

SP120 Autopilot

User Manual v1



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IMPORTANT: PLEASE RETAIN ON BOARD

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- The autopilot is a navigational aid; an adequate watch must be maintained at all times when autopilot is in use.
- The autopilot must be placed in manual mode when the vessel is stationary as the system will continue to drive the rudder to the end of its travel and damage the system can result.
- It is strongly recommended that the autopilot not be used while navigating in restricted waterways as water currents, wind changes or radio transmitter interference can endanger your own or other vessels.
- If a GPS is connected to the system, the auto mode will not engage below a speed of one knot and will disengage from auto when the vessel slows to one knot.

The SP120 Autopilot control system comprises the following units:

- SP120 display and control head.
- SI-TEX E-compass
- Rudder Feedback Unit (SP120R only).

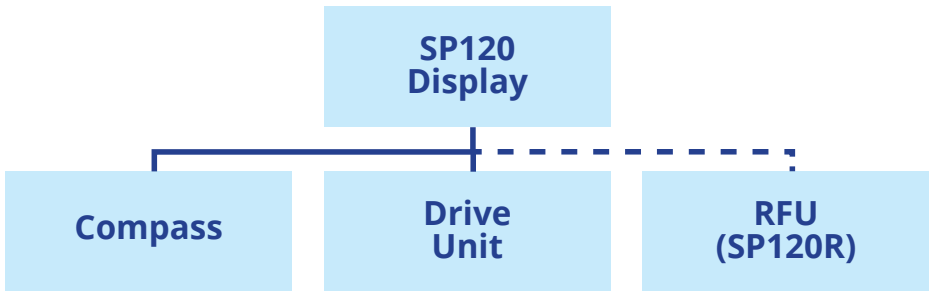
In addition the SP120 has to be connected to a drive unit which controls the rudder actuator system in order to complete the full autopilot system. The actuator system provides the physical movement to the rudder responding to the direction of control signals provided by the SP120. A rudder actuator system comprises one of the following:

- Hydraulic system with helm pump and ram
- Mechanical steering system

The autopilot should be connected to a:

- Reversing motor / pump set connected into the existing hydraulic steering system; or
- Reversing mechanical drive unit connected to the existing steering mechanism

Block Diagram of full system



**Dashed line (RFU) only for applicable for SP120R.*

The SP120 display provides full control of the autopilot system and indicates different modes for heading, course to steer and rudder angle.

The system requires a supply voltage of 12 Volts DC.

Installation of System Components:

Ensure you have all the components of the autopilot.

Tools required:

- Screwdrivers – flat blade and Phillips
- Side cutting pliers
- Wire strippers
- Spanners (various) or adjustable spanner
- 70mm hole saw
- Power drill + assortment of drill bits
- Multi meter (DVM)
- Ancillaries such as tape, connecting block, screws, cable ties, etc.

Access for wiring must be provided. Cables have to be run to the power switchboard, display, compass, rudder feedback (if fitted) and drive unit.

All wiring should be kept as far as possible from radio aerials and aerial cables to prevent interference to the radio and to prevent transmitted signals from the radio influencing the SP120.

The compass must be mounted a minimum distance of 1 metre from any boat compass, radios, speakers or other products with magnetic properties to avoid interference.

The SP120 must have a direct connection to power supply via a 15 amp circuit breaker or a 15 amp fused circuit and an isolating switch.

Display Unit

Position:

The SP120 Head unit should be mounted in a position accessible to the steering position and protected from direct rain or salt water

- Select a dry position
- For in dash mounting cut a 70mm (2. 5”) hole (an optional mounting bracket is available and may be used for display mounting– see your supplier)
- Drill mounting screw holes
- Mount the display using screws supplied (304 SS – 6G)
- Fit dome plugs to cover screws
- Ensure motor (yellow) and clutch (green) wires are not exposed before connecting power to the SP120
- Connect red wire to + 12 volts DC (Positive)
- Connect black wire to - 12 volts DC (Negative)



SP120 Display (Rear) Wiring Diagram

Compass

Take care when handling the compass as it is a sensitive piece of equipment. The compass position is the most important item in the installation of the autopilot. Good course holding is dependent on the compass being free from magnetic interference and excessive rolling or pitching.

