

SI-TEX

SP36 Autopilot

Installation & Operation Manual

Warranty Notice

Prior to the installation and/or operation of the equipment, please take a moment to read and accept the conditions of the warranties as detailed.

WARNING

When operating in one of the auto-steering modes, the SP 36 will steer your boat in the direction you have set.

However it is only an *aid to navigation*. Its performance can be affected by many factors, including equipment failure, environmental conditions, and improper handling or use.

The system does not reduce your responsibility for the control of the boat when underway. You must always be in a position to monitor the course, supervise the autopilot, and resume manual control if the need to do so arises.

Whenever underway, your boat must be under the control of a qualified and alert person.

General Notice

This document, SI-TEX part number 29010086 Version 1 Revision 0, is the approved Installation and Operation Manual for use with the SP 36 Autopilot system.

Where versions of this manual exist in other languages, the English language version shall be considered authoritative.

Special Note

This manual applies ONLY to SP 36 systems running firmware version 1.00.

About this Manual

This manual provides essential information for the safe and reliable operation of the SP 36 Autopilot System.

You are urged to read this manual in its entirety before you use your autopilot for the first time, and to keep it handy until you become thoroughly familiar with the operation of your autopilot.

Typefaces, Common Phrases & Terms

Throughout this manual, you will see a number of different typefaces used, and several commonly-used words & phrases with very specific meanings, to describe concepts & actions that are fundamental to the operation of the autopilot. Please take a moment to become familiar with the following:

- System Component
Specific system components are capitalized.
Example: the Control Head
- Modes of Operation
Specific “modes of operation” are placed in bold uppercase lettering.
Example: **POWER STEER** mode.
- LCD Display
Text that appears in the LCD display is in quotation marks.
Example: “Waypoint Arrival”
- Button
Control Head buttons & the knob are in bold small-caps lettering.
Example: the **TURN** button
- Press or momentary press
Press and release the indicated button
- Double-press
Press and release the indicated button twice in rapid succession.
Although this sounds a little complicated, it is actually very easy to do. If you use a personal computer, you will find that this is similar to a “double-click” of the mouse buttons.
- Press and hold
Press and hold the indicated button for approximately 1 second.
- Press and maintain
Press and hold the indicated button for as long as required to achieve a desired result.

Manual Format

This manual has been formatted to be printed on both sides of the pages of the manual, and on standard North American Letter-size paper (8.5" x 11").

If you have obtained this manual as a soft-copy, please note that it is in Adobe® Portable Document Format ("pdf"), and so may be viewed & printed with Adobe Reader®, or compatible pdf-format viewers.

When printing this manual with Reader, you should select "duplex printing" (or the equivalent term used by your printer's software driver), in order to print it double-sided on the paper. If your printer does not have built-in duplexing capability, you can still print this manual double-sided by following the instructions that came with your printer for doing "hand duplexing".

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Introduction

How Autopilots Work

The purpose of this introductory section is to describe briefly what an autopilot does, and some of the things you should expect when using an autopilot with your boat.

Manual Steering

Every boat has unique design dynamics, which depend on its shape and dimensions, and on current speed, loading, and sea conditions. The net result is that every boat (or rather, every unique boat *design*) “steers” in a unique way.

To understand what an autopilot does when it is steering your boat, it is helpful to think for a moment about steering the boat by hand.

- When you are holding the boat on some Heading, you know, from instinct & experience, how much rudder to apply, and how fast to apply it, to keep the boat on-course. Corrections are usually just a small, quick movement of the helm to one side, then back to the dead-ahead position.
- You won't always try to correct when the boat rolls or accelerates off a wave, especially in heavy seas – because when the boat rolls back the other direction, it will usually come right back on-course.

Instead, your experience lets you allow the boat to yaw those necessary degrees on either side of the Heading, to reduce the fight.

- To turn the boat to a new Heading, instinct & experience again tell you how much rudder to use, and how fast, to get the boat turning at your normal rate of turn.

If the boat is not turning as rapidly as you want (for example, with a cross-wind or cross-current holding back the bow), you increase the amount of rudder a bit.

On the other hand, if the boat is turning too fast, you reduce the applied rudder a bit.

You then gradually reduce the applied rudder, as the boat approaches the desired Heading.

You might even put the helm over opposite for a moment, to stop the boat swing more quickly – in order to come to the desired Heading without overshoot.

The single most basic purpose of an autopilot is to do the same as you would ... let the boat “work with the seas”, yet still maintain as straight a Track as possible in the current sea conditions, on the desired Heading or Course.

The Autopilot Systems use the latest generation of SI-TEX's carefully-designed, well-proven steering control algorithms¹, which are based on our many years of designing & manufacturing autopilots.

There are a number of parameters used in the steering algorithms, collectively referred to as “the Steering Parameters”. The SP 36 has been tested on a wide variety of boats, of different types and sizes. The default settings for the Steering Parameters are average values derived from that testing, and provide a good starting place for most boats.

During Sea Trials, and later on normal operation, you may want to adjust some of those values, so that they better match your boat's unique design dynamics.

¹ ... however, the information in this section can be applied in general to any SI-TEX autopilot, and is not necessarily specific to the SP 36.

An Autopilot System

This is a block diagram of the major components of an autopilot system:

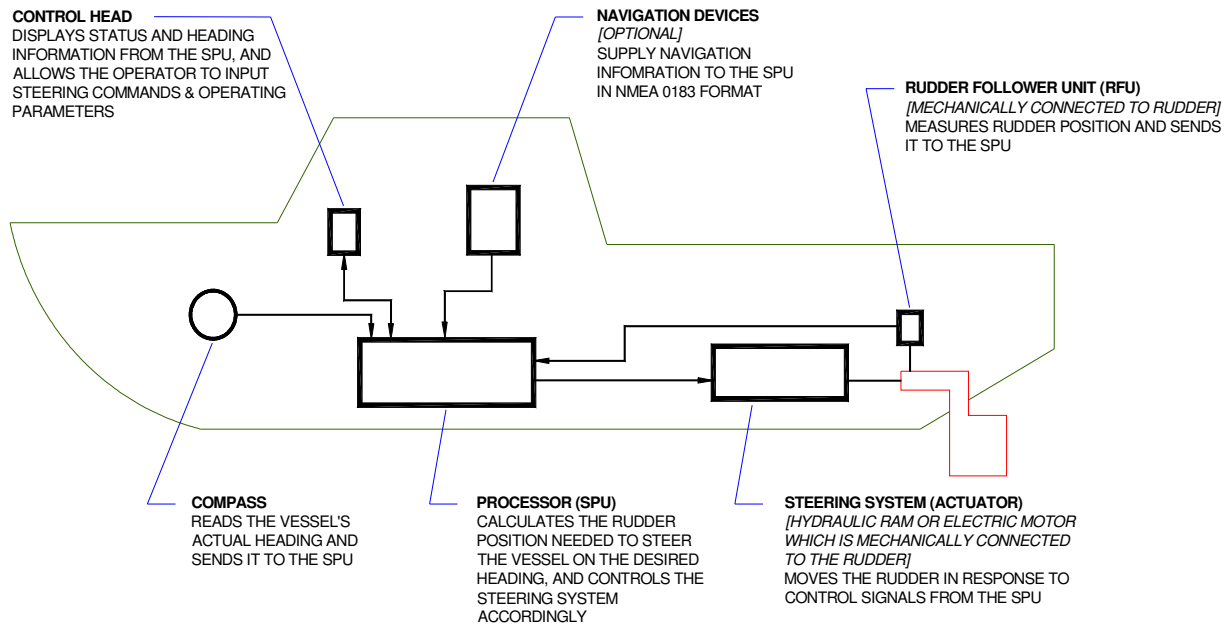


Figure 1 – Basic Autopilot System

The Compass indicates the direction in which the boat is pointed – often referred to as the “actual Heading”. Depending on the type of boat & installed equipment, the Compass may be a magnetic compass, an electronic fluxgate compass, a gyroscopic compass, or a GPS Compass.

ⓘ *A reliable Compass is **absolutely vital** to an autopilot – because, without it, the autopilot has no way of knowing which way the boat is headed.*

The actual Heading is fed electronically from the Compass to the Processor (SPU) – which is the “brains” of the autopilot. The SPU contains the microcontroller(s) & other electronic hardware, and the sophisticated control software necessary to steer the boat on any *desired Heading*.

The Control Head, normally located in the wheelhouse, is the interface between the boat’s operator (that’s you ...) and the autopilot. The Control Head displays information about what the autopilot is doing, and it has various controls (buttons &/or knobs) that allow you to give commands to the autopilot.

The final part of the picture is the Steering System. In order for the autopilot to steer the boat, there must be a steering system capable of moving the rudder independently of the ship’s helm. This might be a hydraulic ram that is connected to the rudder post or tiller quadrant, or an electric motor connected to the steering cables.

But no matter what type of steering system the boat uses, electronic signals from the SPU tell the system to move the rudder, when needed – how far and in which direction.

Your autopilot may also have a Rudder Follower Unit (also called a Rudder Feedback Unit, or just “RFU”), a device that tells the SPU what position the rudder is in at any given time.

Autopilot Operation

Maintaining a Heading: AUTO Mode

Following a Track or Course you want to be on is simple, with a SI-TEX Autopilot:

- Put the autopilot into **AUTO** mode.
- Tell the autopilot the Heading you want to follow², using the Control Head.
- The autopilot then moves the rudder from side to side as required, to put & keep the boat on that Heading ... just like you would if you were steering by hand.

But as you might expect, inside the autopilot it's a bit more complicated than that!

Here's how it works:

The steering control algorithms running in the firmware on the SPU's microcomputer are constantly comparing – many times per second – the boat's actual Heading (as indicated by the Compass) to the desired Heading you have given it.

If there is a difference, the algorithms then calculate how much to move the rudder, to bring the boat back onto the desired Heading. The amount of corrective rudder movement is based on:

- How much the Headings differ.
- How long there has been a difference, & by how much.
- How rapidly the difference is changing.

Here's an example which illustrates how the autopilot maintains a Heading in **AUTO** mode. Let's say the boat is a few degrees off-course to Port:

- The SPU will signal the steering system to move the rudder to Starboard, by a few degrees.
How many degrees the rudder moves depends on the type of boat, and its dynamics (which you have specified & tested when you set up the autopilot).
Note: on a SP 36 without an RFU, the SPU estimates the rudder position by computing it, based on various factors determined during setup.
- The boat begins to turn to Starboard.
- As the boat turns, the difference between the desired and actual Heading gets smaller, and as it does, the SPU then starts to 'back off' the rudder – i.e., move it back to centre – so that the boat does not overshoot the desired Heading.
- If the boat isn't coming back on-course very quickly, the SPU's algorithms will not back the rudder off right away, and might even move the rudder a bit farther to Starboard for a while.
- On the other hand, if the boat is coming back too quickly, the rudder will be moved quickly back to dead-ahead – or maybe even a bit to Port for a few seconds.
- Eventually, the actual Heading will match the desired Heading.
- If (when!) the boat falls off-course again, the same sequence will be repeated.

In summary, if you look back at page 11, you can see that this is all very much like steering by hand. But it's all happening many times per second, much more precisely & rapidly than a human can manage – and without coffee breaks or naps, either!

² SI-TEX Autopilots have an important safety feature: when you first enter **AUTO** mode, the autopilot will use the boat's current Heading as the desired Heading, so there's not a turn right away ... until you order one, with the Control Head.

Changing Heading

That's easy, too!

Let's say, for example, that the autopilot is steering your boat Southwest, and you now wish to change direction to Southeast (see Figure 2, below).

To initiate the turn in **AUTO** mode, you would turn the knob on the Control Head to set the desired Heading (as shown on the Control Head's display screen) to 135° ... Southeast.

After that, the autopilot behaves much the same as when maintaining a Heading – but with an initially large "Heading error" (90° to Starboard, in this example) that must be dealt with:

- When the SPU moves the Rudder to Port, it will probably be by quite a bit, maybe even all the way to the stops – but not so much that the boat turns too rapidly.
- Eventually, the actual Heading will match the desired Heading ... and the boat will then be going Southeast.
- The SPU will keep steering the boat on the 135° "new" Heading – i.e., maintaining that Heading, as described previously – until you select some other Heading.

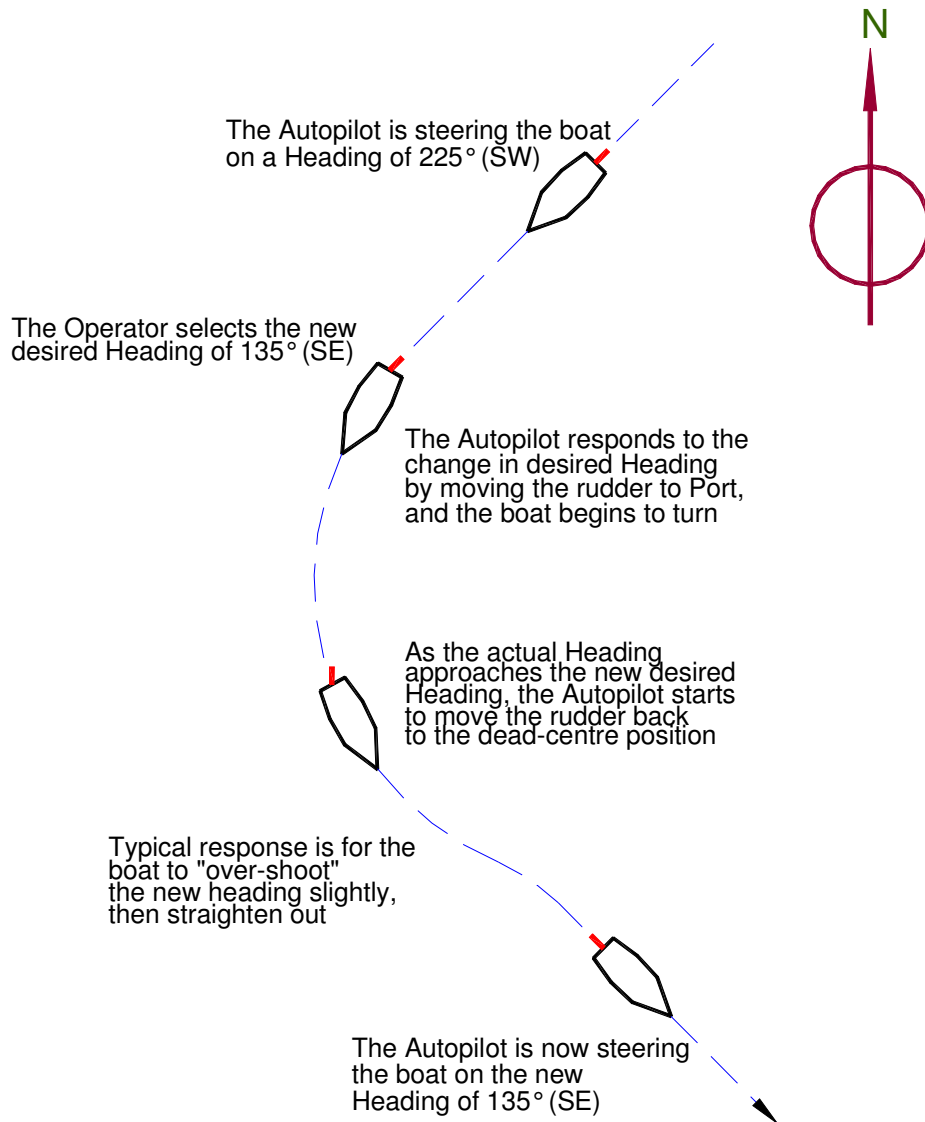


Figure 2 – Heading Change in AUTO Mode

Wind and Current Effects

If your boat encounters a crosswind, and/or a tidal current, at some angle to the desired Heading, it will be pushed away – in the direction of the wind or current. And so, the autopilot will be constantly making Heading corrections with the rudder, as it tries to maintain your desired Heading.

As that condition persists, the SPU will gradually begin to maintain the rudder a few degrees to Port or Starboard of the centred position, to counter the effect of wind and/or current. This feature, known as *Automatic Rudder Trim*, will keep your boat pointed in the right direction, despite the wind or current.

However, one side-effect of Auto-Trim is that your boat may not follow the *Track* you want – it will maintain your desired Heading, but the Track will “slip” sideways in the direction of the crosswind and/or current. This potential problem can be solved by using another mode that SI-TEX Autopilots provide: **NAV** mode, described next.

Following a Track: NAV Mode

So far, we have seen how an autopilot operates in **AUTO** mode: a new *desired Heading* must be selected on the Control Head each time you wish to change direction. This is handy for short trips or when you know the direct course to your objective.

But for longer trips, which often involve a number of “legs” at different headings, it would be useful to be able to have your autopilot steer your boat along all the legs, in sequence.

SI-TEX autopilots allow you to do just that, with **NAV** mode.

The autopilot must be connected to an external source of navigation information (commands & data) – such as a chart plotter, or a Navigation program running on a PC. A source of position data is required, too; it may be built into the external Navigation System, or it may be another device or system: a GPS receiver (such as a SI-TEX Vector GPS Compass), a LORAN C receiver, etc.³

SI-TEX Autopilots implement the industry-standard NMEA 0183 protocol for reception & transmission of navigation information. Almost all modern Navigation System equipment complies with NMEA 0183, so interfacing to a SI-TEX autopilot is relatively simple.

A long passage will consist of a series of *waypoints*, which are specific locations on the Earth’s surface (hopefully on the water!) defined by their Latitude & Longitude. These waypoints define the *route* which you want the boat to travel on, from your starting position to your destination. You enter them into the external Navigation System when creating the route.

That system determines the current location of the boat (from the source of position data), and then calculates the course that must be steered in order to reach the next waypoint.

When the Autopilot is switched into **NAV** mode, it begins to look for some specific navigation information from the Navigation System: the course to steer to the next waypoint, and the Cross-Track Error (which is the distance from the boat to the desired Track from the last waypoint to the next one). Using these two pieces of information, the autopilot steers the boat on the shortest possible Track to the next waypoint.

Crosswinds and/or currents are compensated for automatically each time the Navigation System updates the Cross-Track Error. This is why **NAV** mode is the answer to the “track slip” problem that can occur in **AUTO** mode, when a crosswind/current exists.

When a waypoint is reached, the Navigation System sends the SPU the next set of navigation information – for the next waypoint – and the SPU then turns the boat to head to that next waypoint.

³ ... all such external devices are in general referred to in this manual using the generic term *Navigation System*.

Following a Track: AUTO/ALC Mode

This feature can be turned on in **AUTO** mode.

ALC is similar to **NAV** mode, in that it uses NMEA 0183 Latitude & Longitude data to sense if the boat is following the desired Track.

Unlike **NAV** mode, however, a SI-TEX autopilot with the **ALC** feature only needs Latitude & Longitude data in **AUTO/ALC** mode. It does not need Cross-Track Error data from the external Navigation System, nor to have any waypoints set in the system. The **ALC** feature calculates the Cross-Track Error on its own, using the *desired Heading* active at the point in time when **AUTO/ALC** mode is first engaged.

Power Steer: “Drive by Wire”

Most SI-TEX autopilots have a **POWER STEER** mode, which provides a way for the user to control the rudder directly. In effect, the autopilot acts as a sort of “electronic steering wheel”, allowing the operator to steer the boat manually, in a similar way as when using a standard manual steering wheel or tiller – but instead steering the boat with the autopilot’s Control Head, or any remote controls it is equipped with.

Steering, when using the autopilot in this mode, is done with two buttons and/or a knob on the Control Head. One button, and/or a clockwise turn of the knob, will move the rudder to Starboard, causing the boat to turn that way; the other button, and/or a counter-clockwise turn of the knob, will move the rudder to Port so that the boat turns that way.

Using the buttons/knob, the rudder can be placed in any desired position where it will remain. This feature is useful when docking or manoeuvring, because the person steering the boat can take their hands off the controls between rudder movements.

More Information (for the Technically Inquisitive)

Mathematically, the autopilot’s steering algorithms are based on a control method known as a “PID Loop” ... a mnemonic for a “Proportional, Integral, Derivative” error-correction technique.

The amount of rudder movement to correct for any Heading error (or to make a turn), is continuously re-computed, in a processing loop, as a value that is:

- Proportional to the error (or how much more of the turn is still to be done).
- An Integral of the error/turn ... how big for how long.
- A Derivative of the error/turn ... how fast it is changing.

Many references can be found on PID Loops, on the Internet & elsewhere, if you want to know more! And SI-TEX occasionally holds training seminars – check with your Dealer.

System Overview

System Overview

This chapter gives a brief description of the major elements of the SP 36 Advanced Autopilot System, their functions, and their relationships to each other.

Below is a block diagram of a typical example of the SP 36 system, showing the interconnections between the elements of the system:

- The Signal Processor Unit (SPU)
- The Main Control Head
- A Compass or other Heading Sensor
- Solenoid(s), Reversing Motor, or Cable Drive, which move the Rudder
- The Rudder Follower Unit (optional on a SP36)
- Optional Auxiliary Control Head(s) & Remote Controls
- Various optional accessories & external equipment
- Other Navigation equipment

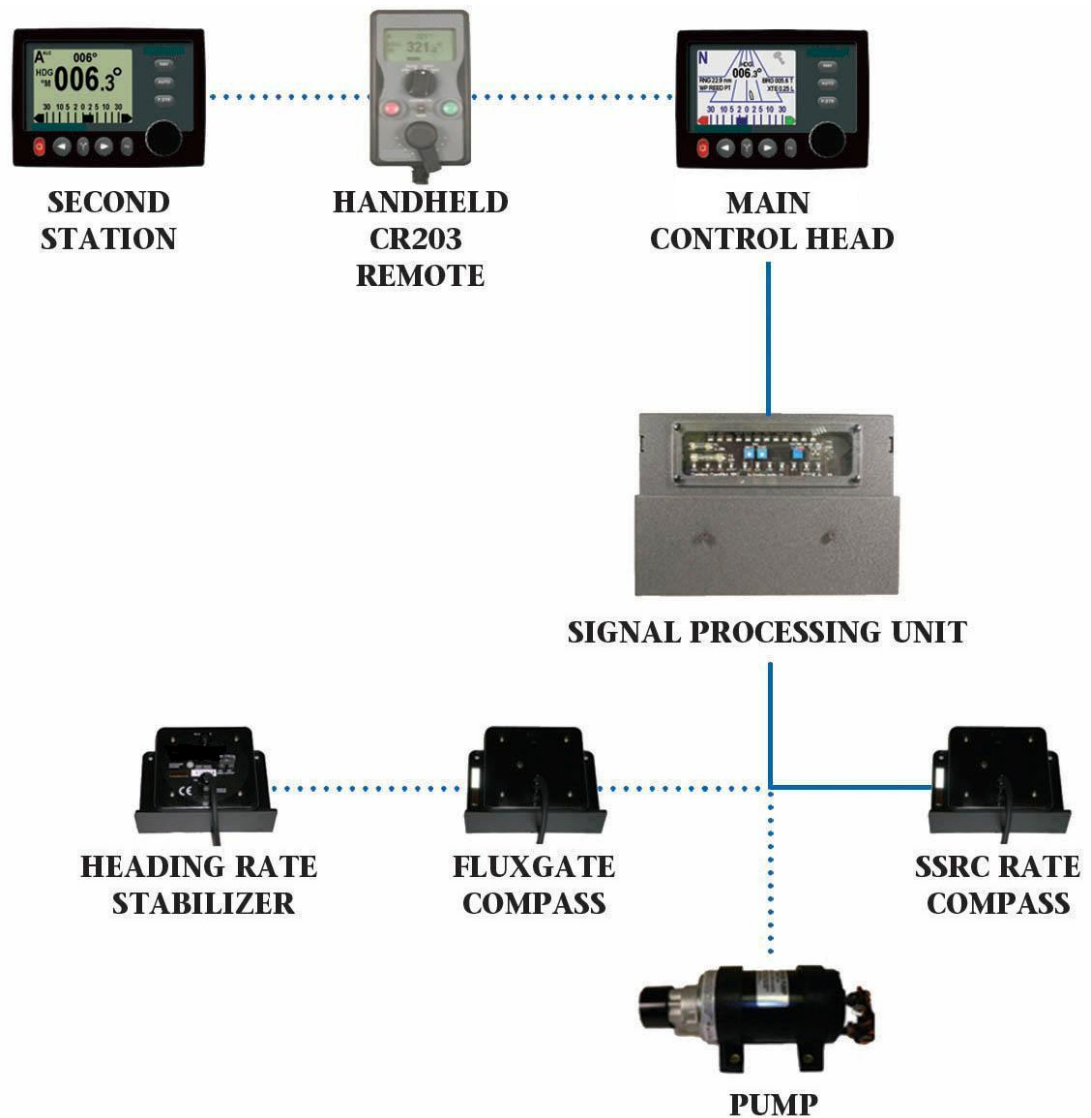


Figure 3 – SP 36 System Block Diagram

Control Head

The Control Head connects directly to the Signal Processor Unit (SPU), via a nine-conductor cable that plugs into a waterproof connector on the rear of the Head. This cable is wired onto a plug (supplied with the Kits), which in turn is plugged into the **CONTROL HEAD**, **AUX1** or **AUX2** receptacles on the SPU.

Two versions of the Control Heads are available. The monochrome versions have a silver-backed monochrome LCD display. The colour versions incorporate a state-of-the-art, sunlight-viewable QVGA TFT colour LCD display.

The Second Station Kits include the Head, cable & SPU connector, surface mount kit & mounting hardware and a cover.

Signal Processor Unit

The Signal Processor Unit (SPU), as its name suggests, accepts a number of signals from the other components of the autopilot system, and processes them as necessary to control the movement of the boat's rudder so as to maintain a given Heading. As well as steering the boat, the sophisticated software within the SPU continually checks all aspects of the autopilot's performance, and will advise the user via the Control Head if any problems are encountered.

The SPU is the central hub for all wiring in the system, with 13 connectors for all power and input/output signals. A Wiring Cover protects the connectors when the system is in use – but is easily removable for installing cables & wiring.

It also contains a diagnostic section, containing several status & activity LEDs, some test points for service use, some adjustment controls and the system's two fuses. The diagnostic section has a clear cover, which allows easy viewing of the LEDs, and inspection of the status of the fuses.

Compasses

The Compass is a critical component in the proper operation of the SP 36 Autopilot System. *The autopilot system's ability to steer the boat to a given Heading desired by the Operator can **only** be as accurate as the Compass.*

The SP 36 system is designed for use with SI-TEX Rate Compass.

Rudder Follower Units

Standard Rotary Rudder Follower Unit & Rudder Linkage

PN 20330008 (Follower Unit) & 20330007 (Linkage)

Note: *SP36 kits do not include an RFU – although one may optionally be used.*

The Rudder Follower Unit is used to transmit (i.e., “feed back”) the position of the boat’s rudder to the SPU. It is mechanically coupled to whichever part of the steering system the autopilot controls. Normally, this is the boat’s rudder; however, it can be mounted to the servo ram rather than the rudder, if the boat has two-stage steering (where the autopilot drives a control or servo ram).

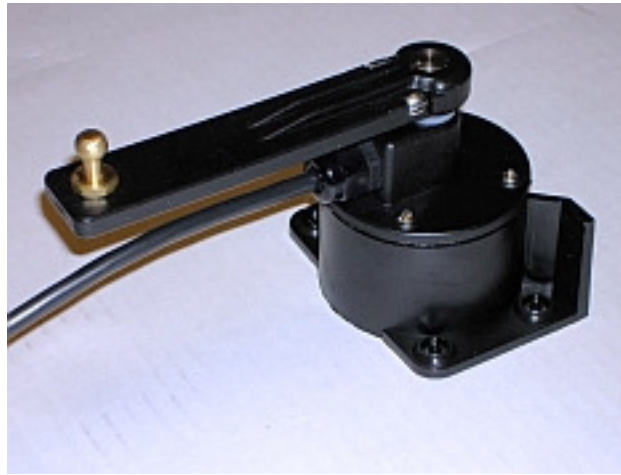


Figure 4 – Standard Rotary RFU

Linear Rudder Follower Unit

PN 20330002

Note SP36 kits do not include a linear feedback unit – although one may optionally be used

Installations on boats with outboard motors may use a SI-TEX Linear RFU. It is mechanically coupled to the motor’s steering cylinder.



Figure 5 – Linear RFU

Auxiliary Controllers

Up to two Auxiliary Controllers may be added to the standard SP 36 system. There may be any combination of SP 36 Control Heads and TS-203 Fixed Remotes.

TS-203 Remote

The TS-203 Fixed Remote is a heavy duty Full-Follow-Up (FFU) Lever control which allows the operator to control the tiller steering and autopilot functions from any work station, flying bridge or remote location on the boat.

The TS-203 is designed to be mounted anywhere convenient, inside or outside (it is fully waterproof), and positioned horizontally, vertically or at any angle desired. The attached 12 (or 18) metre strain-relieved cable plugs directly into either of the SPU's **AUX** Head inputs; the cable can be routed to exit the TS-203's case from the back side, or from the top edge.

The optional Ball Knob Kit is a replacement for the TS-203's standard tapered-handle Tiller lever. It is intended to be used where a "ball handle" is preferred, or in installations where there is limited space in which to mount the TS-203.

The kit's ball & shaft are the same as used on SI-TEX's NFU Jog Steering Control (see page 24). The total ball-shaft length is 12 cm (5"), as compared to the TS-203's standard handle-shaft length of 18 cm (7").

Other Controls & Indicators

NFU Jog Steering Control

SI-TEX's NFU (Non-Follow-Up) Jog Steering Control is a permanently mounted, watertight, electrical switch specifically designed for marine use. The spring-centered lever can be moved to Port or Starboard as desired to provide non-follow-up (time dependent) electrical control of the boat's steering system.

Rudder Angle Indicator (RAI)

PN 20360023 (metal backshell)

The SI-TEX RAI is a backlit 76 mm (3") diameter gauge that displays the actual position of the boat's rudder. The RAI is flush mounted, with a corrosion-resistant metal backshell, and a water-resistant front face; it accepts a lighting voltage supply of 12 or 24 VDC.

An optional Bezel Kit (PN 30360004), a Watertight Case (PN 20360016) and a Wheelhouse Case (PN 20360017) are available.

Please note that if you don't install an RFU, there is no RAI output.

Control Head Mounting & Cover Kits

The Control Head (when shipped as part of a complete SP 36 system) is a "core" module, and comes with accessory kits for three methods of mounting it: a snap-on bezel for flush mounting, a snap-on bezel for surface mounting, and a two-piece bracket for bracket mounting. All required hardware is included with each kit (except for two fasteners needed to fasten the bracket to the desired mounting surface).

A cover for the Head is also supplied (for use with the surface & bracket mounts); it slips on easily, to provide protection against the elements, UV rays, and so on.

The Surface mount kit, the cover, and the Head ↔ SPU cable & connector, are also included with the Second Station Kits.

Rudder Drives and Interfaces

Pumps & Drives

SI-TEX offers several types of electric-motor Hydraulic Pumps, matching Solenoid Valves & related equipment, as well as a number of high-quality Cable Drives and accessories.

Each drive comes with its own Installation Manual.

Please contact your SI-TEX Dealer for information and details.



Figure 6 – Hydraulic Pump & Solenoid Valve



Figure 7 – Cable Drives

Other Equipment

Besides the optional equipment described above, there is a wide choice of other equipment available for use with the autopilot systems.

Contact your SI-TEX Dealer for information and details.

Installation

Installation

This chapter describes all the steps you must follow while doing the physical installation of the Autopilot System on your boat.

Each of the standard components of a system is described – both physical mounting & electrical wiring – and then some final checks are given. Commonly-used accessories are also described. Many components come with their own specific instructions, and you should pay attention to those, as well.

Basic Requirements

Please refer to the Error! Reference source not found. section of this manual before proceeding with installation.

Hazard warning!

CAUTION!

Extreme caution is advised when using tools powered by alternating current (AC) from main AC supply circuits, regardless of whether the supply circuits are “indoor”, “outdoor”, “marine” or “industrial” rated. Water, especially sea water, is an excellent conductor of electricity, and can complete a path to AC Ground through a person’s body, causing injury or death, if a tool malfunctions or short-circuits.

ⓘ Battery powered tools are STRONGLY recommended ⓘ

If AC tools are used, they must be plugged into a circuit that is adequately protected against Ground Faults & safety hazards, in accordance with local electrical codes.

Steering System

To obtain the best performance from your autopilot system, your boat’s steering system must be in good working order. The hydraulic system should be bled, and should be operating with minimal play.

When installing a Reversing Motor Pump, a Constant Running Pump, or an Engine Driven Pump, it is recommended that you install shutoff valves on all hydraulic lines between the Pump and the steering system.

Power Supply

For reliable operation of your Autopilot, your boat’s power supply system must have an adequately-breakered, or fused, DC (direct current) power supply at a nominal voltage of either 12 or 24 volts. If the circuits are fused, a power switch should also be provided. Ensure that adequate wire sizes are used to handle the expected maximum currents.

Special Tools

A slot screwdriver with a tip size of ~2.5 mm (0.1”) is required, for tightening the small screws of the wire clamps in the plugs which mate with the SPU’s pin-receptacle connectors.

Fasteners

In general, fasteners are not supplied with the system – since different surfaces need various types of fasteners.

But, no matter which types are best suited to your boat, SI-TEX strongly recommends that you use non-corroding hardware to secure all equipment in the system.

Control Head

The Control Head is normally mounted in the boat's wheelhouse. It can also be mounted in more exposed locations, such as on a flying bridge, since it is fully splash-proof (but note that it is not submersible).

Each Head is supplied (when ordered as part of System Kits) with a surface mounting kit. Optional flush-mount and Bracket mount kits are available. Flush mount is meant to be used when the Head is installed inside the boat; the bracket & surface mounts can be used inside or outside.

Each kit is packaged in a separate bag. Complete instructions, including drilling/cutting templates for each type of mounting, are contained within the bag for each kit.

There is a bag (PN 30110005) containing a number of screws, washers, and nuts. The fasteners in this bag are to be used with either the surface mount kit or the flush-mount kit. They are not used for bracket-mount installations.

A slide-on, friction-fit cover is also supplied, for use with either the bracket or surface mounts. Despite that, the Control Head should not be located where it is exposed to prolonged direct sunlight.

The Control Head comes with a 7.6 metre (25') detachable cable. The cable has a 9-pin circular connector on one end, flying leads on the other end, and a loose plug that the leads will be wired into after the cable is routed; the plug mates with a matching connector on the SPU. The cable and Head-end connector are fully waterproof.

Electrical Connection

Route the Control Head Cable to where the SPU will be located. Avoid running the cable parallel to antenna cables, AC power, or DC wires/cables carrying heavy current. Excess Control head Cable can be coiled up, or the cable can be trimmed to a suitable length.

See **Control Head** on page 42 for details on connecting the cable to the SPU.

Signal Processor Unit

The SPU should be mounted in a clean and dry location inside the boat, and away from heat, moisture, and water of any kind. It should be somewhere central: between the Control Head, the main electrical panel, and the rudder drive system. It need not be visible during normal operation, but it should be located so that there is easy access to it during wiring & maintenance operations. Typical locations are right next to the electrical panel, at (or under or above) the Navigation station, or in a dry storage locker in or near the wheelhouse.

The SPU should be mounted far enough away from your boat's magnetic compass(es) so as to minimize any electrical/magnetic interference to it (them); a good rule-of-thumb is at least 1 metre (3') – but see **Compass Safe Distances** on page 162 for specific values, if you do not have that much space.

The SPU can be mounted vertically on a bulkhead or horizontally on a deck or shelf.

- If mounted vertically, it should be positioned so that all wires and cables will exit from the bottom of the SPU (after running sideways, left &/or right as appropriate, from the SPU connectors under the SPU's wiring cover).
- If mounted horizontally, all wires and cables should have a drip loop formed in them.

Each SPU is shipped with a package of four mounting feet and an instruction sheet that includes dimensions for drilling holes to fasten the feet to the boat.

Electrical Connection

See **Wiring the System** on page 38 for SPU wiring details.

Compasses

Autopilot systems are usually supplied as a complete System Kit, with SI-TEX Rate Compass.

Compass Deviation

When first installed, most Compasses will exhibit Deviation effects.

Magnetic Deviation is the error between the compass reading and the boat's actual Magnetic heading. Deviation is a result of magnetic fields induced in the boat's hull (especially on steel boats) by various factors. It can also be caused by electromagnetic fields from objects such as engines, davits, galley equipment and the like, from the boat's electrical/electronic systems & wiring, and even from ordinary electronic items such as PCs, cell phones, CD/MP3 players & AM/FM radios.

If you have a SI-TEX Rate Compass the SP 36 can electronically compensate for the Hard-Iron portion of the Deviation. The compensation procedure is done during the Sea Trials.

Common Installation Considerations

Caution! *Do not permanently install any compasses until Sea Trials are complete. You may have to relocate the compasses, during the trials.*

Avoid running the cable from Compass parallel to antenna cables, AC power, or DC wires/cables carrying heavy current.

Any excess cable or cables should be individually coiled up, in a suitable location near the destination. SI-TEX recommends that compass cables NOT be shortened.

Rudder Follower Unit

Note: *the SI-TEX SP 36 does not use a Rudder Follower Unit when operating using its Virtual Rudder Feedback feature, and so SP 36 system kits do not include an RFU.*

The Rudder Follower Unit (RFU) is used to transmit (i.e., “feed back”) the position of the rudder to the autopilot.

The RFU should be connected to whatever part of the steering system that the autopilot controls. Normally, this will be the boat’s rudder. However, if the boat has a two-stage steering system where the autopilot drives a control or servo ram, the RFU should be mounted to the servo ram rather than to the rudder.

Typically, the RFU is mounted in the stern of the boat, close to the rudder post. A mounting base may have to be fabricated to position the RFU properly. Mount the RFU in a location where the possibility of damage from any equipment stowed in the area is minimized.

