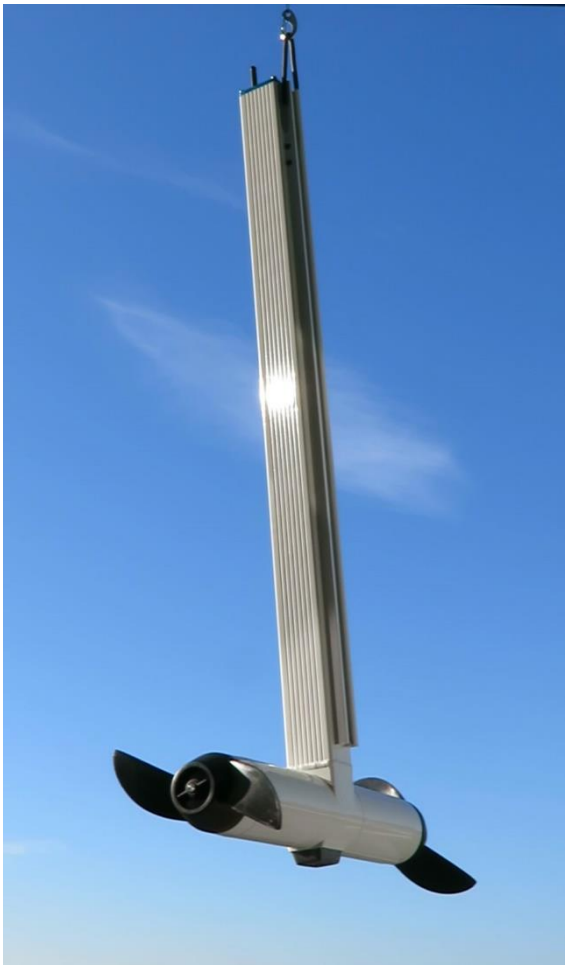
DockStar

Smart Thruster

Operations Manual



WELCOME

Thank you for purchasing a Smart Thruster from DockStar. This product was created to improve the safety and the enjoyment of recreational boating. We hope it gives you years of satisfaction with its simplicity and effectiveness.

This manual covers the operation of the Smart Thruster once the T-track and stainless tube have been mounted to the boat. See the "Bow Installation Guide" and the "Stern Installation Guide" on our Manuals page for information on how to mount your T-track and stainless tube installation kit to your boat.

The Smart Thruster is a simple device, so not much instruction is required. However, please read the instructions completely to make sure you achieve the safety and enjoyment intended. While the operation of the Smart Thruster is simple, the piloting of a recreational boat in a tight marina with wind and current is not. We strongly advise that you practice maneuvering your boat with the aid of the Smart Thruster several times in calm and uncrowded conditions before moving onto more challenging docking maneuvers. Practice is definitely required to get the feel of using this aid.

Limitations of Use for DockStar Smart Thruster

We believe this product will greatly add to your boating enjoyment and safety. As with any product, there are some limitations that must be observed.

The Smart Thruster is intended only for non-commercial recreational pleasure craft for the purpose of low-speed maneuvering assistance in sheltered harbors. The Smart Thruster is suitable for use as a bow thruster on displacement hulls with top speeds not exceeding 8 knots, and as a stern thruster on all boats with suitable clearance for raising and lower the thruster on its track. The Smart Thruster is not suitable for mounting to the bow of high-speed boats where the thruster is not able to be raised out of the path of the rushing water. Pontoon boats, for example, travel at high speed and yet allow for retracting the Smart Thruster above the deck and out of the path of the water force. This is not possible on most planning V-hull boats.

The use of the Smart Thruster is not a substitute for proper boat handling by the user. The boat should always be handled in such a way to avoid damaging the boat or other boats and docks. The Smart Thruster can only exert a finite amount of force (about 65 lbs.). It cannot compensate for excessive boat speed, excessive wind speed, or excessive currents. Practice the use of the Smart Thruster in light winds and light current until proficient in coordinating the use of the thruster with the use of the boat's main propulsion. **Problems likely will result if insufficient practice has been had.**

The DockStar Smart Thruster is designed to provide years of reliable service. However, any electro-mechanical device has failure modes. Always handle the boat such that should a failure with the Smart Thruster occur, you are able to either proceed with the docking without the Smart Thruster, or can safely abort the docking.

Do not operate the boat at speeds greater than 5 knots with the Smart Thruster deployed. The Smart Thruster is cantilevered into the water from the above-the-water mounting. Speeds greater than 5 knots put tremendous pressure on the thruster housing and this force coupled with the cantilevered mounting puts a great deal of torque on the mounting system. Operation above 5 knots with the thruster deployed may result in failure of the mounting and damage to the thruster or your boat.

