

ND-ULTRA TWIN TRANSDUCER ULTRASONIC ANTIFOULING SYSTEM

Installation and Operation Manual

Marine Ultrasonic Antifouling System

Ultrasonic antifouling systems prevent or hinder marine growth on hulls constructed from acoustically transmissive materials.

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Document Applicability

This document is applicable to ND-ULTRA Twin Transducer ultrasonic systems using:

- Hardware Revision 2 (PCB Rev2). These can be identified by the use of a solid red power LED during operation.

Background

The ND-ULTRA system was first developed for experimentation and research on board the 43' aluminium sloop Nordkyn in 2014 as an alternative to commercial products.

The market for ultrasonic antifouling systems has been damaged by dishonest marketing claims and poor products from some vendors targeting the yacht market, but the original experiment proved that the technology itself is interesting and has value.



Ultrasonic antifouling systems operate by inducing a low-power vibration into the hull skin, which deters organisms from attaching themselves and contributes to disrupting the formation of slime and algae growth up to a point. In spite of claims sometimes made, the vibration is confined to the hull and doesn't "travel through the water and protect nearby boats". To some extent, it can travel down rudders and propeller shafts by transmission through the bearings. These systems don't produce cavitation and a "layer of micro-bubbles against the hull" either, as more inept claims sometimes suggest. This would require the kind of power used in ultrasonic cleaning tanks and it would first strip the antifouling off.

Ultrasonic systems work best *in conjunction with* antifouling paint, as no single measure is ever completely effective at preventing hull fouling over time, regardless of some of the marketing material

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showing freshly water-blasted hulls as “results”. When installed correctly on a hull of a suitable material, an ultrasonic system can easily be up to 100% effective at preventing hard growth, such as barnacles, from attaching to the hull and developing, even in the complete absence of antifouling. Provided sufficient power is transmitted into the hull, the technology is also able to delay the formation of slime and keep the hull cleaner for longer, but it doesn’t replace antifouling paint for that matter. If soft growth can take hold and develop, it is possible to cause it to recede using an ultrasonic system, but it is difficult to eliminate it entirely in the absence of bottom paint.

While marine fouling originates both from weed and shells, the damage to the underwater surfaces is associated with hard growth and its subsequent removal. The installation of an ultrasonic antifouling system normally extends the life of the antifouling, because it does not become colonised by shells and can keep ablating normally. It then greatly facilitates repainting as pressure washing is able to return the surface to a state directly suitable for recoating.

As long as the hull doesn’t run out of antifouling altogether, the technology can extend haul-out intervals. This can favour using harder antifouling products. As the paint ages and loses its effectiveness, it is possible in many instances to clean the hull, underwater or after drying up on the tide, which lightly abrades the coating and helps with exposing a new layer. This is particularly true for craft that mostly remain stationary. It is not feasible if the hull is covered with barnacles and this is the value proposition.

The system consists of a driver module and one or two transducers, which must be attached tightly to the hull from the inside. As a result, the installation work can be carried out afloat. The standard twin transducer system is intended for vessels of 9-15 metres (30-50 feet), which represents the bulk of the cruising yacht market. A single transducer version exists for smaller craft. Ultrasonic systems should remain powered continuously to prevent attachment. Algae in particular is sensitive to cumulative exposure to ultrasonic energy.

Critical Performance Factors

There are four critical success factors with ultrasonic antifouling systems:

1. **Transducer quality**. A high quality transducer has a higher conversion efficiency between the electrical power absorbed and the ultrasonic power delivered. We only use the best transducers money can buy, sourced directly from an ISO 9001-certified manufacturer.
2. **Transducer assembly construction**. In order for the energy to leave the transducer, the vibration must not have to cross compressible, absorbent materials as found on many mass-produced systems, where the active face of the transducer is covered with a rubbery compound. We use thin, dense, hard fibreglass on transducer faces.
3. **Transducer installation**. A poorly installed transducer will fail to efficiently transfer the ultrasonic energy into the hull. A whole section of this manual is dedicated to transducer installation.
4. **Hull material and construction**. The hull material must be suitable for transmitting sound, so the ultrasonic energy can propagate. Hull materials are also discussed in the transducer installation section.

