NORTHROP GRUMMAN

Sperry Marine

NAVIPILOT 4000
NAVIPILOT 4000 TRACK
NAVIPILOT 4000 HSC
NAVIPILOT 4000 TRACK HSC
Heading Control System

Installation and Operation Manual

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SAFETY PRECAUTIONS

The following safety notice conventions are followed throughout this manual:

 A **WARNING** contains an operating or maintenance procedure, practice, condition, statement, etc., which, if not strictly observed, could result in injury or death of personnel.

 A **CAUTION** contains an operating or maintenance procedure, practice, condition, statement, etc., which, if not strictly observed, could result in damage to, or destruction of, equipment.

A **NOTE** contains an essential operating or maintenance procedure, condition or statement which is considered important enough to be highlighted.

 **WARNING**:

Proper use of the NAVIPILOT 4000 is critical to ship navigation. Careless OR improper use of this system may result in vessel damage and/or SERIOUS INJURY OR DEATH.

BEFORE using this system, operators MUST be appropriately trained AND familiar with the warnings, safety instructions and information contained in this manual AND on system components.

ALWAYS keep technical manuals in a well-known, readily available location.

 **CAUTION**:

NEVER attempt to open ANY system components OR make ANY internal repairs yourself. Only Sperry Marine trained Service Technicians may service or repair this equipment. Breaking a seal will void the warranty!

NEVER exceed specified system power OR environmental limits.

NEVER install unauthorized additional cards OR devices into this system.

NEVER provide unauthorized modifications to this system.

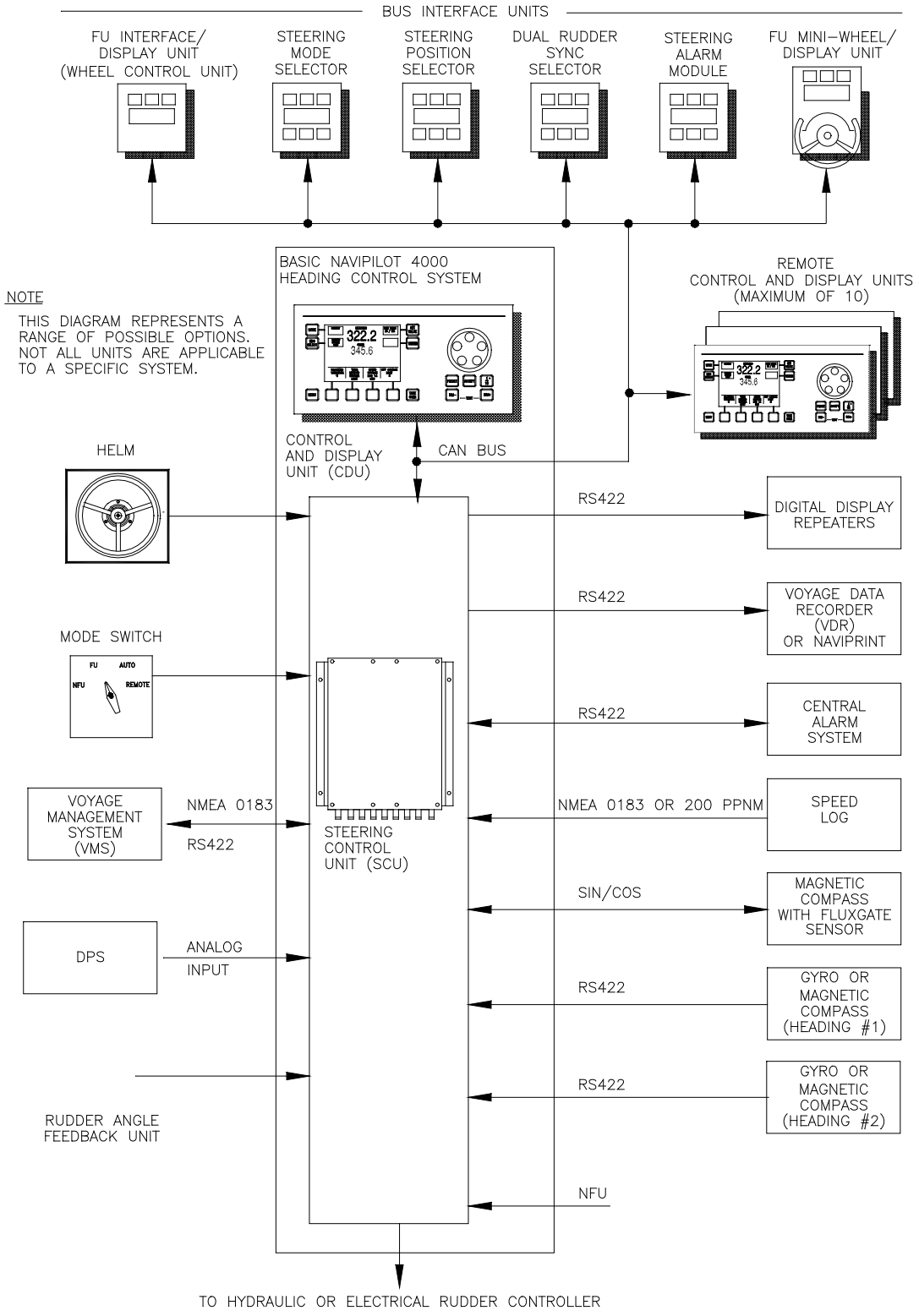


Figure 1-1. NAVIPILOT 4000 and Ancillary Equipment

CHAPTER 1
DESCRIPTION

1.1 INTRODUCTION

This manual provides information on the installation and operation of the NAVIPILOT Heading Control System, which is available in four product types, as follows:

NAVIPILOT 4000:

- NAVIPILOT 4000 – Provides the standard set of system capabilities, in accordance with ISO 11674
- NAVIPILOT 4000 TRACK – Provides additional capabilities for Track Control, in accordance with IEC 62065

NAVIPILOT 4000 High Speed Craft (HSC):

- NAVIPILOT 4000 HSC – Provides required capabilities for High Speed Craft, in accordance with ISO 16329
- NAVIPILOT 4000 TRACK HSC – Provides Track Control capabilities for High Speed Craft, in accordance with IEC 62065

All the NAVIPILOT systems provide self-tuning capabilities, and additional features beyond those required by international standards. System configurations typically include various ancillary units, as shown in Figure 1-1. This manual does not cover operating procedures for the many varieties of optional devices that may be connected to the system. For such equipment, the user should consult the applicable technical manual.

The contents of this manual are organized in five chapters and five appendices. Each page is marked with a tab which identifies the chapter or appendix name. Where necessary, content that is specific to the NAVIPILOT 4000 and the NAVIPILOT 4000 HSC are separated. The arrangement and applicability of chapters and appendices are as follows:

Chapter No.	Title	Applicable To
Chapter 1	Description	All product types
Chapter 2	NAVIPILOT 4000 Operation	NAVIPILOT 4000 and NAVIPILOT 4000 TRACK
Chapter 3	NAVIPILOT 4000 HSC Operation	NAVIPILOT 4000 HSC and NAVIPILOT 4000 TRACK HSC
Chapter 4	Installation and Initialization	All product types
Chapter 5	Alarm System	All product types
Appendix A	Configuration Data for NAVIPILOT 4000	NAVIPILOT 4000 and NAVIPILOT 4000 TRACK
Appendix B	Configuration Data for NAVIPILOT 4000 HSC	NAVIPILOT 4000 HSC and NAVIPILOT 4000 TRACK HSC
Appendix C	Service Setup Considerations for NAVIPILOT 4000 Tuning	NAVIPILOT 4000 and NAVIPILOT 4000 TRACK
Appendix D	Service Setup Considerations for NAVIPILOT 4000 HSC Tuning	NAVIPILOT 4000 HSC and NAVIPILOT 4000 TRACK HSC
Appendix E	Acronyms and Abbreviations	All product types

NOTE: In this manual, the acronym HSC has two meanings: High Speed Craft, and Heading to Steer Command. Where the meaning is not clear from the context, the acronym is defined in the text.

1.2 SYSTEM FEATURES

Available features for the NAVIPILOT 4000 will depend upon the installed product type (NAVIPILOT 4000, NAVIPILOT 4000 TRACK, NAVIPILOT 4000 HSC, OR NAVIPILOT 4000 TRACK HSC), and on other installed options.

Identification of the installed product type is displayed at the Control and Display Unit (CDU) on startup. An operator can also obtain this information by selecting the DISPLAY OPTIONS feature at the CDU, and then selecting CONFIG ID, as described in section 2.19 (for NAVIPILOT 4000 and NAVIPILOT 4000 TRACK), and section 3.19 (for NAVIPILOT 4000 HSC and NAVIPILOT 4000 TRACK HSC).

All NAVIPILOT product types are installed as part of a NAVINET Steering Control Network, utilizing a Controller Area Network (CAN) bus architecture.

1.2.1 Standard Features

The following standard features are included with all NAVIPILOT product types:

- Heading keeping with minimum rudder motion
- Course change control by setting either turn rate or turn radius
- Rudder limit setting (available as an alternative to setting rate or radius)
- Two redundant non-isolated analog outputs, configurable as proportional rudder order or proportional rudder error
- Direct RS-422 connection to external heading reference or navigation systems
- Full alarm complement via the display unit and the alarm contacts

1.2.2 Self-Tuning

All NAVIPILOT product types provide self-tuning capabilities, which enable the system to monitor performance and to automatically adjust rudder gain and counter rudder settings as needed, to keep the tuning optimized even if vessel behavior is affected by changes in loading or trim.

Adaptive Self-Tuning is included with NAVIPILOT 4000 and NAVIPILOT 4000 TRACK systems. This feature enables the system to adjust control settings automatically as sea conditions change, to continuously provide the best possible steering performance and efficiency.

1.2.3 High Speed Craft Features

The following additional features are provided with the NAVIPILOT 4000 HSC:

- All standard features (see section 1.2.1)
- Jet dead band compensation setting
- Configu*rable hysteresis setting which provides an additional dead zone where the outputted rudder comma*nd will not order the steering servo to cross the effective rudder engine dead band unless it reaches a certain threshold

1.2.4 Track Control

The NAVIPILOT 4000 TRACK and the NAVIPILOT 4000 TRACK HSC are equipped with the capability for Track Control, when interfaced to the Sperry VisionMaster FT (VMFT). When so equipped, the system will receive and execute external heading orders that are generated by the VMFT, in the form of Heading to Steer commands.

Track Control operation is available when NAV mode is selected while a VisionMaster route plan is active. The VMFT will compute heading orders to keep the vessel on the active route's planned track line, and the system will execute course changes based on stored data, including route parameters that are stored in the plan, and constant values representing the ship's known turning characteristics. When the vessel reaches the wheel-over point computed by the VMFT, the system will generate and execute heading commands as necessary to accurately control the vessel's progress through the course change.

When the NAVIPILOT (any product type) is interfaced to a GPS, or to a type of electronic chart system other than the Sperry VisionMaster FT, Waypoint mode is available, in which the GPS or chart system calculates the bearing to the next waypoint and calculates Cross-Track Error (XTE) with respect to the plan. This data is sent to the NAVIPILOT, which computes the heading order required to stay on the plan, and automatically adjusts the set heading accordingly.

IMPORTANT SAFETY NOTE: An external navigation system's configuration settings, and user selections made at the external system, can have a significant effect on the operational characteristics of the NAVIPILOT in NAV mode or WAYPOINT mode. The available modes of operation must be adequately tested and validated at sea. The person in charge of vessel navigation must establish safe and appropriate guidelines for using the system, based on observed performance. All users must understand and accept any limitations of the NAV or WAYPOINT interface, and receive the appropriate familiarization training before attempting to utilize NAV or WAYPOINT mode.

1.3 EQUIPMENT DESCRIPTION

Table 1-1 provides the dimensions and weights of the NAVIPILOT 4000 equipment. Table 1-2 lists the equipment part numbers. Table 1-3 lists the options that can be purchased with the NAVIPILOT 4000. The part numbers listed in these tables are associated with the following organization within Northrop Grumman Systems Corporation (Sperry Marine):

Northrop Grumman Sperry Marine GmbH and Co. KG
Woltmanstrasse 19
D-20097
Hamburg, Germany

1.3.1 Control and Display Unit

The Control and Display Unit (CDU) contains the operator controls and indicators used for Heading Control System operation (Figure 1-2). The CDU contains a Liquid Crystal Display (LCD), which displays information during installation, operation, and troubleshooting.

Displays at the CDU indicate the current heading, the ordered heading (set heading), and related information. Also included at the CDU are various other operator-accessible controls, which are used for testing the system, for adjusting the intensity level of the CDU indicators for day or nighttime viewing, and all other operator-controlled functions, including muting the audible alarm. Detailed information on operator-accessible CDU controls and indicators is provided in Chapters 2 and 3 of this manual.

1.3.2 Product Keys

The Product Keys are read-only memory devices, which provide licensing and security data to enable NAVIPILOT operation. These devices are attached to a serial port on the back of each CDU, and they must remain in place while the system is in use. Normally, any change to the Product Key will be made by Sperry technicians only. Data stored in the Product Keys is used each time the SCU is powered up.

More detailed information on the Product Keys, including information on error conditions related to the Product Keys, is provided in section 2.4 (NAVIPILOT 4000 and NAVIPILOT 4000 TRACK), and in section 3.4 (NAVIPILOT 4000 HSC and NAVIPILOT 4000 TRACK HSC).

1.3.3 Steering Control Unit (SCU)

The SCU (Figure 1-3) contains a microcomputer, input/output terminals, and other control circuitry required for processing the steering commands and controlling the steering gear.

1.3.4 NAVINET 4000 Steering Control Network

The NAVINET 4000 Steering Control Network provides communications between the SCU, the CDU, and various bus interface devices. The NAVINET 4000 Steering Control Network utilizes a 120-ohm controlled-impedance Controller Area Network (CAN) bus. CAN is a two-wire, half-duplex, serial network technology which is well suited for high-speed microcontroller applications.

Characteristics of the CAN bus in the NAVINET 4000 implementation are as follows:

- The data transfer rate of the bus is 250 kilobits per second (kbps).
- The maximum length of the backbone is dependent on the type of Bus Interface Units being used. For a configuration in which the Bus Interface Units are version 0.16.03 or later, the maximum bus length is 200 meters. In all other configurations, the maximum bus length is 100 meters.
- When the NAVINET 4000 bus is powered by the SCU's internal 15v bus power supply, up to 30 devices can be connected to the bus. Each end of the bus must be terminated with a 120-ohm resistor.

Table 1-1. Dimensions and Weights

Control and Display Unit (CDU)	
Width	287.8 mm
Height	143.8 mm
Depth	44 mm (requires 150 mm minimum clearance for interface cable)
Weight	1.5 kg
Steering Control Unit (SCU)	
Width	413 mm
Height	400 mm (requires 550 mm minimum for interface cable clearance)
Depth	152 mm (requires 280 minimum clearance for cover removal)
Weight	4.2 kg

Table 1-2. NAVIPILOT Equipment Part Numbers

Part Number	Description	Notes
074856-0000-000	Control and Display Unit (CDU)	Includes cable 020456-0000-000
074851-0000-000	Steering Control Unit (SCU)	
022922-0000-000	Product Key – NAVIPILOT 4000	
022923-0000-000	Product Key – NAVIPILOT 4000 TRACK	
022924-0000-000	Product Key – NAVIPILOT 4000 HSC	
022925-0000-000	Product Key – NAVIPILOT 4000 TRACK HSC	

Table 1-3. Optional Equipment Used With the NAVIPILOT

Part Number	***Description***	Function
020040-0000-000	AC Solenoid Daughter PCB (without relay-switched I/O)	Interface to steering gear. 24-230VAC, 4 ampere inrush, 1 ampere holding maximum.
020041-0000-000	AC Solenoid Daughter PCB (with relay-switched I/O)	Interface to steering gear. 24-230VAC, 4 ampere inrush, 1 ampere holding maximum.
020042-0000-000	DC Solenoid Daughter PCB (without relay-switched I/O)	Interface to steering gear. 12-110VDC, 2 amperes maximum. Pump on sense: contact closure < 1 ohm ON, > 100K OFF.
020043-0000-000	DC Solenoid Daughter PCB (with relay-switched I/O)	Interface to steering gear. 12-110VDC, 2 amperes maximum. Pump on sense: contact closure < 1 ohm ON, > 100K OFF.
020044-0000-000	Isolated Proportional PCB	Interface to steering gear. $\pm$10VDC output (maximum load $\pm$20 mA). Pump on sense: contact closure < 1 ohm ON, > 100K OFF.
022196-0000-000	CAN Interface Unit (CIU)	Interface of devices to the NAVINET 4000 Steering Control Network bus

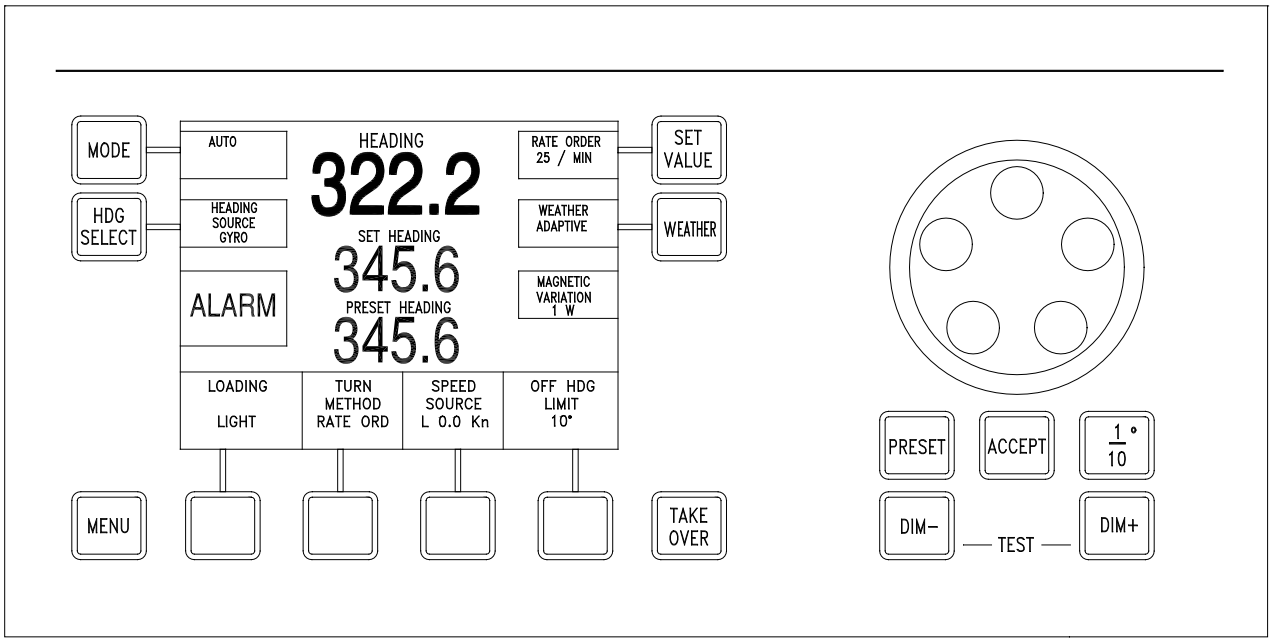


Figure 1-2. Control and Display Unit (CDU)

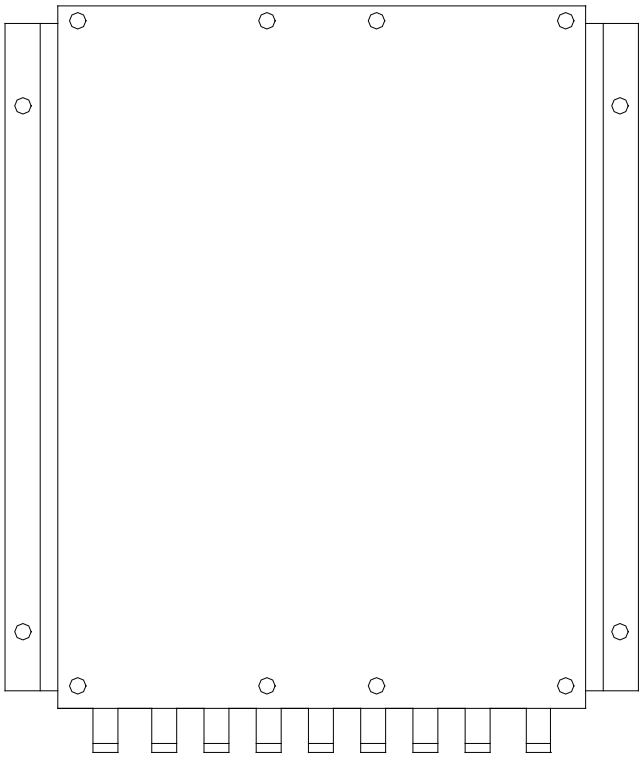


Figure 1-3. Steering Control Unit (SCU)

1.4 TECHNICAL DATA

1.4.1 Navipilot 4000 – Vessel Application Rules

The NAVIPILOT 4000 and NAVIPILOT 4000 TRACK are applicable to vessels meeting the following requirements:

- Vessel Type - Displacement Hull
- Vessel Size - Any
- Vessel Speed - Up to 35 knots
- Vessel Steering Devices - Any of the following: Rudders, Azimuthing Propellers, Azipods.

In order to use the Adaptive Self-Tuning capabilities of the NAVIPILOT 4000, the vessel must be rudder-controlled, with a Tau greater than or equal to 5 seconds. Tau is the time (in seconds) that it takes the vessel to sail its own length (at waterline) at its service speed. Figure 1-4 is a nomogram for determining Tau; refer to Appendix C for additional information on calculating Tau.

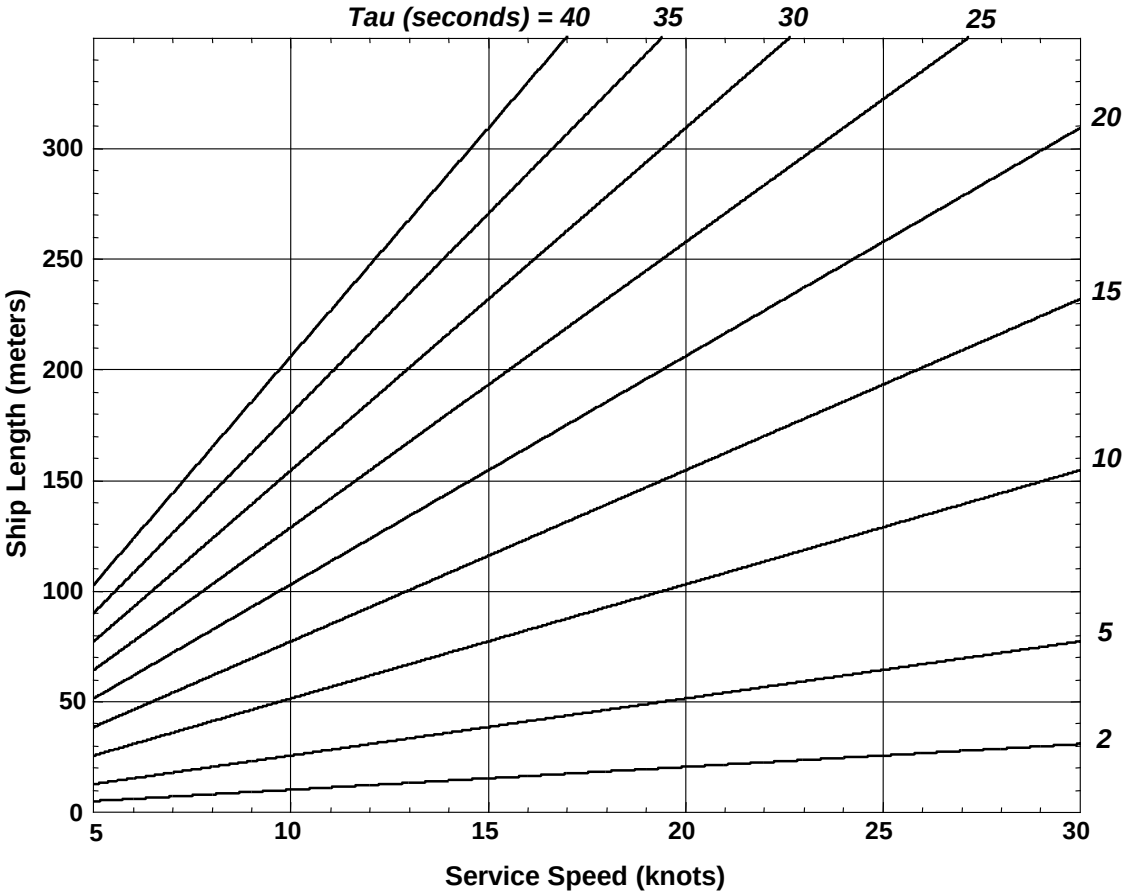


Figure 1-4. Tau Nomogram (for Navipilot 4000)

The NAVIPILOT 4000's minimum turn Rate Order and maximum turn Radius Order are also dependent on the vessel's Tau. Figure 1-5 shows the minimum turn rate as a function of Tau; Figure 1-6 shows the maximum turn radius as a function of Tau and the actual speed of the ship. These Rate Order and Radius Order limitations are imposed by the software.

NOTE: The operator may have to select a higher turn Rate Order than shown, in order to control heading in high winds.

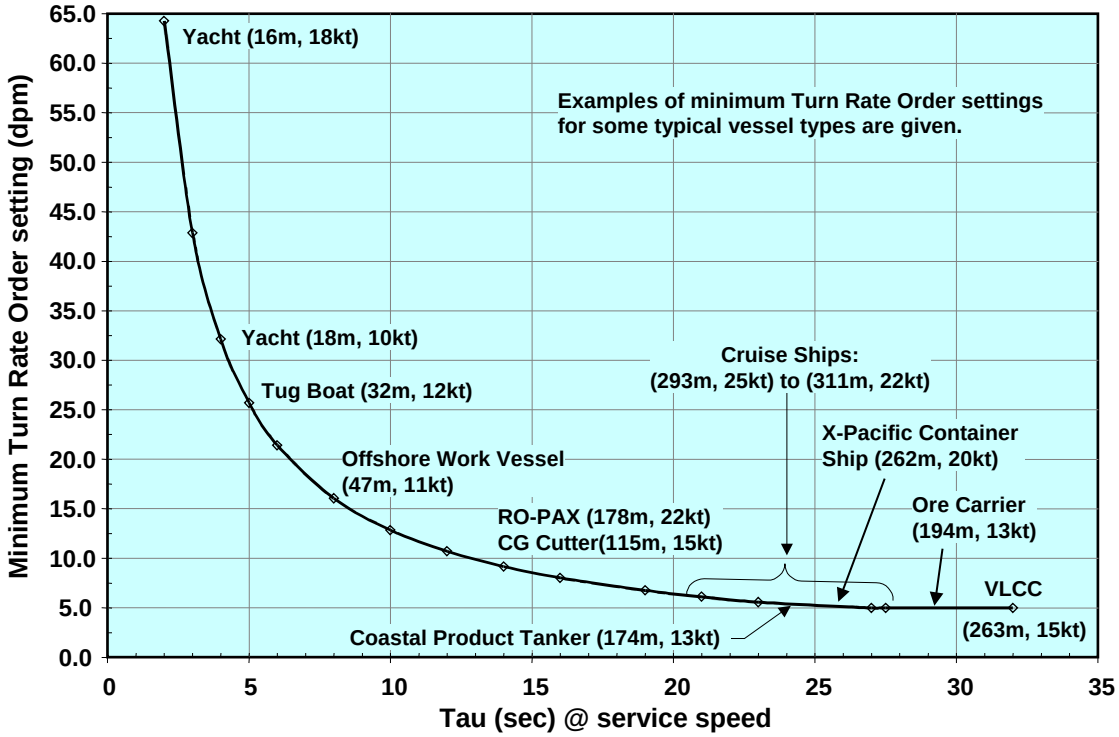


Figure 1-5. Minimum Turn Rate Order Chart (for Navipilot 4000)

NOTE: The operator may have to select a lower turn Radius Order than shown, in order to control heading in high winds.

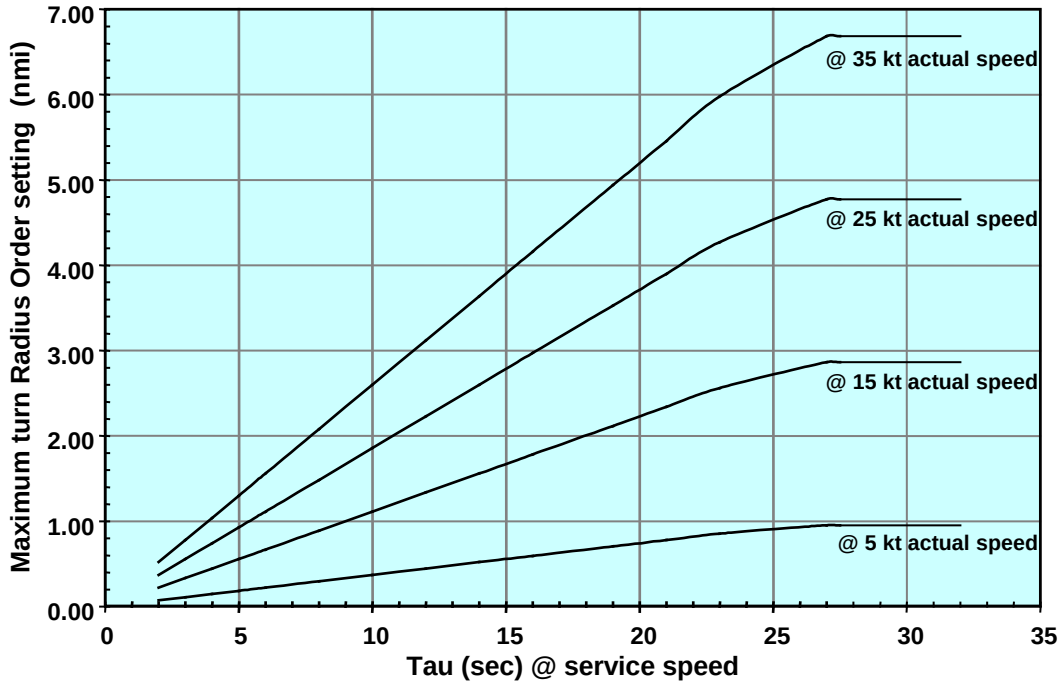


Figure 1-6. Maximum Turn Radius Order Chart (for Navipilot 4000)

1.4.2 Navipilot 4000 HSC – Vessel Application Rules

The NAVIPILOT 4000 HSC and NAVIPILOT 4000 TRACK HSC are applicable to vessels meeting the following requirements:

- Vessel Type - Monohull and Multihull High Speed Vessels
- Vessel Size - Any
- Vessel Speed - 5 to 99 knots
- Vessel Steering Devices - Any of the following: Rudders, Azimuthing Propellers, Azipods, Jet Thrusters

Figure 1-7 is a nomogram for determining Tau; refer to Appendix D for additional information on calculating Tau.

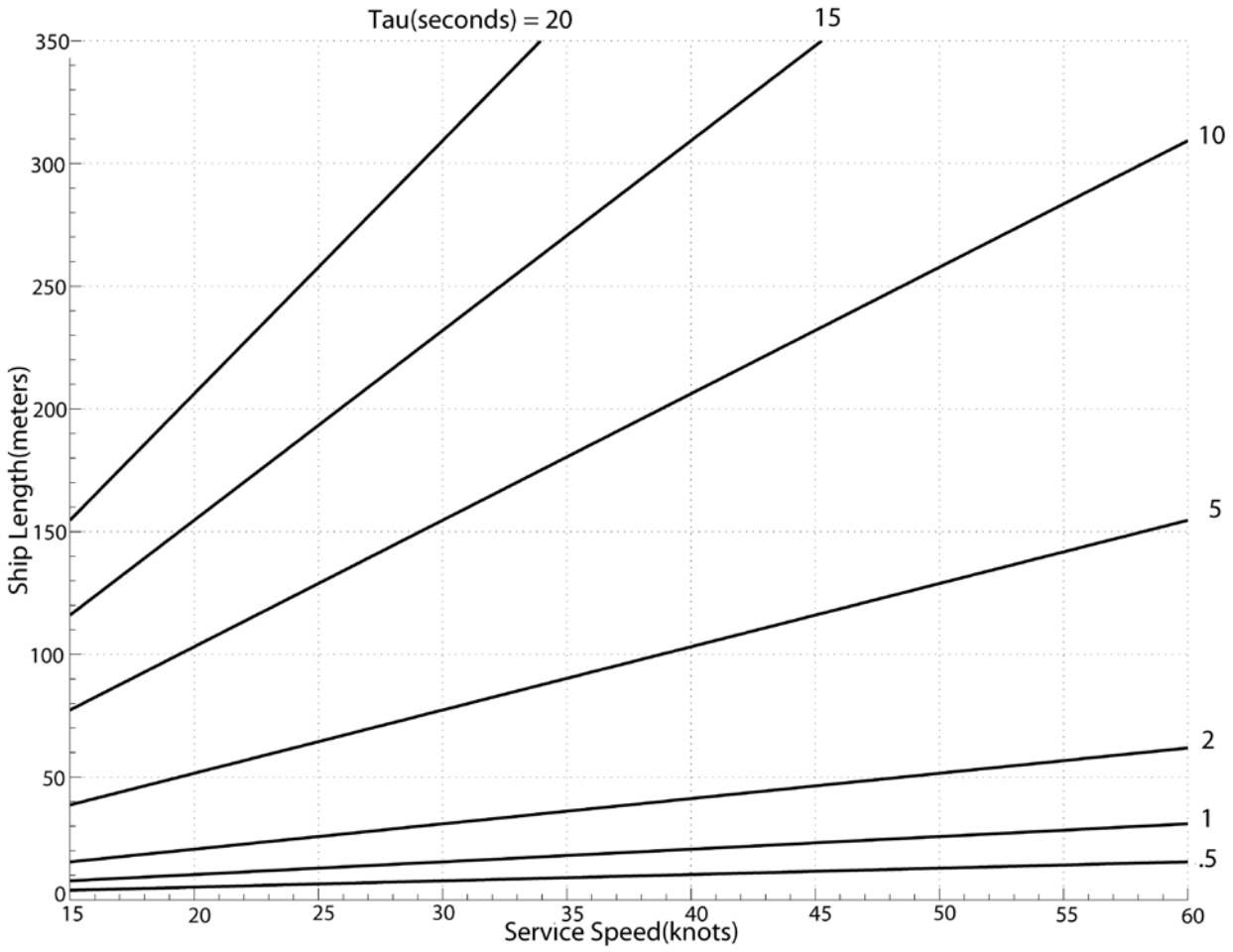


Figure 1-7. Tau Nomogram (for Navipilot 4000 HSC)

1.4.3 Interface Requirements

Interface specifications for the NAVIPILOT are listed in Table 1-4.

Table 1-4. NAVIPILOT Interface Specifications

Power:	
SCU Primary Power Input	24V AC/DC, 3A (18 – 36 V range)
SCU Backup Supply Input	24 VDC, 3A (18 – 36 V range)
SCU Power Output to CDU	24 VDC, 1 Amp Max. (unregulated, based on Primary Power)
SCU DC Supply Output to CDU	24 VDC, 0.5 Amp Max. (unregulated, based on Primary Power)
Heading Inputs:	
Heading 1 and Heading 2:	
Interface Type	RS-422, optically isolated
Message Format	NMEA 0183
Selectable Message Types	HDT (True Heading) HEHDT (North-Seeking Gyro - True Heading) NSD (Navigation Status Data) HDM (Magnetic Heading) HDG (Heading, Deviation, and Variation) HCHDT (Magnetic Compass - True Heading)
Message Rate	10 Hz
Fluxgate	Interface to C.Plath Jupiter Magnetic Compass
Speed Inputs:	
Serial Speed:	
Interface Type	RS-422, optically isolated
Message Format	NMEA 0183
Selectable Message Types	VBW (Dual Ground/Water Speed) VHW (Water Speed and Heading) VTG (Course Over Ground and Ground Speed)
Message Rate	1 Hz
Pulse Speed	200 pulse per nautical mile contact closure input, internal pull-up to +24V

Table 1-4. NAVIPILOT Interface Specifications (Continued)

Navigator Interface:	
Interface Type	RS-422, optically isolated
Message Format	NMEA 0183
Selectable Message Types:	
NAV Mode (Sperry VisionMaster FT)	HSC (Heading to Steer Command), PROP-HTC (Proprietary Heading To Complete), HTR (Heading Turn Rate)
Waypoint Mode (GPS and compatible non-Sperry chart systems)	APB (Heading/Track Controller [Autopilot] Sentence B) HSC/XTE (Heading-to-Steer Command/ Cross-Track Error)
Voyage Data Recorder (VDR) Interface:	
Interface Type	RS-422, serial output, 9600 baud
Message Format	NMEA 0183
Selectable Message Types	HTD (Heading/Track Control Data) RSA (Rudder Sensor Angle)
External System Analog Input	+/-10V range, via an onboard isolation amplifier
Repeater Output:	
Interface Type	RS-422. Configurable to be on or off.
Message Format	NMEA 0183
Message Types	Depending on heading inputs: AGHDT (Heading/Track Controller [General] - True Heading) AGNSD (Heading/Track Controller [General] - Navigation Status Data) AGHDM (Heading/Track Controller [General] - Magnetic Heading)
Central Alarm Interface:	
Interface Type	RS-422. Central Alarm Manager (CAM) or Rudder Repeatback (RRB) output (not optically isolated). Acknowledge input (optically isolated).
Alarm Message Format	NMEA 0183
Configurable Functions	CAM, RRB, Off
Baud Rates	38.4k (RRB) 4800, 9600, 19.2k, 38.4k (CAM)
Alarm Contacts:	
Dedicated	Primary Supply Failure, Backup Supply Failure, Off Heading Alarm, System Alarm. NO and NC contacts provided for each. All contacts rated 115 VAC @ 0.5 A max. or 30 VDC @ 1A max.
Configurable	Three configurable relays. NO and NC contacts provided for each. All contacts rated 115 VAC @ 0.5 A max. or 30 VDC @ 1A max.

1.5 RELATED PUBLICATIONS

Table 1-5 lists Sperry Marine publications related to the NAVIPILOT. These publications describe Sperry Marine steering control equipment which may be used in conjunction with the NAVIPILOT.

Table 1-5. Related Publications

Number	***Title***	Remarks
056336	NAVIGUIDE 4000 - User, Installation, and Service Manual	Contains descriptions of the following equipment: Bus Interface Units (BIUs): FU Mini-Wheel/Display Unit (FMW) FU Interface/Display Unit (FID) Steering Mode Selector (SMS) Steering Position Selector (SPS) Dual Rudder Sync Selector (DRS) Steering Alarm Module (SAM) Steering Mode Selector/NFU (Non-Followup) Tiller Mechanical Mode Switch (MMS) FU (Followup) Hand Wheel NFU Override Unit
056246	Proportional Amplifier for Solenoid Valves - Changing Factory Settings	--
056319	***Override Control Type 4218 - Operating Instructions***	**--**
056328	Rudder Angle Feedback Unit Type 4968 - Operator, Technical, Installation, and Service Manual	**--**
65900012-2	VisionMaster FT ECDIS User Guide	**--**

CHAPTER 2

OPERATION (NAVIPILOT 4000 / NAVIPILOT 4000 TRACK)

2.1 INTRODUCTION

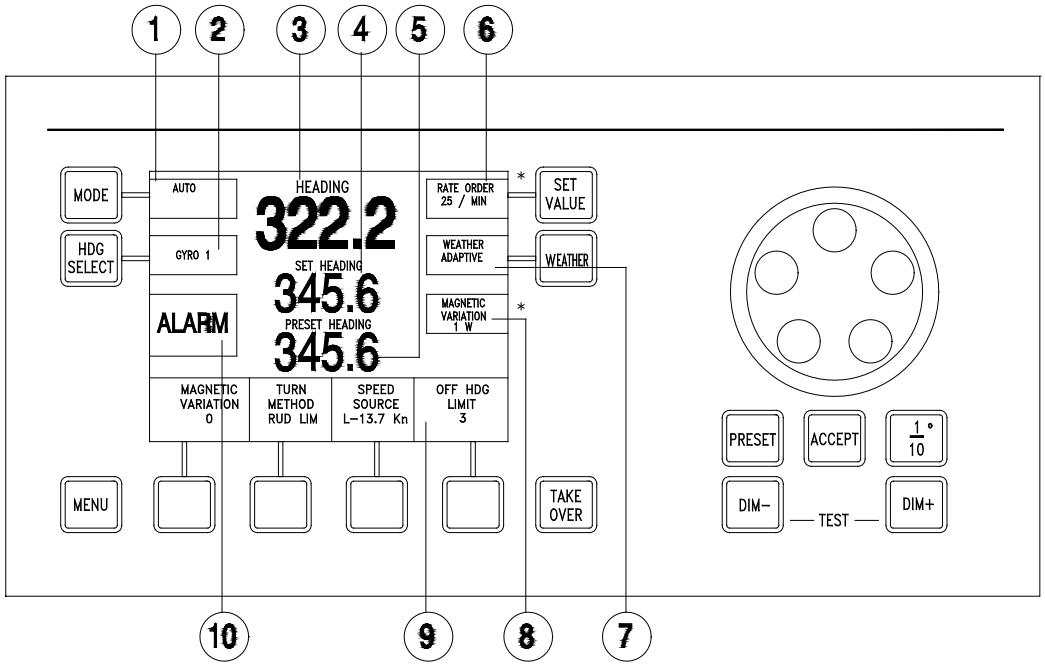
This chapter describes operating procedures and associated Control and Display Unit (CDU) displays for the following systems: NAVIPILOT 4000 and NAVIPILOT 4000 TRACK. Throughout this chapter, the system is generally referred to as NAVIPILOT 4000, or simply as the NAVIPILOT. All features of the NAVIPILOT 4000 also apply to the NAVIPILOT 4000 TRACK.

