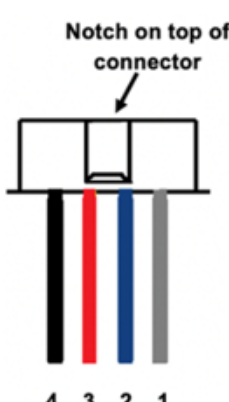
Appendix C: Onboard API

Similar in functionality to the Network API, the Onboard API allows for direct communication between your robot/drone and the WiBotic Onboard Charger. Rather than using Ethernet, however, the Onboard API uses a Control Area Network (CAN) interface - specifically “UAVCAN”, a lightweight protocol used for communication in many industrial applications (<https://uavcan.org/>). Using the CAN API, users have complete access to the WiBotic Onboard Charger for monitoring and charge setting control directly from CAN-enabled robot controllers. We currently have full support for UAVCAN V0 and UAVCAN V1 (enabled when a UAVCAN V1 heartbeat is detected).

CAN Interface

See the “Connectors” diagram on Page 15 of this User Guide for the specific location of the CANBus connector on each OC model. The following diagrams shows the CAN cable pinouts for the referenced models. Note that wire colors may be different depending upon the brand of connector or cable used.

OC-150, OC-251, OC-301 and OC-1000 CAN CABLE PINOUT



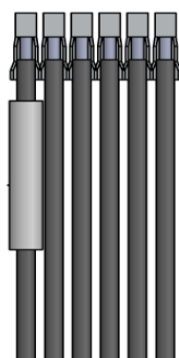
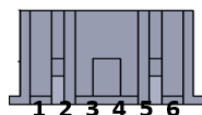
Notch on top of connector

4 3 2 1

Pin	Function	Description
Pin 1	VIN (or unused in older models)	Auxiliary power input (9-55VDC, ~20mA max) to provide standby power for MCU. Useful when there is not a direct battery connection to the OC. <i>(For the OC-110, OC-210, OC-251 prior to Rev B, and OC-301 prior to Rev B, Pin 1 is unused)</i>
Pin 2	CAN_L	CAN Low. User should provide an appropriate termination resistor to CAN_H. Due to relatively low data rate, this resistor can be physically located remotely.
Pin 3	CAN_H	CAN High. Termination resistor is NOT included on-board, to allow flexibility for additional devices on CAN bus.
Pin 4	GND	Common Ground

CAN cable connector type:
JST PHR-04 AWG 24

OC-262-ST CAN CABLE PINOUT



WiBotic cable has
heat shrink on Cable 1

Pin	Function	
Pin 1	GND	Common ground.
Pin 2	VIN	Auxiliary power input (9-55VDC, ~20mA max) to provide standby power for MCU. Useful when there is not a direct battery connection to the OC.
Pin 3	CAN_L	CAN Low. User should provide an appropriate termination resistor to CAN_H. Due to relatively low data rate, this resistor can be physically located remotely.
Pin 4	CAN_H	CAN High. Termination resistor is NOT included on-board, to allow flexibility for additional devices on CAN bus.
Pin 5	GPO	Optional programmable General Purpose Output (12VDC max, 100mA max, 24Ω series). Enough to power LEDs, relays, small fans, and logic circuits.
Pin 6	RSVD	Reserved. No function at this time.

CAN Cable Connector Type:
JST PAP-06V-S

OC-262-WP CAN CABLE PINOUT

WIRE VIEW



FRONT VIEW



Plug	Potted Cable	Molded Cable	Function	Description
740-000027	770-000022 RevA	770-000022 RevB		
Pin 1	Black	Black	GND	Common ground.
Pin 2	Red	Orange	VIN	Auxiliary power input (9-55VDC, ~20mA max) to provide standby power for MCU. Useful when there is not a direct battery connection to the OC.
Pin 3	White	White	GPO	Optional programmable General Purpose Output (12VDC max, 100mA max, 24Ω series). Enough to power LEDs, relays, small fans, and logic circuits.
Pin 4	Yellow	Brown	CAN_H	CAN High. Termination resistor is NOT included on-board, to allow flexibility for additional devices on CAN bus.
Pin 5	Blue	Blue	CAN_L	CAN Low. User should provide an appropriate termination resistor to CAN_H. Due to relatively low data rate, this resistor can be physically located remotely.
Pin 6	Green	Green	RSVD	Reserved. No function at this time.

CAN Cable Connector Type:
Switchcraft 16982-6SG-522

USB to CAN Adaptor



It is possible to communicate with an Onboard Charger via CAN through any device that has a USB port by using a USB2CAN converter (or similar) and adapter cable. Two options can be found at the link below, but any good USB-to-CAN adapter should do the job.

8Devices Korlan USB2CAN: https://shop.8devices.com/index.php?route=product/product&path=67&product_id=95

Peak System PCAN-USB adapter: <https://www.peak-system.com/PCAN-USB.199.0.html?&L=1>



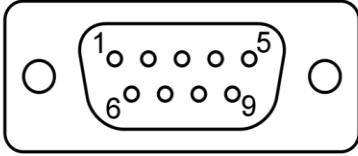
Note: A 120 Ω terminator resistor must be placed between CAN High and CAN Low on each end of the bus (but not every node) as per ISO-11898 standard. The WiBotic OC does not have a built in termination resistor.

The adapter cable must be plugged into the USB2CAN device with the wires connecting the JST connector for the CAN bus on the on-board charger.

Pin-out for USB to CAN Adaptor

PIN	SIGNAL	DESCRIPTION
1	-	No Connection
2	CANL	CANL bus line (dominant low)
3	CAN GND	Can Ground
4	-	No Connection
5	CAN_SHLD	Connected to CAN GND via 100 Ω /0.1 μ F
6	CAN GND	Can Ground
7	CANH	CANH bus line (dominant high)
8	-	No Connection
9	-	No Connection

USB2CAN Device Connector



CAN API

WiBotic's CAN API uses the UAVCAN protocol (<https://uavcan.org/>). UAVCAN handles the packet serialization and communication when using the API through the CAN bus. How information is sent through UAVCAN is determined by its DSDL (data structure description language) definition. The system currently has full support for both V0 and V1 of the protocol. V1 support is disabled until the WiBotic OC sees other V1 packets (like a heartbeat).