All four aspects need to have been addressed correctly in order to obtain good results. The first two are relevant to the manufacturer and are easily compromised when profit margins are all what matters and the latter two must be taken care of by the owner/installer.

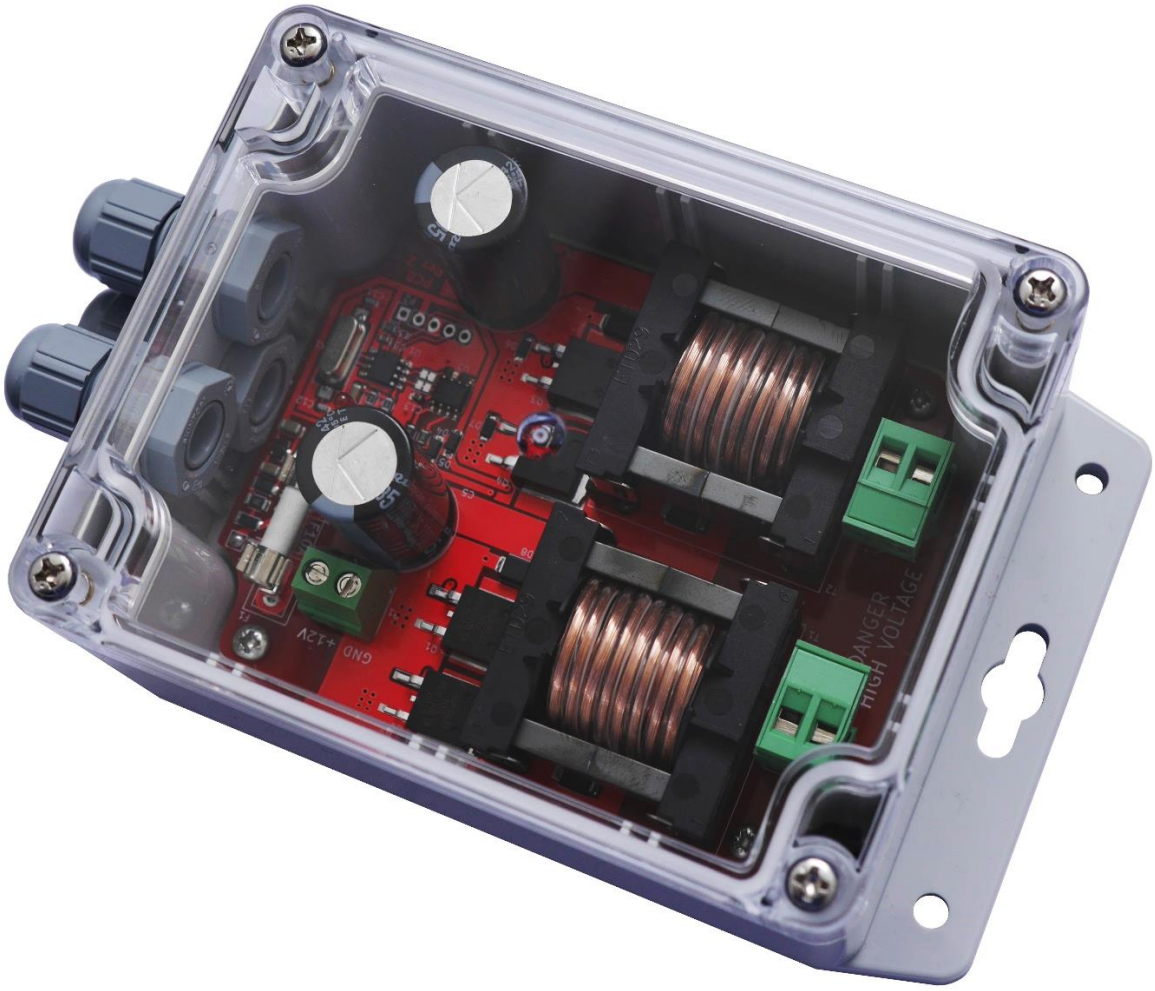
A system with high energy transfer efficiency can use less power and deliver superior results.