The DockStar Smart Thruster installation varies from boat to boat. Make sure the Smart Thruster is properly installed to handle the forces exerted on the Smart Thruster while deployed and while underway. It is the boater's responsibility to ensure the integrity of the installation on your boat.

The DockStar Smart Thruster should be mounted such that when the boat is cruising at speed no part of the Smart Thruster is submerged even temporarily. This may require removing the Smart Thruster from its rail under some sea conditions. Submersion at speed creates tremendous forces on the Smart Thruster and could lead to damaging your boat or thruster.

The Smart Thruster is held up out of the water when retracted by the lanyard. Periodically inspect the lanyard attached to the thruster. Immediately replace any frayed line in the lanyard.

Be careful when deploying the Smart Thruster so as not to let the thruster slide down the rail too fast. Should the thruster be "dropped" down the rail the impact with the track stop could cause damage to the thruster or the boat.

The supplied battery charger limits its charging current to 4 Amps and is specifically designed to charge LiFePo batteries. Do not use another charger that supplies more than 4 Amps or one that is not intended for LiFePo batteries.

Never submerge the Smart Thruster's faceplate. It is splash proof but not suitable for submersion.

Never submerge the Smart Thruster radio transmitter. It is neither splash proof nor waterproof.

Replace the radio transmitter battery every year, or more often if you are a frequent boater. A low transmitter battery will result in unreliable communication with the Smart Thruster and could create a hazardous situation.

The Smart Thruster has a safety feature that inhibits the motor operation unless the Smart Thruster is deployed. A sensor inside the Smart Thruster inhibits the motor controller unless a strong magnetic field is sensed. A magnet assembly is located inside the installation kit's stainless tube.

The LED light in the On/Off button flashes on and off quickly to indicate the magnetic field is sensed. If this flashing pattern should be observed at any time when the motor is not deployed, turn off the Smart Thruster and do not use it until the problem is resolved.

Never place a magnet near the Smart Thruster when it is not deployed. This may allow for accidentally turning the thruster on.

Prior to deploying the Smart Thruster each time, verify that the Smart Thruster is at least 50% charged by observing the status LED in the On/Off button. Please refer to the sections below for how to interpret the LED flashing pattern.

Each time the thruster is deployed, verify its operation to both starboard and port prior to entering confined space or prior to leaving the dock if undocking.

The Smart Thruster's radio is a modern remote-control device certified to FCC requirements. It uses a frequency band assigned to remote control applications. The FCC keeps this frequency clear by limiting the permissible power of certified devices. However, it is still possible under some situations for there may be sufficient energy on this frequency as to interfere with the communication with the Smart Thruster. If you detect communication problems between the transmitter and the Smart Thruster, retract the thruster and turn it off until the problem can be resolved.

The transmitter can be assigned one of 255 different codes (see the "pairing" instructions below). The Smart Thruster must be paired with the transmitter as described in this manual prior to use. If the Smart Thruster is responding to transmissions from some other device, turn off the Smart Thruster. Try selecting a different code and pair the thruster with the radio transmitter again. If the problem persists, discontinue all use of the Thruster until the problem can be resolved.

For convenience, the Smart Thruster can be turned on in a latching manner by pressing the appropriate buttons on the radio transmitter as described later in this manual. This latching can be turned off by pressing one of the momentary control buttons on the radio transmitter. This latching is automatically turned off after 30 seconds of operation if no further button pushing occurs. This is a safety feature in case radio communications between the transmitter and the Smart Thruster are interrupted after the latching command has been issued. If radio transmissions are being interfered with, discontinue use of the Smart Thruster.

Prior to using the Smart Thruster after installation, ensure that radio transmissions can be reliably made to the Smart Thruster with the transmitter at any point on the boat

If the Smart Thruster is dropped onto a hard surface or the faceplate is submerged, discontinue use of the thruster as internal damage may have occurred that is not apparent from the outside. Use of a damaged thruster is not safe.

Do not use the Smart Thruster if one of the propellers is damaged.

Do not deploy or operate the thruster in close proximity to people swimming in the water or sitting on the dock. The spinning propeller could hurt them.

Please contact DockStar at Info@DockStarThrusters.com if you have any questions about the safe operation of your thruster.