Adjustments to the data sent out from the on-board charger and the ID of the CAN bus can be changed by modifying the *CANMessageConfig* and *CANID* NVM parameters on the on-board charger. For access to all data accessible via the CAN API use custom WiBotic provided DSDL definitions.

Basic Setup (DroneCAN, formerly UAVCAN V0)

Python is a programming language that allows for quick setup and execution of commands. Detailed documentation of the programming language itself can be found at: <https://www.python.org/doc/>. When using the CAN API via Python it is strongly recommended that Python 3.8 or greater is used.

Windows

1. Navigate to the official Python website and download the latest version of Python 3: <https://www.python.org/downloads>. For this guide we chose to download the executable installer.
2. Run the downloaded executable.
3. Make sure the "Add Python 3.x to PATH" box is checked and click "Install Now."
4. Install a CAN driver for Windows (See vendors best practice). Use the vendor specified CAN tools to set the CAN interfaces bitrate to 500000.
5. Open a Command Prompt.
6. Run: `pip install uavcan`

Now you can either select the Python executable or type `python` into the command prompt to use Python.

Linux (Debian based)

1. Make sure the systems package information is up to date by running: `sudo apt-get update`.
2. Install Python 3 by running: `sudo apt install python3`.
3. Install PIP by running: `sudo apt install python3-pip`.
4. Install the UAVCAN Python library by running: `sudo -H pip3 install uavcan`.
5. Install a native CAN interface package (e.g. SocketCAN or pyserial). For this example, we install SocketCAN by running: `sudo apt install can-utils`.
6. If necessary for your CAN hardware, load the CAN kernel modules. Most CAN adapters do not need these modules; however, built in CAN interfaces like on a BeagleBone generally do:

```
sudo modprobe can
sudo modprobe can-dev
sudo modprobe can-raw
```

7. Bring up the CAN interface by running: `sudo ip link set up can0 type can bitrate 500000`.

8. Confirm CAN interface is running by checking: `ip addr`.
9. (Optional) For debugging purposes when using SocketCAN running the command `candump can0` will display the raw communications happening on the CAN bus.

```
can0 012 [8] DA EB B1 68 03 4A 00 80
can0 012 [8] 00 00 00 00 00 00 00 20
can0 012 [8] 00 00 00 00 00 00 00 00
can0 012 [8] 00 00 00 00 57 69 42 20
can0 012 [6] 6F 74 69 63 00 40
can0 012 [8] D8 03 03 4A 00 00 C4 81
can0 012 [8] 2C 00 00 B1 68 00 00 21
can0 012 [7] 00 00 00 00 00 00 41
```

`candump` should result in a stream of data that looks similar to the image.

Talking over CAN

In order to talk to an Onboard Charger across CAN, the UAVCAN protocol must be setup. For ease of use it is recommended that `pyuavcan` (which was installed as a part of setup) is used. More descriptions of how to use `pyuavcan` can be found here: https://dronecan.github.io/Implementations/Pydronecan/Tutorials/2._Basic_usage/

Setting up a DroneCAN (formerly UAVCAN v0, see <https://dronecan.github.io>) Node in Python

1. Open a Python 3 terminal.
2. Import UAVCAN by typing: `import uavcan`
3. Setup node information (NOTE: lines starting with “#” are interpreted as comments in Python):

```
# Creates a Node Info object
node_info = uavcan.protocol.GetNodeInfo.Response()

# Set the name of the object
node_info.name = 'org.uavcan.pyuavcan_demo'

# Set the version of the node
node_info.software_version.major = 1

# Gives the node a unique ID
node_info.hardware_version.unique_id = b'12345'
```

4. Initialize a node to your device (make sure to replace `can0` with your device name if it differs) and start it spinning in another thread:

```
node = uavcan.make_node(
    'can0',
    node_id=123,
    node_info=node_info,
    mode=uavcan.protocol.NodeStatus().MODE_OPERATIONAL)

# Start the UAVCAN node in its own thread
import threading
```



```
threading.Thread(target=node.spin, daemon=True).start()
```

After this the node variable is all set and ready to use.

Including WiBotic's DSDL definitions

The function `uavcan.load_dSDL(PATH)` can be used to load WiBotic's DSDL definitions as a third party definition. This will add the `thirdparty` path to the definition (e.g. `uavcan.thirdparty.wibotic.*`).

Sending a Message Over the CAN Bus with a UAVCAN Node

For this example, we will send a command to change the Onboard Charger's maximum top-off charge time to 36000 seconds.

1. Make sure to have already setup your node. We will be using the variable name "node" for this example.
2. Create a UAVCAN GetSet request:

```
# Note - the default node ID for WiBotic systems is 18. This can be
# read or changed from the WiBotic web GUI under "CAN Settings"
target_node_id = 18

# Creates the UAVCAN GetSet request for the parameter
# VTIM - the max top off charge time for the Onboard Charger
request = uavcan.protocol.param.GetSet.Request(
    name='VTIM',
    value=uavcan.protocol.param.Value(integer_value=36000))

# Send the request to the WiBotic system on the bus
node.request(
    request,
    dest_node_id=target_node_id,
    callback=lambda event: print(uavcan.to_yaml(event)))
```

3. Create and send a parameter read message:

```
# Creates the GetSet request
request = uavcan.protocol.param.GetSet.Request(name='VTIM')

# Broadcasts the message through the CAN bus
node.request(
    request,
    dest_node_id=target_node_id,
    callback=lambda event: print(uavcan.to_yaml(event)))
```

Within a second or two you should see the message from the callback function appear with data from the Onboard Charger on the CAN bus. The value should match what was sent in the initial write request.

Provided Code

- `wibotic_can_sample.py`: Example code that shows how to read, write, and save parameters over CAN. The example sets the maximum CV charge timeout to 36000 seconds, reads the value back, and saves the change.