Equipment Supplied

Ultrasonic Driver

The ND-ULTRA driver is both compact and powerful when compared to mass-produced products. It includes advanced power management features to protect the battery from excessive discharge, allow a low battery to recharge, while also making the best of abundant energy when available by switching to a higher output mode.

The driver is contained a sealed housing with a compact footprint of 145 x 91mm. The housing contains a user-replaceable protection fuse and a LED, which are visible through the clear acrylic lid.



Ultrasonic Transducers

The standard scope of supply includes two ultrasonic transducers joined by 10 metres (33 feet) of cable for twin transducer systems. This is more than the distance normally found between the transducers. The cable must be cut once the installation location of the ultrasonic driver has been finalised and the ends led into the driver module.

The transducers are built to maximise energy transfer into the hull by using a thin bonded layer of high compressive strength insulation over the active face of the device.

A mounting flange is included with each transducer as an installation option (see section “Transducer Installation”).

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Figure 1 – Transducer and mounting flange.

Smart Power Management

The normal energy requirements of a twin transducer ND-ULTRA system are about 20Ah/day. If enough charging power is available to raise the battery voltage above 13.8V, the driver switches to a higher output power mode and can consume up to about 27Ah/day for as long as the battery voltage stays above 13.2V. This allows vessels with access to shore power and fitted with an on-board charger to operate at maximum output continuously while docked. Vessels with solar panels can also benefit from the high power mode during daylight hours. The higher power output is not necessary to prevent hard growth, but it is beneficial for fighting algae biofilms or even weed, which are much more resilient. Single transducer systems operate at half of these values.

The output power is also reduced gradually at low battery voltage. If the battery voltage falls down to 12.2V, the system stops operating to allow the battery to recharge and restarts at 13.0V. This prevents very deep discharge from taking place on the basis that the system can only be operated sustainably for as long as its consumption is being offset by a charging source.

Transducer Installation

The transducers must be mounted inside the boat, attached to the hull. They do not reach through the hull like depth or speed instrument transducers and the installation work can normally be done afloat.

Hull Materials

The best hull materials are those that also best transmit sound. Aluminium and steel are excellent. Solid fibre-reinforced plastics (FRP, i.e. fiberglass, Kevlar, carbon fibre) are normally good. Cored hulls require the removal of the core material so the transducer(s) can be installed against the outer skin, unless the core is extremely hard like resin-infused end-grain balsa. In this case, it may react almost like a solid material.

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Ferro-cement is quite poor and plywood is worse, especially when it is of low density and hasn't been stiffened with fiberglass. Wooden hulls are not worth considering at all due to their sound-damping properties.

Counter-Moulded Fibreglass Hulls

Some fibreglass production yachts have counter-moulded structures where an inner shell effectively hides the actual hull skin. This counter-mould sometimes extends over the bilges as a bonded floor grids and conceals the hull skin completely. This leaves no suitable area for the installation of transducers, as locating the transducer against the counter-mould would be completely ineffective.

In such cases, a hole needs to be cut into the counter-mould between floors or other stiffeners to gain access the hull skin and mount the transducer(s). In doubt, it can make sense to contact a boatbuilder or surveyor to formulate the best way to reach the hull itself. Bonded floor grids are typically found on low-end, low-cost production fiberglass yachts: beware of warranty issues before doing anything to the floor grid.