Position:

- Select a dry position free from magnetic interference. (Note other side of bulkheads and deck heads for magnetic type objects)
- Avoid positions near radios, speakers, aerial cables or any other current carrying cable.
- Mount the compass horizontally with the arrow (bow) pointing in the same direction as the boat's bow. Use non-magnetic screws (304 / 316 grade stainless steel)
- Run cable to SP120 display position (keep away from other cables)
- Connect compass cable to SP120 compass socket

Compass Mounting:

Vessel Bow



Rudder Feedback Unit

**Only for SP120R version.*

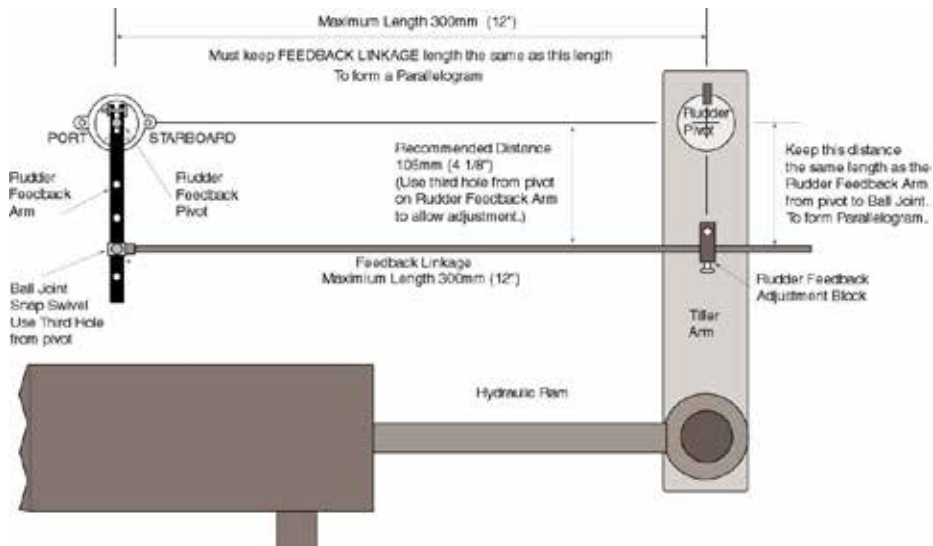
The SP120R Autopilot is supplied with an RFU (rudder feedback unit), which provides to the pilot a precise position of the boat rudder.

Position:

- Refer to diagram on page 8
- Mount rudder feedback adjacent to the tiller (rudder feedback movement must copy the angular movement of the tiller). Use mounting bracket if required
- Note markings on the rudder feedback unit. P & S indicate the required movement of the tiller for course correction (Port and Starboard).
- Rudder feedback is mounted with shaft uppermost
- Fit snap lock swivel joint to rudder feedback arm
- Fit link block to tiller arm
- Fit link arm from rudder feedback to tiller – adjust for correct angle
- Route cable to SP120R display position
- Connect rudder feedback cable to SP120R rudder socket
- When installation is complete, slowly move the steering by hand to ensure:
 - a) The direction indicated on the top of the RFU is correct
 - b) No undue mechanical strain is placed on the feedback or linkage

Note: The rudder feedback unit is water resistant. However, if it is to be mounted in a wet position, some protection should be provided to ensure the unit does not become excessively exposed or submersed in water.

The rudder feedback unit may be mounted upside down, in which case the blue and red wires in the cable must be reversed (yellow wire in cable is not used in the feedback).



Rudder Feedback Installation Diagram

Note: The rudder feedback is factory aligned. The arm should not be removed or loosened the shaft as this will affect the "O" ring seal.