- `wibotic_can_battery_setting_demo.py`: Opens an interactive terminal that can be used to configure a battery. Type “help” to see the list of available commands, or “help <command>” to see detailed information on a specific command.

OpenCyphal (formerly UAVCAN V1, see <https://opencyphal.org>)

Note: Before proceeding in this section, we recommend that you review [The Cyphal Guide](#) published on the OpenCyphal forum

[Yakut](#) can be used to communicate with a WiBotic OC via a terminal on Windows, macOS, and Linux. To get started, install Python 3.8 or greater on your platform of choice (see V0 instructions above for more details).`cd ..cdcd`

Note: Going forward, this guide uses `pipenv` as a Python virtualenv wrapper, but you can use another virtualenv solution or install directly into your default python environment.

Create a new `pipenv` and install UAVCAN V1 tooling

```
$ pipenv --python 3.x
$ pipenv shell
$ pipenv install pyuavcan[transport_can_pythoncan,transport_serial,transport_udp] yakut -pre
```

Compile DSDLs used for decoding data

```
$ yakut compile https://github.com/UAVCAN/public_regulated_data_types/archive/master.zip
$ yakut compile wibotic_api/can/uavcan_v1/dsdl/dsdl_wibotic -L
https://github.com/UAVCAN/public_regulated_data_types/archive/master.zip
```

Determine how to instruct Yakut to use your CAN hardware by creating a transport string. This transport string can be passed in with the “--transport” option to yakut or stored in a `YAKUT_TRANSPORT` environment variable. More information can be found in the Yakut documentation.

Examples:

```
CAN(can.media.socketcan.SocketCANMedia('can0',8),99)
CAN(can.media.pythoncan.PythonCANMedia('usb2can:ABCDABCD, 500000), 99)
```

Read the connected OC’s info:

```
$ yakut --transport "CAN(can.media.socketcan.SocketCANMedia('can0',8),99)" call 18 uavcan.node.GetInfo.1.0 '{}'
```

Read parameters from the connected OC: (in this case the number of battery cells)

```
yakut --transport "CAN(can.media.socketcan.SocketCANMedia('can0',8),99)" call 18 uavcan.register.Access.1.0
"{'name':{'name':'CELL'}}"
```

Write parameters to the connected OC: (in this case setting the restart mV per cell to 1.374v)

```
yakut --transport "CAN(can.media.socketcan.SocketCANMedia('can0',8),99)" call 18 uavcan.register.Access.1.0
"{'name':{'name':'BRPC'},'value':{'natural32':{'value':1374}}}"
```

See live status updates from the OC:

```
yakut --transport "CAN(can.media.socketcan.SocketCANMedia('can0',8),99)" subscribe
4050:dSDL_wibotic.WiBoticInfo.1.0
```

Serializing Packets

General Concepts

DSDL (data structure description language) is a UAVCAN provided format to define data structures that can be read and written by the UAVCAN protocol. A DSDL definition is a description of how the data will be serialized and deserialized during communication.

Just setting up UAVCAN on a system will enable communication with any of UAVCAN's default DSDL definitions. WiBotic's CAN API has support for the BatteryInfo definition; however, only the temperature, voltage, and current will have values filled in.

For more in-depth information WiBotic's custom DSDL definitions can be used: WiBoticInfo and RadioBaseStation. Full details about WiBotic's custom DSDL definitions can be found under *WiBotic DSDL Definitions*.

NOTE: Endianness for receiving parameters is little endian byte order, sending is big endian byte order. WiBotic's Python and JavaScript API's handle this discrepancy for the programmer, self-written implementations need to handle endianness on their own.

WiBotic DSDL Definitions

WiBoticInfo

WiBoticInfo sends the information available from the on-board charger's ADC packets across the CAN bus.

PARAMETER	DESCRIPTION
VMonBatt	Battery Voltage
IBattery	Battery Current
VRect	Rectified Voltage
VMonCharger	Charger Voltage
TBoard	Board Temperature
TargetIBatt	Battery Target Current
ICharger	Charger Current
ISingleCharger2	Charger 2 Current
ISingleCharger3	Charger 3 Current

RadioBaseStation

RadioBaseStation sends information on a transmitter that is in radio range.

PARAMETER	DESCRIPTION
unique_id	MAC address of in range TR

 rssi Received Signal Strength Indicator of the TR radio

Parameters

NAME	CAN NAME	DESCRIPTION	READ	WRITE
Address	ADDR	Address of the device on the internal point to point wireless link	Yes	No
RadioChannel	RADC	Current device radio channel	Yes	No
DigitalBoardVersion	DBRD	Version of the digital board that is running the system	Yes	No
HardwareCommand	HCMD	Commands that manage hardware operations that are common across systems Commands: 1 = Reboot System	No	Yes
BatteryCurrentMax	IMAX	Maximum current that should be delivered to the battery in milliamps	Yes	Yes
ChargerCurrentLimit	ILIM	Current limit that the system has decided can be delivered to the battery (in milliamps)	Yes	No
MobileRxVoltageLimit	VLIM	Calculated maximum battery voltage (mV) based on chemistry, number of cells, and voltage per cell	Yes	No
RxBatteryVoltageMin	VMIN	Calculated minimum battery voltage (mV) based on chemistry, number of cells, and voltage per cell	Yes	No
BuildHash	HASH	Version hash of the firmware that is loaded on the device	Yes	No
TargetFirmwareId	FWID	Type of firmware image that is running on the device	Yes	No
RxBatteryVoltage	VBAT	Last seen value of the battery's voltage (millivolts)	Yes	No
RxBatteryCurrent	IBAT	Last seen value of the battery's current (milliamps)	Yes	No
RxTemperature	TEMP	Last seen value of the power board's temperature (Celsius)	Yes	No
DevMACOUl	MACO	MAC Address Organizationally Unique Identifier	Yes	No
DevMACSpecific	MACS	MAC Address Specific Identifier	Yes	No
ChargeEnable	ENBL	Enable or disable the ability for this device to transfer power or charge a battery	Yes	Yes
I2cAddress	I2C	Address of this device on a I2C bus	Yes	Yes