Note: *if you are connecting the SP 36 to a mechanical Cable Drive (for boats that use cable steering instead of hydraulic steering), the RFU is built into the Cable Drive. See the Cable Drive Installation Manual for details.*

Rotary Rudder Follower Unit

Mount the Rudder Post Arm on the rudder post using a stainless steel band clamp (not supplied). Bolt the ball joint to the hole in the Rudder Post Arm corresponding to the diameter of the post in inches, making sure the ball is facing upwards.

Mount the RFU so that the RFU Arm is the same height as the Rudder Post Arm. The RFU is centered when the arm is directly above the cable gland (see Figure 8).

The distance between the centerline of the Rudder Post and the RFU must not exceed 24 inches. Make sure that the ball joints on the Rudder Arm and RFU arm are facing upwards as shown in Figure 8.

Snap the rod assembly onto the ball joints. Be sure to close the release clamps on each socket. Refer to Figure 8, and adjust the length of the rod to get the correct geometry with the rudder dead-ahead.

If the locking screw in the RFU arm has been loosened, or the arm has been removed from the RFU, re-attach the arm and check the potentiometer center position.

When the rudder is dead-ahead, the electrical resistance between the wires of the black & green wire pair, and the wires of the white & green wire pair, should be equal (approx. 600 ohms each).

Be careful to check the installation for any mechanical obstructions or binding of the linkage, and correct it now, before it becomes a problem.

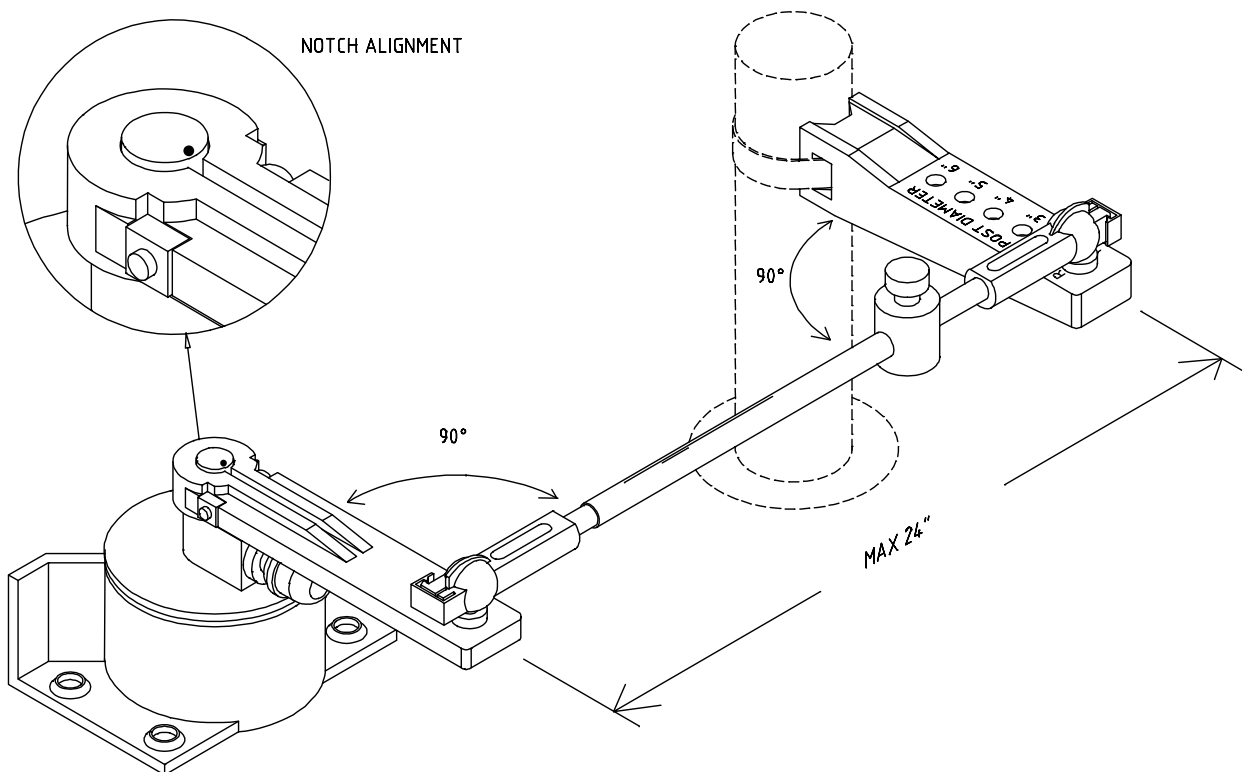


Figure 8 – RFU Linkage Geometry

Electrical Connection

The Rudder Follower Unit is normally supplied with approximately 15.5 metres (50') of cable. Run the cable from the RFU towards the SPU, ensuring that a hose or conduit protects it wherever it passes through bulkheads, holds, or any other area where it could be damaged.

If the length of cable supplied is too short to reach all the way to the SPU, obtain a terminal strip and sufficient additional cable from your SI-TEX Dealer. Mount the terminal strip in a convenient DRY location where it will not be subjected to moisture of any kind.

See **Rudder Follower Unit** on page 44 for further details on connecting the cable to the SPU.

Heavy Duty Rotary Rudder Follower Unit

The Heavy Duty Rotary RFU is also compatible with systems. If you have purchased one of these devices, follow the installation instructions supplied with the unit.

See **Rudder Follower Unit** on page 44 for further details on connecting the cable to the SPU.

Linear Rudder Follower Unit

Installations on boats with outboard motors will typically use a Linear RFU.

- 1) If the Linear Rudder Follower is to be mounted with the sliding rod facing towards the port side of the boat, turn the steering wheel so the motor is hard over to starboard.

If the Linear RFU is to be mounted with the sliding rod facing towards the starboard side of the boat, turn the steering wheel so the motor is hard over to port.

- 2) Carefully measure the travel of the outboard motor's steering cylinder. It must not exceed 25.4 cm (10"). If it is more than that, corrosion resistant spacers will need to be fabricated to go over the rod of the hydraulic cylinder to limit its travel (see Figure 9).

Caution! If the travel of the steering cylinder is more than 25.4 cm (10"), the Linear RFU will be over-extended, causing it to be damaged or destroyed.

ⓘ There is no warranty on the Linear RFU for damage due to over-extension.

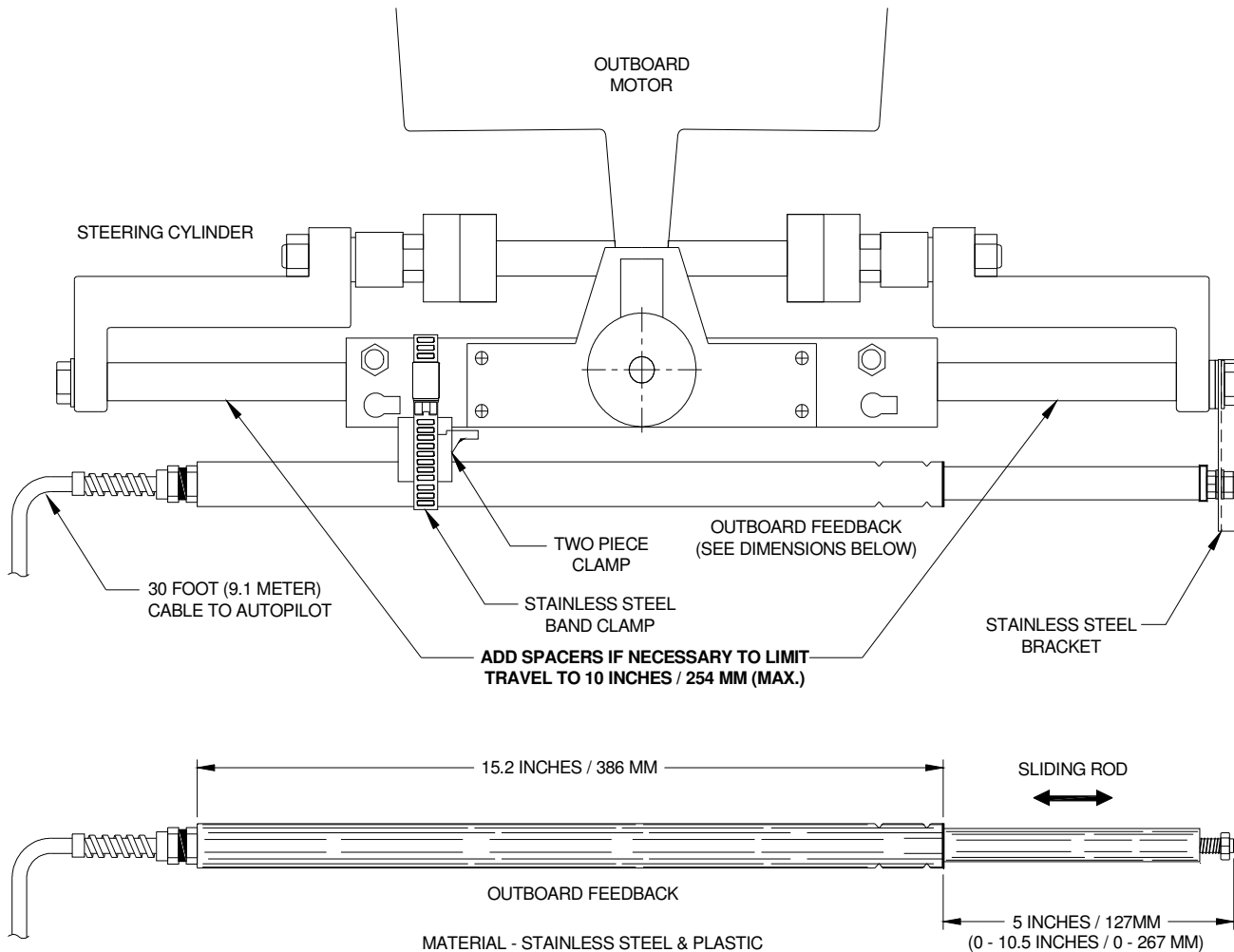


Figure 9 – Typical Arrangement of Linear RFU on an Outboard's Steering Cylinder

- 3) The clamps and band should be positioned as far as possible towards the end of the Linear RFU which has the cable that goes to the autopilot (see Figure 9). Loosely place the stainless steel band clamp around the Linear RFU and the outboard's steering cylinder.

Place the larger plastic mount bracket on the RFU, curved face on the Follower. Place the smaller plastic mount bracket on the steering cylinder, curved face on the cylinder body. Loosely tighten the band clamp around the RFU, the cylinder and the brackets (see Figure 10 and Figure 11).

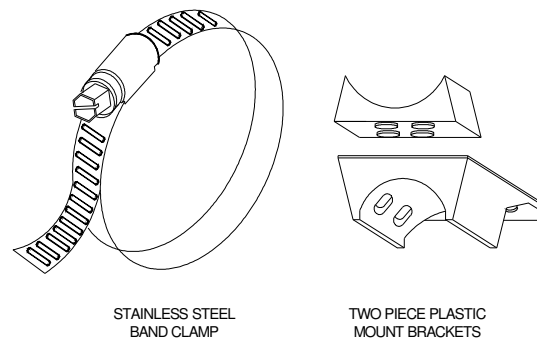


Figure 10 – Band Clamp and Plastic Brackets

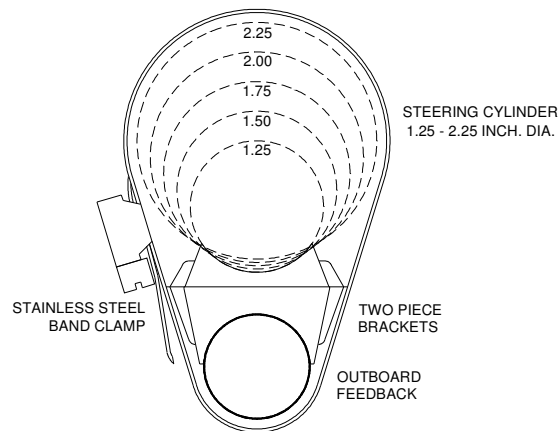


Figure 11 – Installed Arrangement of Brackets

- 4) Remove the nut from the steering cylinder rod's end (see Figure 12). Place the thick nylon flat washer (1.57 mm / 0.062" thick), then the thinner nylon flat washer (0.81 mm / 0.032" thick) and lastly the stainless steel bracket, over the threaded end of the rod. Place the stainless steel flat washer on the other side of bracket, and then replace the cylinder rod's nut. Do not tighten it yet – just thread it part-way, far enough to stay on.
- 5) Extend the sliding rod completely out of the Linear RFU. Push it back in slightly (about 3mm / 1/8"). Adjust the position of the Follower so that the end of the sliding rod is flush with the stainless bracket. Place the nylon washer between the nut and the stainless steel bracket. Place the stainless steel washer on the other side of bracket, and screw the Nylock nut part-way onto the threaded rod at the end of the Linear RFU.

- 6) Carefully adjust the position of the Linear RFU so that it is parallel with the hydraulic cylinder, in both horizontal and vertical planes.
- 7) Finally, tighten both nuts and the stainless steel band clamp securely.

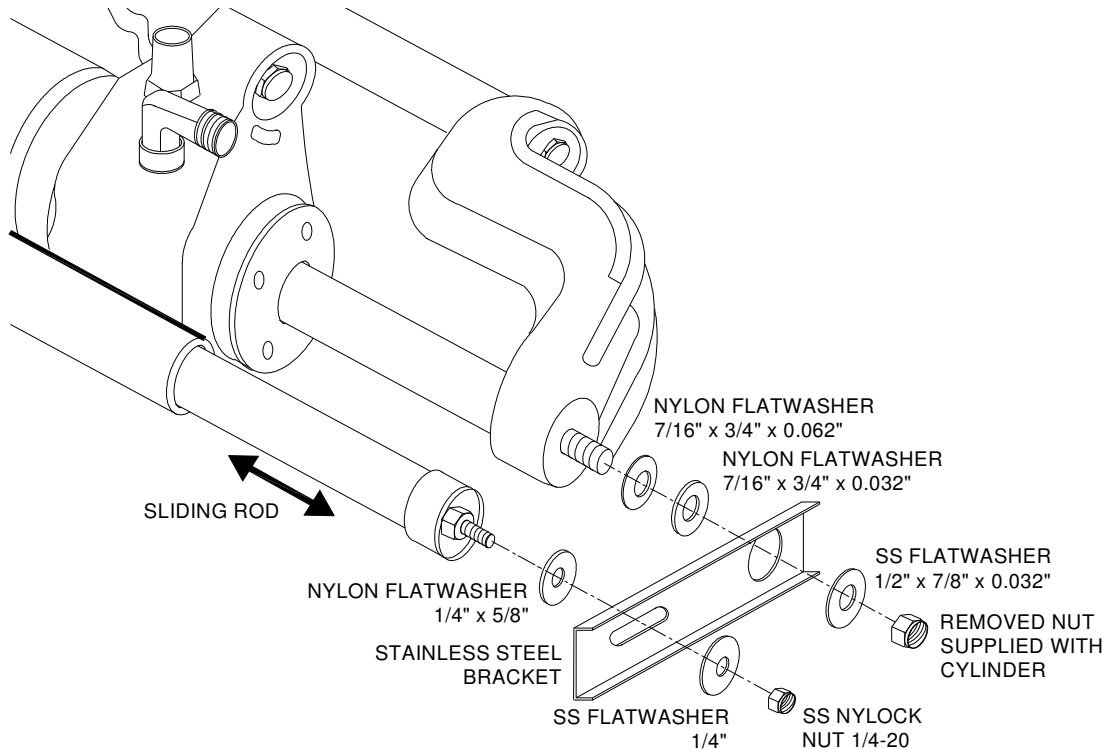


Figure 12 – Fasteners, Stainless Bracket Arrangement

Caution! To avoid the possibility of contaminants entering the Linear RFU, it is advisable to do an occasional wipe-down of the sliding rod, while it is fully extended, with a clean rag.

If you trailer your boat, it is especially important to do this on a regular basis. A good time to clean the rod is during the on-shore preparation for every launch, since that will take care of any “road grime” picked up during the trip to the launching ramp.

Electrical Connection

The Linear RFU is normally supplied with approximately 9.5 metres (30') of cable. Run the cable from the Linear RFU towards the SPU, ensuring that a hose or conduit protects it wherever it passes through bulkheads, holds, or any other area where it could be damaged.

If the length of cable supplied is too short to reach all the way to the SPU, obtain a terminal strip and sufficient additional cable from your SI-TEX Dealer. Mount the terminal strip in a convenient DRY location where it will not be subjected to moisture of any kind.

See Rudder Follower Unit (Optional) on page 44 for further details on connecting the cable to the SPU.

Other Equipment

You should install the remaining components of your system according to the installation instructions that come with that equipment:

- Auxiliary Controllers
- Jog Steering Controls
- Rudder Angle Indicators
- Pumps & Drives
- ... and etcetera ...

Electrical wiring instructions for all these are a combination of the information in the manual supplied with each piece of equipment, and specific information for the Autopilot which is given in the following sections of this chapter.

Wiring the System

Once everything is securely mounted, you can begin wiring the various components of the system, one at a time.

❗ *SI-TEX strongly recommends that ABYC wiring standards, or the equivalent for your locale, be followed.*

Signal Processor Unit

Start by removing the Wiring Cover from the SPU. It is held in place by two knurled plastic nuts (see Figure 41).

Set the cover & nuts aside – they will be re-installed once all the wiring of the SPU is complete.

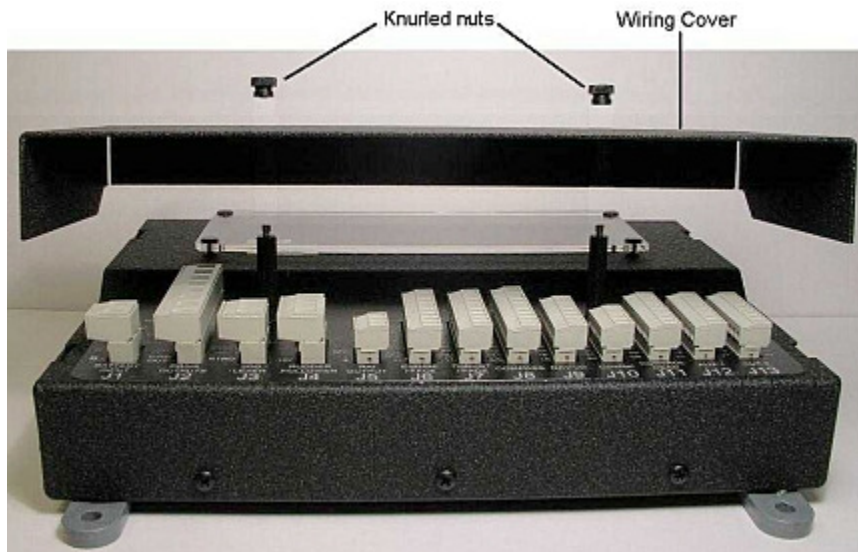


Figure 13 – Removal of the SPU Wiring Cover

Connectors on the SPU

With the wiring cover off, all the SPU's connectors are visible & accessible.

Each connector is a pin receptacle, with the pins sized according to how much current will be carried – bigger pins for higher current. Each pin has a signal name, rather than a number, to make it easier to match wires with pins (see connector label, below).

Each pin receptacle mates with a matching plug; the wires from external equipment & devices (battery, drive system, compasses, etc.) are inserted into those plugs. The plugs allow quick installation & removal of system wiring, yet are fully secure, once the various cables are strain-relieved.

The SPU is shipped with all the plugs normally required, pre-installed on the matching receptacles (except the Control Head's plug, which is supplied with it).

The plugs are "Euro style"; they have an internal U-shaped rising-cage wire clamp, driven by a slot-head screw. To attach a wire, the clamp's screw must be turned counter-clockwise several turns (using the small slotted screwdriver mentioned on page 28 – Special Tools), which drives the clamp downwards to open it up; then the wire can be fully inserted into that clamp. The screw must then be turned clockwise until the wire is tightly held in the clamp.

Wire Sizes

It is important to use the correct size wires in each connector, in both the mechanical & electrical sense!

Mechanically, due to the amount of vibration & impact shocks that can occur on a boat (from propeller & engine vibration, hitting waves, etc.), the stripped end of wires must be securely clamped in the plugs; using a too-small or too-large wire can cause poor clamping.

Electrically, due to the relatively high current requirements of an autopilot compared to many other types of electronic equipment, it is vital to use the largest possible size of wire to connect the various components. Undersized wiring will result in power losses which can affect overall efficiency and performance.

At the same time, due to the corrosive affects of the marine environment on bare wire, stripping too much or too little insulation from the ends of wires is poor practice. All the connectors used on the SPU are marine grade, and use corrosion-resistant materials.

The acceptable wire size range, DC current rating, stripped wire depth and pin spacing for all the SPU's connectors are as follows:

Connector Name	Wire Gauge	Rated Current	Wire Depth	Pin Spacing
J1, J2	12 – 22 AWG	12 A	6 mm	7.62 mm
J3, J4	12 – 22 AWG	12 A	6 mm	5.08 mm
J5 – J13	14 – 22 AWG	8 A	6.5 mm	3.81 mm

Table 1 – SPU Connector Ratings

Below are the recommended minimum gauges for the connections to the various elements of the system. All cables should use stranded wire, and have marine-grade insulation; only the ones so indicated must be shielded. If in doubt, contact your SI-TEX Dealer for help.

Function / Use	Wire Gauge
SPU Power Supply	2 x 12 AWG
12/24 VDC Solenoid Valve Steering System	3 x 18 AWG
Reversing Motor Steering System	2 x 14 AWG
Rudder Follower Unit	3 x 18 AWG (shielded)
GPS, Chartplotter, Navigation Computer	2 x 22 AWG (shielded)
Rudder Angle Indicator	2 x 22 AWG

Table 2 – Recommended Minimum Wire Gauges

Power Supply

The SP 36 will operate on any voltage between about 11 VDC and 30 VDC. This allows operation with boat battery systems with nominal voltages of 12 to 24 VDC.

Caution! Do not power up the SPU until you have completed the installation, and performed the steps outlined in "Post-Installation Checks".

If you are following the ABYC wiring standard, the positive leg of a DC system will use Red wires, while wiring for the negative leg (usually referred to as Ground) will be Yellow or Black.

Power to supply the autopilot should be taken directly from a breaker or distribution panel. The autopilot should be wired into its own individual breaker or fuse. Using appropriately sized wire or cable (see Table 2 on the previous page), wire the battery connections to the connector plug and receptacle labelled **J1 - BATTERY INPUT**. Double-check the wiring polarity before inserting the plug into the receptacle.

Caution! The SPU is NOT reverse-polarity protected.

If you connect the wrong voltage polarity at J1, you WILL damage the SPU and Head!

This will void the Warranty!

The following diagram shows a typical power supply circuit:

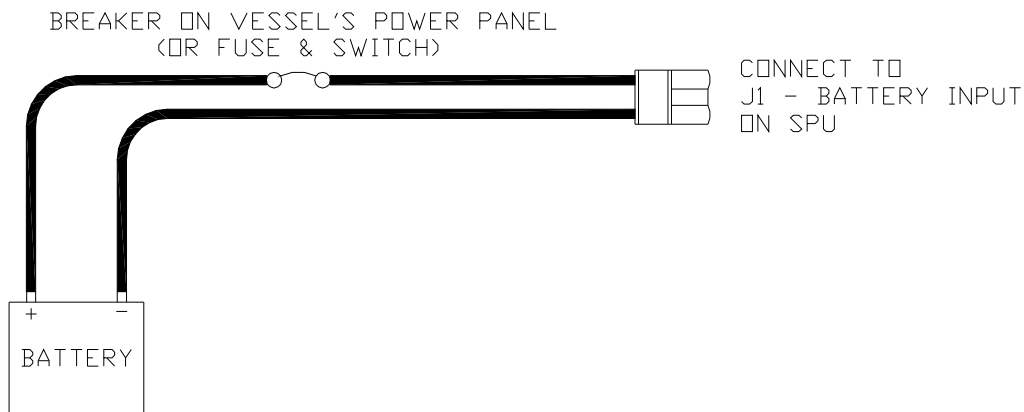


Figure 14 – Typical Power Connection to SPU

Caution! Do not plug the power plug into the **J1** receptacle on the SPU until all the electrical checks listed in **Final Steps & Post-Installation Checks** on page 55 have been passed.

Power Supply Extension

If the SPU is mounted a long distance from the ship's breaker panel, it is recommended that heavy gauge wire (#8 AWG or larger) be routed between the breaker panel and a suitable terminal block, which is mounted in close proximity to the SPU. A short length of #12 AWG wire can then be used between the terminal block and the SPU. This minimizes voltage drop between the breaker panel and the SPU. The terminal block is needed, in this situation, because the wire openings in the plug for J1 can accept a maximum wire size of 12 AWG, so wire larger than that can not be directly connected to J1.

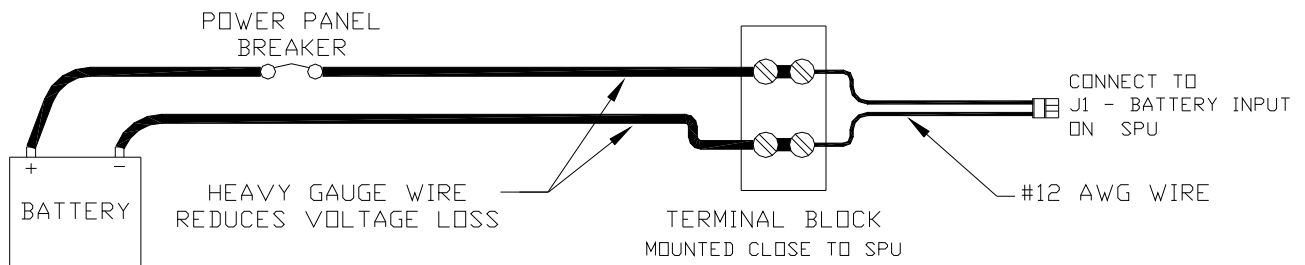


Figure 15 – Reducing Supply Voltage Losses

You may also want to use the same heavy-gauge extension wire technique for the Rudder Drive output wiring, if the SPU is located a long ways from the Rudder solenoids, valves, actuator, motor, etc. (see **Drive Outputs** on page 45).

Drive Box Power Supply

If your autopilot system utilizes one of SI-TEX's CT Drive Boxes, it should be wired back to the breaker or fuse separately from the rest of the autopilot system.

Do **NOT** ever "daisy-chain" power wiring!

The following diagram shows the proper method when using a CT Drive Box:

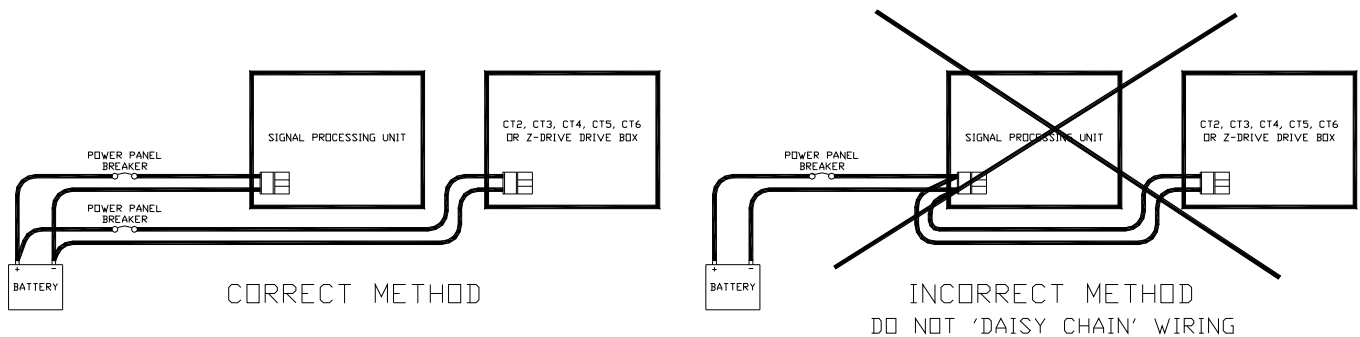


Figure 16 – Typical Battery Connection to Drive Boxes

Input & Output Connections

Control Head

Two types of control cable are used in manufacturing SP 36 systems. The only difference between them is the colour-coding of the wires. Wire the cable from the main Control Head onto the nine-position plug-in connector according to the following diagram:

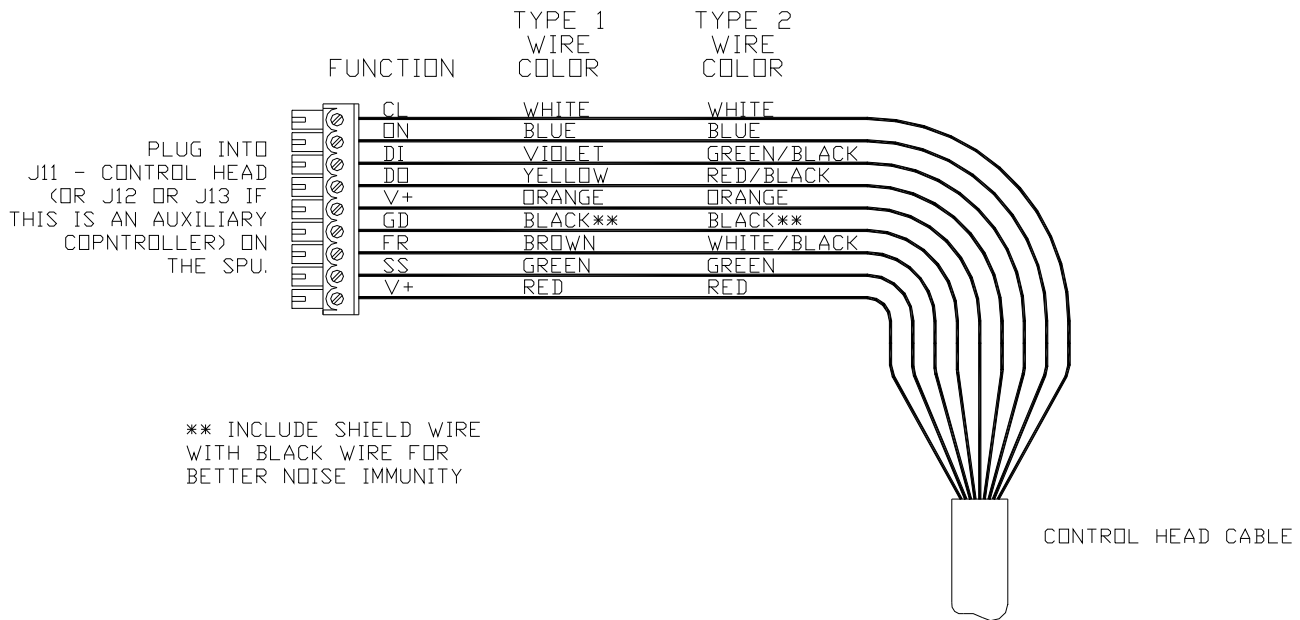


Figure 17 – Wiring Connections for Control Head, Handheld Remotes, and Fixed Remotes

Plug the nine-position plug connector into the SPU receptacle labelled **J11 - CONTROL HEAD**.

Auxiliary Controller(s)

All Control Heads, Handheld Remotes, and Fixed Remotes designed to work with the SP 36 utilize the same wiring diagram as the Main Control Head (see Figure 17, above). The only difference is that these devices are plugged into the receptacles **J12 - Aux 1** or **J13 - Aux 2** instead of **J11 - CONTROL HEAD**.

Note: Auxiliary Head Power On/Off

The SP 36 SPU is shipped from the factory configured so that power can only be turned on or off from the Main Control Head. The Main Control Head is designated as the Head which is plugged into the SPU receptacle labelled J11 - Control Head.

However, the system can also be configured so that it can be turned on or off by any Control Head plugged into the receptacles J12 - Aux 1 or J13 - Aux 2 (note: power cannot be turned on from CR-203 or TS-203 Remotes). If reconfiguration is desired, follow the instructions for enabling Auxiliary Head / Remote Power On (see page 155).

NFU Jog Steering Controls

Any number of Non-Follow-Up (NFU) Jog Steering Controls can be connected to the SP 36 SPU. They are simply wired in parallel to each other. Connect them to the terminal labelled **J3 - JOG LEVER** as per the following diagram⁴:

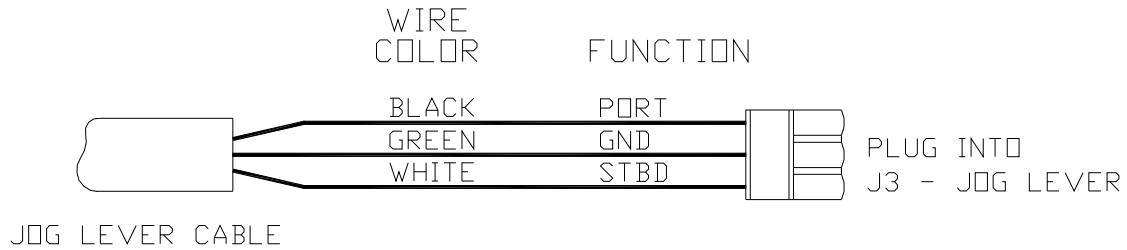


Figure 18 – Wiring Connections for Jog Controls

In order to use the Jog Controls connected in the above manner, the autopilot must be turned on. While the Control's lever is held activated, the autopilot will move the rudder either to Port or Starboard. However, the autopilot will stop the rudder when it gets to the (user-adjustable) rudder limits programmed into the autopilot; this is done to reduce stress on the steering system.

SI-TEX Rate Compass

If you have a SI-TEX rate compass, you need to wire the compass to the NAV port as per the diagram in Figure 19 - Wiring connections for Si-Tex Compass

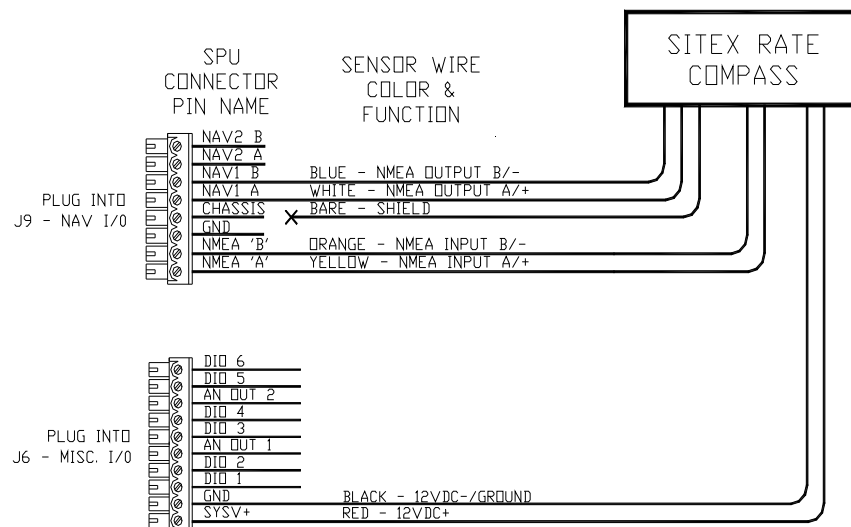


Figure 19 - Wiring connections for Si-Tex Compass

⁴ This diagram assumes the Jog Control is mounted with the lever pointing up, and you want the boat to turn to Port when you move the Control's lever leftward. See the Control's Instructions for how to wire other orientations.

Rudder Follower Unit (Optional)

The RFU is connected to the four-position receptacle on the SPU labelled **J4 – RUDDER FOLLOWER**. Wire the RFU to the plug-in connector as per the following diagram.

Note: an RFU is optional on SP 36 systems.

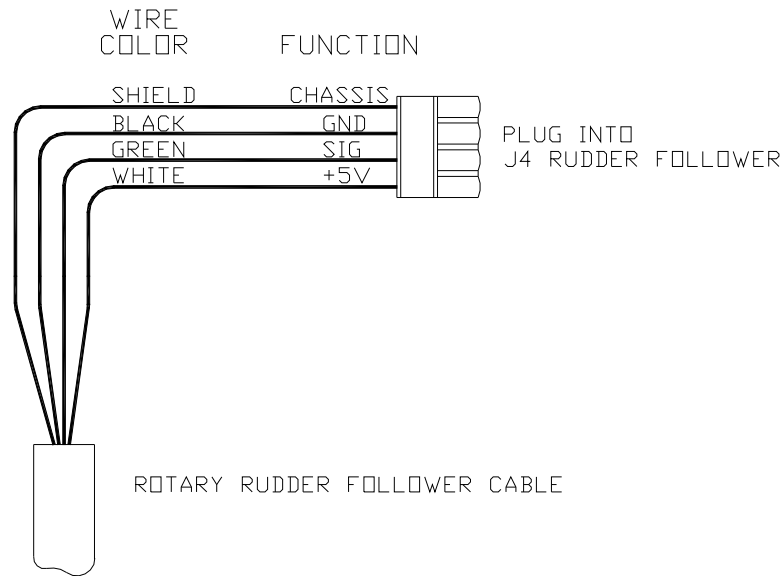


Figure 20 – Wiring Connections for RFUs

Rudder Angle Indicators (Optional)

The SP 36 system will drive Rudder Angle Indicator (RAI) meters – such as those supplied by SI-TEX (PN 20360014 or 20360023), **if you have a Rudder Follower Unit**. Mounting instructions are included with the meter. Wire the meter to the plug for the SPU receptacle labelled **J5 – RAI OUTPUT**. If you have more than one RAI, they should all be wired in series, as shown below (up to five, 500 µA RAI meters may be used):

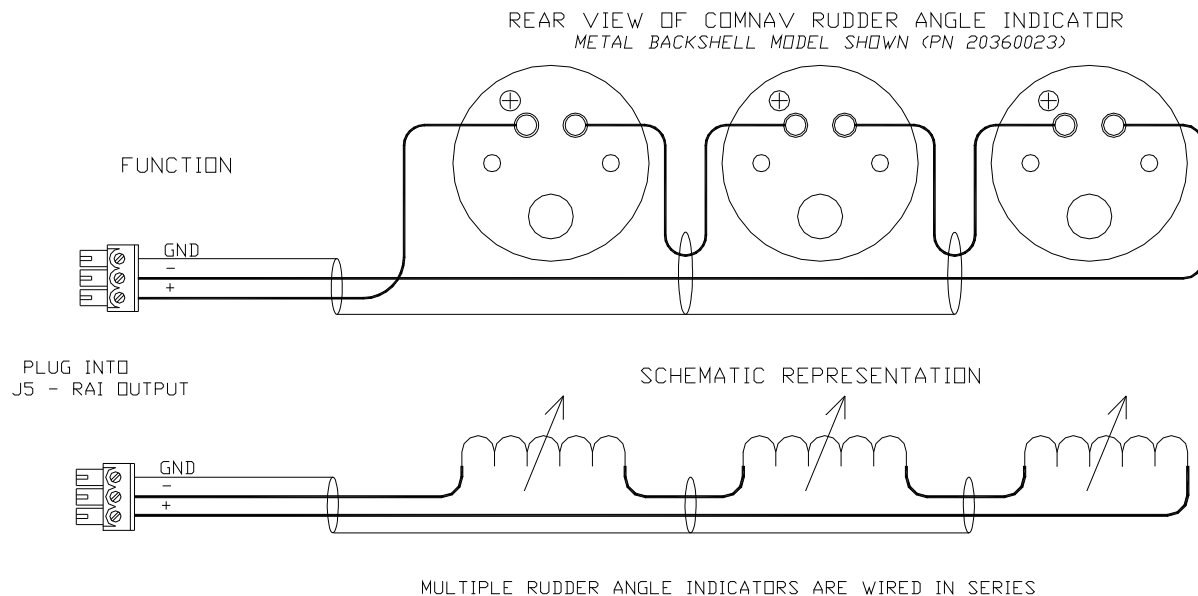


Figure 21 – Wiring Connections for Rudder Angle Indicators

Drive Outputs

The SP 36's SPU is capable of directly driving a variety of steering systems. Optional Drive Boxes are available for those systems not handled directly by the SPU. Contact your SI-TEX Dealer for more information.