Locating the Transducers

The ultrasonic vibration travels away from the transducers and gradually fades with distance. The level of attenuation depends on how transmissive the hull material is. The transducers should always be installed below the waterline. As a result, the following guidelines should be observed when positioning the transducers:

1. Estimate the position of the centre of the hull wetted area. It is always some distance aft of the middle of the waterline. Fast power boats and some modern yachts with a wide *waterline* towards the stern (which is very different than a "wide stern") have more wetted area aft than others.
2. For a single transducer installation, this is approximately the optimal fore-and-aft position. For twin-transducer systems, consider the two areas forward and aft of this point individually and estimate their approximate centres instead. For an approximately triangular forebody, the centre of the area is roughly one third of the way forward.
3. Consider the construction of the hull in the area(s) identified and look for a hull panel away from frames, girders and major supporting members. The transducers are best mounted off the centreline if there is stiffening present in this area, which is often the case. The keel is also a major stiffening component with strengthening extending into the surrounding area and the transducers must be kept away from it.
4. Consider the way the transducer cables can be routed back to the driver module from the location(s) identified and finalise the installation location(s).

Permanently Installed Transducers

If removing the transducers is not considered to be a likely requirement, then bonding them directly to the hull with a high-strength epoxy glue represents the *simplest and most effective installation method*. The hull surface must be cleaned and abraded the same way as described in the next section for installation using a mounting flange, but the resin can be relied upon to bridge any gap between the transducer face and the hull if the surface is not perfectly flat.

Removable Transducers

If the vessel owner wishes to be able to easily remove the transducers, for example to later transfer them onto another boat, screwing the transducers into a threaded flange bonded to the hull is an alternative solution. The surface must be **perfectly flat** so the face of the transducer can be coupled tightly with the hull. If the hull surface is curved, as it is frequently the case, a flat area of the diameter of the flange must be prepared as follow:

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1. Clean the hull thoroughly with thinners to remove all traces of oil, dirt and other contamination.
2. Thoroughly abrade the hull surface with a coarse sandpaper to ensure good adhesion.
3. Build up the area with a high-density epoxy filler suitable for underwater repairs. A simple method for obtaining a perfectly flat circular surface is placing a disc of plywood or other stiff material covered with smooth plastic packing tape or cellophane over the wet filler. Once cured, the filler adheres very poorly to the tape and the disc can be pried off.

Both the surface of the hull/filler and the underside of the mounting flange must be thoroughly sanded with a coarse-grit paper (P40 typically) and then the flange can be epoxy-glued to the hull. *Do not squeeze all the resin out when positioning the flange.* Not all epoxy resins bond the same to materials. JB Weld™ and International HT9000™ with a thickener are examples of resins that have worked extremely well in this application, bonding to metals as well as plastics. Araldite™ is commonly available internationally in hardware stores and is worth considering. The resin must not be allowed to contaminate the thread and any excess resin that would show inside the flange must be removed.

The bond must be allowed to fully cure by waiting at least 24 hours (preferably a few days) before the transducers are threaded in. Applying a thin coat of petroleum jelly to the face of the transducer before installing it facilitates tightening and improves the contact with the hull.

The transducer must be tightened very firmly by hand. **Do not apply force to the cable exit in this process or it may break.** It is generally preferable to run the cables after screwing the transducers in place, otherwise remember to first "pre-twist" them in the direction opposite to the thread.

Driver Module Installation

Important Safety Considerations

The installation of the system can generally be carried out by the vessel owner without issues as long as the following precautions are respected:

1. The DC power supply must always be disconnected when the ultrasonic driver housing is open.
2. **Do NOT handle live 12V wires within the driver housing.** Unintentional contact with the internal components may cause irreversible damage to the module.
3. The transducer cables and transducers must be free of physical damage. **This includes damage to the cores where the cable cover is stripped during installation for connection to the terminal blocks within the enclosure.**

Use the services of an electrician if needed.

4. The transducers must be mounted in place before the driver is powered up, as it eliminates the possibility of making contact with the transducer faces.

The system has been engineered to maximise safety. The transducer outputs are fully independent and isolated from the boat electrical system as well as from each other. However, ultrasonic drivers operate at high voltages and making contact with the transducer supply terminals inside the enclosure can result in an electric shock.