The Smart Thruster is controlled by a wireless transmitter manufactured by Linx Technologies, one of the USA's leading wireless equipment manufacturers. The transmitter is certified by Linx Technologies to meet FCC requirements for a radio transmitter. The user does not need a license to operate this device. However, the user should be aware of the limitations in using radio transmitters in North America mentioned above (i.e. that radio interference can happen and the user should be prepared in case the Smart Thruster frequency is interfered with).

The FCC has provided the following statement pertaining to the use of wireless equipment that we are required to include in our manual. It is a generic statement to be published by the suppliers of radio equipment including equipment used in residential homes, so it is not specific to marine applications:

INSTRUCTION TO THE USER
This device complies with Part 15 of the FCC Rules and Industry Canada license-exempt RSS standard(s). Operation of this device 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.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio / TV technician for help.

The user is cautioned that changes and modifications made to the equipment without the approval of manufacturer could void the user's authority to operate this equipment.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radioexempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Safety Considerations Employed in the Design of the Smart Thruster

The impetus for founding DockStar LLC was to improve boating safety and enjoyment while docking. Safety has been an important consideration in the development of the Smart Thruster since the very beginning. The product makes boating safer by giving more maneuverability to the boater. This maneuverability can eliminate the need for jumping off the boat onto the dock with mooring lines in hand to secure the boat before it drifts away (a common scene at any marina). It also eliminates the need for running on the boat to hurriedly get the lines ashore. In addition, more maneuverability greatly reduces the risk of running into another boat or the dock in tight conditions such as in a typical marina.

It is also important the product itself be safe to use. This section discusses the Smart Thruster features that have been designed in to make it a safe product.

Motor Safety Inhibit: The Smart Thruster produces a fair amount of thrust. To make sure this power is not released at the wrong time the Smart Thruster incorporates a safety interlock scheme that prevents the motors from being turned on unless fully deployed into the water. This is accomplished by fitting a special magnet assembly into the stainless T-track and stainless tube assembly that the Smart Thruster is mounted to. The Smart Thruster has a magnetic sensor that inhibits operation of the motors unless this strong magnetic field is sensed. This inhibit function is executed in two ways. First, the software constantly monitors the magnetic sensor and inhibits the motor control software unless the sensor indicates the thruster is deployed. Secondly, the motor driver hardware is inhibited directly by the magnetic sensor signal. When the thruster is fully deployed and the motors are armed the Smart Thruster's status LED flashes a pattern to let the boater know it is armed and fully deployed.

Battery Isolation: The internal 12-volt LifePo batteries are capable of producing 100 amps of current. The electrical contacts of the battery must be accessible to the battery charger during charging. To improve safety, the battery contacts are isolated from the recharger port by a relay. This relay prevents any current flow unless the charger is plugged in. When the recharger is plugged into this port the Smart Thruster's microcomputer detects the presence of the charger by monitoring the input voltage. When the charger is detected, the relay is turned on allowing the charger current to flow into the batteries. The charger itself has circuitry that prevents it from recharging the batteries too fast. In addition, the Smart Thruster has a self-resetting fuse device that will open the circuit if excess current is detected.

Motor Current limit: The motor controller constantly monitors the current supplied to the motors from the battery. If an over-current situation occurs, the motor controller immediately turns off current to the motor. This protects the motor from damage, but it also prevents excess current draw on the batteries. The batteries employed in the Smart Thruster are LifePo technology, which is one of the safest lithium battery chemistries available. It is possible to directly short these batteries out without any fire risk (unlike many lithium technologies). Still, to be safe, the current drain from the batteries is limited by the Smart Thruster's electronics as a double safety.

Battery over-voltage protection: During charging the Smart Thruster microcomputer is constantly monitoring each individual battery cell. If an over-voltage condition is detected, the charging is stopped and the Smart Charger discharges the offending cell until it is safely within normal limits. This not only prevents excessive heat buildup in the battery cell, it also protects the life and reliability of the battery.

Battery under-voltage protection: During motor operation the motors draw considerable current from the batteries (although well below their rated 100-amp capability). Should this high current draw result in a battery cell being drained excessively, the Smart Thruster microcomputer will suspend motor operation. This again prevents excessive heat in the affected cell, it also protects the life and reliability of the battery.