Rudder Feedback / GPS Wiring Diagrams

Pin connections from rear of plug, solder connection side. Pin 1 has adjacent dot.

- Pin 1 5V Rudder Feedback Supply
- Pin 2 Rudder Feedback Wiper Return
- Pin 3 0V Rudder Feedback Supply
- Pin 4 TX Data (heading information)
- Pin 5 + GPS Input (Positive)
- Pin 6 - GPS Input (Negative)

Note: Pin locations are relative to pin 1 which always has a dot adjacent.

GPS Wiring Connections

Pin connections from rear of plug, solder connection side.

Pin 5
+ GPS Input (Positive)
- white wire

Pin 6
- GPS Input (Return)
- green wire

For GPS navigation, connect the GPS unit via the two wires coming from the back of the rudder feedback plug on the SP120 display unit.

Heading Data out is also available

Pin 4
+ Heading Data Out (Positive)
- red wire

Pin 3
- Heading Data Out (Negative)
- blue wire (0 volt line)

Note: For information on connecting different brands of GPS units, refer to the relevant GPS manual

Hydraulic Reversing Motor Connection

- Route suitable two core cable (10 amp min) from motor to SP120 display
- Connect motor cable to the yellow and yellow/black motor wires at SP120

Notes:

1. With SP120 in MANUAL yellow motor wires are both at + 12 VDC
2. Yellow/black wire will give negative voltage out when port rudder movement is required.
3. Motor direction can be checked with SP120 in MANUAL by pressing ◀ or ▶ once power has been connected to the SP120

Mechanical Reversing Motor Connection

- Route suitable four core cable (10 amp min) from motor to SP120 display
- Connect motor wires to the yellow and yellow/black motor wires at SP120
- Connect one clutch wire to green wire at SP120
- Connect second clutch wire to + 12 VDC voltage supply

Note: If a linear hydraulic drive is used, the connections are for mechanical drive.

Initial Operational Settings

The initial set up of the SP120 is done once the system installation is complete and power has been connected to the SP120 display control. The set up can be done automatically or manually

Automatic installation set up determines the output polarity for motor direction and rudder limit setting. This method can only be used where a rudder feedback is fitted. The installation procedure is designed to work on a rudder speed of 8 to 20 seconds hard over to hard over. The process may fail with faster or slower rudder movement in which case the manual set up should be used.

The maximum rudder travel will be set to approx. 33° each side in the automatic set up.

Note: If the manual set procedure is used both motor direction and rudder must be set individually.

Motor Direction – Automatic Set up

To commence:

- Switch power on to SP120
- MANUAL light is lit
- Press MODE button until display shows InSt
- Press ◀ and ▶ together to start the process
- Display will show UAIt (Wait)

- Process will take between 20 and 60 seconds to complete depending on the speed of the motor
- If process is successful display will show dOnE (Done)
- Press either MODE or AUTO to cancel the installation process
- Display will show CAnC (Cancel)
- If ErrO is displayed an error has occurred
- Check the drive output is connected and rudder feedback is moving
- If FAIL is displayed the installation process has not been successful because rudder travel angle is too narrow
- Check rudder feedback installation

Motor Direction – Manual Set up

- Switch power on to SP120
- MANUAL light is lit
- Display indicates compass heading – example H123
- Press ◀ Rudder should move to port
- Press ▶ Rudder should move to starboard
- If direction is incorrect, reverse the yellow wires.

Sensitivity

Available on the SP120R version only.

Factory default setting is 04 and should only be altered during seas trials

- SP120 in MANUAL
- Press MODE button until display shows 04
- Press ► to increase setting (more tolerance to the rudder position error)
- Press ◀ to decrease setting (less tolerance to the rudder position error)
- Display returns to MANUAL and shows heading after 3 seconds

Rudder Ratio

Factory default setting is 03 and should only be altered during seas trials

- SP120 in MANUAL
- Press Mode until display shows r 03
- Press ► to increase setting (larger rudder ratio)
- Press ◀ to decrease setting (smaller rudder ratio)
- Display returns to MANUAL and shows heading after 3 seconds

Note: A value of 1 signifies the minimum amount of applied rudder. When the rudder setting is too low, vessel track will be a slow "S" i.e. : understeer through too little rudder applied.