The NAVIPILOT 4000 TRACK provides additional capabilities, for operation in NAV CONTROL mode (see section 2.8). The applicability of procedures and displays associated with this mode of operation is indicated in the text.

For operation of the NAVIPILOT 4000 HSC and NAVIPILOT 4000 TRACK HSC, see Chapter 3.

2.2 CDU DISPLAYS

The Control and Display Unit (CDU) display for the NAVIPILOT 4000 is shown in Figure 2-1. A description of each CDU display area is provided in Table 2-1.



* IF THE TOP WINDOW IS CONFIGURED TO DISPLAY RUDDER LIMIT, RATE ORDER, OR RADIUS ORDER (OPERATOR RUDDER LIMIT IS SET TO W/O RAD/RATE CTRL IN SERVICE SETUP 2) THEN THE BOTTOM WINDOW WILL DISPLAY MAGNETIC VARIATION. IF THE TOP WINDOW IS CONFIGURED TO DISPLAY RUDDER LIMIT ONLY (OPERATOR RUDDER LIMIT IS SET TO W/RAD/RATE CTRL IN SERVICE SETUP 2), THEN THE BOTTOM WINDOW IS AUTOMATICALLY CONFIGURED TO DISPLAY RATE ORDER OR RADIUS ORDER. MAGNETIC VARIATION WILL BE DISPLAYED AS AS A DISPLAY OPTION.

Figure 2-1. NAVIPILOT 4000 CDU Display

Table 2-1. NAVIPILOT 4000 CDU Display Controls and Indicators

Item No.	*Title*	*Description*	
①	*MODE Display*	Displays the following information:	
		a. Mode - Operating mode of the NAVIPILOT 4000:	
		AUTO	The NAVIPILOT performs automatic heading keeping. Using heading data from the compass and the operator's SET HEADING setting, the NAVIPILOT automatically generates rudder commands as needed to keep the actual heading as close as possible to the set heading. See section 2.8.1 for details.
		WAYPOINT CONTROL	The NAVIPILOT computes heading orders based on waypoint data and cross-track error received from a GPS or a compatible navigation system other than the Sperry VisionMaster FT (see section 2.8.2).
		NAV CONTROL	The NAVIPILOT executes heading commands received from the Sperry VisionMaster FT (see section 2.8.3). This mode is available with NAVIPILOT 4000 TRACK.
		NFU or STANDBY	A Non Follow-Up (NFU) device, such as a tiller, is in control of steering. (An NFU device moves the rudder in the desired direction, but not to a specific final angle.) The rudder command signals are sent to the steering gear, independent of the NAVIPILOT system. On most vessels, this is considered an emergency mode of steering. Whether the display indicates NFU or STANDBY is dependent on the system configuration–refer to Appendix A (Table A-4) for details.
		FU or HELM	A Follow-Up (FU) device, such as the ship's helm wheel or a Followup Mini-Wheel (FMW), is in control of steering. (An FU device commands the steering control equipment to move the rudder to a specific angle.) Whether the display indicates FU or HELM is dependent on the system configuration–refer to Appendix A (Table A-4) for details.
		EXTERNAL or external system name	An external system such as a Dynamic Positioning System (DPS) is in control of steering. The external system sends rudder commands through the NAVIPILOT, which routes the signals to the steering gear to move the rudder. The external system will sometimes include its own available modes of operation. A number of names may be selected as the External System Name to make the indication more appropriate to the specific type of external system–refer to Appendix A (Table A-4) for details.
		b. ACTIVE status - When the CDU is the station in control of steering, ACTIVE is displayed in reverse video below the operating mode.	
		c. OVERRIDE status - When steering control has been overridden by an external device, OVERRIDE is displayed in reverse video below the operating mode. The OVERRIDE indication flashes when it is displayed. See section 2.6 for details.	

Table 2-1. NAVIPILOT 4000 CDU Display Controls and Indicators (Continued)

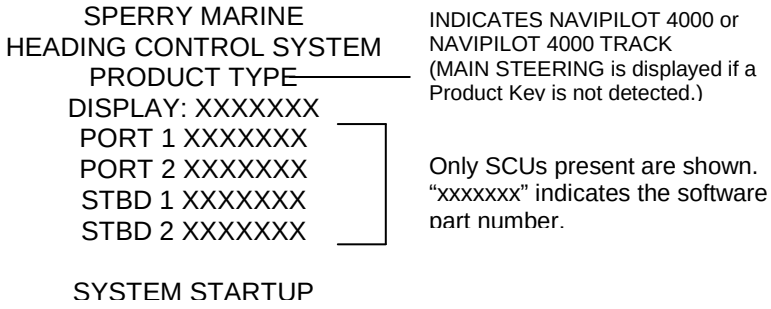
Item No.	*Title*	*Description*	
②	**HDG SELECT Display**	Displays the heading source selected by the operator.	
③	**HEADING Display**	Displays the actual heading from the selected compass. "****" indicates loss of heading data.	
④	**SET HEADING Display**	Displays the set heading (heading order).	
⑤	**PRESET HEADING Display**	Displays the preset heading value which has been selected using the PRESET button and the order control knob. If manual speed has been selected (and the CDU is in control), this area will display the selected manual speed (MAN SPD) in knots. If a Preset Heading function is selected while manual speed is displayed, the Preset Heading information will be displayed in place of the MAN SPD information as needed.	
⑥	**TURN METHOD Display**	Displays information on the selected turn method:	
		RUD LIM	Rudder Limit. Maximum rudder angle, in degrees. RL icon in reverse video indicates that the rudder limit has been reached.
		RATE	RATE order is accessed in this position if system is configured to w/o RAD/RATE CTRL in service setup 2. Shown Ordered turn rate, in degrees per minute.
		RADIUS	RADIUS order is accessed in this position if system is configured to w/o RAD/RATE CTRL in service setup 2. Ordered turn radius, in nautical miles. (This method is only available if the speed source is set to LOG).
		The display will flash if an alarm occurs that forces a change in turn method or in the turn method's current value. (see also item 10 below).	
⑦	**WEATHER Display**	Displays the gain selection chosen to compensate for sea conditions. If Adaptive Self-Tuning is enabled, either Manual or Adaptive weather control can be selected. If Manual weather control is selected, the WEATHER display shows a number from 1 through 7, which is selectable by the operator. 1 is the highest gain (for low sea states); 7 is the lowest gain (for high sea states). If Adaptive weather control is selected, the WEATHER display shows the word ADAPTIVE, and the NAVIPILOT automatically adjusts the gain to compensate for sea conditions. If Adaptive Self-Tuning is disabled, only the Manual mode of weather control is available, as described above.	
⑧	**MAGNETIC VARIATION Display or TURN METHOD**	Configurable display area. If system is configured w/o RAD/RATE CTRL in service setup 2 and Magnetic Variation is selected from display options, displays the magnetic compass correction for the geographical location. This information is displayed if a fluxgate magnetic compass has been connected directly to the NAVIPILOT SCU. The operator may adjust the variation. If system is configured w/ RAD/RATE CTRL in service setup 2, displays either RADIUS ORDER or RATE ORDER.	

Table 2-1. NAVIPILOT 4000 CDU Display Controls and Indicators (Continued)

Item No.	*Title*	*Description*
⑨	**Soft Key Displays**	Display the control and monitoring functions that are selectable using the MENU button and the four soft keys located below the display area.
⑩	**ALARM Display**	When ALARM is displayed in this area, one or more alarm conditions are present. If the alarm is caused by an Off Heading condition, OFF HDG will also be displayed.

2.3 POWER-UP

The system in which the NAVIPILOT is installed must be set to a manual steering mode before the NAVIPILOT is powered-up. During power-up, the NAVIPILOT performs a self-test. After the self-test, the system beeps once and presents the following start-up screen:



2.4 PRODUCT KEY

The Product Key is a hardware device, which is installed to each CDU at the time of system installation, and which provides read-only data to the NAVIPILOT for system licensing and security. The data that is stored at the Product Key is used to unlock the system's automatic pilot functions, including operation in AUTO, NAV or WAYPOINT modes.

During operation, only one product type (NAVIPILOT 4000, NAVIPILOT 4000 TRACK, NAVIPILOT 4000 HSC, or NAVIPILOT 4000 TRACK HSC) can be active throughout the system. The NAVIPILOT uses the Key Type data stored at the Product Key for recognition of the installed product type, and so the Key Type of the Product Keys at all CDUs should always match the active product type.

The NAVIPILOT is supplied with matched Product Keys, installed at all CDU's. These should remain in place while the system is in use, and should be changed (if necessary) only by a Sperry field engineer.

NOTE: Any change to the Product Keys does not become active until after the SCU is shut down and restarted.

2.4.1 Product Key Activation on Startup

The NAVIPILOT uses the data from the Product Keys each time the SCU is powered up. To ensure continued operation in case of a short power disruption, the most recent previous key value is used at system startup, and the keys are inspected 30 seconds after startup of the SCU. If a new key value seen after 30 seconds is different from the previous value then the new key value is saved for the next startup. This new key value is not used until after the next SCU startup, but an alarm is issued if a problem with the key is detected.

The Key Type for the active Product Key at any CDU can be displayed using the KEY TYPE indication, which is accessed from the Display Options feature (see section 2.19). The system-wide product type can also be displayed using the CONFIG ID indication of the Display Options feature. Under normal conditions, the KEY TYPE and CONFIG ID indications will match.

If a Product Key should malfunction, the system will start and operate normally as long as a valid Product Key remains in place at one CDU. The additional keys provide redundancy to provide for normal operation, for example, after failure of a single CDU.

2.4.2 Product Key Error Conditions

After startup, the NAVIPILOT verifies the status of the Product Key at each CDU, and will issue alarms under the following conditions:

- If no key is detected at a single CDU, or if other conditions exist which prevent the detection of the key at a CDU, a Missing Key alarm is issued (see Alarm 196, Table 5-1).
- If the baud rate on the CDU Service Interface port is set incorrectly, a Missing Key alarm is issued (see section A.4.2, Table A5).
- If the SCU(s) are powered up before the CDUs, a Missing Key alarm is generated after 30 seconds. After the CDUs have started this alarm can be acknowledged and will not recur if valid key(s) are present.
- If a mis-match is detected between Product Keys at different CDUs, a Key Mismatch alarm is issued (see Alarms 197-198, Table 5-1).
- If no Product Keys are detected, the SCU will continue to function but will be limited to its manual modes of operation. Under these conditions, capabilities which are specifically associated with any of the four product types (see section 1.2) will not be available. This limited mode of operation is known as Main Steering mode.

NOTE: If the Product Key is changed at any CDU during system operation, without a restart of the SCU, a mis-match will occur between the system's displayed CONFIG ID (representing the product type), and the active Key Type at that CDU. If this should occur, NO ALARM IS ISSUED. In order for the new Product Key to take effect, each SCU should be shut down and restarted. Inappropriate changes to the Product Key can result in the NAVIPILOT transitioning to MAIN STEERING mode, as described above, with associated loss of full functionality.

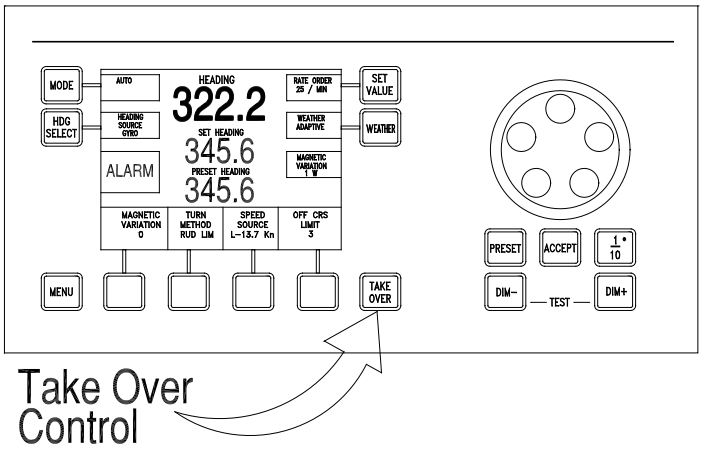
2.5 STEERING CONTROL TRANSFER (TAKEOVER METHOD)

The methods for transferring steering control to or from a NAVIPILOT Control and Display Unit (CDU) are dependent on the NAVIPILOT's configuration settings for TAKEOVER METHOD (see Appendix A), and on the types of external devices included in the steering system. The paragraphs below describe the NAVIPILOT's general functionality with respect to each of the three possible TAKEOVER METHOD configurations: NONE, CALL UP, or TAKEOVER. Optional units such as a Mechanical Mode Switch or the various types of Bus Interface Units (see Table 1-5) may be installed as part of the NAVIPILOT system, and will play a role in the control transfer process described below. In many cases, the specific devices installed will dictate which method is configured at the CDU and at optional remote devices.

IMPORTANT SAFETY NOTE: The person in charge of navigation must ensure that all personnel have a working knowledge of the transfer method(s) used for the particular installation, including optional override capabilities at devices external to the NAVIPILOT. Inappropriate transfer of control could result in hazards to navigation, resulting in danger to personnel.

2.5.1 NONE

When the NAVIPILOT is configured for NONE as the method of steering control transfer, steering control is transferred to the NAVIPILOT via a Mechanical Mode Switch, a Bus Interface Unit (see Table 1-5), or another external device. Pressing the TAKE OVER button at the CDU (see illustration) has no effect. In this case, the label on the button will normally be hidden, to avoid possible misinterpretation of the button function.



2.5.2 CALL UP

When the NAVIPILOT is configured for CALL UP as the method of steering control transfer:

1. The station in control of steering must make an offer to transfer control.

2. The station taking control of steering must accept that offer.

At the CDU or Bus Interface Unit (see Table 1-5) with control of steering, the operator presses the TAKE OVER button to offer control. When the CDU makes an offer in this manner, or receives an offer from another location, READY FOR TAKEOVER is displayed at the CDU in reverse video. Also, the Preset Heading selection (section 2.8.1) is cancelled at the CDU offering control. An operator at another CDU or Bus Interface Unit receiving the offer presses the TAKE OVER button at that device, to complete the transfer and take control.

To cancel an offer of steering control before it has been accepted, the operator at the station in control presses TAKE OVER again.

2.5.3 TAKEOVER

When the NAVIPILOT is configured for TAKEOVER as the method of steering control transfer:

- A CDU can take control of steering without a formal offer from the station in control, when the operator presses the TAKE OVER button.
- However, the CDU's ability to take control in this manner is dependent on:
    a. The setting(s) of the external mode selection device(s).
    b. Whether the CDU is configured to be at the main steering location, or at a remote steering location.

The "main" or "remote" designation of a CDU is established by its configuration setting for LOCATION (see Appendix A, Table A-5), not by its physical placement. All LOCATION settings for a CDU other than MAIN are considered to be remote locations. The TAKEOVER method is normally used only when there is more than one CDU at the main location, and/or more than one CDU at remote location(s). With a single CDU, one would normally use the NONE configuration for takeover method, and use a Mechanical Mode Switch or Steering Mode Selector for control transfer.

IMPORTANT SAFETY NOTE: When TAKEOVER method is configured, it is important to realize how easy it is to take control of steering at a new location. Personnel access to locations with takeover devices must be appropriately restricted or monitored.

For a CDU at the main steering location:

1. If a Mechanical Mode Switch (MMS) (see Table 1-5) is used for steering mode selection, the switch must be set to AUTO for a main steering CDU to be able to take control of steering.

    a. When the MMS is changed to AUTO from any other mode setting, READY FOR TAKEOVER is displayed at each main steering CDU in reverse video, and any main steering CDU can take control by pressing TAKE OVER.

    b. As long as the MMS remains set to AUTO, the operator at any main steering CDU can take control from any other main steering CDU by pressing the TAKE OVER button.

2. If a Steering Mode Selector (SMS) (see Table 1-5) is used for steering mode selection, a main steering CDU may take control regardless of the SMS setting. If the system was not in AUTO mode when the CDU took control, the SMS mode display will automatically change to indicate that the system is now in AUTO mode.

For a CDU at a remote steering location:

1. The MMS or SMS must be set to REMOTE for a remote CDU to be able to take control of steering.

2. When the MMS or SMS is changed to REMOTE from any other mode setting, READY FOR TAKEOVER is displayed at each remote steering CDU in reverse video, and any remote CDU can take control by pressing TAKE OVER.

3. As long as the MMS or SMS remains set to REMOTE, the operator at any remote CDU can take control from any other remote CDU by pressing the TAKE OVER button.

However, if there are two steering control devices on the CAN bus which are configured to be at the same remote location, such as a CDU and a Followup Mini-Wheel (FMW):

1. An SMS must also be installed at that remote location.

2. To perform takeover of steering control, the operator must press TAKEOVER at the SMS, rather than at the CDU or FMW.

2.6 STEERING CONTROL OVERRIDE

The NAVIPILOT can be configured to allow override of steering control by an external device in various operating modes. Configuration instructions for the service technician are provided in Appendix A. There are three types of steering control override:

- EXTERNAL OVERRIDE - Override when an external device is actuated, as indicated by a contact-closure at the SCU's OVERRIDE input (pins 32 and 33).
- MINIWHEEL OVERRIDE - Override when a Follow-Up Mini-Wheel (see Table 1-5) is actuated.
- ABS OVERRIDE - Override when the main helm wheel is actuated.

2.6.1 External Override and Miniwheel Override

By using the SCU CONFIGURATION - OVERRIDE ACTIVE IN menu (see Appendix A), the service technician can select the operating modes in which the NAVIPILOT will allow External Override and Miniwheel Override. This menu provides the following options (refer to Table 2-1 for mode descriptions):

- None
- AUTO, NAV, and WAYPOINT modes
- EXTERNAL mode
- FU mode
- AUTO, NAV, WAYPOINT, and EXTERNAL modes
- AUTO, NAV, WAYPOINT, and FU modes
- AUTO, NAV, WAYPOINT, EXTERNAL, and FU modes
- EXTERNAL and FU modes

The NAVIPILOT will allow External Override in each of the configured modes. For Miniwheel Override:

- Override capability must be enabled at the Follow-Up Mini-Wheel (FMW). Otherwise, the FMW cannot override steering control in any mode.
- If override capability is enabled at the FMW, the FMW can override steering control in the configured operating mode(s) as listed above, with one exception. An FMW can never override steering control when the system is in FU mode, even if FU is configured as one of the modes that can be overridden. This means, for example, that one FMW cannot override another FMW, nor can it override the main helm wheel.

When steering control has been overridden by an external device, OVERRIDE is displayed in reverse video below the operating mode on the CDU display. The OVERRIDE indication flashes when it is displayed.

The NAVIPILOT can be configured to generate an alarm if steering control is overridden. The following options are configurable (see Appendix A for details):

- NONE. No override alarms are generated
- FMW. An alarm is generated if Miniwheel Override occurs
- EXT. An alarm is generated if External Override occurs
- FMW+EXT. An alarm is generated if Miniwheel Override or External Override occurs

2.6.2 ABS Override

By using the SCU CONFIGURATION - ABS OVERRIDE menu (see Appendix A), the service technician can enable or disable ABS Override. (ABS Override is normally not enabled unless required by the inspecting agency.) If ABS Override is enabled, actuation of the main helm wheel will override AUTO, NAV, and WAYPOINT modes. For override to occur, the wheel must be moved from the center position for more than two seconds, by more than the value configured by the service technician (3 to 8 degrees).

When the helm wheel overrides control of steering:

- OVERRIDE is displayed in reverse video below the operating mode on the CDU display, as described above for External Override and Miniwheel Override.
- An ABS OVERRIDE alarm is generated.

After an ABS override takes place, the steering system should be set to HELM mode. To resume automatic mode, the system should be set back to AUTO.

2.7 MODE SELECTION

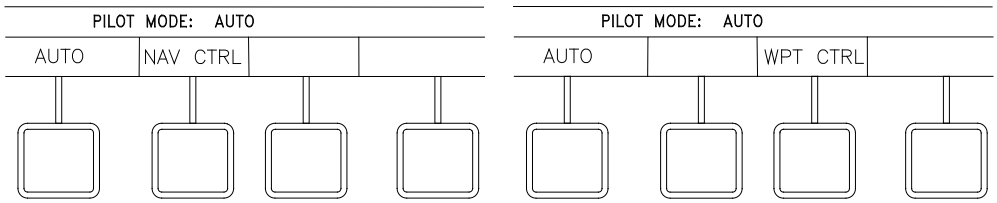
A CDU can be used to select AUTO, or WAYPOINT operating modes, or NAV mode on systems where it is available. Other operating modes (NFU/STANDBY, FU/HELM, EXTERNAL) can only be selected by an external device, such as a Mechanical Mode Switch (MMS) or Steering Mode Selector (SMS). For instructions on selecting the operating mode using external devices, refer to the technical manual(s) for those devices (see Table 1-5).

NOTE: Mode selection can be performed at the CDU only if the CDU is the station in control of steering.

The available operating modes (also known as Pilot Mode) are described in Table 2-1. A more detailed description of heading control in AUTO, WAYPOINT and NAV modes is provided in section 2.8. NAV mode (see section 2.8.3) is available with the NAVIPILOT 4000 TRACK.

To select the operating mode at the CDU in control of steering:

Press the MODE button to display the available mode options. If the system has the capability for NAV mode operation, the NAV CTRL soft key will be available. If the system has the capability for WAYPOINT mode operation, the WPT CTRL soft key will be available.



The current operating mode (for example, PILOT MODE: AUTO) is indicated above the soft key labels. To select a different operating mode, press the associated soft key.

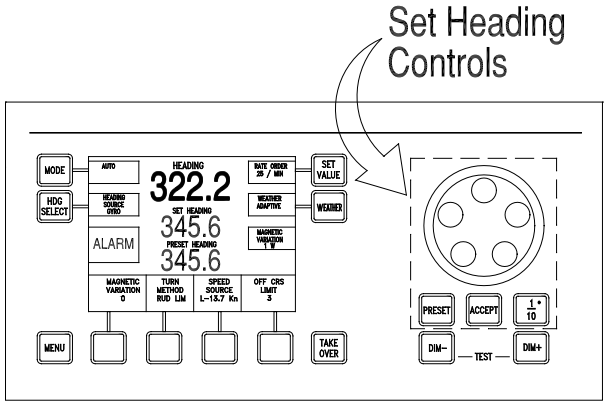
2.8 HEADING CONTROL

The following sections provide information on heading control in the following modes of operation: AUTO mode (section 2.8.1), WAYPOINT mode (section 2.8.2), and NAV mode (section 2.8.3).

2.8.1 AUTO Mode

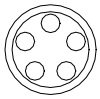
AUTO mode can be selected from the CDU in control of steering, by selecting the AUTO soft key, as shown in section 2.7.

In AUTO mode, the NAVIPILOT performs heading keeping by automatically moving the rudder as needed to keep the actual heading as close as possible to the Set Heading. Course changes can be made in AUTO mode either by turning the Set Heading knob, or by using the two-step Preset and Accept method described below.



Set Heading

NOTE: The Set Heading controls are functional only when the CDU is the station in control of steering.



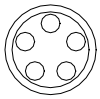
To increase the Set Heading, turn the order knob clockwise. To decrease the Set Heading, turn the order knob counterclockwise. The Set Heading will increase or decrease in 1° increments as the knob is turned.

To increase or decrease the Set Heading in 1/10° increments, press and release the 1/10° button, then turn the order knob. The 1/10° symbol will appear on the display while this function is active, and the function will timeout automatically.

Preset Heading

NOTE: The Preset Heading function should not be used when an OVERRIDE condition is indicated at the CDU (see section 2.6). The PRESET button is disabled when the CDU is overridden.

Press the PRESET button to enable preset heading entry.



To select the Preset Heading value in 1° increments, use the order knob as described in the Set Heading instructions above.

To select the Preset Heading value in 1/10° increments, use the 1/10° button and order knob as described in the Set Heading instructions above.

Press ACCEPT to make the preset heading the set heading. The PRESET HEADING value will clear, and that value will appear as the SET HEADING, indicating that the entered preset heading has been accepted. If PRESET is pressed prior to ACCEPT, the preset mode is canceled.

NOTE: If an alarm occurs while using the Preset function, pressing the ACCEPT button will first acknowledge (silence) the alarm. ACCEPT must be pressed a second time to accept the preset order.

2.8.2 WAYPOINT Mode

WAYPOINT mode can be selected from the CDU in control of steering by selecting the WPT CTRL soft key, as shown in section 2.7.

In WAYPOINT mode, the NAVIPILOT computes heading orders based on waypoint and cross-track error data received from a GPS or other compatible navigation system. WAYPOINT mode is used when the NAVIPILOT is interfaced to a system other than the Sperry Marine VisionMaster FT.

To operate in WAYPOINT mode, a route plan must be programmed and active at the connected system. While WAYPOINT mode is active, the NAVIPILOT computes the heading order required to stay on the plan, and automatically adjusts the Set Heading accordingly.

Before selecting WAYPOINT mode at the NAVIPILOT, the operator must have a good working knowledge of the connected system. The method used for waypoint course changes will depend on the connected system's configuration and operator setup. In some cases, the operator must approve the next leg at the connected system before the vessel steers the new planned course. In other cases, the next leg of the plan is automatically selected at an operator-specified distance from the waypoint. In some instances, the NAVIPILOT will steer the new planned course with no operator action required. It is important that appropriate setup choices be made at

the connected system, so that course changes will be executed as intended.

SAFETY NOTE: Some systems may allow course changes to occur with no alarms or warnings. The operator must monitor progress on the route plan, and be prepared to take appropriate action when approaching plan waypoints. If there is any uncertainty with regard to how the connected system will respond at the waypoint, the operator should switch the NAVIPILOT to AUTO mode to make the course change. WAYPOINT mode operation can be resumed on the next leg of the plan, after the operator verifies that the connected system has selected the appropriate waypoint.

When a turn is made in WAYPOINT mode, the NAVIPILOT 4000 controls the turn using the operator-selected Turn Method (section 2.13), and the active value for Rudder Limit, Turn Rate, or Turn Radius (section 2.14). If it becomes necessary to change the Turn Method or adjust the associated values, the NAVIPILOT must be switched out of WAYPOINT mode. These values cannot be adjusted while WAYPOINT mode is active.

The CROSS TRACK ERROR display option (section 2.19) becomes available when WAYPOINT mode is selected. The bar graph and numeric readout of cross-track error represent truncated values to a resolution of 0.1 nautical mile. This display should not be viewed as a precise indication of XTE. The connected system will normally provide a more precise display of XTE.

The Cross-Track configuration settings (see Appendix A, Table A-3) will affect performance in WAYPOINT mode. Default values normally provide good results, but adjustments may be needed for certain types of vessels. Only a Sperry Marine authorized service technician should make these adjustments.

As described in Appendix A (Table A-4), the NAVIPILOT is configured for WAYPOINT mode operation by selecting one of the following NMEA 0183 message types for the NAV interface, as appropriate for the external system being used:

- APB - Heading/Track Controller (Autopilot) Sentence “B.”
- HSC/XTE - Heading-to-Steer Command/Cross-Track Error.

2.8.3 NAV Mode

NAV mode can be selected from the CDU in control of steering by selecting the NAV CTRL soft key, as shown in section 2.7. NAV mode is available when the NAVIPILOT is interfaced to a Sperry VisionMaster FT (VMFT).

When the NAVIPILOT is in NAV mode, the VMFT determines the required heading order and delivers it to the NAVIPILOT in the form of Heading to Steer commands. The generation of heading commands at the VMFT is based on the present mode of operation of the VMFT/Autopilot interface, as controlled at the VMFT. For more information on the operation of the VMFT, refer to the applicable technical manual (see Table 1-5).

Track Control operation is available when the NAVIPILOT is set to NAV mode while a route plan is active at the VMFT. In this mode of operation, the VMFT sends heading orders to the NAVIPILOT to keep the vessel on the planned track line. Course changes are executed at wheel-over points, which are calculated by the VMFT based on vessel characteristics and the planned turn radius. When the vessel reaches the wheel-over point, the VMFT changes the heading command gradually, to control the vessel’s progress through the course change.

For full functionality of VisionMaster Joystick or VM Heading modes under adverse sea conditions, VisionMaster 4.0.2 (or later) should be used in order to insure optimum behavior.

SAFETY NOTE: NEVER select NAV mode if the NAVIPILOT is controlled by a system other than the Sperry VisionMaster FT. Steering behavior could become unpredictable, resulting in danger to personnel and to the vessel.

When NAV mode is selected, the Turn Method (see section 2.13) is automatically switched to Rate Order. At wheel-over points programmed in the route plan, the NAVIPILOT indicates RATE ORDER OFF while the VMFT controls the turn rate through the turn. The Turn Method and Turn Rate cannot be adjusted at the NAVIPILOT while in NAV mode. During NAV mode turns, the gradually changing heading order, as well as the required rate order, can be viewed at the VMFT display. The VMFT default turn rate is displayed while on a straight leg in the route plan.

As described in Appendix A (Table A-4), the NAVIPILOT 4000 HSC is configured for NAV mode operation by setting the NMEA 0183 message type for the Track Control interface to HSC, PROP-HTC, HTR (Heading to Steer Command, Proprietary Heading To Complete, Heading Turn Rate).

In NAV mode, the NAVIPILOT provides predictable heading control even if there is a failure of the controlling system during a turn.

As described in Appendix A (Table A-4), two LOST NAV options are configurable, as follows:

- RES HDG (Resume on Heading). The current heading at the time that NAV mode functionality is lost becomes the Set Heading.
- COMPL TURN (Complete the Turn). When NAV mode functionality is lost, the bearing of the next leg of the turn becomes the Set Heading, allowing the NAVIPILOT to complete the turn to the new course. The COMPL TURN configuration is mandatory under the rules of some classification societies (including DNV Watch 1), and is optional for other vessels.

The LOST NAV configuration also affects:

- The functionality of the NAVIPILOT Set Heading display during a NAV mode turn, and
- The functionality of the NAVIPILOT when the operator changes the operating mode from NAV to AUTO during a turn.

The specific behavior of the NAVIPILOT for each LOST NAV configuration is dependent on whether the NAV STEERING MODE MSG (message) from the VisionMaster FT is configured for use (see Appendix A, Table A-4).

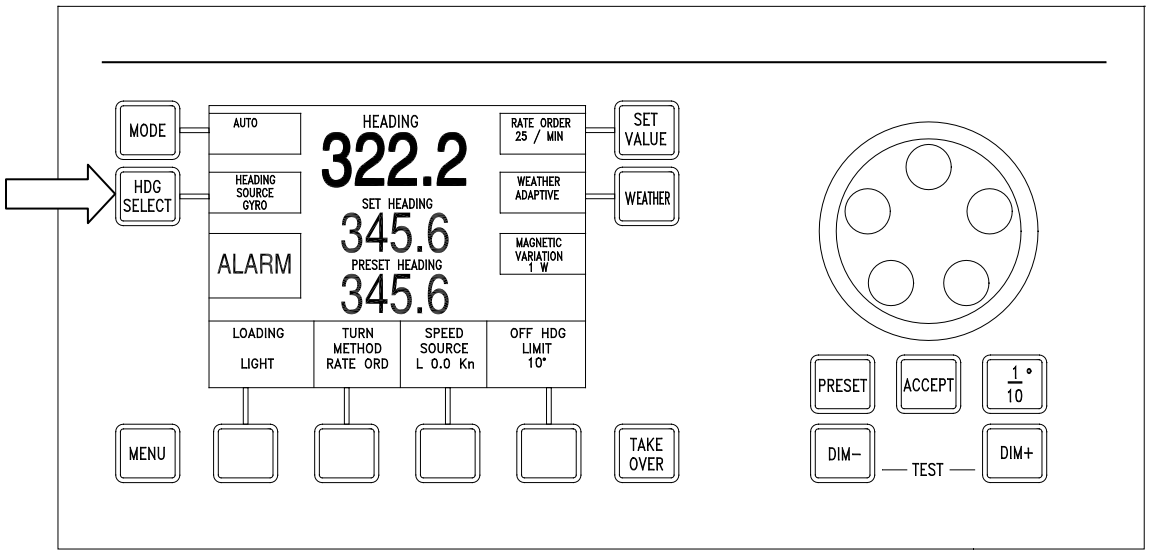
Table 2-2 describes NAV mode functionality in each LOST NAV and NAV STEERING MODE MSG configuration.

Table 2-2. NAV Mode Functionality – NAVIPILOT 4000 TRACK

LOST NAV Configuration	*NAV STEERING MODE MSG Configuration*	*Event*	*Behavior*
Any	Any	A turn is executed in NAV mode.	The Set Heading displayed at the CDU will change incrementally, in accordance with the Heading to Steer Command from the VisionMaster FT.
RES HDG	Any	The operator changes the mode from NAV to AUTO during a turn.	The NAVIPILOT will Resume on Heading.
	YES (see Note)	NAV mode functionality is lost during a turn.	The NAVIPILOT will automatically transition to AUTO mode and Resume on Heading.
	NO	NAV mode functionality is lost during a turn.	The NAVIPILOT will generate a NAV MODE NOT AVAILABLE alarm and Resume on Heading. The operator must then change the NAVIPILOT from NAV to AUTO mode.
COMPL TURN	YES (see Note)	The operator changes the mode from NAV to AUTO during a turn.	The NAVIPILOT will Resume on Heading.
		NAV mode functionality is lost during a turn.	The NAVIPILOT will automatically transition to AUTO mode, and Complete the Turn.
	NO	The operator changes the mode from NAV to AUTO during a turn.	The NAVIPILOT will Complete the Turn.
		NAV mode functionality is lost during a turn.	The NAVIPILOT will generate a NAV MODE NOT AVAILABLE alarm, and Complete the Turn. The operator must then change the NAVIPILOT from NAV to AUTO mode.

2.9 SELECT HEADING REFERENCE

This feature is used to select the heading source from the configured heading inputs.



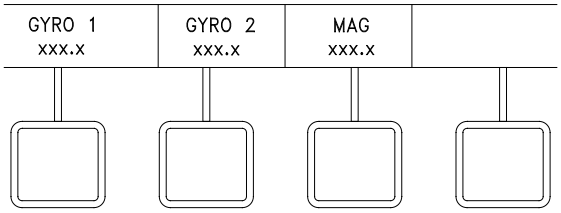
SAFETY NOTE: In some installations, an external compass monitor unit such as the Navitwin III is used to change the heading source. The operator should not change the source of heading while in an automatic mode of steering, particularly if there is a significant difference between the heading data. Normally, the compass monitor is connected in a way that allows mode detection. In this case, the compass selection is disabled while the NAVIPILOT is in AUTO, NAV, or WAYPOINT mode. The operator should verify that the compass monitor does not allow selection of a new source while in an automatic steering mode, by performing a test in an appropriate operational setting.

Press to display Heading Source menu options.

NOTE: ***The HDG SELECT control is not functional if any of the following conditions exist:***

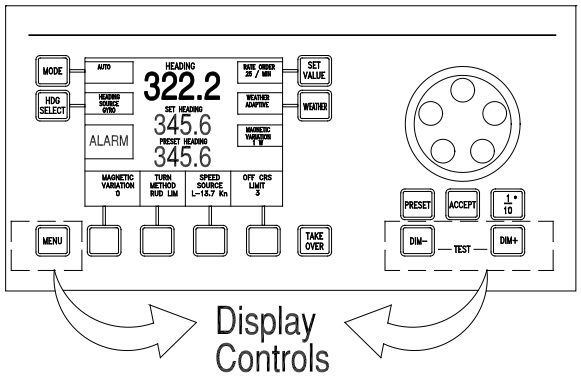
1. The CDU is not the station in control.
2. The system is in an automatic mode (AUTO, NAV, or WAYPOINT).
3. There is only one heading source.
4. The heading source is selected via an external unit.

Available heading sources are dependent on the system in which the NAVIPILOT is installed. A typical display is shown below. If GYRO 3 is available, it will appear above the fourth soft key.



Select the soft key for the desired heading source. **NOTE:** When the heading source is lost, asterisks are displayed for Heading in the main display area.

2.10 DISPLAY ADJUSTMENT AND TEST



Display Illumination

DIM+ Press key. Display becomes darker.

DIM– Press key. Display becomes brighter.

Display Contrast

MENU + DIM– Press and hold keys simultaneously. The display contrast decreases

MENU + DIM+ Press and hold keys simultaneously. The display contrast increases.

NOTE: To view a display of the contrast settings while contrast is being increased or decreased, first press the menu key repeatedly until no labels are displayed for the soft keys. While the display contrast is being adjusted, a display will appear showing TEMPERATURE, CONTRAST, and SELECTION. Display contrast is temperature-sensitive; the SELECTION value indicates the selected curve used by the NAVIPILOT to compensate for temperature variations.

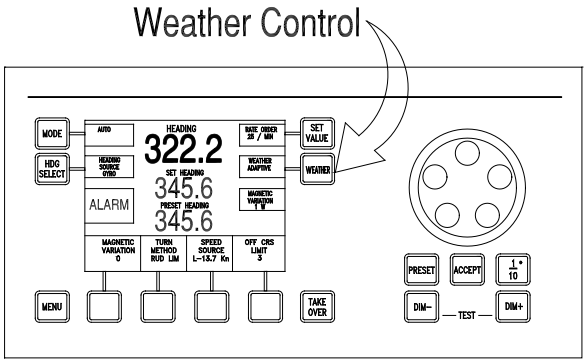
MENU + DIM– + DIM+ Press and hold keys simultaneously. This sets the display contrast to its default value. This also displays the introductory screen that shows the software version. (This function is disabled when the CDU is the station in control.)

Display Test

DIM+ + DIM– Press and hold keys simultaneously. All display elements are activated, and the alarm buzzer sounds. (This function is disabled when the CDU is the station in control.) The appearance of the display during the test depends on the contrast settings that were in effect. If the display was showing dark text on a light background (normal contrast), the entire display becomes dark during the test. If the display had been showing light text on a dark background (inverse contrast), the entire display becomes light during the test.

2.11 SET WEATHER CONTROL

This feature is used to tailor the steering performance for different weather conditions and heading keeping requirements. The procedure for using this feature is dependent on whether the Adaptive Self-Tuning feature of the NAVIPILOT is enabled (section 2.11.1) or not enabled (section 2.11.2).

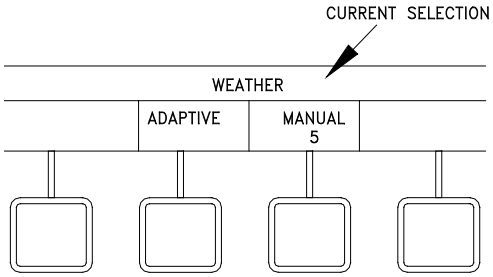


NOTE

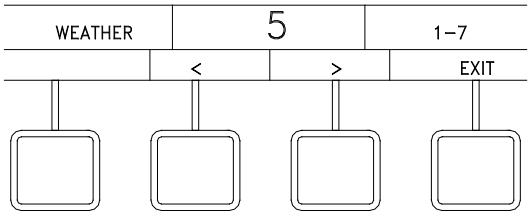
The weather control is functional only when the CDU is the station in control of steering (in an automatic mode), or when the CDU is at the location of the station in control (in a manual mode).

2.11.1 Weather Control – Adaptive Self-Tuning Enabled

Press to display the Weather Control menu options.



Press soft key to select ADAPTIVE or MANUAL. In ADAPTIVE mode, the NAVIPILOT automatically adjusts the setting as sea conditions change, to continuously provide the best possible steering performance and efficiency. In MANUAL mode, the operator manually sets a specific setting, as described below.

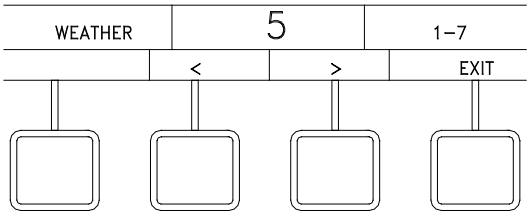


If MANUAL mode was selected, the display above will appear. Press the < or > soft key to change the WEATHER value. 1 is for low seas (high gain - tight heading keeping); 7 is for high seas (low gain - relaxed heading keeping).

Press EXIT to clear the menu.

2.11.2 Weather Control – Adaptive Self-Tuning Not Enabled

Press to display the Weather Control menu options.