The transducer cables must be secured and protected from chafe to prevent insulation damage in service. Always turn the system off before inspecting or handling the cables. Do not operate a system with patched-up cables.

Do not handle unmounted active transducers. Ultrasonic energy can break small blood vessels underneath the skin and cause bruising if close contact is made with a transducer face.

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Driver Module Overview

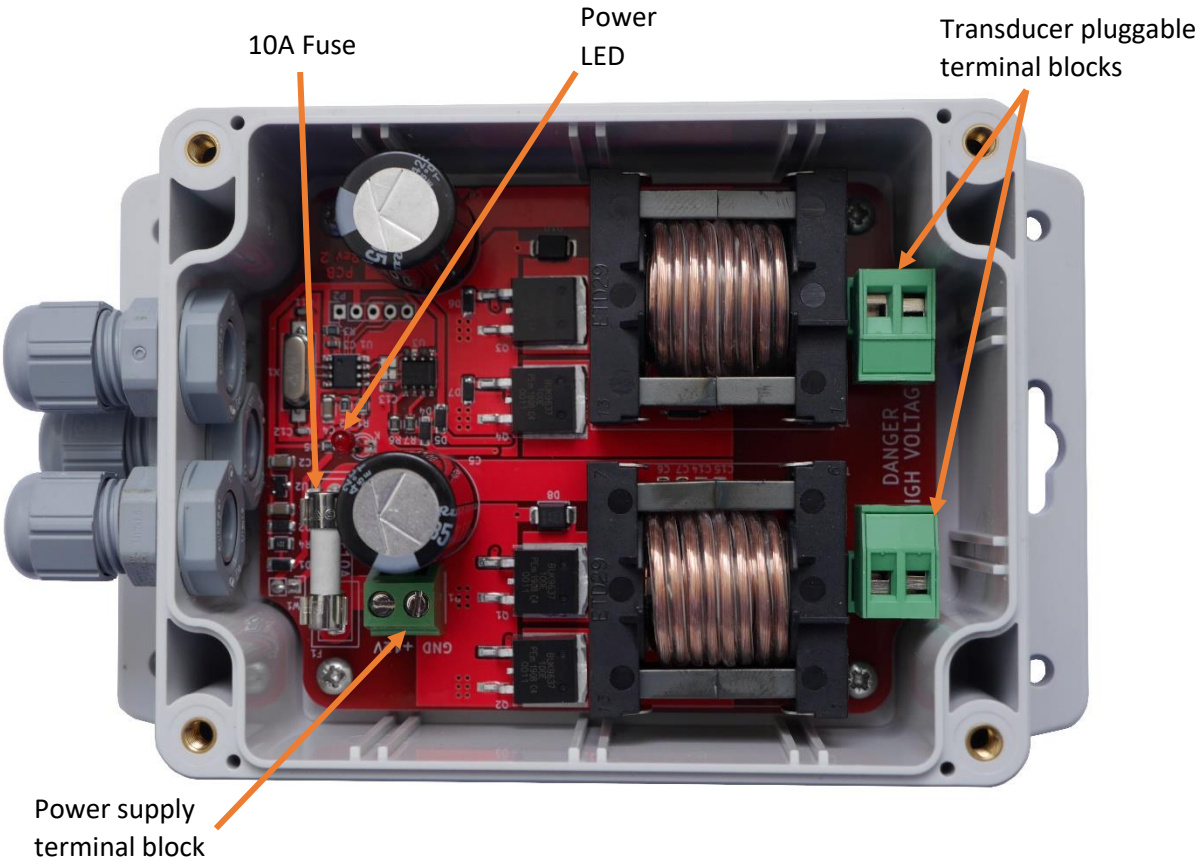


Figure 2 - Controller layout and connection terminals

Selecting a Location for the Driver

The driver should be installed in a clean dry location away from vibrations, moisture, oil, dust and the heat of the engine. It must not be able to become submersed under water ever.