Almost all connections to the steering system are done at the **J2 – DRIVE OUTPUTS** connector.

Reversing DC Motor Hydraulic Systems

The SP 36 SPU can directly handle reversing DC motor hydraulic⁵ pumps drawing up to approximately 20 amps. For larger current requirements, the SI-TEX CT2 Drive Box should be used. To connect the pump motor directly to the SPU, use the following diagram. Note that wire polarity is not important, since the SPU will automatically make the necessary adjustments internally when the system is set up.

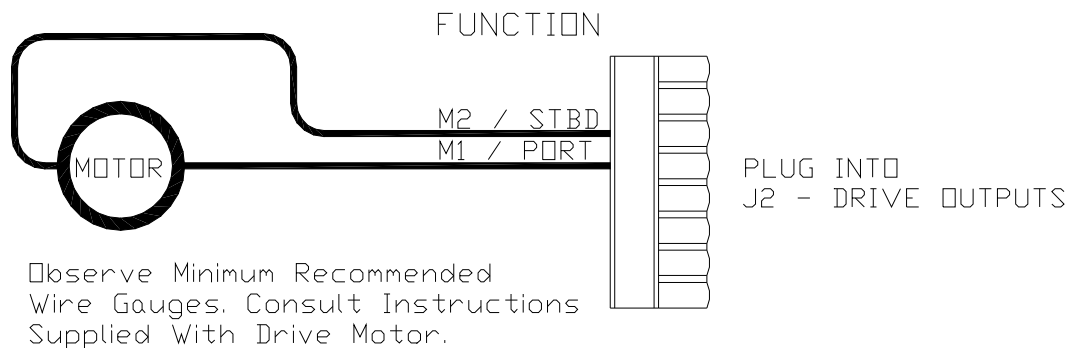


Figure 22 – Wiring Connections for Reversing DC Motors

Linear Actuators or Mechanical Rotary Drives

Some Linear Actuators incorporate a Bypass Valve. To operate properly, the Bypass Valve should be activated by the SPU's **SW'D B+** output. Similarly, most mechanical drives incorporate a solenoid-activated clutch. The clutch solenoid should also be activated by the **SW'D B+** output. Refer to the following diagram:

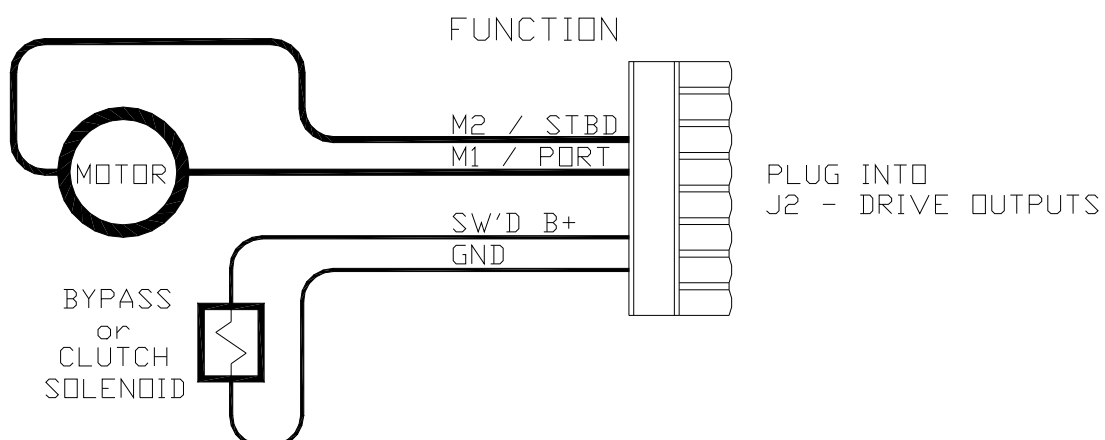


Figure 23 – Wiring Connections for Linear Actuators or Mechanical Rotary Drives

⁵ Two very important steps when installing any hydraulic system are to bleed it of any air trapped in the fluid, and to check for fluid leaks. This will be done later, during the Drive Setup procedure.

Shunt-Field Reversing Motors

For shunt-field reversing motors, connect the shunt field coil positive terminal to **SW'D B+** and the coil negative terminal to **SW'D B-** as per the following diagram:

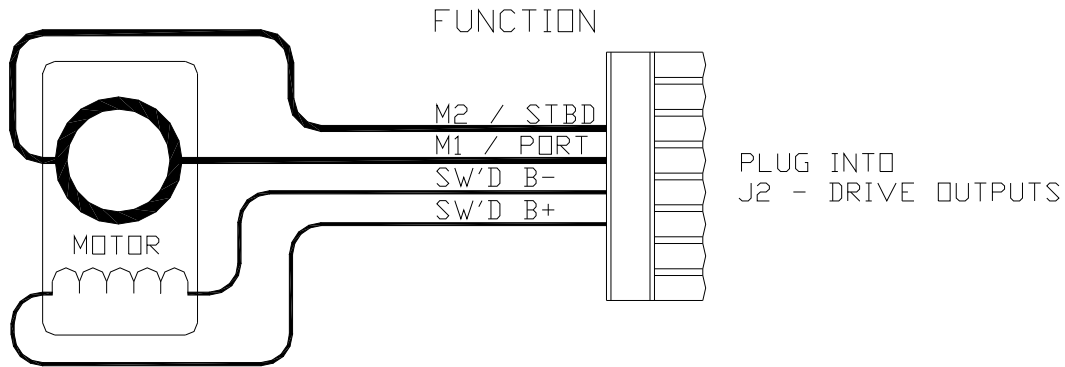


Figure 24 – Wiring Connections for Shunt Field Reversing Motors

Standard Four-Way Solenoid-Activated Hydraulic Valves

Connection to 12 VDC or 24 VDC solenoids should be made as per the following diagram.

In this configuration, the autopilot supplies the positive voltage (**SW'D B+**) whenever the autopilot is in **POWER STEER, AUTO, or NAV** modes. **SW'D B+** is turned off in **STANDBY** mode, thus providing an extra measure of safety.

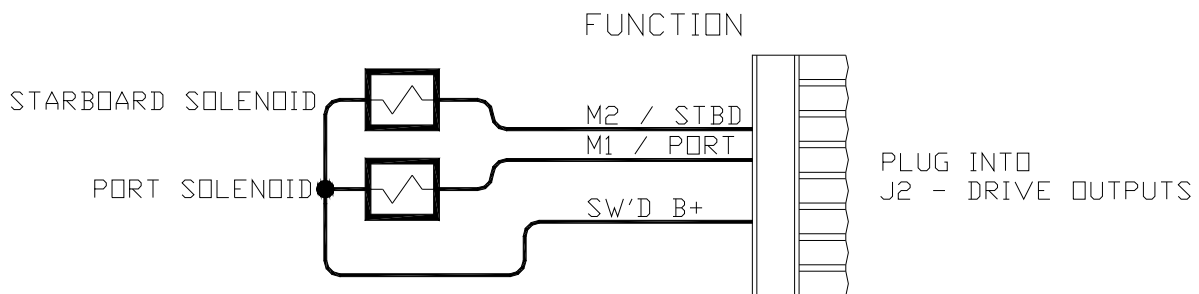


Figure 25 – Wiring Connections for Standard Four-Way Solenoid Valves

The diagram above assumes that an engine driven pump is used for the hydraulic system. In the case of an electrically powered constant running pump, use the following connection:

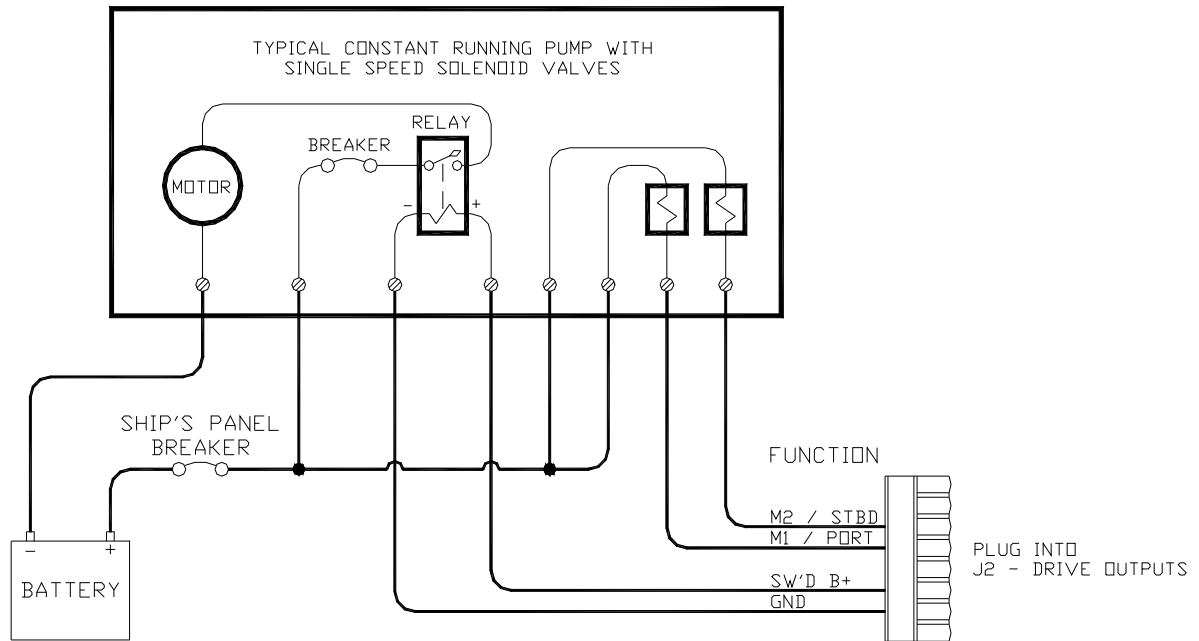


Figure 26 – Wiring Connections for Constant Running Electric Pump.

External Alarm Output

An external alarm can be connected to the SPU.

The autopilot can be configured to activate the external alarm whenever any alarm or error message appears on the Control Head, or to activate the external alarm only if the Watch Alarm is not answered. See the description of the **Watch Alarm** & External Alarm on page 127 on how to choose those options.

One of two outputs can be used for the external alarm. Typically, you would choose to connect the external alarm between Battery Positive (**PWR OUT**) and the Switched B- (**SW'D B-**) outputs on **J2**, as in the following diagram:

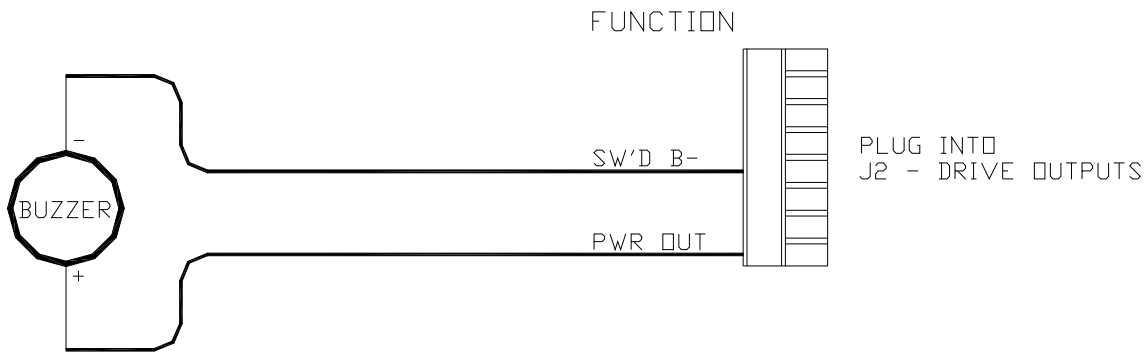


Figure 27 – External Alarm, using SW'D B- Output

Alternatively, you may choose to use the **SW'D B+** and **GND** outputs as shown here:

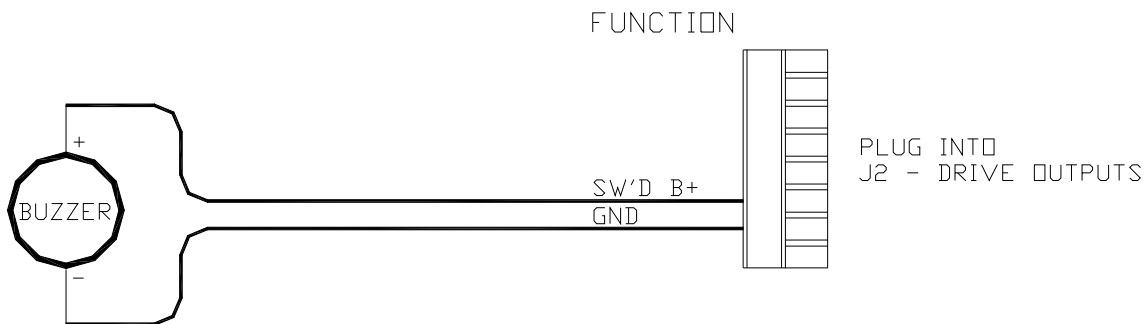


Figure 28 – External Alarm, using SW'D B+ Output

Note: when using the External Alarm configuration shown in Figure 27, there is a small current which will be flowing constantly between the pins, even when the alarm is OFF. This will not be a problem with many types of alarms; however, with certain types of sensitive Piezo-electric audible alarms, the leak current can cause a constant low-level tone from the Piezo device.

An Application Note is available which describes this potential problem in detail, with suggested remedies.

If you are experiencing this problem, please ask your SI-TEX Dealer (or go to SI-TEX's web site) for Application Note 2007-01.

Some installations require separate monitoring for power failures. This can be accomplished with the following circuit, which utilizes two relays. The coil voltage of the relays should match the supply voltage for the autopilot. The Alarm Supply, which must be a separate, dedicated supply from the autopilot supply, should match the voltage of the alarm.

This is the circuit for using Switched B- as the alarm output:

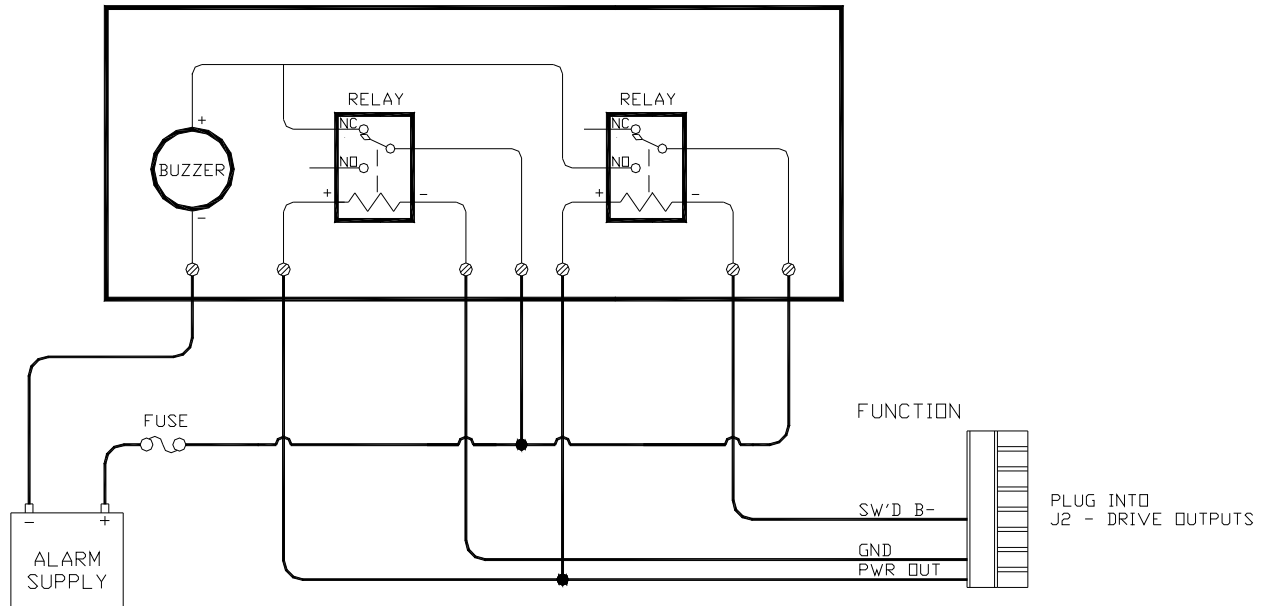


Figure 29 – External Alarm, SW'D B- Output with Power Fail Option

This is the alternative circuit, using Switched B+ as the alarm output:

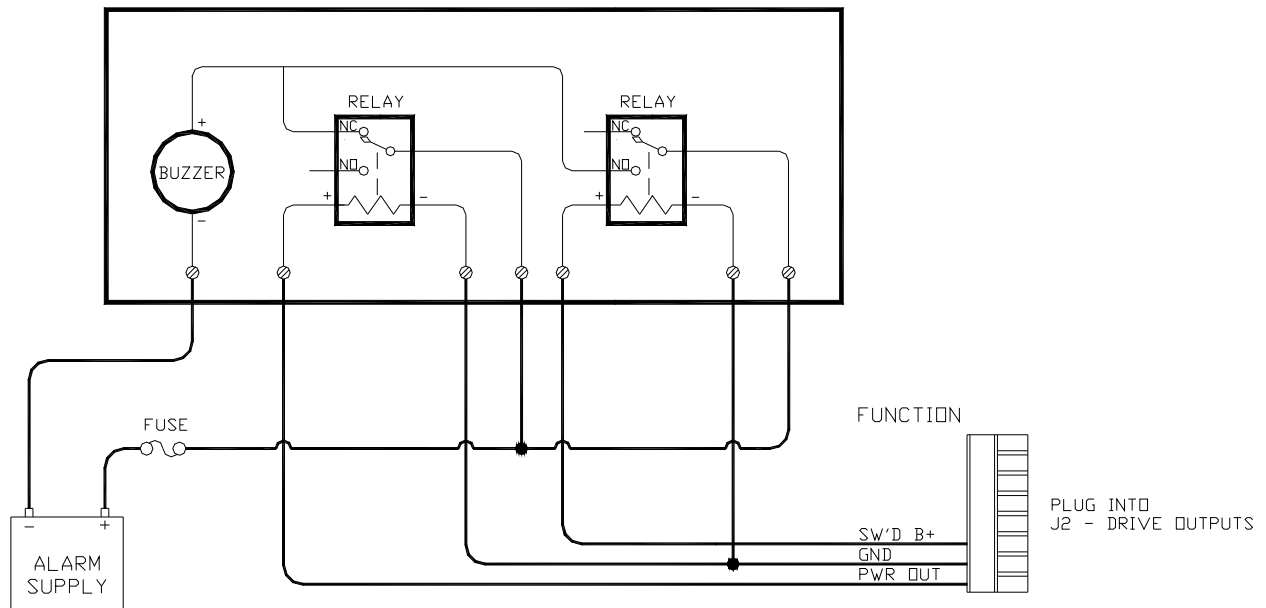


Figure 30 – External Alarm, SW'D B+ Output with Power Fail Option

Speed Mode & Timing Outputs

The SPU outputs two status signals on the **J6 – MISCELLANEOUS**⁶ connector. The receptacle is supplied with a 10-pin mating plug.

These two status signals indicate:

- If the system is operating with the Hi or Lo speed steering parameters in effect (see page 95), in **AUTO** or **NAV** modes.
- If the system is operating in **WORK** mode (see page 118).

The status signals are meant to be used to allow indication of those conditions on an external alarm or indicator. Both conditions are indicated on the Control Head's LCD display (see Figure 46 & Figure 59) – but it is also sometimes useful to have them indicated with an external alarm or lamp at locations other than where the Control Head is located.

These two outputs can also be used to control automatic deployment (& retrieval) of external “stabilizer” equipment, to enhance the boat's steering & stability when it is moving at a slow speed, or when **WORK** mode is in effect. In both these situations, the boat is moving slowly, and so there is not as much steerageway (i.e., less water flowing over the Rudder, so it does not generate as much sideways force).

All two outputs are logic-level open-drain outputs directly from the SPU's microcontroller, and must be used only within the following voltage/current limits:

- Each output requires its own external pull-up resistor, which **must** be wired **only** to the SPU's logic power supply (5 VDC, created by a linear regulator on the SPU, and available at the V+ pin of **J6**), and to the external alarm, lamp &/or control circuit. The resistor value plus the impedance of the load must total **no less** than 3K3 Ohms (to limit the current into the pin in the “0 V” state to **less than 1.6 mA**).
- If needed, the SPU's Ground reference for these signals is on the GND pin of **J6**.

Signal	J6 Pin	When at 0 V	When Open-circuit
WORK MODE	WORK	Normal mode	WORK mode engaged
SPEED MODE	HI SPD	Lo Speed	Hi Speed

Table 3 – Speed Mode Outputs

All outputs are ESD-protected – but you still must use them with care:

- Do not use more than about 0.5 m of cable to connect them to the external alarm/indicator or stabilizer-control circuit.
- If you must connect to something farther away than that, use a suitable buffer or isolator circuit – a transistor, a relay or (preferred) an opto-isolator block. With a relay, be sure to wire a flyback-suppressor diode across the coil.
- If shielded wire is used, connect the shield only at the SPU – to the GND pin of **J6**.

Note: *unused pins on J6 are reserved for possible future use.*

⁶ All the pins of **J6** are unused, on those prior versions (this connector was labelled **J6- ENGINE I' FACE** on P Series SPUs manufactured before 2008).

Navigation Data

The SP 36 has the ability to accept Navigation data & information formatted according to the NMEA 0183 standard (version 3.00).

Many marine electronics devices (such as digital compasses, GPS receivers, chartplotters, and electronic charting systems, to name a few) have outputs complying with NMEA 0183.

One such device can be connected directly to the SP 36's SPU, by wiring it into the plug mated to the receptacle labelled **J9 – NAV I/O**.

The SPU also has an NMEA output; it transmits the autopilot's real-time Heading data and status information, for use by devices such as a radar display, a chart plotter or a navigation program on a PC.

Refer to **Appendix 2** for more information on the NMEA 0183 sentences accepted and sent by the system.

The diagram below shows typical wiring for the **J9** connector.

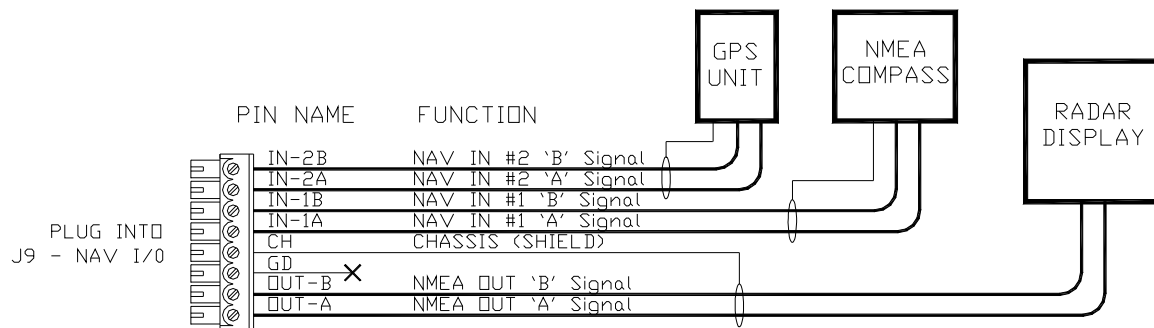


Figure 31 – Typical NMEA 0183 Connections

For proper operation, the connected device(s) must fully comply with NMEA 0183 Standard (version 3.00):

- RS-422 electrical levels
- Baud rate: 4800
- Serial data format: 8 data bits, no parity, 1 stop bit
- Correct NMEA sentence structure
- Checksums are optional, but must be valid if present

It may also be possible to use RS-232 electrical levels, in some cases – such as when using a PC (see page 138).

The **Nav2** port can optionally be run at 9600 Baud.

- To do so, you need only set the other device to transmit at that rate. The SPU automatically sets the rate for this port, by looking for “valid NMEA data” at all possible Baud rates.

Signal Names

The names of the NMEA data signals, and of the paired wires carrying them (see below), are specified in NMEA 0183: `A` & `B`.

The SPU's wiring label uses those names, on the **J9 – NAV I/O** connector (see Figure 31).

However, sometimes other equipment will use different names:

NMEA Name	J9 Connector Label	Function	Alternative Names
`A` signal	IN 1A or IN 2A OUT A	Positive voltage with respect to `B` is a logical 0 (aka Active or Space or ON ⁷)	+ or NMEA + SIG or SIGNAL POS or +VE
`B` signal	IN 1B or IN 2B OUT B	Positive voltage with respect to `A` is a logical 1 (aka Idle or Mark or OFF)	- or NMEA - RTN or RETURN NEG or -VE

Table 4 – NMEA Signal Translation Guide

RS-422 Electrical Interface

The RS-422 electrical interface specified in the NMEA 0183 Standard uses a pair of balanced signals (aka “differential signals”), in paired wires, with the ‘A’ signal on one wire & the complementary ‘B’ signal on the other.

It is necessary to maintain the correct signal polarity, when connecting one of the SP 36 SPU's RS-422 input or output wire pairs to another NMEA 0183 device:

- The SP 36 input port's `A` signal pin must be connected to the `A` output terminal of the other device; similarly, the SP 36's `B` input pin must be connected to the `B` output terminal of the other device.
- Similarly, the SP 36 output port's `A` & `B` signal pins must be connected to the `A` & `B` input terminals of the other device.

Other points to be aware of:

- There is no Ground wire for the SP 36's **NAV1 - IN** ports. Both ports are NMEA Listeners (as defined in the Standard), and so are optically isolated from the rest of the SPU circuitry; they need only the `A` & `B` signal pair to function properly.
- The SP 36's **NAV - OUT** port (an NMEA Talker) is not optically isolated from the rest of the SPU circuitry. However, since the other device will have an optically-isolated input (if it is a fully-compliant NMEA Listener), no Ground wire for the **NAV - OUT** port is necessary⁸.
- The CH pin on **J9** is connected directly to the SPU chassis, and is also AC-connected to the SPU's Signal Ground, via a 100 nF capacitor. If the cable carrying the NAV signal wires from/to the other NMEA device is shielded, the shield should be wired to the CH pin.

i *The cable's shield must not be connected at the other end, or anywhere else but to J9's CH pin!*

⁷ An NMEA 0183 serial data stream is inverted by the transmitter, and inverted again by the receiver, and so a logical ‘1’ in the data appears as a logical ‘0’ on the `A`/`B` wire pair.

⁸ The “ground reference” voltage for the output signals is available on the GD pin of **J9** – but note that this is *not* the SPU's signal Ground, rather it is a synthesized reference voltage, and so it must *not* be connected to *any* other Ground.

Typical RS-422 Signals

The only way to troubleshoot problems with the RS-422 NMEA signals to & from the SP 36 is with an oscilloscope; that's because a multimeter is essentially useless for differential signals. The figure below is an example of a typical NMEA 0183 RS-422 transmission, captured on a dual-trace oscilloscope.

The data stream is from a SP 36 SPU's **NAV - OUT** port. Channel 1 is the RS-422 `A` signal, Channel 2 is the `B` signal, and the Math trace is the differential voltage between `A` and `B`; the 'scope probes were manually set at 10x, so the voltages of the signals are 10 times larger than measured below. The Ground Reference for the 'scope's inputs was the GD pin of the **J9 - NAV I/O** connector. The Baud Rate was 4800 (or ~208.3 msec per bit).

The data being sent is the first two characters at the start of the NMEA sentence: \$A (the full sentence might have been \$APHDM,346.5,M*37 or something similar - see page 145).

In hexadecimal, \$A is: 0x24, 0x41; in binary: 0b00100100, 0b01000001.

Following the rules of NMEA 0183, that binary data was transmitted starting with the least significant bit of the first character, in 8-bit groups: 00100100, then 10000010 (as shown in the blue overlay in the figure below). The transmitter circuit demarked each group ("byte") by a leading `0` Start bit and a trailing `1` Stop bit. Finally, the train of bits was sent to the RS-422 differential driver output circuit, which put inverted bits on the `A` signal line, and non-inverted bits on the `B` line.

Before transmission from the RS-422 driver started, the signals were in the Idle state: `A` was at a low voltage with respect to `B` (the same state as a `1` bit). After all the bits of the full sentence had been transmitted, the signals would have returned to the Idle state.

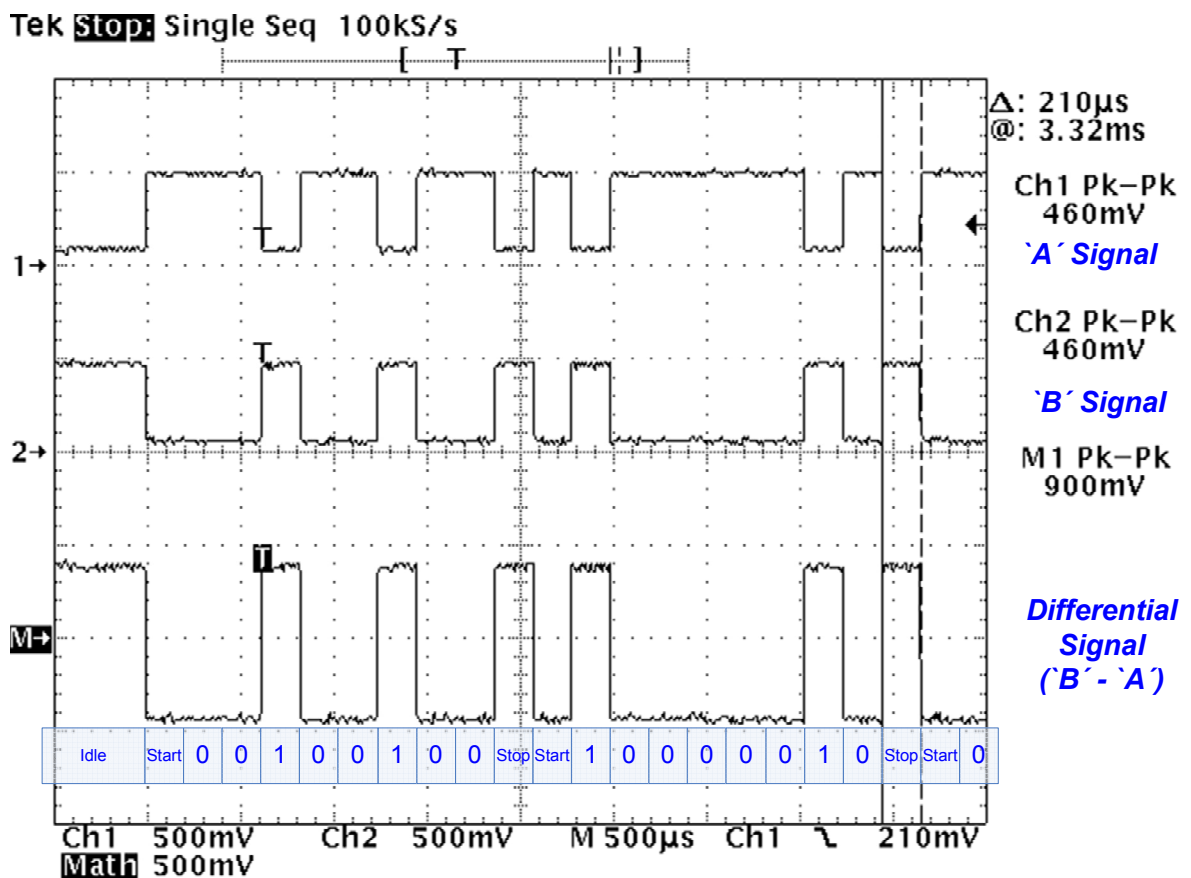


Figure 32 - Typical RS-422 Signals

RS-232 Electrical Signals

It is common for non-marine equipment (especially PCs) to be able to transmit & receive NMEA-formatted data – but not using the RS-422 electrical interface specified in the NMEA Standard, instead using another electrical interface, RS-232. A prime example is Personal Computers: the “COM port” on a PC is always at RS-232 levels.

An RS-232 interface, in contrast to RS-422, does not use differential-signal wiring. Instead, a single wire is used for each of the main signals⁹ – Receive (usually labelled “Rx”) & Transmit (“Tx”) – and for the Signal Ground (“Gnd”). The voltage levels are also different than RS-422.

Such equipment (often described as being “NMEA compatible”) can usually be connected directly to the SP 36 – although there is some risk of reduced electrical noise immunity. See the section on **PC COM Ports** on page 138 in **Appendix 1** for more details.

Status LEDs

When the autopilot is turned on, the Status LED labelled **NMEA 0183 IN #1** in the SPU's Diagnostic section will be flashing whenever the autopilot is receiving data on **NAV1 - IN**. Similarly, the **NMEA 0183 #2** LED will be flashing whenever the autopilot is receiving data on **Nav2 - IN**.

Typically, an LED will flash at a rate of about once per second for regular data from a GPS or Chartplotter. It will typically flash at a rate of about ten times per second when connected to a Heading source, such as the Vector G2 GPS Compass.

ⓘ *The LEDs only show that data is being received on the associated Nav1 (or Nav2) port. They do not mean that the data received is valid!*

*If the LED for a port is flashing, but you are seeing INVALID or NO DATA Navigation (Heading, Speed, Course, NAV) error messages for that port on the Control Head, and yet you are sure the other device is in fact sending valid data, try reversing the wires connected to **NAV1 – IN**, or **NAV2 – IN**. It is possible that the other device's signal names are not NMEA's `A` & `B` (see Table 4, above), and so might have been connected the wrong way round; reversing the wire pair at **J9** often solves this situation.*

If you are still seeing error messages, something else is wrong. Contact your SI-TEX Dealer for assistance.

SI-TEX Network

The **J10 – SI-TEX NETWORK** connector is reserved for possible future use. The receptacle is not supplied with a mating plug.

⁹ There are also several RS-232 status signals, but these are not used in the SP36.

Final Steps & Post-Installation Checks

Before using the SP 36 for the first time, please verify that the entire system & all its components are safely and securely mounted, and will not shake loose from the vibrations that can be expected in a marine boat.

Electrical Checks

ⓘ *Only after all these checks are passed should you plug the power plug into the **J1-BATTERY INPUT** receptacle on the SPU.*

- 1) Check the power supply wiring (from the battery/breaker).
 - Verify that the polarity and voltage are correct (use an accurate voltmeter for this).
 - Check for correct wire size, tightness of all connections, fusing, and proper operation of the battery power breaker or switch.
- 2) Check the connections from the Compass(es) to the SPU.
- 3) Check the connections from the Rudder Follower Unit to the SPU.
- 4) Check that when the rudder is manually moved from full Starboard to full Port, and vice-versa, the RFU moves completely freely, and is not being restricted in any way.
- 5) Check the connection(s) from the Control Head(s) to the SPU.
- 6) Check the connections to the drive equipment from the SPU.
- 7) Check that all cables are neatly placed and secured.
- 8) Ensure that extraneous materials (bits of insulation, wire pieces or strands, etc.) have been removed.

During the first few weeks of operation, repeat the checks above at least once.

Completing the Wiring

- 1) Route all the wires and cables sideways out from the SPU (to the left &/or right, as appropriate). Use external tie-downs or cable holders to keep the wires & cables secure, with no excess strain on them, or on the plugs that are mated to the SPU's receptacles.

Many potential problems can be avoided by ensuring that cabling and wiring do not cause strain on the connectors!

- 2) If the SPU is mounted on a vertical surface, route all wires & cables downwards, within a few centimetres of the edge of the SPU. If the SPU has been mounted on a horizontal surface, form drip loops in all wires & cables, close outside the edges of the SPU.
- 3) Finally, carefully re-install the Wiring cover on the SPU. Be sure not to pinch any of the wires or cables between the Wiring Cover and any other part of the SPU.
- 4) Secure the Wiring Cover with the two knurled thumb-nuts.
- 5) Ensure that the cabling and wiring to all system components, *especially Remote Controls*, are well secured with clamps or alternative fasteners.