Radio Communications Integrity: The Smart Thruster radio transmitter is manufactured by one of the leading U.S. wireless device manufacturers, Linx Technologies of Oregon. The Smart Thruster incorporates Linx' matching receiver module for a very robust wireless connection. As with all wireless devices, the radio frequency can be jammed. The FCC prevents this situation by limiting the transmitted power of all devices on this frequency to a very low energy level. Still, it is technically possible for the Smart Thruster to experience interference and temporarily lose connectivity with the transmitter. Although this situation has never been detected in DockStar's testing, some safety features were added to address this situation. First, the Linx Technologies transmitter and receiver must be paired together using a matching code scheme. Any transmission received that does not have the proper code is ignored. Second, the Smart Thruster microcontroller will not acknowledge a valid code command until it has been received consecutively several times. This further limits the chance of a spurious signal commanding the Smart Thruster. Lastly, the latching commands of the Smart Thruster are automatically turned off after 30 seconds unless retriggered by the user. This is in case radio interference happens to interfere with the user's command to turn the thruster off. Fortunately, modern wireless control technology is very robust. These safeguards are just additional safety measures taken by DockStar.

Mounting Hardware: The cost of creating custom components can be high. Furthermore, proving the safety and reliability of custom components can be a lengthy process. To avoid these challenges, DockStar made a decision early on not to rely on custom components for mounting the Smart Thruster. Instead, a T-track manufactured by respected marine equipment manufacturer, Schaefer Marine, was chosen as the primary mechanical interface to the Smart Thruster. This is mounted to a standard stainless-steel tube, also common in the marine industry. This allowed the use of standard marine grade rail mounting hardware. This not only gives the end-customer a large assortment of mounting fixtures, it also allows DockStar to benefit from the years of production quality behind these components. The Smart Thruster installation kits are supplied with fixtures from Suncor Marine located in Massachusetts or SeaDog Line in Washington.

Smart Thruster Operation

Thanks for reading the preceding important information. We are now ready to talk more specifically about how to operate the Smart Thruster.

Propeller Installation: The Smart Thruster is shipped without the propellers mounted to reduce the risk of damage during shipping. The propellers can be mounted without the use of tools other than the plastic sprocket wrench provided.

The propeller kit bag contains small parts. Do not open it where the parts can be lost if dropped. For example, do not assemble the props on the dock where small parts tend to jump into the water!

The propeller kit bag contains two propellers, one socket wrench, and two small plastic bags. The two small bags each contain a prop-nut and a sheer pin. Be sure to locate the sheer pins and not lose them. They are small parts and can be easily missed.

Each drive shaft has a hole through it for inserting the sheer pin. Insert a sheer pin into each drive shaft and rotate the shaft so that the pin is horizontal. This keeps it from falling out for the next step. Make sure the sheer pin is centered on the shaft.

There is a slot in the back of the propeller. The sheer pin slides into this slot when the propeller is slid onto the drive shaft. The slot in the propeller needs to be aligned with the sheer pin as the propeller is slid onto the shaft.

When the propeller is properly aligned and the sheer pin is properly engaged into the propeller's rear slot it will look like the picture on the far right. Also, spinning the propeller will turn the motor shaft which can be observed sticking out the middle of the prop. The motor resistance can also be felt when turning the propeller.

Confirm that the sheer pin is properly seated in the propeller's rear slot, by spinning the prop by hand. Using the sprocket wrench, tighten the propeller nut firmly before submerging the propellers in the water.

When properly installed the propellers should look like the one on the right. There should be about a 3/16" gap between the larger diameter of the motor and the propeller hub. There should be no play in the propeller and you should feel a slight resistance from the motors when you spin the propeller.

Remote Battery Replacement: The integrity of the transmitter's signal is important; always use a fresh battery. Replacing the battery every year, or more frequently if you are an active boater. The transmitter uses a standard CR2032 battery. Please refer to Figure 1 for replacing the battery. The battery cover is a little sticky. The end of the cover lifts straight up as shown by the red arrow. Also, like all plastics, this case gets brittle when cold so do not open the battery cover when it is cold.