The location must be compatible with the cable length of the transducer(s) and a pathway must be available to route the cabling. It is generally recommended that the cables lead downwards from the enclosure so any water cannot follow them.

Power Supply

The ND-ULTRA ultrasonic driver is designed to operate from a 12VDC nominal supply. Vessels with 24VDC electrical systems must use a 24VDC/12VDC converter. Ultrasonic systems are intended to operate continuously when the vessel is not under way and can normally stay powered under way. The power supply should be sourced from a switch, so the system can be turned off when required. Alternatively, a local on/off switch can be added to the driver enclosure itself, see “

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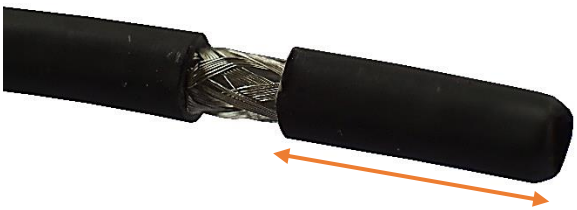
Appendix B - Instructions for Adding Local Power Switch".

The supply must NOT be sourced from cabling also used to feed starter motors, anchor winches, thrusters and other heavy current motors as these cause spikes that are dangerous to electronics each time they turn off.

Connecting the Transducers

The transducer coaxial cables must be run back to the driver with an adequate amount of slack along their path, so they are never stressed. They must also be secured and protected from chafe. Two pluggable terminal blocks (**Error! Reference source not found.**) are present inside the driver module o feed the transducer(s). The cables must be cut long enough to reach the terminal blocks with 100mm to spare to facilitate handling the plugs. Use the top two cable glands on the driver enclosure for the transducer cables as shown in Figure 4.

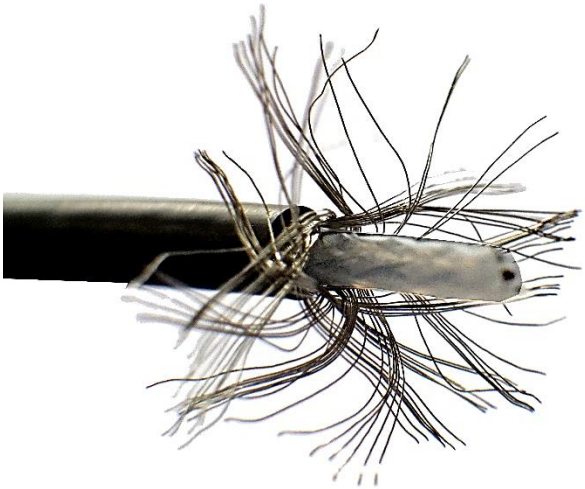
The coaxial cable is constructed out of a braided copper screen surrounding a centre core conductor. The following table illustrates the correct way to strip the insulation and connect the cable.



Step 1: Carefully cut the outer cover about 15mm (5/8'') from the end of the cable, taking care not to damage the braided screen inside.



Step 2: Pull the cover off and expose the braided screen.



Step 3: Open up and pull back the strands in the braid.



Step 4: Bring all the strands to one side and twist them tightly together.

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Step 5: Cut and strip the insulation of the core over approximately half of its length and twist the strands in the core.



Step 6: Engage the core into the plug terminal *further away* from the cable entry and tighten the connection. Repeat the same for the braid.

Figure 3 – Stripping and terminating the transducer cables

Optional EMI Shielding

The power supply to the transducers contains high-frequency harmonics and can causes low-power electromagnetic interference (EMI) in AM radios typically, which include SSB receivers. When deemed necessary, the option of grounding the screen of the transducer cables to shield the circuit is available.

Use a 3-core cable for the power supply and dedicate the third core to grounding the screens of the transducer cables, as shown in Figure 4. The grounding wire should be tied to the hull on metal vessels and a suitable ground on fiberglass hulls, like the keel or the engine block. The grounding wire does not and cannot carry any current, see also the section “Operational Considerations” further in this document.