NAME	CAN NAME	DESCRIPTION	READ	WRITE
RxBatteryNumCells	CELL	Number of cells in the battery this charger is configured to charge	Yes	Yes
RxBatteryVmVPerCell	CLMV	Voltage of a battery cell (in millivolts) that this charger is configured to charge	Yes	Yes
RxBatteryChemistry	CHEM	Chemistry of the attached battery	Yes	Yes
IgnoreBatteryCondition	IGNR	Ignore battery condition when charging. Potentially Dangerous.	Yes	Yes
PowerBoardVersion	PBRD	Version of the power board that is running the system	Yes	No
AccessLevel	ACCS	Current level of access that external entities have to the system	Yes	Yes
CANMessageConfig	CNMG	Bitset for which DSDL definitions should be used to send ADC packet information. 0: None 1: BatteryInfo 2: WiBoticInfo 3: Both	Yes	Yes
CANID	CNID	ID of the CAN node on the Onboard Charger	Yes	Yes
CoilCheckBaseStation	CCHK	Partial MAC of the device that is connected to when in coil range	Yes	No
RecoveryChargeEnable	RCOV	Allow slow charging of a battery that has been over discharged	Yes	Yes
CANBitRate	CNBR	Bit rate of the CAN device (kbit/s)	Yes	Yes
BatteryRestartPerCell	BRPC	Number of millivolts per cell to allow the battery to drop before initiating charge	Yes	Yes
MaxCVChargeTime	VTIM	Maximum charge time in seconds while a battery is in constant voltage mode	Yes	Yes
ActiveTempAlarms	ATMP	Bitset specifying which temperature alarms are currently active	Yes	Yes
SystemMaxPowerWireless	SMPW	Maximum amount of power that can charge the battery under wireless power (mW)	Yes	No
SystemMaxCurrentWireless	SMIW	Maximum amount of current that can charge the battery under wireless power (mA)	Yes	No
SystemMaxPowerWall	SMPM	Maximum amount of power that can charge the battery under wall power (mW)	Yes	No
SystemMaxCurrentWall	SMIM	Maximum amount of current that can charge the battery under wall power (mA)	Yes	No
OnlyWallPower	FWAL	Limit System to only charging on wall power	Yes	Yes
ComputedCurrentLimit	CCLI	Maximum amount of current that a battery or load will be charged with using the current power source	Yes	No
StayRecovery	STRE	Stay in recovery mode for 10 minutes regardless of what the battery voltage does. Can prevent	Yes	No

NAME	CAN NAME	DESCRIPTION	READ	WRITE
		erroneous battery full detection with certain batteries.		
SystemMaxVoltage	VMAX	Maximum amount of voltage that can charge the battery (mV)	Yes	Yes
Boot Count	BOOT	Number of times the device has booted up	Yes	No
RadioPowerLevel	RPOW	Transmit power level for 2.4GHz radio	Yes	No
Bootloader Version	BTLD	Current bootloader version on the device	Yes	No
BaseUAVCANV1SubjectID	BUID	Starting ID for UAVCAN V1 WiBotic Subject Identifiers. Must be in range of 0 to 6143 inclusive	Yes	Yes
IMin	IMIN	Minimum battery current setpoint	Yes	Yes
BaseUAVCANV1ServiceID	BSID	Starting ID for UAVCAN V1 WiBotic Service Identifiers. Must be in range of 0 to 255 inclusive.	Yes	Yes

Parameter Status Codes

NAME	CODE	DESCRIPTION
Failure	0	The parameter was not set due to a general failure
Hardware Failure	1	Some hardware did not respond as expected. The parameter was not set.
Invalid Input	2	The data that was to be written to the parameter was not valid for the parameter.
Non-critical Fail	3	The data was not written to the parameter, but this should be anticipated for the given parameter
Read only	4	The parameter is currently in a read only state and should only be read
Success	5	The data to be written to the parameter was written successfully
Not Authorized	6	The current session was not authorized to change the selected parameter
Pending	7	Item is waiting to be processed
Value Clamped	8	The set value has been limited into a safer range for the given parameter

UAVCAN V0 GUI Tool

The UAVCAN GUI tool (https://legacy.uavcan.org/GUI_Tool/Overview/) be used for interacting with WiBotic OC's.

Windows

Download and install the latest MSI package from https://files.zubax.com/products/org.uavcan.gui_tool

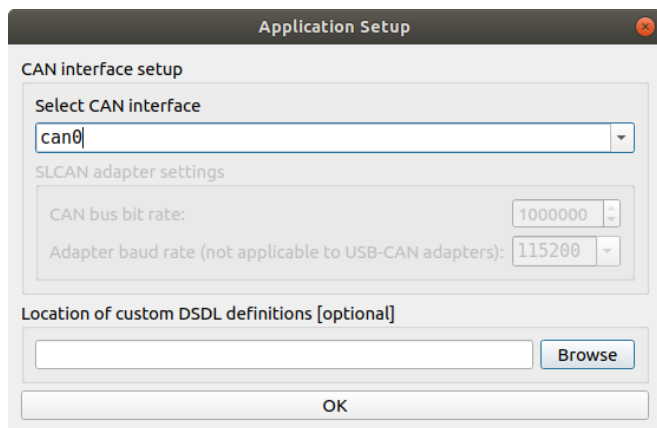
Linux (Debian based)

Make sure the systems package information is up to date by running:

```
sudo apt-get update
sudo apt-get install -y python3-pip python3-setuptools python3-wheel
sudo apt-get install -y python3-numpy python3-pyqt5 python3-pyqt4.qtsvg git-core
sudo apt-get install git+https://github.com/UAVCAN/gui_tool@master
```