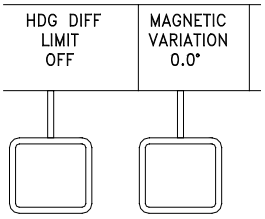
Press the < or > soft key to change the WEATHER value. 1 is for low seas (high gain - tight heading keeping); 7 is for high seas (low gain - relaxed heading keeping).

Press EXIT to clear the menu.

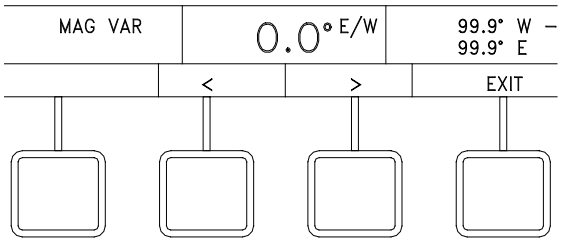
2.12 SET MAGNETIC VARIATION

This menu is displayed only if a fluxgate magnetic heading source is connected directly to the NAVIPILOT, and the NAVIPILOT is configured to use a fluxgate heading source. This feature is used to input the correct magnetic variation for the vessel's current location.

Press MENU until the MAGNETIC VARIATION soft key is visible in the menu area.



Press the MAGNETIC VARIATION soft key to display magnetic variation menu controls.



Press the < or > soft key to change the value.

Press the EXIT key to clear the menu.

2.13 SET TURN METHOD

This feature is used for selection of Rudder Limit (RUD LIM), Turn Rate order (RATE), or Turn Radius (RADIUS) as the Turn Method used with the NAVIPILOT.

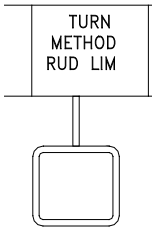
During configuration, the OPERATOR RUDDER LIMIT can be set up without radius and rate control, or with radius and rate control. When configured without radius and rate control, the system uses either the Rudder Limit, the Radius order, or the Rate order as the Turn Method. When configured with radius and rate control, the system uses the operator setting for Rudder Limit with the active Radius order or Rate order. Procedures for setting these values are provided in section 2.14.

SAFETY NOTES:

- For all turn methods, it is possible to set values that are not appropriate and/or not possible given the vessel's maneuvering characteristics or present operating conditions (weather, speed, load, draft, etc.). It is important for the operator to verify that the speed input is accurate, the desired Turn Method has been selected, and appropriate values have been set before using the NAVIPILOT to make a course change.
- Although the NAVIPILOT disables the RADIUS turn method unless a speed log is selected as the speed source, some speed logs allow manual input of speed data. For the RADIUS turn method, the speed log must be providing actual measured speed at all times for accurate turn control. NEVER use the RADIUS turn method with manual speed inputs to the speed log. Incorrect speed will cause incorrect radius control, potentially causing serious hazards for the ship and personnel.

NOTE: The RADIUS turn method can only be selected if the active speed source is a speed log (select LOG as described in section 2.15). If speed log messages are lost during a radius-controlled turn, the turn method will automatically change to RATE, and an equivalent rate order will be computed based on the current radius order and last known speed.

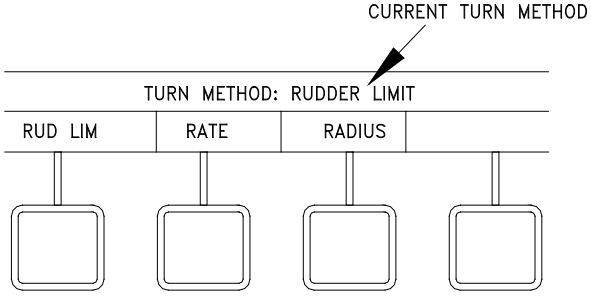
Press MENU to display the TURN METHOD soft key in the menu area.



NOTE

RUD LIM IS NOT AVAILABLE IN THIS MENU IF OPERATOR RUDDER LIMIT IS SET TO W/RAD/RATE CTRL IN SERVICE SETUP 2. THE OPERATOR RUDDER LIMIT IS ALWAYS ENABLED WITH THIS SETTING.

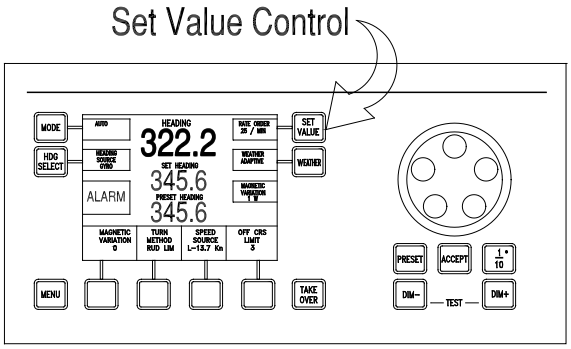
Press the TURN METHOD soft key to display the Turn Method menu.



Select the soft key for the desired Turn Method : RUD LIM, RATE, or RADIUS.

2.14 SET VALUE (RUDDER LIMIT, RATE ORDER, RADIUS ORDER)

The Set Value feature is used for operator selection of active values for Rudder Limit (see section 2.14.1) Turn Rate (see section 2.14.2) and/or Turn Radius (see section 2.14.3). The application of these operator-selectable values is related to the selected Turn Method (see section 2.13).



NOTE

The SET VALUE control is functional when the CDU is the station in control of steering (in AUTO mode), or when the CDU is at the location of the station in control (in a manual mode).

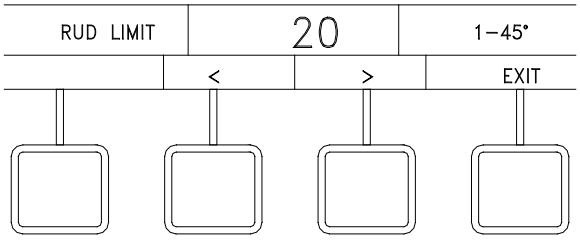
2.14.1 Set Rudder Limit

While active Turn Method is Rudder Limit (RUD LIM) (see section 2.13), pressing the SET VALUE button displays the RUD LIMIT control menu. The rudder limit can be set to a value between 1 degree and the maximum rudder angle configured by the service technician (see Appendix A, Table A-4).

The NAVIPILOT also has a configurable Speed Scaled Rudder Limit (SSRL), which applies regardless of the set rudder limit or turn rate/radius order. Refer to Appendix A, Table A-3 for a description of the Speed Scaled Rudder Limit.

When the rudder reaches the limit set by the operator, “RL” is displayed in inverse video at the bottom of the turn method display area. “RL” will also be displayed if the Speed Scaled Rudder Limit is reached. When counter-rudder is being applied to stop vessel momentum at the conclusion of an ordered heading change, the rudder limit may temporarily be exceeded if necessary.

Press to display Rudder Limit menu options.



Press the < or > soft key to change value.

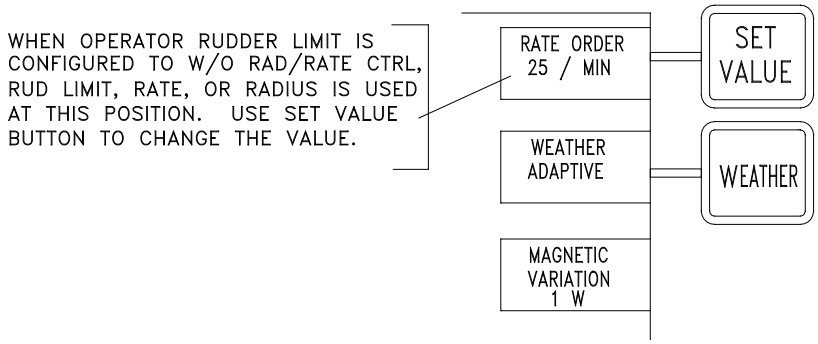
Press EXIT to clear the menu.

2.14.2 Set Rate Order

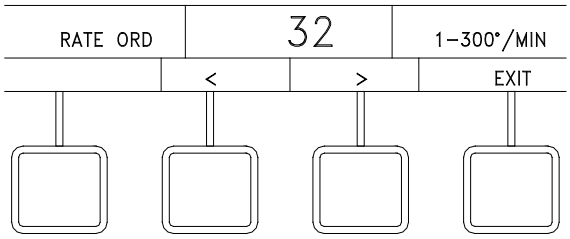
While the active Turn Method is RATE (see section 2.13), proceed as follows:

a. If OPERATOR RUDDER LIMIT is configured to w/o RAD/RATE CTRL (without radius and rate control, the SET VALUE button is used to change either the RUDDER LIMIT, RATE ORDER, or RADIUS ORDER.

a.1



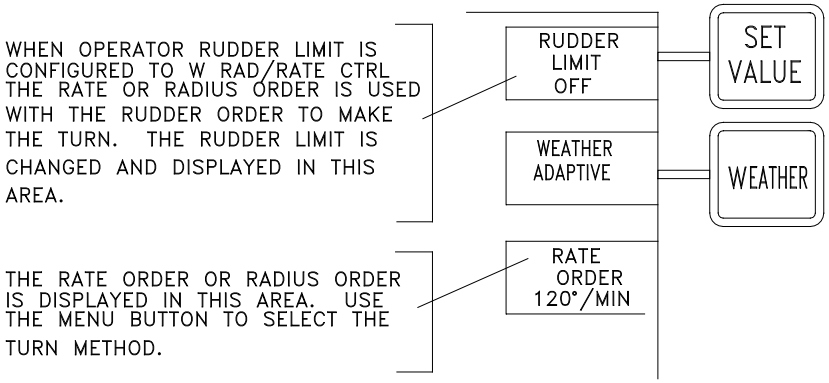
a.2 Press SET VALUE to display Rate Order menu options.



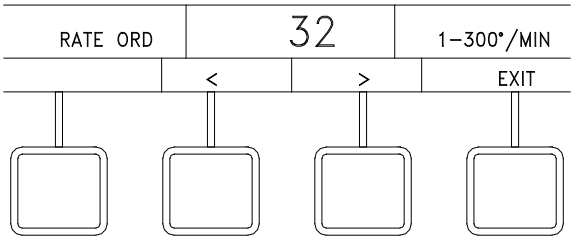
a.3 Press the < or > soft key to change value. Press EXIT to clear the menu.

b. If OPERATOR RUDDER LIMIT is configured to “w/ RAD/RATE CTRL” (with radius and rate control), the SET VALUE button is used to only change the Rudder Limit. Rate order or Radius order is used with rudder limit when RATE ORDER or RADIUS ORDER is selected as the turn method (paragraph 2.13).

b.1



b.2 While RATE is the active Turn Method (see section 2.13), press the MENU button. Then press the RATE ORDER button to display the Rate Order (RATE ORD) menu options.



Press the < or > soft key to change value.

Press EXIT to clear the menu.

When a course change is ordered in AUTO mode, the rudder will move as needed to achieve the rate order.

The minimum turn Rate Order is dependent on the vessel's Tau (the time in seconds that it takes the vessel to sail its own length at its service speed). See Appendix C for the procedures for calculating Tau. Figure 2-2 shows the minimum turn rate as a function of Tau.

NOTE: The operator may have to select a higher turn Rate Order than shown, in order to control heading in high winds.

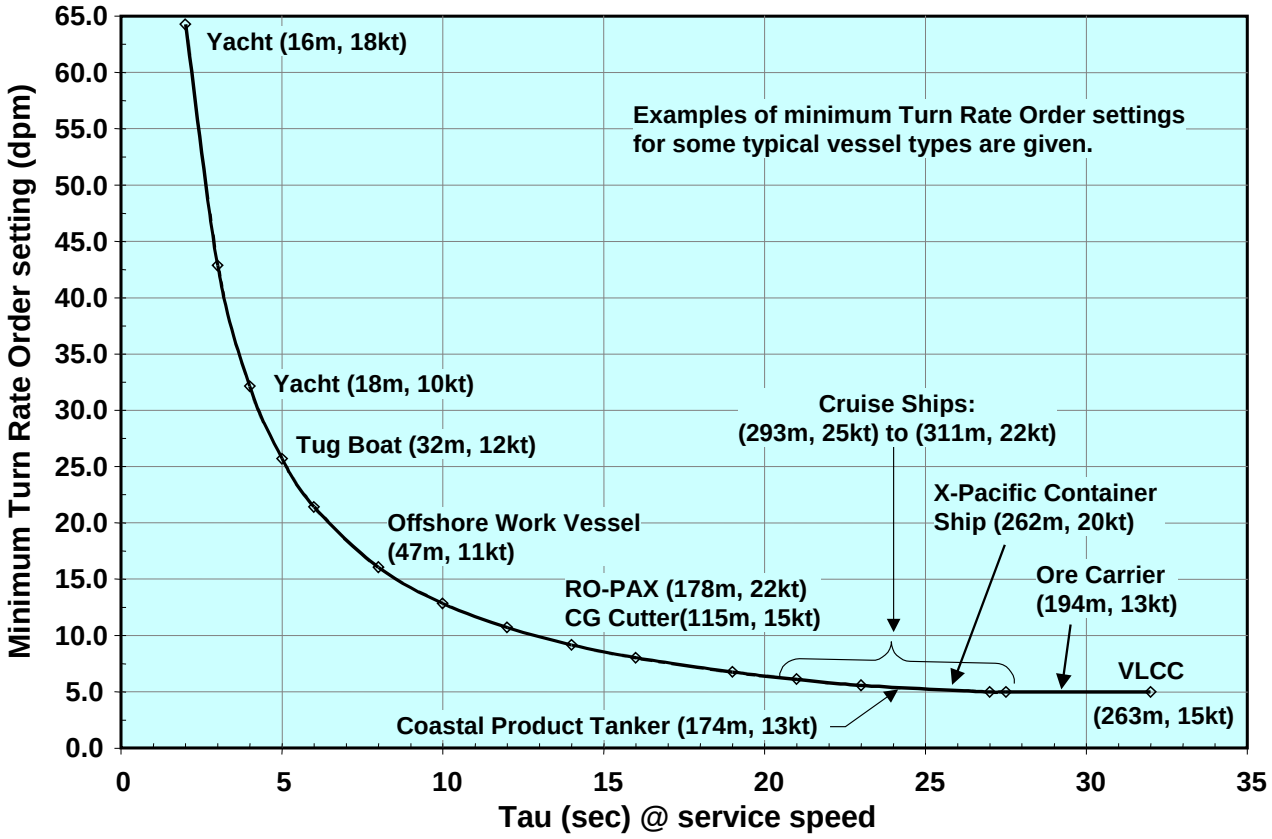


Figure 2-2. Minimum Turn Rate Order Chart

Rate Order limitations shown in Figure 2-2 are imposed by the software. The screen displays the available range for Rate Order selection (from the imposed minimum to a maximum of 300 degrees/minute).

For Rate Order limitations, the operator is responsible for setting values that are safe and reasonable for the particular vessel.

Also, although rate control is normally the preferred method for controlling course changes, rate control may be degraded on certain types of vessels, such as small craft with fast yaw rates in combination with coarse rudder control (such as with solenoids). Such limitations should be identified during sea trial of the system, after the system has been properly tuned and the values for Tau, Rudder Gain (RG), and Counter Rudder (CR) have been set appropriately (see Appendix C). If turns cannot be adequately controlled using the Rate Order method, the Rudder Limit method should be used instead (see section 2.14.1).

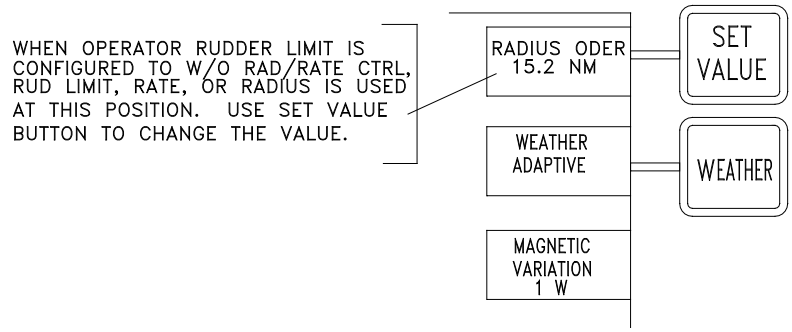
SAFETY NOTE: If maneuvers are not sharply initiated or heading is not adequately held during times of significant wind, the operator may need to increase the turn Rate Order above the minimum or typical rate. This will produce a greater rudder angle for initiating turns, to compensate for the combined effects of the wind and waves.

2.14.3 Set Radius Order

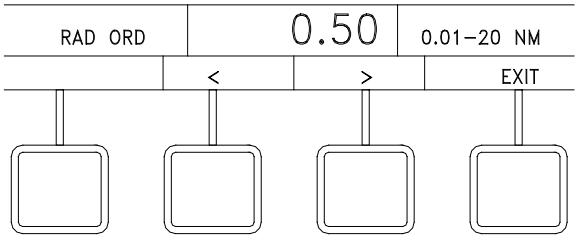
While the RADIUS turn method is selected (see section 2.13), proceed as follows:

a. If OPERATOR RUDDER LIMIT is configured to wo/ RAD/RATE CTRL (without radius and rate control), the SET VALUE button is used to change the RUDDER LIMIT, RATE ORDER, or RADIUS ORDER.

a.1



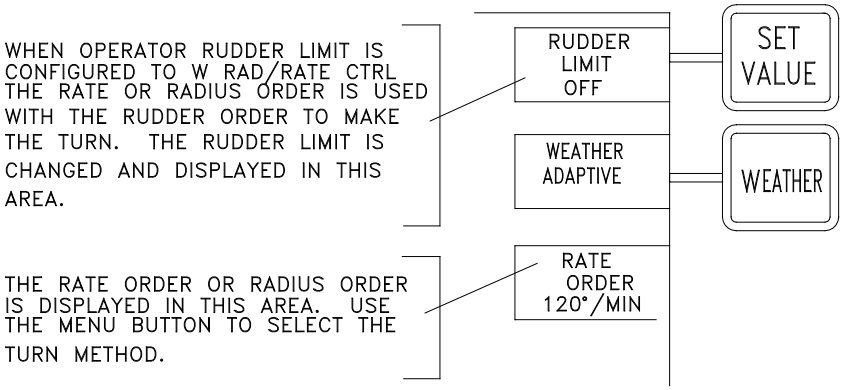
a.2 Press SET VALUE to display Radius Order menu options.



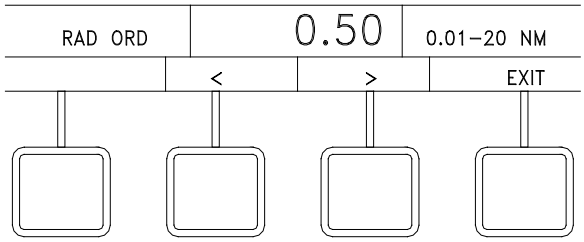
a.3 Press the < or > soft key to change value. Select EXIT to clear menu.

b. If OPERATOR RUDDER LIMIT is configured to w/ RAD/RATE CTRL (with radius and rate control), the SET VALUE button is used to only change the rudder limit. Rate order or radius order is used with rudder limit. RATE ORDER or RADIUS ORDER is selected as the turn method (paragraph 2.11).

b.1



b.2 While RADIUS is the active Turn Method, (see section 2.13), press the MENU button. Then press the RADIUS ORDER button to display the Radius Order (RAD ORD) menu options.



Press the < or > soft key to change value.

Select EXIT to clear the menu.

When a course change is ordered in AUTO mode, the rudder will move as needed to achieve the radius order. The system uses the present Log speed to calculate the required rate to achieve the ordered radius. If Log input is not available, Radius Order control cannot be used.

Figure 2-3 shows the maximum turn radius as a function of Tau and speed. (See Appendix C for the procedures for calculating Tau.)

The Radius Order limitations shown in Figure 2-3 are imposed by the software. The screen displays the available range for Radius Order selection, from 0.01 nautical miles (NM) to the imposed maximum.

However, whether or not the software imposes Radius Order limitations, the operator is responsible for setting values that are safe and reasonable for the particular vessel.

If maneuvers are not sharply initiated or heading is not adequately held during times of significant wind, the operator may need to decrease the turn Radius Order below the maximum or typical radius. This will produce a greater rudder angle for initiating turns, to compensate for the combined effects of the wind and waves.

NOTE: The operator may have to select a lower turn Radius Order than shown, in order to control heading in high winds.

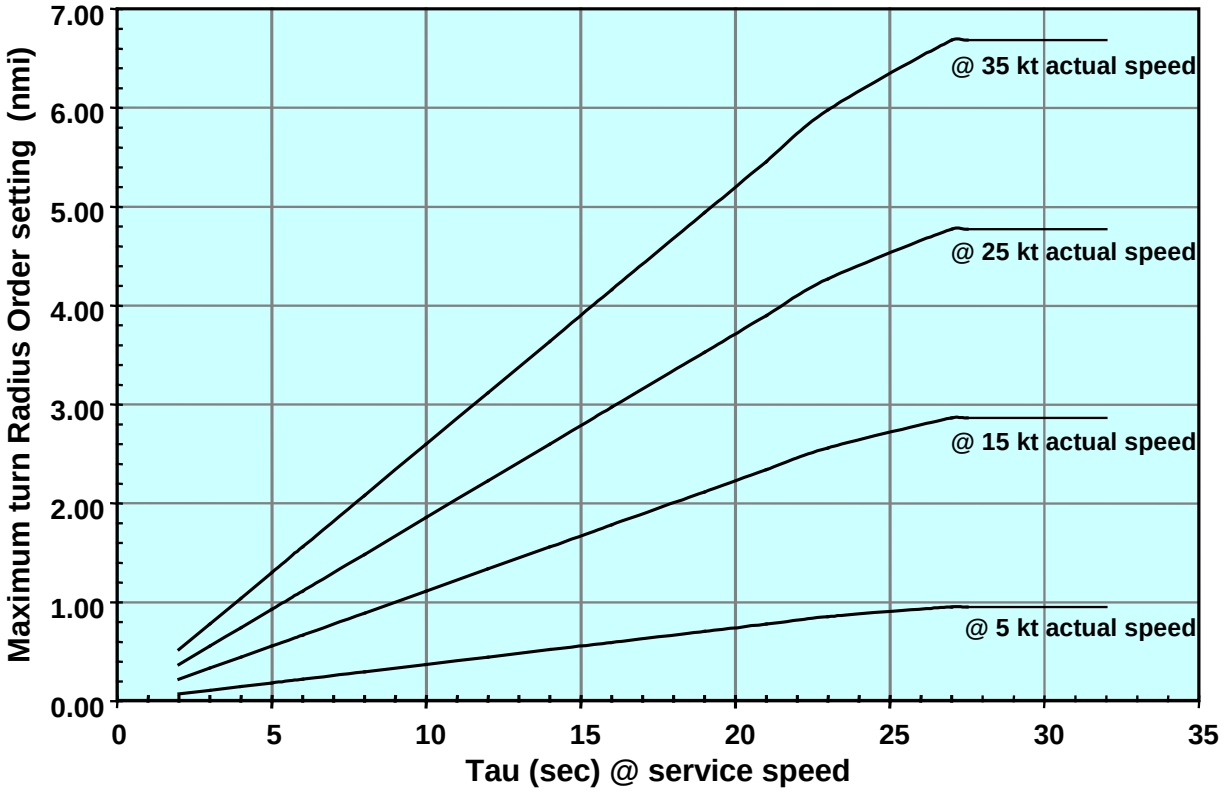


Figure 2-3. Maximum Turn Radius Order Chart

2.15 SELECT SPEED SOURCE

The Speed Source feature is used for selection of the active source of speed data—either a speed log (LOG) or manual speed input (MANUAL).

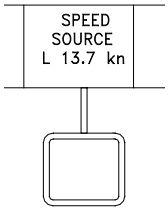
As described in Appendix A, Table A-4, the NAVIPILOT is configurable for several types of message formats for speed log inputs. If the NMEA 0183 VBW (Dual Ground/Water Speed) message is used, water speed has preference. Ground speed is used by the NAVIPILOT only when water speed is not available.

If Manual speed is selected, it is important to set a value as close as possible to the actual vessel speed. If vessel speed changes significantly, the operator must adjust the manual speed value. When manual speed is used, the active CDU provides an indication on the display (MAN SPD xx KN) as a reminder.

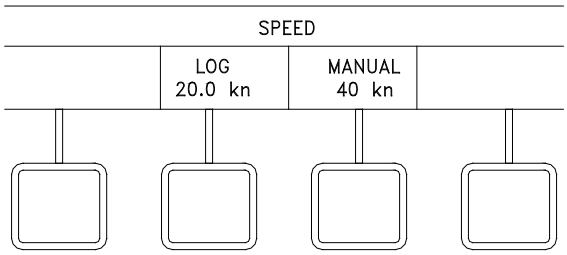
Manual speed inputs cannot be used with the RADIUS Turn Method (see section 2.13). If a manual speed input is selected while the RADIUS Turn Method is active, the NAVIPILOT will automatically switch to the RATE Turn Method, with a rate order based on the last radius order and log speed.

MENU

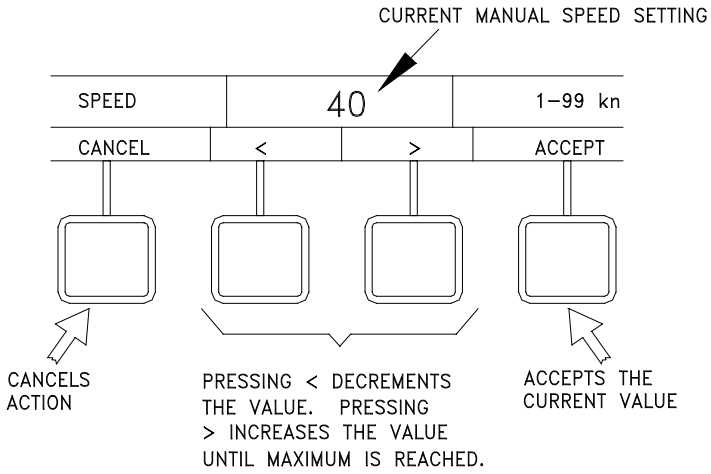
Press MENU to display the SPEED SOURCE soft key in the menu area.



Press the SPEED SOURCE soft key to display Speed Source menu options.



Press LOG or MANUAL to select the desired speed source.



If manual speed is selected, press the < or > key to change value.

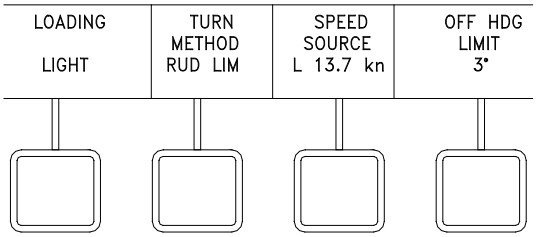
Press ACCEPT to accept the changed value, or select CANCEL to clear the menu.

2.16 SET OFF-HEADING LIMIT

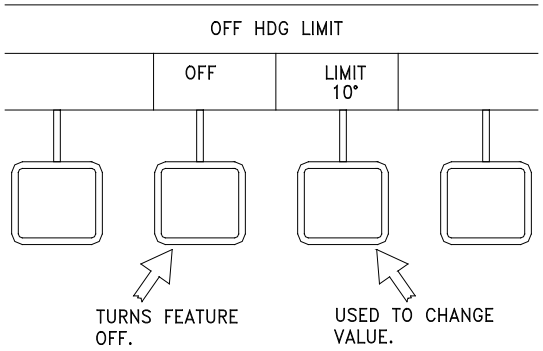
The Off-Heading Limit feature provides for operator selection of a limit value which is used for activation of the Off-Heading alarm. The alarm is activated if the heading deviates from the set heading by more than the operator-selected limit for longer than the configured off-heading delay. The off-heading delay can only be adjusted in the SERVICE SETUP 2 menu (see Appendix A).

SAFETY NOTE: The operator-set limit for the Off Heading alarm is temporarily increased when a course change is initiated, to make nuisance alarms less likely during the maneuver. For this reason, it is important for the operator to visually confirm that a course change is being controlled as ordered. In the unlikely event that the system does not successfully control the course change, the Off Heading alarm may not be activated.

Press MENU to display the OFF HDG LIMIT soft key in the menu area.



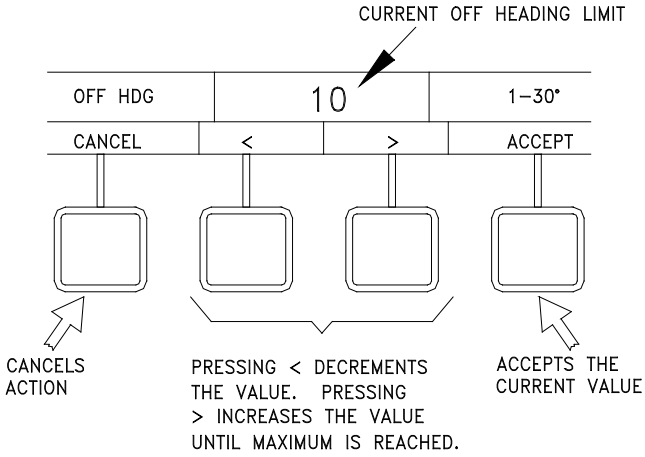
Press the OFF HDG LIMIT soft key to display the Off Heading Limit menu options.



NOTE

The “OFF” selection is available only if OFF HEADING ALARM DISABLE is enabled in the SYSTEM SETUP 2 menu (see Appendix A). Some regulatory agencies do not allow this option.

Press the OFF soft key to disable the Off Heading alarm, or press the LIMIT soft key to display the menu for changing the Off Heading limit.



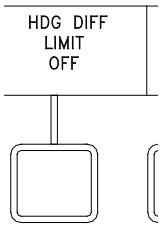
Press the < or > soft key to change the Off Heading limit value.

Select ACCEPT to accept the value, or select CANCEL to clear the menu.

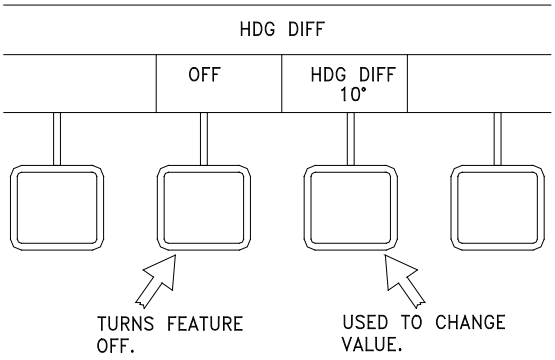
2.17 SET HEADING DIFFERENCE LIMIT

The Heading Difference Limit feature provides for operator selection of a limit value which is used for activation of the Heading Difference alarm. The alarm is activated if the difference between the heading values from any two heading sources is greater than the operator-selected limit. This menu is available only if heading inputs to the NAVIPILOT are made from multiple sources.

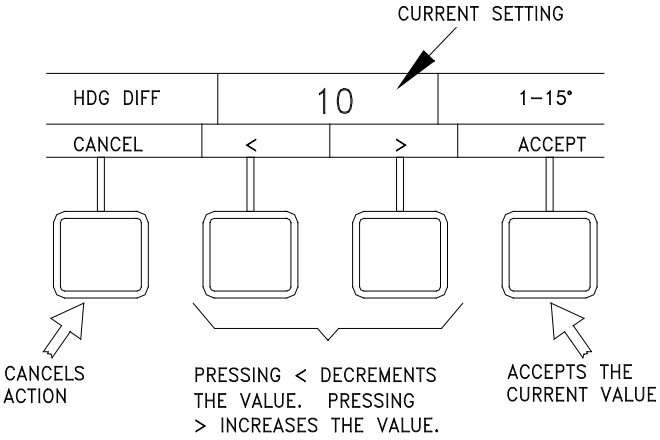
Press MENU until the HDG DIFF LIMIT soft key is visible in the menu area.



Press HDG DIFF LIMIT soft key to display Heading Difference menu options.



Select the OFF soft key to turn off the Heading Difference limit or select the HDG DIFF soft key to display menu controls for changing the Heading Difference Limit value.



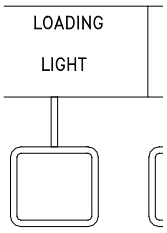
Press the < or > soft key to change the Heading Difference limit value.

Select ACCEPT to accept the value, or select CANCEL to clear the menu.

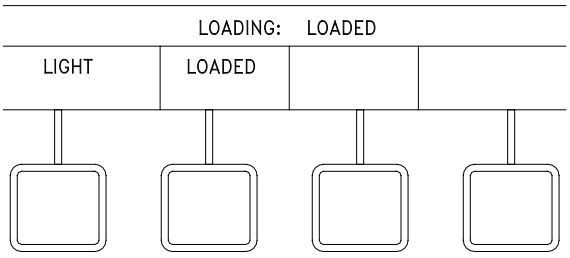
2.18 SELECT LOADING

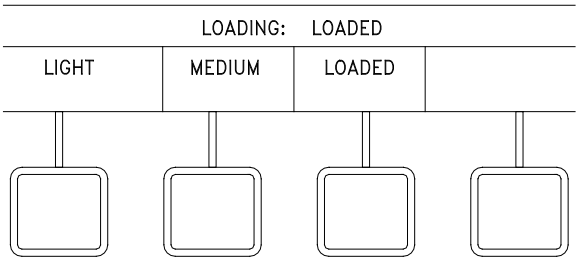
This feature allows the operator to select the gains associated with the ship's load condition. The NAVIPILOT stores a set of tuning parameters (rudder gain, counter rudder, and tune level) for each loading condition. Refer to section 2.20 for tuning instructions.

Press MENU to display the LOADING soft key in the menu area.



Press the LOADING soft key to display Loading menu options.



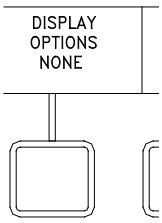


Select the soft key for the desired loading condition. If the NAVIPILOT's Adaptive Self-Tuning feature is enabled (see Appendix A), loading options are LIGHT and LOADED. If the Adaptive Self-Tuning feature is not enabled, loading options are LIGHT, MEDIUM, or LOADED.

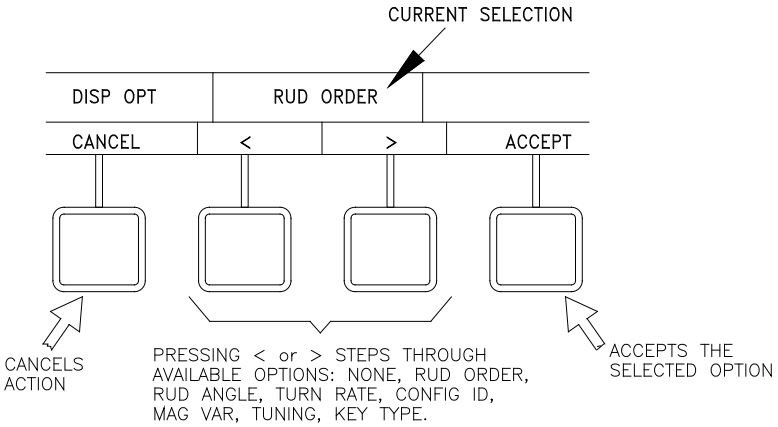
2.19 DISPLAY OPTIONS

The DISPLAY OPTIONS feature allows the operator to select a data item to be indicated at the bottom of the CDU display. The available displays include graphical indicators for Rudder Order, Rudder Angle, Turn Rate, Cross Track Error, or Tuning. Text indications are available for Magnetic Variation, Config ID, or Key Type.

Press MENU until the DISPLAY OPTIONS soft key is visible in the menu area.



Press the DISPLAY OPTIONS soft key to display the Display Options menu.

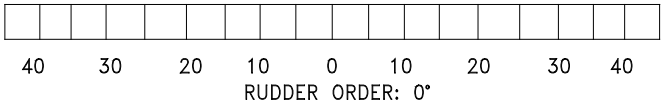


Press the < or > soft key to change the selected option. (The NONE option can be selected if desired, to turn off the indication at the bottom of the CDU display.)

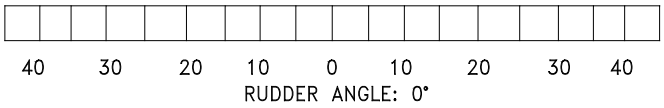
Select ACCEPT to accept the selected option. CANCEL will cancel the selection.

Press MENU again until the menu area is cleared, and the selected indication is visible at the bottom of the display.

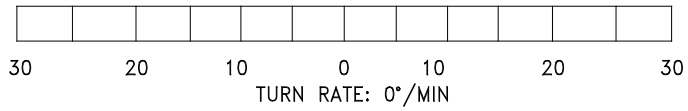
Examples of the available graphical indicators are shown below.



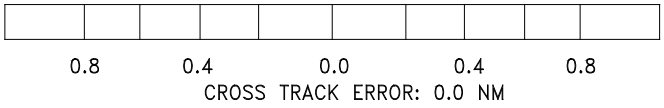
RUDDER ORDER – Rudder Order output from SCU in FU or A/N/W



RUDDER ANGLE – Rudder angle indication from the steering system



TURN RATE – Heading rate of change in degrees per minute



CROSS TRACK ERROR – Received from connected system in WAYPOINT mode

RG	CR	TIMER	LVL	PHASE	BIAS	INF
1.5	1.0	0	3	0	0.0	0

TUNING

TUNING – Refer to 2.20.2.1 for a description of the displayed data

NOTE: "Two-loop" steering control systems do not provide an accurate feedback of rudder angle to the RUDDER ANGLE display shown above. In two-loop systems, the rudder angle feedback comes from the control loop for the equipment which drives the rudder, rather than from an actual indication of rudder position. For such systems, do not use the NAVIPILOT's RUDDER ANGLE display.

Examples of the available text indications are:

MAGNETIC VARIATION : 0.0	MAGNETIC VARIATION – Present value for Magnetic Variation (if configured).
NAVIPILOT 4000 or NAVIPILOT 4000 TRACK MAIN STEERING	CONFIG ID – The active product type is displayed. (MAIN STEERING is displayed when no valid product type is active).
NAVIPILOT 4000 or NAVIPILOT 4000 TRACK MAIN STEERING	KEY TYPE – The Key Type of the installed Product Key is displayed. (MAIN STEERING is displayed when no valid Key Type is detected).

NOTE: The KEY TYPE indication will normally match the active product type, which is displayed in the CONFIG ID indicator. If the KEY TYPE and CONFIG ID indications do not match, a problem is indicated. See section 2.4 for more information on the Product Key, and error conditions related to Product Key and Product Type.

2.20 TUNING

2.20.1 Overview

The NAVIPILOT must be properly tuned in order to steer the ship effectively and efficiently. When the NAVIPILOT is first installed, parameters are set based on the ship's specifications. Then, a tuning sequence is performed during sea trials, or as soon as possible after the vessel goes to sea. During a tuning sequence, a series of maneuvers are performed, and the following parameters are adjusted to optimize NAVIPILOT performance:

- **Rudder Gain (RG).** The sensitivity of the NAVIPILOT's response to heading errors. RG is also referred to as Proportional Gain, because it generates rudder orders proportional to the heading error. Increasing the RG value increases rudder sensitivity.
- **Counter Rudder (CR)**. The sensitivity of the NAVIPILOT's response to turn rate. CR is also referred to as Rate Gain, because it generates rudder orders in direct response to the turn rate of the ship. Increasing the CR value increases the amount of counter rudder, and hence reduces the tendency for the ship to overshoot the desired heading.

If Adaptive Self-Tuning is enabled, two tuning modes are available:

- **AUTO tuning mode.** In this mode, the NAVIPILOT monitors performance (heading overshoot, heading undershoot, rudder oscillations), and automatically adjusts RG and CR to the optimal values.
- **MANUAL tuning mode.** In this mode, the operator must monitor performance during tuning maneuvers, and manually adjust RG and CR to the desired values.

MANUAL tuning can be selected to lock in the values after a successful initial AUTO tuning sequence, or AUTO can remain selected for continued dynamic tuning during normal maneuvers. If the tuning mode remains set to AUTO after the tuning maneuvers are performed, the NAVIPILOT will automatically adjust RG and CR as needed to compensate for changes in sea state, loading, or trim.

If Adaptive Self-Tuning is disabled, only the manual tuning mode is available. Refer to Appendix A, Table A-6 for instructions on enabling or disabling Adaptive Self-Tuning.

Tuning is performed with heading control in AUTO mode (section 2.8.1), during heading changes of 10º or more. Maneuvers of less than 10º are generally not good indicators of tuning performance, and in the case of Adaptive Self-Tuning, the NAVIPILOT will not allow the system to tune automatically. Tuning will be most effective with maneuvers of 10º during rudder-limit turns, and maneuvers of 20º or more for rate-order or radius-order turns.

Vessels using the Rate Order or Radius Order turn methods during normal operation should use the Rate Order turn method while performing the initial tuning sequence. The turn rate should be set to a value that will typically be used for an automatic course change at service speed. Overshoots may vary if the tuning sequence is performed using the Rudder Limit turn method instead of Rate Order.

Tuning is best performed in relatively calm seas at normal service speed. Full service speed will provide the best results during tuning. Ship's speed must remain above 50% of service speed for Adaptive Self-Tuning to function.