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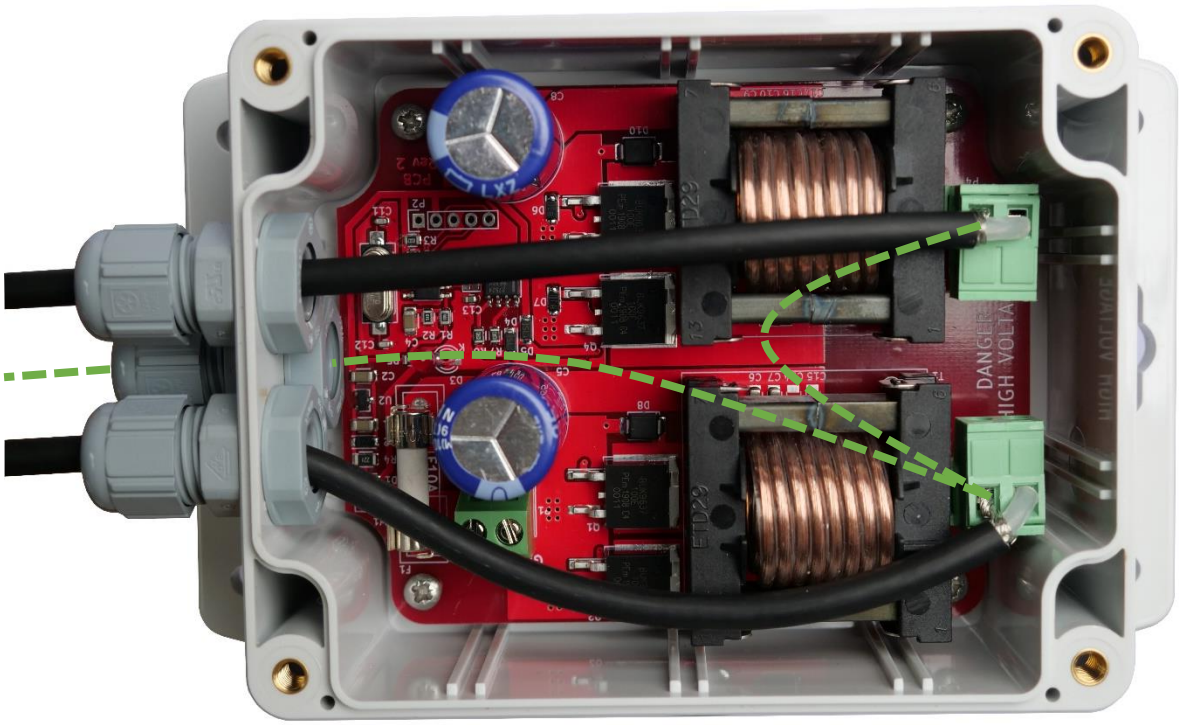


Figure 4 - Transducer cables connection and optional EMI shielding (green wire)

Connecting the Power Supply Cable

The recommended size for the power supply cable is 2 cores of 1.5mm^2 or 16AWG. The cable must be led into the enclosure the same way as the transducer cable(s) and terminated on the power supply terminal block **before the other end is connected to a supply.**

Never handle a live supply cable within the driver enclosure.

The circuit board is marked “GND” for the negative core and “+12V” for the positive one. Inverting the polarity will cause the destruction of the fuse and possibly also damage the driver.

Finalising the Installation

Check that all the cable terminations inside the driver housing are clean and devoid of copper strands which could cause short circuits. The insulation of the wires must reach all the way to the terminal blocks.

Screw the clear acrylic lid of the enclosure into place before powering up the system. The housing includes a seal, which is compressed by the screws.

Operational Considerations

Powering Up

Upon power-up, a red LED lights up inside the driver housing and the transducers power up after about 2 seconds. The transducers typically emit faint clicking sounds as they stop and restart between frequencies.