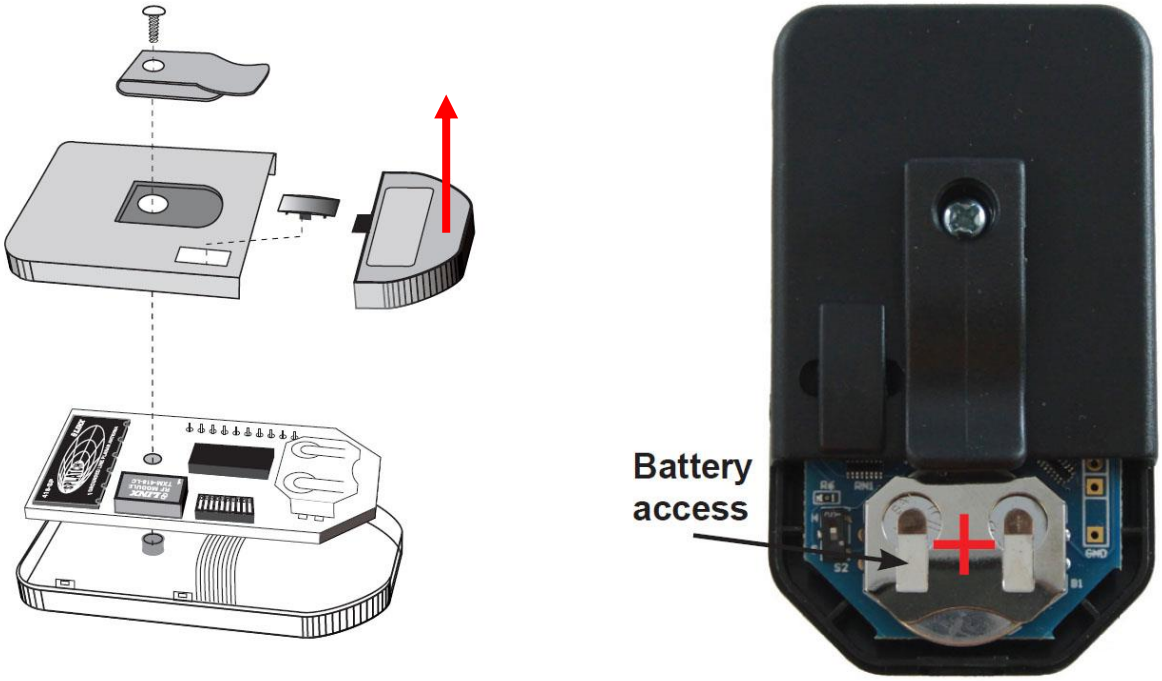


Figure 1: Battery access and replacement.

Pairing Transmitter to Smart Thruster: The next step is to pair your transmitter with your thruster. Your thruster comes with a transmitter that is already paired with your thruster. If you have both Bow and Stern Thrusters that were purchased at separate times, you can pair both transmitters to operate both devices. If they were purchased at the same time, they have already been paired, and both remotes will operate both Thrusters equally.

Pairing is accomplished by doing the following:

1. Plug the "pairing plug" (shown to the right) into the battery charger jack of the thruster to be paired.
2. Turn on the thruster
3. Observe that the pairing blinking pattern on the blue LED is correct (See table 1 later in this document)
4. To pair and configure your thruster as a BOW thruster, press and hold one of the four bow control buttons for 15 seconds.
5. To pair and configure your thruster as a STERN thruster, press and hold one of the four stern control buttons for 15 seconds.
6. Sometime in the 15 second period, the LED blinking pattern will switch from the pairing blinking pattern to solid on. At this point, the unit is properly paired and configured.
7. You can verify you have connection by releasing the button. The LED should go off. Press any bow button if configured as BOW, or any stern button if configured as STERN, and the light will go back on until that button is released.
8. Only one pairing cycle can be performed during one power up cycle. To pair the thruster to a different code, turn off the thruster and then turned it back on.
9. To pair and configure a second transmitter to the same thruster, you must change the code switches on the second transmitter to match the code switches on the first transmitter. See Figure 3. Only switches A0 through A7 are used. Switches A8 and A9 MUST always be left in the right position ("ON"). Look very carefully at the switch pattern in the first transmitter already configured. Now match that pattern on the second transmitter. A magnifying glass comes in handy here. If the codes do not match, only the last transmitter paired will control that thruster.
10. To pair and configure the transmitters to a second thruster, repeat steps 1 through 7 using one of the transmitters (with their codes already matched). You should configure one of the thrusters to be the BOW thruster and the other one to be the STERN thruster.

Figure 2: Pairing Plug

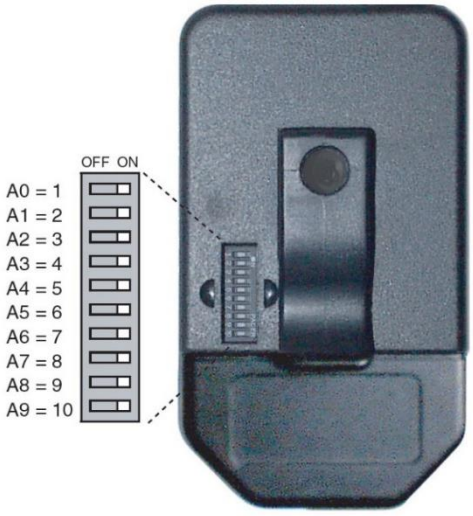


Figure 3: Code Switches

Using the Faceplate Features: There are three(3) components on the Smart Thruster faceplate:

1. The antenna (does not come installed but packaged with the remote control. Install to finger tight only; do not over-tighten please).