The performance of the NAVIPILOT's steering algorithm is dependent on an accurate value for the ship's Time Constant (Tau). Tau is the time (in seconds) that it takes the vessel to sail its own length (at waterline) at its service speed. The tuning process does not affect the Tau value. **Therefore, before tuning is performed, it is critical that an accurate value for Tau value be entered in the Service Setup menus.** Also, for Adaptive Self-Tuning, it is important that appropriate initial values for RG and CR be entered in the Service Setup menus. Initial overshoot/undershoot is reduced, the time required for tuning is reduced, and the quality of the tuning level achieved may be significantly improved. Also, if Tuning is reset, RG and CR will be reset to their initial values. If the initial RG and CR values are not appropriate for the vessel, the NAVIPILOT may be unable to

steer the ship effectively. Refer to Appendix C for instructions on calculating Tau and selecting initial RG/CR values. Refer to Appendix A for instructions for entering these values in the Service Setup menus.

The NAVIPILOT has operator-selectable loading conditions. For Adaptive Self-Tuning operation, two separate tunings are maintained: Light (for use when the ship is lightly loaded), and Loaded (for use when the ship is heavily loaded). For Manual Tuning operation, three separate tunings are maintained: Light, Medium, and Loaded. For each loading condition, a different Tau value may be entered in the Service Setup Menu. **Normally, Tau should be set to the same value for all load conditions.** The exception is the case of Notch Tugs, where two Tau settings can be used for the two operating conditions of the vessel: (1) When the Notch Tug is operating as an unattached tugboat (in which case the ship length is short, producing a small Tau), and (2) When the Notch Tug is docked into a ship-shaped hull (producing a much longer ship length, and thus a large Tau). It is important that the proper loading condition be selected for the current operating condition of the ship.

Tune Level and Sea State affect the Adaptive Self-Tuning performance. Tune Level is an integer value with a range from 0 to 5, which indicates how effectively the NAVIPILOT has been tuned to the ship. Tune levels of 3, 4, or 5 are normally acceptable, providing efficient and effective heading control performance. If the tune level is 2 or greater, the Adaptive Self-Tuning function will be incrementally suppressed as sea-state influence increases. This prevents undesirable tuning adjustments that might otherwise occur due to rough sea conditions. If the Tune Level is 0 or 1, Adaptive Self-Tuning should not be enabled in rough seas, because the self-tuning process is not effective in rough conditions. Rough conditions are characterized by excessive yawing in the seaway, and a Seaway Influence (INF) value of 50 or more. **Note***: Tune Level will always display a value of 0 when Adaptive Self-Tuning is not enabled.* The Tune Level and Seaway Influence values are shown on the TUNING display (section 2.20.2.1).

2.20.2 Tuning Controls and Displays

The controls and displays described in this section are used when tuning the NAVIPILOT. These controls and displays must be used ONLY as described in the Tuning Procedures (section 2.20.3). NEVER adjust any of these controls except in accordance with the Tuning Procedures.

2.20.2.1 TUNING Display

The TUNING display is shown in Figure 2-4. Refer to section 2.19 (Change Display Options) for instructions on how to select the TUNING display. Table 2-3 describes each of the parameters which appear on the TUNING display.

RG	CR	TIMER	LVL	PHASE	BIAS	INF
1.5	1.0	0	3	0	0.0	0

TUNING

Figure 2-4. TUNING Display

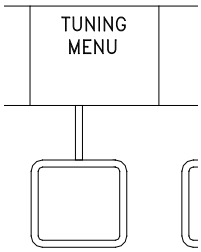
Table 2-3. TUNING Display Indicators

Item	Definition	Function
RG	Rudder Gain	The sensitivity of the NAVIPILOT's response to heading errors. RG is also referred to as Proportional Gain, because it generates rudder orders proportional to the heading error. Increasing the RG value increases rudder sensitivity.
CR	Counter Rudder	The sensitivity of the NAVIPILOT's response to turn rate. CR is also referred to as Rate Gain, because it generates rudder orders in direct response to the turn rate of the ship. Increasing the CR value increases the amount of counter rudder, and hence reduces the tendency for the ship to overshoot the desired heading.
TIMER	Wait Timer	During tuning maneuvers, indicates when the next tuning maneuver can be executed, without interfering with the Adaptive Self-Tuning calculations associated with the previous maneuver. The timer starts at the value of Tau (rounded off to the nearest 5-second increment) and counts down by 5-second intervals after a maneuver has been completed. If another maneuver is started before the timer counts down to zero, then the maneuver will not be used for tuning.
LVL	Tune Level	Indicates from 0 to 5 how effectively the NAVIPILOT has been tuned to the ship. Level 2 is considered good; Level 3 or above is preferred. A higher tune level inhibits further changes to the gain values through automatic tuning. But if the vessel begins to overshoot course changes, or performance otherwise degrades, the tune level will decrease. The system is then able to re-tune more quickly (if AUTO tune mode is selected).
PHASE	Turn Phase	Indicates the different phases of a course change, for reference during the tuning sequence. The phases are as follows: Phase 6 – A maneuver has been ordered, but the heading is not yet changing in the direction ordered. Phase 5 – The heading has begun to change in the direction ordered - initial acceleration has begun. Phase 4 – A steady turn rate has been achieved (not indicated if rudder limit control is used). Phase 3 – This is the counter-rudder / overshoot phase. Phase 2 – This is the subsequent undershoot phase. Phase 0 – This indicates steady heading keeping after turning is complete. The wait timer begins to count down after Phase 0 is indicated.
BIAS	Rudder Order Bias	The amount of rudder required in order to maintain the heading, given the ship's characteristics and wind effects.
INF	Seaway Influence	A measure of the effect of waves on the heading-keeping activity. The displayed values can range from 0 to 250. When the Tune Level is 2 or greater, Adaptive Self-Tuning will be incrementally suppressed as Seaway Influence increases. If the seaway influence increases to a value of 75 or more during the initial tuning sequence, it may be necessary to reset tuning and start again. If this happens repeatedly it may be an indication that conditions are not calm enough to tune the system.

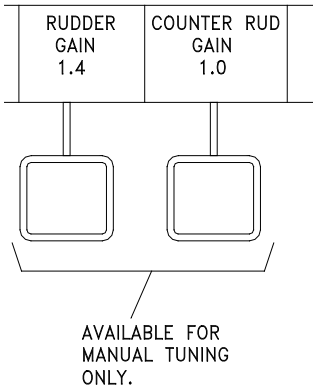
2.20.2.2 RUDDER GAIN (RG) and COUNTER RUDDER (CR) Controls

If MANUAL tuning mode is selected (section 2.20.3.2.3), the operator can adjust the rudder gain (RG) and counter rudder (CR) in accordance with the procedures described below. Refer to section 2.20.1 for a description of RG and CR. These controls must be adjusted ONLY as described in the Tuning Procedures (section 2.20.3). NEVER adjust any of these controls except in accordance with the Tuning Procedures.

Press MENU until the TUNING MENU soft key is visible in the menu area.



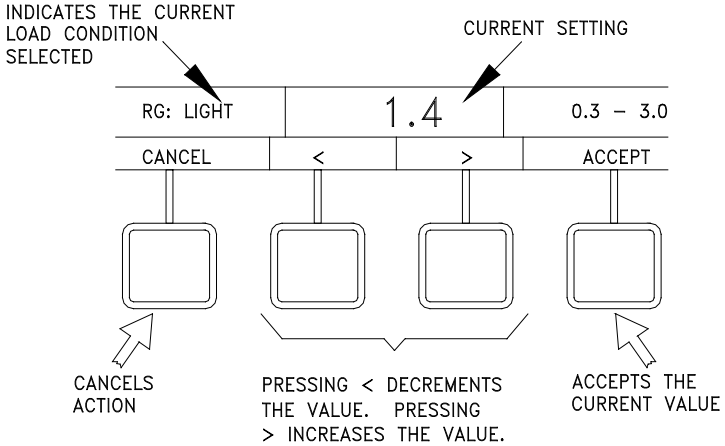
Press the TUNING MENU soft key to display Tuning menu options.



NOTE

A speed log providing actual measured speed is recommended for NAVIPILOT 4000 tuning. Manually entered speed MUST be kept up to date if no speed log is available. Refer to section 2.20.1 for more information on vessel speed.

Select the desired soft key to change Rudder Gain or Counter Rudder Gain.



Press the < or > soft key to change the value.

Select ACCEPT to accept the value, or select CANCEL to clear the menu.

2.20.2.3 WEATHER RATIO Control

The WEATHER RATIO control allows the operator to adjust the scaling range for the amount of Rudder Gain (RG) reduction produced in response to sea conditions. Mathematically, the weather ratio is RG_{MAX}/RG_{MIN}. Lower values for the weather ratio minimize the range of gain reduction; higher values maximize the range of gain reduction. The range is from a maximum of 3.0 to a minimum of 1.1.

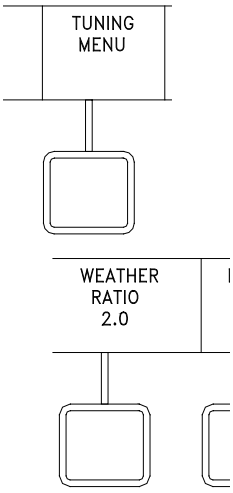
The WEATHER RATIO must be adjusted ONLY as described in the Tuning Procedures (section 2.20.3). NEVER adjust this control except in accordance with the Tuning Procedures.

If Adaptive Self-Tuning is enabled:

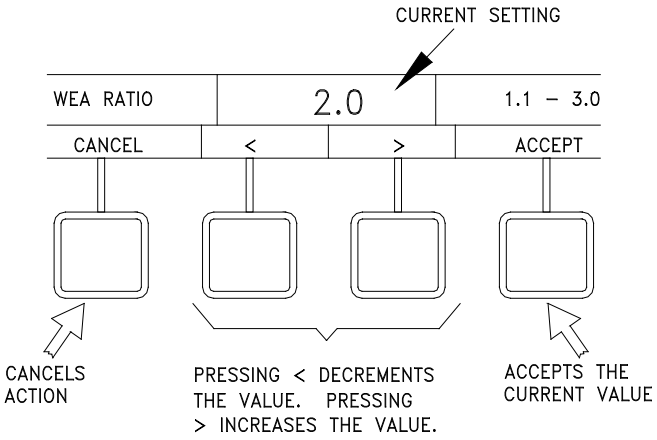
- When the WEATHER control (section 2.11) is set for ADAPTIVE mode, the WEATHER RATIO control selects the range of RG reduction produced automatically by the Adaptive Self-Tuning function.
- When the WEATHER control is set for MANUAL mode, the WEATHER RATIO control selects the range of RG reduction produced by WEATHER control settings 1 through 7.

If Adaptive Self-Tuning is disabled, the WEATHER RATIO control functions as described above for MANUAL mode.

Press MENU until the TUNING MENU soft key is visible in the menu area.



Press the WEATHER RATIO soft key to display Weather Ratio menu options.



Press the < or > soft key to change the value.

Select ACCEPT to accept the value, or select CANCEL to clear the menu.

2.20.3 Tuning Procedures

2.20.3.1 Before Starting the Tuning

Before tuning the NAVIPILOT:

1. The NAVIPILOT must be configured properly by a Sperry Marine Field Service Engineer, in accordance with the Service Setup instructions in Appendix A. It is particularly critical that an accurate value for Tau be entered. Refer to Appendix C for instructions for calculating Tau.

2. The ship should be operating in **calm water**. Otherwise, tuning results will be poor.

3. During tuning procedures, vessel speed should be as close as possible to the configured service speed. (Service speed is configured as part of Service Setup, as described in Appendix A.) Use of a speed log, which provides speed thru water (STW), is recommended. Whenever a source of STW is not available, the following alternatives may be substituted:

    a. Speed over ground (SOG) may be used, provided that the effect on vessel speed due to wind and current is negligible, so that there is very little difference between STW and SOG.

    b. When speed must be manually entered, use the best available reference (such as by propeller shaft speed) and ensure that the speed entered is up to date at all times.

4. Enough space should be available for making the required heading changes. It is recommended that 10º heading changes be made for RUDDER LIMIT turn methods, and 20º heading changes be made for RATE order or RADIUS order turn methods.

5. Input the initial settings for the NAVIPILOT as follows:

    a. Set the MODE of operation to AUTO (section 2.7).

b. Select the appropriate TURN METHOD (section 2.13):

   i. If the RATE order or RADIUS order turn method will be used during normal operation, select the RATE order turn method for tuning.

   ii. If the RUDDER LIMIT turn method will be used during normal operation, select the RUD LIMIT turn method for tuning.

c. Use the Set Value menu (section 2.14) to select appropriate values as follows :

   i. If the RATE turn method was selected, set the RATE ORDER (section 2.14.2) to a value that will typically be used for an automatic course change at service speed.

   ii. If the RUD LIMIT turn method was selected, set the RUD LIMIT (section 2.14.1) to a value that will typically be used for an automatic course change at service speed.

d. Select LOADING based on the current loading condition of the ship (section 2.18).

e. Set the RUDDER GAIN (RG) and COUNTER RUDDER (CR) (section 2.20.2.2). Use the values listed below as a guideline for the initial settings:

RG - Normal configurations	**1.4**
RG - High-lift rudder configurations	**0.7**
CR	**1.0**

f. Set the WEATHER RATIO (section 2.20.2.3). Use the values listed below as a guideline for the initial setting:

Cargo/container ships, tankers	**2.0**
Open water work vessels, larger ferries	**1.6**
Harbor work vessels, smaller ferries	**1.2**

2.20.3.2 Performing the Tuning

The procedure for performing the tuning is dependent on whether the NAVIPILOT's Adaptive Self-Tuning capabilities are enabled, as described in the Service Setup instructions in Appendix A.

If Adaptive Self-Tuning is enabled:

1. Select the desired TUNING MODE, as described in section 2.20.3.2.1. The operator can select AUTO or MANUAL tuning mode. In AUTO mode, the NAVIPILOT monitors performance, and automatically adjusts Rudder Gain (RG) and Counter Rudder (CR) as needed, to keep the tuning optimized even if vessel behavior is affected by changes in loading or trim. In MANUAL mode, RG and CR are not automatically adjusted. Instead, the operator can manually enter the desired values for RG and CR, to compensate for the current loading or trim.

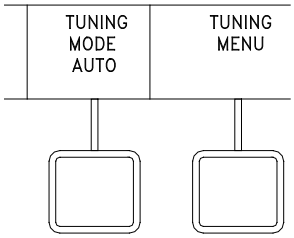
2. If AUTO mode is selected, perform the AUTO tuning procedure, as described in section 2.20.3.2.2. If MANUAL mode is selected, perform the MANUAL tuning procedure, as described in section 2.20.3.2.3.

If Adaptive Self-Tuning is disabled, only the MANUAL tuning procedure is available. Perform the MANUAL tuning procedure as described in section 2.20.3.2.3.

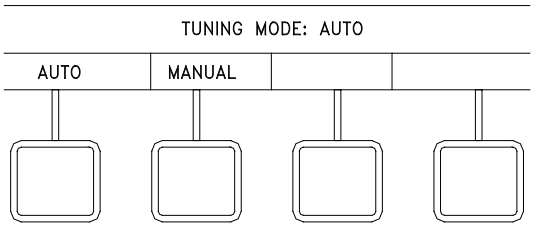
2.20.3.2.1 Select TUNING MODE

To select the TUNING MODE:

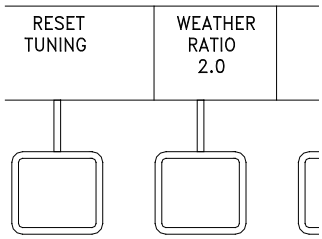
Press the MENU button until the TUNING MODE soft key is displayed.

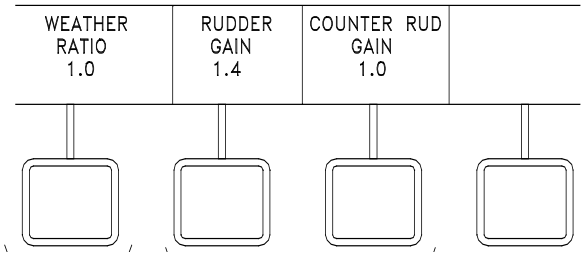


Press the TUNING MODE soft key, then press AUTO or MANUAL to select the desired tuning mode.



If AUTO mode is selected, the RESET TUNING and WEATHER RATIO soft keys will appear. If MANUAL mode is selected, the WEATHER RATIO, RUDDER GAIN (RG), and COUNTER RUD GAIN (CR) soft keys will appear.





2.20.3.2.2 Perform AUTO Tuning

NOTE: The tuning values are stored only for the LOADING condition (LIGHT or LOADED) selected at the time of tuning (see section 2.18). The tuning performed is applicable to the loading condition of the ship at the time of tuning, and will continue to adjust to loading changes which occur thereafter. If another, significantly different loading condition will repeatedly occur, then also perform the tuning procedure for that loading condition, with the other LOADING condition selected.

To perform AUTO tuning:

1. At the CDU, set the DISPLAY OPTIONS to TUNING. Refer to section 2.19 for instructions on how to select the display options; see section 2.20.2.1 for a description of the TUNING display.

2. Make a 10º heading change.

3. As the turn completes, the heading should approach the set heading, overshoot the set heading slightly, and then settle on the set heading. Observe the amount of heading overshoot as the maneuver completes, and wait for the TIMER on the TUNING display to count down to zero.

4. After the timer counts down to zero:

    a. If the RATE order turn method is used, make a series of 20º heading changes.

    b. If the RUDDER LIMIT turn method is used, make a series of 10º heading changes.

After each heading change, wait for the TIMER to count down to zero before making another heading change. No self-tuning adjustment is performed if the TIMER is not allowed to reach zero. The TIMER will count down in five-second increments after the maneuver is finished, starting from the initial value of Tau (rounded off to the nearest 5). The normal sequence requires approximately four heading changes to achieve Tuning Level (LVL) 3, which is the goal. However, if conditions do not permit achievement of a higher Tune Level, LVL 2 is acceptable. If time and space permit, continue on to LVL 4 or 5.

5. If the RATE order turn method is used, further evaluate tuning performance with one or two large turns (40º to 60º), if space permits.

6. Tuning is now complete. Proceed to section 2.20.3.3 (“*After Completing The Tuning”).*

The effectiveness of AUTO tuning is affected by the initial settings for RG and CR. The recommended initial settings for RG and CR (see section 2.20.3.1) work well for most vessels. However, there may be special cases in which these initial values do not result in acceptable tuning. In such a case, manually tune the NAVIPILOT as described below, to determine the best final tune settings for the vessel and for the vessel’s loading condition. If the necessary RG and CR are significantly different from the normal defaults, request that Sperry Field Service update the initial values of RG and CR in the service set-up menu accordingly. Thereafter, allow Adaptive Self-Tuning to continue to adjust to loading changes over time and usage.

2.20.3.2.3 Perform MANUAL Tuning

NOTE: The tuning performed is applicable to the loading condition of the ship at the time of tuning, and will be stored only for the LOADING condition (LIGHT, MEDIUM or LOADED) selected at the time of tuning (see section 2.18). If other loading conditions will be used, the tuning procedure must be repeated for each loading condition, with the appropriate LOADING condition selected at the NAVIPILOT.

To perform MANUAL tuning:

1. At the CDU, set the DISPLAY OPTIONS to TUNING. Refer to section 2.19 for instructions on how to select the display options; see section 2.20.2.1 for a description of the TUNING display.

2. Make a 10º heading change.

3. As the turn completes, the heading should approach the set heading, overshoot the set heading slightly, and then settle on the set heading. Observe the amount of heading overshoot as the maneuver completes, and wait for the TIMER on the TUNING display to count down to zero.

4. Adjust Counter Rudder (CR) (see section 2.20.2.2) as follows:

    a. If the heading overshoot was greater than 0.5º, increase CR by 0.1.

    b. If the heading overshoot was less than 0.1º or never overshot past the set heading, decrease CR by 0.1.

5. If the RATE order turn method is used, make a 20º heading change. If the RUDDER LIMIT turn method is used, make a 10º heading change.

6. Observe the amount of heading overshoot as the maneuver completes, and wait for the TIMER on the TUNING display to count down to zero.

7. Adjust Counter Rudder (CR) as follows:

    a. If the heading overshoot was greater than 0.5º, increase CR by 0.1, and repeat steps 5 thru 7.

    b. If the heading overshoot was less than 0.1º or never overshot past the set heading, decrease CR by 0.1, and repeat steps 5 thru 7.

    c. If the heading overshoot was between 0.1º and 0.5º, the NAVIPILOT has been correctly tuned.

8. If the RATE order turn method is used, further evaluate tuning performance with one or two large turns (40º to 60º) if space permits, and adjust CR if necessary.

9. After completing the above procedure:

    a. If more rudder response is desired during turns, then repeat the tuning procedure with a higher RG value, and an initial CR of 1.0.

    b. If less rudder response is desired during turns, then repeat the tuning procedure with a lower RG value, and an initial CR of 1.0.

    c. For a vessel with a very effective rudder in combination with a very fast yaw response, rudder oscillation may occur during Phase 2 of the tuning maneuver (refer to Table 2-3). If this is the case, reduce RG by 20%, reset CR to 1.0, and return to step 2.

    d. Otherwise, tuning is complete. Proceed to section 2.20.3.3.

2.20.3.3 After Completing the Tuning

After completing the tuning procedure:

1. Record the new RG and CR values in Appendix A, Table A-1, for future reference.

2. Tune the WEATHER RATIO setting (see section 2.20.2.3), as follows:

    a. With the vessel on a steady heading, set the WEATHER control to 7 (see section 2.11), and observe the heading-keeping performance with this most relaxed gain selection for heading keeping.

    b. If more accurate course control is desired for this condition, then reduce the WEATHER RATIO by an increment or two at a time, until a satisfactory result is achieved. Conversely, if less rudder activity is desired and course control can be allowed to decrease, then increase the range by an increment or two at a time until a satisfactory result is reached. *The WEATHER RATIO setting should not require further adjustment.*

3. Set the WEATHER control as needed for the current conditions, as described in section 2.11.

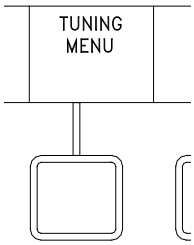
4. For best performance when not using a speed log, ensure that the NAVIPILOT's manually entered speed is kept up to date.

2.20.4 Resetting the Tuning

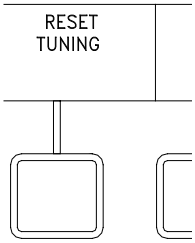
If the NAVIPILOT's Adaptive Self-Tuning function is enabled, the operator has the capability to reset the tuning of the system back to its starting condition. When Reset Tuning is selected, the tune level value is set to zero, and the rudder gain (RG) and counter rudder (CR) are set to their initial values, as configured in the Service Setup menus (see Appendix A). Once the tune level is set to zero, the tune level will not change except by automatic tuning. In order to perform the Reset Tuning function, the TUNING MODE must be set to AUTO, as described in section 2.20.3.2.1.

NOTE: The tuning should not be reset unless the tuning performance is so poor that it is better to start tuning again from the beginning.

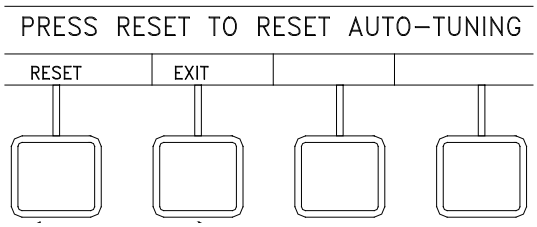
Press the MENU button until the TUNING MENU soft key is displayed.



Press the TUNING MENU soft key to display Tuning menu options.



Press the RESET TUNING soft key to display the Reset Tuning menu options.



Press the RESET soft key to reset the automatic tuning, or press EXIT to cancel the action.

2.21 VIEWING AND ACKNOWLEDGING ALARMS

The alarm subsystem of the NAVIPILOT provides the operator with audible and visual indications of system faults. The audible indication is via a piezoelectric buzzer in the CDU, as well as alarm relay contacts, which may be connected to an optional external alarm system. The visual indications at the CDU include a flashing ALARM indication, and an alarm list accessible via the menu button. The flashing ALARM indication is displayed using inverse video, and becomes steady when the alarm is acknowledged. Refer to Chapter 5 (Alarm System) for instructions on viewing and acknowledging alarms.

2.22 EMERGENCY OPERATION

Refer to Chapter 5 (Alarm System) for instructions on diagnosing NAVIPILOT failures. In case of NAVIPILOT failure, the operator should use manual control.

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CHAPTER 3
OPERATION (NAVIPILOT 4000 HSC / NAVIPILOT 4000 TRACK HSC)

3.1 INTRODUCTION

This chapter describes operating procedures and associated Control and Display Unit (CDU) displays for the following systems: NAVIPILOT 4000 HSC and NAVIPILOT 4000 TRACK HSC. Throughout this chapter, the system is generally referred to as NAVIPILOT 4000 HSC, or simply as the NAVIPILOT. All features of the NAVIPILOT 4000 HSC also apply to the NAVIPILOT 4000 TRACK HSC.

The NAVIPILOT 4000 TRACK HSC provides additional capabilities, for operation in NAV CONTROL mode (see section 3.8). The applicability of procedures and displays associated with this mode of operation is indicated in the text.

For operation of the NAVIPILOT 4000 and NAVIPILOT 4000 TRACK, see Chapter 2.

3.2 CDU DISPLAYS

The Control and Display Unit (CDU) display for the NAVIPILOT 4000 HSC is shown in Figure 3-1. A description of each CDU display area is provided in Table 3-1.

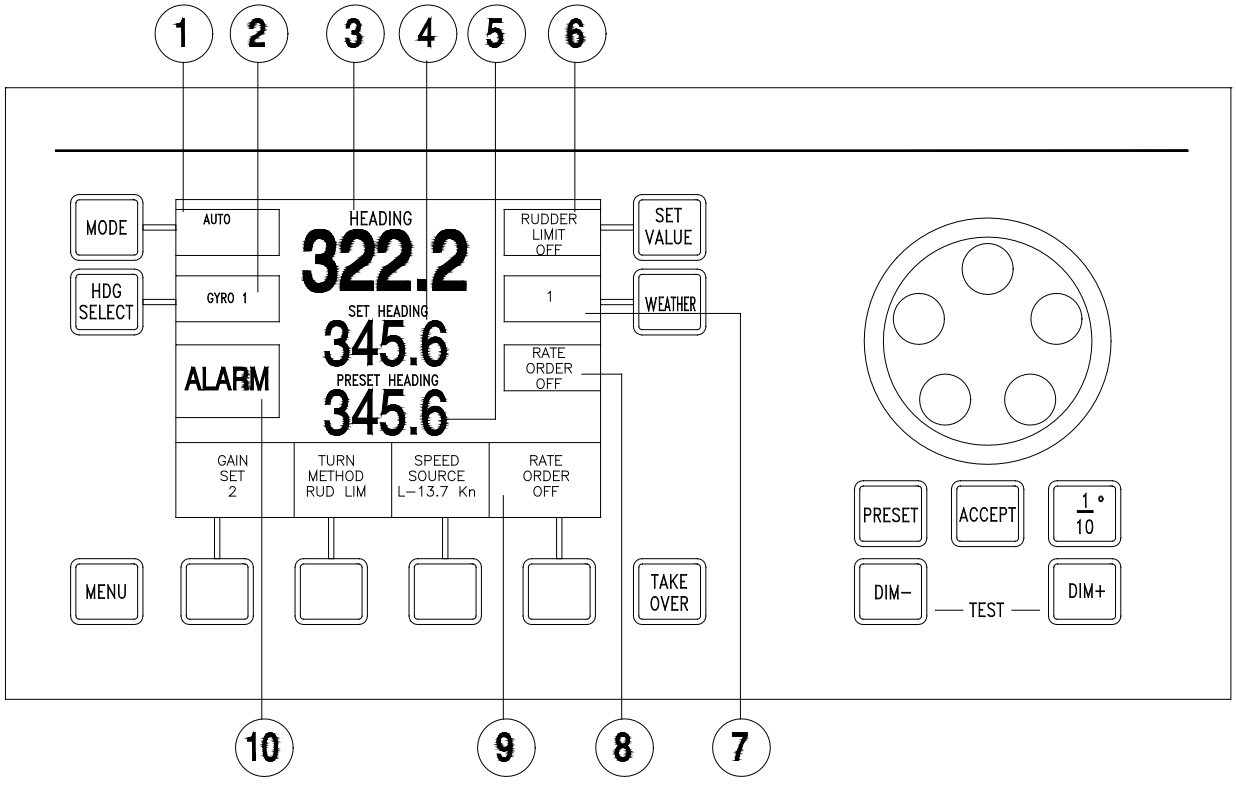


Figure 3-1. NAVIPILOT 4000 HSC CDU Display

Table 3-1. NAVIPILOT 4000 HSC CDU Display Controls and Indicators

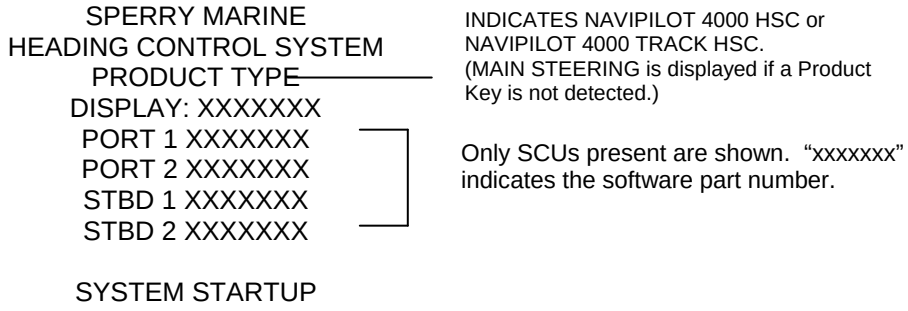
Item No.	*Title*	*Description*	
①	*MODE Display*	Displays the following information:	
		a. Mode – Operating mode of the NAVIPILOT 4000 HSC	
		AUTO	The NAVIPILOT performs automatic heading keeping. Using heading data from the compass and the operator's SET HEADING setting, the NAVIPILOT automatically generates rudder commands as needed to keep the actual heading as close as possible to the set heading. See section 3.8.1 for details.
		WAYPOINT CONTROL	The NAVIPILOT computes heading orders based on waypoint data and cross-track error received from a GPS or a compatible navigation system other than the Sperry VisionMaster FT (see section 3.8.2).
		NAV CONTROL	The NAVIPILOT executes heading commands received from the Sperry VisionMaster FT (see section 3.8.3). This mode is available with NAVIPILOT 4000 TRACK HSC.
		NFU or STANDBY	A Non Follow-Up (NFU) device, such as a tiller, is in control of steering. (An NFU device moves the rudder in the desired direction, but not to a specific final angle.) The rudder command signals are sent to the steering gear, independent of the NAVIPILOT system. On most vessels, this is considered an emergency mode of steering. Whether the display indicates NFU or STANDBY is dependent on the system configuration– refer to Appendix B (Table B-4) for details.
		FU or HELM	A Follow-Up (FU) device, such as the ship's helm wheel or a Followup Mini-Wheel (FMW), is in control of steering. (An FU device commands the steering control equipment to move the rudder to a specific angle). Whether the display indicates FU or HELM is dependent on the system configuration–refer to Appendix B (Table B-4) for details.
		EXTERNAL or external system name	An external system such as a Dynamic Positioning System (DPS) is in control of steering. The external system sends rudder commands through the NAVIPILOT, which routes the signals to the steering gear to move the rudder. The external system will sometimes include its own available modes of operation. A number of names may be selected as the External System Name to make the indication more appropriate to the specific type of external system–refer to Appendix B (Table B-4) for details.
		b. ACTIVE status - When the CDU is the station in control of steering, ACTIVE is displayed in reverse video below the operating mode.	
		c. OVERRIDE status - When steering control has been overridden by an external device, OVERRIDE is displayed in reverse video below the operating mode. The OVERRIDE indication flashes when it is displayed. See section 3.6 for details.	

Table 3-1. NAVIPILOT 4000 HSC CDU Display Controls and Indicators (continued)

Item No.	*Title*	*Description*	
②	**HDG SELECT Display**	Displays the heading source selected by the operator.	
③	**HEADING Display**	Displays the actual heading from the selected compass. "****" indicates loss of heading data.	
④	**SET HEADING Display**	Displays the set heading (heading order).	
⑤	**PRESET HEADING Display**	Displays the preset heading value which has been selected using the PRESET button and the order control knob. If manual speed has been selected (and the CDU is in control), this area will display the selected manual speed (MAN SPD) in knots. If a Preset Heading function is selected while manual speed is displayed, the Preset Heading information will be displayed in place of the MAN SPD information as needed.	
⑥	**RUDDER LIMIT Display**	Displays information on the selected turn method:	
		RUD LIM	Rudder Limit. Maximum rudder angle, in degrees. RL icon in reverse video indicates that the rudder limit has been reached.
⑦	**WEATHER Display**	Displays the gain selection chosen to compensate for sea conditions.	
⑧	**RATE ORDER or RADIUS ORDER Display**	RATE	Ordered turn rate, in degrees per minute.
		RADIUS	Ordered turn radius, in nautical miles. (This method is only available if the speed source is set to LOG.)
		The display will flash if an alarm occurs that forces a change in turn method or in the turn method's current value. (see also item 10 below).	
⑨	**Soft Key Displays**	Display the control and monitoring functions that are selectable using the MENU button and the four soft keys located below the display area.	
⑩	**ALARM Display**	When ALARM is displayed in this area, one or more alarm conditions are present. If the alarm is caused by an Off Heading condition, OFF HDG will also be displayed.	

3.3 POWER-UP

The system in which the NAVIPILOT is installed must be set to a manual steering mode before the NAVIPILOT is powered-up. During power-up, the NAVIPILOT performs a self-test. After the self-test, the system beeps once and presents the following start-up screen:



3.4 PRODUCT KEY

The Product Key is a hardware device, which is installed to each CDU at the time of system installation, and which provides read-only data to the NAVIPILOT for system licensing and security. The data that is stored at the Product Key is used to unlock the system's automatic pilot functions, including operation in AUTO, NAV or WAYPOINT modes.

During operation, only one product type (NAVIPILOT 4000, NAVIPILOT 4000 TRACK, NAVIPILOT 4000 HSC, or NAVIPILOT 4000 TRACK HSC) can be active throughout the system. The NAVIPILOT uses the Key Type data stored at the Product Key for recognition of the installed product type, and so the Key Type of the Product Keys at all CDUs should always match the active product type.

The NAVIPILOT is supplied with matched Product Keys, installed at all CDU's. These should remain in place while the system is in use, and should be changed (if necessary) only by a Sperry field engineer.

NOTE: Any change to the Product Keys does not become active until after the SCU is shut down and restarted.

3.4.1 Product Key Activation on Startup

The NAVIPILOT uses the data from the Product Keys each time the SCU is powered up. To ensure continued operation in case of a short power disruption, the most recent previous key value is used at system startup, and the keys are inspected 30 seconds after startup of the SCU. If a new key value seen after 30 seconds is different from the previous value then the new key value is saved for the next startup. This new key value is not used until after the next SCU startup, but an alarm is issued if a problem with the key is detected.

The Key Type for the active Product Key at any CDU can be displayed using the KEY TYPE indication, which is accessed from the Display Options feature (see section 3.19). The system-wide product type can also be displayed using the CONFIG ID indication of the Display Options feature. Under normal conditions, the KEY TYPE and CONFIG ID indications will match.

If a Product Key should malfunction, the system will start and operate normally as long as a valid Product Key remains in place at one CDU. The additional keys provide redundancy to provide for normal operation, for example, after failure of a single CDU.

3.4.2 Product Key Error Conditions

After startup, the NAVIPILOT verifies the status of the Product Key at each CDU, and will issue alarms under the following conditions:

- If no key is detected at a single CDU, or if other conditions exist which prevent the detection of the key at a CDU, a Missing Key alarm is issued (see Alarm 196, Table 5-1).
- If the baud rate on the CDU Service Interface port is set incorrectly, a Missing Key alarm is issued (see section B.4.2, Table B-5).
- If the SCU(s) are powered up before the CDUs, a Missing Key alarm is generated after 30 seconds. After the CDUs have started this alarm can be acknowledged and will not recur if valid key(s) are present.
- If a mis-match is detected between Product Keys at different CDUs, a Key Mismatch alarm is issued (see Alarms 197-198, Table 5-1).
- If no Product Keys are detected, the SCU will continue to function but will be limited to its manual modes of operation. Under these conditions, capabilities which are specifically associated with any of the four product types (see section 1.2) will not be available. This limited mode of operation is known as Main Steering mode.

NOTE: If the Product Key is changed at any CDU during system operation, without a restart of the SCU, a mis-match will occur between the system's displayed CONFIG ID (representing the product type), and the active Key Type at that CDU. If this should occur, NO ALARM IS ISSUED. In order for the new Product Key to take effect, each SCU should be shut down and restarted. Inappropriate changes to the Product Key can result in the NAVIPILOT transitioning to MAIN STEERING mode, as described above, with associated loss of full functionality.

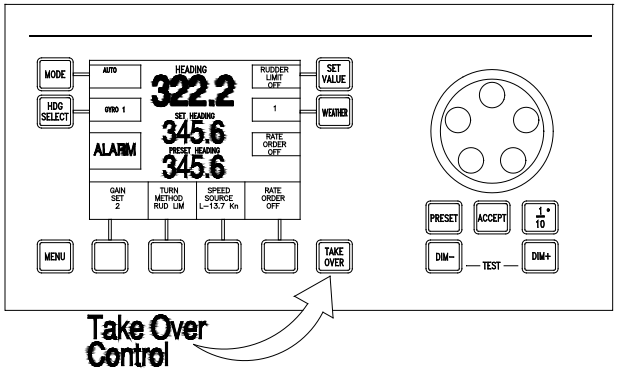
3.5 STEERING CONTROL TRANSFER (TAKEOVER METHOD)

The methods for transferring steering control to or from a NAVIPILOT Control and Display Unit (CDU) are dependent on the NAVIPILOT's configuration settings for TAKEOVER METHOD (see Appendix B), and on the types of external devices included in the steering system. The paragraphs below describe the NAVIPILOT's general functionality with respect to each of the three possible TAKEOVER METHOD configurations: NONE, CALL UP, or TAKEOVER. Optional units such as a Mechanical Mode Switch or the various types of Bus Interface Units (see Table 1-5) may be installed as part of the NAVIPILOT system, and will play a role in the control transfer process described below. In many cases, the specific devices installed will dictate which method is configured at the CDU and at optional remote devices.

IMPORTANT SAFETY NOTE: The person in charge of navigation must ensure that all personnel have a working knowledge of the transfer method(s) used for the particular installation, including optional override capabilities at devices external to the NAVIPILOT. Inappropriate transfer of control could result in hazards to navigation, resulting in danger to personnel.

3.5.1 NONE

When the NAVIPILOT is configured for NONE as the method of steering control transfer, steering control is transferred to the NAVIPILOT via a Mechanical Mode Switch, a Bus Interface Unit (see Table 1-5), or another external device. Pressing the TAKE OVER button at the CDU (see illustration) has no effect. In this case, the label on the button will normally be hidden, to avoid possible misinterpretation of the button function.



3.5.2 CALL UP

When the NAVIPILOT is configured for CALL UP as the method of steering control transfer:

1. The station in control of steering must make an offer to transfer control.

2. The station taking control of steering must accept that offer.

At the CDU or Bus Interface Unit (see Table 1-5) with control of steering, the operator presses the TAKE OVER button to offer control. When the CDU makes an offer in this manner, or receives an offer from another location, READY FOR TAKEOVER is displayed at the CDU in reverse video. Also, the Preset Heading selection [section 3.8.1] is cancelled at the CDU offering control. An operator at another CDU or Bus Interface Unit receiving the offer presses the TAKE OVER button at that device, to complete the transfer and take control.

To cancel an offer of steering control before it has been accepted, the operator at the station in control presses TAKE OVER again.

3.5.3 TAKEOVER

When the NAVIPILOT is configured for TAKEOVER as the method of steering control transfer:

- A CDU can take control of steering without a formal offer from the station in control, when the operator presses the TAKE OVER button.
- However, the CDU's ability to take control in this manner is dependent on:
    a. The setting(s) of the external mode selection device(s).
    b. Whether the CDU is configured to be at the main steering location, or at a remote steering location.

The "main" or "remote" designation of a CDU is established by its configuration setting for LOCATION (see Appendix B, Table B-5), not by its physical placement. All LOCATION settings for a CDU other than MAIN are considered to be remote locations. The TAKEOVER method is normally used only when there is more than one CDU at the main location, and/or more than one CDU at remote location(s). With a single CDU, one would normally use the NONE configuration for takeover method, and use a Mechanical Mode Switch or Steering Mode Selector for control transfer.

IMPORTANT SAFETY NOTE: When TAKEOVER method is configured, it is important to realize how easy it is to take control of steering at a new location. Personnel access to locations with takeover devices must be appropriately restricted or monitored.