A value of 20 signifies the maximum amount of applied rudder. When the rudder setting is too high, vessel track will be a rapid "S" i.e. : oversteer through too much rudder applied.

Backlighting

When using the autopilot at night, the backlighting can be turned on.

- Press MODE four times SP120R
- Press MODE until display shows LitE
- Press e ► to increase the backlight
- Press ◀ to decrease the backlight

Set Rudder Limits

Available on the SP120R version only

- SP120 in MANUAL
- Press MODE until display shows PL - (port limit)
- Turn boat helm until rudder reaches required angle - example 28° Port
- Press ◀ and ► together to save this setting
- Press MODE again until display shows SL - (starboard limit)
- Turn boat helm until rudder reaches required angle - example 28° Stbd
- Press ◀ and ► together to save this setting
- Press AUTO to return to MANUAL

Compass Heading

- Switch on power to SP120
- Check display heading - example H 123
- Check this heading against a known accurate bearing
- If display reading differs from known heading*, the compass can be calibrated.

** Note: Compass headings rarely agree on every heading for 360° rotation. The compass heading is set for optimum alignment only*

Compass Calibration

To carry out this procedure the boat must be in open waters and be able to safely turn through 360°.

- Switch on power to SP120
- Press MODE button until display reads CCAL
- Slowly turn boat in a circle
- Display shows dOnE when calibration is complete

Compass Alignment

The compass may need to be aligned with a known heading

- Loosen the two mounting screws on the compass base plate
- Rotate compass until display reads the same the known bearing
- Re-tighten the screws

Technical Adjustments

These procedures are used to adjust internal parameters of the SP120.

Each routine can be set or reset and can be displayed individually.

To enter the procedures:

- SP120 in MANUAL
- Press MODE until display shows P-41 (if the firmware version is 41)
- Press ► to access the first technical parameter
- Display changes to 1- 02
- Press ◀ and ► together to entered the first routine
- Display changes to 1= 02

- Change the setting by pressing ◀ or ► to increase or decrease
- Press ◀ and ► together accept the new setting
- Display changes back to 1 - 03 (example if setting was increased by one)
- Press ► again to access the next routine and continue as above

Press MODE or AUTO to return SP120 to MANUAL operation.

Parameters List:

1. Pulse Drive Time

The minimum pulse width when the autopilot is in NO RFU mode.

When the system is near to the desired position, the pulse of current applied to the motor will have this length. This parameter is not used when in RFU mode.

This parameter may be necessary to be increased if the rudder is not moving and the course error of the boat is bigger than the dead band. It depends on the power of the system which moves the rudder and the inertia of the rudder. The pulse must be long enough for start moving the rudder.

Range: 0 to 99

Recommended: 25

2. Reverse Delay

Sets the delay time between rudder movement direction changes. The purpose of this parameter is to prevent damage to the system that moves the rudder due high electrical currents.

Range: 0 to 99

Recommended: 40

3. Dead Band

Sets the tolerance in degrees concerning the desired heading. For example, if the desired course is 90° and the dead band is 1°, the control will actuate for correcting the heading when it is out of the interval from 89° to 91°.

The dead band can not be zero, as there are some oscillation in the heading readings due the movement of the waves and the accuracy of the compass.

Range: 0 to 50

Recommended: 5

4. Maximum Rate of Turn

It limits the rate of turn of the boat, mainly when occur big changes in the desired course.

The bigger the course error of the vessel, the faster is the turn speed calculated by the control for correcting this error. Therefore, it has to have a limit on this turn speed accordingly to the type of boat.

The number of this parameter represents the degrees per minute allowed.

Range: 0 to 400

Recommended: 250 (260°/min)

5. Minimum Speed in Knots

Set at 1 knot in the factory, it gives the minimum speed acceptable for turning on the autopilot in NO RFU mode.