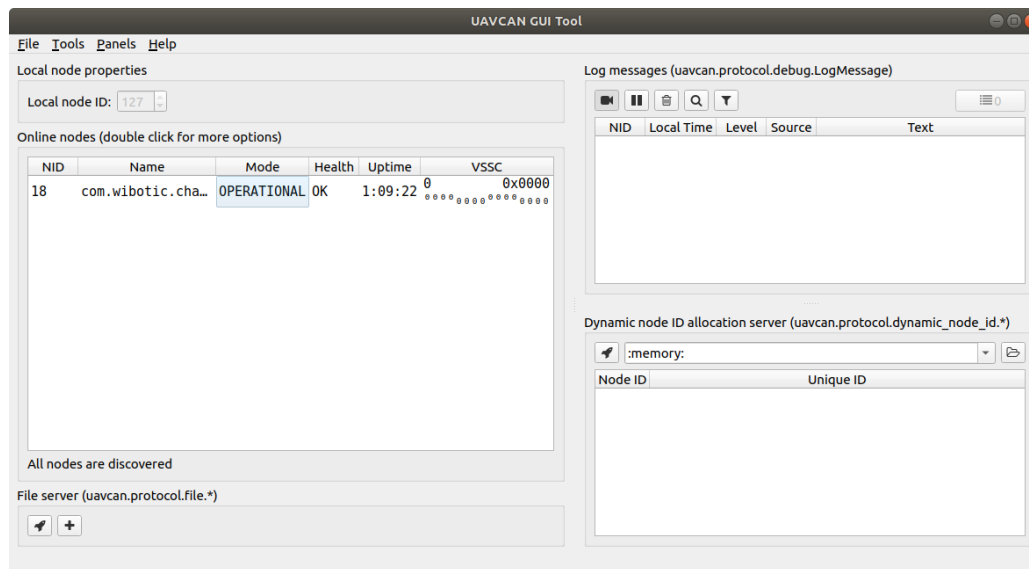
Using the UAVCAN GUI Tool

With the GUI tool installed, it can be launched from anywhere on your computer. For Linux users, open a terminal window and run `uavcan_gui_tool`. For Windows users, search for “UAVCAN GUI Tool” and run the application that is found. A setup window will appear and prompt you to select a CAN interface. If the instructions above for setting up the CAN device have been completed, the device should appear in the list. Select it and click OK to proceed.



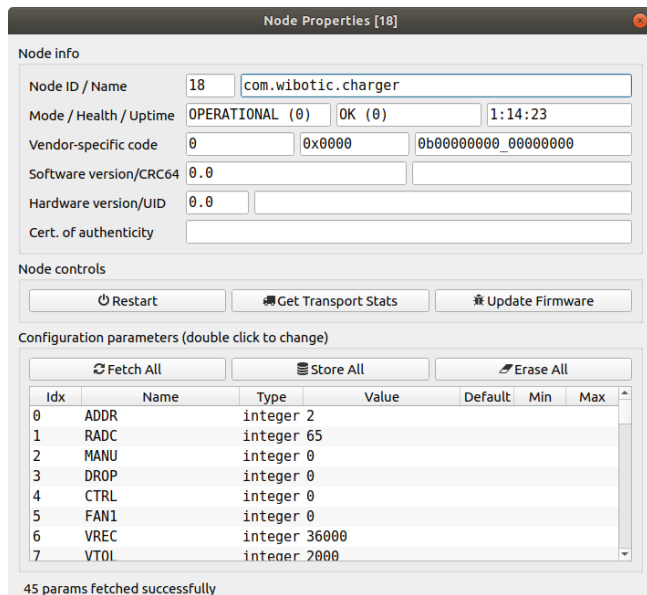
The UAVCAN GUI Tool will appear. At the top of the window, there is an option labeled “Set local node ID”. The default ID is 127 and is fine for this demonstration. This should be changed if there is already a UAVCAN device on your bus using node ID 127.

Click the check box next to the ID to assign it to your device. If your WiBotic OC has been plugged in and powered on, it should show up in the online nodes within a couple of seconds.



Configuring System Parameters

Double click on the online WiBotic charger to view detailed information about the UAVCAN node. From here, parameters can be inspected and manipulated, and firmware can be updated. To view system parameters, click “Fetch All” under the Configuration parameters subsection. The list will populate with parameter names and values.



Double clicking on a parameter opens up a window that will allow you to set a new value. For this example, scroll to the bottom of the list and double click the parameter named “VTIM”. From the parameter description above, we can see that VTIM corresponds to the parameter MaxCVChargeTime, which sets the maximum time that an OC will charge a battery in CV mode. In the value box, change the number to 3600, meaning 3600 seconds (or 1 hour), and click “Send”.

The screenshot shows a dialog box titled "Edit configuration parameter". It has a close button in the top right corner. The dialog contains the following fields and buttons:

- Name:** A text field containing "VTIM".
- Type:** A text field containing "integer".
- Min/Max:** Two text fields. The first contains "23372036854775808" and the second contains "23372036854775807".
- Default:** An empty text field.
- Value:** A text field containing "3600".
- Buttons:** Four buttons at the bottom: "Fetch" (with a circular arrow icon), "Send" (with a lightning bolt icon), "Restore" (with an upward arrow icon), and "Cancel" (with an 'x' icon).

The parameter will now be changed on your system. Close the window and you will see that the parameter value has been updated. To save the parameter to memory so that it will remain 3600 across reboots, click the "Store All" button. **NOTE:** This will save all parameters that have been changed. If you only wish to save certain parameters, set and save those first before manipulating other parameters.

Updating System Firmware

Firmware can also be updated using the UAVCAN GUI Tool. From the same Node Properties window, click the button labeled "Update Firmware". A dialog box will pop up indicating that a local dynamic node ID allocator is not configured. This is not necessary for upgrading firmware on WiBotic OC's, so click Yes to continue.

A file selector will appear. Select a WiBotic OC firmware file and the update will proceed automatically. You will see the mode of your WiBotic OC will change to "SoftwareUpdate" as the update is written to your device. When the update completes, the OC will reboot and the mode will change back to "Operational".

Appendix D: Charge Cycle Options

This Appendix provides an overview of the currently available charging algorithms for Wibotic-supported battery chemistries. Each of these charge cycles has been created following industry standards and feedback from battery manufacturers.



CAUTION: The following charge cycles should only be used with their identified battery chemistries. For instance, never select a Lead Acid charge cycle to use with a lithium battery or any other battery type.