Setting Up the System

Setting Up

This chapter describes all the steps needed to prepare your SP 36 for use on your boat, after you have installed it.

Note: *to do the procedures described in this chapter, you will need to be familiar with the basic concepts of using the autopilot's Control Head – modes, menus, turning the system on & off, and so on.*

*If you have not already done so, please read the introductory parts of the **Basic Operations** chapter.*

Dockside Setup Menu

Almost all the steps involved in setting up your SP 36 for use on your boat require using the Control Head's Dockside Setup menu – so it will be described here first.

Typically, the Dockside Setup menu is used only infrequently after initial setup.

A special combination of buttons must be used to access the Dockside Setup menu:

- 1) Start with the SP 36 system powered off.
- 2) Press and hold the **Fn** button and the **TURN** button.
- 3) Then press & hold the **STANDBY** button. Power will turn on.
- 4) Hold all three buttons activated until the software version numbers are displayed, then release the buttons.



Figure 33 – Entering Dockside Setup



- 5) After several seconds, the display will show the Dockside Setup menu (see page 58).

Note that a large `D` (which is the indicator that the system is in Dockside Setup) appears in the upper left portion of the display.

Note: *on a SP36 without an RFU installed, an alarm may sound while the system is starting up. You can ignore this alarm; it will stop when the menu appears.*

The Dockside Setup menu is unlike other menus:

- There is no time-out feature associated with it.
- When you exit it, the system performs a full Power-On sequence, ending up in **STANDBY** mode.
- Many of the items listed in the Dockside Setup menu are not simple *parameters*, but instead are *automated scripts* (sequences of pre-defined steps) that perform a variety of functions and system tests.
 - ⇒ The letters “Fn” on the right hand side of the menu display identify the items that are scripts. To activate the associated script, press the **Fn** button.

D 		D 	
Reset	Fn	Alarm O/P	None
Vessel Type	Displ.	Thrust Type	Prop.
Compass Setup	Fn	Thrust MIN	0
Drive Setup	Fn	Thrust MAX	30
		Language	English

Dockside Setup menu

Reset

A full reset of all the SP 36's operating parameters is done when the **Fn** button is pressed; the word "Reset" changes to "RESET" to show that it has been done.

Caution! A "full reset" means that **ALL** parameters in the entire autopilot system are set back to the default settings installed at the factory.

This means any configuration (Compass & Drive Setup) you have done, and all parameter adjustments you have made, **WILL BE LOST!**

You should use this full-reset function only on the advice of an authorized SI-TEX service representative!

Vessel Type

Set this to match as closely as possible to the type of boat that the autopilot is installed on. The system then automatically selects a specific set of equations & constants – for use in the SP 36's steering algorithms – which have been found to work reasonably well with typical boats of the chosen type. Also selected are the initial values of the Steering Parameters used in those equations (see **Sea Trials** on page 72 and **Auto Menu** on page 93 for more details).

Note: during Sea Trials, and later in normal operation, you can adjust any or all of the Steering Parameters' values, to better suit your own boat, and/or the current sea conditions.

Setting	Vessel Type	Comments
Stern	Stern Drive	Choose this for planing-hull boats with outboards or stern-drive legs.
Displ	Full Displacement	Choose this setting for full displacement boats that do not plane or rise out of the water at cruising speed.
Semi	Semi-Displacement	Choose this if your boat rises partially out of the water at cruising speed.
Plane	Planing Hull	Choose this for boats that are mostly out of the water at cruising speed.

Table 5 – Vessel types

Compass Setup

The SP 36 has 4 physical ports to interconnect with a variety of different compasses.

NOTE You can only use *SITEX solid state compass supplied or Fate stabilizer and Fluxgate compass combination when not using any rudder feedback in the system,*

Analog compasses, which output the traditional “Sine and Cosine” signals, should connect to the **J8 – COMPASS** receptacle. Installations are required for this type of compasses.

Another two compass ports are NAV1 and NAV2. Compasses connected to these two ports do not require an installation, but some of them require calibration.

During the compass setup procedure, you will be asked to choose the right type of your compass(es). Refer to Table 6 – Compass Types to identify and select the correct type for the compass(es) in your system.

Compass Source	Compass Type	Comments
Analog	Mag	Choose this setting if you have an externally gimballed magnetic compass fitted with a SI-TEX Magnetic Sensor.
	Flux	<i>Only with RFU installed.</i>
	Fixed	The autopilot can accept a variety of Analog compasses. Consult the manufacturer’s documentation, or contact the manufacturer, to determine whether the reference signal is fixed or floating, and set the An. Compass Type to match. <i>Only with RFU installed.</i>
	Float	
	HRS	Choose this setting if you are using a Heading Rate Stabilizer (& Fluxgate Compass).
NAV Port	SI-TEX	SI-TEX rate compass can be calibrated through the dockside setup menu.
	GPS	Any digital rate compass or GPS with NMEA 0183 HDG,HDM or HDT, other than the SI-TEX rate compass. <i>Only with RFU installed.</i>

Table 6 – Compass Types

Pressing the **Fn** button when this line is highlighted tells the autopilot to verify the Analog Compass connections.

If the connections are found to be correct, the autopilot will then query whether you want it to do an automatic compensation for Magnetic Deviation of the compass(es) it has found. See the **Compass Setup – Dockside** procedure for full details.

Drive Setup

Pressing the **Fn** button when this line is highlighted starts a script in which the autopilot automatically determines the orientation of the RFU, measures the physical limits of the

rudder's range of motion, figures out what kind of steering system (i.e. reversing motor, solenoid, etc.) is installed, and then tests all these to make sure everything is operating properly.

This is explained more fully under **Drive Setup** on page 63.

Exit

Press the **Fn** button to exit the Dockside Setup menu and restart the autopilot in **STANDBY** mode.

Alternately, you can press and hold the red **STANDBY** button to shut off the autopilot.

Alarm O/P (Alarm Output)

This parameter controls the functioning of the External Alarm Output. See **Watch Alarm & External Alarm** on page 127 in the **Advanced Operations** chapter for full details.

Language

This parameter allows you to set the language used for almost all menus & messages that appear on the Control Head.

Note that a few items remain in English at all times – typically where there is no simple translation for that item. Also, the word “Language” on the menu is always shown in English.

Choices are as follows:

- English
- Français
- Español
- Íslenska
- Italiano
- Norsk

Note: other languages may be added in future Firmware Upgrades.

Configure Sys. (Configure System)

This menu item allows you to save (or retrieve) the full set of operating parameters, from all menus & internal settings, of the system to (or from) an external device (e.g., a PC).

See **Configuration Save & Restore** on page 146 for full details.

Setup Procedures

After your autopilot system is installed, you must:

- First, tell the autopilot what type of boat you have, and then help it determine the characteristics of the Rudder Drive mechanism on the boat.
- Next, tell the autopilot what type of Compasses it will be using, and have it verify that it can use those compass(es).
- Next compensate & calibrate all your compasses.
- Next, do the initial settings of the various operating parameters (Rudder gain, etc.) at high & low speed.
- Finally, test how well the autopilot performs in various sea conditions, re-adjusting parameters as needed.

Vessel Type

- 1) Power the system up, in the Dockside Setup menu
- 2) Select the **Vessel Type** menu line, and set the type of your boat according to the table on page 59.

Note: *at this step in the setup process, all the various Vessel Types (Displacement, Stern, Plane, etc.) can be selected.*

*However, if there is no RFU detected on the SP 36 during the **Drive Setup** procedure, the Vessel Type parameter will automatically change to "Stern", since that is the only valid selection for Virtual Rudder Feedback operation.*

When this happens, the vessel type displayed on the menu line will not change to "Stern" – but the change has taken effect internally. If you exit & re-enter Dockside Setup, the menu line will then show that change.

Drive Setup

The procedure for setting up the autopilot to work properly with your boat's steering system¹⁰ varies, depending on whether or not you have fitted a Rudder Follower Unit.

- For a SP 36 which has an RFU fitted, the Rudder's characteristics are automatically measured by the autopilot, during Drive Setup¹¹.
- For a SP 36 without an RFU – where you will be using its *Virtual Rudder Feedback* feature – you will need to “tell” the SP 36 what the Rudder has done at various points in the Drive Setup process, and help it make a few measurements of the associated hydraulic/electrical drive system.

But in both cases, the purpose of the procedure is to find out:

- The type of drive system – solenoid(s) or a reversing motor – the boat has.
- The orientation of the RFU (if one is fitted).
- The direction the Rudder moves in relation to the voltage polarity of the drive outputs from the SPU.
- The Hard-Over to Hard-Over time of the Rudder.
- The physical limits of the Rudder's travel.

To begin the Drive Setup procedure, move the Dockside Setup menu highlight to “Drive Setup”, and press the **Fn** button. This will start the setup's automated script.

You will see a series of screens, prompting you to for various actions or information; for example: move the Rudder all the way to Port, or centre it, or enter the maximum deflection of the Rudder, and so on.

Some points to keep in mind, while doing this procedure:

- 1) Use the boat's manual steering system (wheel, tiller, etc.) to move the Rudder, when prompted.
- 2) When moving the Rudder to the maximum Port or Starboard position, be sure to move it all the way to the physical stops.

Note: *in normal operation, the autopilot always stops the Rudder a few degrees shy of that position, to avoid pounding it against the stops.*

- 3) On a SP 36 without an RFU, enter the angle (in degrees) at the maximum Port & Starboard deflections which you want the autopilot to use.

ⓘ *The values you enter should be no larger than the Rudder's mechanical limits! If you enter different values for Port & Starboard, the smaller of the two will be used for both.*

- 4) On a SP 36 without an RFU, when you press the **PORT** or **STBD** button to move the rudder, try to stop at the maximum Port & Starboard deflections you enter in step 3).
- 5) The speed at which you move the Rudder manually does not matter, nor does it matter if you move the Rudder back and forth a bit when it reaches the requested position.
- 6) Do not be concerned if the Rudder Angle Indicator shown on the screen initially goes in the wrong direction. The autopilot will sort that out during the procedure.
- 7) If for some reason, the autopilot was not able to detect the type of drive, you will see a “Drive Detection Failed” screen.

¹⁰ ... which could be a Rudder, an I/O leg, an outboard motor, and so on – but is referred to here as “Rudder”.

¹¹ The word “Drive”, as used on the menus, sometimes refers to the hydraulic &/or electrical system that the boat uses to control the steering mechanism (Rudder, etc.), and other times to the mechanism itself.

- Go back to the Dockside Setup screen, re-check all the drive wiring, and then re-start the Drive Setup procedure.
 - If you continue to have problems, contact your SI-TEX Dealer for assistance.
- 8) After detecting the drive type, a SP 36 with an RFU, gives you the option to bleed your hydraulic steering system:
- If you wish to do this, please refer to the hydraulic system's manual.
- When all Bleeding is done, press the **Fn** button on the Control Head.
- If you do not have a hydraulic system, just press the **Fn** button on the Control Head.
- Note:** *on a SP36 without an RFU, the bleed option is not provided. You must have already done proper bleeding, before starting the drive setup procedure.*
- 9) When a SP 36 with an RFU is testing the drive system's performance, it will run the Rudder from hard-over to hard-over a number of times. It will also make a series of short movements – quick starts & stops – of the Rudder, in order to determine a base reference for how the steering system responds to the typical small movements the autopilot uses during normal operation.
- Note:** *a SP36 without an RFU does not do any "performance testing" of the rudder drive system.*
- 10) After the autopilot has determined the time span for a Hard Over to Hard Over movement of the Rudder, there are several possible results:
- If the HO-HO time is too fast (less than ~5 seconds), the setup may fail. That's because if the Rudder moves too quickly, it can not be safely controlled by the autopilot.

On the other hand, the setup may also fail if Rudder is too slow (more than ~22 seconds HO-HO), because the autopilot will not be able to control the Heading of the boat properly.

⇒ In either case, you will need to make some changes to the drive system, to slow it down or speed it up, as appropriate.
 - If the drive system is a reversing motor (in a hydraulic or cable drive system), and it did not test as too slow, you will see an option to have the autopilot slow down the Rudder intentionally.

Slowdown is done by using Pulse Width Modulation of the SPU's drive output voltages. PWM in effect lowers the voltage "seen" by your drive system's motor(s), and thus slows down the Rudder's HO-HO time.

⇒ On most boats, it is probably not necessary to slow down the Rudder, unless the HO-HO time is less than ~10 seconds. However, every boat is different, and so the choice is left up to you.

If you choose to slow down, the Rudder movement will be re-tested (in the same sequence of test steps as you just did), but with it slowed down using a PWM signal that should run the motor(s) at about 65% of full speed (i.e., the HO-HO time should be ~50% longer than at full speed).

Note: *slow-down is automatically selected for Stern Drive boats when operating using the "Hi" Parameter Set (see page 95).*

ⓘ *PWM may increase the electrical "noise" emitted from the drive system's wiring, potentially causing interference with other equipment.*

If this happens, but you still wish the autopilot to slow down the Rudder, you may have to re-route the wiring, and/or use better (possibly shielded) wiring, and/or

take other typical “noise reduction” steps. Contact your SI-TEX Dealer for assistance.

When Drive Setup is all done, record the settings & choices you made, in the **Settings** chapter at the back of this manual.

Compass Setup – Dockside

The first step in setting up your compasses is to verify correct wiring connections into the SPU unit.

For an NMEA compass, you may also have to configure its output sentences. It is recommended that this all be done at the dock, in case any re-wiring needs to be done, or if it turns out that some elements of the SP 36 system need to be moved.

Note: during these steps, the autopilot may issue an *INVALID HEADING* alarm (see page 154). These alarms should be ignored, or cancelled by hitting the **Fn** button.

Once compass is “found” during this procedure, the alarm would clear itself.

Highlight Compass Setup and press Fn. The list of all four supported compass sources will be displayed.

An. Comp. Type	None
Digi. Compass	None
NAV1 Port	GPS
NAV2 Port	GPS
Exit	Fn

Highlight the line of the source your compass is to be installed. If you have more than one compass, you need to do the installation one at a time.

Digi. compass (Digital compass)

- 1) If you have a 45° compass, highlight Digi. Compass and set the Type to Fixed.
- 2) Press Fn and the autopilot starts to search for the compass.
 You will not be able to move away from this line without press the Fn button if you have changed the parameter from None to Fixed.
 A “Please Wait” screen will be displayed briefly. Then, the results of the search will be displayed, along with an option to “Compensate Now?”.
- 3) Skip the compass/HRS compensation process (press the Port button), since this can not be done while still tied up at the dock.

NAV1 Port & NAV2 Port

NAV Ports are always available as a compass source and needs not be installed. However, if you have a SITEX rate compass connected to NAV1 port, you can calibrate the compass when your boat is on the water. See Compass Setup – on the water. It is recommended that you always connect your SITEX to NAV1.

You may connect your SITEX rate compass to NAV2 but you will not be able calibrate it from the autopilot. Therefore it is not recommended to put your SITEX to NAV2.

To verify that an NMEA compass is connected, look at the **NMEA IN** LEDs in the Diagnostic section; the LED for the SPU’s NAV input which the compass is connected to should be flickering.

Note: if the ‘A’ & ‘B’ wires are connected backwards, the LED will still flicker; but when NAV1 or 2 is later selected at the Compass Source in the Standby menu,

no Heading will be displayed, and a NO HEADING alarm will occur. If this is the case, simply swap the `A` & `B` wires.

Bandwidth of an NMEA Compass Connection

You must always be sure that maximum bytes/second capability (aka “data rate” or “bandwidth”) of the serial link between the NMEA compass & the autopilot is not exceeded by the enabled sentences.

The maximum data rate of an NMEA 0183 serial link is always 1/10th of the link’s Baud Rate.

An example calculation:

- The Baud Rate of the SPU’s NAV1 input is fixed at 4800, so if the NMEA compass is connected to NAV1, it must be configured to output at 4800 Baud, and the max data rate is then 480 bytes/sec.
- HDT & HDM sentences are each 20 bytes long, and HDG is 33.
- Thus, it is possible to have both HDT & HDM at 10 Hz each, connected into NAV1:
 - $20 \times 10 + 20 \times 10 = 400 \text{ bytes/sec} \dots < 480 \text{ bytes/sec}$
- But it is *not* possible to have both HDT (or HDM) & HDG into NAV1:
 - $20 \times 10 + 33 \times 10 = 530 \text{ bytes/sec} \dots > 480 \text{ bytes/sec}$
- However, since the Baud Rate of the SPU’s NAV2 input can be either 4800 or 9600¹², the max data rate is 960 bytes/sec ... and so both HDT (or HDM) & HDG *can* be used into NAV2, at 10 Hz each.

This check must include any other NMEA sentences output from the NMEA compass.

As an example: the Vector G2/G2B can also output the boat’s Speed Over Ground (in the VTG sentence – 45 bytes), which can then be used as the autopilot’s Speed Source data input:

- The factory default setting of the G2/G2B is HDT & HDM at 10 Hz each, and VTG at 1 Hz (on Port B). That is indeed useable on NAV1, as well as on NAV2:
 - $20 \times 10 + 20 \times 10 + 1 \times 45 = 445 \text{ bytes/sec} \dots < 480 \text{ bytes/sec}$
- i** *The total bytes/sec of all sentences must always be less than the link’s max data rate!*

*Problems caused by exceeding the max data rate are usually **very** hard to troubleshoot.*

The excessive rate will cause data errors, mostly in the form of partial sentences (caused by buffer memory overflow in the sending device, and/or in the SPU). These are always invalid, so the SPU discards them.

But that causes subtle problems. For example, if the Heading sentences are being truncated, a few will usually still get through OK, and so the SPU will not raise a NO HEADING alarm (the SPU’s error-detection routines do not measure update rate, but only check if any valid data is being received). However, the effective Heading update rate will be less than is required for “good steering” – so the autopilot will seem to be “steering poorly”.

A specific case: if the Heading data source device is nominally transmitting valid Heading sentences at 10 Hz, but only 2 are getting through OK per second, then the effective Heading update rate that the autopilot is using is 2 Hz ... and that’s much, much too low for “good steering”.

Similar problems can occur with other NMEA data used by the autopilot (Speed, Position, Waypoints, etc.), if the link max data rate is exceeded.

¹² NAV2’s Baud Rate is automatically set by the SPU – by looking for “correct” NMEA sentences at each rate possible.

Compass Setup – On the Water

The final steps of compass setup should normally be performed after all other installation and setup procedures for the autopilot system are completed, so that all net electrical and magnetic effects of the installation on the compass(es) are taken into account.

First you must compensate the compass(es) for Magnetic Deviation. Then, you may need to calibrate each compass (i.e., correct for any inherent constant directional offset in each).

You will need to take your boat away from the dock, and out onto a body of open water (the sea, a lake, a river, etc.), and in relatively calm conditions.

It is important that there be sufficient sea room to put the boat through a series of fairly slow & wide circle turns, and to run the boat for several minutes on a straight Track at various Headings, without encountering obstacles, other marine traffic, etc. You should also avoid areas around bridges, underwater power lines, and pipelines, as these can affect your compass(es).

ⓘ Caution! *Be sure to keep a proper lookout for other boats, and any hazards, while doing any of the circle turns & manoeuvres described below.*

Note: *some of the steps performed here require that you be familiar with the **STANDBY** mode & menu of the autopilot (see page 79).*

*During all these procedures, the **INVALID HEADING** alarm may occur. You can cancel it (press the **Fn** button), or leave it active.*

Compensation for Magnetic Deviation

The procedure you will follow to compensate your compass(es) depends on the type(s) of compasses you have installed.

Some elements of all the procedures are the same:

- You can take as long as you like to start the turns required to compensate any of the compasses requiring it, but once the SPU detects that you have started the turns, you have ~6 minutes to complete enough turns, before a “Failed ...” screen appears.
- You may choose to do the turns either to Port or to Starboard. It doesn't matter which way, as long as you do not reverse direction during the compensation step.

Boat speed matters only in that it should be sufficient to hold a constant rate of turn of about 2 to 3 degrees per second, meaning that the full circle should take between 3 & 2 minutes. As well, it should be sufficient that you can steer smooth, steady turns in the current sea conditions.

Magnetic Compass Sensor

SI-TEX strongly recommends that a professional compass adjuster compensate Magnetic Compasses.

The Sensor itself does not require compensation, only calibration.

Calibrating for Compass Offset

Even after your compass(es) are compensated for Deviation, they still may not be giving a correct reading.

Any or all of them may have an individual fixed offset, so you must tell the SP 36's SPU what each one's *calibration* value is.

Calibration is a simple matter of synchronizing each compass's directional readings, as seen by the SPU, to the actual Magnetic direction values of the Earth's magnetic field.

Bring the boat onto a known bearing and maintain it there by steering manually. The autopilot should be in **STANDBY** mode.

- 1) Double-press the **STANDBY** button to bring up the Standby menu. Select "Compass Source", and set it to the correct value for the first of your compasses:
 - "SSRC1" on "NAV1" for an SI-TEX Rate compass connected to the J9 – **NAV I/O** & J6 – **MISC I/O**
 - "GPS" on "NAV1" for an NMEA compass connected to the IN-1 pins of the **J9 – NAV I/O** connector
 - "GPS" on "NAV2" for an NMEA compass connected to the IN-2 pins of **J9**
- 2) Move the highlight down one position to "Compass Cal". Using the **COURSE CHANGE** knob, adjust the reading so that it agrees with the known bearing that the boat is on.
 - Any changes simply increase or decrease the value stored in the SP 36's settings memory, by 1° per click of the **COURSE CHANGE** knob.
 - When you first set up your compass(es), the initial calibration value for each compass is the value it was outputting at the time it was detected during Dockside Setup.
- 3) Move the highlight back to "Compass Source", select the next type of compass you have, and repeat step 2). Repeat for all your compasses.
- 4) Double-press the **STANDBY** button to exit the Standby menu.
- 5) Verify that the compass heading shown agrees with the actual heading of the boat, and stays steady, by holding a number of constant-heading courses for a few minutes each.

However, if you wish to set a calibration value for an NMEA compass in the autopilot, you may do so. Indeed, you may set two values – one for each of NAV1 & NAV2.

Compass Setup – Final Steps

At this point, the entire Compass Setup procedure is complete.

All the compass settings & compensation/calibration values will be retained when the autopilot is turned off.

You should record all compass selections & settings, in the **Settings** chapter at the back of this manual.

It should not be necessary to re-compensate or re-calibrate any of your compasses again, unless the electrical/magnetic environment on your boat changes substantially. Examples of when that might be so are if you add some new piece of electronic equipment, or add new machinery, and so on. You should also re-do compass setup if you take your boat a long way away from where you did the setup just now – say, more than 10° of Latitude – or to an area where the local Magnetic Deviation is known to be different (say, where there are a lot of submerged wrecks).

And it is also a good idea to check all the compasses on your boat, for accuracy in all directions, on a regular basis – say perhaps once or twice a year – and before setting off on a long voyage.

A good way to do a quick check is with any of the traditional “box the compass” methods which even a novice boater learns almost right away:

- Find some convenient ranges which have good cuts between them, and steer back & forth along them.
- Steer various straight Tracks, in as many directions as possible, between pairs of charted objects.
- Determine the CMG between various plotted positions (with GPS, or with two or three-bearing LOP fixes with a good Pelorus or hand-bearing compass, etc.) on your paper charts.

You might even want to do a box-the-compass check right now, simply as a final “sanity” check of the compass setup you just did!

Sea Trials

Sea Trials allow you to test out the basic functions of the autopilot under way, and to fine-tune the steering parameters for best performance. The goal is to achieve accurate Course-keeping, and smooth, rapid changes of Heading – without excessive movements of the boat's rudder.

Note: *before you begin Sea Trials, it is a good idea to review how you steer a boat by hand ... and how that compares to what the SP 36 does when steering the boat. Please re-read the **How Autopilots Work** chapter, page 11.*

During Sea Trials, you will test the default Steering Parameters of the autopilot SP 36, on **your** boat, and if necessary, make adjustments.

When the Steering Parameters are properly adjusted & fine-tuned for your boat, the autopilot will do the same as you would ... let the boat “work with the seas”, yet still maintain as straight a Track as possible in the current sea conditions, on the desired Heading or Course.

Sea Trial Procedure

The initial Sea Trials should be done in relatively calm conditions.

Note: *to do Sea Trials, you must be familiar with operation of the autopilot in **AUTO** mode (see page 92), and with the Auto menu.*

Sea Trials on a SP 36 with an RFU fitted, are slightly different that on a SP 36 without an RFU; the places where this is so are indicated below.

Adjust Rudder Gain & Counter Rudder for Hi Speed

- 1) Bring the boat up to a speed where the boat's rudder (or steerable-thrust system, such as an outboard or I/O leg), provides sufficient steerageway that it has accurate, firm control of the boat's direction of travel.

Typically, this will be less than your normal “cruising speed”, perhaps by quite a lot. For many boats, this will be around 7 Knots.
- 2) Bring up the Auto menu, highlight “Parameter Set” and select “Hi”.
- 3) If ALC is set to “On”, highlight it and set it to “Off”.
- 4) Start with “Rudder Gain” & “Counter Rudder” set to the factory defaults (for Hi): 5 & 3.
 - On a SP 36 without an RFU, start with Counter Rudder set to 0.
- 5) Highlight “Seastate” and set it to 1.
- 6) Highlight “Turn Rate”. Select a setting that is approximately $\frac{3}{4}$ of your boat's comfortable turning rate¹³ at normal cruising speed.
- 7) Exit the Auto menu.
- 8) Switch to **AUTO** mode. The autopilot will automatically take the current boat Heading and use that as the Course to Steer.
 - On a SP 36 without an RFU, you should always manually steer a steady, straight Heading (in **STANDBY** mode) for at least 10 seconds – or longer, until you don't have to continue to move the wheel/tiller to maintain a straight Track – before switching into **POWER STEER, AUTO** or **NAV** modes. The rudder *must* be at the dead-ahead position when you switch modes.
- 9) Run for about 5 minutes. If the boat “esses” back and forth more than about 3 degrees, bring up the Auto menu and reduce the Rudder Gain setting by 1 step, and test again.

¹³ If you need to measure it: time a complete circle while the vessel is turning at a rate that seems ‘comfortable’, at the normal cruising speed. ‘Comfortable turning rate’ is 360° divided by the number of seconds it took to complete the circle.

- 10) On a SP 36 with an RFU, make a medium Heading change, say 15° – 20° , with the **COURSE CHANGE** knob.

Observe how the boat responds, as it turns & settles onto the new Heading:

- If the boat stops turning before the new Heading is reached and then approaches it slowly, either increase Rudder Gain by 1, or decrease Counter Rudder by 1.
- If the boat overshoots the new Heading, and then makes several turns back & forth across the new Heading before settling down (known as “essing”, or “overshooting”), either decrease Rudder Gain by 1, or increase Counter Rudder by 1.
- If the boat approaches the new Heading, shies away, then approaches & shies away again, decrease Counter Rudder by 1.
- Continue making those medium Heading changes, adjusting Rudder Gain and Counter Rudder as needed, until the boat settles smoothly onto the new Heading without excessive overshoot.

Go to step 12).

- 11) On SP36 without an RFU, it is necessary to start by testing how well the boat does small turns, before testing how well it settles onto a new Heading. Also, the optimum Rudder Gain setting must be found first, before adjusting the Counter Rudder setting.

Make a small Heading change ($\sim 5^{\circ}$), and observe the turn:

- If it makes an abrupt turn, reduce the Rudder Gain one step.
- If it takes too long to turn, increase the Gain by one step.
- Repeat the small change of Heading in the same direction, observe the response, and adjust the Gain as needed, until the turn is at a safe, comfortable rate.
- Repeat the sequence in the other direction. Then repeat in both directions a couple of times, until you are satisfied.

Now make a bigger Heading change ($\sim 10^{\circ}$). Observe how the boat settles on each new Heading:

- If it approaches the new Heading too slowly, increase the Rudder Gain.
- If it keeps “essing” back & forth across the new Heading, reduce the Gain.
- Keep doing turns, and adjusting the Rudder Gain as needed, until the boat settles on the new Heading with no more than two overshoots.

Now make some 30° Heading changes, in both directions.

- Adjust the Rudder Gain up or down a bit as needed, until the boat settles on the new Heading with no more than two “esses”.

Now increase Counter Rudder by 1, and make some 10° Heading changes.

- Repeat this until the boat settles on the new Heading with little or no “essing”.

- 12) Repeat step 10) (step 11) for a SP 36 without an RFU), using gradually larger Course changes, up to 40° – 50° .
- 13) Repeat the above adjustments on several different Headings until you get consistently satisfactory results.
- 14) Reduce the Rudder Gain by 1, then increase speed to your normal cruising speed, and repeat steps 10) to 13). If the rudder is moving by large amounts – more than about 5° side to side – during any of the steps, you should reduce the Rudder Gain even more. You should also do so if the boat steps up onto the plane when you increase speed, because the rudder’s steering effect is typically much stronger once a boat is planing.
- You can leave the higher speed tests for later, if it is not safe to run at that speed where you are doing the Sea Trials.

Adjust Turn Rate for Hi Speed

- 1) Adjust the Turn Rate setting to the full comfortable rate (per step 6), above).
- 2) In **AUTO** mode, make a few course changes of 20° or more, to ensure that the rate of turn is indeed comfortable at normal cruising speed; if it is not, reduce the Turn Rate setting until it is.

Adjust Seastate for Hi Speed

To set Seastate, switch to **AUTO** mode, and then watch the Port & Starboard rudder movement arrows at the ends of the screen's RAI bar.

In normal conditions, there should be rudder movement about 15% to 20% of the time.

If the autopilot is over-active, increase Seastate until the arrows blink less often. If the autopilot is under-active, decrease Seastate.

Adjust Rudder Gain, Counter Rudder, Turn Rate and Seastate for Lo Speed

- 1) Adjust boat speed to what will be your lowest normal "low speed" – that is, the lowest speed at which you will ever want to use the autopilot. For most boats, a good speed to do the "low speed" adjustments is at or below the maximum speed in a Speed Control Zone or "no wash" area – usually 5 Knots.
- 2) Bring up the Auto menu, highlight "Parameter Set" and select "Lo".
- 3) Repeat steps 3) through 13) in the Hi speed Rudder Gain & Counter Rudder adjustment process above (the starting value to use for Lo speed Rudder Gain is the factory-default of 8).
- 4) Adjust the Lo speed Turn Rate setting to suit. Make a few Course changes of 40° or more to ensure that the rate of turn is comfortable.
- 5) Adjust the Lo speed Seastate setting to suit.

Adjust Speed Trip Point

- 1) Bring up the Auto menu, and set the Trip Point speed to something mid-way between the speeds used for setting the Hi & Lo speed parameters in the steps above. This should be a speed you will never travel at for any length of time – for example, in a planing-hull boat, it would be a speed just a little bit less than where the hull starts to get up on the step.
- 2) Bring up the Auto menu, highlight "Parameter Set" and select "Auto".
- 3) In **AUTO** mode, change the boat speed back & forth between the Lo & Hi speeds you will normally use. The boat should continue to maintain a straight Track along the Heading you are on, and you should see that the display's Parameter Set indicator (see page Figure 46 on page 95) changes back & forth between "L Auto" & "H Auto" as you change speeds.

Adjusting for Rougher Sea Conditions

The primary desire of any autopilot user is that it steer the boat well, across all sea conditions.

Adjusting the steering parameters in calm conditions – as you did during the initial part of the Sea Trials, above – gives a base reference for all other conditions. After doing those adjustments, you can then venture into rougher sea conditions.

Take all the time necessary to ensure that you are getting the best performance from your autopilot!

Some suggestions and points to keep in mind:

- Typically, you will find that you will only need to make small changes to the “calm conditions” steering parameters to handle a wide variety of sea conditions.
- Observe the wake of the boat while maintaining a straight Course in **AUTO** mode. This is one of the best indications of how well the autopilot is steering.
- The boat should come on to each new Course Heading smoothly. Any undershoot or overshoot can usually be observed in the wake. Adjustments to Rudder Gain & Counter Rudder, as in the tests above, are how you achieve “smoothly”.
- Generally speaking, the Rudder Gain & Counter Rudder settings for Hi speed will be less than those for Lo speed.
- As the seas get rougher, you will probably need to increase the Rudder Gain one or two steps.
- In very rough conditions, you may want to reduce the Counter Rudder setting, as well as increasing the Rudder Gain.
- In quartering seas, you may wish to increase Rudder Gain and the Seastate settings. This will allow the boat to yaw a bit more as it comes off of the waves, but typically the boat will come back onto course with minimal rudder movement.
- In the tests above, you will have determined the Turn Rate value which corresponds to the full “comfortable turn rate” of your boat.

But you do not have to leave Turn Rate always set to that value. You can, and should, change Turn Rate as required, to have safe, comfortable turning rates for the current sea conditions; you may also want to lower the Turn Rate for other reasons.

Once the autopilot system is steering satisfactorily, make a note of all your steering parameter settings, and record them in the **Settings** chapter, at the back of this book.

Basic Operations

Basic Operations

This chapter describes the basic modes of operation & features of a system, and shows you how to use them.

The Control Head's LCD Screen & Buttons

All of your interaction with your autopilot system will be done using the Control Head:

- selecting an operating mode
- setting up the parameters you wish to use in each mode
- monitoring your boat's Heading
- setting a desired Heading to be followed
- ... etcetera ...

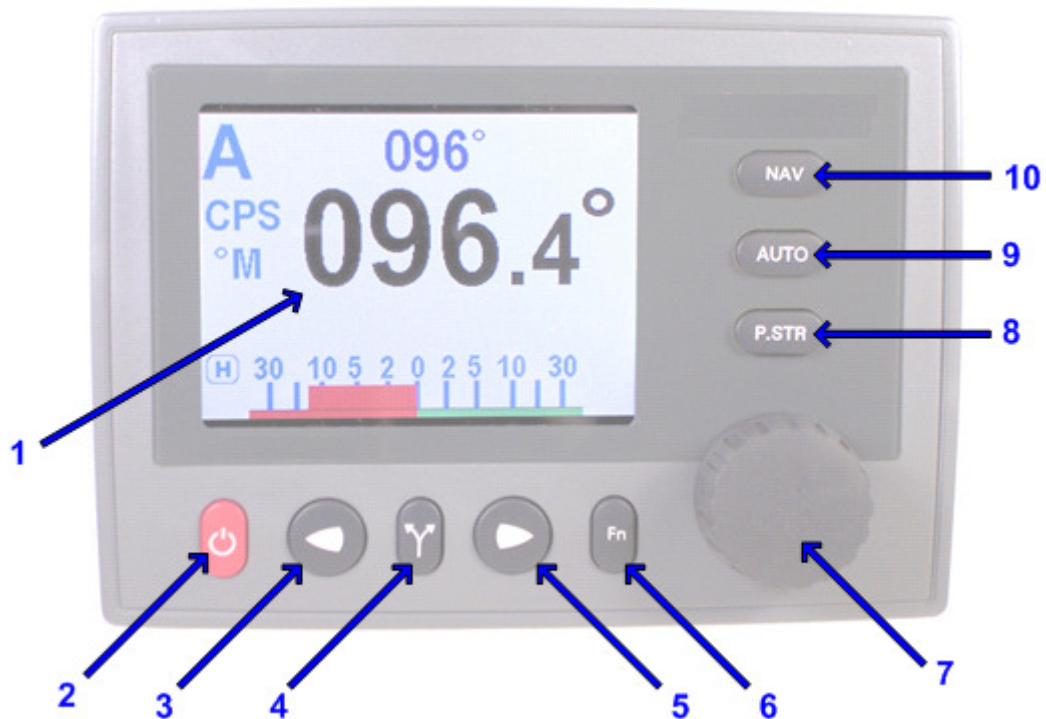


Figure 34 – Using the Control Head

The elements of the Control Head (with reference to the identifiers above) are:

1) LCD Screen.

While the system is powered, the LCD screen is normally displaying the compass Heading, rudder angle, and mode of operation; it can also be displaying desired Heading, system status, other information, or various menus.

2) **STANDBY** (and On/Off) button.

To power on the system, press and hold this button until the LCD screen lights up, and then release it.

To power off, press & hold this button approximately 3 seconds.

The autopilot always powers up in **STANDBY** mode, and it can always be put into **STANDBY** mode, by pressing and holding this button for approximately 1 second.

Double-pressing this button brings up (or exits) the Standby menu.

3) **PORT** button.

Pressing and holding this button while in **POWER STEER** mode moves the rudder to Port – and it keeps moving for as long as the button is held.

Pressing and holding this button while in **AUTO** or **NAV**, modes allows you to avoid obstacles in the boat's path, by turning to Port.

This button is also used in menu operations – to move the highlight to the previous line.

4) **TURN** button.

Pressing this button once while in **AUTO** mode queues the default pre-programmed turn; Subsequent presses of the **TURN** button scroll through all of the available turn-types.

The pre-programmed turn sequence is then initiated by pressing either the **PORT** or **STARBOARD** button to indicate the direction of the turn.

See **Default Turn** on page 86 for more details on setting the default turn from the Special Turns available.

5) **STARBOARD** button.

Pressing and holding this button while in **POWER STEER** mode moves the rudder to Starboard – and it keeps moving for as long as the button is held.

Pressing and holding this button while in **AUTO** or **NAV** modes allows you to avoid obstacles in the boat's path, by turning to Starboard.

This button is also used in menu operations – to move the highlight to the next line.

6) **Fn** button. This is a multi-function button:

- Pressing this button when an alarm occurs will cancel the alarm.
- This button is also used during Dockside Setup, and in operating modes & menus.

7) **COURSE CHANGE** knob. This is used in several ways:

- In **POWER STEER** mode, it changes the rudder angle in the same direction as the knob is turned.
- In **AUTO** mode, it changes the Commanded Heading in the same direction as the knob is turned.

***Note:** Heading can not be changed during any HEADING Alarm.*

- The knob is also used to change parameters in the various menus.