For a CDU at the main steering location:

1. If a Mechanical Mode Switch (MMS) (see Table 1-5) is used for steering mode selection, the switch must be set to AUTO for a main steering CDU to be able to take control of steering.

    a. When the MMS is changed to AUTO from any other mode setting, READY FOR TAKEOVER is displayed at each main steering CDU in reverse video, and any main steering CDU can take control by pressing TAKE OVER.

    b. As long as the MMS remains set to AUTO, the operator at any main steering CDU can take control from any other main steering CDU by pressing the TAKE OVER button.

2. If a Steering Mode Selector (SMS) (see Table 1-5) is used for steering mode selection, a main steering CDU may take control regardless of the SMS setting. If the system was not in AUTO mode when the CDU took control, the SMS mode display will automatically change to indicate that the system is now in AUTO mode.

For a CDU at a remote steering location:

1. The MMS or SMS must be set to REMOTE for a remote CDU to be able to take control of steering.

2. When the MMS or SMS is changed to REMOTE from any other mode setting, READY FOR TAKEOVER is displayed at each remote steering CDU in reverse video, and any remote CDU can take control by pressing TAKE OVER.

3. As long as the MMS or SMS remains set to REMOTE, the operator at any remote CDU can take control from any other remote CDU by pressing the TAKE OVER button.

However, if there are two steering control devices on the CAN bus which are configured to be at the same remote location, such as a CDU and a Followup Mini-Wheel (FMW):

1. An SMS must also be installed at that remote location.

2. To perform takeover of steering control, the operator must press TAKEOVER at the SMS, rather than at the CDU or FMW.

3.6 STEERING CONTROL OVERRIDE

The NAVIPILOT can be configured to allow override of steering control by an external device in various operating modes. Configuration instructions for the service technician are provided in Appendix B. There are three types of steering control override:

- EXTERNAL OVERRIDE - Override when an external device is actuated, as indicated by a contact-closure at the SCU's OVERRIDE input (pins 32 and 33).
- MINIWHEEL OVERRIDE - Override when a Follow-Up Mini-Wheel (see Table 1-5) is actuated.
- ABS OVERRIDE - Override when the main helm wheel is actuated.

3.6.1 External Override and Miniwheel Override

By using the SCU CONFIGURATION - OVERRIDE ACTIVE IN menu (see Appendix B), the service technician can select the operating modes in which the NAVIPILOT will allow External Override and Miniwheel Override.

This menu provides the following options (refer to Table 3-1 for mode descriptions):

- None.

- AUTO, NAV and WAYPOINT modes
- EXTERNAL mode
- FU mode
- AUTO, NAV, WAYPOINT, and EXTERNAL modes
- AUTO, NAV, WAYPOINT, and FU modes
- AUTO, NAV, WAYPOINT, EXTERNAL, and FU modes
- EXTERNAL and FU modes

The NAVIPILOT will allow External Override in each of the configured modes. For Miniwheel Override:

- Override capability must be enabled at the Follow-Up Mini-Wheel (FMW). Otherwise, the FMW cannot override steering control in any mode.
- If override capability is enabled at the FMW, the FMW can override steering control in the configured operating mode(s) as listed above, with one exception. An FMW can never override steering control when the system is in FU mode, even if FU is configured as one of the modes that can be overridden. This means, for example, that one FMW cannot override another FMW, nor can it override the main helm wheel.

When steering control has been overridden by an external device, OVERRIDE is displayed in reverse video below the operating mode on the CDU display. The OVERRIDE indication flashes when it is displayed.

The NAVIPILOT can be configured to generate an alarm if steering control is overridden. The following options are configurable (see Appendix B for details):

- NONE. No override alarms are generated
- FMW. An alarm is generated if Miniwheel Override occurs
- EXT. An alarm is generated if External Override occurs
- FMW+EXT. An alarm is generated if Miniwheel Override or External Override occurs

3.6.2 ABS Override

By using the SCU CONFIGURATION - ABS OVERRIDE menu (see Appendix B), the service technician can enable or disable ABS Override. (ABS Override is normally not enabled unless required by the inspecting agency.) If ABS Override is enabled, actuation of the main helm wheel will override AUTO, NAV, and WAYPOINT modes. For override to occur, the wheel must be moved from the center position for more than two seconds, by more than the value configured by the service technician (3 to 8 degrees).

When the helm wheel overrides control of steering:

- OVERRIDE is displayed in reverse video below the operating mode on the CDU display, as described above for External Override and Miniwheel Override.
- An ABS OVERRIDE alarm is generated.

After an ABS override takes place, the steering system should be set to HELM mode. To resume automatic mode, the system should be set back to AUTO.

3.7 MODE SELECTION

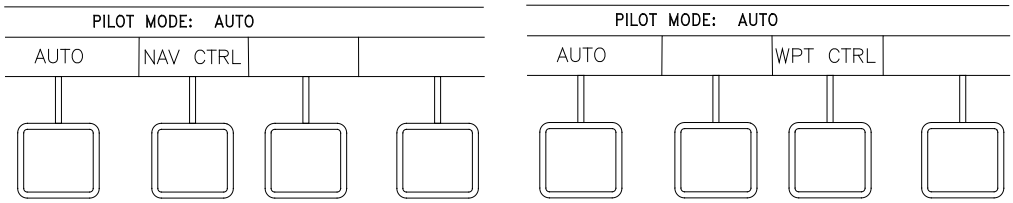
A CDU can be used to select AUTO or WAYPOINT operating modes, or NAV mode on systems where it is available. Other operating modes (NFU/STANDBY, FU/HELM, EXTERNAL) can only be selected by an external device, such as a Mechanical Mode Switch (MMS) or Steering Mode Selector (SMS). For instructions on selecting the operating mode using external devices, refer to the technical manual(s) for those devices (see Table 1-5).

NOTE: Mode selection can be performed at the CDU only if the CDU is the station in control of steering.

The available operating modes (also known as Pilot Mode) are described in Table 3-1. A more detailed description of heading control in AUTO, WAYPOINT and NAV modes is provided in section 3.8. NAV mode (see section 3.8.3) is available with the NAVIPILOT 4000 TRACK HSC.

To select the operating mode at the CDU in control of steering:

Press the MODE button to display the available mode options. If the system has the capability for NAV mode operation, the NAV CTRL soft key will be available. If the system has the capability for WAYPOINT mode operation, the WPT CTL soft key will be available.



The current operating mode (for example, PILOT MODE: AUTO) is indicated above the soft key labels. To select a different operating mode, press the associated soft key.

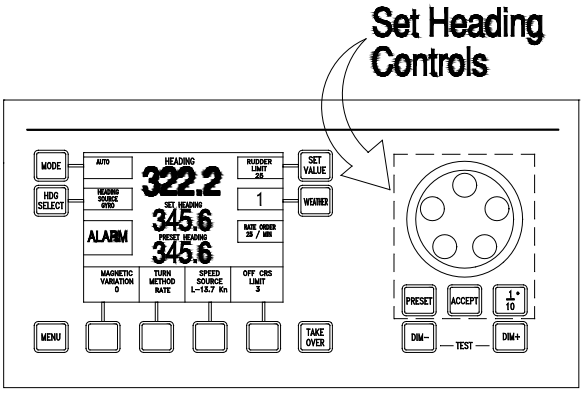
3.8 HEADING CONTROL

The following sections provide information on heading control in the following modes of operation: AUTO mode (section 3.8.1), WAYPOINT mode (section 3.8.2), and NAV mode (section 3.8.3).

3.8.1 AUTO Mode.

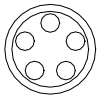
AUTO mode can be selected from the CDU in control of steering, by selecting the AUTO soft key, as shown in section 3.7.

In AUTO mode, the NAVIPILOT performs heading keeping by automatically moving the rudder as needed to keep the actual heading as close as possible to the Set Heading. Course changes can be made in AUTO mode either by turning the Set Heading knob, or by using the two-step Preset and Accept method described below.



Set Heading

NOTE: The Set Heading controls are functional only when the CDU is the station in control of steering.



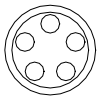
To increase the Set Heading, turn the order knob clockwise. To decrease the Set Heading, turn the order knob counterclockwise. The Set Heading will increase or decrease in 1° increments as the knob is turned.

To increase or decrease the Set Heading in 1/10° increments, press and release the 1/10° button, then turn the order knob. The 1/10° symbol will appear on the display while this function is active, and the function will timeout automatically.

Preset Heading

NOTE: The Preset Heading function should not be used when an OVERRIDE condition is indicated at the CDU (see section 3.6). The PRESET button is disabled when the CDU is overridden.

Press the PRESET button to enable preset heading entry.



To select the Preset Heading value in 1° increments, use the order knob as described in the Set Heading instructions above.

To select the Preset Heading value in 1/10° increments, use the 1/10° button and order knob as described in the Set Heading instructions above.

Press ACCEPT to make the preset heading the set heading. The PRESET HEADING value will clear, and that value will appear as the SET HEADING, indicating that the entered preset heading has been accepted. If PRESET is pressed prior to ACCEPT, the preset mode is canceled.

NOTE: If an alarm occurs while using the Preset function, pressing the ACCEPT button will first acknowledge (silence) the alarm. ACCEPT must be pressed a second time to accept the preset order.

3.8.2 WAYPOINT Mode

WAYPOINT mode can be selected from the CDU in control of steering, by selecting the WPT CTRL soft key, as shown in section 3.7.

In WAYPOINT mode, the NAVIPILOT computes heading orders based on waypoint and cross-track error data received from a GPS or other compatible navigation system. WAYPOINT mode is used when the NAVIPILOT is interfaced to a system other than the Sperry Marine VisionMaster FT.

To operate in WAYPOINT mode, a route plan must be programmed and active at the connected system. While WAYPOINT mode is active, the NAVIPILOT computes the heading order required to stay on the plan, and automatically adjusts the Set Heading accordingly.

Before selecting WAYPOINT mode at the NAVIPILOT, the operator must have a good working knowledge of the connected system. The method used for waypoint course changes will depend on the connected system's configuration and operator setup. In some cases, the operator must approve the next leg at the connected system before the vessel steers the new planned course. In other cases, the next leg of the plan is automatically selected at an operator-specified distance from the waypoint. In some instances, the NAVIPILOT will steer the new planned course with no operator action required. It is important that appropriate setup choices be made at the connected system, so that course changes will be executed as intended.

SAFETY NOTE: Some systems may allow course changes to occur with no alarms or warnings. The operator must monitor progress on the route plan, and be prepared to take appropriate action when approaching plan waypoints. If there is any uncertainty with regard to how the connected system will respond at the waypoint, the operator should switch the NAVIPILOT to AUTO mode to make the course change. WAYPOINT mode operation can be resumed on the next leg of the plan, after the operator verifies that the connected system has selected the appropriate waypoint.

When a turn is made in WAYPOINT mode, the NAVIPILOT 4000 HSC controls the turn using the operator-selected Turn Method (section 3.13), and the active values for Rudder Limit and Rate/Radius order. If it becomes necessary to change the Turn Method or adjust the associated values, the NAVIPILOT must be switched out of WAYPOINT mode. These values cannot be adjusted while WAYPOINT mode is active.

The CROSS TRACK ERROR display option (section 3.19) becomes available when WAYPOINT mode is selected. The bar graph and numeric readout of cross-track error represent truncated values to a resolution of 0.1 nautical mile. This display should not be viewed as a precise indication of XTE. The connected system will normally provide a more precise display of XTE.

The Cross-Track configuration settings (see Appendix B, Table B-3) will affect performance in WAYPOINT mode. Default values normally provide good results, but adjustments may be needed for certain types of vessels. Only a Sperry Marine authorized service technician should make these adjustments.

As described in Appendix B (Table B-4), the NAVIPILOT is configured for WAYPOINT mode operation by selecting one of the following NMEA 0183 message types for the NAV interface, as appropriate for the external system being used:

- APB - Heading/Track Controller (Autopilot) Sentence "B."
- HSC/XTE - Heading-to-Steer Command/Cross-Track Error.

3.8.3 NAV Mode

NAV mode can be selected from the CDU in control of steering by selecting the NAV CTRL soft key, as shown in section 3.7. NAV mode is available when the NAVIPILOT is interfaced to a Sperry VisionMaster FT (VMFT).

When the NAVIPILOT is in NAV mode, the VMFT determines the required heading order and delivers it to the NAVIPILOT in the form of Heading to Steer commands. The generation of heading commands at the VMFT is based on the present mode of operation of the VMFT/Autopilot interface, as controlled at the VMFT. For more information on the operation of the VMFT, refer to the applicable technical manual (see Table 1-5).

Track Control operation is available when the NAVIPILOT is set to NAV mode while a route plan is active at the VMFT. In this mode of operation, the VMFT sends heading orders to the NAVIPILOT to keep the vessel on the planned track line. Course changes are executed at wheel-over points, which are calculated by the VMFT based on vessel characteristics and the planned turn radius. When the vessel reaches the wheel-over point, the VMFT changes the heading command gradually, to control the vessel's progress through the course change.

For full functionality of VisionMaster Joystick or VM Heading modes under adverse sea conditions, VisionMaster 4.0.2 (or later) should be used in order to insure optimum behavior.

SAFETY NOTE: NEVER select NAV mode if the NAVIPILOT is controlled by a system other than the Sperry VisionMaster FT. Steering behavior could become unpredictable, resulting in danger to personnel and to the vessel.

When NAV mode is selected, the Turn Method (see section 3.13) is automatically switched to Rate Order. At wheel-over points programmed in the route plan, the NAVIPILOT indicates RATE ORDER OFF while the VMFT controls the turn rate through the turn. The Turn Method and Turn Rate cannot be adjusted at the NAVIPILOT while in NAV mode. During NAV mode turns, the gradually changing heading order, as well as the required rate order, can be viewed at the VMFT display. The VMFT default turn rate is displayed while on a straight leg in the route plan.

The NAVIPILOT 4000 HSC uses an operator-controlled rudder limit along with the radius/rate control commanded by the VMFT. If the rudder limit is not set properly, the ship may be prevented from properly completing course changes in NAV mode. If the rudder limit is ever reached during a NAV mode turn, the RUDDER LIMIT REACHED alarm is issued (see Table 5-1).

As described in Appendix B (Table B-4), the NAVIPILOT 4000 HSC is configured for NAV mode operation by setting the NMEA 0183 message type for the Track Control interface to HSC, PROP-HTC, HTR (Heading to Steer Command, Proprietary Heading To Complete, Heading Turn Rate).

In NAV mode, the NAVIPILOT provides predictable heading control even if there is a failure of the controlling system during a turn.

As described in Appendix B (Table B-4), two LOST NAV options are configurable, as follows:

- RES HDG (Resume on Heading). The current heading at the time that NAV mode functionality is lost becomes the Set Heading.
- COMPL TURN (Complete the Turn). When NAV mode functionality is lost, the bearing of the next leg of the turn becomes the Set Heading, allowing the NAVIPILOT to complete the turn to the new course. The COMPL TURN configuration is mandatory under the rules of some classification societies (including DNV Watch 1), and is optional for other vessels.

The LOST NAV configuration also affects:

- The functionality of the NAVIPILOT Set Heading display during a NAV mode turn, and
- The functionality of the NAVIPILOT when the operator changes the operating mode from NAV to AUTO during a turn.

The specific behavior of the NAVIPILOT for each LOST NAV configuration is dependent on whether the NAV STEERING MODE MSG (message) from the VisionMaster FT is configured for use (see Appendix B, Table B-4)

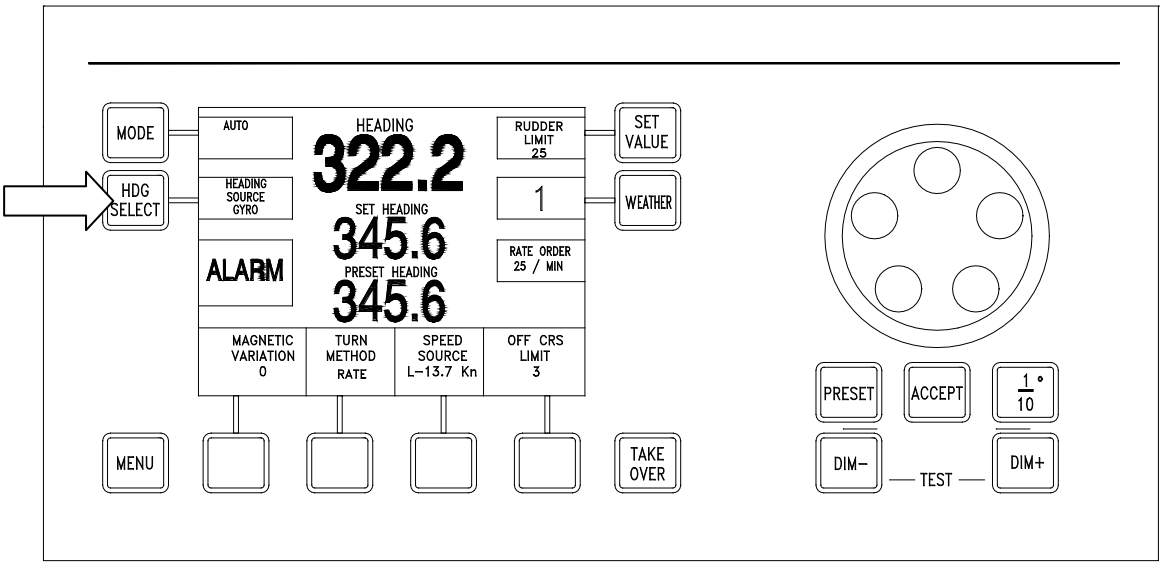
Table 3-2 describes NAV mode functionality in each LOST NAV and NAV STEERING MODE MSG configuration.

Table 3-2. NAV Mode Functionality – NAVIPILOT 4000 TRACK HSC

LOST NAV Configuration	*NAV STEERING MODE MSG Configuration*	*Event*	*Behavior*
Any	Any	A turn is executed in NAV mode.	The Set Heading displayed at the CDU will change incrementally, in accordance with the Heading to Steer Command from the VisionMaster FT.
RES HDG	Any	The operator changes the mode from NAV to AUTO during a turn.	The NAVIPILOT will Resume on Heading.
	YES (see Note)	NAV mode functionality is lost during a turn.	The NAVIPILOT will automatically transition to AUTO mode, and Resume on Heading.
	NO	NAV mode functionality is lost during a turn.	The NAVIPILOT will generate a NAV MODE NOT AVAILABLE alarm, and Resume on Heading. The operator must then change the NAVIPILOT from NAV to AUTO mode.
COMPL TURN	YES (see Note)	The operator changes the mode from NAV to AUTO during a turn.	The NAVIPILOT will Resume on Heading.
		NAV mode functionality is lost during a turn.	The NAVIPILOT will automatically transition to AUTO mode, and Complete the Turn.
	NO	The operator changes the mode from NAV to AUTO during a turn.	The NAVIPILOT will Complete the Turn.
		NAV mode functionality is lost during a turn.	The NAVIPILOT will generate a NAV MODE NOT AVAILABLE alarm, and Complete the Turn. The operator must then change the NAVIPILOT from NAV to AUTO mode.

3.9 SELECT HEADING REFERENCE

This feature is used to select the heading source from the configured heading inputs.



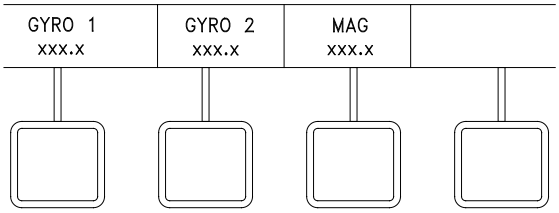
SAFETY NOTE: In some installations, an external compass monitor unit such as the Navitwin III is used to change the heading source. The operator should not change the source of heading while in an automatic mode of steering, particularly if there is a significant difference between the heading data. Normally, the compass monitor is connected in a way that allows mode detection. In this case, the compass selection is disabled while the NAVIPILOT is in AUTO, NAV, or WAYPOINT mode. The operator should verify that the compass monitor does not allow selection of a new source while in an automatic steering mode, by performing a test in an appropriate operational setting.

Press to display Heading Source menu options.

NOTE: ***The HDG SELECT control is not functional if any of the following conditions exist:***

1. The CDU is not the station in control.
2. The system is in an automatic mode (AUTO, NAV, or WAYPOINT).
3. There is only one heading source.
4. The heading source is selected via an external unit.

Available heading sources are dependent on the system in which the NAVIPILOT is installed. A typical display is shown below. If GYRO 3 is available, it will appear above the fourth soft key.



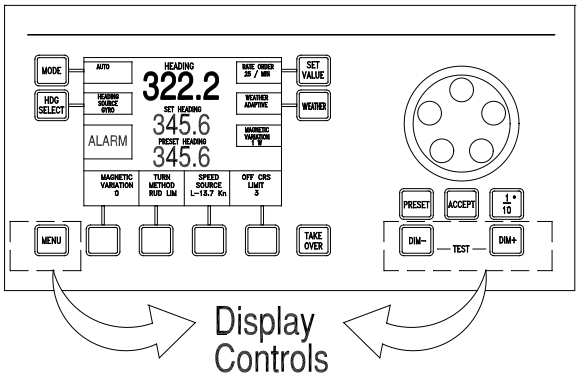
Select the soft key for the desired heading source. **NOTE:** When the heading source is lost, asterisks are displayed for Heading in the main display area.

3.10 DISPLAY ADJUSTMENT AND TEST

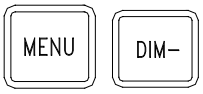
Display Illumination

Press key. Display becomes darker.

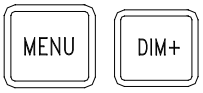
Press key. Display becomes brighter.



Display Contrast

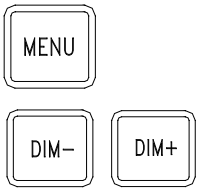


Press and hold keys simultaneously. The display contrast decreases



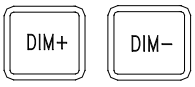
Press and hold keys simultaneously. The display contrast increases.

NOTE: To view a display of the contrast settings while contrast is being increased or decreased, first press the menu key repeatedly until no labels are displayed for the soft keys. While the display contrast is being adjusted, a display will appear showing TEMPERATURE, CONTRAST, and SELECTION. Display contrast is temperature-sensitive; the SELECTION value indicates the selected curve used by the NAVIPILOT to compensate for temperature variations.



Press and hold keys simultaneously. This sets the display contrast to its default value. This also displays the introductory screen that shows the software version. (This function is disabled when the CDU is the station in control.)

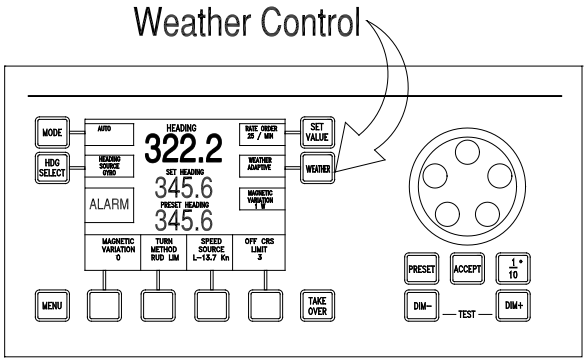
Display Test



Press and hold keys simultaneously. All display elements are activated, and the alarm buzzer sounds. (This function is disabled when the CDU is the station in control.) The appearance of the display during the test depends on the contrast settings that were in effect. If the display was showing dark text on a light background (normal contrast), the entire display becomes dark during the test. If the display had been showing light text on a dark background (inverse contrast), the entire display becomes light during the test.

3.11 SET WEATHER CONTROL

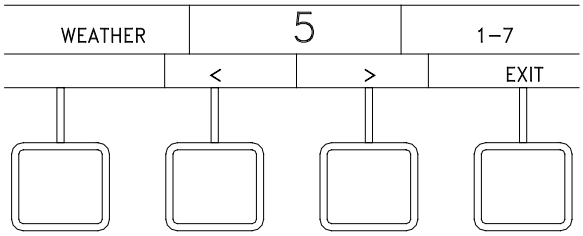
This feature is used to tailor the steering performance for different weather conditions and heading keeping requirements



NOTE

The weather control is functional only when the CDU is the station in control of steering (in an automatic mode), or when the CDU is at the location of the station in control (in a manual mode).

Press to display the Weather Control menu options.



Press the < or > soft key to change the WEATHER value. 1 is for low seas (high gain - tight heading keeping); 7 is for high seas (low gain - relaxed heading keeping).

Press EXIT to clear the menu.

The NAVIPILOT uses weather to adjust the tolerable heading error at the autopilot. Under high weather conditions it may save fuel to allow for natural wave included oscillations of the heading without causing high wear and tear on the rudder servo system. The estimated heading error for different weather settings is as follows:

Weather Setting	Estimated Freedom of Yaw
1	.3 degrees
2	2 degrees
3	3 degrees
4	4 degrees
5	5 degrees
6	6 degrees
7	8 degrees

A Weather setting of 1 is suitable for calm seas and navigation in confined waters where the ship must be held on course exactly. However, frequent rudder action and an increased resistance to propulsion will have to be accepted.

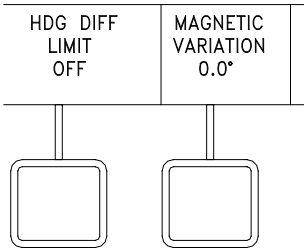
A setting from 2 to 4 is suitable for moderate to medium-heavy seas. The vessel will be held on course with seldom an only small rudder movements. This results in low wear and tear and high fuel efficiency.

A setting from 5 to 7 is suitable for medium-heavy to rough seas. The autopilot will permit larger temporary deviations from the set heading and will not actuate the rudder permanently to correct periodic back-and-forth movements of the ship in the seaway. The ship will still be held on course reasonably well over a time average.

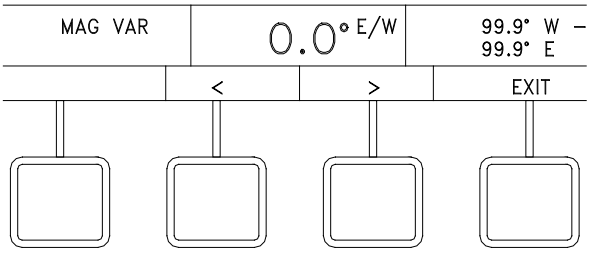
3.12 SET MAGNETIC VARIATION

This menu is displayed only if a fluxgate magnetic heading source is connected directly to the NAVIPILOT, and the NAVIPILOT is configured to use a fluxgate heading source. This feature is used to input the correct magnetic variation for the vessel's current location.

Press MENU until the MAGNETIC VARIATION soft key is visible in the menu area.



Press the MAGNETIC VARIATION soft key to display magnetic variation menu controls.



Press the < or > soft key to change the value.

Press the EXIT key to clear the menu.

3.13 SET TURN METHOD

This feature is used for selection of Turn Rate (RATE) or Turn Radius (RADIUS) as the active Turn Method used with the NAVIPILOT (see section 3.13.1). Controls are also provided for operator selection of the active values for Turn Rate (see section 3.13.2) or Turn Radius (see section 3.13.3).

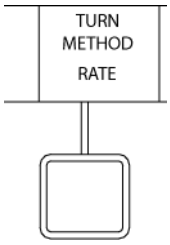
3.13.1 Turn Method Selection

SAFETY NOTES:

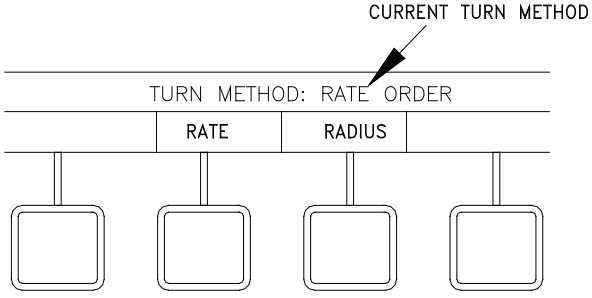
- For all turn methods, it is possible to set values that are not appropriate and/or not possible given the vessel's maneuvering characteristics or present operating conditions (weather, speed, load, draft, etc.). It is important for the operator to verify that the speed input is accurate, the desired Turn Method has been selected, and appropriate values have been set before using the NAVIPILOT to make a course change.
- Although the NAVIPILOT disables the RADIUS turn method unless a speed log is selected as the speed source, some speed logs allow manual input of speed data. For the RADIUS turn method, the speed log must be providing actual measured speed at all times for accurate turn control. NEVER use the RADIUS turn method with manual speed inputs to the speed log. Incorrect speed will cause incorrect radius control, potentially causing serious hazards for the ship and personnel.

NOTE: The RADIUS turn method can only be selected if the active speed source is a speed log (select LOG as described in section 3.15). If speed log messages are lost during a radius-controlled turn, the turn method will automatically change to RATE, and an equivalent rate order will be computed based on the current radius order and last known speed.

Press MENU to display the TURN METHOD soft key in the menu area.



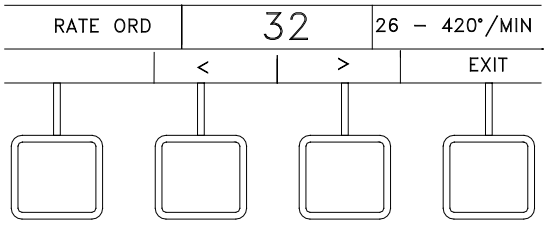
Press the TURN METHOD soft key to display the Turn Method menu.



Select the soft key for the desired Turn Method: RATE or RADIUS.

3.13.2 Set Rate Order

While the active Turn Method is RATE (see section 3.13.1), press the MENU button. Then press the RATE ORDER button to display the Rate Order (RATE ORD) controls as shown below:



Press the < or > soft key to change value.

Press the EXIT key to clear the menu

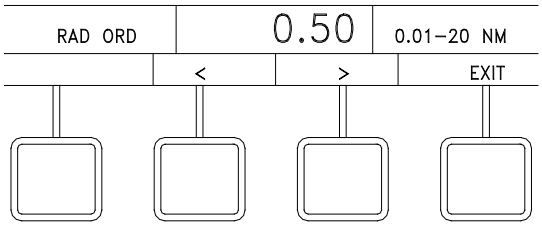
When a course change is ordered in AUTO mode, the rudder will move as needed to achieve the rate order.

The minimum turn Rate Order is dependent on the vessel's Tau (the time in seconds that it takes the vessel to sail its own length at its service speed). See Appendix D for the procedures for calculating Tau.

NOTE: The screen displays the available range for Rate Order selection (from the imposed minimum of 26 degrees/minute to a maximum of 420 degrees/minute). However, whether or not the software imposes Rate Order limitations, the operator is responsible for setting values that are safe and reasonable for the particular vessel.

3.13.3 Set Radius Order

While the active Turn Method is RADIUS, (see section 3.13.1), press the MENU button. Then press the RADIUS ORDER button to display the Radius Order (RAD ORD) controls as shown below:



Press the < or > soft key to change value.

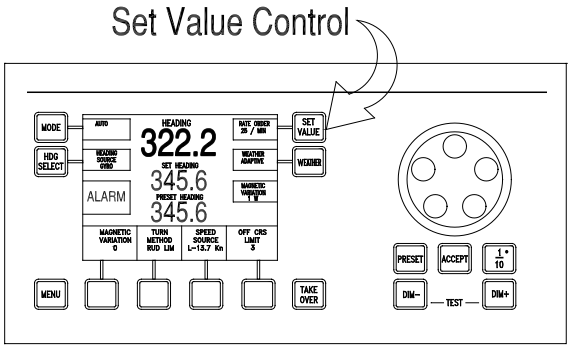
Press the EXIT key to clear the menu

When a course change is ordered in AUTO mode, the rudder will move as needed to achieve the radius order. The system uses the present Log speed to calculate the required rate to achieve the ordered radius. If Log input is not available, Radius Order control cannot be used.

NOTE: The screen displays the available range for Radius Order selection, from 0.01 nautical miles (NM) to the imposed maximum. However, whether or not the software imposes Radius Order limitations, the operator is responsible for setting values that are safe and reasonable for the particular vessel.

3.14 SET VALUE (Rudder Limit)

The SET VALUE control is used to set the active value for Rudder Limit as described below.

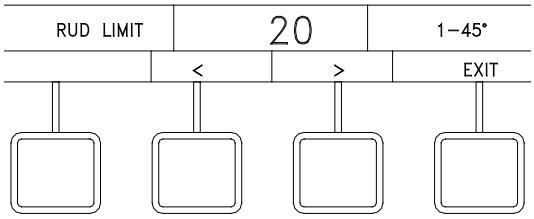


NOTE

The SET VALUE control is functional only when the CDU is the station in control of steering (in AUTO mode), or when the CDU is at the location of the station in control (in a manual mode).

In the NAVIPILOT 4000 HSC, pressing the SET VALUE button displays the Rudder Limit (RUD LIMIT) control menu, as shown below. The rudder limit can be set to a value between 1 degree and the maximum rudder angle configured by the service technician (see Appendix B, Table B-4).

Press to display Rudder Limit menu options.



Press the < or > soft key to change value.

Press the EXIT key to clear the menu

When the rudder reaches the limit set by the operator, “RL” is displayed in inverse video at the bottom of the turn method display area. “RL” will also be displayed if the Speed Scaled Rudder Limit is reached. When counter-rudder is being applied to stop vessel momentum at the conclusion of an ordered heading change, the rudder limit may temporarily be exceeded if necessary.

SAFETY NOTE: An operator rudder limit is based on effective rudder limit and is not incorporated in the dead band compensator calculation. For example, if a vessel has a dead band setting of 2 degrees and an operator rudder limit of 20 degrees, the maximum rudder is 22 degrees.

3.15 SELECT SPEED SOURCE

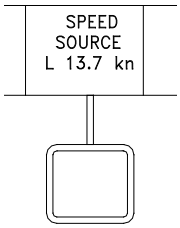
The Speed Source feature is used for selection of the active source of speed data—either a speed log (LOG) or manual speed input (MANUAL).

As described in Appendix B, Table B-4, the NAVIPILOT is configurable for several types of message formats for speed log inputs. If the NMEA 0183 VBW (Dual Ground/Water Speed) message is used, water speed has preference. Ground speed is used by the NAVIPILOT only when water speed is not available.

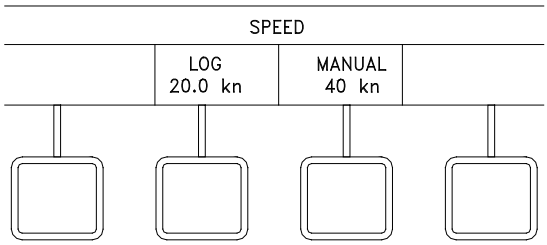
If Manual speed is selected, it is important to set a value as close as possible to the actual vessel speed. If vessel speed changes significantly, the operator must adjust the manual speed value. When manual speed is used, the active CDU provides an indication on the display (MAN SPD xx KN) as a reminder.

Manual speed inputs cannot be used with the RADIUS Turn Method (see section 3.13). If a manual speed input is selected while the RADIUS Turn Method is active, the NAVIPILOT will automatically switch to the RATE Turn Method, with a rate order based on the last radius order and log speed.

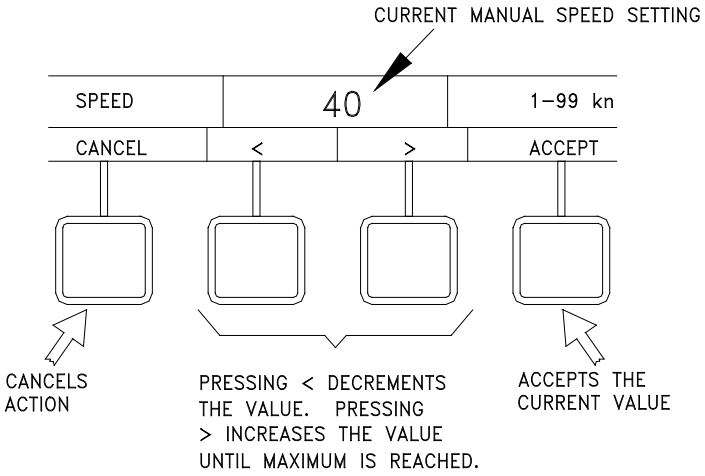
Press MENU to display the SPEED SOURCE soft key in the menu area.



Press the SPEED SOURCE soft key to display Speed Source menu options.



Press LOG or MANUAL to select the desired speed source.



If manual speed is selected, press the < or > key to change value.

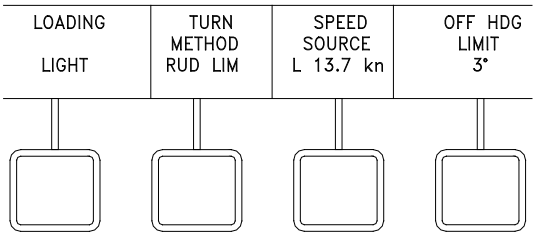
Press ACCEPT to accept the changed value, or select CANCEL to clear the menu.

3.16 SET OFF-HEADING LIMIT

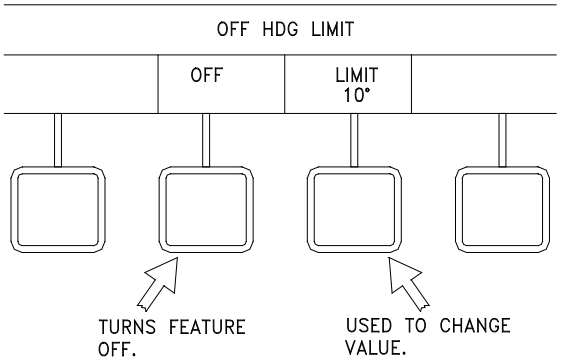
The Off-Heading Limit feature provides for operator selection of a limit value which is used for activation of the Off-Heading alarm. The alarm is activated if the heading deviates from the set heading by more than the operator-selected limit for longer than the configured off-heading delay. The off-heading delay can only be adjusted in the SERVICE SETUP 2 menu (see Appendix B).

SAFETY NOTE: The operator-set limit for the Off Heading alarm is temporarily increased when a course change is initiated, to make nuisance alarms less likely during the maneuver. For this reason, it is important for the operator to visually confirm that a course change is being controlled as ordered. In the unlikely event that the system does not successfully control the course change, the Off Heading alarm may not be activated.

Press MENU to display the OFF HDG LIMIT soft key in the menu area.



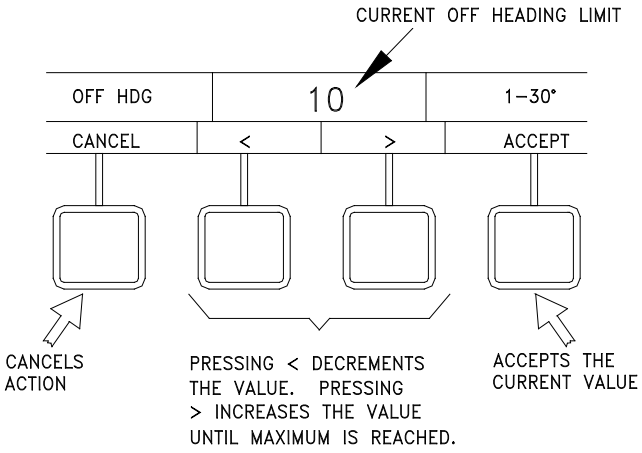
Press the OFF HDG LIMIT soft key to display the Off Heading Limit menu options.



NOTE

The “OFF” selection is available only if OFF HEADING ALARM DISABLE is enabled in the SYSTEM SETUP 2 menu (see Appendix B). Some regulatory agencies do not allow this option.

Press the OFF soft key to disable the Off Heading alarm, or press the LIMIT soft key to display the menu for changing the Off Heading limit.



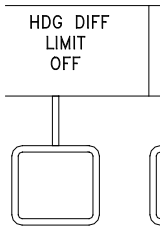
Press the < or > soft key to change the Off Heading limit value.

Select ACCEPT to accept the value, or select CANCEL to clear the menu.

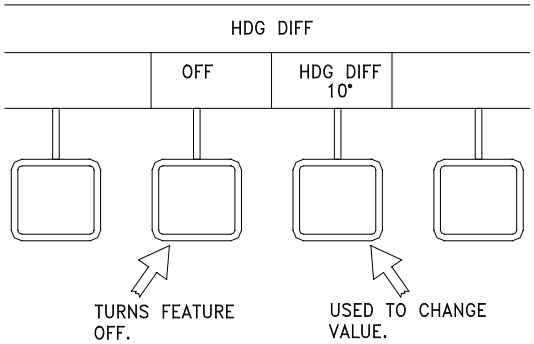
3.17 SET HEADING DIFFERENCE LIMIT

The Heading Difference Limit feature provides for operator selection of a limit value which is used for activation of the Heading Difference alarm. The alarm is activated if the difference between the heading values from any two heading sources is greater than the operator-selected limit. This menu is available only if heading inputs to the NAVIPILOT are made from multiple sources.