2. The On/Off button – Press in for ON, press out for Off. The blue LED in the center of the On/Off button blinks in a number of patterns to provide status information. Please see Table 1 later in this document to see the various blinking patterns.

3. The Battery Charging Port – Remove the charger port cover to access the charger jack. Plug the battery charger into the charger jack when recharging the batteries. Plug the "pairing plug" into the charger jack when pairing the thruster with the radio transmitter. Plug the charger port cover into the charger port grommet at all other times. Do not use the charger port cover lanyard to pull the cover out. Instead, pry the cover off with your finger nails. It is very important that the charger port cover is in place at all times except when charging or pairing. This keeps water from entering through the connector which could damage the thruster electronics.

[Note] The latest version of Smart Thruster faceplate does not have the USB Port.

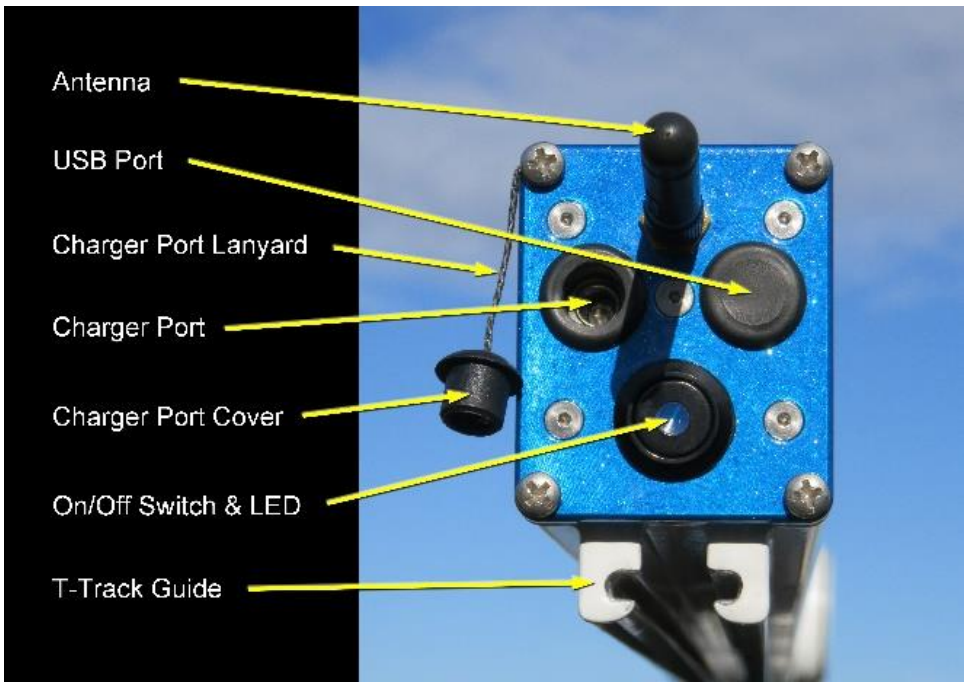


Figure 4: Smart Thruster Faceplate

Thruster Operation: When the unit is turned on, it is controlled by the radio transmitter and the magnetic interlock circuit. The magnetic interlock circuit prevents the thruster motors from being activated unless the thruster is fully slid down the T-track. This is a safety feature that keeps the motors from turning on at all other times. Referring to Figure 5 below, the magnetic interlock switch locks out commands from the transmitter when the thruster is retracted (on the left), and allows the transmitter to control the motors when deployed (on the right).

Figure 5: Thruster Retracted (Motors inhibited) and Deployed (Motors armed and ready)

With the Smart Thruster On/Off button in the ON position and the Smart Thruster deployed down the T-track, the thruster motors can be controlled by the radio transmitter. The blinking sequence of the LED indicates the status of the thruster. When the Smart Thruster is armed by the magnetic interlock circuit, the blinking pattern changes to a series of rapid blinks at uniform periods. That way the user knows when the thruster is armed.