8) **POWER STEER (P.STR)** button.

Pressing & holding this button places the autopilot into **POWER STEER** mode.

A double-press of this button brings up (or exits) the Power Steer mode menu.

9) **AUTO** button.

Pressing & holding this button places the autopilot into **AUTO** mode.

A double-press of this button brings up (or exits) the Auto mode menu.

10) **NAV** button.

Pressing & holding this button places the autopilot into **NAV** mode.





A double-press of this button brings up (or exits) the Nav mode menu.


Operating the System

Operating Modes – Overview

Your autopilot system has four basic operating modes, known as **STANDBY**, **POWER STEER**, **AUTO**, and **NAV** mode.

Changing modes is done by pressing & holding the button on the Control Head which is associated with the mode you want to enter:

- for **STANDBY** mode  the **STANDBY** button
- for **POWER STEER** mode  the **POWER STEER** button
- for **AUTO** mode  the **AUTO** button
- for **NAV** mode  the **NAV** button

 *You must press & hold the new mode's button down for ~1 second. While you're holding it down, the current mode's indicator letter (in the upper-left corner of the screen) will flash.*

After the time delay, the mode change occurs, and the previous mode's letter is replaced by the new mode's letter (not flashing).

This time delay is deliberately designed, as a safety feature, into the system's response to the mode-change (& some other buttons), to prevent accidental activation of those buttons' functions.

Descriptions of the operating modes (& associated menus) can be found as follows:

- **STANDBY**, **POWER STEER**, **AUTO**, and **NAV** modes are in this chapter.

Mode Menus

Each of the operating modes has its own set of parameters that you can adjust, to configure and fine-tune how your autopilot system behaves in the respective mode. These parameters are stored in the system's non-volatile memory; you can view & change them with the Control Head, via sets of menus that appear on the LCD screen.

Note: *there is an additional menu – Docksider Setup – for parameters unique to the boat (e.g., compass type). It is described in the **Setting Up** chapter.*

The menus of the four main operating modes (**STANDBY**, **POWER STEER**, **AUTO**, and **NAV**) are accessed by using the respective mode buttons: the **STANDBY** button, the **POWER STEER** button, the **AUTO** button, and the **NAV** button. To access a particular operating mode menu, double-press the button associated with that mode (e.g., the **NAV** button for the **NAV** mode's menu).

- To exit a particular operating mode menu, double-press the associated button again, or wait about 10 seconds. The display will then revert to the active display of whatever mode the autopilot is operating in.
- You can access any mode's menu whether or not the autopilot is currently operating in that mode.

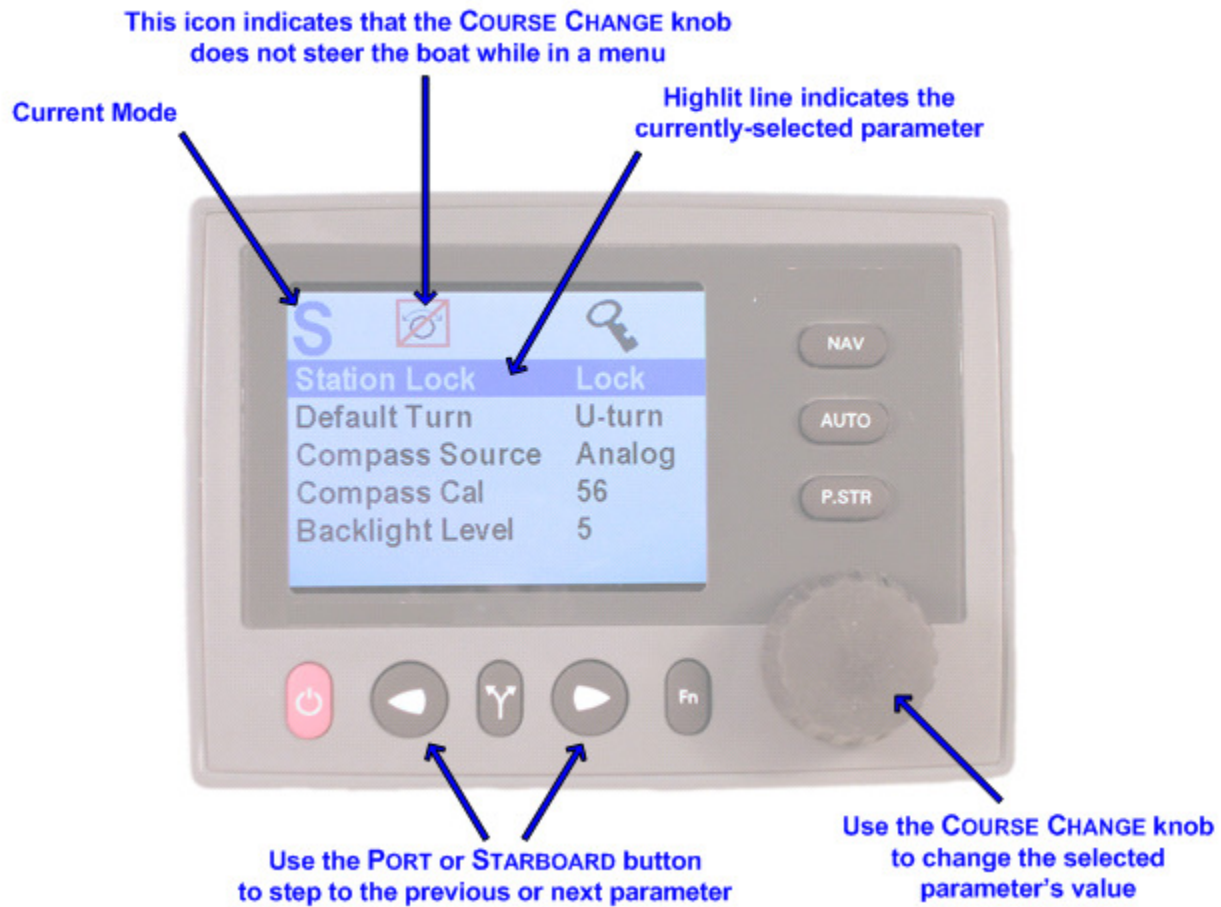


Figure 35 – A Typical Menu

All menus are arranged with parameter names on the left side of the screen, and the current value for each parameter on the right side.

In each menu, one line is always high-lit in a contrasting colour – it indicates which parameter is currently selected (for example, see the “Station Lock ... Lock” line in the figure above).

You can move the highlight to other lines on the menu by pressing the **PORT** button (moves the highlight up) or **STARBOARD** button (moves it down).

Some menus have more lines than can be shown on a single screen. In this case, when the highlight has been moved to the last line on a screen, each subsequent press of the **STARBOARD** button will cause the menu to scroll up by one line, revealing a new high-lit line.

Similarly, when the highlight has been moved to the first line on a screen, each subsequent press of the **PORT** button will scroll the menu down one line. These long menus are arranged in a circular fashion, so that the scrolling action can be carried on indefinitely.

Use the **COURSE CHANGE** knob to change the value of the currently high-lit parameter. For parameters with numbered values, a clockwise turn of the knob will increase the value; counter-clockwise movements will decrease the value. Non-numerical values are generally arranged in a circular list for ease of use.

- In general, changes made with the knob are effective immediately.

i For safety reasons, a few items do not take effect until the highlight is moved to the next or previous line, or the menu is exited.

When a menu is being displayed, there is an icon at the top of the screen which looks like the **COURSE CHANGE** knob, but with a line drawn through it. This is a reminder that the knob is not available for its normal function of changing the boat's course – because the knob is now being used to change parameter values.

The autopilot's mode indicator letter continues to be displayed in menus. The current mode may not be the same as the menu (since all menus can be accessed in any mode). For example, in the figure above both the mode ('S') & the menu are **STANDBY** – but the mode could be any of the others: 'P' (**POWER STEER**), 'A' (**AUTO**), etc.

All menus – except Dockside Setup – have a time-out feature that triggers after about 10 seconds, if no button presses, or movements of the **COURSE CHANGE** knob, are detected during that time-out interval.


When a menu times out, the display reverts to the previously active display, just as though you had double-pressed the mode button again.

Rudder Angle Indicator (RAI)

At the bottom of the screen in all operating modes is the Rudder Angle Indicator (an example can be seen in Figure 37 on page 85).

- On SP 36 system with an RFU fitted, the RAI shows the current position of the boat's rudder, as measured by the RFU (see pages 23 & 44).
- On SP36 system without an RFU, the RAI shows the estimated position of the rudder.

A "V" in a small box is shown at the right end of the RAI, to indicate that the autopilot is using the *Virtual Rudder Feedback* feature.


 *The estimated rudder position on a SP36 may not always be accurate!*

*Please refer to the **Cautions** on page 113 for more information.*

The current or estimated rudder position is shown by a solid bar extending from the centre (rudder Dead Ahead, i.e., at 0°) to the right for Starboard rudder, or to the left for Port. The numerical scale above the bar (in degrees) is expanded around the centre, and compressed at the ends. On colour Control Heads, Starboard is shown in a green bar, and Port in red; on monochrome, the bar is always black. In the figure on page 84, the rudder is about 4.5° to Port.

The maximum length of the rudder position bar is defined by the rudder travel limit values detected or entered during setup.

The thin solid bar below the rudder position bar shows the rudder travel limits (see page 91 for details of the limits); in Figure 37, all the limits are 40°.

 *On a SP36 without an RFU, the position bar does not appear in **STANDBY** mode.*

Whenever the autopilot is moving the boat's rudder, to Port or Starboard, a small "rudder movement" arrow symbol will be shown at the corresponding end of the RAI.

Alarm Clear

Whenever an alarm or error message occurs on the SP 36 an audible alarm will sound, both at the SPU & at the Control Head, and a message will be displayed on the LCD.

The alarm will remain activated until the condition that caused it is remedied, or the alarm is cleared manually by you.

- To clear the alarm manually, press the **Fn** button once.

If the condition that caused the alarm remains, the alarm will reappear after approximately 20 seconds.

Power On

The first step in using your SP 36 system is to **turn it on** ...

- Press the Control Head's **RED** button (referred to as the **STANDBY** button).
 - ⇒ Press & hold until the introductory display (see below) appears on the LCD screen, then release the button.
- On the SPU, the BATT PWR, DRV PWR & VCC diagnostic LEDS should all light up.



After a few seconds, the firmware versions of both the Control Head and the SPU are listed on the display. You should record those version numbers in the **Notes** section at the back of the manual, to refer to should your autopilot ever require servicing.

The autopilot then goes into STANDBY mode.

Power Off

You can turn off the autopilot, at any time:

- Press and hold the **STANDBY** button.
 - The autopilot will switch first to **STANDBY** mode, if it was not already there.
 - Then, if you keep pressing the button, the autopilot will start a 3 second power-down sequence.
 - Once the countdown has expired, the display will prompt you to release the **STANDBY** button ... and once you do, the whole autopilot system will immediately shut off.

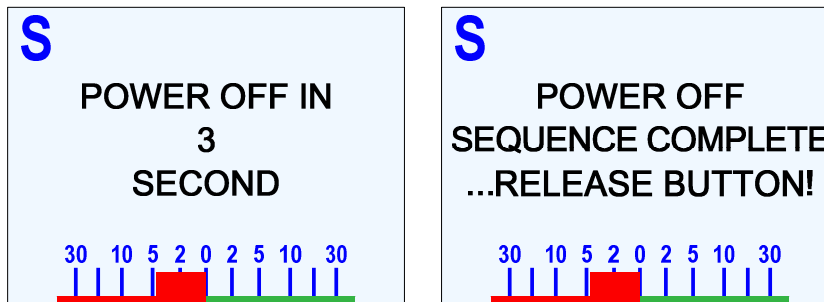


Figure 36 – Power Off Sequence

- If you release the **STANDBY** button before the 3-second countdown has completed, the autopilot will abort the countdown, and remain in **STANDBY** mode.

STANDBY Mode

The autopilot always turns on in **STANDBY** mode.

To switch to **STANDBY** mode from any other mode, press the **STANDBY** button for approximately 1 second, until the large letter `S` appears in the upper left corner of the screen.

The `S` indicates that the system is now in **STANDBY** mode.

In this mode, the autopilot displays the boat's current Heading and the rudder's angle, but has no control over the steering of the boat.

i To steer in **STANDBY** mode, you must use the boat's manual steering system: wheel, tiller, etc.

To the left of the Heading value is shown its source (e.g., Compass, one of the SPU's Navigation data inputs, etc.), and whether it is in Degrees Magnetic or Degrees True.

The latter is determined automatically by the autopilot, based on the type of the Heading source:

- All analog compasses are in Magnetic.
- NMEA sources may be in Magnetic or True, depending on which NMEA data sentences they are configured to transmit, and on the NMEA Heading Type parameter in the Standby Menu (see page 87 for more details).

The Heading source & type indicators appear in all operating modes, whenever the boat's current Heading is being displayed.

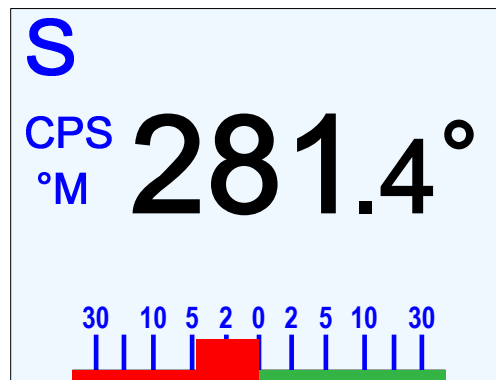



Figure 37 – Typical **STANDBY** Mode Screen

i On a SP36 without an RFU, the rudder position bar on the RAI does not appear in **STANDBY** mode (it does appear in all other modes)

Also, when switching to any other mode from **STANDBY**, the position bar is always set at Dead Centre – 0° – when the new mode begins.

Standby Menu

The Standby menu consists of a number of items that have a general bearing on how the autopilot operates. To access the Standby menu, double-press the **STANDBY** button.

S 	
Station Lock	Unlock
Default Turn	U-turn
Compass Source	NAV1
Compass Cal	360
NMEA Hdg Type	Auto


S 	
Backlight Level	5
Display	A
Watch Alarm	Off
Fishzag Time	60
Battery	13.0

Figure 38 – Standby Menu

Station Lock

The SP 36 system can accommodate up to three Control Stations – one main Control Head, and any combination of Control Heads & Remotes on the two AUX ports.

One of these Control Stations is always in control, and the others are simply repeater stations. You can take command with any of the repeater stations by simultaneously pressing the **PORT** and **STARBOARD** buttons on the repeater.

However, to prevent unauthorized personnel from doing this, the main Control Head can lock out all of the others. Station Lock must be changed to Unlock before the repeater stations can take command. For more details, refer to **Station Lock/Unlock** in the **Advanced Operations** chapter of this manual.

Default Turn

The autopilot system has a number of Special Turns pre-programmed into it. The variety of turns available depends on the system configuration, and what mode you are operating in.

Set the Default Turn parameter to the type that you are likely to use most often. Then, when you press the **TURN** button to initiate a Special Turn, the default turn will be the first one offered. See Special Turns in the **Advanced Operations** chapter for more details.

Compass Source

It is possible to have more than one type of compass connected at the same time, since there are a number of inputs for the different compass types which the autopilot can use. The boat's current "compass" can also be Heading data supplied by an NMEA device. SP36 currently only supports SI-TEX Rate compass. Call SI-TEX dealer for other options.

This menu line allows you to switch from one Heading source to another, whenever you want to.

- The available types always include NAV1 & NAV2; others depend on what types are detected during Dockside Setup. The default is NAV1; if an Analog compass type is detected during Dockside Setup, the default changes to Analog.
- If the selected source is one of the NAV inputs, it can be the same one used for the Navigation source¹⁴ (page 106), and/or the Speed source (page 96).

¹⁴ ... assuming the data source provides not only Navigation (&/or Speed) data, but also valid NMEA Heading data.

Compass Cal (*Compass Calibration*)

This line allows you to synchronize the Heading source the autopilot is currently using with an external reference – for example, some type of high-accuracy compass, or a navigation range which the boat is currently on, etc.

Simply turn the **COURSE CHANGE** knob until the Compass Cal value reads the same as your reference.

Note: for safety reasons, the Compass Source & the Compass Cal values may not be adjusted in **AUTO** or **NAV** modes, so neither menu line appears if the Standby menu is entered when operating in one of those modes.

NMEA Hdg Type (*NMEA Heading Type*)

Note: this menu line only appears if the Compass Source parameter is set to NAV1 or NAV2.

This line allows you to choose which type of value – Degrees Magnetic or True – from an NMEA source will be used by the autopilot for its Heading:

- “Auto”: the autopilot will automatically select whether to use Magnetic or True, depending on which NMEA sentences are received (assuming all sentences have valid data):
 - If the HDG sentence is being received (no matter whether HDM &/or HDT are also being received), then the autopilot will use Magnetic Heading (indicated on the display by an ‘M’ beside the boat’s actual Heading value on the screen), and it will be the value in the HDG sentence.
 - If only HDM & HDT are being received, or just HDT, then the autopilot will use True Heading (indicated by a ‘T’), from the HDT sentence.
 - If only HDM is being received, then the autopilot will use Magnetic Heading (indicated by an ‘M’), from that sentence.
- “True”: the autopilot will use True Heading from the HDT sentence. If HDT is not being received, a Heading Error alarm will occur.
- “Mag”: the autopilot will use Magnetic Heading from the HDG sentence, if that is being received, or from HDM if only that is being received. If neither HDG nor HDM are being received, a Heading Error alarm will occur.

Backlight Level

There are 9 levels of backlighting available, numbered 0 through 8.

Level 8 offers the brightest possible backlight. Each level below 8 offers a correspondingly lower level of backlight.

Level 0 is completely off (no backlighting). To change from Level 0 to any other level, double-press the **STANDBY** button to bring up the Standby menu. The screen will temporarily light up with level “3” brightness, so that you can see the menu.

For colour Control Heads, the screen automatically changes to a “night” colour scheme (see scheme “C” below), whenever the backlight level is set to “1”, “2”, or “3”.

Contrast (*monochrome Head only*)

There are 8 levels of contrast available. Level 5 is usually the optimum value.

Contrast of the LCD is affected primarily by temperature. The Control Head is internally compensated for fluctuations over a wide temperature range – but manual adjustments can be made to the contrast by changing this parameter, if necessary.

Display

For colour Heads, there are three built-in colour schemes:

- The standard is scheme is “A” – a white background with most text in black, and various red, green & blue colours to emphasize important elements of the various displays.
- Colour scheme “B” is an alternate that you may prefer – a light blue (cyan) background, with suitably-contrasting colours for text & the various display elements & information.
- Colour scheme “C” utilizes red colours on a black background, and was developed for use at night, to avoid impairing the boat operator’s night vision.

Note: schemes “B” & “C” are shown below; “A” is used for all other figures & pictures of the Colour Head in this manual.

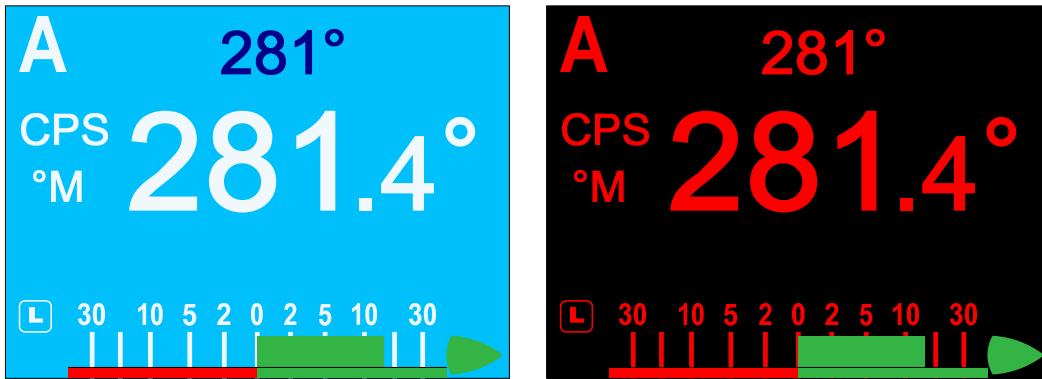


Figure 39 – Colour LCD: B & C Colour Schemes

Watch Alarm

The autopilot has a built-in Watch Alarm. This menu line allows you to turn on the Watch Alarm, and set how much time is allowed to elapse before the alarm goes off. This menu line is “password protected” to prevent unauthorized personnel from changing the settings of this alarm. See the **Advanced Operations** chapter of this manual for complete details on the Watch Alarm & password.

Battery

This is a read-only display; it can not be changed.

The number shown is the battery voltage as measured at the Signal Processor Unit, after the logic fuse F1 – so it will be a little less than the voltage at the SPU's **J1 – BATTERY INPUT** connector, and (depending on how you have wired the SPU) somewhat less than the voltage at your boat's battery terminals.

- If the measured voltage is 10 Volts or less, a BATTERY LOW alarm will occur (see page 152).

POWER STEER Mode

In this mode, you can directly control the rudder. In effect, the autopilot is acting as an “electronic steering wheel”, allowing you to steer the boat manually – on any Heading you want, or into a turn.

To enter **POWER STEER** mode, press and hold the **POWER STEER** button for about 1 second, until the large letter ‘P’ appears in the upper left portion of the display.

The Control Head displays the boat’s current Heading, source & type, and the rudder’s angle, but only so you know what they are.

The **PORT** and **STARBOARD** buttons are used to control the rudder. Press one or the other to move the rudder in that direction. The rudder will keep moving for as long as the button is pressed, until it gets to the physical rudder limits (or the limits you set in the Power Steer menu – see next page).

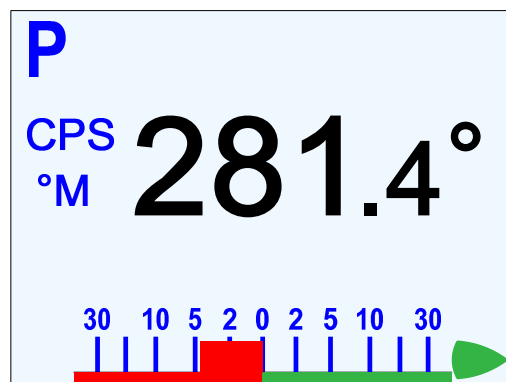


Figure 40 – Typical POWER STEER Mode Screen

The **COURSE CHANGE** knob can also be used to move the rudder in **POWER STEER** mode:

- One ‘click’ changes the rudder angle by approximately 1 degree.
- A quick spin moves the rudder approximately 10 degrees.

You can limit the maximum amount of rudder travel in **POWER STEER** mode, with the Power Steer limits. Turning on these limits, and adjusting them to suit, is done in the Power Steer menu (see next page).

ⓘ *On a SP36 without an RFU, you should always manually steer a steady, straight Heading, in **STANDBY** mode, for at least 10 seconds – or longer, if necessary, until you don’t have to continue to move the wheel/tiller to maintain a straight Track – before switching into **POWER STEER, AUTO** or **NAV** modes. The rudder must be at the dead-ahead position when you switch modes.*

*If the estimated rudder position (as shown on the RAI) reaches Dead Centre while you are pressing the **PORT** or **STARBOARD** button to move the rudder, the rudder will stop moving. This is to allow you to check that the actual & estimated rudder positions are the same (see page 113 for more information on the topic of actual versus estimated rudder position).*

If they are the same (or at least close), you can then continue to move the rudder by pressing the same button again.

*If they are not, you should go to **STANDBY** mode, manually steer a straight Heading, etc. (as above), before re-entering **POWER STEER** mode.*

Power Steer Menu

The Power Steer menu contains the “mechanical” steering parameters (which are common to all modes). To access the Power Steer menu, double-press the **POWER STEER** button.


P	
P.STR Limits	Off
AUTO/NAV Limits	Off
RAI Offset	0

Figure 41 – Power Steer Menu

P.Str Limits (Power Steer Rudder Limits)

When you set up the autopilot system, you will move the rudder from hard-over Port to hard-over Starboard so that the autopilot can measure these positions¹⁵. These hard-over positions are known as the “physical limits”, beyond which the rudder simply cannot be turned. However, you can also limit the amount of rudder travel which the autopilot will allow you to use in **POWER STEER** mode.

To do so, set the Power Steer Limits to the number of degrees Port and Starboard that you would like to limit the rudder movement to. These rudder limits will be in effect whenever the autopilot is in **POWER STEER** mode, and during all Dodge and Jog Control turns.

The minimum setting is 5°; the maximum is the same as the physical limits measured in Dockside Setup. Setting the limits to “Off” means that the full range (up to the physical limits) will be allowed.

The physical range beyond the selected limits of the current mode¹⁶ will be shown on the thin bottom bar of the Rudder Angle Indicator display during normal operation – in a contrasting colour on a colour Control Head, and in a light grey on a monochrome Head.

Auto/Nav Limits

The Auto/Nav Limits are similar to the Power Steer Limits detailed above, but they are in effect only when the autopilot is in **AUTO** or **NAV** modes.

RAI Offset

The RAI (Rudder Angle Indicator) display at the bottom of the autopilot display may require a slight offset adjustment in order to read zero degrees when the boat is moving in a straight line. This is a fairly common scenario and may be due to boat loading or design, rudder design or function, or the installation of the Rudder Follower Unit.

For example, if the boat is traveling in a straight line, but the RAI reads 2° to Starboard, adjust the RAI Offset to Port so that the RAI display reads zero.

Note: *this menu line does not appear on a SP36 operating without an RFU.*

¹⁵ On SP36, you enter those positions manually.

¹⁶ In **STANDBY** mode, the **POWER STEER** limits are shown.

AUTO Mode

In **AUTO** mode, the autopilot will steer the boat on your desired Heading.

To enter **AUTO** mode, press and hold the **AUTO** button for about 1 second, until the large letter 'A' appears in the upper left portion of the display.



Figure 42 – Typical AUTO Mode Screen

- The boat's current actual Heading is shown in large letters in the middle of the LCD screen, with the source & type.
- Your desired Heading – aka “Commanded Heading” – is shown in smaller digits at the top-center of the screen.
- When you first enter **AUTO** mode, the autopilot will use the Heading that the boat was on at the moment the mode was entered as the initial Commanded Heading.

To change the Commanded Heading, use the **COURSE CHANGE** knob:

- A clockwise turn will result in an increase of the Heading.
- A counter-clockwise turn will decrease the Heading.
- One 'click' will change the Heading by 1 degree.
- A quick spin of the knob changes the Heading by 10 degrees.

The autopilot will then bring the boat around to the new Commanded Heading at no more than the rate of turn specified for Turn Rate in the Auto menu. The actual Heading shown in the display will gradually change to match the Commanded Heading.

Notes on AUTO Mode

- If you need to, you can quickly “dodge” around obstacles, and automatically return to your original Commanded Heading when the boat is clear of the obstacle, without having to turn the **COURSE CHANGE** knob – see **Dodge & Jog Steering Turns**, pages 108 & 111.
- You can limit the maximum amount of rudder travel in **AUTO** mode by turning on the Auto/Nav rudder limits. Turning them on, and adjusting them to suit, is done in the Power Steer menu (see page 91).
- The autopilot has an automatic Off-Course Alarm that will be activated should the boat fall off the Commanded Heading by more than 20°. There is a 32 second delay on this alarm.

ⓘ On SP36 without an RFU, you should always manually steer a steady, straight Heading, in **STANDBY** mode, for at least 10 seconds – or longer, if necessary, until you don't have to continue to move the wheel/tiller to maintain a straight Track – before switching into **POWER STEER, AUTO** or **NAV** modes. The rudder must be at the dead-ahead position when you switch modes.

Auto Menu

The Auto menu contains all the autopilot's Steering Parameters.

To access the Auto menu, double-press the **AUTO** button.



A  321°		A  321°	
Rudder Gain	8, 5	Speed Trip Point	10
Counter Rudder	3, 3	Speed Source	NAV1
Seastate	A, A	ALC	Off
Turn Rate	8.0, 5.0	Thruster Assist	Off
Parameter Set	Lo	Thruster Gain	Low

Figure 43 – Auto Menu

Rudder Gain

Rudder Gain controls the amount of corrective Rudder movement applied, in proportion to an error in Heading¹⁷.

The parameter does not have any units.

autopilots are able to accommodate a wide range of Rudder Gains, but restrict the user to a certain portion of this range, depending on the setting of the Vessel Type parameter (see page 59).

The effect of Rudder Gain on the amount of Rudder movement also depends on the type of boat.

Some examples:

- On a Stern Drive boat which is off-Heading by 5° to Port, with Rudder Gain set to 6, and Counter Rudder 0, the boat's rudder will be moved to 20° Starboard, and stay there for as long as the Heading error is 5°.
- On a Semi-Displacement boat under the same circumstances, the boat's rudder will be moved to 30° Starboard.

¹⁷ ... or amount to turn – when you change the Commanded Heading, the resulting “turn” is processed as if it is an “error”.

Hi & Lo Speed Rudder Gain

There are two numbers shown for Rudder Gain in the Auto menu. The number on the left is the value used when the autopilot is operating in Lo speed. The number to the right is the value used when the autopilot is operating in Hi speed.

Note: see the **Parameter Set** menu item for details on Hi & Lo speed selections.

If the autopilot is in Lo speed, only the Lo speed Rudder Gain will change when you rotate the **COURSE CHANGE** knob; the Hi speed Rudder Gain value will be shown in a greyed-out colour. Similarly, if the autopilot is operating in Hi speed, the **COURSE CHANGE** knob will only affect the Hi speed Rudder Gain value, and the Lo speed value will be greyed-out.

The following diagram provides general guidelines for setting Rudder Gain:

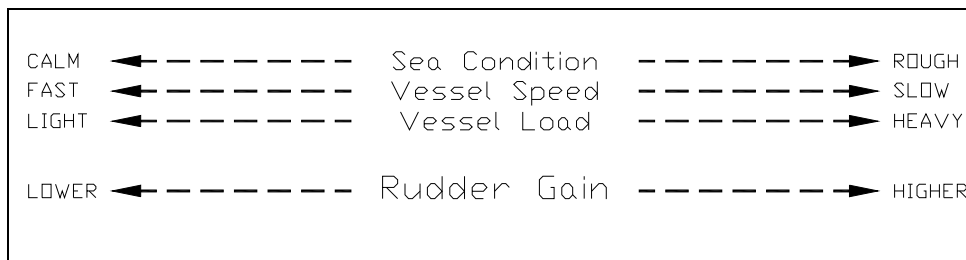


Figure 44 – Guidelines for setting Rudder Gain

Counter Rudder

Counter Rudder controls the amount of Rudder movement, in proportion to the rate of change in the amount of Heading error. The parameter does not have any units.

If the Heading error is increasing, the Counter Rudder movement adds to the Rudder Gain movement; if the error is decreasing, it is subtracted.

Similarly to Rudder Gain, the effect of Counter Rudder on the amount of Rudder movement depends on the type of boat.

An example:

- A Sailboat is off-Heading to Starboard by some amount, and the error is increasing by 2° per second: the amount the boat's rudder will be moved to Port – set by the Rudder Gain – will be increasing by 4° per second.

Hi & Lo Speed Counter Rudder

Like Rudder Gain, there are two numbers shown in the menu – one for Lo speed, and one for Hi speed. Only the Counter Rudder for the currently-active Speed setting will be changeable; the other will be greyed-out.

The following diagram provides general guidelines for setting Counter Rudder:

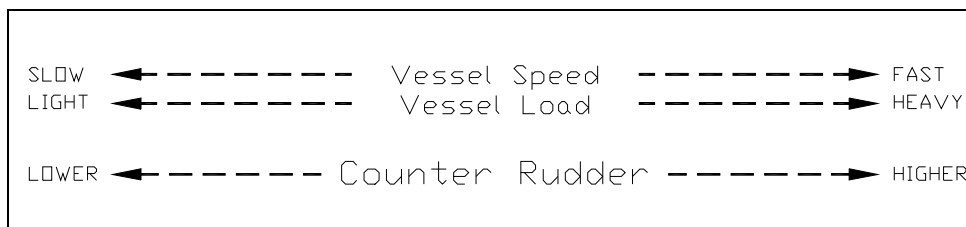


Figure 45 – Guidelines for setting Counter Rudder

Seastate

The Seastate parameter tells the autopilot how much deviation – also called Yaw – from the set Course to allow before taking corrective action.

Seastate should be set according to sea conditions. As conditions worsen, the Seastate setting can be increased. This may result in slightly worse steering performance, but will reduce the amount of rudder movement and strain on the steering system.

This parameter's units are degrees, and the value is the total across to either side of the set Course; that means that a value of 1 will allow the boat's Heading to yaw up to 0.5° on either side of the set Course before the autopilot brings it back on-course. The maximum value is 10°.

There is also an Automatic Seastate Control feature that will monitor and adjust the Seastate setting for you. To activate this, highlight "Seastate" in the menu and turn the **COURSE CHANGE** knob counter-clockwise until the value reads "A".

There are two Seastate settings; one is for Lo speed operations and one is for Hi speed operations. Only the Seastate for the currently-active Speed setting will be changeable; the other will be greyed out.

Turn Rate

Varying the Turn Rate parameter controls the maximum rate at which the boat may make a Heading change (in **AUTO** or **NAV** modes), return to its original heading after a dodge manoeuvre, or execute a Special Turn. Factors such as speed, load, hull characteristics and weather conditions may limit the maximum achievable Turn Rate.

This parameter's units are in degrees per second. Up to 1.5 %/sec, the value increments by 0.1° per click of the **COURSE CHANGE** knob; then it goes to 2.0 %/sec, and from there to the maximum of 10.0 %/sec (or 12.0 %/sec if the Vessel type is set to "Sail"), it changes by 1° per click.

There are two Turn Rate settings; one is for Lo speed operations and one is for Hi speed operations. Only the Turn Rate for the currently-active Speed setting will be changeable; the other will be greyed out.

Parameter Set

The system gives you the ability to store two sets of steering parameters, "Lo" (low) and "Hi" (high). This allows for best performance under varying boat speeds and/or loading conditions.

The autopilot can be set manually to use either the Lo or the Hi settings. There is also a selection for "Auto". If "Auto" is chosen, the autopilot will automatically switch from Lo to Hi, or vice-versa, depending on the boat's speed. For "Auto" to work, the autopilot must be connected to an NMEA 0183 Navigation System that outputs speed information. The Speed Trip Point, described below, governs the point at which the switch is made.

When the autopilot is in **AUTO** or **NAV** mode, it always indicates which steering parameter set is in effect. This is shown just to the left of the Rudder Angle Indicator, and consists of a small box shape with either L for "Lo" or H for "Hi" in it. If the Parameter Set value is set to Auto, then the word "AUTO" also appears in the box.

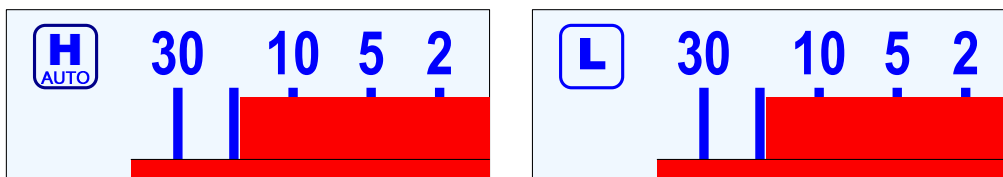


Figure 46 – Hi (AUTO) and Lo Speed Indicators (to left of the Rudder Angle Indicator)

Speed Trip Pt (Speed Trip Point)

The Speed Trip Point governs the point at which the autopilot automatically transitions from the Lo steering parameters to Hi. For automatic transition to take place, the Parameter Set must be set to "Auto".

The value can be set from 2 to 20; the units (Knots, Km/h, etc.) are what the **Speed Source** is providing.

Note: *this parameter is also used to control the SPEED MODE status output (see Speed Mode & Timing Outputs on page 50).*

Speed Source

The SP 36 can obtain information about the boat's speed from a variety of sources which provide NMEA 0183 data, at either the **NAV1** or **NAV2** inputs on connector **J9**.

This menu line is used to select which of the two inputs the autopilot will use.

- The selected input can be the same one used for the Compass Source (see page 86), and/or the Navigation data source (see page 106).

ⓘ *A source of Speed data is strongly recommended on SP36 systems being used without an RFU, in order to give the Virtual Rudder Feedback algorithms a way to gauge the rudder's effectiveness.*

If you do not have a Speed Source, then you should always set the Parameter Set to "Hi".

ALC (Automatic Leeway Correction)

The autopilot's ALC feature is turned on or off with this parameter. See the description on page 16 for details of what it does. It can be turned on only in **AUTO** mode.

When it is active, the letters "ALC" are shown, to the right of the 'A' mode indicator.

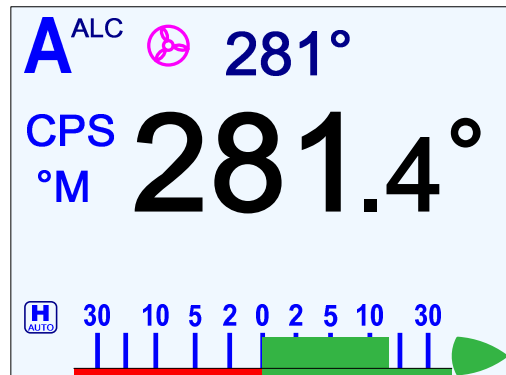


Figure 47 – Typical AUTO Mode Screen

"propeller" icon is shown to the left of the Commanded Heading when a thruster is present (see the figure above).

NAV Mode

In **NAV** mode, the autopilot can use navigation data from an external NMEA 0183 Navigation System, to steer the boat directly to a specific destination, or along a route of waypoints leading to a destination.

To use **NAV** mode:

- Turn on your Navigation System
- Create and activate a waypoint at the destination you want to go to, or a series of waypoints along a route to the destination.
- Press & hold the **NAV** button on the Control Head until the large letter 'N' appears in the upper left portion of the display

The Control Head will display a screen similar to the figure below.