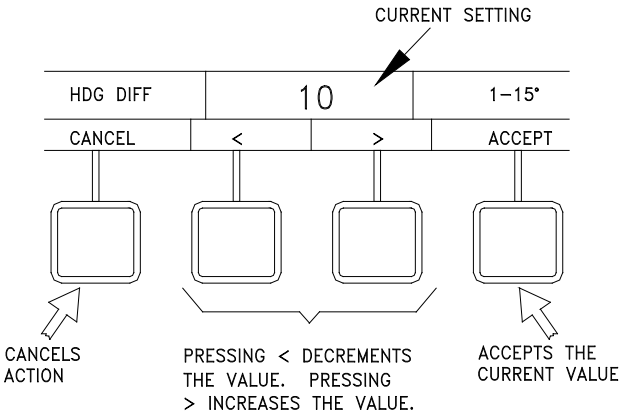
Press MENU until the HDG DIFF LIMIT soft key is visible in the menu area.



Press HDG DIFF LIMIT soft key to display Heading Difference menu options.



Select the OFF soft key to turn off the Heading Difference limit or select the HDG DIFF soft key to display menu controls for changing the Heading Difference Limit value.



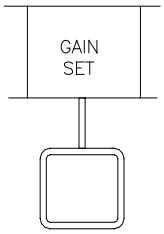
Press the < or > soft key to change the Heading Difference limit value.

Select ACCEPT to accept the value, or select CANCEL to clear the menu.

3.18 SELECT GAIN SET

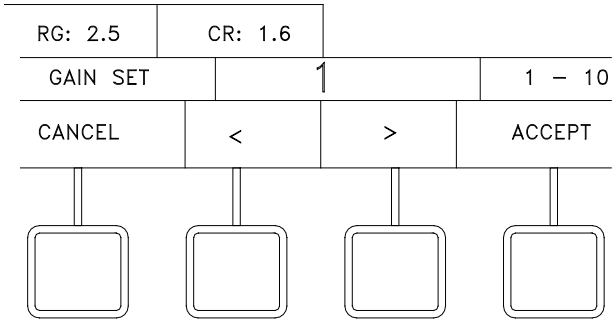
This feature allows the operator to select the gains associated with the ship's load condition. The NAVIPILOT 4000 HSC stores a set of tuning parameters (rudder gain and counter rudder) for each loading condition. Refer to section 3.20 for tuning instructions.

Press MENU to display the GAIN SET soft key in the menu area.



Press the GAIN SET soft key to display Gain Set menu options.

NOTE: The Rudder Gain (RG) and Counter Rudder (CR) values are set using the tuning menu.



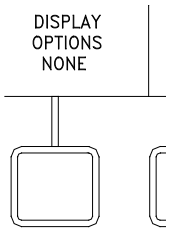
Press the < or > soft key to change the selected Gain Set.

Select ACCEPT to accept the selected Gain Set, or select CANCEL to clear the menu.

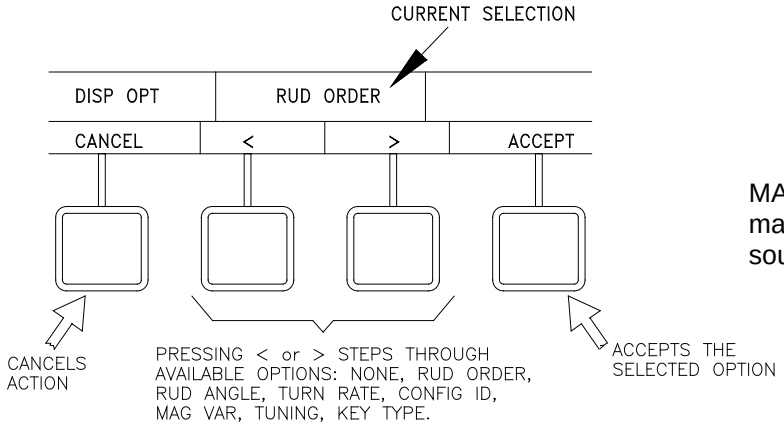
3.19 DISPLAY OPTIONS

The DISPLAY OPTIONS feature allows the operator to select a data item to be indicated at the bottom of the CDU display. The available displays include graphical indicators for Rudder Order, Rudder Angle, Turn Rate, Cross Track Error, or Tuning. Text indications are available for Magnetic Variation, Config ID, or Key Type.

Press MENU until the DISPLAY OPTIONS soft key is visible in the menu area.



Press the DISPLAY OPTIONS soft key to display the Display Options menu.



NOTE

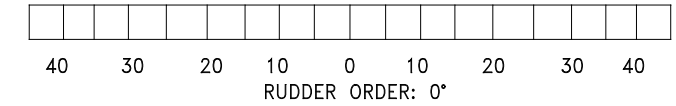
MAG VAR is available when a magnetic compass is the Heading source.

Press the < or > soft key to change the selected option. (The NONE option can be selected if desired, to turn off the indication at the bottom of the CDU display.)

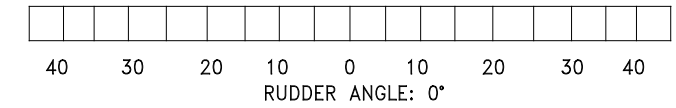
Select ACCEPT to accept the selected option. CANCEL will cancel the selection.

Press MENU again until the menu area is cleared, and the selected indication is visible at the bottom of the display.

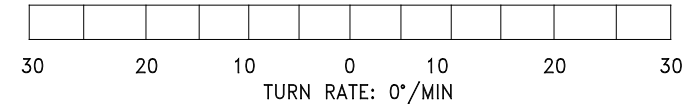
Examples of the available graphical indicators are shown below.



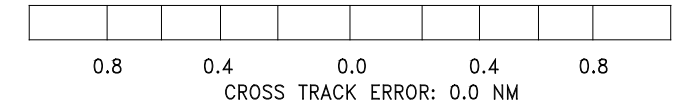
RUDDER ORDER – Rudder Order output from SCU in FU or A/N/W



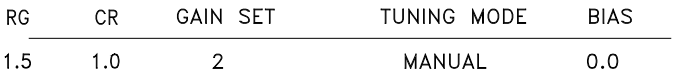
RUDDER ANGLE – Rudder angle indication from the steering system



TURN RATE – Heading rate of change in degrees per minute



CROSS TRACK ERROR – Received from connected system in WAYPOINT mode



TUNING – Refer to 3.20.2.1 for a description of the displayed data

NOTE: "Two-loop" steering control systems do not provide an accurate feedback of rudder angle to the RUDDER ANGLE display shown above. In two-loop systems, the rudder angle feedback comes from the control loop for the equipment which drives the rudder, rather than from an actual indication of rudder position. For such systems, do not use the NAVIPILOT's RUDDER ANGLE display.

Examples of the available text indications are:

MAGNETIC VARIATION : 0.0	MAGNETIC VARIATION – Present value for Magnetic Variation (if configured).
NAVIPILOT 4000 HSC or NAVIPILOT 4000 TRACK HSC MAIN STEERING	CONFIG ID – The active product type is displayed. (MAIN STEERING is displayed when no valid product type is active).
NAVIPILOT 4000 HSC or NAVIPILOT 4000 TRACK HSC MAIN STEERING	KEY TYPE – The Key Type of the installed Product Key is displayed. (MAIN STEERING is displayed when no valid Key Type is detected).

NOTE: The KEY TYPE indication will normally match the active product type, which is displayed in the CONFIG ID indicator. If the KEY TYPE and CONFIG ID indications do not match, a problem is indicated. See section 3.4 for more information on the Product Key, and error conditions related to Product Key and Product Type.

3.20 TUNING

3.20.1 Overview

The NAVIPILOT must be properly tuned in order to steer the ship effectively and efficiently. When the NAVIPILOT is first installed, parameters are set based on the ship's specifications. Then, a tuning sequence is performed during sea trials, or as soon as possible after the vessel goes to sea. During a tuning sequence, a series of maneuvers are performed, and the following parameters are adjusted to optimize NAVIPILOT performance:

- **Rudder Gain (RG).** The sensitivity of the NAVIPILOT's response to heading errors. RG is also referred to as Proportional Gain, because it generates rudder orders proportional to the heading error. Increasing the RG value increases rudder sensitivity.
- **Counter Rudder (CR)**. The sensitivity of the NAVIPILOT's response to turn rate. CR is also referred to as Rate Gain, because it generates rudder orders in direct response to the turn rate of the ship. Increasing the CR value increases the amount of counter rudder, and hence reduces the tendency for the ship to overshoot the desired heading.

If CR Self-Tuning is enabled, two tuning modes are available:

- **AUTO tuning mode.** In this mode, the NAVIPILOT monitors Turn Rate performance and automatically adjusts CR to the optimal values.
- **MANUAL tuning mode.** In this mode, the operator must monitor performance during tuning maneuvers, and manually adjust RG and CR to the desired values.

MANUAL tuning can be selected to lock in the values after a successful initial AUTO tuning sequence, or AUTO can remain selected for continued dynamic tuning during normal maneuvers. If the tuning mode remains set to AUTO after the tuning maneuvers are performed, the NAVIPILOT will automatically adjust CR for the current conditions and rate order.

If CR Self-Tuning is disabled, only the manual tuning mode is available. Refer to Appendix B, Table B-6 for instructions on enabling or disabling CR Self-Tuning.

Vessels using the Rate Order or Radius Order turn methods during normal operation should use the Rate Order turn method while performing the initial tuning sequence. The turn rate should be set to a value that will typically be used for an automatic course change at service speed.

Tuning is best performed in relatively calm seas at normal service speed. Full service speed will provide the best results during tuning. Ship's speed must remain above 50% of service speed for CR Self-Tuning to function.

The performance of the NAVIPILOT's steering algorithm is dependent on an accurate value for the ship's Time Constant (Tau). Tau is the time (in seconds) that it takes the vessel to sail its own length (at waterline) at its service speed. The tuning process does not affect the Tau value. **Therefore, before tuning is performed, it is critical that an accurate Tau value must be entered in the Service Setup menus.** Refer to Appendix D for instructions on calculating Tau and selecting initial RG/CR values. Refer to Appendix B for instructions for entering these values in the Service Setup menus.

The NAVIPILOT 4000 HSC has ten (10) operator-selectable Gain Sets for different loading and environmental conditions. It is important that the proper Gain Set be selected for the current operating condition of the ship.

3.20.2 Tuning Controls and Displays

3.20.2.1 TUNING Display

The TUNING display is shown in Figure 3-2. Refer to section 3.19 (Change Display Options) for instructions on how to select the TUNING display. Table 3-3 describes each of the parameters which appear on the TUNING display.

RG	CR	GAIN SET	TUNING MODE	BIAS
1.5	1.0	2	MANUAL	0.0

Figure 3-2. TUNING Display

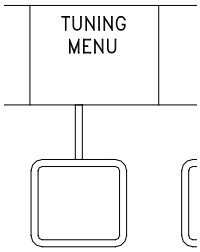
Table 3-3. TUNING Display Indicators

Item	Definition	Function
RG	Rudder Gain	The sensitivity of the NAVIPILOT's response to heading errors. RG is also referred to as Proportional Gain, because it generates rudder orders proportional to the heading error. Increasing the RG value increases rudder sensitivity.
CR	Counter Rudder	The sensitivity of the NAVIPILOT's response to turn rate. CR is also referred to as Rate Gain, because it generates rudder orders in direct response to the turn rate of the ship. Increasing the CR value increases the amount of counter rudder, and hence reduces the tendency for the ship to overshoot the desired heading.
GAIN SET	Stored Gain ID	This is the identifier for stored RG and CR values. Operators may store gains for different loads, seaway conditions, and operating speeds.
TUNING MODE (either manual or auto)	CR Self Tuning Mode	Indicates if the system will automatically tune CR based on turning conditions (Auto) or will hold CR locked (Manual)
BIAS	Rudder Order Bias	The amount of rudder required in order to maintain the heading, given the ship's characteristics and wind effects.

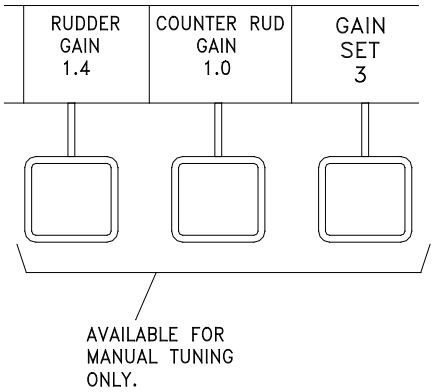
3.20.2.2 RUDDER GAIN (RG) and COUNTER RUDDER (CR) Controls (Manual Tuning)

If MANUAL tuning mode is selected (section 3.20.3.2.3), the operator can adjust the rudder gain (RG) and counter rudder (CR) in accordance with the procedures described below. Refer to section 3.20.1 for a description of RG and CR. These controls must be adjusted ONLY as described in the Tuning Procedures (section 3.20.3). NEVER adjust any of these controls except in accordance with the Tuning Procedures.

Press MENU until the TUNING MENU soft key is visible in the menu area.



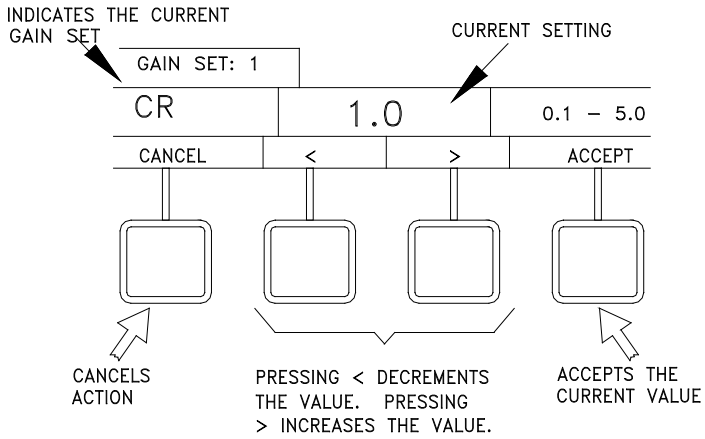
Press the TUNING MENU soft key to display Tuning menu options.



NOTE

A speed log providing actual measured speed is recommended for NAVIPILOT tuning. Manually entered speed MUST be kept up to date if no speed log is available. Refer to section 3.20.1 for more information on vessel speed.

Select the desired soft key to change Rudder Gain or Counter Rudder Gain.



Press the < or > soft key to change the value.

Select ACCEPT to accept the value, or select CANCEL to clear the menu.

3.20.3 Tuning Procedures

3.20.3.1 Before Starting the Tuning

Before tuning the NAVIPILOT:

1. The NAVIPILOT must be configured properly by a Sperry Marine Field Service Engineer, in accordance with the Service Setup instructions in Appendix B. It is particularly critical that an accurate value for Tau be entered. Refer to Appendix D for instructions for calculating Tau.

2. The ship should be operating in **calm water**. Otherwise, tuning results will be poor.

3. During tuning procedures, vessel speed should be as close as possible to the configured service speed. (Service speed is configured as part of Service Setup, as described in Appendix B.) Use of a speed log, which provides speed thru water (STW), is recommended. Whenever a source of STW is not available, the following alternatives may be substituted:

    a. Speed over ground (SOG) may be used, provided that the effect on vessel speed due to wind and current is negligible, so that there is very little difference between STW and SOG.

    b. When speed must be manually entered, use the best available reference (such as by propeller shaft speed) and ensure that the speed entered is up to date at all times.

4. Enough space should be available for making the required heading changes. It is recommended that at least 60 º is available for heading changes.

5. Input the initial settings for the NAVIPILOT as follows:

    a. Set the autopilot MODE of operation to AUTO (section 3.6.2).

    b. Set the TURN METHOD to RATE (section 3.13):

    c. Select the appropriate turn parameters:

        i. If the RATE turn method was selected, set the RATE ORDER (section 3.13.2) to a value that will typically be used for an automatic course change at service speed.

        ii. Set the RUD LIMIT (section 3.14) to a value that will typically be used for an automatic course change at service speed.

    d. Select GAIN SET based on the current loading condition and environmental conditions of the ship (section 3.18).

3.20.3.2 Performing the Tuning

The procedure for performing the tuning is dependent on whether the NAVIPILOT's CR Self-Tuning capabilities are enabled, as described in the Service Setup instructions in Table B-6.

If CR Self-Tuning is enabled:

1. Select the desired TUNING MODE, as described in section 3.20.3.2.1. The operator can select AUTO or MANUAL tuning mode. In AUTO mode, the NAVIPILOT monitors performance, and automatically adjusts Counter Rudder (CR) as needed, to keep the tuning optimized even if steering behavior is affected by changes in loading or speed. In MANUAL mode, RG and CR are not automatically adjusted. Instead, the operator can manually enter the desired values for RG and CR, for desired steering performance.

2. If AUTO mode is selected, perform the AUTO tuning procedure, as described in section 3.20.3.2.2. If MANUAL mode is selected, perform the MANUAL tuning procedure, as described in section 3.20.3.2.3.

If CR Self-Tuning is disabled, only the MANUAL tuning procedure is available. Perform the MANUAL tuning procedure as described in section 3.20.3.2.3. (CR self-tuning must be enabled; for instructions on enabling/disabling CR self-tuning, refer to Table B-6.)

General points about tuning, whether AUTO or MANUAL tuning:

1. Tuning is performed either in AUTO tuning mode or MANUAL tuning mode.

2. MANUAL tuning is to be used if the operator is not going to use Rate or Radius controlled turns, and is only going to use Rudder Limit controlled turns.

3. Automatic mode of tuning is recommended if the operator will use the autopilot for Rate or Radius controlled turning. Manual tuning mode is also available as a back-up in case the operator prefers to tune the autopilot based on his own judgment of performance. There may be special situations of sea state or speed when that is preferred.

4. Tuning is the selection of Rudder Gain and Counter Rudder Gain. Each gain has a different effect on the heading control performance of the vessel. Basic information to aid in understanding the effects of tuning values on heading control is given below. This information applies for either tuning mode, whether it be AUTO or MANUAL tuning.

    a. Rudder Gain determines how aggressively the autopilot will try to hold Set Heading and how strongly the autopilot starts the turn to a new Set Heading. A larger Rudder Gain value causes a stronger rudder response to heading errors and to heading changes than a smaller Rudder Gain.

    b. Counter Rudder Gain determines how much overshoot occurs on a new Set Heading after the turn. Too small a value of Counter Rudder Gain causes excessive overshoot.

    c. TURN RATE or TURN RADIUS during a steady turn is determined by the difference between the values of Rudder Gain and Counter Rudder Gain (diff = Rudder Gain – Counter Rudder Gain). If the difference is too small then the Turn Rate (or Turn Radius) will be lower (or radius larger) than the Set Turn Rate (or Radius).

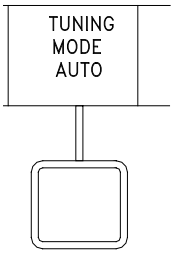
5. Note that automatic tuning mode is a “semi-automatic” tuning, as it requires operator selection of Rudder Gain value. In automatic tuning mode the Counter Rudder Gain is automatically adjusted during turns (preferably large ones such as +/- 60 degrees, or more if possible) to achieve Set TURN RATE (or Radius). In MANUAL tuning mode the same steady Turn Rate evaluation needs to be made by the operator.

6. If overshoot is excessive once the Turn Rate is suitable in Turn Rate controlled turns (thus indicating “diff” is suitable), then Counter Rudder Gain and Rudder gain are to be raised by equal amount until an acceptably low overshoot is obtained.

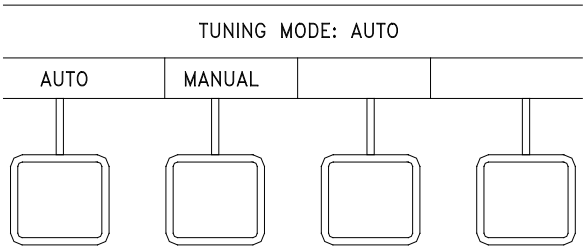
3.20.3.2.1 Select TUNING MODE

To select the TUNING MODE:

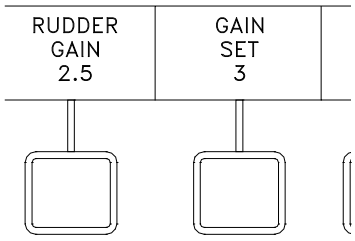
Press the MENU button until the TUNING MODE soft key is displayed.



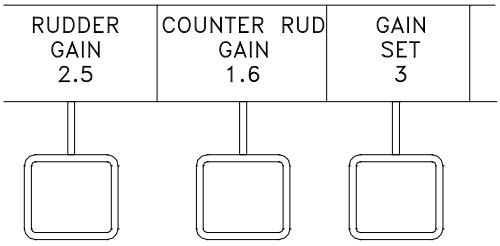
Press the TUNING MODE soft key, then press AUTO or MANUAL to select the desired tuning mode.



If AUTO mode is selected, the RUDDER GAIN and GAIN SET soft keys will appear. If MANUAL mode is selected, the RUDDER GAIN, COUNTER RUDDER (RUD), and GAIN SET soft keys will appear.



FOR AUTO TUNING



FOR MANUAL TUNING

3.20.3.2.2 Perform AUTO Tuning

NOTE: There are ten gain sets to store RG and CR pairs for different conditions. During different conditions (loading, sea state, or speed) a different GAIN SET can be used to achieve the desired performance results of the autopilot.

NOTE: The tuning performed is applicable to the loading condition of the ship at the time of tuning, and will be stored only for the GAIN SET selected at the time of tuning (see section 3.18). If other loading conditions will be used, the tuning procedure must be repeated for each loading condition, with a different GAIN SET selected at the NAVIPILOT 4000 HSC.

The initial set of Rudder Gain and Counter Rudder Gain is entered in any selected GAIN SET setting, using MANUAL tuning mode to enter CR. Initially set Counter Rudder Gain value to the same value as the Rudder Gain. It is suggested that initially a few different sets of gains are entered into a corresponding number of GAIN SETS. Initial pairs suggested are described in Table 3-4. A good starting set would be the mid set, with RG = 2.5 and CR = 2.5. Other sets can be tried, allowing the AUTO Tuning to adjust the Counter Rudder value during turns.

Table 3-4. Suggested Initial Gain Sets

GAIN SET	RUDDER GAIN (RG)	COUNTER RUDDER (CR)
3	1.5	1.5
4	2.0	2.0
5	2.5	2.5
6	3.0	3.0
7	3.5	3.5

1. Set the autopilot to the GAIN SET that is to be tuned
2. Set the RG to a desired value for heading keeping and turn initiation
3. Set the autopilot system to AUTO tuning
4. Perform turns of sufficient size (+/- 60 deg or more) to automatically tune CR (The autopilot's controlled TURN RATE of a vessel is determined by the RATE ORDER and the difference between RG and CR (RG-CR)).
    a. Auto tuning will automatically adjust CR to achieve the ordered TURN RATE.
    b. Continue performing the maneuvers until a steady ordered TURN RATE and steady CR is achieved
    c. If overshoot is excessive, then raise both gains an equal amount and re-evaluate with more turns. (Need to put into MANUAL tuning mode to manually change CR).
    d. If there is no overshoot and final approach to Set Heading is sluggish or has obvious undershoot, then lower both gains an equal amount and re-evaluate with more turns. (Need to put into MANUAL tuning mode to manually change CR).

A suitable tuning is one which has small overshoot (less than 1 degree), suitably accurate heading keeping, and sufficiently quick initiation of the turn. A variety of settings can be suitable, with the primary difference being the Rudder Gain value, but with the similarity between the suitable sets being the arithmetic difference between Rudder Gain and Counter Rudder Gain. The operator might find a preference for specific sets of gains for heavily vs. lightly loaded, calm vs. heavy weather, following vs. head seas, or high vs. low speed, etc., thus 10 different GAIN SETS are available for use.

The various RG and CR gain sets are to be recorded in Table B-1 of Appendix B for future reference.

3.20.3.2.3 Perform MANUAL Tuning

NOTE: The tuning performed is applicable to the loading condition of the ship at the time of tuning, and will be stored only for the GAIN SET selected at the time of tuning (see section 3.18). If other loading conditions will be used, the tuning procedure must be repeated for each loading condition, with a different GAIN SET selected at the NAVIPILOT 4000 HSC.

Manual Tuning for Rate Limited Turns

This section describes the manual tuning procedure for RG and CR to achieve an ordered Rate or TURN RADIUS. This method is similar to automatic tuning except that CR will be changed manually after observing each turn.

Set autopilot to MANUAL tuning mode. The initial set of Rudder Gain and Counter Rudder Gain is entered in any selected GAIN SET setting. Initially set Counter Rudder Gain value to the same value as the Rudder Gain. It is suggested that initially a few different sets of gains are entered into a corresponding number of GAIN SETS. Initial pairs suggested are described in Table 3-4. A good starting set would be the mid set, with RG = 2.5 and CR = 2.5.

1. Set the autopilot to the GAIN SET that is to be tuned
2. The RG should be set to a desired value for heading keeping and turn initiation
3. Perform turns of sufficient size (+/- 60 deg or more) to observe the Turn Rate tuning of CR. (The autopilot's controlled Turn Rate of a vessel is determined by the Rate Order and the difference between RG and CR (RG-CR)).
    a. If the vessel's steady Turn Rate exceeds the ordered Turn Rate during the turn then increase CR to decrease the steady state Turn Rate.
    b. If the vessel's steady Turn Rate never reaches the ordered Turn Rate during the turn then decrease CR to increase the steady state Turn Rate.
    c. Continue performing the maneuvers until an accurate steady TURN RATE is achieved. The difference between RG and CR (RG-CR) should be noted for Rate tuning.
    d. If overshoot is excessive, then raise both gains an equal amount and re-evaluate with more turns.
    e. If there is no overshoot and final approach to Set Heading is sluggish or has obvious undershoot, then lower both gains an equal amount and re-evaluate with more turns.

A suitable tuning is one which has small overshoot (less than 1 degree), suitably accurate heading keeping, and sufficiently quick initiation of the turn. A variety of settings can be suitable, with the primary difference being the Rudder Gain value, but with the similarity between the suitable sets being the arithmetic difference between Rudder Gain and Counter Rudder Gain. The operator might find a preference for specific sets of gains for heavily vs. lightly loaded, calm vs. heavy weather, following vs. head seas, or high vs. low speed, etc., thus 10 different GAIN SETS are available for use.

The various RG and CR gain sets are to be recorded in Table B-1 of Appendix B for future reference.

Manual tuning for Rudder Limited Control Turns

This section describes the manual tuning procedure for RG and CR when rudder limit is the primary method of controlling the autopilot. The initial set of Rudder Gain and Counter Rudder Gain is entered in any selected GAIN SET setting, using MANUAL tuning mode to enter CR. Initially set Counter Rudder Gain value to the same value as the Rudder Gain.

It is suggested that initially a few different sets of gains be entered into a corresponding number of GAIN SETS.

Initial pairs suggested are shown below:

GAIN SET	RUDDER GAIN (RG)	COUNTER RUDDER (CR)
3	1.5	1.5
4	2.0	1.5

To perform MANUAL tuning for Rudder Limited Controlled Turns:

1. Set the RATE ORDER to a large number so that it does not inhibit the rudder command during the turn (i.e. 200 deg/min).

2. At the CDU, set the DISPLAY OPTIONS to TUNING. Refer to section 3.19 for instructions on how to select the display options; see section 3.20.2.1 for a description of the TUNING display.

3. Make a series of +/- 10º heading change.

4. As the turns complete, the heading should approach the set heading, overshoot the set heading slightly, and then settle on the set heading. Observe the amount of heading overshoot as the maneuver completes.

5. Adjust Counter Rudder (CR) (see section 3.20.2.2) as follows:

   a. If the heading overshoot was greater than 2º, increase CR.

   b. If the heading overshoot was less than 0.1º or never overshot past the set heading, decrease CR.

6. Make a 20º heading change.

7. Observe the amount of heading overshoot as the maneuver completes.

8. Adjust Counter Rudder (CR) as follows:

   a. If the heading overshoot was greater than 2º, increase CR, and repeat steps 5 thru 7.

   b. If the heading overshoot was less than 0.1º or never overshot past the set heading, decrease CR by 0.1, and repeat steps 5 thru 7.

   c. If the heading overshoot was between 0.1º and 2º, the NAVIPILOT has been correctly tuned.

9. Using the RATE order turn method, further evaluate tuning performance with one or two large turns (40º to 60º) if space permits, and adjust CR if necessary.

10. After completing the above procedure:

    a. If more rudder response is desired during turns, then repeat the tuning procedure with a higher RG value.

    b. If less rudder response is desired during turns, then repeat the tuning procedure with a lower RG value.

    c. Otherwise, tuning is now complete. Proceed to section 3.20.3.3.

3.20.3.3 After completing the tuning procedure:

Record the new RG and CR values in Appendix B, Table B-1, for future reference.

3.21 VIEWING AND ACKNOWLEDGING ALARMS

The alarm subsystem of the NAVIPILOT provides the operator with audible and visual indications of system faults. The audible indication is via a piezoelectric buzzer in the CDU, as well as alarm relay contacts, which may be connected to an optional external alarm system. The visual indications at the CDU include a flashing ALARM indication, and an alarm list accessible via the menu button. The flashing ALARM indication is displayed using inverse video, and becomes steady when the alarm is acknowledged. Refer to Chapter 5 (Alarm System) for instructions on viewing and acknowledging alarms.

3.22 EMERGENCY OPERATION

Refer to Chapter 5 (Alarm System) for instructions on diagnosing NAVIPILOT failures. In case of NAVIPILOT failure, the operator should use manual control.

CHAPTER 4
INSTALLATION AND INITIALIZATION

4.1 INTRODUCTION

This chapter describes installation and initialization procedures applicable to all NAVIPILOT systems, including NAVIPILOT 4000, NAVIPILOT 4000 TRACK, NAVIPILOT 4000 HSC, and NAVIPILOT 4000 TRACK HSC.

4.2 STEERING CONTROL UNIT (SCU) HARDWARE CONFIGURATION

Once the Steering Control Unit (SCU) has been installed, the cover must be removed, and the jumpers must be configured in accordance with Table 4-1. Refer to Figure 4-1 for jumper locations. Using the jumpers, the technician can select: the rudder unit controlled by the SCU, the power source for the NAVINET 4000 Steering Control Network bus, the identification number of the SCU in the system, and whether the CAN bus is terminated at the SCU. The correct configurations of all factory-installed jumpers are also listed, for reference.

Table 4-1. SCU Jumper Configurations

Jumper	Function	Configuration	Notes
E1-E2	Rudder Unit Selection	In: *Starboard* Out: *Port*	All SCUs that are connected to the same rudder must have the same setting (all *Port* or all *Starboard*). For single-rudder vessels in which a Voyage Data Recorder (VDR) is used, all SCUs must be set to *Starboard*. (The VDR reads the rudder angle from the starboard field of the NMEA message.) For dual-rudder vessels, all SCUs that control the port rudder must be set to *Port,* and all SCUs that control the starboard rudder must be set to *Starboard*.
E3-E4	NAVINET 4000 Steering Control Network - Bus Power Source	In: *Internal* Out: *External*	The internal supply is 15 vdc, 500 mA. If more than 500 mA is required to supply all devices which communicate over the bus, an external supply will be required. A diode is inserted inline with the internal supply, for protection with parallel SCU operation.
E5-E6	FL2 Selection	In	Filter FL2 not installed.
E7-E8	FL2 Selection	In	Filter FL2 not installed.
E9-E10	Not used	--	--
E11-E12	Node ID EEPROM	In	Storage enabled.
E13-E14	Watchdog Timer	In	Timer enabled.

Table 4-1. SCU Jumper Configurations (continued)

Jumper	Function	Configuration	Notes
E15-E16	SCU Identification	In: *SCU 2* Out: *SCU 1*	This jumper is needed only if the system has more than one SCU per rudder. If two SCU's are connected to a rudder, set one SCU to *SCU 1* and the other to *SCU 2.*
E17-E18, E19-E20	Not used	--	Reserved for future use as option selection jumpers.
E21-E22	Not used	--	--
E23-E24	NAVINET 4000 Steering Control Network - Bus Termination	In: *Terminated* Out: *Not Terminated*	See Section 4.4 for bus termination instructions. E23-E24 is either a soldered bridge (earlier configurations) or a removable jumper (later configurations).
E25 thru E30	DC/DC Converter Input Normal/ Reversed	E25-E26 Jumpered; E28-E29 Jumpered. E26-E27 Jumpered; E29-E30 Jumpered.	Normal input. Reversed Input

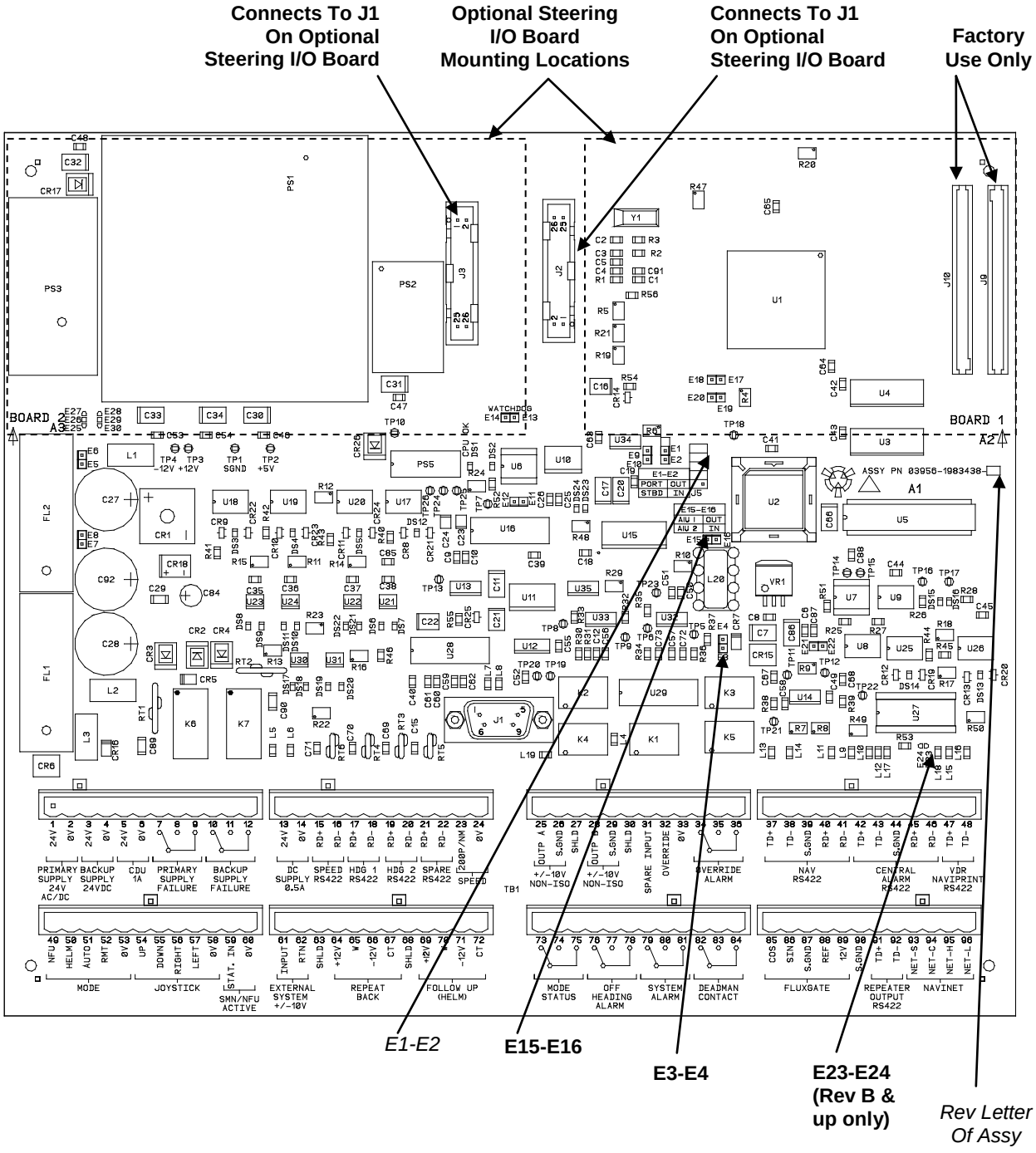


Figure 4-1. Steering Control Unit PCB

4.3 OPTIONAL STEERING I/O PCB INSTALLATION AND CONFIGURATION

The optional steering I/O PCBs provide a configurable means for intelligent control of steering gear systems. Three types of optional steering I/O PCBs are available:

- ❑ Isolated Proportional Output Interface PCB (section 4.3.1).
- ❑ Solenoid Interface PCBs (section 4.3.2):
    a. DC Solenoid Interface PCB.
    b. AC Solenoid Interface PCB.

An SCU can be equipped with up to two steering I/O PCBs. Figure 4-1 shows the locations for installing the steering I/O PCBs on the SCU PCB. The processor in the SCU will automatically determine if steering I/O PCB(s) are installed, and the type(s) of card installed.

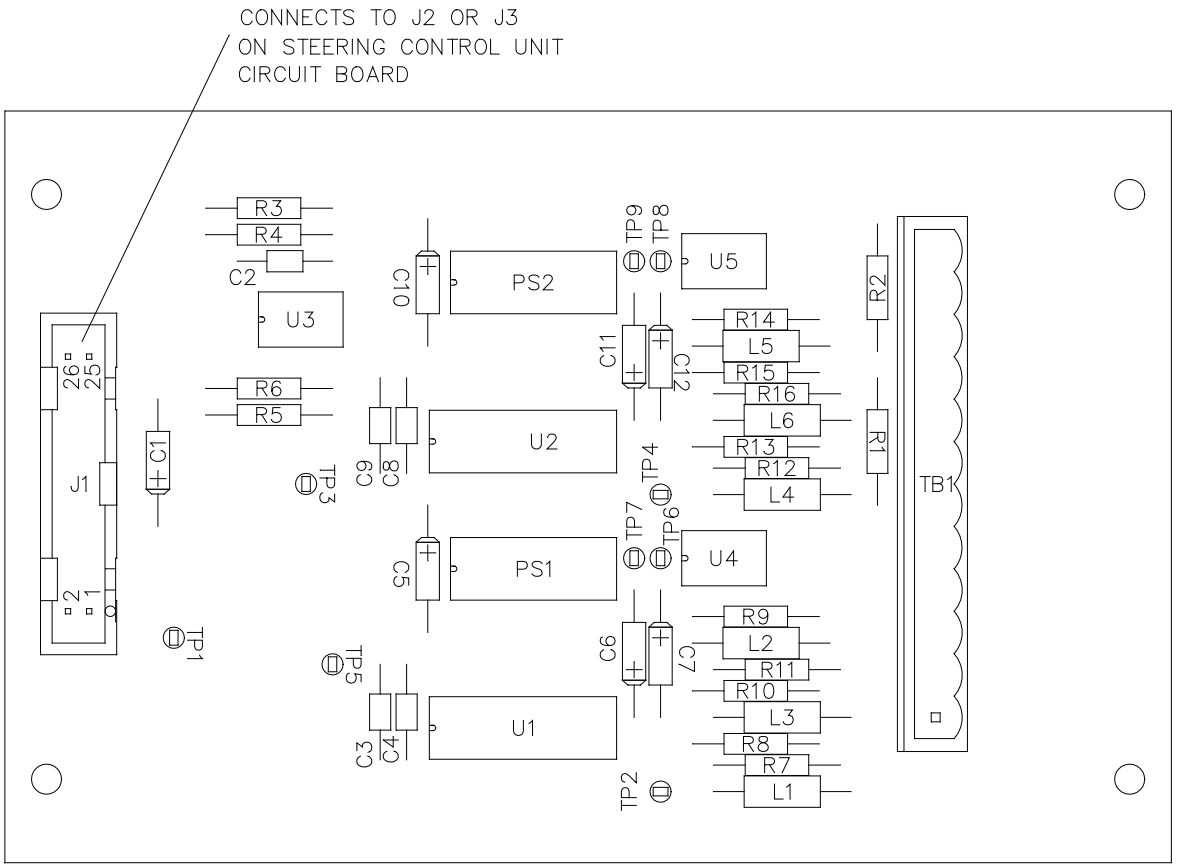
4.3.1 Isolated Proportional Output Interface PCB

The Isolated Proportional Output Interface PCB (Figure 4-2) provides two analog voltage outputs for rudder control. The single analog output generated in the SCU is routed into both channels of this circuit board, so both channels will have the same output. However, both channels are electrically isolated from each other, and from the internal SCU power supply.

The outputs from the PCB are configurable by the service technician to be either PRO (Proportional to Rudder Order) or PRE (Proportional to Rudder Error). For PRO outputs, the voltage scaling is configurable over a range of 80 to 350 millivolts per degree of rudder order. For PRE outputs, the voltage scaling is configurable over a range of 500 to 2000 millivolts per degree of rudder error. Configuration instructions are provided in Appendixes A and B. (In the SERVICE SETUP 2 - SCU CONFIGURATION settings, refer to the STEERING GEAR - ANALOG OUTPUT menu.)