It should also be noted that there are four different charge cycles for Lead Acid batteries. The Lead Acid battery's specific chemical and metal composition, its physical design (sealed vs. open/wet), and the way it is used (deep vs. shallow discharge) are all important factors to consider when choosing the correct cycle. Always refer to your battery manufacturer's specifications when deciding which charge cycle to use.

Overview

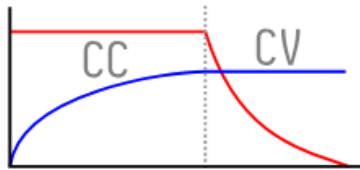
WiBotic Onboard Chargers are inherently programmable, meaning they can be configured to output different voltages and currents at stages throughout the charge cycle. Charge termination can also be implemented based on various measurements or timeouts. The system currently supports 10 different battery charge cycles as described below the following chart.

Selection	Description	Default Volts per Cell (Charge Voltage)
Custom	Fully customizable battery settings	N/A
Lithium Ion / LiPo	Lithium Ion batteries (including Lithium Polymer batteries commonly used on aerial drones). CC/CV Charge Cycle	4.2
NiCad	Nickel Cadmium batteries. Negative ΔV Charge Cycle	1.8
Lead Acid (IU)	Lead Acid batteries. Standard CC/CV Charge Cycle	2.44
LiFePO4	Lithium Iron Phosphate batteries. CC/CV Charge Cycle	3.65
LiHV / TB47/48/50/55	Lithium Ion batteries for DJI Drones. CC/CV Charge Cycle	4.35
NiMH	Nickel Metal Hydride batteries. Negative ΔV Charge Cycle	1.65
Lead Acid (IUoU)	Lead Acid batteries. CC/CV with Float Charge Cycle	2.46
Lead Acid (IUIPulse)	Lead Acid batteries. Standard CC/CV with Pulse Charge Cycle	2.46
Lead Acid (IUIdV)	Lead Acid batteries. Standard CC/CV with Voltage Change Rate Charge Cycle	2.46

Custom

The Custom charge cycle is designed to allow flexible battery settings for users who may have unique batteries or who wish to more precisely define the charge current and voltage. Most commonly, the user will enter “1” for the number of cells and then enter a very specific Charge Voltage (such as 29.6V). This is an easier way to adjust the Charge Voltage compared to modifying the number of cells and per-cell voltage in the other cycles.

This charge cycle then follows a two stage Constant Current/Constant Voltage process as described and shown in the image below.



Stage 1: Constant current is delivered to the battery at the Maximum Battery Charge Current level entered by the user via the battery settings page. As current is delivered, battery voltage will rise toward the programmed Charge Voltage for the battery pack. This stage ends when the voltage reaches the Charge Voltage. At this point the battery is typically at approximately 80% State of Charge (SOC).

Stage 2: When the Charge Voltage is reached, charge current will begin to drop. It will steadily decline as the battery's SOC increases from 80% to 100%. When the charge current drops to the level entered into the “Charge Termination” section in the Battery Settings, the battery is considered “full” and the WiBotic system will cease charging.

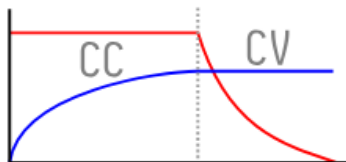
As described earlier in the User Guide, the Charge Termination value is entered as a fraction of the programmed charge current. For instance, for many batteries the battery is considered full when the charge current drops to 10% of the programmed value. Therefore, the value entered for Charger Termination on the Battery Settings page would be “0.1”. However, this is always a user-settable parameter so other charge termination values can be used if desired.

If the robot remains at the charging station after Charge Termination, it is possible that its battery will begin discharge due to the load from onboard systems. The WiBotic system will monitor battery voltage until the “Restart Threshold” is met, at which point charging will resume to again top off the battery.

Lithium Ion/ LiPo

The Lithium Ion / LiPo cycle is designed for common Lithium battery chemistries with a nominal voltage of 3.7V/cell. There are many types of these batteries, but one of the most common is the “pouch” system unprotected “LiPo” batteries used with aerial drones. These cells charge up to 4.2V during the charging process.

This charge cycle follows a two stage Constant Current/Constant Voltage process as described and shown in the image below.



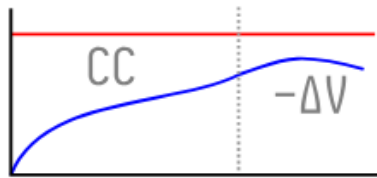
Stage 1: Constant current is delivered to the battery at the Maximum Battery Charge Current level entered by the user via the battery settings page. As current is delivered, battery voltage will rise toward the programmed Charge Voltage for the battery pack. This stage ends when the voltage reaches the Charge Voltage. At this point the battery is typically at approximately 80% State of Charge (SOC).

Stage 2: When the Charge Voltage is reached, charge current will begin to drop. It will steadily decline as the battery's SOC increases from 80% to 100%. When the charge current drops to the level entered into the "Charge Termination" section in the Battery Settings, the battery is considered "full" and the WiBotic system will cease charging.

As described earlier in the User Guide, the Charge Termination value is entered as a fraction of the Maximum Battery Charge Current.

NiCad

Although used less often in modern autonomous devices, the WiBotic charging system nonetheless supports Nickel Cadmium batteries. Nickel-based batteries are slightly more complex to charge than Lithium and Lead Acid batteries and have a unique charge termination process known as "Negative Delta V". As described below, this is a three staged process whereby a change in battery voltage ultimately signals the "battery full" condition:



Stage 1: Constant current is delivered to the battery at the beginning of the charge cycle causing a rapid initial rise in battery voltage. The rate of increase then slows as the battery charges from approximately 20% and 80% SOC. During this period the battery is efficiently absorbing energy and thus remains relatively cool.