- The boat's actual Heading is shown in large letters in the middle of the LCD screen, with the source & type; the Commanded Heading is shown in smaller digits at the top centre of the screen.
- The Range & Bearing to the next Waypoint, its ID, and the current Cross-Track Error are shown below the Heading; these are all taken from the data provided by the Navigation System¹⁸.

Note: *this is the normal NAV mode display; see the next page for the alternate "highway" display.*

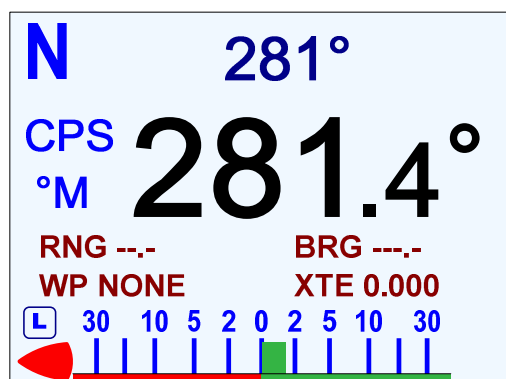


Figure 48 – Typical NAV Mode Screen (Normal Display)

Note: *the Commanded Heading shown on the Control Head may not be the same as the actual bearing to the target point, especially when using "XTE" or "Both" Correction (see page 100). It may even not be the same as a "current Heading" shown by the Navigation System.*

The difference is due to the effects of the correction method the autopilot uses, which may or may not match with what the Navigation System does in calculating "course to steer" & "bearing to destination".

¹⁸ Some Navigation Systems do not provide all of this information. In such cases, the display will show dashes (---) or "NONE" in place of any missing data.

NAV Highway Display

An alternative “highway” display is available for **NAV** mode.

To access this display, press & hold the **NAV** button until the autopilot enters **NAV** mode. Then press the **NAV** button again.

The display will change to a “perspective” representation, as in the figure below:

To change back to the normal display, press the **NAV** button again.

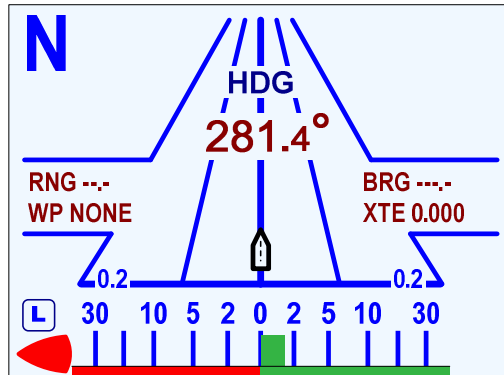


Figure 49 – Typical NAV Mode Highway Screen

In the NAV Highway display, the Track to the destination is the centreline of the “highway”. The boat’s position with respect to that Track is shown by the small “boat” shape.

Cross-Track Error is shown graphically by the boat being located to the left or right of the centreline. The offset is proportional to the amount of Cross-Track Error.

Note the small numbers in the lower corners of the highway display. These indicate the scale of the display. There are four scales that can be shown on the highway display: 0.2, 0.5, 1.5, and 3.0 Nautical Miles. The scale changes automatically to give the best resolution.

Notes on NAV Mode

- If you need to, you can quickly “dodge” around obstacles, and then automatically return to your original Track when the boat is clear of the obstacle – see **Dodge & Jog Steering Turns**, pages 108 & 111.
- You can limit the maximum amount of rudder travel in **NAV** mode by turning on the Auto/Nav rudder limits. Turning them on, and adjusting them to suit, is done in the Power Steer menu (see page 91).
- The autopilot has an automatic Off-Course Alarm that will be activated should the boat fall off the Commanded Heading by more than 20°. There is a 32 second delay on this alarm.

ⓘ *On a SP36 without an RFU, you should always manually steer a steady, straight Heading, in **STANDBY** mode, for at least 10 seconds – or longer, if necessary, until you don’t have to continue to move the wheel/tiller to maintain a straight Track – before switching into **POWER STEER, AUTO** or **NAV** modes. The rudder must be at the dead-ahead position when you switch modes.*

Understanding NAV Mode

In **NAV** mode, the autopilot steers the boat as required to maintain a Commanded Heading, just like it does in **AUTO** mode.

And it also uses the compass source which you have selected for its “current Heading”, for course-keeping purposes – again, just like in **AUTO** mode.

But there’s an important difference between the two modes:

- In **AUTO** mode, the autopilot “obeys” the Command Heading you give it (with the **COURSE CHANGE** knob) ... when you set an initial Heading, and later when you adjust it, as & when sea conditions change, to keep the boat on a straight Track to your destination.
- In **NAV** mode, after you enter a destination, or a route of waypoints, in the Navigation System, the autopilot uses the “steering & navigation” data received from that system to determine the Commanded Heading required to get there, and then does it.

Another key feature of **NAV** mode is that, as each waypoint in a route to your destination is reached, the autopilot can (either automatically, or when you “acknowledge” arrival at the waypoint) change the Commanded Heading, to turn the boat onto the Track to the next waypoint.

And then when the destination waypoint is reached, the autopilot will typically steer the boat so that it orbits that waypoint¹⁹, until the autopilot either is switched out of **NAV** mode, or you give it new navigation information via the Navigation System.

Checking the Navigation Data

It is important to be sure that the Navigation System is providing good-quality data to the autopilot. You can test this by following these steps:

- 1) Make sure the Navigation System is turned on and that a waypoint is programmed in and activated.
- 2) Steer the boat close to the Track from the starting position to the waypoint.
- 3) In the NAV menu, select “CTS” for the “Correction” parameter.
- 4) Put the autopilot in **NAV** mode.
- 5) Observe the boat’s response for several minutes.
 - If the boat seems to be continually falling off-course (away from the Track), you probably need to change “XTE Sense” (Cross-Track Error sense) in the Nav menu from “Norm” (normal) to “Rev” (reverse). Then repeat this step.
- 6) If the boat is wandering back and forth, but there are no alarms on the autopilot or Navigation System, the data being provided to the autopilot may not be good enough.

The most common cause of this is poor signal quality in the sensor or antenna wiring of the Navigation System. This may be due to:

- Improper grounding
- Electrical noise generated in the boat (alternators, power packs, etc.)
- Poor antenna location

In this case, you should refer to the Navigation System’s manual for how to deal with poor signal quality, and for what to do to make improvements.

It may also be helpful to consult your SI-TEX Dealer.

¹⁹ ... although it depends on what the Navigation System is set up to do when the destination is reached.

Correction Methods

There are three different methods that the autopilot can use to process data from the Navigation System, in order to update its Commanded Heading. Each has different effects on the path that the boat follows.

You select which method you want the autopilot to use, by specifying “CTS”, “XTE” or “Both” for the Correction parameter in the Nav menu.

The table below is a brief overview of the 3 methods. Full details on each method follow, over the next several pages.

The data used in these methods is defined as follows:

- “Direction data” is the Bearing Origin To Destination (BOD) data in the NMEA sentences from the Navigation System, or – if there is no BOD data – the boat’s initial Heading at the time **NAV** mode is entered.
Note: the no-BOD condition for a whole route is possible only when the route is straight to a destination – i.e., it has only the one destination waypoint. For routes with multiple waypoints, the first leg can be with “initial Heading”, but the Navigation System must provide BOD data for subsequent legs.
- “Steering data” is either the Course To Steer (CTS) data provided by the Navigation System, or – if there is no CTS data – the Bearing Present To Destination (BPD) data.
- The Cross-Track Error (XTE) data from the Navigation System, in Nautical Miles.

Setting	Method	Comments
CTS	Course To Steer	The autopilot uses “steering data” only: Heading = CTS or BPD ❖ <i>Cross-Track Error is displayed, but not used.</i>
XTE	Cross-Track Error	The autopilot steers so as to minimize Cross-Track Error as quickly as possible, using “direction” data: Heading = (BOD or Heading) + (XTE × 400° / NM) ❖ <i>CTS/BPD data is not used, even if provided.</i>
Both	Course To Steer plus Cross-Track Error	The autopilot steers so as to minimize Cross-Track Error smoothly, using either “steering data” or “direction data”, depending on what the Navigation System provides: ❖ <i>If CTS or BPD data is provided:</i> Heading = (CTS or BPD) + (XTE × 360° / NM) ❖ <i>If neither CTS nor BPD data is provided:</i> Heading = (BOD or Heading) + (XTE × 400° / NM).

Table 7 – NAV Mode Correction Methods

CTS – Steering a Direct Bearing

When Correction is set to “CTS”, the autopilot uses only the “steering” data (CTS or BPD) from the Navigation System – and therefore is always steering directly to the destination, or next waypoint, from the present position, as depicted in the following diagram.

Cross-Track Error is not used in the calculation.

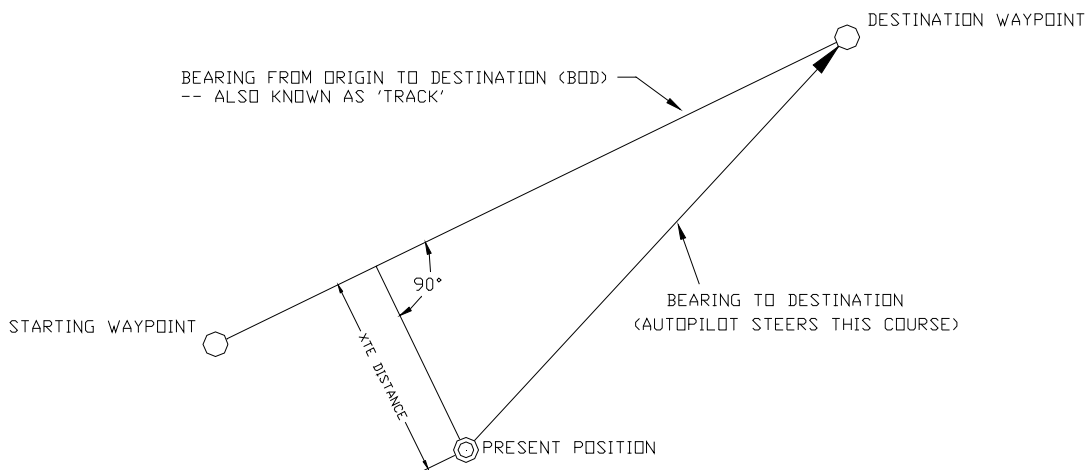


Figure 50 – Steering with Correction set to CTS

To see how this method works, try it out by performing the following steps:

- 1) Change Correction in the Nav menu to “CTS”.
- 2) Make sure the Navigation System is turned on, that a route consisting of at least a starting position (origin) and a destination point is entered, and that the Navigation System is set to output sentences which contain either CTS or BPD data.
- 3) Activate the route.
- 4) Switch the autopilot into **STANDBY** mode and manually steer the boat away from the Track between the starting position & destination, by at least a few hundred metres.
- 5) Place the autopilot into **NAV** mode.
- 6) Observe the Commanded Heading on the Control Head’s display. It should match the Bearing Present to Destination value displayed on the Navigation System – rather than the bearing of the desired Track.

Caution! *Be sure to maintain a sharp lookout to ensure that there are no obstacles between the boat and the destination, when Correction is set to “CTS”.*

XTE – Steering Quickly Back to a Track

Cross-Track Error is the perpendicular distance from the desired Track to the boat's position.

When using Cross-Track Error Steering (Correction set to "XTE"), the autopilot initially steers on the Heading that was current when you enter **NAV** mode, and also monitors the Cross-Track Error reported by the Navigation System.

If there is any Cross-Track Error, the autopilot changes the Commanded Heading so as to minimize the Cross-Track Error as rapidly as possible – so that the boat returns to the desired Track as quickly as possible.

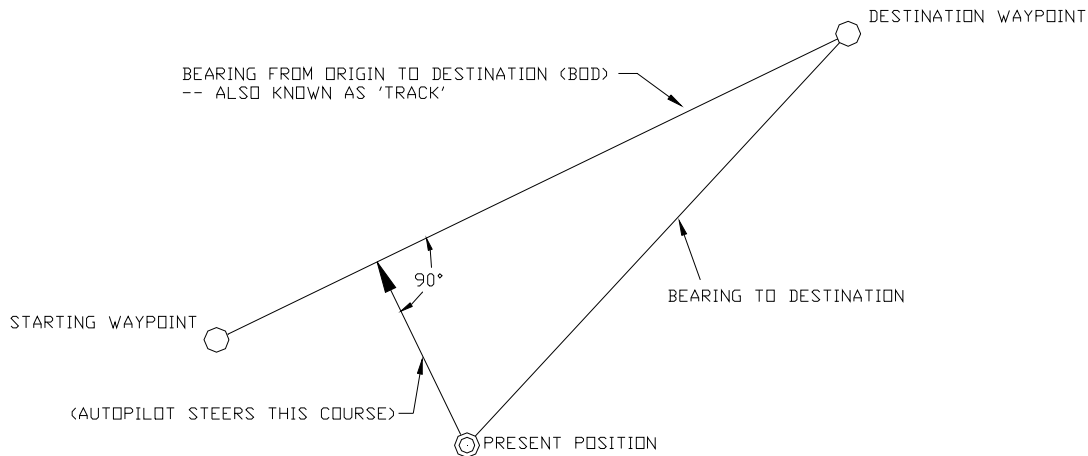


Figure 51 – Steering with Correction set to XTE

To see how this method works, try it out by performing the following steps:

- 1) Change "Correction" in the Nav menu to "XTE", and "MAX Correction" to 90°.
- 2) Make sure the Navigation System is turned on, that a route consisting of at least a starting position (origin) and a destination point is entered, and that the Navigation System is set to output sentences which contain BOD data.
- 3) Activate the route.
- 4) Switch the autopilot to **STANDBY** mode and manually steer the boat onto the Track.
- 5) Place the autopilot into **NAV** mode.
- 6) Observe the boat's Heading and the Cross-Track Error. The autopilot should be steering so as to minimize any Cross-Track Error that develops (from wind, waves, cross-currents, etc.), as rapidly as possible.
- 7) Switch the autopilot to **STANDBY** mode and manually steer the boat to a position well off the desired Track.
- 8) Place the autopilot back into **NAV** mode.
- 9) Observe the boat's Commanded & actual Heading and the Cross-Track Error. The Commanded Heading should shift to something approximately 90° different than the desired Track (less than the Track if you are to Starboard of it, greater if you are to Port).

The autopilot should keep steering that Heading until the boat nears the Track, thus minimizing Cross-Track Error as rapidly as possible, and then turn the boat onto the Track.

Caution! Be sure to maintain a sharp lookout to ensure that there are no obstacles between the boat's current position & the desired Track, with "XTE" Correction.

There is one major drawback to XTE Correction, however.

The course steered when Correction is set to “XTE” is usually not the most efficient in terms of overall distance traveled.

The main problem is that the sum of the distance travelled at a right angle to the Track (i.e., along the XTE distance), and then along the Track – in other words, along the two “right angle” sides of the triangle, in the figure below – is obviously greater than the path direct to the destination.

Also, if there is a large Cross-Track Error, the autopilot may overshoot the desired Track, and then gradually settle on to it. This is a function of turn rate, boat speed, and position updates received from the Navigation System.

- All of these effects are lessened when “Correction” is set to “Both” (see next page).

ⓘ For best performance, it is always best to minimize any Cross-Track Error before putting the autopilot into NAV mode!

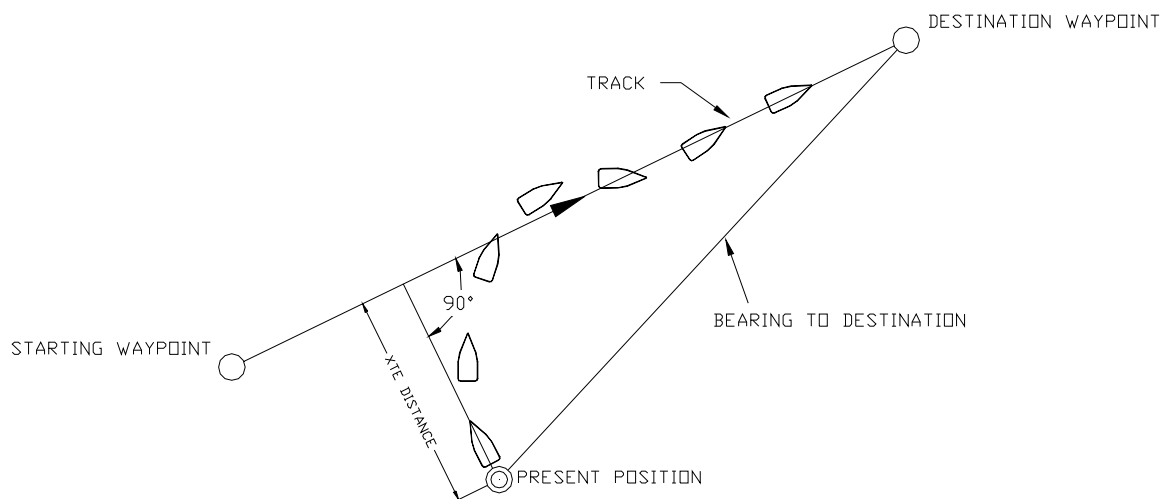


Figure 52 – Response of Boat to a Large Cross-Track Error

Large Cross-Track Error Effects

There is another potential drawback to XTE Correction.

If the Cross-Track Error is large, the autopilot will steer a Heading which can be almost perpendicular to the desired Track.

This may be annoying – and it might even be unsafe, depending on what objects or other boats are near you at the time.

However, the total number of degrees that the autopilot will adjust the Commanded Heading away from the desired Track is limited to the value set for “Max Correction”.

By using this parameter – by setting it to something less than the factory-default of 90° – you can thus limit the possibly-undesired effects of the “perpendicular to Track” behaviour of the autopilot.

Both – Steering Smoothly Back to a Track

When Correction is set to “Both”, the autopilot will bring the boat onto the desired Track as smoothly and efficiently as possible.

Experience has shown that this is generally the best method for most boats.

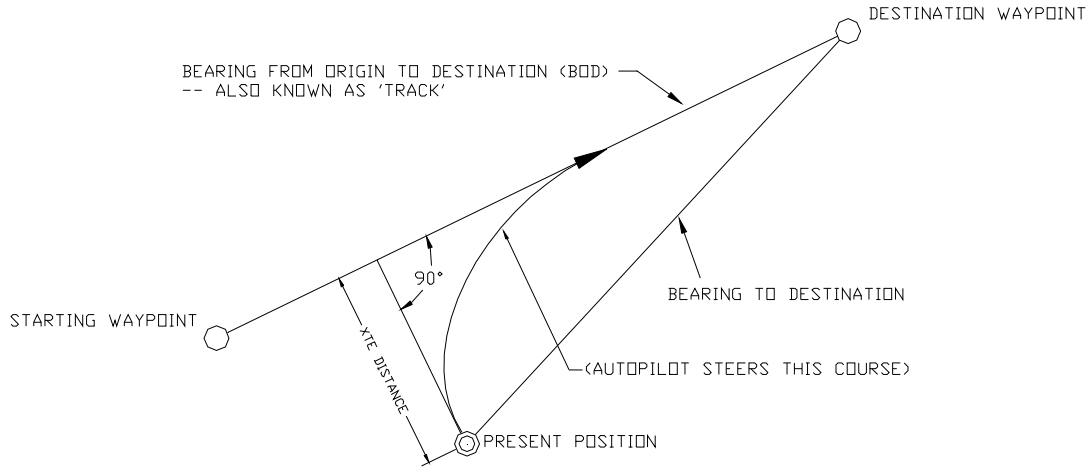


Figure 53 – Steering with Correction set to Both

When steering using this method, the autopilot tries to minimize Cross-Track Error by steering to a Heading that lies between a perpendicular to the Track and the current bearing to the destination waypoint.

The farther you are off-track, the closer to the perpendicular the Heading will be. As you come closer to the Track, the Heading of the boat will change closer to the Heading of the Track.

When you are on-track, the boat’s Heading and the Track will be identical.

To see how this method works, try it out by performing the following steps:

- 1) Change “Correction” in the Nav menu to “Both”, and “MAX Correction” to 90°.
- 2) Make sure the Navigation System is turned on, that a route consisting of at least a starting position (origin) and a destination point is entered, and that the Navigation System is set to output sentences which contain CTS or BPD data.
- 3) Repeat steps 3) to 9) of the **XTE – Steering Quickly Back to a Track** test.
- 4) At step 6), the autopilot should be steering so as to minimize Cross-Track Error as smoothly as possible. It may be hard to tell if the steering is any different than with “XTE Correction”.
- 5) At step 9), the autopilot should steer the boat in a smooth arc back onto the Track.

If the Commanded Heading does initially go to 90° different than the Track, it should stay there for a much shorter time that with XTE Correction, and then gradually change back to the Track’s bearing.

- Similarly to XTE Correction, you can limit the effects of the autopilot’s potential “perpendicular to Track” steering with large Cross-Track Error values, with the Max Correction parameter.

Caution! Be sure to maintain a sharp lookout to ensure that there are no obstacles between the boat’s current position & the desired Track, with “Both” Correction.

An example of NAV Mode in Operation

Here's an example of **NAV** mode in operation, to help make the real-world effects of all that math clearer!

Let's say that your boat is running on a waypoint-to-waypoint leg which has a charted bearing of 120° True, and the autopilot is using degrees True Heading data from an NMEA source. You've selected XTE Correction in the NAV menu, and set up the Navigation System to output Bearing Origin To Destination data in degrees True, and XTE data (in NM), with both in the NMEA APB sentence.

When you departed the first waypoint, you were right on the Track between the waypoints, and so the data in the APB sentence was BOD = 120° True, & XTE = 0.0 NM. Thus, the autopilot calculated a Commanded Heading of 120° True, and that's also the boat's actual Heading.

That's good ... you're going straight to the next waypoint ... you can relax!

Ooops ... where did that cross-current come from? Seemingly all of a sudden, you're a tenth of a mile off-track to Port, although the boat's actual Heading is still ~120° ...

No worries! The autopilot will handle it:

- BOD is still 120° T, but XTE is now 0.010 NM
... so the Commanded Heading is now $120^\circ + (0.010 \text{ NM} \times 400\%/ \text{NM}) = 124^\circ$, and the actual Heading is something close to 124°

A few minutes later, you're a little more than half-way back to the Track:

- BOD is still 120°, XTE is now 0.004 NM, so Commanded Heading is now 121.6° (and the actual Heading is close to that)

And after a few more minutes, you're back on-Track, with both Headings holding at ~120°.

Some other points about **NAV** mode to keep in mind:

- The XTE value the autopilot uses in its correction calculations is always in Nautical Miles, and has a precision of 3 decimal places (0.001 NM).

When XTE is 0.01 NM or less, the full 3-digit precision is used. But, when XTS is greater than 0.01 NM, the value is rounded to 2 decimal places (0.01 NM), before the correction calculations are done. The reason for that is to provide smoother & more efficient steering when XTE is "large".

To explain: there's really no point to making many fine adjustments to Commanded Heading when the boat is a long way off-track. For example, if XTE above were to change from 0.024 NM down to 0.015 NM, the Commanded Heading would stay at 128°, rather than going in 0.4° steps from 129.6° down to 126°. But ... the total time to come back on-track would be about the same.

And it's easier on the rudder & drive mechanism too. A few larger changes cause less wear & tear than many small ones – and also use less power!

- Very small changes in, or values of, the XTE value may not always cause a change of Heading - depending on the Sea State parameter value (see page 95).

Example: if Sea State is 1, a change in XTE of 0.001 NM yields a change of Heading of 0.4° - but that's less than the 0.5° of Yaw that is allowable for Sea State 1.

On the other hand, if very small XTE values exist for a time, what will happen instead is that the autopilot's Automatic Rudder Trim will gradually build up a "trim" which *does* have the same effect as changing the Commanded Heading.

In the example above, a steady XTE of 0.001 would cause the rudder to wind up a bit off-centre to Starboard – keeping the boat "crabbing" a bit into that cross-current from Starboard, so that you stay right on the Track that you want.

Nav Menu

The Nav menu contains a number of parameters used when operating the autopilot in **NAV** mode.

To access the Nav menu, double-press the **NAV** button.



N  321°		N  321°	
Nav Source	NAV2	XTE Limit	0.25
XTE Limit	0.25	Waypoint Arrival	Manual
Waypoint Arrival	Manual	Correction	Both
Correction	Both	XTE Sense	Norm
XTE Sense	Norm	Max Correction	60

Figure 54 – Nav Menu

Nav Source

Set Nav Source to the input connector (NAV1 or NAV2) that the external Navigation System is connected to. The autopilot will then look at that input when in **NAV** mode to obtain the bearing and course-to-steer information it needs.

- The selected input can be the same one used for the Compass source (see page 86), and/or the Speed source (see page 96).

XTE Limit (Cross-Track Error Limit)

The autopilot will raise an alarm while in **NAV** mode if the boat's Cross-Track Error exceeds the limit set here.

Waypoint Arrival

When the boat arrives at a waypoint or the end of a route, an NMEA "arrival" sentence is sent to the autopilot from the Navigation System.

This menu line tells the autopilot how you want it to react to the arrival sentence.

Auto (automatic sequencing):

- The autopilot will automatically turn the boat onto the Heading to next waypoint. "Waypoint Arrival" will be displayed on the Control Head screen, along with an audible alarm; both will continue until acknowledged by pressing the **Fn** button.

ⓘ Caution! *Because the boat will turn automatically, it is crucial when planning the trip that you verify there will be sufficient room to execute the turn – at each waypoint.*

Manual (manual sequencing):

- "Waypoint Arrival" will be displayed on the Control Head screen, accompanied by an audible alarm; both will continue until acknowledged by pressing the **Fn** button.

The autopilot will **not** automatically turn the boat to the next waypoint's Heading. Instead, the current Heading will be maintained until the **Fn** button is pressed.

Off (silent sequencing):

- Automatically turn the boat to the next waypoint in a route.

ⓘ Caution! In “Off”, **no waypoint arrival alarm will be displayed.**

Typically, you would choose this option if your Navigation System has its own waypoint arrival alarm that cannot be turned off, and you do not wish to acknowledge the same alarm on multiple devices.

Correction

This parameter selects which of the three methods the autopilot will use to update the Commanded Heading when in **NAV** mode:

- “CTS” – Course To Steer
- “XTE” – Cross-Track Error
- “Both”

See **Understanding NAV Mode**, above for full details.

XTE Sense (Cross-Track Error Sense)

Cross Track Error (XTE) contains two pieces of information. First, it contains the *amount* of the error. Secondly, it gives information about the ‘sense’ of the error – that is, whether the boat is to the *left* or the *right* of the line between the beginning and ending waypoints.

The NMEA 0183 Standard specifies how the Cross-Track Error should be identified. An ‘L’ indicator in the data sentence means the boat should steer to the left, and an ‘R’ indicator meaning the opposite.

However, some manufacturers of GPS, chartplotters, and other Navigation devices & systems have taken the ‘L’ indicator to mean that the boat is to the left of the line, so the boat should steer to the right, and the ‘R’ indicator to mean the opposite.

Because of this confusion, the autopilot’s handling of XTE can be switched from “Norm” (normal) to “Rev” (reverse).

- In “Norm”, the autopilot will respond normally (i.e., in the way defined in the NMEA Standard) to the sense of the Cross-Track Error.
- In “Rev”, the autopilot will respond in the opposite way in response to the same information.

Max Correction

When activating pre-stored routes when there will be a large amount of initial Cross-Track Error, the autopilot will steer the boat at almost 90° to the Track to the first waypoint, in order to get back on-track as fast as possible.

In certain circumstances, this can appear as though the boat is actually moving away from the waypoint.

You can minimize this phenomenon by setting Max Correction to something less than 90°.

Dodge Turns

When in **AUTO** or **NAV** modes, you can use the **PORT** and/or **STARBOARD** buttons to avoid (“dodge around”) an obstacle in the water.

Pressing & maintaining either the **PORT** or **STARBOARD** button will cause the autopilot to turn the boat in that direction.

As long as one of the “direction” buttons is pressed, the rudder will keep moving in the corresponding direction.

- The autopilot will stop moving the rudder when it gets to the Auto/NAV Rudder Limits (see page 91), or when it gets within a few degrees of the physical limits of rudder travel if those limits are not set.

Once the button is released, the Autopilot will turn the boat back to the Commanded Heading, Track, or Wind Angle (depending on which operating mode is in effect).

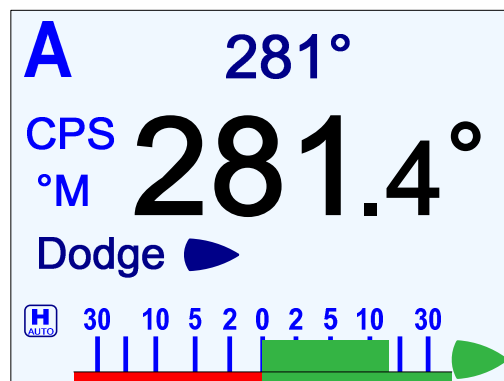


Figure 55 – A Dodge in Progress (in AUTO Mode)

- If you dodge the boat in **AUTO** mode, then when you release the **PORT** or **STARBOARD** button, the boat will return to the same Heading – but **not** the same Track. The new Track will be offset from the original Track by the distance traveled during the Dodge manoeuvre. This is illustrated below.

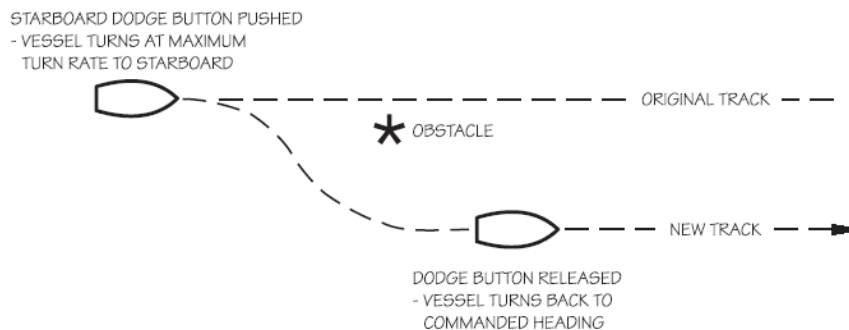


Figure 56 – Boat Track During a Dodge Manoeuvre in AUTO Mode

- In contrast, when you execute a Dodge in **NAV** mode, the autopilot **will** return the boat to the original Track, once you release the **PORT** and/or **STARBOARD** button.

- ❗ **Caution!** During a Dodge turn (i.e., while one of the **PORT** or **STARBOARD** buttons is maintained), the Autopilot will **not** limit the rate of turn of the boat.

Once the **PORT** or **STARBOARD** button is released, the autopilot will begin to turn the boat back to the Commanded Heading or Track, but this time the turn will occur at no greater than the maximum turn rate that is set in the Steering Parameters.

- ❗ **Caution!** If dodge is necessary during a special turn (see Advanced Operation sections for Special Turns), it is recommended that after the release of dodge, you stop the special turn. Dodge during a special turn may cause the vessel continuing to the turn for a 360-degree, or moving to the opposite direction depending on the circumstances.

- ❗ Special notes for a SP36 without an RFU:

Too much rapid &/or repeated side-to-side dodging can cause the autopilot to lose track of the estimated rudder position.

Also, be especially careful not to “dodge in the opposite direction” to get back on-course.

Instead, it is recommended that you always follow a dodge with a “dodge-centre” (see below), until the rudder reaches the dead-ahead position. Then release both the direction buttons, and the autopilot will perform a turn to get back onto the desired Heading. Typically, you will then be off-Track – so if you want to get back on Track, you can change Heading as required.

If you are in a situation where you do have to dodge frequently, it is better to change into **Power Steer** mode, until you are back in a situation where there will be a long period of “steady Heading”. The same is true if you are on a Track where you will have to change Heading frequently.

Dodge Centre

You can bring the rudder back to centre (Dead Ahead) part-way through a Dodge. For example, you might want to center the rudder in order to maintain, for a while, a specific Heading that the boat has reached during the dodge.

- Press the “other direction” button (**PORT** if you are dodging to Starboard, and vice-versa), without releasing the button already being pressed.
- Maintain both buttons simultaneously for as long as you wish to keep the rudder centred.

The Track that the boat follows while both buttons are pressed will typically be straight, at approximately the Heading that was current at the time the second button was pressed.

However, this can be affected by wind and waves, by the boat’s rudder speed and steering response time, and any directional offset that the boat exhibits when the rudder is centred.

- Releasing one button will re-start a Dodge in the other direction.
- Releasing both buttons will end the dodge completely, with the same mode-dependant behaviour with respect to “resuming the Track” as noted above.

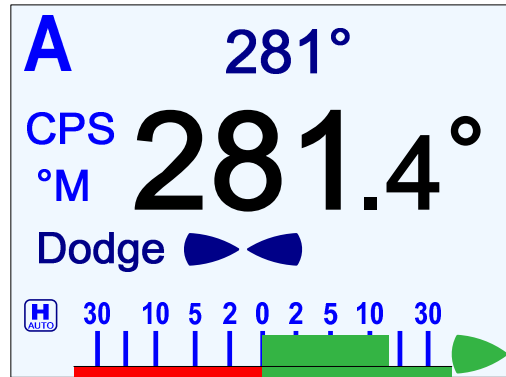


Figure 57 – Holding at a Heading Part-way Through a Dodge Turn

Jog Steering Turns

If a Jog Steering Control Lever is connected to the SPU terminal block **J3**, you can directly change the boat's heading with that Jog Control²⁰, while the autopilot is in **POWER STEER**, **AUTO**, **NAV** or **WORK** modes.

This is identical to a Dodge, except that you use a Jog Control to start and control it, and you can do it while in **POWER STEER** mode.

When the Control's lever is moved far enough to activate the internal switch, the rudder will move immediately in the requested direction (to Port or Starboard).

As long as the Jog Control is held activated, the rudder will keep moving in the corresponding direction.

- If one, or both, of the Power Steer Rudder Limits and/or the Auto/NAV Limits are set (see page 91), then the autopilot will stop moving the rudder when it gets to the smaller of the limits.
- If neither of the Rudder Limits are set, then the autopilot will stop moving the rudder when it gets within a few degrees of the physical limits of rudder travel.

When you release the Control's lever, the autopilot will return the boat:

- to the current Commanded Heading, if in **AUTO** or **WORK** mode, or in **NAV** mode with "CTS" correction
- or to the current Track to the next Waypoint, if in **NAV** mode with "XTE" or "Both" correction

ⓘ Important! You should be prepared for a change in the boat's direction when you release the Lever.

A large 'J' is displayed in the upper left corner of the Control Head's screen – temporarily replacing the current mode's indicator letter – whenever a Jog Control is activated.

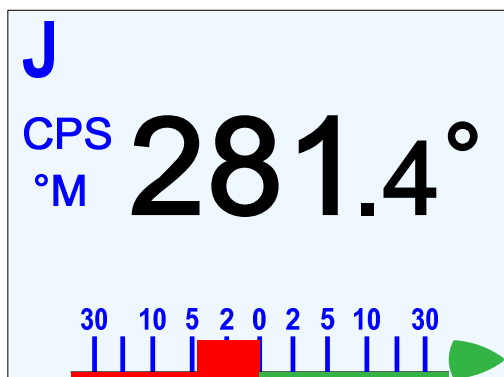


Figure 58 – Typical Jog Control Activated Screen

The Jog Controls are ignored when the autopilot is in **STANDBY** mode, and during **DOCKSIDE SETUP**.

ⓘ Caution! If dodge through JOG is necessary during a special turn in Auto mode (see Advanced Operation sections for Special Turns), it is recommended that after the release of the JOG, you stop the special turn. Dodge (by JOG) during a special turn may cause the vessel

²⁰ The autopilot system allows connecting any desired number of Jog Levers (see page 94).

continuing the turn for a 360-degree, or moving to the opposite direction depending on the circumstances.

Operating in Virtual Rudder Feedback

The SP36 was developed primarily for use on boats with Outboard motors or steerable Inboard-Outboard drives, where installing an RFU is usually very difficult.

Cautions

It is important to keep in mind that – when operating without an RFU – the SP36 can *not* sense where the rudder is positioned, *nor* if it is in motion.

It can only *estimate* the rudder's position & how far it moves while the “move rudder” signal is being output.

Note: *the word “rudder” is used in the generic sense in this section. It refers to whatever mechanism the boat uses to control its direction of travel – e.g., outboard motor(s), an I/O leg, and so on.*

Here is some background to, and some effects of, that “only an estimate” condition:

- During **Drive Setup**, you enter the rudder travel limits, and then the rudder's HO-HO travel time is measured. Together, those give the speed (degrees per second) at which the rudder moves.

Later, during normal operation when the SP36 is controlling the rudder (**POWER STEER, AUTO** or **NAV** modes), the SPU continuously re-calculates the current estimated rudder position – by multiplying the measured rudder speed & the length of time it outputs each “move rudder” signal.
- The SP36 VFRU steering algorithms also make some assumptions about the rudder position, at certain “reference points”.

For example, it is assumed that the rudder is in the Dead Ahead position when the boat is running on a straight Heading.

On most boats, in calm sea conditions, “dead ahead” is indeed where the rudder is at the “dead centre” position. But that may not be so if the boat is towing something, or in rough seas, or if there is some condition that requires the rudder to be positioned off-centre for the boat to follow a straight Track.
- There are many factors that can cause errors in the rudder position estimation:
 - ⇒ The only measurable effect of the rudder that the SP36 VFRU steering algorithms can sense is changes in the Heading of the boat²¹. But the rudder's effect on Heading varies with different boat speeds, current, tide, wind, etc.
 - ⇒ The rudder and the associated drive mechanism (hydraulic ram, electric solenoids, cable, etc.) typically respond to “move signals” from the SPU in a non-linear way. The rudder's movement may also be asymmetric – different when moving to Port than Starboard.

²¹ ... which is why a *reliable* Heading source is so vital during VFRU operation.