The Isolated Proportional Output Interface PCB employs two small isolation power supplies and two isolation amplifiers. The amplifiers are limited to a maximum swing of +/- 10 volts. When using the isolated outputs, do not couple the output return to any power returns or commons in the SCU, or the electrical isolation will be lost.

This PCB also has two 4-20mA current-loop outputs, and two Pump On status inputs. These signals are for future use, and are not currently supported by the NAVIPILOT.



PROPORTIONAL ANALOG INPUTS/OUTPUTS		
TB1–1	OUTP A	ISOLATED ORDER/ERROR OUTPUT A
TB1–2	RTN A	
TB1–3	4–20mA	
TB1–4		
TB1–5	PUMP ON	PUMP_ON INPUT
TB1–6		
TB1–7	OUTP B	ISOLATED ORDER/ERROR OUTPUT B
TB1–8	RTN B	
TB1–9	4–20mA	
TB1–10		
TB1–11	PUMP ON	PUMP_ON INPUT
TB1–12		

Figure 4-2. Isolated Proportional Interface PCB (sheet 1 of 2)

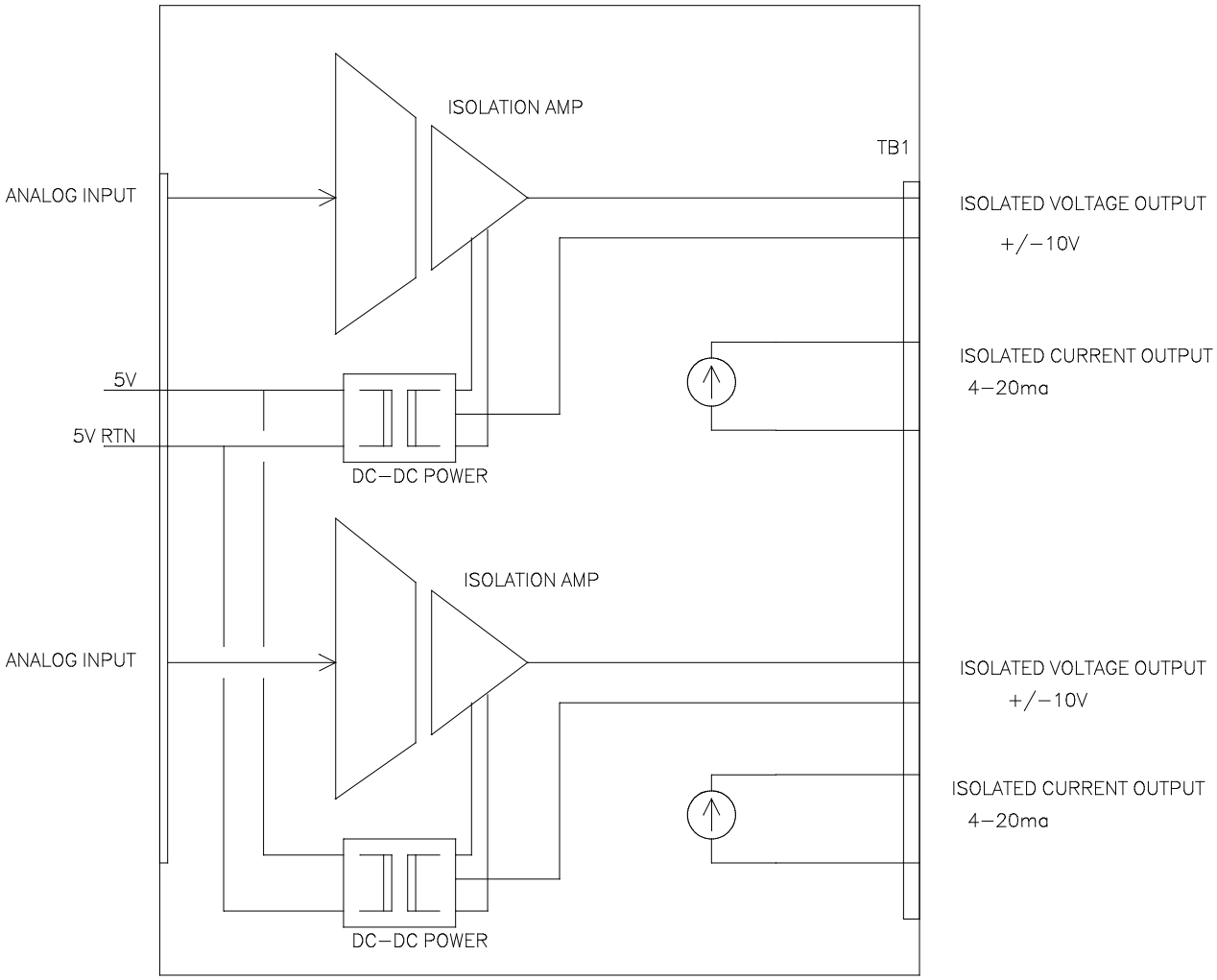


Figure 4-2. Isolated Proportional Interface PCB (sheet 2 of 2)

4.3.2 Solenoid Interface PCBs

A Solenoid Interface PCB generates control signals for solenoids that actuate steering pumps, providing the capability for multi-stage steering pump control. There are two types of Solenoid Interface PCBs:

- DC Solenoid Interface PCB (section 4.3.2.1). This PCB generates control signals for dc solenoids using supply voltages of 12 to 110 vdc.
- AC Solenoid Interface PCB (section 4.3.2.2). This PCB generates control signals for ac solenoids using supply voltages of 24 to 230 vac.

Each Solenoid Interface PCB contains two pump control sections (PUMP 1 and PUMP 2), and each SCU can have up to two PCBs installed. In the SCU Service Setup menus (see Appendixes A and B), each pump control section of each Solenoid Interface PCB is individually configurable for a specific stage of pump control. For each configurable stage, the solenoid is actuated when the rudder error rises above the ON threshold associated with that stage, and de-actuated when the rudder error falls below the OFF threshold associated with that stage.

Stages of directional valve control are designated STAGE 1 thru STAGE 4 in the SCU Service Setup menus; stages of dump valve control are designated DUMP 2 thru DUMP 4. (Stage 1 can only be configured for a directional valve.) For a system with a single SCU controlling a rudder, the ON and OFF thresholds for each stage are shown in Table 4-2. For a system with two SCUs controlling the same rudder, the staging alternates between the two SCUs. One SCU will be the Master and the other the Slave. The ON and OFF thresholds for each stage in this configuration are shown in Table 4-3.

Table 4-2. STAGE/DUMP Control - Single SCU Controlling a Rudder

STAGE or DUMP	Threshold Configuration Stages	Rudder Error ON Threshold	Rudder Error OFF Threshold
STAGE 1	STAGE 1	≥ the configured value for Stage 1 ON (default = 0.8˚)	≤ the configured value for Stage 1 OFF (default = 0.1˚)
STAGE 2 or DUMP 2	STAGE 2	≥ 3˚	≤ 2˚
STAGE 3 or DUMP 3	STAGE 3	≥ 5˚	≤ 4˚
STAGE 4 or DUMP 4	STAGE 4	≥ 7˚	≤ 6˚

Table 4-3. STAGE/DUMP Control - Two SCUs Controlling a Rudder

STAGE or DUMP	Threshold Configuration Stages	Rudder Error ON Threshold	Rudder Error OFF Threshold
STAGE 1 (Master SCU)	STAGE 1	≥ the configured value for Stage 1 ON (default = 0.8˚)	≤ the configured value for Stage 1 OFF (default = 0.1˚)
STAGE 1 (Slave SCU)	STAGE 2	≥ 3˚	≤ 2˚
STAGE 2 or DUMP 2 (Master SCU)	STAGE 3	≥ 5˚	≤ 4˚
STAGE 2 or DUMP 2 (Slave SCU)	STAGE 4	≥ 7˚	≤ 6˚
STAGE 3 or DUMP 3 (Master SCU)	STAGE 5	≥ 9˚	≤ 8˚

Table 4-3. STAGE/DUMP Control - Two SCUs Controlling a Rudder (continued)

STAGE or DUMP	Threshold Configuration Stages	Rudder Error ON Threshold	Rudder Error OFF Threshold
STAGE 3 or DUMP 3 (Slave SCU)	STAGE 6	≥ 11˚	≤ 10˚
STAGE 4 or DUMP 4 (Master SCU)	STAGE 7	≥ 13˚	≤ 12˚
STAGE 4 or DUMP 4 (Slave SCU)	STAGE 8	≥ 15˚	≤ 14˚

When configuring each pump control section of a Solenoid Interface PCB:

- The PUMP 1 section can only be configured for actuation of a directional valve, and it can only be configured to operate as STAGE 1 or STAGE 2.
- The PUMP 2 section can be configured for actuation of a directional valve or a dump valve, and it can be configured to operate as any of the possible stages (STAGE 1 thru STAGE 4; DUMP 2 thru DUMP 4).

When connecting a pump control section of a Solenoid Interface PCB to the solenoid(s):

- If the PUMP 1 or PUMP 2 section is configured for actuation of a directional valve, the Solenoid Interface PCB provides LEFT and RIGHT output signals from that section for directional control.
- If the PUMP 2 section is configured for actuation of a dump valve, the Solenoid Interface PCB provides the control signal at the LEFT output of that section.

On each Solenoid Interface PCB, each pump control section has an associated Pump On (pump running) status input. This input can be enabled or disabled for use by the PCB, via the SCU Service Setup menus (see Appendixes A and B). If the Pump On input is configured for use, that pump control section will be staged only when its status input indicates that the pump is running. If the Pump On input is not configured for use, it will be ignored, and the section will always be staged.

If the Pump On inputs are configured for use, the SCU can change the solenoid staging based on pump status. When a lower-stage pump is off or has failed, the staging will “fall back”--the next-highest stage pump will be controlled as if it were the lower-stage pump. For example, if two pump control sections are configured for Stage 2 and Stage 3 respectively, and the status input indicates that the Stage 2 pump is not running, the Stage 3 section will control its pump according to the Stage 2 rudder error thresholds. For directional valve control, each section will configure to the next lowest stage, including Stage 1, as appropriate. However, for dump valve control, each section can never go below Dump 2.

Additionally, in a system with two SCUs controlling the same rudder:

- “Fall back” does not occur across SCUs, as long as there is at least one active pump. For example, if the Stage 2/Dump 2 (Master SCU) pump is off or has failed, the Stage 3/Dump 3 (Master SCU) pump will be controlled as if it were the Stage 2/Dump 2 (Master SCU) pump.
- If one SCU has no pumps active, and the other SCU on the same rudder has active pumps, the SCU with active pumps will control the staging as if it were a single SCU controlling the rudder, as described in Table 4-2.
- If both SCUs have no pumps active, then all pumps will become Stage 1, to facilitate emergency steering if at least one pump is functioning sufficiently to steer the vessel.

4.3.2.1 DC Solenoid Interface PCB

The DC Solenoid Interface PCB generates control signals for dc solenoids using supply voltages of 12 to 110 vdc, for solenoid control of two steering pumps. Figure 4-3 shows component locations on the PCB.

There are two configurations of the DC Solenoid Interface PCB:

1. Part number 20042 – In this configuration, an unswitched I/O interface is used. TB1 is the signal interface, and relays K5 thru K9 are not installed (see section 4.3.2.1.1, Figure 4-4).

2. Part number 20043 – In this configuration, a switched I/O interface is used. TB2 is the signal interface, and relays K5 thru K9 are installed (see section 4.3.2.1.2, Figure 4-5).

4.3.2.1.1 Unswitched Configuration

Figure 4-4 shows a functional block diagram of the unswitched configuration of the DC Solenoid Interface PCB, and a pinout of the signal interfaces. A 12 to 110 vdc supply voltage is input to the PCB for each pump. For directional control valves, the PCB supplies Left and Right actuation signals for each pump. For dump valves, a control signal for the pump is supplied at the Left output of the PCB. However, as described in section 4.3.2, Pump 1 must always be configured for a directional valve. Only the Pump 2 output can be configured for dump valve control.

The SCU communicates actuation commands to the DC Solenoid Interface PCB via a serial interface to connector J1. The PCB converts the serial data to parallel, and latches it to drive four solid-state (MOSFET) SPST-NO relays. An LED is connected to each output of the latch, to indicate activation of the solenoid. When a relay is actuated, a diode bridge is biased on, supplying the dc supply voltage input to the associated solenoid-control output.

Snubber diodes on the board protect against reverse EMF. These diodes must be configured with jumpers to match the type of drive employed: Source (negative dc supply voltage) or Sink (positive dc supply voltage). Table 4-4 lists the required jumper settings for each configuration.

The interface card has two optocoupler inputs to monitor the Pump On status signal for each pump. Each Pump On input is a contact closure (closed = On). The Pump On input must be a low-impedance, potential-free contact.

4.3.2.1.2 Switched Configuration

Figure 4-5 shows a functional block diagram of the switched configuration of the DC Solenoid Interface PCB, and a pinout of the signal interfaces. The switched configuration functions the same as the unswitched configuration described above, with the following exceptions:

1. The dc supply inputs and solenoid control outputs are enabled or disabled by a set of mechanical DPST relays. The relays are actuated, and the outputs are enabled, only if the “This SCU On” input is active (+24 vdc).

2. The Pump On status input for Pump 1 is +24 vdc when the pump is on, 0 vdc when the pump is off. This signal actuates a DPST relay, which supplies the contact-closure signal to the PCB’s optocoupler, and also supplies a contact-closure pump status output to the other SCU in a two-SCU configuration.

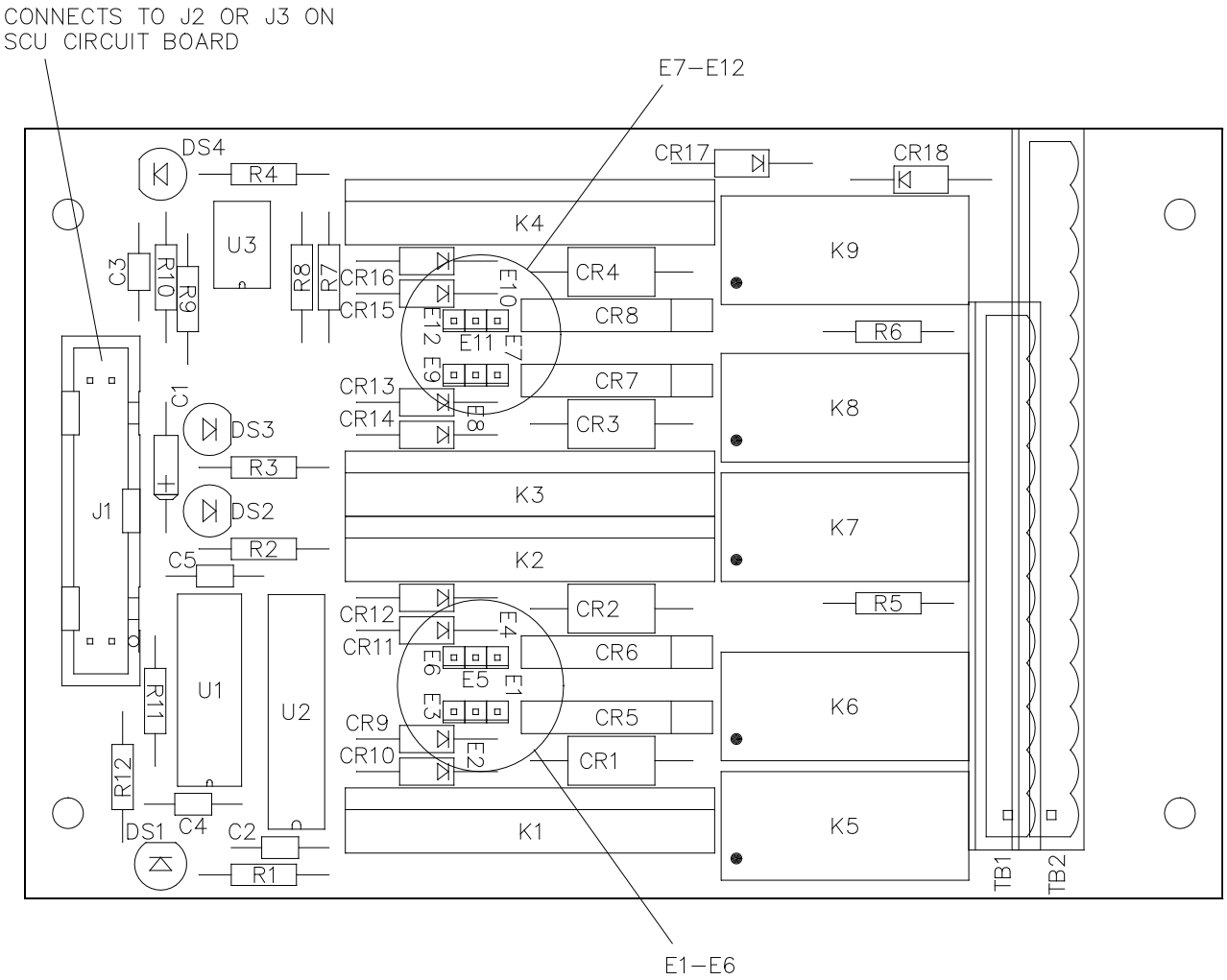


Figure 4-3. DC Solenoid Interface PCB

Table 4-4. DC Solenoid Interface PCB Jumper Configurations

Configuration	Jumper Installation
Sink Configuration (-)	E2-E3, E5-E6, E8-E9, E11-E12
Source Configuration (+)	E1-E2, E4-E5, E7-E8, E10-E11

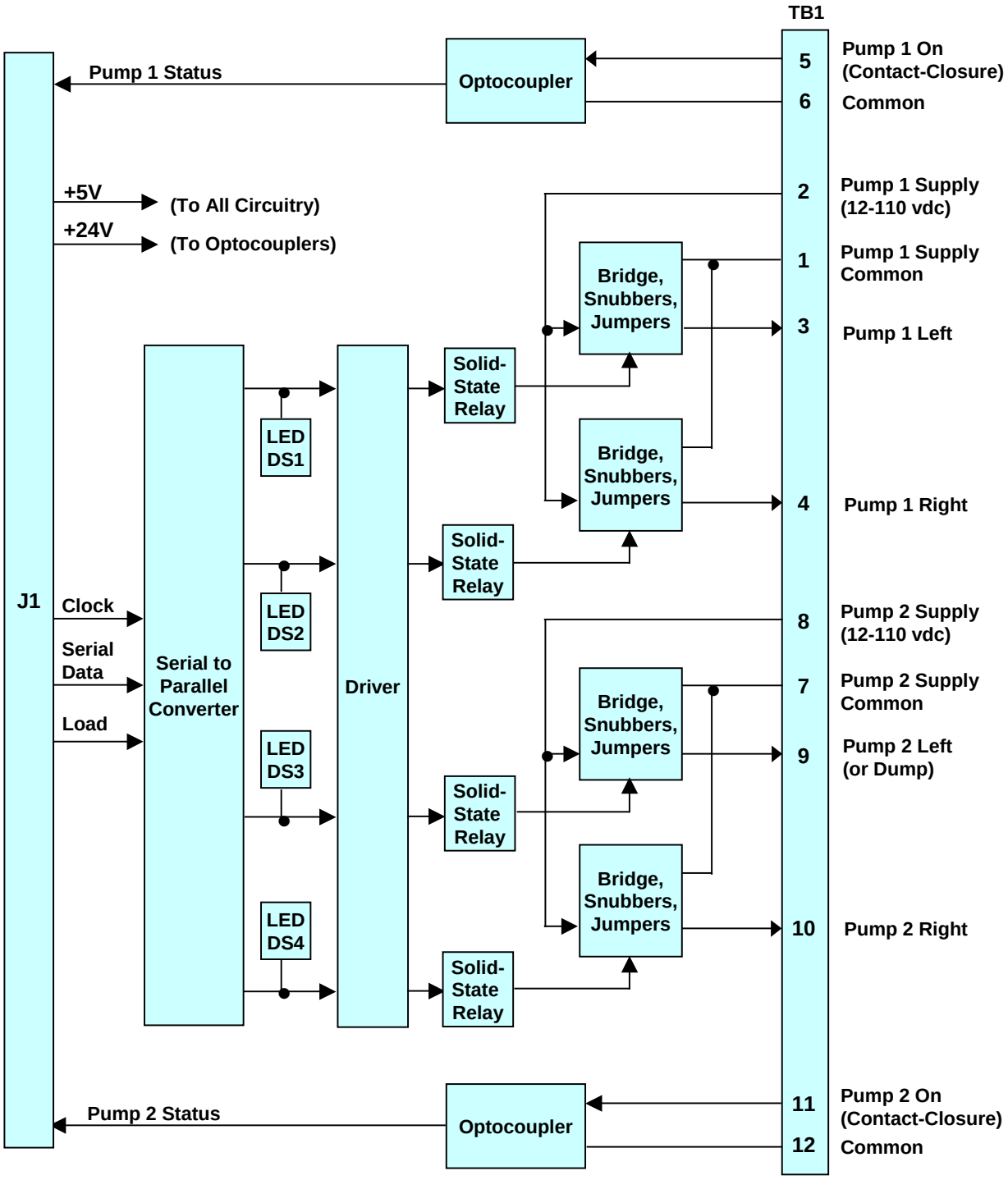


Figure 4-4. DC Solenoid Interface PCB (Unswitched Configuration) Functional and Interface Diagram

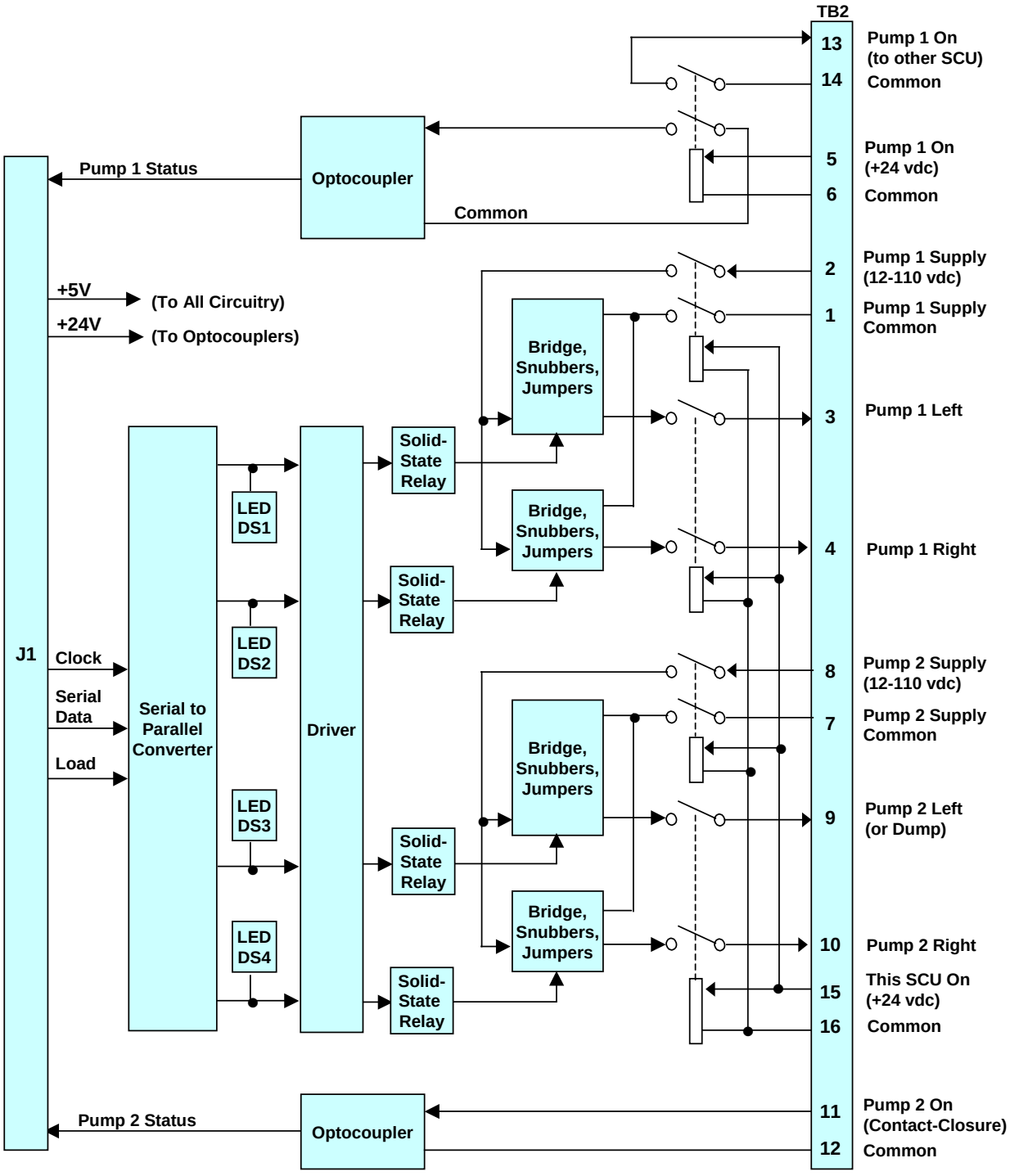


Figure 4-5. DC Solenoid Interface PCB (Switched Configuration) Functional and Interface Diagram

4.3.2.2 AC Solenoid Interface PCB

The AC Solenoid Interface PCB generates control signals for ac solenoids using supply voltages of 24 to 230 vac, for solenoid control of two steering pumps. Figure 4-6 shows component locations on the PCB.

There are two configurations of the AC Solenoid Interface PCB:

1. Part number 20040 – In this configuration, an unswitched I/O interface is used. TB1 is the signal interface, and relays K5 thru K9 are not installed (see section 4.3.2.2.1, Figure 4-7).

2. Part number 20041 – In this configuration, a switched I/O interface is used. TB2 is the signal interface, and relays K5 thru K9 are installed (see section 4.3.2.2.2, Figure 4-8).

4.3.2.2.1 Unswitched Configuration

Figure 4-7 shows a functional block diagram of the unswitched configuration of the AC Solenoid Interface PCB, and a pinout of the signal interfaces. A 24 to 230 vac supply voltage is input to the PCB for each pump. For directional control valves, the PCB supplies Left and Right actuation signals for each pump. For dump valves, a control signal for each pump is supplied at the Left output of the PCB. However, as described in section 4.3.2, Pump 1 must always be configured for a directional valve. Only the Pump 2 output can be configured for dump valve control.

The SCU communicates actuation commands to the AC Solenoid Interface PCB via a serial interface to connector J1. The PCB converts the serial data to parallel, and latches it to drive four solid-state (SCR-based) SPST-NO relays. An LED is connected to each output of the latch, to indicate activation of the associated solenoid. When a relay is actuated, the ac supply voltage input is supplied to the associated solenoid-control output.

The interface card has two optocoupler inputs to monitor the Pump On status signal for each pump. Each Pump On input is a contact closure (closed = On). The Pump On input must be a low-impedance, potential-free contact.

4.3.2.2.2 Switched Configuration

Figure 4-8 shows a functional block diagram of the switched configuration of the AC Solenoid Interface PCB, and a pinout of the signal interfaces. The switched configuration functions the same as the unswitched configuration described above, with the following exceptions:

1. The ac supply inputs and solenoid control outputs are enabled or disabled by a set of mechanical DPST relays. The relays are actuated, and the outputs are enabled, only if the “This SCU On” input is active (+24 vdc).

2. The Pump On status input for Pump 1 is +24 vdc when the pump is on, 0 vdc when the pump is off. This signal actuates a DPST relay, which supplies the contact-closure signal to the PCB’s optocoupler, and also supplies a contact-closure pump status output to the other SCU in a two-SCU configuration.

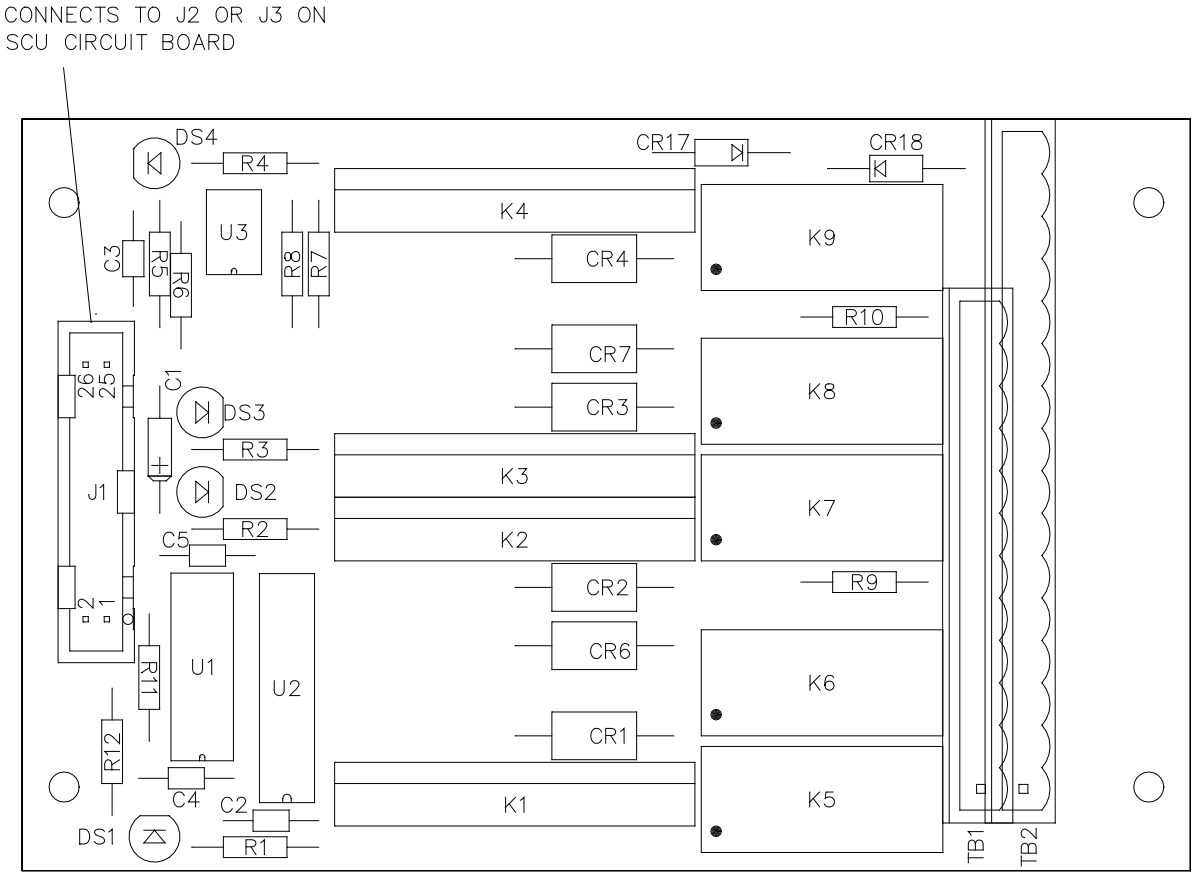


Figure 4-6. AC Solenoid Interface PCB

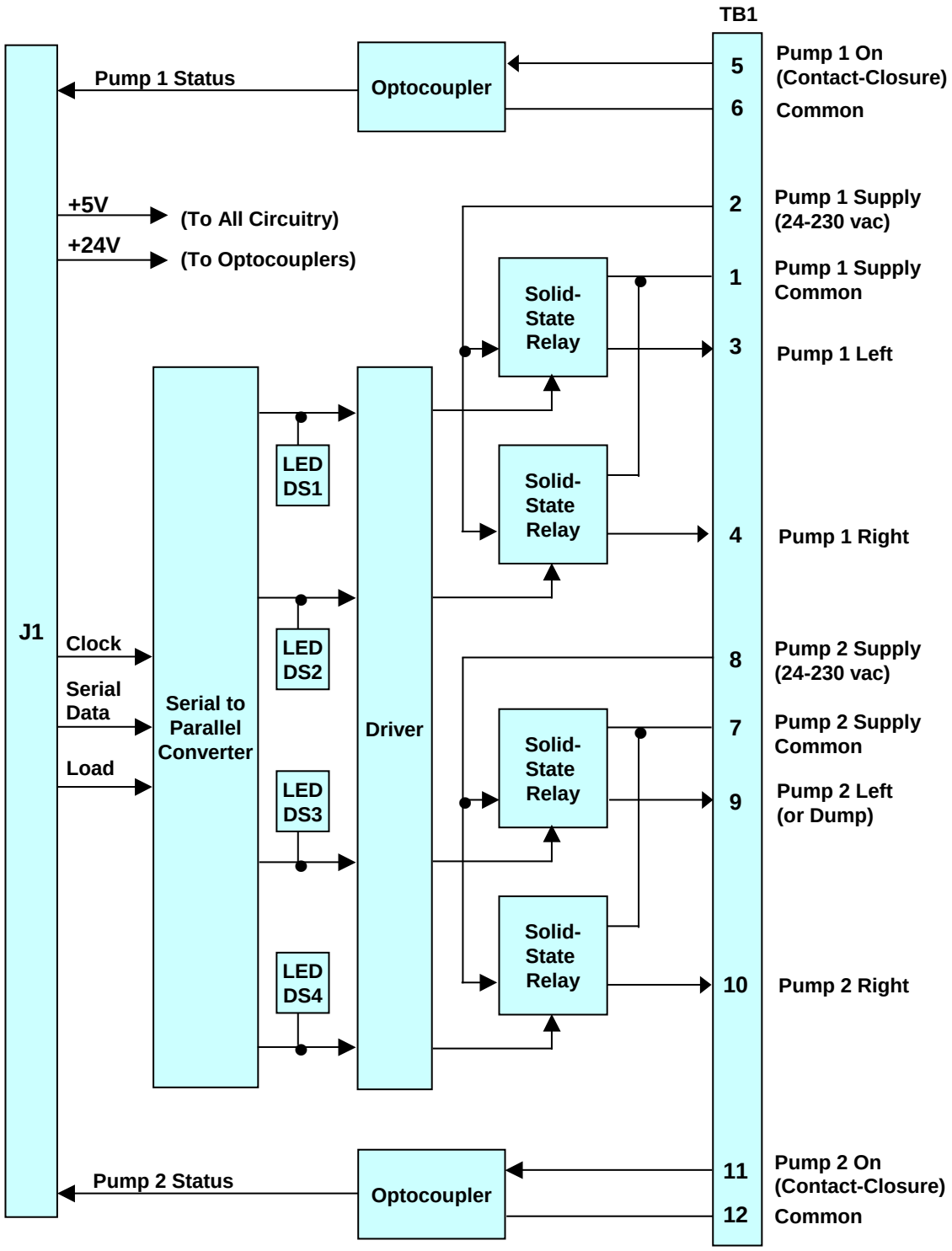


Figure 4-7. AC Solenoid Interface PCB (Unswitched Configuration) Functional Block Diagram)

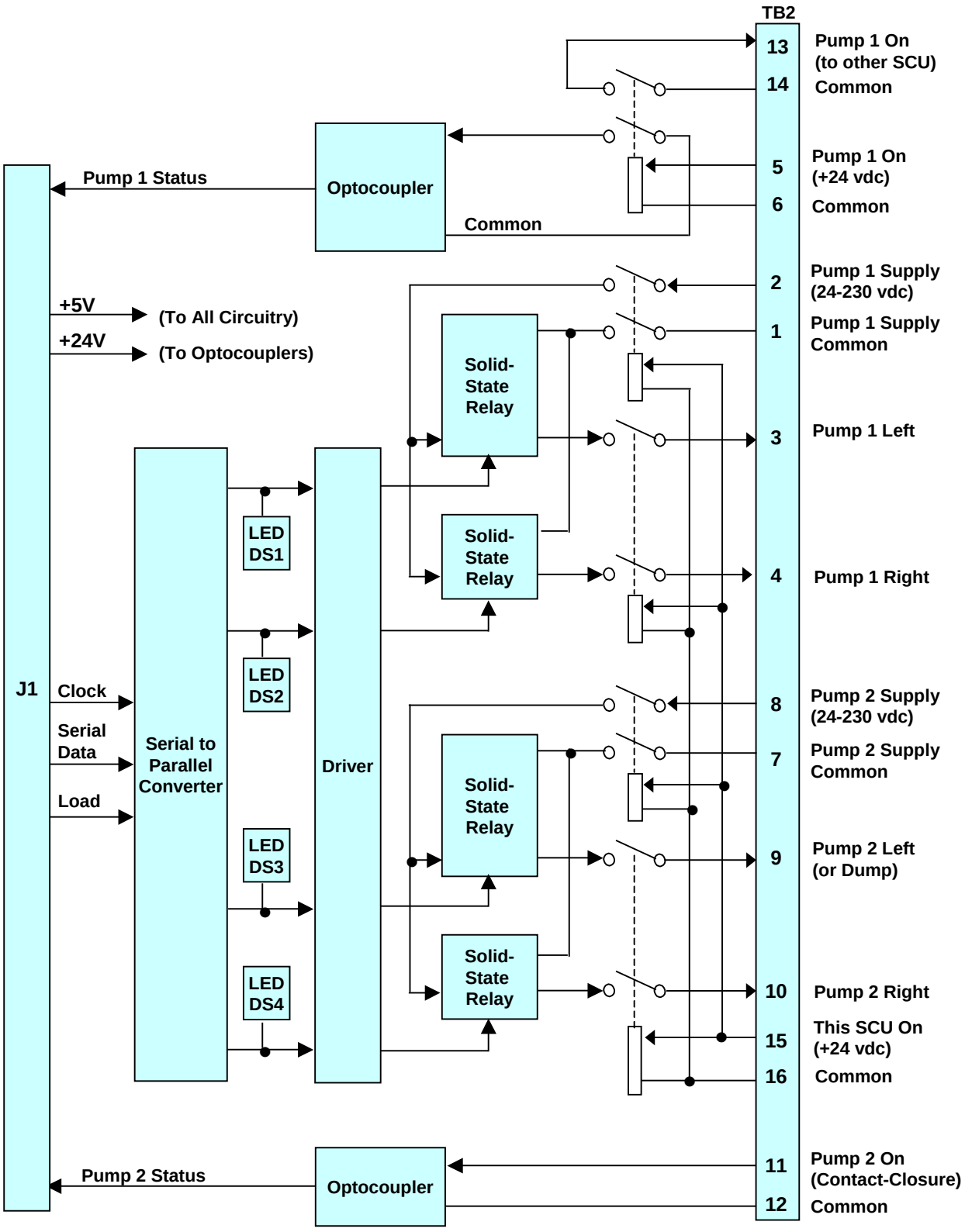


Figure 4-8. AC Solenoid Interface PCB (Switched Configuration) Functional Block Diagram

4.4 NAVINET 4000 STEERING CONTROL NETWORK — BUS CONFIGURATION.

The NAVINET 4000 Steering Control Network utilizes a 120-ohm controlled-impedance Controller Area Network (CAN) bus, with a data transfer rate of 250 kilobits per second.

This bus requires a cable which is approved for compatibility with the CAN requirements (such as the Lapp USA Unitronic® Bus DeviceNet™ cable, part number 2170340). Bus communications will not operate reliably over other types of cable. The CAN cable is divided into two sections: the bus backbone, and the stubs which connect to individual devices. The backbone must maintain a controlled impedance of 120 ohms. The maximum length of the backbone at 250 kbps is dependent on the type of Bus Interface Units (BIUs) being used in the system. For a configuration in which the BIUs are version 0.16.03 or later, the maximum bus length is 200 meters. In all other configurations, the maximum bus length is 100 meters.

To attach bus devices, a splice with an in-line terminal block or a CAN Interface Unit (CIU) is used to tap into the bus. Figure 4-9 shows a CAN Interface Unit; Figure 4-10 shows the CAN bus cable stub used to interface to Heading Control System units.

Each end of the bus must be terminated with a 120-ohm (1/8 watt or greater) resistor. The only exception to this rule is for a system in which the only devices on the bus are a single Control and Display Unit (CDU) and a single Steering Control Unit (SCU), which are directly connected together. In this case only, use of a single 120-ohm resistor at the interface point is adequate termination.

The bus can be terminated in any of the following ways:

- Via discrete resistors.
- Via resistors R1 and R2 on a CAN Interface Unit.
- Via the built-in termination resistor on the Steering Control Unit PCB. (NOTE: Only Revision B or later SCU PCB's have the built in termination resistor.)

The installer must ensure that no more than two termination resistors are present. Additional termination resistors may cause unreliable operation of the bus. If more than two devices installed on the bus have built-in termination resistors, the installer must remove or disconnect those resistors as needed, to ensure that terminations are present only at each end of the bus. For example:

- On the SCU PCB, the termination resistor is connected to the bus when a soldered bridge (earlier configurations) or a removable jumper (later configurations) is connected across terminal pair E23-E24 (Figure 4-1). If the termination resistor on the SCU PCB is not to be used, remove the bridge or jumper across E23-E24.
- On the CAN Interface Unit, each of the two resistors provides a separate bus termination. Remove both resistors to provide no bus terminations at the CIU; remove either resistor to provide a single bus termination at the CIU.

The CAN cable shield must be grounded at only one point on the bus. All other taps or splices must pass the shield through to the connection at the destination device. Equipment ground and other cable shield grounds must be kept separate. In all cases, use proper shield grounding techniques, usually connecting the shield to the vessel hull ground at only one point.