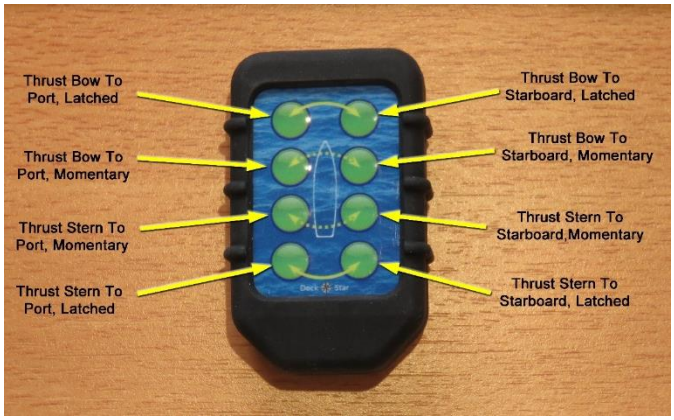
It is always a good practice for the person deploying the thruster to turn the motors on with the transmitter to verify the thruster is operating properly before entering the marina (but after the boat has slowed to 5 Knots or less). Deploying the thruster at speeds over 5 knots puts excessive force on the mounting hardware and makes it difficult for the thruster to slide down the T-track due to the increased friction forces created. This should definitely be avoided.

OK. The Smart Thruster is turned on, the transmitter and thruster have been paired, the thruster is deployed down its T-track, and the LED light is blinking rapidly and uniformly. At this point, the radio transmitter will control the operation of the thruster motors.

Both motors of the Smart Thruster turn on for both port and starboard motion, although they turn on in opposite directions. For example, when thrusting to starboard, the port motor is turned on forward and the starboard motor is turned on in reverse. They are not turned on quite at the same time. The forward motor (in our example the port motor) is turned on first and about a half second later the reverse motor is turned on. The turning on process is a ramp up from zero current to full current over a half second period. This "soft start" prolongs the life of the motors and minimizes the jerking on the T-track and mounting hardware. When turned off, the motors are both turned off at the same time, but they are turned off in a similar "soft ramp down".

The thruster's microcomputer performs these soft start and soft stop operations as well as constantly monitors for over-current, over-voltage, or under voltage conditions. This protects the motors and batteries from abuse. The user does not have to worry about throwing the motors from full forward to full reverse. This will not damage the batteries or the motors. If the user runs through a forest of bulb kelp, the motors will likely jam up, but the over-current protection will shut the motors off. (Please don't run through a forest of bulb kelp with the thruster lowered. The force on the thruster's mounting system will likely be too great).

The four buttons on the top of the transmitter control the BOW thruster and the four buttons on the bottom control the STERN thruster. These buttons should be depressed for at least half a second to make sure the command is received by the thruster. This is very important to remember when things get hectic. Be sure to practice before that happens.



The inner four buttons with the dotted line arrows are momentary buttons. In other words, the thruster is turned on as long as the button is depressed. Because of the soft start and soft stop functions, the motors are turned on for a minimum of 1 second for momentary pushes.

The outer four buttons with the solid line arrows are latching buttons. In other words, the motors are turned on as soon as one of those buttons is pushed and stay on even after being released. This latching function is automatically terminated 30 seconds after the last button push. The user can "retrigger" the latching function before the initial 30 seconds runs out. The latching function can be terminated at any time by pressing one of the appropriate momentary buttons (BOW momentary buttons do not affect STERN motors and vice versa). If the thruster is latched to starboard and the starboard momentary button is depressed, the motors will stay on for as long as the momentary button is pressed and will stop once the momentary button is released cancelling the latching function. If the port momentary button had been pushed instead, the motors will stop immediately and then reverse one second later provided the momentary button is still being pushed. The motors will stop again when the momentary button is no longer being pushed.

The two BOW buttons on the right side of the transmitter cause the thruster to push the BOW to starboard. The two BOW buttons on the left side of the transmitter cause the thruster to push the BOW to port. The two STERN buttons on the right side of the transmitter cause the thruster to push the STERN to starboard. The two STERN buttons on the left side of the transmitter cause the thruster to push the STERN to port.

Cold Weather Operation: All batteries tend to lose their effectiveness in cold weather. LiFePo batteries are known for their good performance in cold weather. However, at temperatures near freezing and below, the internal resistance of the LiFePo batteries goes up. This reduces the current draw available from the batteries. To accommodate this, the Smart Thruster turns on the "pushing motor" (the starboard motor when thrusting to port and the port motor when thrusting to starboard) first and then checks to see if the internal resistance is too high indicating a cold battery. If it is, it holds off turning on the "pulling motor". The first motor's current draw flowing through the battery's internal resistance will heat the battery up. Once sufficiently heated, the second motor will be turned on. The operator needs to be aware of this cold weather operation as the effectiveness of the Smart Thruster is reduced until the battery has had time to heat up. Please operate your boat accordingly in near-freezing weather.