- The Rudder Angle Indicator (the one shown on the Control Head, and any RAI meters connected to the SPU) displays the estimated rudder angle.

Usually, when the RAI's rudder position bar is at the centre (& when the needle on an RAI meter is at the "0" mark), the SP 36 is indicating that the boat is holding a steady Heading on a straight Track.

At other times, for many possible reasons, the RAI may be showing a "rudder is off-centre" condition, even though the boat is on a straight Track. This is especially so in **AUTO** & **NAV** modes; however, the misalignment between the RAI & the rudder's actual position will be eliminated gradually, if the boat runs straight for some time.

- During autopilot-controlled steering (**POWER STEER**, **AUTO** or **NAV** modes), the rate of turn is limited to the value you enter in the **Turn Rate** parameter. This is usually well below the rate which a maximum deflection of the rudder would cause, at a normal speed. The result is that the rudder is normally always positioned well within the maximum-deflection limits, and moves more or less equally around the "centre" Dead-Ahead position.

However, if for some reason the boat will only run straight with a big offset of the rudder to one side or the other (or if there is a temporary false offset in the RAI), the arc which the rudder can move within, on the side of the offset (i.e., between that offset "Dead-Ahead" position & the maximum deflection), is reduced. Since the SP 36 VFRU steering algorithms have no way to know the size of any such offset, they can not properly assess how close the rudder is to the maximum-deflection boundary.

In such circumstances, the responsibility for keeping the rudder's movement safely within the physical limits lies solely on the operator.

This is especially true when the Dodge Turn function is used.

- ① *If you see that the rudder has a big offset while the boat is travelling Dead Ahead, or if the RAI shows a much different "rudder position" than the rudder is actually at for any length of time, it is **strongly** recommended that you put the autopilot into **STANDBY** mode.*

*Then, determine the cause of the offset or RAI misalignment, before continuing on in **POWER STEER**, **AUTO** or **NAV** modes.*

- It is vital that you can see the rudder during the **Drive Setup** procedure (or at least have a reliable way to monitor it), that you position it correctly when prompted, that you enter accurate values for the rudder travel limits, and that you carefully perform all the steps required.

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Advanced Operations

Advanced Operations

This chapter describes the advanced modes of operation & features of a SP 36 system, and shows you how to use them.

WORK Mode

WORK mode is special mode, for use under conditions that are different from normal autopilot operation; prime examples are dragging, trawling, and pair trawling. It is also useful for towing or when traveling at very slow speeds. **WORK** mode can be activated in either **AUTO** or **NAV** mode. You can even switch from **AUTO** to **NAV** mode or vice-versa, while **WORK** mode is active.

Note: *WORK mode is not available on a SP 36 without an RFU.*

Initial set up of **WORK** mode is easily accomplished. Only two parameters need to be adjusted: a Work Trip Point and the Rudder Scaling Factor. Some other parameters can be used to monitor and fine-tune the operation of **WORK** mode.

Note: *the autopilot has an automatic Off-Course Alarm that will be activated should the boat fall off the Commanded Heading by more than 20°. There is a 32 second delay on this alarm.*

Automatic WORK Mode

Although **WORK** mode can be used manually, it works best if a valid NMEA source of the boat's speed is also interfaced to the autopilot. The speed source must also be properly configured (in the Auto menu, see page 96. With a valid NMEA speed source, **WORK** mode can be engaged automatically when the boat's speed falls below the Work Trip Point, and disengaged when the boat's speed increases beyond the Work Trip Point.

To use **Automatic WORK** mode, first go into either **AUTO** or **NAV** mode. Then press and hold the **Fn** button for approximately 1 second, until a confirming beep is heard. A small letter **W** will appear beside the bigger mode-indicator letter (**A** or **N**) in the upper left portion of the LCD screen, to indicate that the **WORK** mode feature is enabled.

If the boat's speed is above the Work Trip Point, the **W** will flash slowly, about once per second, indicating that **WORK** mode is enabled – but not yet engaged. If the **W** appears continuously (not flashing), the boat speed is below the Work Trip Point, and **WORK** mode is actually engaged.

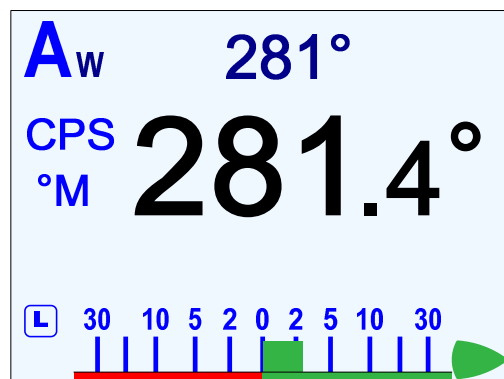


Figure 59 – Typical WORK Mode Screen (Engaged)

To disable **WORK** mode, press the **Fn** button again, for approximately 1 second, until a confirming beep is heard and the letter **W** disappears from the display. **WORK** mode can also be cancelled by switching to either **STANDBY** or **POWER STEER** mode.

When **WORK** mode is engaged, the Rudder Scale Factor changes the amount of corrective rudder movement which the steering algorithms calculate using the Rudder Gain setting. In **WORK** mode, that calculated amount (i.e., proportional to the course error) will also be multiplied by the Scale Factor, resulting in larger rudder movements for a given course error. The Rudder Scale Factor is entered on the Work menu (see page 120).

Other effects take place in **WORK** mode too.

- The corrective rudder movement calculated for Counter Rudder is reduced to the minimum possible for the Vessel type (i.e., as if the Counter Rudder parameter was set to 0), which enhances the effect of the Rudder Gain and Rudder Scale Factor.
- Turn Rate is limited to 10%/second while **WORK** is active, for all changes of Heading controlled by the autopilot, and for Special Turns.
- Particularly useful for pair trawling, the autopilot also disables the automatic course trim unless Autotrim (in the Work menu) is specifically turned on.
- Finally, the built-in off-course alarm will be disabled the entire time **WORK** mode is engaged.

If the user is not satisfied with the fixed helm bias determined by the Autopilot at the onset of **WORK** mode, manual adjustments can be made “on-the-fly” while **WORK** mode is engaged. A double-press of the **Fn** button will bring up the regular Work menu, but with an additional line. Rudder Bias will be the first line on the list, and will show the current helm bias. You can change this value to suit, using the **COURSE CHANGE** knob. This feature is useful in order to accommodate changing load or sea conditions.

As mentioned earlier, **WORK** mode will automatically be disengaged if the boat’s speed rises above the Work Trip Point set by the user. While it is disengaged, all normal features such as automatic trim and off-course alarm will be operational.

Manual WORK Mode

Even if no NMEA source of speed data is available, **WORK** mode can still be used, by manually invoking it.

To do so, switch to **AUTO** or **NAV** mode, and then press the **Fn** button for ~1 second until the letter ‘A’ or ‘N’ in the upper left portion of the display stops flashing, and a small letter ‘W’ appears beside it.

Then, double-press the **Fn** button to bring up the Work menu. Highlight “Work Mode State”. Then use the **COURSE CHANGE** knob to change the selection to “M_On” (Manual On).

WORK mode is now engaged.

Caution! When **Manual WORK** mode is engaged, large rudder movements may occur. If your boat is traveling too fast, these rudder movements may affect the stability of the boat. Do not engage **Manual WORK** mode without first ensuring that it is safe to do so and that the boat speed is appropriate for using **WORK** mode.

To disengage **WORK** mode, again select “Work Mode State” in the Work menu and change it to “A_Rdy” (Automatic Ready).

To cancel **WORK** mode completely, press and hold the **Fn** button for 1 second, or switch to **STANDBY** or **POWER STEER** mode.

- You can also manually disengage **WORK** mode, if it has been engaged in the automatic mode. Double-press the **Fn** button to bring up the Work menu. If **WORK** mode is engaged, the “Work Mode State” will show “A_On” beside it. Highlight “Work Mode State”, then use the **COURSE CHANGE** knob to change it to “M_Rdy” (Manual Ready).

Work Menu

The Work menu has all of the adjustable parameters that are involved with **WORK** mode. To access the Work menu, double-press the **Fn** button.


A_w		321°
Rudder Bias		0
Autotrim		Off
Work Trip Pt.		2
Rudder Scale		3.00
Work Mode State		A_On

Figure 60 – WORK Mode Menu

Rudder Bias

This menu line only appears when **WORK** mode is active. It shows the current rudder bias, which can be adjusted if desired.

Autotrim

The autopilot's **WORK** mode can be configured to use manual or automatic rudder bias trim when in **WORK** mode (the default is to use automatic bias).

Manual rudder bias is fixed by the position of the rudder when the autopilot first enters **WORK** mode, but can be adjusted by the user if desired (see **Rudder Bias**, above).

Automatic rudder bias is initially set to the position of the rudder when the autopilot first enters **WORK** mode, but is automatically adjusted on a continual basis thereafter to ensure that the boat remains on-course.

Work Trip Pt. (Work Trip Point)

This is the speed below which **WORK** mode can be engaged, and above which **WORK** mode will be disengaged automatically. The value can be 1 to 10, and is in the units that the **Speed Source** (see the Auto menu) is using.

Rudder Scale (Rudder Scale Factor)

When **WORK** mode is engaged, the Rudder Scale Factor" will multiply the Rudder Gain setting in the Auto menu. Normally, the rudder is moved an amount proportional to the course error detected (i.e., the error times the Rudder Gain, and using some constants which depend on boat type), but in **WORK** mode that amount will also be multiplied by the Scale Factor. This will always result in larger rudder movements for a given course error

Work Mode State

This parameter shows the current status of **WORK** mode. It is also a means to force **WORK** mode to be active or not. Normally, **WORK** mode is engaged or disengaged depending on the speed of the boat as given by a Navigation System. In cases where this information is not available, **WORK** mode can still be made to function by forcing it on.

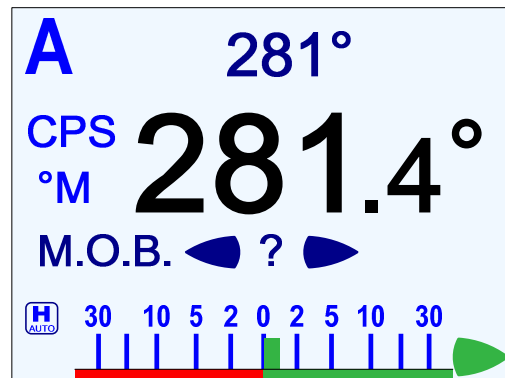
The states shown are "Off", "A_On" and "A_Rdy" (abbreviations for Automatic On & Automatic Ready, respectively), or "M_On" and "M_Rdy" (Manual On & Manual Ready).

Special Turns

There are a number of Special Turns pre-programmed into the system.

To execute a Special Turn (with the autopilot in the appropriate mode):

- 1) Press the **TURN** button. The default special turn will be displayed, along with a query for a direction.



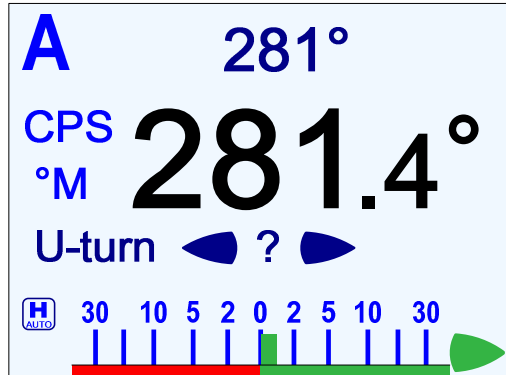
Typical Special Turn Query

- 2) If a different special turn other than the default shown is desired, press the **TURN** button again. The next special turn in the available list will be shown. Press the **TURN** button again and again until the desired special turn is shown.
- 3) Press & hold either the **PORT** or **STARBOARD** button to select the direction in which to execute the Special Turn.

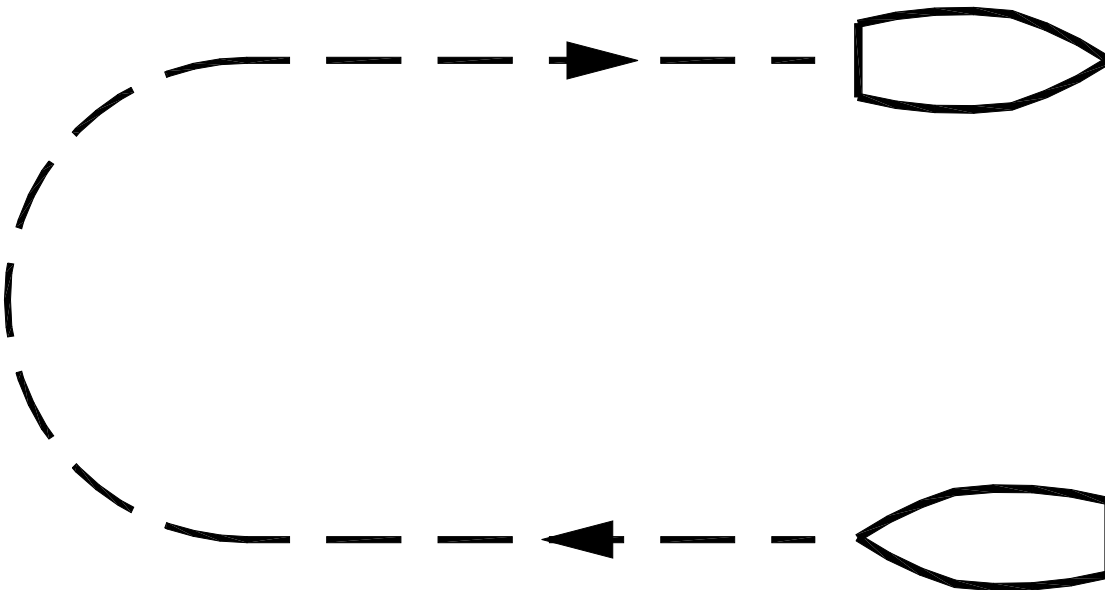
The default Special Turn can be changed as desired by adjusting the “Default Turn” in the Standby menu.

Special Turns can be aborted by pressing the **TURN** button again while the Special Turn is executing, or by changing modes.

U-Turn



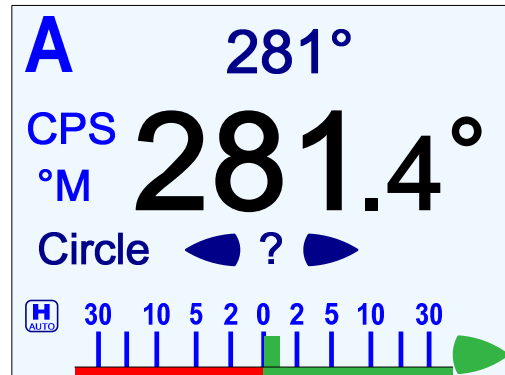
U-Turn Query



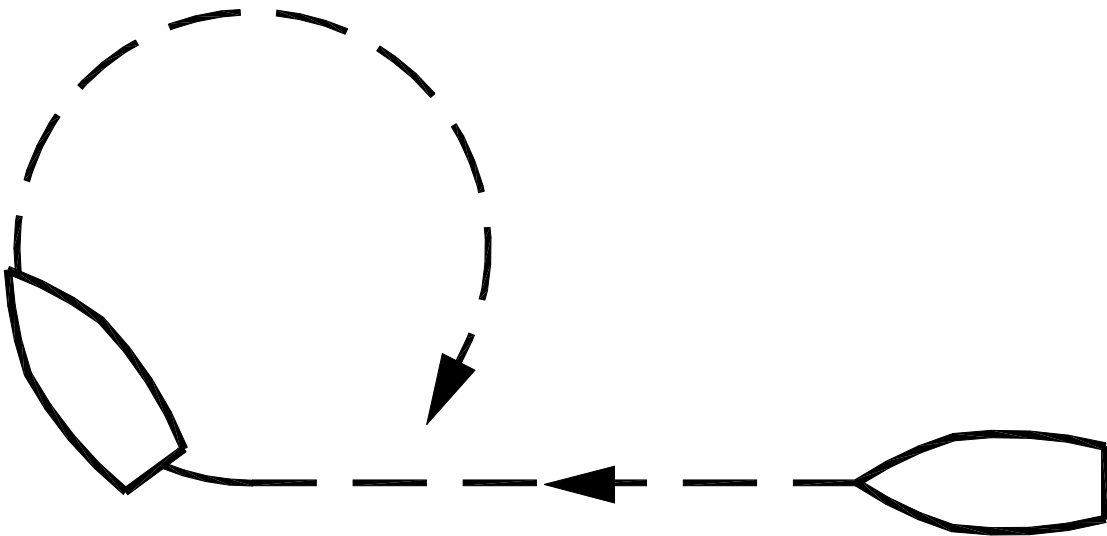
U-Turn Boat Path

The autopilot calculates a reciprocal course to the boat's heading, and then turns the boat to that heading, in the appropriate direction, once the **PORT** or **STARBOARD** button is pressed.

Circle Turn



Circle Turn Query

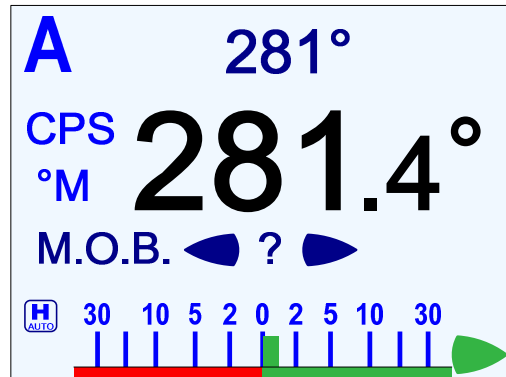


Circle Turn Boat Path

The autopilot steers a never-ending circle in the appropriate direction once the **PORT** or **STARBOARD** button is pressed. The Turn Rate setting in the Auto menu governs the rate of turn.

To stop the circle, press the **TURN** button again, or switch modes.

M.O.B. – Man Over-Board



M.O.B. Turn Query

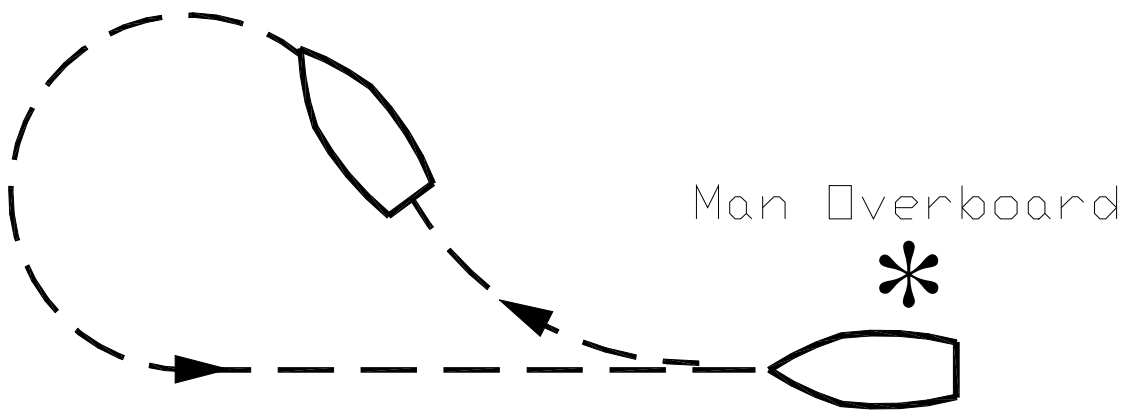


Figure 61 – M.O.B. Turn Boat Path

The autopilot will perform a Williamson Man-Overboard turn, sometimes known as an Emergency or E-turn. This will bring the boat onto a reciprocal heading; typically right down the boat's own wake. The **PORT** or **STARBOARD** buttons are used to determine the initial turning direction.

For best accuracy, do not adjust boat speed once this turn has been initiated.

Multiple Control Heads & Auxiliary Controllers

Two additional Control Heads or Auxiliary Controllers may be added to the standard system. These may be any combination of Control Heads, CR-203 Handheld Remotes, and TS-203 Fixed Remotes.

Only one Control Head or Auxiliary Controller may be *In-command* at any given time. When the autopilot system is first powered on, the main Control Head (connected to J11 of the SPU), will always be In-command.

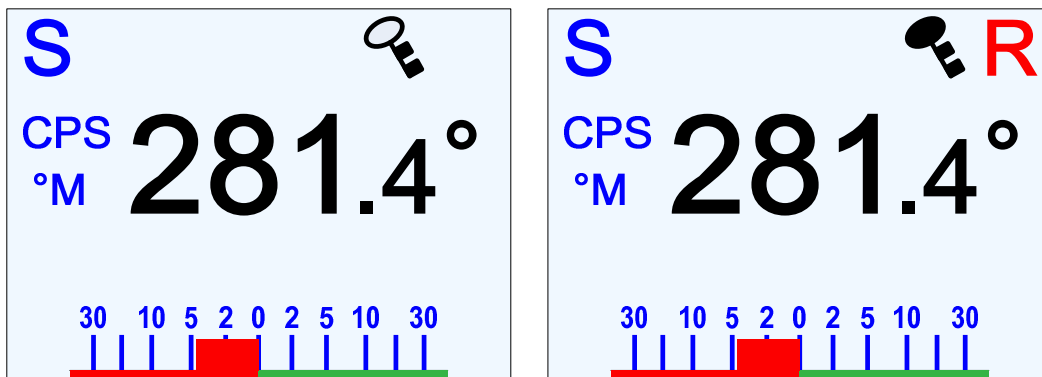
The other Control Heads and/or Auxiliary Controllers are said to be Repeaters. As a Repeater, the unit simply repeats the display information from the In-command unit, but does not affect the operation of the autopilot. You can always tell whether a particular unit is a Repeater, because it will display a large letter `R` in the upper right corner of the display.

Command can be transferred from an In-command unit to a Repeater. To do so, press and hold the **PORT** and **STARBOARD** buttons on the Repeater until the audible alarm beeps and the `R` disappears. The Repeater now becomes the In-command unit, and the previous unit becomes a Repeater.

Station Lock/Unlock

Setting the Station Lock parameter in the Standby menu to Lock prevents any of the Repeaters from being able to take command.

When the parameter is set to Lock, a key icon will be shown in the upper right corner of the display (to the left of the `R` on Repeaters).



Station Lock Icon on In-Command (left) and Repeater Auxiliary Control Head (right)

The key icon will either be outlined or filled-in. The unit In-command will display an outlined key icon. Repeater units, except for the main Control head, will display a filled-in key icon, indicating that they are locked out and so cannot take command.

The main Control Head always shows the outlined key icon, even when it is a Repeater, because you can always take command back with the main Control head. The ability to take command unconditionally at the main Control head is an important safety feature.

Important! *If your system is equipped with Jog Steering Controls, you must be aware that they can be activated any time the autopilot is turned on. They can not be locked out. Ensure that appropriate measures are taken to ensure that they cannot be activated by accident.*

Watch Alarm & External Alarm

The Watch Alarm is a special timer that is built into the autopilot.

It measures how long it has been since any of the buttons on the Control Head have been pressed. If the time exceeds the amount set for the Watch Alarm parameter in the Standby menu, an alarm is set off, to alert the helmsman & crew.

The External Alarm output from the SPU is meant to be used to drive some type of audible or visual indicator outside the SPU – a buzzer or horn, a red light, etc. – when the SPU detects an error condition that boat's helmsman &/or crew should be alerted about.

Configuring the Watch Alarm

There are two ways that the Watch Alarm feature can be configured:

- 1) When the Watch Alarm's timer expires, an alarm message will appear on the Control Head, and the audible alarms on the Control Head & in the SPU will turn on.

To use the Watch Alarm this way, the Alarm O/P parameter in the Dockside Setup menu (see below) must be set to "none", "Sw'd B+" & "all", or "Sw'd B-" & "all".


- 2) The Watch Alarm operates exactly in the same manner as above, but in addition, if the alarm is not reset (by pressing the **Fn** button) within 30 seconds, an external alarm connected to the SPU will be activated. The external alarm can be used to alert the whole ship's crew that the helm may be unattended.

To use the Watch Alarm this way, the Alarm O/P parameter in the Dockside Setup menu must be set to "Sw'd B+" and "Watch", or "Sw'd B-" and "Watch". You must also have a compatible external alarm connected. See **External Alarm Output** on page 48 for more details.

Configuring the External Alarm

The value of the Alarm Output parameter in the Dockside Setup menu controls which outputs from the **J2 – DRIVE OUTPUTS** connector will be used to activate the external alarm.

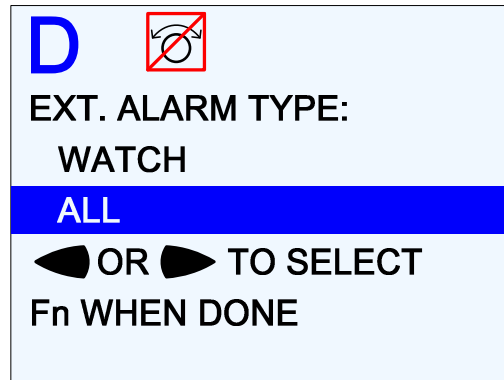
- 1) In Dockside Setup, highlight the "Alarm O/P" menu line, and use the **COURSE CHANGE** knob to select the Alarm O/P that you want to use.

D	
An. Comp Type	Mag
Compass Setup	Fn
Drive Setup	Fn
Exit	Fn
Alarm O/P	Sw'd B-

External Alarm Configuration

- When set to "None", the external Alarm Output is deactivated.
- When Set to "Sw'd B-", the Switched B- output on **J2** will be used to activate the External Alarm.
- When Set to "Sw'd B+", the Switched B+ output on J2 will be used to activate the External Alarm.

- 2) Press the **Fn** button. A new screen will appear. This is where you choose whether you want to activate the External Alarm Output for all alarms and error messages, or just when the Watch Alarm has not been answered.



External Alarm Type Configuration

Note: *the autopilot will not allow you to change the Alarm O/P without choosing either "Watch" or "All".*

- 3) Press the **Fn** button to get back to the Dockside Setup menu. You can now move the highlight to a different parameter.

Using the Watch Alarm

Once the Watch Alarm occurs, it can only be reset by pressing the **Fn** button.

The Watch Alarm timer is controlled by the Watch Alarm parameter in the Standby menu. The value may be adjusted from "OFF" (Watch Alarm completely inactive) to 30 minutes, in 1-minute increments.

The Watch Alarm parameter is password protected. The autopilot will not allow you to change the Watch Alarm timer without first correctly entering a password.

There are a few key points to remember about passwords:

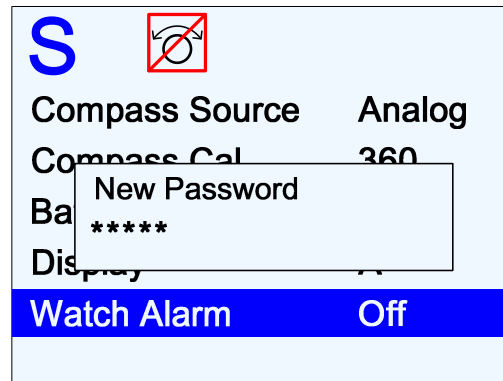
- 1) For safety reasons, only authorized personnel should be allowed to know or change the Watch Alarm password.
- 2) The password consists of a button sequence entered on the Control Head, from 0 to 10 button presses in length. We recommend choosing a password with at least a 5-button sequence.
- 3) All of the buttons, except the **STANDBY** button, may be used for the password sequence, and a button may be used more than once in the sequence.
- 4) The **STANDBY** button is reserved to signify the end of the sequence (like the ENTER key on a computer).
- 5) The autopilot is shipped from the factory with a null password – just press the **STANDBY** button when prompted for the password.
- 6) Once you have created a password, test it out – to be sure it works. Then write it down on a piece of paper or in a log book, and store the paper/logbook somewhere safe – in case you forget the password!

Changing the Password

As mentioned above, the autopilot is shipped from the factory with a null password – which means that you would simply push the **STANDBY** button, when prompted by the “Password?” query in the box that pops up when you try to change the Watch Alarm Timer (see next page). To prevent unauthorized personnel from tampering with the Watch Alarm, it is recommended that you change the password from the default null password.

You may also wish to change the password on a regular basis, for security reasons.

To change the password, enter the old password when prompted, but instead of pressing the **STANDBY** button to enter/confirm the password, press the **Fn** button at the same time as you press the **STANDBY** button. The autopilot will respond with a “New Password?” query:



New Password Pop-Up Window

Now enter a new button sequence, finishing with the **STANDBY** button. Once the **STANDBY** button has been pushed, the autopilot will store the new password sequence in its memory and the pop-up window will disappear.

Important! *Be sure to record the new password sequence in a secure place, in case it is forgotten!*

The password can be changed as often as desired.

- When you are entering a password – either when changing it, or to change the Watch Alarm timer – there is no way to do a “backspace” or “delete”, if you happen to press a wrong button. But you can just press the **STANDBY** button, which will result in a “Password Error” message; you can then enter the correct password.
- If you have forgotten the password, *and* can not find the piece of paper you wrote it down on (... the “safe place” was *too* safe ...), you can reset it back to the factory default null password, as follows:

⇒ In Dockside Setup, move to the Reset menu line, then press & hold the **STANDBY** button, and then press & hold the **Fn** button, then release both.

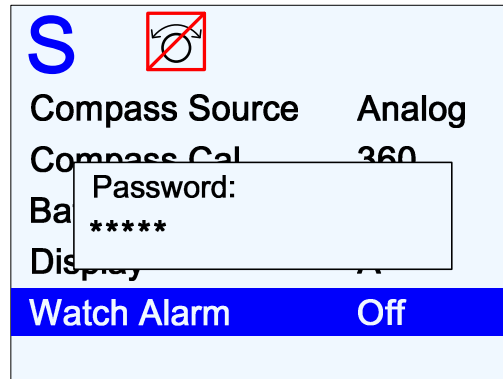
Unlike the full “factory reset” that the Reset menu line is usually used for (and *only* when absolutely necessary – see below & page 59!), the **STANDBY & Fn** combination resets only the Watch password.

ⓘ *Be careful not to press the **Fn** button first!*

If you do that, you will reset everything in the autopilot back to the factory defaults – which means that you will have to re-do Compass & Drive Setup, and again change any parameters you have adjusted (Rudder Gain, etc.) from the factory defaults, during Sea Trials & normal operation.

Entering the Password

When you attempt to change the Watch Alarm timer, (highlight “Watch Alarm” in the Standby menu, then turn the COURSE KNOB in either direction), the Control Head responds by showing a special pop-up box on the LCD screen with the query “Password?”



Password Query Pop-Up Window

Now enter the password by pressing each button in the sequence. An asterisk (*) will appear on the screen as each button is pressed.

Complete the sequence by pressing the **STANDBY** button.

If the sequence is correctly entered, the pop-up box will disappear, and you will be able to use the COURSE KNOB to change the value of the Watch Alarm timer.

If the sequence was not correctly entered, “Password Error” is displayed. Try entering the password sequence – correctly! – again.

- The pop-up box will remain until the correct password sequence is entered, or the Standby menu times out, or you exit it with a double-press of the **STANDBY** button, or you press and hold the **STANDBY** button to shut the autopilot off.

Care & Maintenance

Care & Maintenance

The SP 36 Autopilot Systems have been designed to provide many years of reliable service. Periodic care and maintenance will help to ensure the longevity of your autopilot.

Cleaning and Appearance

Both the Control Head and SPU should be carefully cleaned with a damp cloth and mild soap. This is particularly important for the LCD screen overlay.

 *Do not use abrasive cleaners or chemicals.*

The Control Head is designed to be weatherproof and splash resistant, but it should not be immersed in water for a prolonged period of time.

Environments exceeding a maximum temperature of 140° F (60° C) or below a minimum temperature of 5° F (-15° C) **MUST BE AVOIDED.**

Exposure to prolonged direct sunlight should be avoided in order to prevent damage to the electronics and housing, and UV-induced fading of the LCD.

Periodic Checks

After the first six months of operation a thorough examination of the entire Autopilot system **MUST BE UNDERTAKEN.**

Electrical & Mechanical Checks

All electrical connections, cables, clamps, mounting brackets, and mechanical connections (e.g., the Rudder Follower Unit's connection to the rudder post) must still be secure.

An ANNUAL inspection should be undertaken thereafter.

Hydraulic Checks

It is unfortunate – but true – that *no hydraulic system is always trouble-free!* Hydraulic oil under even mild pressure can find its way through any weak spot – often holes too small to see with the naked eye.

And so, regular inspection & maintenance is *always* needed.

In particular, all hydraulic pumps, hoses, fittings & joints must be regularly inspected for leakage, cracks or loose mounting, and for correct tightness of all the fittings & joints.

A very good, yet easy, test for leaks is to check the oil level at the reservoir (or the highest helm pump in your steering system). If the level constantly goes down, there are quite probably some leaks in the system; the most likely culprits are the hoses, joints & fittings.

Manual Steering Operation

The most basic check is to see if your manual steering system is working. Be sure to test it at each steering station on the boat, one at a time.

- 1) Check that when turning the helm to Starboard, the rudder actually moves so as to turn the boat to Starboard.
- 2) Check that when the helm is turned to Port, the rudder moves to turn the boat to Port.

Air Trapped in the Hydraulic System

Following the initial installation and bleeding of a hydraulic pump – or after repairing a leaking hose/fitting/etc. – some residual air may remain suspended in the hydraulic oil.

During the first few weeks after installation or repair, this air will gradually bleed out through the header tank or the highest helm pump, and as a result the hydraulic fluid level may go down. Check the fluid level several times during this period, and add more oil as required.

Fuse Replacement

There are two fuses used on the SPU.

Replace fuses only with the same type and rating, as per the table below.

ⓘ Should a fuse blow, determine the cause before replacing!

To replace a fuse, the clear plastic cover over the SPU's Diagnostic section must be removed. To do so, gently pry up the center portion of the plastic rivets which fasten the cover to the SPU's case; be careful not to lose any of the plastic pieces.

After the fuse(s) are replaced, the cover must be re-installed, and remain in place during normal operation.

Designator	SI-TEX Part Number	Generic Description <i>Manufacturer(s) & Part Number(s)</i>
F1	60810012	3.15 A Medium Time Delay, 125V or better, 5 x 20mm (DIN 41571, IEC 127)) <ul style="list-style-type: none"> <i>Bussman GMC 3.15A</i>
F2	60810009	20A, Non-Time Delay, 125V, 1/4" x 1-1/4" <ul style="list-style-type: none"> <i>Bussman ABC-20</i>

Table 8 – Fuse Replacement Guide

Appendices

Appendix 1

Interfacing to a PC

The SPU can be connected to a desktop or laptop Personal Computer, for Navigation control & monitoring purposes, using the **J9 – NAV I/O** connector (see **Navigation Data** on page 51).

The PC would typically be running a Navigation program (e.g., programs from Fugawi™, Jeppesen®/Nobeltec®, Rose Point Navigation, or similar), and/or Hyperterminal® or some other “dumb terminal” program.

For best results, connections to a PC should be done with a suitable RS-422 electrical interface. The interface can be either on a dedicated add-in board, or via an external convertor box; typically, the latter convert between RS-422 and either RS-232, or to USB, so that the signals may be connected to the PC’s standard serial “COM” or USB ports (see the next section for more details on using these types of PC ports).

Various brands of RS-422 interface boards and convertor boxes are available; contact your SI-TEX Dealer for details.

PC COM Ports

It is also sometimes possible to wire the standard serial I/O ports on a PC directly to the SPU’s **J9 – NAV I/O** connector.

These PC serial ports – commonly referred to as “COM ports” – always use RS-232 signal levels.

Connecting a PC’s COM port directly to **J9** mixes the RS-232 electrical levels of the COM port with the RS-422 levels of the SPU’s NMEA 0183 NAV port. In general, doing this is not recommended – but it does work well in many cases. However, it should be noted that there is some risk of increased electrical noise in the autopilot–PC system, due to the use of the COM port’s Signal Ground as the ‘B’ signal – which may create a partial “ground antenna” effect in the system wiring.

***Note:** should you encounter any problems, RS-422 ⇔ RS-232 convertors are available – or, even better, RS-422 ⇔ USB convertors. Contact your SI-TEX Dealer for details.*

PC COM ports typically use a DE9²² male (a “pin type”, aka DE9-P) connector; older PCs (especially desktops) may use a DB25 (aka DB25-P) connector instead.

- Laptop PCs usually have only one COM port.
- Desktop PCs sometimes have 2 (or more) COM ports, although newer models usually only have one COM port. It is possible to add COM ports to most desktop PCs, by adding a suitable “COM Port Expander” card.
- Many newer PCs – desktops & especially laptops – do not have a real “COM port”. Instead, they only have one or more USB ports.

For such PCs, an external convertor (a USB “COM Port”, aka “USB Serial Adapter”) will be required. These convertors typically have a USB “A size” plug at one end, and a DE9 male connector at the other end. They come with driver software to allow application programs to access the USB ports as “virtual COM ports”

Most brands of these convertors should work fine. A number of different ones have been tried at SI-TEX, all with success.

²² These connectors are often referred to as “DB9”, but that is technically incorrect. The letters “B” & “E” designate the shell sizes; a B shell is much bigger than an E shell – it can hold up to 25 pins, compared to 9 or 15 pins in an E shell.