The position of the rudder will turn the boat as expected only above of certain speed. Therefore, it is necessary to set a minimum speed for the control start working.

Range: 5 to 100

Recommended: 10 (1.0 knot)

6. rF – 0: no rudder feedback mode 1: with feedback mode

When it is not provided a rudder feedback sensor in the vessel, this parameter must be set to 0. Without this information, the control will make its calculations based only on the heading readings

Range: 0 or 1

Recommended: 1 if there is an RFU available

7. Integral Control Gain

Sets the integral parameter for the PID control. It is used only when in RFU mode. See the section “Adjusting the PID control” below for further information.

Range: 0 to 99

Recommended: 5

8. Derivative Control Gain

Sets the derivative parameter for the PID control. It is used only when in RFU mode. See the section “Adjusting the PID control” below for further information.

Range: 0 to 99

Recommended: 20

rESt

General Reset – Reset all the configurable parameters of the device to the factory values. It must be double pressed both arrows ◀ ▶◀ ▶.

After this command is applied, it may be required setting some parameters again, according the vessel.

A XTE Proportional GAin

Sets the correction factor associated with the current Cross Track Error value. Care must be taken if a quick response of the control is desired. If this parameter is too high, the direction of the vessel can become oscillatory.

Range: 0 to 99

Recommended: 10

B Steer Routine;

This version is equipped with 2 steering routine parameters that can cater for all types of vessels. In some cases the PID routine will cause oscillations, so it could be recommended to select the difernt routine.

0 is for PID.

1 is for a conventional Bang Bang Linear system.

C Wind Damping

This parameter can be set ON (1) or OFF (0). When it is ON, the action of the wind on the desired course the vessel will be compensated.

For this functionality works, it is necessary to feed the autopilot with the wind value information via serial port.

Range: 0 or 1

Recommended: depends on the availability of wind information.

D Power supply voltage

Displays the voltage of the power supply.

E SI-TEX Use Only

F XTE Integral Multiplier

Allows for adjustment of fine control of the Steering routine.

If the vessel is not keeping on course with a tide or large course different. Then increasing this value will help. To high a value will cause oscillation.

Range: 0 to 99

Recommended: 5

G Steering Control period

Adjusts the timing routine of the Steering PID routine. Slightly related to the speed of the rudder.

H Heading adjustment

In this mode you can adjust the heading offset of the compass. Range: -10.0 to 10.0

I Baud rate of Serial Port 1

The GPS input port. Baud rates up to 38400 are available.

J Baud rate of Serial Port 2

The Compass input port.

However, this proportional value may be not enough when the vessel's direction is being disturbed by some force that takes it from its route (unbalanced load, wind...).

In the autopilot, the gain (contribution) of this value is adjusted with the rudder ratio.

- **Integral value:**

This portion of the control value integrates the error, for the compensation of forces and disturbances that the proportional control value can't cope with. It is intended to provide no error on the vessel's direction result.

Adjusting the PID control

PID stands for Proportion, Integral and Derivative, which are the three calculated values that when summed, result in the adjustment value. This value is the position to where the Rudder must be driven.

Below it is described how each of these values contributes to the control of the vessel. These value differ for the different vessel setups and different types of rudder feedback used.

- **Proportional value:**

The larger the error from the desired direction from the current direction of the vessel, the larger this value is. It provides a more responsive system when the boat is too far from its desired direction.

The adjustment of the gain for this parameter is explained in the sections "Technical Adjustments" and "Parameters List" (parameter 7) above;

- **Derivative value:**

This value is intended for providing stability to the system avoiding "hunting". It is based in the variation of the error, in this case, how fast the boat is turning. This value will be zero when the vessel is not turning, and will oppose the to the turn movement when it happens.

The adjustment of the gain for this parameter is explained in the sections "Technical Adjustments" and "Parameters List" (parameter 8) above.