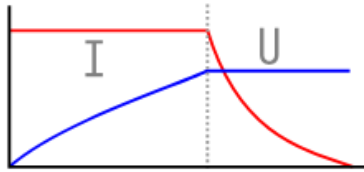
Stage 2: Current remains constant at the Stage-1 level during Stage 2, which results in a continued increase in battery voltage until a maximum safe overvoltage level is reached. During this period pressure from internal gasses and battery temperature both increase.

Stage 3: The NiCad battery will enter a phase where voltage slightly decreases (the dip in the plot above). The WiBotic Onboard Charger looks for this decrease and considers the battery full when voltage has dropped 0.005V per cell from the peak. Ending the charge cycle at this point keeps the battery from overheating or venting internal gasses. Note that batteries may not get to the maximum voltage specified due to the nature of the way negative delta V charge cycles are terminated; this is normal and expected.

If the robot remains at the charging station after Charge Termination, it is possible that its battery will begin to discharge due to onboard systems. The WiBotic system will monitor battery voltage until the "Restart Threshold" is met, at which point charging will resume to again top off the battery.

Lead Acid (IU) Constant Current/Constant Voltage

The IU charge cycle is essentially a Constant Current/Constant Voltage cycle that is similar to the cycle used for many Lithium battery chemistries. This is a two-stage algorithm as shown in the following chart.



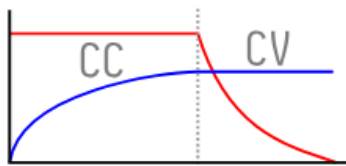
Stage 1: Constant current is delivered to the battery at the level entered by the user via the battery settings page. As this constant current is delivered, battery voltage will rise toward the programmed “Charge Voltage” for the battery pack. This stage ends when the voltage reaches the Charge Voltage. At this point the battery is typically at an 80% State of Charge (SOC).

Stage 2: When the Charge Voltage is reached, charge current will begin to drop. It will steadily decline as the battery SOC increases from 80% to 100%. When the charge current drops to the level entered into the “Charge Termination” section in the Battery Settings, the battery is considered “full” and the WiBotic system will cease charging. As described earlier in the User Guide, the Charge Termination value is entered as a fraction of the Maximum Battery Charge Current. For instance, for many batteries the battery is considered full when the charge current drops to 10% of the programmed value. Therefore, the value entered for Charge Termination on the Battery Settings page would be “0.1”. However, this is a user-settable parameter so other charge termination values can be used if desired.

If the robot remains at the charging station after Charge Termination, it is possible that its battery will begin to discharge due to onboard systems) the WiBotic system will monitor battery voltage until the “Restart Threshold” is met, at which point charging will resume to again top off the battery.

LiFePO4

The stages of the Lithium Iron Phosphate (LiFePO4) charge cycle are identical to the CC/CV process described for Lithium Ion / LiPo batteries above.

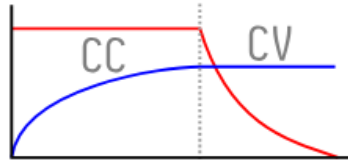


The primary difference between the two charge cycles, however, is the default per-cell Charge Voltage. For LiFePO4 batteries a value of 3.65V/cell is the industry standard (compared to 4.2V/cell for Lithium Ion).

LiHV / TB47/48/50/55

LiHV (or Lithium - High Voltage) batteries are very similar to the LiPo batteries and are commonly found with pouch style cells. LiHV has a slightly higher energy density than standard LiPo batteries as well as a higher operating voltage. These benefits combine to provide more propeller thrust for the same size and weight as LiPo batteries, making them popular for aerial drone applications. The specific TB47, TB48, TB50 and TB55 models listed here are DJI drone battery models that use the LiHV chemistry..

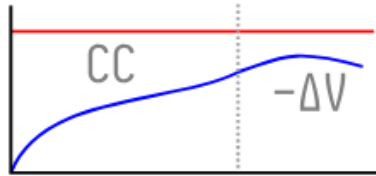
The stages of the Lithium High Voltage (LiHV) charge cycle are identical to the CC/CV process described for Lithium Ion / LiPo batteries as shown below.



The primary difference between the two charge cycles is the default per-cell Charge Voltage , For LiHV batteries a value of 4.35V/cell is the industry standard (compared to 4.2V/cell for LiPo and Lithium Ion).

NiMH

Nickel Metal Hydride (NiMH) batteries are another long-established battery chemistry support by WiBotic OCs. The charge cycle for these batteries matches that of the NiCad batteries described above. A change in voltage at the end of the charge cycle signals the Battery Full condition and turns off the WiBotic charger.



The primary difference between NiCad and NiMH batteries, however, is the default per-cell Charge Voltage , For NiMH batteries a value of 1.65V/cell is the industry standard, whereas 1.8V/cell is standard of NiCad. Note that batteries may not get to the maximum voltage specified due to the nature of the way negative delta V charge cycles are terminated; this is normal and expected.

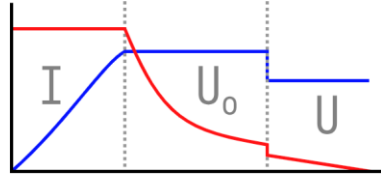
Lead Acid (IUoU) “Float”

This algorithm follows a 3-stage charge cycle that includes a “float” period to maintain full charge once the Charge Voltage is achieved. This “Float Voltage” is typically a lower voltage than the main Charge Voltage. It helps the battery maintain full SOC over a longer period without causing damage to the battery. When the IUoU charge cycle is selected, an additional input field labelled “Final Voltage per Cell” is provided in the Battery Settings menu as shown here.

Float Voltage per Cell Final float voltage for lead acid charge cycle	2.27 ↑ ↓ V
Float Voltage	36.32 V

We recommend setting the Float Voltage per Cell value based on your battery manufacturer’s recommendations. The Control Panel then uses the number of cells to calculate and display the Float Voltage for the battery pack.

The IUoU algorithm then follows the stages shown in the following image:



Stage 1: This stage is identical to the first stage in the IU cycle. Constant Current (CC) is delivered to the battery at the level entered by the user via the battery settings page. As current is delivered, battery voltage will rise toward the programmed “Charge Voltage” for the battery pack. This stage ends when the voltage reaches the Charge Voltage. This is sometimes referred to as the “bulk” stage.