DE9 Connection

To connect to a PC serial port (or to the DE9-P end of a USB-to-Serial adapter), connect the wires from **J9** to a DE9 female connector (a “socket type”, aka DE9-S) as follows:

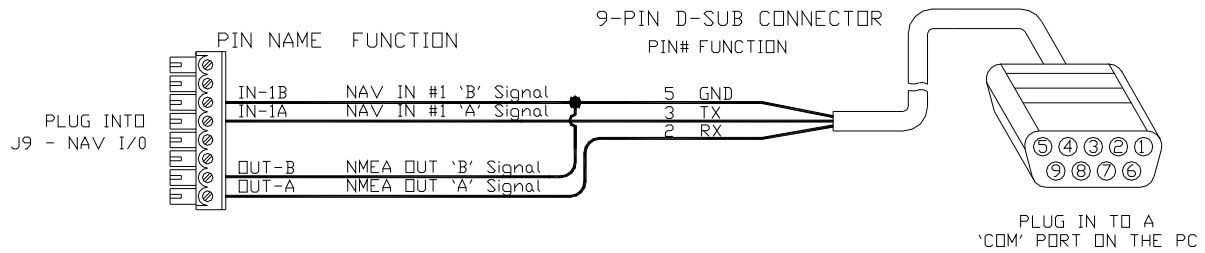


Figure 62 – Connection to a PC with a DE9-S Connector

DB25 Connection

If the PC has a DB25 COM port connector, connect the wires from **J9** to a DB25 female connector (aka DB25-S) as follows:

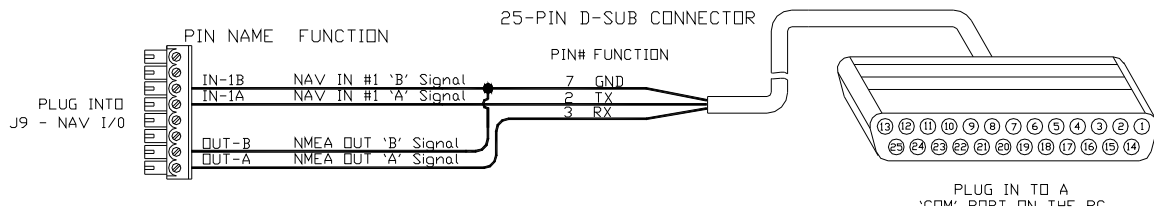


Figure 63 – Connection to a PC with a DB25-S Connector

Note: none of the other RS-232 signals that are normally available on PC COM ports (& sometimes used by the ports &/or equipment connected to them), such as the “status” & “flow control” signals (RTS, CTS, DSR, DCD, etc.), can be connected to the SPU.

You must also set the COM port's Baud Rate to 4800, and the serial format to 8 data bits, no parity, one Stop bit.

Please also keep in mind the data bandwidth considerations discussed in **Bandwidth of an NMEA Compass Connection** on page 68.

D Connector Pinouts

The figure below shows the pin-numbering scheme for a PC COM port's DE9 & DB25 connectors. This figure can be looked at in two ways:

- It is the view from the outside of the PC, looking at the pins of the male connector (DE9-P or DB25-P) in the PC, typically located somewhere on the back panel of the PC.
- It is also the view of matching female connector (aka a "socket type" – a DE9-S or a DB25-S) when looking at the *back* – i.e., wire side – of that connector, on the cable that plugs into the PC's male connector.

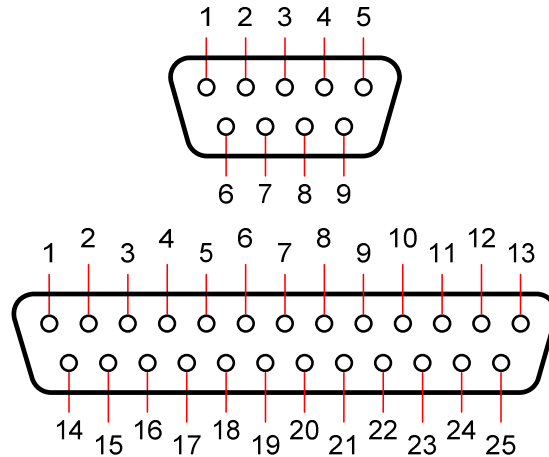


Figure 64 – DE9 & DB25 Pin Numbering

Note: older PCs may have another DB25 connector – but it is a female type (DB25-S), and is the Parallel Printer (aka "LPT") port.

Appendix 2

NMEA 0183 Sentences Accepted and Transmitted by the Autopilot

Autopilot Systems receive and transmit serial data in NMEA 0183 format, in compliance with Version 3.00 of the NMEA Standard.

Sentences Accepted

The autopilot accepts the following NMEA 0183 sentences, from NMEA *Talkers*:

Sentence	Description	Data Used
*APA	Autopilot Sentence "A"	Cross-Track Error, Arrival Status, Bearing from Origin to Destination, Waypoint ID
*APB	Autopilot Sentence "B"	Cross-Track Error, Bearing from Origin to Destination, Waypoint ID, Course to Steer
*BOD	Bearing – Origin to Destination	Bearing from Origin to Destination, Waypoint ID
*BWC	Bearing & Distance to Waypoint	Range to Destination
*GLL	Geographic Position (Latitude & Longitude)	Latitude, Longitude
*HDG	Heading, Deviation & Variation	Magnetic Heading, Magnetic Variation
*HDM	Heading, Magnetic	Magnetic Heading
*HDT	Heading, True	True Heading
*HSC	Heading Steering Command	Course to Steer
*RMA	Recommended Minimum Specific Loran-C Data	Speed
*RMB	Recommended Minimum Navigation Information	Cross-Track Error, Waypoint ID, Range to Destination, Bearing from Origin to Destination, Arrival Status
*RMC	Recommended Minimum Specific GNSS Data	Speed, Magnetic Variation
*VBW	Dual Ground / Water Speed	Speed
*VHW	Water Speed & Heading	Speed
*VTG	Course Over Ground & Speed	Speed
*XTE	Cross-Track Error	Cross-Track Error

Table 9 – NMEA 0183 Sentences Accepted by the SP 36

- The ``*` in front of the sentences indicates that the Talker Identifier is always ignored.
- All sentences can have checksums, or not. Sentences which have invalid checksums will be ignored.

Sentence & Data Priority

A number of the various data values used by the autopilot can be received in one or more different sentences. For example, Boat Speed can be received in VTG, VHW, VBW, RMA or RMC.

If a particular data value is received in more than one sentence, then the value in the highest-priority sentence will be the one used by the autopilot.

- An item of data will be taken from the sentence without a checksum only if the data is not found in any sentences with a valid checksum – even if the no-checksum sentence is of higher priority, per the table below – than the with-checksum sentence(s).
- In some cases, if the invalid-checksum condition persists long enough, an INVALID CRS DATA, SPEED DATA, &/or HEADING error will occur (see page 153).

It is also worth noting that the names of some sentences reflect the data (or else just the “main data”) in that sentence. For example, the BOD sentence contains “Bearing Origin to Destination” data.

But that does not always mean that those “named” sentences are the only source for that data – for example, BOD data could also come from the APB sentence.

Sentence Priority <i>(higher to lower)</i>	Sentence	Data Used
4	*GLL	Latitude & Longitude
5	*RMC	Latitude & Longitude, Boat Speed, Magnetic Variation
6	*RMA	Latitude & Longitude, Boat Speed ③
7	*APB	Cross-Track Error, Arrival Circle Entered, Bearing Origin to Destination Magnetic or True, Waypoint ID, Bearing Present to Destination Magnetic or True, Heading to Steer Magnetic or True
8	*RMB	Cross-Track Error, Waypoint ID, Range , Bearing Present to Destination True, Arrival Circle Entered or Perpendicular Passed at Waypoint
9	*HSC	Heading to Steer Magnetic and True ②
10	*APA	Cross-Track Error, Arrival Circle Entered, Perpendicular Passed at Waypoint, Bearing Origin to Destination Magnetic, Waypoint ID
11	*XTE	Cross-Track Error

Sentence Priority (higher to lower)	Sentence	Data Used
12	*BOD	Bearing Origin to Destination Magnetic & True, ② Waypoint ID
13	*VBW	Boat Speed ③
14	*VHW	Boat Speed ③
15	*VTG	Boat Speed ③
16	*BWC	Bearing Present to Destination Magnetic & True, ② Distance to Waypoint Nautical Miles, Waypoint ID (Bearing & Distance are on a Great Circle)
17	*HDG	Magnetic Heading, Magnetic Variation ④
18	*HDT	True Heading
19	*HDM	Magnetic Heading

Table 10 - NMEA Sentence Priority

- ① The different units of Wind Speed (Knots, m/s & Km/H) present in these sentences are all used in Wind calculations by the autopilot.
- ② Magnetic Variation (for setting a Course, but not for Heading) is calculated from the True & Magnetic values in these sentences.
- ③ The units of Boat Speed (Knots & Km/H) are present in these sentences, but do not matter to the autopilot, since all displays & functions related to Boat Speed are used without units.

If both Knots & Km/H values are present in the sentence (in the case of VTG, VHW, VBW only, since the speed values in RMA & RMC are always in Knots), the Knots value is used.

If the VBW sentence is being used, the Longitudinal Water Speed value (in Knots) from it is used for Boat Speed.

The Speed values in RMA, RMC & VTG are Speed Over Ground; the others are relative to the water.

- ④ Magnetic Variation from this sentence is used only for Heading, not for Course.

Note: the VWR, VWT, APA & HDM sentences are classified as “not recommended for new designs” in NMEA 0183 Version 3.00. However, they have been included in the “accepted” list to allow use with existing equipment that might still use them.

Sentences Transmitted

Heading & Status

In normal operation, the SPU outputs NMEA 0183 formatted data at 4800 Baud, on the **OUT A & B** pins of the SPU's **J9 – NAV I/O** connector. This data may be used by NMEA 0183 Listeners, or may be used to observe & record the autopilot's operational data for diagnostic purposes, while the system is running.

The sentences output by the SP 36 are:

- HDG (Heading, Deviation & Variation) – output 9 times per second.
- HDM (Heading, Magnetic) or HDT (Heading, True) – output 9 times per second.
Which one is being put out depends on the type (Magnetic or True) that the autopilot is currently using for the source of Heading. If the source is NAV1 or NAV2, it also depends on the setting of the NMEA Heading Type parameter.
- HTD (Heading/Track Control), or PCMNS (SI-TEX-proprietary Status sentence, see below) – output once per second.
HTD is output for all Vessel Types, except sailboats; PCMS is output for sailboats only.
- The Talker Identifier is AP, in all cases.
- All sentences have valid checksums.

Heading Output

Here is one second of typical Heading output, on a SP36 system equipped with an RFU.

The boat's current Heading is ~347° Magnetic, from an Analog compass.

```
$APHDG,346.5,,,,*5C
$APHDM,346.5,M*37
$APHDG,346.6,,,,*5F
$APHDM,346.6,M*34
$APHDG,347,,,,*46
$APHDM,347,M*2D
$APHDG,347.1,,,,*59
$APHDM,347.1,M*32
$APHDG,346.7,,,,*5E
$APHDM,346.7,M*35
$APHDG,346.9,,,,*50
$APHDM,346.9,M*3B
$APHDG,347,,,,*46
$APHDM,347,M*2D
$APHDG,346.7,,,,*5E
$APHDM,346.7,M*35
$APHDG,346.9,,,,*50
$APHDM,346.9,M*3B
```

Status Output

PCMNS is an NMEA “proprietary” sentence – i.e., a sentence that can be output only by SI-TEX equipment²³. It carries “autopilot status” information, as follows:

Field #	1				2	3	4	5	6	7	8	9	10	11	
	a	b	c	d										e	f
<i>Example</i>	\$	P	CMN	S,	AP,	347,	346.1,	M,	0.6,	0.3,	347,	W,	L	*	03

The fields in this sentence are as follows (fields 1 – 10 are separated by commas, as shown):

- 1) The sentence lead-in:
 - a) \$ is the symbol that starts all NMEA 0183 Proprietary sentences
 - b) P identifies a proprietary sentence
 - c) CMN is the Manufacturer Mnemonic
 - d) S identifies this as a status sentence
- 2) Mode: SB ⇒ **STANDBY** mode, PS ⇒ **POWER STEER** mode, AP ⇒ **AUTO** mode, NA ⇒ **NAV** mode
- 3) Commanded Heading or Wind Angle, in degrees: 347°
- 4) Actual Heading or Wind Angle, in degrees: 346.1°
- 5) Type of Heading (M ⇒ Magnetic, T ⇒ True) or Type of Wind Angle (A ⇒ Apparent, T ⇒ True)
- 6) Commanded Rudder Angle: 0.6°
- 7) Actual Rudder Angle: 0.3°
- 8) ALC-corrected Heading: 347° (field is blank if ALC is not active)
- 9) L indicates that ALC is active (field is blank if ALC is not active, or if **WIND** mode is active)
- 10) Checksum:
 - e) * is the checksum delimiter
 - f) Checksum, as per NMEA 0183 Standard

Here are some examples of typical PCMNS outputs, on the same SP 36 system as above.

- In **AUTO** mode, with ALC on, & a Commanded Heading of 347°:
\$PCMNS,AP,347,346.7,M,5.1,0.3,347,,L*50

When the autopilot powers up, a “start up” variant of PCMNS is output (& repeated several times), showing the version number & timestamp of the SPU firmware:

```
$PCMNS,ST,VS_SPU 1.00 Aug 27/2009 11:41:11*42
```

When the autopilot is powered up in Dockside Setup, another variant of PCMNS is output, & repeated until Dockside Setup is exited:

```
$PCMNS,FS,,,M,0,0.3,,,*2A
```

Configuration Save & Restore

You can save most of the autopilot’s system configuration on an external device – typically a PC running HyperTerminal, set to “capture text to file”. This is done with PCMNC proprietary sentences transmitted on the **OUT A & B** pins of the SPU’s **J9 – NAV I/O** connector.

These sentences can also be sent back to the autopilot (via **J9**, on the **In 1A & B** pins) from a PC, using HyperTerminal’s “send text file” function. This allows the configuration to be

²³ ... in theory ... or at least by equipment which conforms to the NMEA Standard!

“restored” at any time you want to – for example, if a brand new system is installed for any reason, or if you want to have different configurations for different usage of the boat.

- Not all of the configuration can be restored. For safety reasons, the configuration of the drive system can not be restored – so you will have to repeat the **Drive Setup** procedure.

As well, the file stored on the PC is a plain ASCII text file, and so can be edited with any “plain text” editor, if you wish to change anything in the autopilot’s configuration &/or parameters. The full set of configuration sentences is listed in the following table.

The Configuration line in the Dockside Setup menu is how you use the Save/Restore Configuration feature:

- Idle is the default value – no transfer in either direction.
- Rx begins the Restore process. Then, when you press the **Fn** button, a script will guide you through the steps of sending SI-TEX configuration sentences to the SPU.
- Tx begins the Save process. When you then press the **Fn** button, output of the configuration sentences will begin.
 - ⇒ A Save can also be initiated from the PC: send a PCMNS with a “START” ID to the SPU, when Configuration is Idle.
- See **Appendix 1** for details on wiring, Baud rates, etc.

All PCMNC sentences are structured in accordance with the NMEA standard format:

- \$PCMNC,id,field,data,field,data,...*<Checksum>

Each sentence starts with \$PCMNC, followed by the sentence’s ID, then the associated field names & data values, and then an NMEA checksum; commas separate the ID, fields & values, and the checksum.

All the sentences in the table below are output during a Save sequence, with all fields (in the order listed) and data values. Note that some fields are in pairs – shown as Field 1 & 2 below; if there’s only one field for a particular item, then Field 2 is shown as “–”. The table lists all possible values for each field; numerical field values are shown as the range of allowable values, or as “x” or “x.y”, with the implicit units of the value in parentheses where applicable.

In a Restore sequence, the sentences, and their fields & data, can be input in any order; sentences &/or fields can be skipped, if desired.

Here is an example of a PCMNC “save” output,

```
$PCMNC,CMPS,NV2,0,0,0,0,NAV,DONE*31
$PCMNC,CMPS,NV1,0,0,0,0,NAV,DONE*32
$PCMNC,CMPS,DIG,25,1702,1785,7853,7848,FIX,DONE*6D
$PCMNC,SYS,VER,1.00,2,VSL,STRN,AOP,NONE,TYP,NONE*17
$PCMNC,USR,HS,DIG,TN,1,WT,0,ZG,60*79
$PCMNC,AUTO,LP,8,3,A,8,HP,5,3,A,5*74
$PCMNC,AUTO,TC,2,PD,0,SP,10,*5F
$PCMNC,NAV,NAV1,LMT,0.25,MAX,60,AUTO,BOTH,DIR,N*73
$PCMNC,END*
```

ID	Field 1	Field 2	Description	Notes
CMPS	NON, ANA, DIG, NV1, NV2, NM1, NM2	–	Compass Source	Required

ID	Field 1	Field 2	Description	Notes
	x.y (degrees)	–	Offset of the selected Compass Source	Required <i>This & the next 5 fields must follow the source field in the same order listed here.</i>
	0 – 255	–	Compass sine gain	Required
	0 – 255	–	Compass cosine gain	“
	0 – 255	–	Compass sine offset	“
	0 – 255	–	Compass cosine offset	“
	NONE, NAV	–	Compass Type	“
	NONE, DONE	–	Compass compensation status	Optional
SYS	VER	x.yy	Version number	Output only
	x	–	SPU Model	2 = SP 36 or SP 36, 3 = P3
	VSL	DSPL, SEMI, PLAN, STRN, SAIL, LRGB	Vessel Type	LRGB is only valid for P3
	AOP	NONE, SWB+, SWB-	External alarm setting	
	EXT	WATCH, ALL	External alarm type	Not present if AOP = NONE
	TYP	NONE, ONOFF, PROP	Thruster Type	
	TPT	x.y (no units)	Thruster Speed Trip Point	Not present if TYP = NONE
	MIN	x (percent)	Minimum thruster output	“
	MAX	x (percent)	Maximum thruster output	“
	SCL	1 – 3	Thruster Gain	“
THRUST	TYP	ONOFF, PROP	Thruster Type	Not present if SYS/TYP = NONE
	TPT	x.y (no units)	Thruster Speed Trip Point	“
	MIN	x (percent)	Minimum thruster output	“
	MAX	x (percent)	Maximum thruster output	“
	SCL	1 – 3	Thruster Gain	“
USR	HS	ANA, DIG, NV1, NV2, NM1, NM2	Heading Source	
	TN	1 - 5	Default Turn	0 = Circle 1 = U-Turn 2 = M.O.B. 3 = Dodge (only valid for P3) 4 = Fishzag 5 = Pretack
	WT	xx (seconds)	Watch Alarm Time	

ID	Field 1	Field 2	Description	Notes
AUTO	LP	–	Lo Steering Parameters:	
	x	–	Rudder Gain	
	x	–	Counter-Rudder	
	x or A	–	Sea State	
	x.y	–	Turn Rate	
	HP	–	Hi Steering Parameters:	
	x	–	Rudder Gain	
	x	–	Counter-Rudder	
	x or A	–	Sea State	
	x.y	–	Turn Rate	
AUTO	TC	xx	Time const for large boat steering	not valid on SP 36 or SP 36 steering
	PD	xx	Counter helm for large boat steering	not valid on SP 36 or SP 36 steering
	SP	NAV1, NAV2, VANE	Speed Source	
	xx.x (no units)	–	Hi-Lo Trip Point	Optional
NAV	NAV1, NAV2	–	NAV Source	
	LMT	x.xx (no units)	XTE Limit	
	MAX	x.yy (degrees)	Maximum XTE course correction	
	HUSH, MANU, AUTO	–	Handling of the waypoint arrival state	
	XTE, CTS, BOTH	–	NAV steering correction method	
	DIR	N, R	XTE Sense	

ID	Field 1	Field 2	Description	Notes
END	–	–		End of the configuration. When this ID is received during an “Rx” transfer, the Vessel Configuration will return to Idle
START	–	–		Start of the configuration. When this ID is received while in the Dockside Setup menu, if Configuration is not “Rx”, a “Tx” transfer to the NAV1 port will start automatically. <i>This does not ever initiate an “Rx” transfer, however.</i>

Table 11 – Configuration Save & Restore Sentences

Appendix 3

Error Messages

There are a number of different error messages in the autopilot system. These messages are displayed on the Control Head screen, and are usually accompanied by an audible alarm.

Critical Errors

The following messages indicate a serious problem. Operation of the autopilot cannot continue until the problem is resolved.

Message	Description
AUX.STATION ERROR	One or more of the auxiliary Control Heads or Handheld Remotes connected to the SPU can not be used in the system. Typically, this is caused by using Heads or Remotes with firmware versions that are too much older than the SPU's, and hence incompatible with it. ❖ <i>Contact your SI-TEX Dealer for a Firmware Upgrade.</i>
BATTERY TOO HIGH	Battery voltage has risen above ~40 VDC. ❖ <i>Check all wiring and charger systems.</i>
FAULTY HEAD	The main Control Head is not responding to the SPU. ❖ <i>Check all wiring.</i>
FUSE F2 FAULTY	Fuse F2 on the SPU has blown. This fuse supplies current to the drive outputs. ❖ <i>Check all wiring and verify that all output loads (solenoids, pump motors, etc.) are within the specifications given for the SPU.</i> ❖ <i>Replace the fuse with the same type only.</i>
LOW BATTERY	The autopilot has detected that the battery supply voltage is less than ~10 VDC, which is too low to continue safe operation. ❖ <i>Check all wiring and the battery(ies).</i>
ROM ERROR	The autopilot has detected a problem in its program memory. ❖ <i>Return the unit to your SI-TEX Dealer for repair.</i>
RFU NOT FOUND	The autopilot cannot detect the presence of a Rudder Follower Unit ²⁴ . ❖ <i>Check all RFU wiring.</i> ❖ <i>If no faults are found, the RFU may be defective. Contact your SI-TEX Dealer for repair advice or replacement.</i>

Table 12 – Critical Error Messages

²⁴ This message does not apply to SP36 systems

Severe Errors

The following messages are “severe” errors. Typically, these messages describe a condition that prevents normal operation in the current mode, but operation in other modes may still be possible.

These error messages may be temporarily suppressed by pressing the **Fn** button. They are automatically cancelled when the condition that caused them is removed.

Message	Description
COMPASS ERROR	The autopilot cannot read the Analog compass specified in the Standby menu. ❖ <i>Check compass wiring.</i>
FAULTY AUX #1 FAULTY AUX #2	The SPU has detected a problem in communicating with the Control Head connected to J12 – Aux1 (or J13 – Aux 2). ❖ <i>Check all wiring.</i>
HIGH TEMPERATURE	The SPU circuitry has become too hot, typically due to excessive current demands. ❖ <i>Check all wiring and verify that all output loads (solenoids, pump motors, etc.) are within the SPU's specifications.</i> ❖ <i>Check that the SPU has adequate ventilation.</i>
INVALID CRS DATA	Valid NMEA Course data has not been received at NAV1 or NAV2 for ~28 seconds.
INVALID SPEED DATA	Valid NMEA Speed data has not been received at NAV1 or NAV2 for ~28 seconds.
	❖ <i>Check that the Navigation System sending the data is turned on, and configured & functioning properly.</i> ❖ <i>Check the wiring between the system and the SPU.</i>
INVALID HEADING	If an Analog Compass is selected as the Compass Source in the Standby menu, this message indicates that the signals from the compass are faulty. ❖ <i>Check the wiring between the Compass and the SPU.</i> If an NMEA 0183 Compass or other source of Heading data (NAV1 or NAV2 in the Standby menu) is selected as the Compass Source, this message indicates that no valid Heading sentences have been received for ~3 seconds. ❖ <i>Check that the device is turned on and functioning properly.</i> ❖ <i>Check the wiring between the device and the SPU.</i>
NO NAV DATA	The SPU has not been able to detect, for ~32 seconds, at the Nav Source specified in the Nav menu, the NMEA 0183 navigation information it needs to operate in NAV mode.
NO SPEED DATA	The SPU has not been able to detect, for ~32 seconds, at the Speed Source specified in the Auto menu, the NMEA 0183 Speed data it needs to operate in AUTO
	❖ <i>Check that the device sending the data is turned on and functioning properly.</i> ❖ <i>Check the wiring between the device and the SPU.</i>

Table 13 – Severe Error Messages

Warnings

The following errors are warnings. Operation of the autopilot continues normally.

The error messages may be temporarily suppressed by pressing the **Fn** button. Most are automatically cancelled when the condition that caused them is remedied.

Message	Description
COURSE ERROR	The boat is in AUTO or NAV modes, and has been off the Commanded Heading by more than 20° for more than ~32 seconds. ❖ <i>Adjust steering parameters to correct this condition.</i>
EEPROM ERROR	The system has detected a non-fatal error in the non-volatile memory in the SPU. ❖ <i>Contact your SI-TEX Dealer for repair service at your earliest convenience.</i>
NO AUX #1 NO AUX #2	The system previously detected an auxiliary Control Head connected to J12- Aux 1 (or J13- Aux 2), but cannot detect it now. ❖ <i>Check all wiring.</i>
INVALID COMMAND	The button just pressed is not valid at the current time.
SPI ERROR	The Control Head currently plugged in to the Main Head connector (J12- CONTROL HEAD) is running firmware that is older than (although still usable with) the SPU's firmware. ❖ <i>The Head's firmware should be upgraded to match the SPU's, as soon as possible.</i>
TURN RATE HIGH	The measured rate of turn of the boat has exceeded the Turn Rate set in the Auto menu.
TURN RATE LOW	The measured rate of turn of the boat is much lower than the Turn Rate set in the Auto menu.
WATCH ALARM	The watch alarm timer has timed out. ❖ <i>Press the Fn button to reset the timer.</i>
WAYPOINT ARRIVED	The Navigation System used in NAV mode has informed the autopilot that the boat has entered the arrival circle around the active waypoint.
XTE OVER LIMIT	The Cross-Track Error limit set in the Nav menu has been exceeded. ❖ <i>Adjust the Nav menu parameter, if desired.</i> ❖ <i>Check if "XTE Sense" in the Nav menu is set correctly.</i>
DATABASE CHANGED	The SPU has detected (during power-on) that one of the parameters stored in its non-volatile memory is out of range, and has reset the value to the factory default. ❖ <i>Press the Fn button to clear the warning.</i>

Table 14 – Warning Messages

Appendix 4

Auxiliary Head / Remote Power On

The SPU is shipped from the factory configured so that power can only be turned on or off from the main Control Head. The main Control Head is designated as that which is plugged into the SPU receptacle labelled "**J11 - CONTROL HEAD**". However, the SPU can also be configured so that it can be turned on or off by a Control Head plugged into the receptacles **J12 – Aux 1** or **J13 – Aux 2**.

The following instructions detail how this is accomplished.

- 1) Remove the wiring cover from the SPU and unplug all wiring connectors.
- 2) Remove ten sheet metal screws around the edges of the SPU. These screws secure the top portion of the SPU enclosure.
- 3) Lift the top portion of the SPU enclosure off and set it aside. The top of the printed circuit assembly will be visible.
- 4) On the lower right side of the printed circuit assembly are two right-angle pin headers. They are labelled JP1 and J. On each header is a shorting shunt.
- 5) Change the position of the shunts as shown in the pictures below. JP1 determines whether power can be turned on from the Controller attached to **J13 – Aux 2**, while J determines whether power can be turned on from the Controller attached to **J12 – Aux 1**.

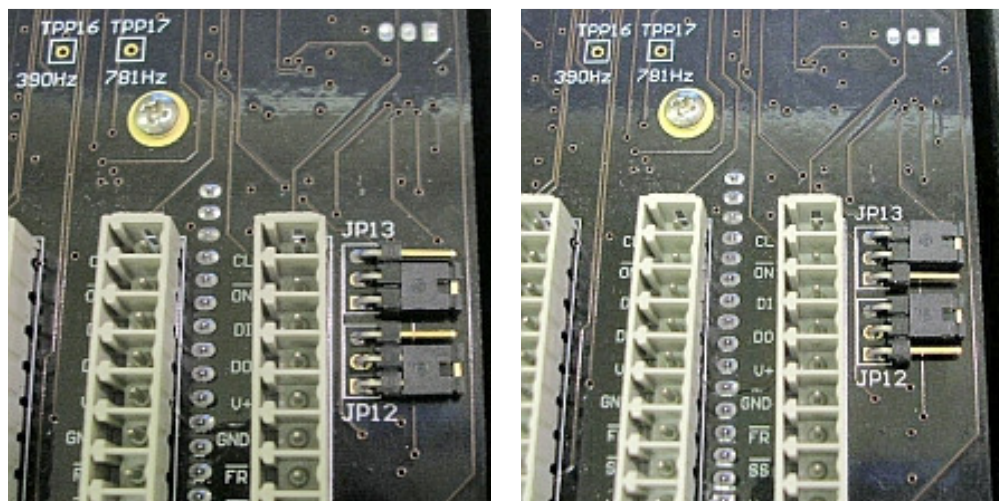


Figure 65 – JP12 & JP13 in Factory Default Position (left) and After Moving Shunts (right)

- 6) Replace the SPU enclosure top and secure it with ten sheet metal screws.
- 7) Replace all wiring plugs and the wiring cover.

You will now be able to turn on power from the auxiliary heads simply by pressing the **STANDBY** button. Note that the SPU always powers on in **STANDBY** mode, with the main Control Head in command, regardless of which station was used to turn the power on. If power was turned on from one of the auxiliary stations, then in order to use that station, you must first take command by pressing the **PORT** and **STARBOARD** buttons.

Note: Power cannot be turned on from a CR-203 or TS-203 Remote.

Appendix 5

Diagnostic LEDs

The Signal Processor Unit is equipped with a number of Light-Emitting Diode (LED) lamps that can assist in trouble-shooting should a problem arise with the autopilot system. To observe the LEDs, remove the metal cover on the Diagnostic section.

LED	Description
ALARM	On whenever there is an alarm condition on the SPU. Lights in conjunction with the audible alarm.
BATT PWR	A general indication of the Battery Power supplied to the SPU. Should be on whenever the autopilot is turned on.
DRV PWR	An indication of the power available for the output Drive. Drive Power should be brightly lit whenever the autopilot is on. If it is off, check fuse F2.
VCC	VCC is the voltage supplying the logic circuits on the SPU. The voltage is nominally 5.25 VDC, and can be measured at testpoint TP3 with respect to ground (GND).
SW'D B+	This indicator will be on whenever the Switched B+ output is turned on.
SW'D GND	This indicator will be on whenever the Switched Ground output is turned on.
M1/PORT	For systems that utilize Solenoid steering valves, this LED will be lit whenever the solenoid is activated. For Reversing Motor systems, this LED will be shut off whenever the motor is activated in one direction (which direction depends on how the reversing motor was plumbed in and wired).
M2/STBD	For systems that utilize Solenoid steering valves, this LED will be lit whenever the solenoid is activated. For Reversing Motor systems, this LED will be shut off whenever the motor is activated in the opposite direction to the M1 output.
NMEA 0183 IN #1	This LED will be lit whenever the autopilot receives serial data on the NAV1 input. Note that this indicator only shows that data was received. It does not mean that the data received is valid. Typically, this LED will flash at a rate of about once per second for regular data from a GPS or Chartplotter; it will flash at a rate of about 10 times per second when connected to a heading source such as an NMEA compass. If the LED does not flash and you are sure the sending device is sending data, try reversing the wires from the device connected to J9 – NAV I/O .
NMEA 0183 IN #2	This LED operates identically to the NMEA 0183 IN #1, but shows the reception of data for the NAV2 input.
NMEA 0183 OUT	This LED flashes whenever NMEA 0183 serial data is sent out of the SPU. During normal operation, this LED will flash at a rate of about ten times per second.
SI-TEX Network RX	This LED is reserved for possible future use.
SI-TEX Network TX	This LED is reserved for possible future use.

Table 15 – Diagnostic LEDs

Appendix 6

Upgrading Firmware

Contact your SI-TEX Dealer for more information.

Transferring the System Configuration & Parameters

After doing a Firmware Upgrade, it is not necessary to repeat everything you did when you installed the system originally – **Compass & Drive Setup** procedures, parameter adjustments during Sea Trials, and so on.

Appendix 7

General Specifications

Parameter	Specification
Dimensions	
SPU	257 x 184 x 78 mm (10.1 x 7.3 x 3.1")
Bracket Mount Head	157 x 118 x 73 mm (6.2 x 4.6 x 2.9") @ 20° max tilt – add 28 mm (1.1") in width for bracket knobs
Surface Mount Head	156 x 113 x 24 mm (6.1 x 4.4 x 0.9") – add 11 mm (.43") for Control Knob & 29 mm (1.1") behind surface to clear rear of Head (not incl. cable)
Flush-Mount Head	165 x 122 x 12 mm (6.5 x 4.8 x .47") – add 11 mm (.43") for Control Knob & 41 mm (1.6") behind surface to clear rear of Head (not incl. cable)
Colour Head	Sunlight viewable high resolution QVGA (320x240) TFT display with cold-cathode fluorescent backlight (400 Cd/m ² typ.)
Operating Voltage	11 to 30 VDC
Power Consumption	
SPU	200 mADC (all outputs off)
Control Head	Colour: 350 mADC (max)
Drive Output	20 Amps (max)
Navigational Interface	
NAV1 input	NMEA 0183 compliant, optically isolated, 4800 Baud
NAV2 input	NMEA 0183 compliant, optically isolated, auto-baud detecting, 4800 & 9600 Baud
NMEA 0183 output	Heading (10x per second) & Autopilot status (1x per second), NMEA 0183 compliant, RS-422 compliant, RS-485 compliant, 4800 Baud, 8 data bits, no parity, one stop bit
Course Detection	0.1°
Course Resolution	
AUTO mode	1°
NAV mode	0.1°
External Rudder Angle Indicator	Optional with RFU installed. Supports up to five 500µA instruments
Jog Steering Control Input	Yes
Rudder Follower Input	1.0 – 4.0 VDC centered at 2.5 VDC.
Control Head cable length	7.6 metres (25') standard Custom lengths up to 15 metres (50') available

Table 16 – General Specifications

Compass Safe Distances

The following Compass Safe Distances were determined using a UKAS calibrated 23 Axis Magnetometer, for both standard compasses and steering/emergency compasses.

SI-TEX PN	Description	Standard Compass Limit 5.4%/H	Steering Compass Limit 18%/H
20110012	Signal Processing Unit (SPU)	28 cm	16.5 cm
30110024	Control Head	32 cm	21 cm
20310025	TS-203 Fixed Remote	31 cm	18 cm
20310003	Jog Steering Control with two sets of switches	13 cm	8 cm
20330008	Medium Duty Rotary Rudder Follower Unit	20 cm	8 cm

H = horizontal flux density in μT

Table 17 – Compass Safe Distances

WARNING

The Equipment is an aid to navigation only. It is not intended or designed to replace the person on watch. A qualified person should always be in a position to monitor the boat's heading, watch for navigational hazards and should be prepared to revert to manual steering immediately if an undesired change of heading occurs, if the heading is not maintained within reasonable limits, or when navigating in a hazardous situation.

ALWAYS REMEMBER:

WHENEVER UNDER WAY, A QUALIFIED PERSON ON WATCH IS REQUIRED BY LAW.

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Settings & Notes

Settings & Notes

Default & User Settings

Once your SP 36 system has been installed and set up correctly, make a record of all the settings for future reference, in the table below.

Parameter	Range	Default Value	User Settings 1	User Settings 2
Dockside Setup Menu				
Reset	<i>press Fn button to do</i>	<i>n/a</i>		
Vessel type	Displ, Semi, Plane, Stern, Sail	Stern		
An. Compass Type	None, Mag, Flux, FIXED, FLOAT	None		
Compass Setup	<i>press Fn button to do</i>	<i>n/a</i>		
Drive Setup	<i>press Fn button to do</i>	<i>n/a</i>		
Exit	<i>press Fn button to do</i>	<i>n/a</i>		
Alarm O/P	None, SW'D B-, SW'D B+	None		
External Alarm Type	All, Watch	All		
Language	English, Français, Español, Íslenska, Italiano, Norsk	English		
Standby Menu				
Station Lock	Lock, Unlock	Unlock		
Default Turn	U-Turn, Circle, M.O.B.,	U-Turn		
Compass Source	Digital, NAV1,NAV2	NAV1		
Compass Cal	0 – 359° (<i>for all types</i>)	<i>Set at Runtime</i>		
Backlight Level	0 – 8	4		
Display	A, B, C (<i>colour Control Heads</i>)	A		
Watch Alarm	Off, 1 – 30 sec	Off		
Battery	<i>Read only value</i>	<i>n/a</i>		

Parameter	Range	Default Value	User Settings 1		User Settings 2	
Power Steer Menu						
P.Str Rudder Limits	Off, or 5° up to physical limits from Dockside Setup	Off				
Auto/Nav Rudder Limits	Off, or 5° up to physical limits from Dockside Setup	Off				
RAI Offset	0° – 15°	0				
Auto Menu						
Rudder Gain	1 – 10	Lo: 8, Hi: 5	Lo:	Hi:	Lo:	Hi:
Counter Rudder	0 – 10	Lo: 3, Hi: 3	Lo:	Hi:	Lo:	Hi:
Seastate	Auto, 1 – 10	Lo: A, Hi: A	Lo:	Hi:	Lo:	Hi:
Turn Rate	1 – 5%/sec, 1 – 10%/sec (if RFU installed)	Lo: 5, Hi: 4 Lo: 8, Hi: 5 (with RFU)	Lo:	Hi:	Lo:	Hi:
Parameter Set	Lo, Hi, Auto	Auto				
Speed Trip Pt.	2 – 20	10				
Speed Source	NAV1, NAV2	NAV1				
ALC	On, Off	Off				
Nav Menu						
Nav Source	NAV1, NAV2	NAV1				
XTE Limit	0.01 – 3.0 (in 0.01 steps)	0.25				
Waypoint Arrival	Silent, Manual, Auto	Auto				
Correction	XTE, CTS, Both	Both				
XTE Sense	Norm, Rev	Norm				
Max Correction	30° – 90°	60°				

Parameter	Range	Default Value	User Settings 1	User Settings 2
Work Menu				
Rudder Bias	Auto/Nav rudder limit or physical limit	<i>Set at Runtime</i>		
Autotrim	Off, On	Off		
Work Trip Pt.	1 – 10	2		
Rudder Scale	0.25 – 3.00 (in 0.25 steps)	1.00		
Work Mode State	A_Rdy, A_On, M_Rdy, M_On	<i>Set at Runtime</i>		