Interference Effects

Ultrasonic systems can typically be heard operating at short distances on AM broadcasting radio bands and over some shortwave bands. It can be necessary to turn the system off if operating SSB radio equipment to eliminate spurious tones.`

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These systems do not interfere with the 200kHz depth sounders typically found on small craft, but in rare cases some types of lower frequency sonars can be affected.

Anodes and Corrosion

It is *impossible* for this system to cause galvanic corrosion (electrolysis) or anode corrosion issues through current leakage for the following reasons:

1. Each transducer circuit is fully independent and insulated both from the battery and earth. The only possible return path for the transducer current is through the cable itself.
2. Each transducer is completely sealed and encapsulated in insulating materials.

Diving

While the energy density in the water is extremely small, the system should be turned off before diving underneath the hull as a matter of principle.

Troubleshooting

No Power

A no-power condition at the driver is indicated by the red power LED being off. Turn the system off and check the fuse inside the driver enclosure. Replace the fuse with a 5x20mm glass cartridge fuse if it has failed. The fuse rating is 10A for dual transducer systems and 5A for single transducer units.

If the fuse is good and the LED is off, the fault should be on the supply side to the driver in the boat electrical system.

If a new fuse blows upon power up, a short circuit on a transducer output is possible, or the driver has suffered from damage. Unplug the transducer(s) and power up again. It is critically important that the supply voltage comes from a clean feed from the battery and doesn't spike up when heavy loads like the starter motor are operated, as this can damage the driver electronics and cause the fuse to blow afterwards.

No Transducer Output

The driver is designed to stop operation if the battery voltage goes outside the range from 12.2V to 14.7V. In this case, the power supply LED stays on, but the transducers are turned off. If this happens, the driver will only resume operation once the voltage is back above 13.0V or below 14.5V. By design, reaching a voltage of 13.0V or more requires the battery to be recharging, so a lack of charging will disable the system rather than ruin the battery completely.

If the battery voltage is well within the range 12.2V to 14.7V, power off the unit, *wait until the LED is completely off* and turn the system back on to restart it. This indicates that the charging system is either not capable of compensating for the consumption of the ultrasonic driver, or it is overcharging and raising the battery voltage to dangerous levels at times. The root cause needs to be addressed before the system can keep operating continuously. Routinely powering it off and on again to restart it is not an option.

Sudden Change in Performance

If barnacles, typically, are suddenly observed to form over the hull in some area(s), this suggests that the nearest transducer is no longer tightly coupled to the hull. Check and retighten as required. It is possible to use *low-strength* thread locking compounds when a transducer is flange-mounted.

If must also be remembered that ultrasonic systems do rely on antifouling paint to some extent to control algae growth and there comes a point where weed, but not hard growth, does manage to grow on a hull.

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Appendix A – Specifications

PCB Rev 2, Firmware Rev 1

The following table contains absolute maximum ratings and electrical operating limits.

Parameter	Minimum	Typical	Maximum
General			
Driver dimensions		115x90x42mm	
Driver weight		0.365kg	
Transducer weight (with 5-metre cable)		0.750kg	
Power Supply			
Nominal system voltage		12VDC	
Operating voltage range	12.2VDC		14.7VDC
Consumption – Low Power Mode			
Average current	0.75A	0.8A	0.9A
Average power consumption			
Single transducer systems	4.6W	5.25W	5.9W
Twin transducer systems	9.2W	10.5W	11.8W
Minimum daily energy requirement			
Single transducer systems	9Ah/day	9.5Ah/day	10.25Ah/day
Twin transducer systems	18Ah/day	19Ah/day	20.5Ah/day
Consumption – High Power Mode			
Average current	1.0A	1.1A	1.1A
Average power consumption			
Single transducer systems	6.75W	7.6W	8.25W
Twin transducer systems	13.5W	15.2W	16.5W
Minimum daily energy requirement			
Single transducer systems	12.3Ah/day	13Ah/day	13.5Ah/day
Twin transducer systems	24.6Ah/day	26Ah/day	27Ah/day

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Appendix B - Instructions for Adding Local Power Switch



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