Sleeping and Power Down: If there has been no activity for 2 hours, the Smart Thruster will go to sleep. This means that there will be no LED activity because the Smart Thruster is in sleep mode. It can, however, recognize when a transmitter button is being pushed while in sleep mode. An appropriate BOW or STERN button must be pushed for up to 5 seconds to wake the Smart Thruster up. The user needs to wake both the BOW and STERN thrusters up individually.

If the Smart Thruster is left in the sleep mode for an additional 6 hours, the Thruster will turn itself off completely. There will be no current drain on the batteries once the self-shut-off occurs even though the On/Off buttons is still on.

These features are for safety and to reduce draining the batteries when the thruster is accidentally left on for several days. To turn the Thruster on after it has been in self-shut-off mode, simply push the On/Off button to the Off position for 5 or more seconds and then push it back to the On position.

Decoding the Status LED Blinking Patterns: Probably the most confusing attribute of the simple-to-use Smart Thruster is decoding all the various blinking patterns of the LED on the On/Off button. This LED gives a fair amount of information that is coded in its various blinking patterns.

The blinking sequence is divided into 24 periods of 125 msec (8 periods to a second). The actual sequence of LED on and LED off are defined in Table 1 on the next page.

The following rules should help with understanding the sequences.:

- When in Normal Operation or with the charger plugged in, there is a sequence of 1, 2, 3, or 4 blinks that indicate battery charge of 0 to ¼, ¼ to ½, ½ to ¾, or ¾ to Full battery respectively.
- When in Normal Operation there is a long 1 second pulse in addition to the 1 to 4 battery status blinks.
- When the charger is plugged in to AC and plugged into the charger port, there is no additional pulse, just the 1, 2, 3, or 4 blinks. This distinguishes charging from normal operation.
- When the charger is plugged into the charger port, but no AC is applied to the charger, there is a single short blink in addition to the 1 to 4 battery status blinks. This alerts the user that the battery charger is not plugged into a 115 socket. One caution: when the charger is energized and plugged in to the Smart Thruster the microcomputer senses this and enables the internal charging relay to turn on. If the Charger AC power is removed after this happens, the Smart Thruster cannot tell that the charger is unpowered because the batteries are now driving that circuit. This can be recognized by the fact that the light on the charger itself will be off when the charger is not plugged in.
- When the “Pairing plug” is plugged in, there is a set of blinking sequences that indicate the state of pairing as shown in Table 1.
- When charging is nearing completion, there are a set of blinking patterns that give information about the state of charging and battery balancing. When the batteries are fully charged and the battery balancing routing has completed, the LED will turn on solid. Sometimes, the charge sequence will go straight to complete once the batteries are full and sometimes the charge sequence will go through a balancing period first. Both situations are normal.
- See Table 1 for all the blinking patterns used.

TABLE 1: Meaning of LED flashing patterns over 24 equal time periods

Condition	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Power Off or Sleeping																								
Charging first quarter																	☼							
Charging second quarter															☼			☼						
Charging third quarter														☼			☼			☼				
Charging fourth quarter												☼			☼			☼			☼			
Charger unplugged from AC, first quarter					☼												☼							
Charger unplugged from AC, second quarter					☼										☼			☼						
Charger unplugged from AC, third quarter					☼									☼			☼			☼				
Charger unplugged from AC, fourth quarter					☼							☼			☼			☼			☼			
Charging, Battery nearly full, Balancing	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼			☼	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼
Charging Complete	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼
Normal Operation, Battery depleted	☼	☼	☼	☼	☼	☼	☼	☼																
Normal Operation first quarter	☼	☼	☼	☼	☼	☼	☼	☼									☼							
Normal Operation second quarter	☼	☼	☼	☼	☼	☼	☼	☼							☼			☼						
Normal Operation third quarter	☼	☼	☼	☼	☼	☼	☼	☼						☼			☼			☼				
Normal Operation fourth quarter	☼	☼	☼	☼	☼	☼	☼	☼				☼			☼			☼			☼			
Transmitter Pairing Mode, waiting to be paired	☼	☼	☼	☼	☼	☼				☼	☼	☼			☼	☼		☼						
Transmitter Paired, button being pushed	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼	☼
Transmitter Paired, no button pushed																								
Thruster Lowered, Armed, and Ready		☼		☼		☼		☼		☼		☼		☼		☼		☼		☼		☼		☼

If you have any questions about the operation of the Smart Thruster please contact us at info@dockstarthrusters.com.