SP120 default settings

<u>Front panel set:</u>	<u>Setting</u>	<u>Range</u>
Rudder Ratio	3	1-40
Sensitivity	4	0-10

<u>Parameters:</u>	<u>Setting</u>	<u>Range</u>
1. Pulse Length	25	0 to 99
2. Reverse Delay	40	0 to 99
3. Dead Band	5 (1o)	0 to 50
4. Maximum Rate of Turn	250 (250o/min)	0 to 400
5. Minimum Speed	1.0 (knot)	5 to 100 (0.5 to 10 knots)
6. No RFU	rf – 1	0 or 1
7. Integral Control Gain	5	0 to 99
8. Derivative Control Gain	3	0 to 99

A. XTE Proportional Gain	10	1 to 99
B. Not used	--	--
C. Wind damping	0	0 or 1
F. XTEInegral Gain Multiplier	3	0 to 99
G. Control Calculation Period	60	0 to 99
H. Heading offset.	0	-10.0 to +10.0
I. Baud Rate GPS	4800	4800 - 57600
J. Baud Rate Compass	4800	4800 - 57600

Setting up your GPS Unit

Because there are a great variety of GPS units that will work with this autopilot, the following is a guide only. For more information, consult your GPS manual.

The GPS unit must be set up to output “NMEA 0183” data on a pair of wires, which are connected to the SP120 unit via the rudder feedback connector. The data generated must include at least one of the following:

- The APA sentence.
- The APB sentence.
- The BOD and XTE sentences.
- If only the XTE data sentence is available, the pilot can steer in a restricted manner only. (See later in this section.**)

The GPS unit must be programmed and activated to navigate to a waypoint, or to follow a line joining two or more waypoints (called a route). This unit should then send information to the autopilot from which can be calculated the course-to-steer.

Under the following conditions:

- several waypoints are linked together into a single route,
- the GPS unit is set and capable of “auto-sequence” between them,
- an “arrival zone” of more than 0.05 NM (Nautical Miles) is set so that the GPS can detect when the vessel has reached a waypoint; then the SP120 will be able to steer from each waypoint to the next without intervention.

** If only the XTE information is available from your GPS unit then your vessel must be on track, and heading in the correct direction, before engaging the GPS unit. The “auto sequence” feature is not available in this instance.

Note: Prior to engaging GPS mode, a route or destination must be programmed and selected in the GPS for the Autopilot to follow.

SP120 Alarms

A number of conditions will cause alarms to sound and an alarm message to flash on the display

Off Course Alarm

In AUTO mode an audible alarm of 3 “beeps” per second will sound when boat heading is greater than 45° from the desired course. The ALARM light will also flash RED on and off.

GPS Alarm

In Waypoint Steering mode an audible alarm of 1 “beep” per second will sound when no GPS data is received by the SP120. The ALARM LED will flash RED and GPS light will also flash RED / GREEN.

Definition of Terms

SP120 Display: The operational control unit with LCD display and push buttons.

Heading: This is the magnetic direction of the vessel at the current time.

Course-to-steer: The direction (heading) which the autopilot is attempting to maintain.

**Note: If there is no compass connected and a GPS is used as heading reference, the display shows COG (course over ground).*

Overview of Operation

MANUAL Mode: “H*”**

The autopilot display unit shows the current heading. The Manual LED will show YELLOW.

The boat is under manual steering control; the autopilot will not apply any automatic steering control.

Vessel can be steered using ◀ or ▶ Buttons or original wheel / lever etc. When vessel is steered, the Manual LED will indicate drive direction.

AUTO Mode: “A*”**

The autopilot will maintain your vessel on the course indicated. The Auto LED will be YELLOW. This course can be set or altered from the display unit. If drive is required. The Auto LED will Show GREEN / RED.

WAYPOINT (SPG) Mode: “A*”**

When receiving information from a GPS plotter, the autopilot can steer a vessel to a precise latitude and longitude (waypoint) or through a sequence of latitudes and longitudes (route).