Stage 2: Similar to the IU cycle, this stage maintains Constant Voltage (CV) while current decreases. As with the IU cycle, this stage is complete when the Charge Termination current is reached. This is sometimes referred to as the “absorption” stage.

Stage 3: Stage 3 of this cycle resets the OCs output voltage to the Float Voltage per Cell value (multiplied by the # of cells). Operating at this lower voltage allows the system to maintain the battery’s SOC without causing damage. This phase will last until the “Maximum Total Charge Time” and “Maximum Top Off Time” timers expire. If users wish to keep the battery in a float condition perpetually, then a very large value should be entered for both timers (see the Charge Settings section of the User Guide for more details on these timers) of time.

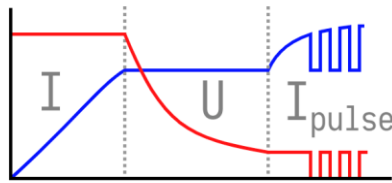
Lead Acid (IUI) “Pulse”

IUI Pulse charging is another 3-stage charging algorithm that uses short pulses of current at the end of the cycle to help extend overall battery lifespan. Like the IUoU cycle, this cycle requires an additional input. Instead of a “Float” voltage, however, the user is asked to enter a Final Voltage Per Cell value as shown below. The Control panel will then calculate the Final Voltage for the battery pack based upon the number of cells.

Final Voltage per Cell Final float or overcharge voltage for lead acid charge cycle	2.27 V
Final Voltage	36.32 V

Unlike the IUoU cycle, the Final Voltage Per Cell in the IUI Pulse method is typically *higher* than the main Volts per Cell setting. We recommend checking with your battery vendor to determine the proper pulse voltage for your specific battery model.

Once selected and configured, this algorithm then follows a 3-stage charge cycle as shown below. However, the final “pulse” charge stage has a variable duration based upon many factors which are explained in the Stage-3 description.



Stage 1: This stage is identical to the first stage in the above cycles. Constant Current (CC) is delivered to the battery at the level entered by the user via the battery settings page. As current is delivered, battery voltage will rise toward the programmed “Charge Voltage” for the battery pack. This stage ends when the voltage reaches the Charge Voltage.

Stage 2: Similar to the other cycles, this stage maintains Constant Voltage (CV) while current decreases. As with the other cycles, this stage is complete when the Charge Termination current is reached.

Stage 3: After the Charge Termination Current is reached, this cycle resets the OC’s output voltage to the value shown in the Final Voltage field. For instance, a value of 2.5V/cell on a six-cell battery would result in an output of 15V. Charge current, however, is not increased and remains at its final Stage-2 level.

This stage will terminate when battery voltage reaches the Final Voltage within 30 seconds of the start of a new pulse. It is unusual for this to occur right away, however, so multiple pulses may occur. During each pulse, the charger outputs the Final Voltage and monitors the rise in battery voltage. The following conditions apply:

Step 1: If the battery reaches Final Voltage within 30 seconds, the battery is considered full and charging terminates.

Step 2: If the battery voltage does not reach Final Voltage within 30 seconds, the charger will continue to charge until the Final Voltage is reached. *(Note that the duration of each pulse may change as the battery approaches charge termination.)*

Step 3: After Final Voltage is reached, the battery charger will turn off for a minimum of 30 second. This period may last longer than 30 seconds since charging will not start again until the battery voltage has sagged back down to the Charge Voltage.

Step 4: Once the battery has reached Charge Voltage a second pulse will start. Again, if the Final Voltage is reached within the first 30 second, the entire charge cycle is complete, and charging will be terminated. If not, the process is Steps 2 and 3 will repeat until this condition exists

In short, the charger will continue to pulse energy into the battery until one of the pulses results in a Final Voltage reading within 30 seconds of the start of the pulse. The normal Charge Timers and Top Off Timers also apply during this cycle and users may want to adjust them to allow for longer pulsing periods.

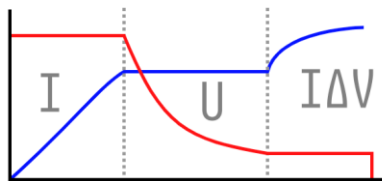
Lead Acid (IUIΔV) “DeltaV”

This charge cycle also uses a 3-stage algorithm. The final stage is considered an “equalization” stage and is terminated based upon the measured rate-of-change in the battery voltage (ΔV).

As with IUI Pulse, a Final Voltage Per Cell value must be entered to configure this cycle and the Final Voltage for the entire battery pack will be calculated and displayed based on the number of cells.

Final Voltage per Cell Final float or overcharge voltage for lead acid charge cycle	2.27 V
Final Voltage	36.32 V

The cycle itself has similar stages to the other cycles but terminates based on a different parameter:



Stage 1: This stage is identical to the first stage most cycles. Constant Current (CC) is delivered to the battery at the level entered by the user via the battery settings page. As current is delivered, battery voltage will rise toward the programmed “Charge Voltage” for the battery pack. This stage ends when the voltage reaches the Charge Voltage.

Stage 2: Similar to the other cycles, this stage maintains Constant Voltage (CV) while current decreases. As with the other cycles, this stage is complete when the Charge Termination current is reached.

Stage 3: This cycle begins by resetting the OCs output voltage to the Final Voltage value. For instance, an entered value of 2.5V/cell on a six-cell Lead Acid battery would set the charger’s output voltage to 15V.

After entering this stage, battery voltage will typically rise rapidly. However, the rate of voltage increase (ΔV) drops as this stage continues. During this stage the WiBotic charger measures battery voltage every 15 minutes and compares it with the prior value. If voltage has not increased sufficiently over the 15-minute period, the battery is considered full and charging stops. The determining value is calculated as follows: $0.01 \times \text{\# of cells}$. For a 6 cell lead acid battery this means charging will stop when the voltage has not changed by more than 0.06V over the course of 15 minutes.

Keep in mind that the overall Charge Timer and Top Off Timer are also still active and will eventually terminate charging if the ΔV value is not met.



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