WIND Mode: “S*” or “P***”**

When receiving information from a Wind Direction System, the autopilot can steer a vessel based on the wind direction. This is especially useful for sailboats.

*** Will be the displayed number for heading etc.

Testing Procedure

Initial Inspection and Testing



1. Confirm power to be connected is the required DC voltage.

2. Power Supply 12V DC is available.

3. Ensure polarity of the voltage supply is correct.

4. All electrical connections are correct.

5. Loose cables are clipped or tied up.

Dockside Tests

1. Turn steering wheel fully clockwise and visually check that moving (mechanical) parts do not foul;

2. Repeat step 1 for anti-clockwise.

3. Return Steering to centre.

4. Switch on SP120 Autopilot system.

5. Press arrow button to operate steering in that direction

6. Check that rudder moves in correct direction

7. Check Rudder direction follows change request

8. Check Course change provides sufficient Rudder movement

9. Check magnetic heading display on SP120

10. Return steering to centre

Trouble Shooting

SP120 Display is not displaying any heading and no light is lit.

- Check power is available:- 12VDC
- Check boat master switch for autopilot
- Check circuit breaker (if applicable)
- Check in-line fuse of SP120 red wire
- Check all wiring connections

SP120 does not move rudder when AUTO is selected

- Confirm SP120 display is showing heading information.
- Check voltage is present at the SP120 motor connections (Yellow and yellow with black stripe) when AUTO is selected and a course change applied.
- Confirm that the supply voltage is 12 volts DC (Red and Black).
- Check all motor and clutch wiring
- Check motor brushes
- Check the hydraulic system:
 1. Ensure there is sufficient hydraulic fluid.
 2. Purge the system of possible air locks / contamination.
 3. Ensure that any flow restricting valves are not completely closed.
 4. Check all connections for leaks.

SP120 display shows LOSP when AUTO selected (when using GPS input)

- Check speed setting in parameter adjustment is greater than one
- Vessel must be moving forward.

SP120 does not follow waypoint route

- Check GPS plotter waypoint setting
- Check GPS and AUTO selected on SP120
- Check alarm status of SP120
- Ensure that the GPS unit has the correct magnetic correction factor.
- Check SP120 compass alignment and possible magnetic interference

No GPS Data Alarm

- Check wiring of the GPS to the SP120 unit.
- Check sentence in GPS unit for correct data output
- Check route is set up or selected in the GPS unit
- Check location fix at the GPS unit.
- Check location fix at the GPS unit.

Warranty

SI-TEX products are thoroughly inspected and tested before shipment from the factory and are warranted to be free of defects in workmanship and materials for a period of one year from the date of shipment from the factory.

This warranty is extended to and is solely for the benefit of the original consumer purchaser.

All units in need of repair will be repaired without charge to the purchaser during the above mentioned period in accordance with the following terms and conditions:

1. The defective unit is returned "freight prepaid" to Si-Tex Marine Electronics : 25 Enterprise Zone Drive, Suite #2 Riverhead, NY 11901
2. Proof of purchase is supplied and original Serial Numbers on equipment have not been changed.
3. Information is provided regarding the nature of the failure or problem occurring.
4. A return address is supplied to enable the equipment to be returned by road freight. Any other means of transport will be charged to the customer's account and must be paid in advance.

This warranty does not cover defects or damages caused by unauthorised service or damage through accident, misuse or abuse. The owner is also responsible for providing reasonable maintenance and weather protection of the equipment.

SI-TEX shall not be liable for damage or loss incurred resulting from the use and operation of this product.

SI-TEX reserves the right to make changes or improvements to later models without incurring the obligation to install similar changes to equipment already supplied. Some states do not allow the exclusion or limitation of incidental or consequential damages; therefore the above limitations or exclusions may not apply to you.

This warranty gives you specific legal rights and you may also have other rights, which vary from state to state.

Additional Information

Si-Tex Marine Electronics

Please refer to the Si-Tex website for more information

Web: www.si-tex.com

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