Stubs or taps to bus devices represent a load on the bus. The length of each stub must be less than 3 meters. Assuming that the CAN bus is powered by the SCU's internal 15V bus power supply, the total number of loads on the bus should not exceed 30. (Load current for the 15V bus power supply is approximately equal to 25mA + (N-1)*8mA, where N is the number of nodes or loads.)

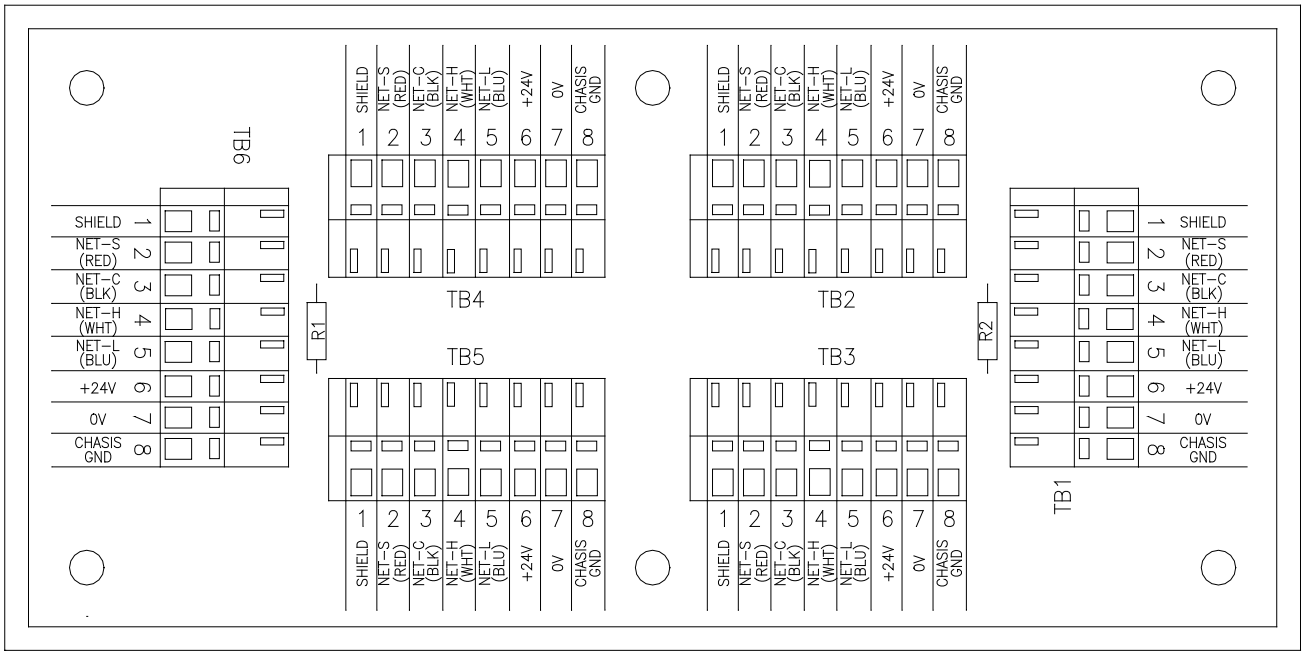


Figure 4-9. CAN Interface Unit (CIU)

CONNECTOR	COLOR	DESCRIPTION
P1–9	RED	NET–S
P1–8	BROWN	NET–C
P1–6	WHITE	NET–H
P1–5	BLUE	NET–L
P1–13	PINK	+24V
P1–11	GRAY	0V
P1–12	GREEN	+24V
P1–10	YELLOW	0V
SHLD	YEL/GRN	SHIELD

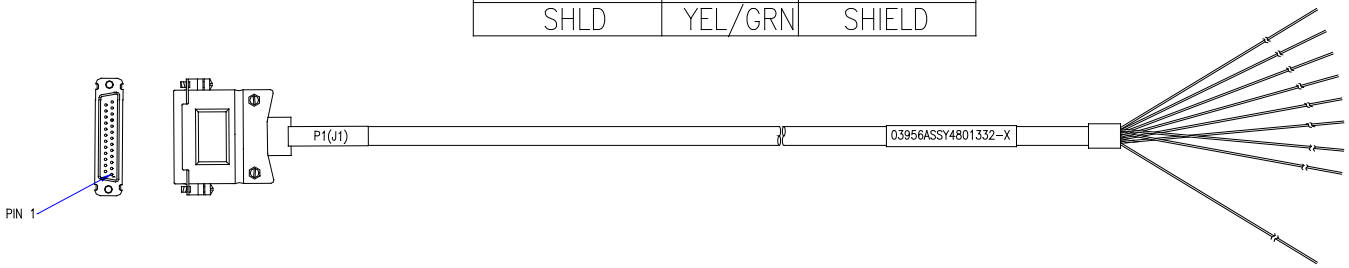


Figure 4-10. Display CAN Bus Drop Cable

4.5 SOFTWARE CONFIGURATION PARAMETERS.

The NAVIPILOT software is configured at installation by the service technician after all hardware connections have been made. The configuration parameters can only be accessed when the steering system is in non-automatic (NFU/Standby or FU/Helm) steering mode. The configuration parameters are protected by access codes to prevent unauthorized changes to the parameters.

To modify the software configuration parameters, refer to Appendixes A and B (Configuration Data) for instructions.

4.6 ALARM/STATUS RELAYS.

The NAVIPILOT SCU provides alarm and status indications via five single-pole double-throw relays. For each relay, the normally closed (NC), normally open (NO), and common (Com) contacts are interfaced to TB1 of the SCU (see Figure 4-1).

The SYSTEM ALARM relay is energized when no unacknowledged alarm exists in the system, and de-energized when an unacknowledged alarm exists. The relay contacts are pins 79 (NC), 80 (NO), and 81 (Com).

The functions of the other four relays are configured at installation when performing the SCU configuration settings (Service Setup 2), as described in Appendixes A and B. Table 4-5 lists the relays and defines the option for each configuration. In each case, the relay is energized when the selected alarm or status signal is active.

Table 4-5. Software-Configurable Alarm Relays

SCU Nomenclature	Terminals	Choices	Description
RELAY 1			
OVERRIDE ALARM *(default setting: Override)*	NC – 34 NO – 35 Com – 36	None	No function assigned to relay.
		Override	Steering control has been overridden by an external device. (See sections 2.6 and 3.6 for details.)
		Ext Sys Active	The system is in EXTERNAL steering mode using an analog input from a system such as a Dynamic Positioning System (DPS). NOTE: When the Ext Sys Active function is configured, and the system is in external steering mode: ❑ The relay will remain actuated if an Override condition occurs.
		G/M Advisor	The heading source selected is magnetic.
		Auto	The system is in automatic steering mode (AUTO), or AUTO is being overridden.
		Off Hdg Alarm	An Off Heading alarm condition exists.

Table 4-5. Software-Configurable Alarm Relays (continued)

SCU Nomenclature	Terminals	Choices	Description
		Deadman Contact	Produces a one-second pulse at each operator interaction (when the system is operated in FU mode, and the operator pushes any button or causes movement of the helm wheel).
		Helm Advisor	A Helm Wheel Not Zeroed condition exists. (The helm wheel has been moved from the center position at least 5 degrees for ten seconds.)
		Mute	Produces a one-second pulse when the operator acknowledges an alarm.
		Hdg Difference	A Heading Difference alarm condition exists.
		Nav Mode	The NAVIPILOT is in the Nav mode of operation. Refer to sections 2.8.3 and 3.8.3 for a description of this mode.
		Waypoint Mode	The NAVIPILOT is in the Waypoint mode of operation. Refer to sections 2.8.2 and 3.8.2 for a description of this mode.
RELAY 2			
MODE STATUS *(default setting: Auto)*	NC – 73 NO – 74 Com – 75	None	No function assigned to relay.
		Override	Steering control has been overridden by an external device. (See sections 2.6 and 3.6 for details.)
		Ext Sys Active	The system is in external steering mode using an analog input from a system such as a DPS.
		G/M Advisor	The heading source selected is magnetic.
		Auto	The system is in automatic steering mode (AUTO), or AUTO is being overridden.
		Off Hdg Alarm	An Off Heading alarm condition exists.
		Deadman Contact	Produces a one-second pulse at each operator interaction (when the system is operated in FU mode, and the operator pushes any button or causes movement of the helm wheel).
		Helm Advisor	A Helm Wheel Not Zeroed fault exists. (The helm wheel has been moved from the center position at least 5 degrees for ten seconds.)
		Mute	Produces a one-second pulse when the operator acknowledges an alarm.
		Hdg Difference	A Heading Difference alarm condition exists.

Table 4-5. Software-Configurable Alarm Relays (continued)

SCU Nomenclature	Terminals	Choices	Description
		Nav Mode	The NAVIPILOT is in the Nav mode of operation. Refer to Sections 2.8.3 and 3.8.3 for a description of this mode.
		Waypoint Mode	The NAVIPILOT is in the Waypoint mode of operation. Refer to Sections 2.8.2 and 3.8.2 for a description of this mode.
RELAY 3			
OFF COURSE ALARM *(default setting: Off Hdg Alarm)*	NC – 76 NO – 77 Com – 78	Off Hdg Alarm	An Off Heading alarm condition exists.
RELAY 4			
DEADMAN CONTACT (*default setting: Deadman Contact)*	NC – 82 NO – 83 Com – 84	None	No function assigned to relay.
		Override	Steering control has been overridden by an external device. (See sections 2.6 and 3.6 for details.)
		Ext Sys Active	The system is in external steering mode using an analog input from a system such as a DPS.
		G/M Advisor	The heading source selected is magnetic.
		Auto	The system is in automatic steering mode (AUTO), or AUTO is being overridden.
		Off Hdg Alarm	An Off Heading alarm condition exists.
		Deadman Contact	Produces a one-second pulse at each operator interaction (when the system is operated in FU mode, and the operator pushes any button or causes movement of the helm wheel).
		Helm Advisor	A Helm Wheel Not Zeroed fault exists. (The helm wheel has been moved from the center position by at least 5 degrees for ten seconds.)
		Mute	Produces a one-second pulse when the operator acknowledges an alarm.
		Hdg Difference	The difference between the heading values from any two heading sources is greater the operator-selected limit (1 to 15 degrees).

Table 4-5. Software-Configurable Alarm Relays (continued)

SCU Nomenclature	Terminals	Choices	Description
		Nav Mode	The NAVIPILOT is in the Nav mode of operation. Refer to Sections 2.8.3 and 3.8.3 for a description of this mode.
		Waypoint Mode	The NAVIPILOT is in the Waypoint mode of operation. Refer to Sections 2.8.2 and 3.8.2 for a description of this mode.

4.7 CONNECTING TO A VOYAGE DATA RECORDER (VDR).

The RS-422 VDR output provides the NMEA 0183 (Version 2.3) Rudder Sensor Angle (RSA) and Heading Track Control Data (HTD) serial messages. For instructions on connecting the NAVIPILOT to a VDR, contact Sperry Marine.

4.8 CONNECTING TO THE NAV CHANNEL

The RS-422 NAV channel provides bi-directional serial communication with an external track control device. For instructions on connecting to the NAV channel of the NAVIPILOT, contact Sperry Marine.

4.9 USING AN EXTERNAL INPUT WITH A MECHANICAL MODE SWITCH (MMS)

In systems using a Mechanical Mode Switch (MMS) (see Table 1-5), the conventional steering modes (NFU, Helm, Auto, Remote) are selected by connecting the appropriate mode pin (49 – 52) to input pin 53. The NAVIPILOT is also capable of using a +/- 10V input as the steering order from an external system. This external steering mode is engaged by using the switch to connect input pins 51 and 52 to pin 53.

4.10 HELM UNIT CALIBRATION

The multipoint (3 to 7 point) calibration procedure for helm feedback is performed by following the instructions provided on the display. All of the SCU's are calibrated at the same time, and each SCU gets its own calibration values. When performing the calibration procedure, some of the calibration points may be skipped. The system will allow the calibration procedure to be completed if at least one PORT position is calibrated, one STARBOARD position is calibrated, and the ZERO position is calibrated (3 points minimum). Up to 7 positions may be calibrated, but only 3 positions are required. The calibration positions are automatically selected based on the maximum calibration angle. For example, if "45 degrees" is the maximum calibration angle, the system will select "45 degrees port", the "30 degrees port", "15 degrees port", “0 degrees", "15 degrees stbd", "30 degrees stbd", and "45 degrees stbd" as the calibration positions. During the calibration process, the CDU will display in realtime the voltage from each SCU of the port that is being calibrated.

To calibrate the helm unit:

1. Confirm that all connections from the steering control system to the steering gear system are correct and secure, and that all mechanical steering gear adjustments have been made.

2. Enter all known configuration parameters (see Appendix A).

3. From the Service Setup 2 – SCU CONFIGURATION SETTINGS menu (Tables A-4 and B-4), select

ANALOG INTERFACE.

4. From the ANALOG INTERFACE menu, select HELM.

5. When the HELM ENABLED prompt appears, press YES. The HELM menu appears.

6. From the HELM menu, select MAXIMUM ANGLE, and enter the desired value for the maximum rudder angle.

7. Zero the helm (helm at amidships).

8. Zero the helm potentiometer.

9. From the HELM menu, select CALIBRATE.

10. From the CALIBRATION menu, follow the instructions on the display to perform the 7 point calibration procedure for the helm. Press OK after performing each step.

4.11 RUDDER REPEATBACK (FEEDBACK) CALIBRATION OR ZEROING

The multipoint (3 to 7 point) calibration procedure for rudder feedback is performed by following the instructions provided on the display. All of the SCU's are calibrated at the same time, and each SCU gets its own calibration values. When performing the calibration procedure, some of the calibration points may be skipped. The system will allow the calibration procedure to be completed if at least one PORT position is calibrated, one STARBOARD position is calibrated, and the ZERO position is calibrated (3 points minimum). Up to 7 positions may be calibrated, but only 3 positions are required. The calibration positions are automatically selected based on the maximum calibration angle. For example, if "45 degrees" is the maximum calibration angle, the system will select the"45 degrees port", "30 degrees port", "15 degrees port", “0 degrees", "15 degrees stbd", "30 degrees stbd", and "45 degrees stbd" as the calibration positions. During the calibration process, the CDU will display in realtime the voltage from each SCU of the port that is being calibrated.

To calibrate the rudder repeatback (feedback) input:

1. Confirm that all connections from the steering control system to the steering gear system are correct and secure, and that all mechanical steering gear adjustments have been made.

2. Enter all known configuration parameters (see Appendixes A and B).

3. From the Service Setup 2 – SCU CONFIGURATION SETTINGS menu (Tables A-4 and B-4), select ANALOG INTERFACE.

4. From the ANALOG INTERFACE menu, select FEEDBACK.

5. When the FEEDBACK ENABLED prompt appears, press YES. The FEEDBACK menu appears.

6. From the FEEDBACK menu:

   a. Select MAXIMUM CAL ANGLE.

   b. Enter the maximum rudder angle, and then press ACCEPT.

7. Use the NFU device to place the rudder at zero degrees.

8. Zero the feedback potentiometer.

9. From the FEEDBACK menu, select CALIBRATION.

10. From the CALIBRATION menu, follow the instructions on the display to perform the 7 point calibration procedure for the helm. Press OK after performing each step.

4.12 CONFIGURING A SIDE MASTER/SIDE SLAVE RRB INTERFACE

The following description is applicable to configuring a side master/slave rudder repeatback (RRB) interface, for the NAVIPILOT software (refer to Figure 4-11). For systems in which two SCUs control the same rudder, the two SCUs can be configured for "Side Master/Side Slave" interface of the rudder repeatback (RRB) signal. When this configuration is used:

- The analog RRB signal from the rudder's repeatback unit is supplied to the REPEATBACK input of both SCUs (pins 64 - 67).
- An RS-422 interface is used for digital communication of RRB data from one SCU to the other:
  a. Each SCU transmits digital RRB data via its CENTRAL ALARM RS422 output (pin 42: TD+; pin 43: TD-).
  b. Each SCU receives digital RRB data via its SPARE RS422 input (pin 21: RD+; pin 22: RD-).
  c. Data format is as follows: 38.4k baud, 8 data bits, 1 stop bit, no handshaking.
- The RRB Side Master is the SCU which is controlling the pump(s) that are actuating the rudder. The other SCU functions as the RRB Side Slave. (Therefore, the SCU that functions as the RRB Side Master is not necessarily the system Master.)
- The Side Master SCU uses its analog RRB input as its source for RRB information, and supplies digital RRB data to the Side Slave via the RS-422 interface. The Side Slave SCU uses the digital RRB messages from the Side Master, and ignores its own analog RRB input.
- If the RS-422 interface fails, the Side Slave SCU will automatically use its analog RRB input as its source for RRB information.

In a quad SCU system (with two rudders and two SCUs per rudder), the two port SCUs are connected as shown in Figure 4-11, and the two starboard SCUs are connected as shown in Figure 4-11. Each pair of SCUs operates as described above.

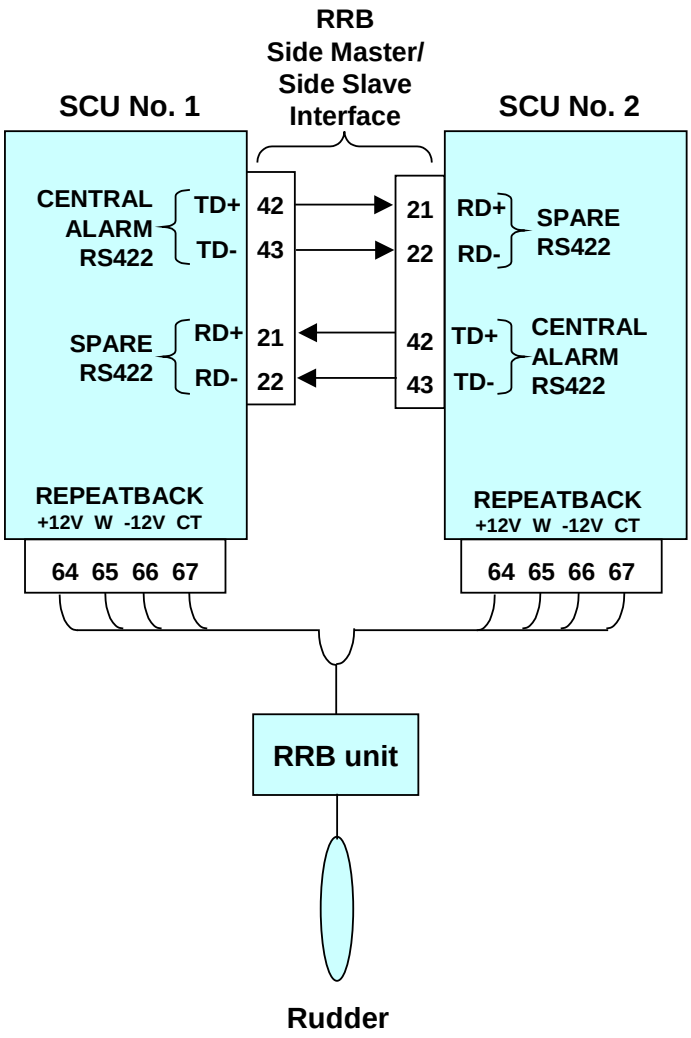


Figure 4-11. Rudder Repeatback (RRB) Interfaces - Side Master/Side Slave Configuration

Appendixes A and B contains the specific procedures for configuring the SCU software for RRB Side Master/Side Slave operation. General guidelines are as follows:

1. In the SCU CONFIGURATION - SERIAL INTERFACE - CENTRAL ALARM INTERFACE menu, the CENTRAL ALARM RS-422 port can be set for Central Alarm Manager interface ("CAM ONLY"), or for RRB interface ("RRB ONLY"). The port must be set to RRB ONLY for RRB Side Master/Side Slave operation. (If a CAM interface is also desired, the SCU's NAV port can be configured for CAM interface via the SCU CONFIGURATION - SERIAL INTERFACE - CENTRAL ALARM INTERFACE ON VMS menu.)

2. In the SCU CONFIGURATION - STEERING GEAR - SIDE SLAVE RRB SOURCE menu, Side Master/Side Slave operation is enabled when both SCUs are set to MASTER. Side Master/Side Slave operation is disabled when both SCUs are set to OWN.

4.13 INITIAL TUNING

Instructions for initial tuning sequence are provided in sections 2.20 (NAVIPILOT 4000 and NAVIPILOT 4000 TRACK), and in section 3.20 (NAVIPILOT 4000 HSC and NAVIPILOT 4000 TRACK HSC).

For the NAVIPILOT 4000 or the NAVIPILOT 4000 TRACK, if the Adaptive Self-Tuning feature is enabled, an initial tuning sequence should be performed during sea trials, or as soon as possible after the vessel goes to sea.

4.14 RESTORING SCU CONFIGURATION DEFAULTS

Should the need arise, the capability exists for the field service engineer to restore the factory default SCU configuration. Whenever it is necessary to reset an SCU, all SCUs in the system should be reset.

To restore the SCU default configuration:

1. Verify that the CDU is communicating with the SCU. (The "SCU NOT RESPONDING" message in inverse video is NOT displayed at the CDU.)

2. Select a non-automatic mode of operation (NFU, Standby, etc.) by using the system's mode switch, or by jumpering pins 59 and 60.

3. Select the Service Setup 2 configuration menus, and enter the appropriate access code, in accordance with the instructions in Appendixes A and B.

4. At the Service Setup 2 menus:

    a. Configure the SCU/Main Mode Switch to MMS.

    b. Configure SCU/Ports to their respective default modes, as listed below. Do not set any port configuration to NONE.

Port	*Configuration*
PORT 1 NFU	NFU or STANDBY
PORT 2 FU	FU or HELM
PORT 3 AUTO	AUTO
PORT 4 RMT	REMOTE

5. Exit the configuration menus, allowing the new configuration to be saved.

6. Power off the system.

7. At TB1 of the SCU, jumper pins 49, 50, 51, 52, and 53 together.

8. Power the system(s) on, and leave the system(s) on for at least 10 seconds.

9. Power off the system(s), and remove the jumper(s).

10. Re-install the proper mode input connector, and power the system(s) on.

11. Configure the Service Setup 1 and Service Setup 2 parameters as desired, in accordance with the instructions in Appendixes A and B.

This operation to restore a default configuration is only for the SCU. The CDU is not affected. When communication with the SCU is not possible, you can modify only the CDU settings by performing the following procedure:

1. Simultaneously press MENU, soft key 3 (the third of the four keys below the display), and DIM+.

2. Press SERVICE SETUP 2, and enter the access code.

4.15 CALIBRATION OF CDU KEYPAD BACKLIGHTING

The following procedure is used to adjust the CDU keypad backlighting for night vision.

1. Use the 'Dim-' key on the CDU front panel to dim down to the absolute minimum level.

2. Access the new menu under Service Setup 2, accessed by pressing the Menu key then selecting CDU CONFIGURATION then KEYPAD CALIBRATION.

3. Use the up and down arrow keys to adjust the keypad calibration until the keypad backlight is barely visible.

4. Press ACCEPT, EXIT, EXIT.

4.16 OUTLINE AND INSTALLATION DRAWINGS

Outline and Installation drawings for the NAVIPILOT system are provided in Figure 4-12 (sheets 1 through 6), on the pages that follow.

NOTES:

1.1 THE CONTROL AND DISPLAY UNIT (CDU) MUST BE MOUNTED USING PROVIDED HARDWARE PER THE CUTOUT SHOWN ON SHEET 3.
1.2 THE NAVIPILOT 4000 INTERCONNECTION CABLE PROVIDES FOR THE CABLE LENGTH BETWEEN CABLE ENTRY LOCATION ON THE DISPLAY ASSEMBLY AND THE STEERING CONTROL UNIT (SCU) OF UP TO 3 METERS, LONGER DISTANCES REQUIRE A CABLE DESIGNED FOR THE CAN BUS e.g. UNITRONICS 2170 250 T.
1.3 SUGGESTED MOUNTING ANGLE OF THE NAVIPILOT 4000 DISPLAY ASSEMBLY IS BETWEEN 15 AND 45 DEGREES FROM HORIZONTAL
1.4 THE CDU AND SCU ARE NOT INTENDED TO BE EXPOSED TO WEATHER OR SUBMERGED IN OR HAVE CONTINUOUS CONTACT WITH SEAWATER.
1.5 CABLING:
  1.5.1 TYPE TO BE DETERMINE FROM APPLICABLE SYSTEM CONNECTION DRAWING.
  1.5.2 IF ARMORED CABLES ARE USED, TERMINATE ARMOR OUTSIDE OF UNIT.
  1.5.3 SECURE CABLING TO SLOTS AT ENCLOSURE OPENING USING CABLE TIES AS REQUIRED.
1.6 USE CARE IN DRESSING CABLING TO ALLOW ACCESS TO INPUT/OUTPUT MEASUREMENT POINTS FOLLOWING INSTALLATION.
1.7 FOR CONNECTIONS TO SCU TERMINAL BOARD, STRIP WIRE END 5 TO 8 MM. IF MORE THAN ONE WIRE IS TO BE CONNECTED TO A TERMINAL, CONNECT THE MULTIPLE WIRES EXTERNALLY AND RUN A SINGLE WIRE TO THE TERMINAL.
1.8 ELECTRICAL INSTALLATION:
  1.8.1 ALL CABLES ARE CUSTOMER FURNISHED EXCEPT CDU INTERFACE CABLES.
  1.8.2 CABLES SHALL CONTAIN A MINIMUM OF 10% SPARE CONDUCTORS IN CABLE TIED BACK TO AVOID SHORTING WITH OTHER CONDUCTORS.
  1.8.3 RS422 SERIAL INTERFACE MAY HAVE TRANSMIT AND RECEIVE LINES SPLIT AND ROUTED TO DIFFERENT EQUIPMENT. IN THESE SPLIT APPLICATIONS, FOR NMEA 0183 COMPLIANCE, ALL RS422 RECEIVER CIRCUITS SHALL BE OPTICALLY ISOLATED AND BOTH THE TRANSMITTER AND RECEIVER MUST HAVE THE SAME BAUD RATE. WHEN IT IS NECESSARY TO CONNECT TWO LINES TO A SINGLE I/O TERMINAL, SPLICE THE SIGNALS EXTERNALLY AND RUN A SINGLE WIRE TO THE I/O TERMINAL.
  1.8.4 THE SCU TO BE LOCATED IN A DRY ACCESSIBLE LOCATION WITH LIGHTING PROVISIONS TO FACILITATE BOTH INSTALLATION AND SERVICE. AN ELECTRICAL SERVICE OUTLET (115VAC OR 230VAC) SHOULD BE PROVIDED NEARBY FOR OPERATION OF TEST OR SERVICE EQUIPMENT.
  1.8.5 SCU APPLICATION CONFIGURATION JUMPERS (REFER TO NAVIPILOT MANUAL 5001916 FOR COMPLETE JUMPER CONFIGURATION LIST):
    E1–E2 IN= PORT RUDDER SCU, OUT= STBD RUDDER SCU
    E3–E4 IN= SCU POWER TO CAN BUS, OUT= EXTERNAL POWER TO CAN BUS
    E15–E16 IN= SCU NO. 1, OUT= SCU NO. 2
    E23–E24 IN= BUS TERMINATED AT SCU, OUT= BUS NOT TERMINATED AT SCU
  1.8.6 CAN DATA LINES MUST HAVE A MINIMUM OF ONE 120 OHM (1/8W MIN) TERMINATION RESISTOR.
  1.8.7 MAXIMUM TOTAL CAN BUS LENGTH NOT TO EXCEED 200M.
  1.8.8 GROUND CDU AND SCU TO SHIP'S HULL USING PROVIDED CONNECTION POINTS.

TABLE 1
ENVIRONMENTAL SPECIFICATIONS

OPERATING TEMPERATURE	MEETS OR EXCEEDS IEC 945, CLASS B
STORAGE TEMPERATURE	-40°C TO +70°C
HUMIDITY	MEETS OR EXCEEDS IEC 945, CLASS B
VIBRATIONS	MEETS OR EXCEEDS IEC 945, CLASS B
EMI/RFI	MEETS OR EXCEEDS IEC 945, CLASS B
DEGREE OF ENCLOSURE	MEETS OR EXCEEDS IEC 529
COMPASS SAFE DISTANCE	0.4M
POWER DISSIPATION	10 WATTS MAX
SUPPLY POWER	24V AC/DC, 3A (18–36V RANGE)

TABLE 2
LIST OF EQUIPMENT

ITEM NO.	NAME	WEIGHT KG
1	CONTROL AND DISPLAY UNIT (CDU)	1.5
2	PRODUCT KEY (INSTALLED ON CDU)	0.02
3	3M INTERFACE CABLE (INSTALLED ON CDU)	0.4
4	STEERING CONTROL UNIT (SCU)	4.2
5	STEERING GEAR INTERFACE PCB (INSTALLED IN SCU)	0.2

ALL DIMENSIONS IN MM

NORTHROP GRUMMAN SYSTEMS CORPORATION SPERRY MARINE CHARLOTTESVILLE, VA 22901		TITLE:	DRAWING NO.
REFERENCE INFORMATION:	R RICHARDSON APPROVED FOR SPERRY MARINE 1/30/09 DATE	NAVIPILOT 4000 OUTLINE AND INSTALLATION DRAWING SHEET 1 OF 6	B2786B01 REV SHEET

Figure 4-12. Outline and Installation Drawing (sheet 1 of 6)

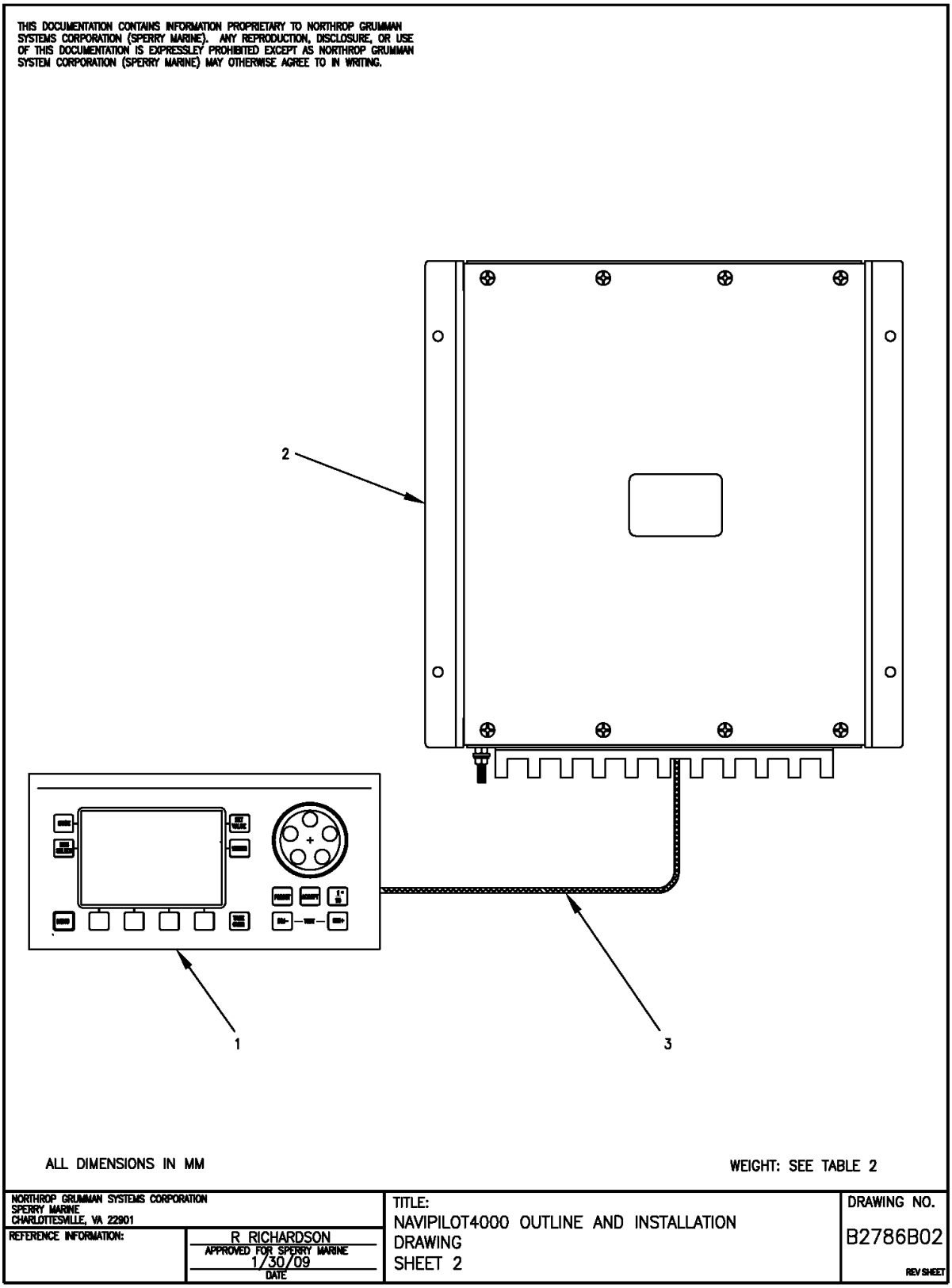


Figure 4-1. Outline and Installation Drawing (sheet 2 of 6)

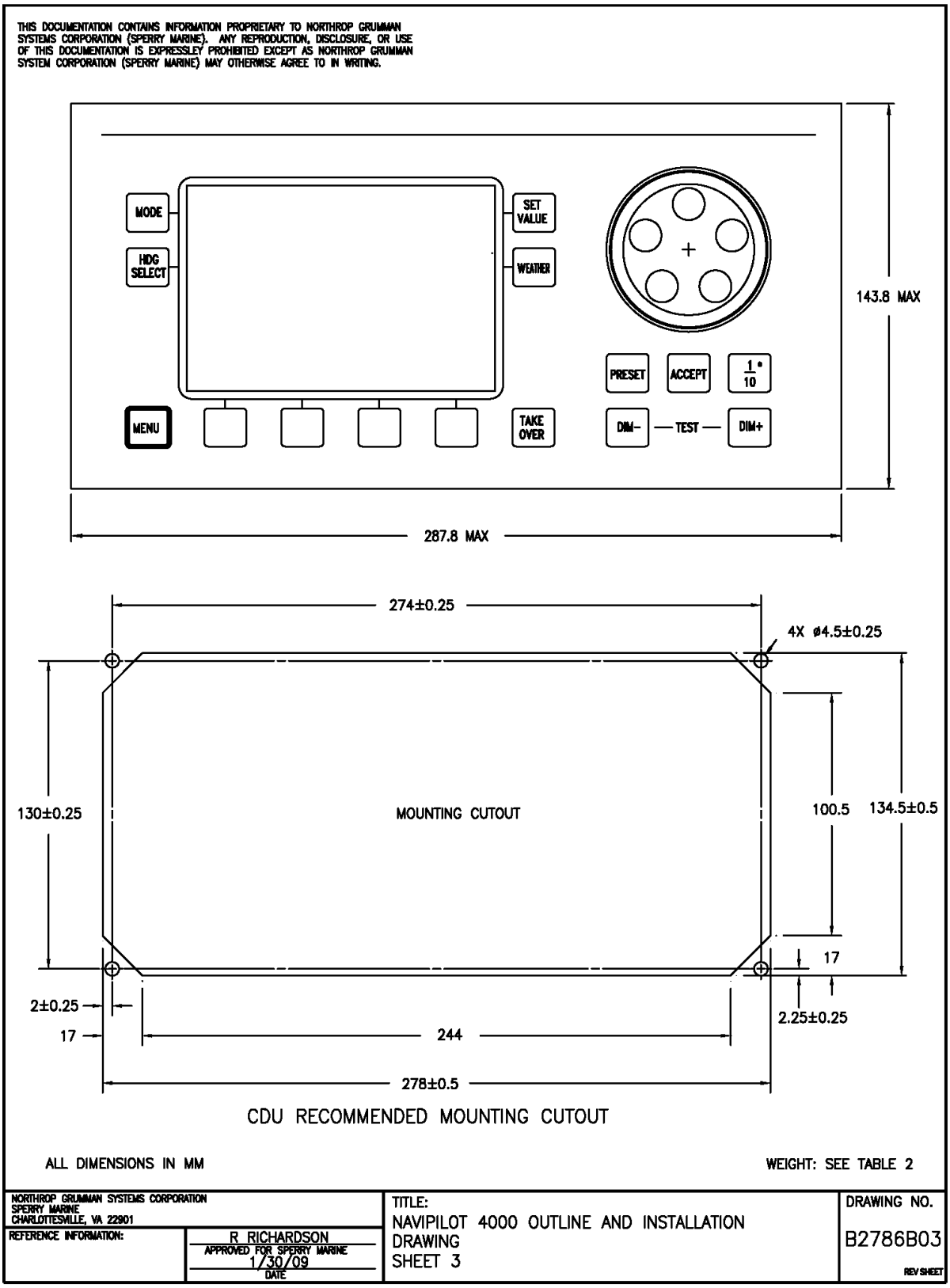


Figure 4-12. Outline and Installation Drawing (sheet 3 of 6)

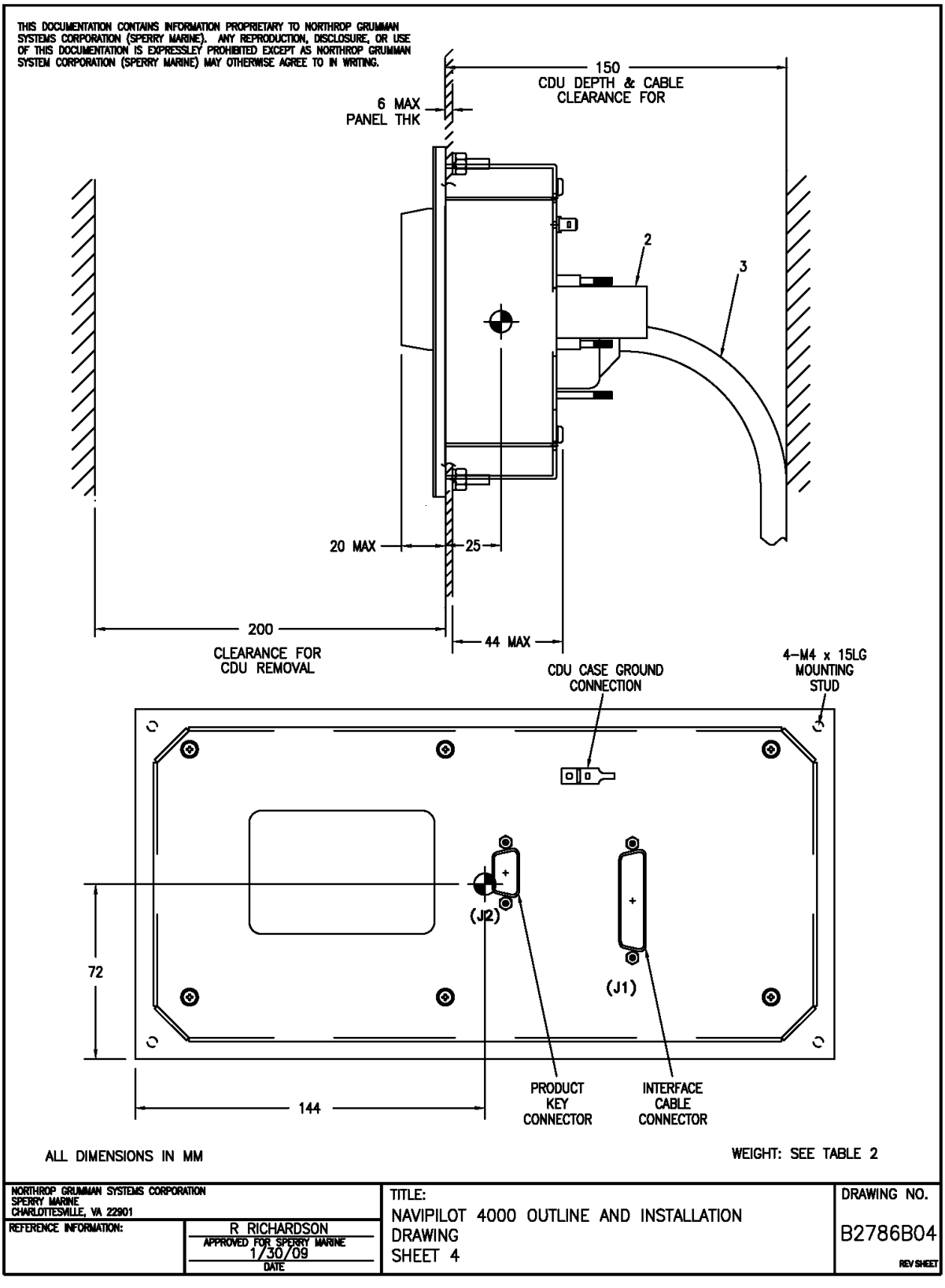


Figure 4-12. Outline and Installation Drawing (sheet 4 of 6)

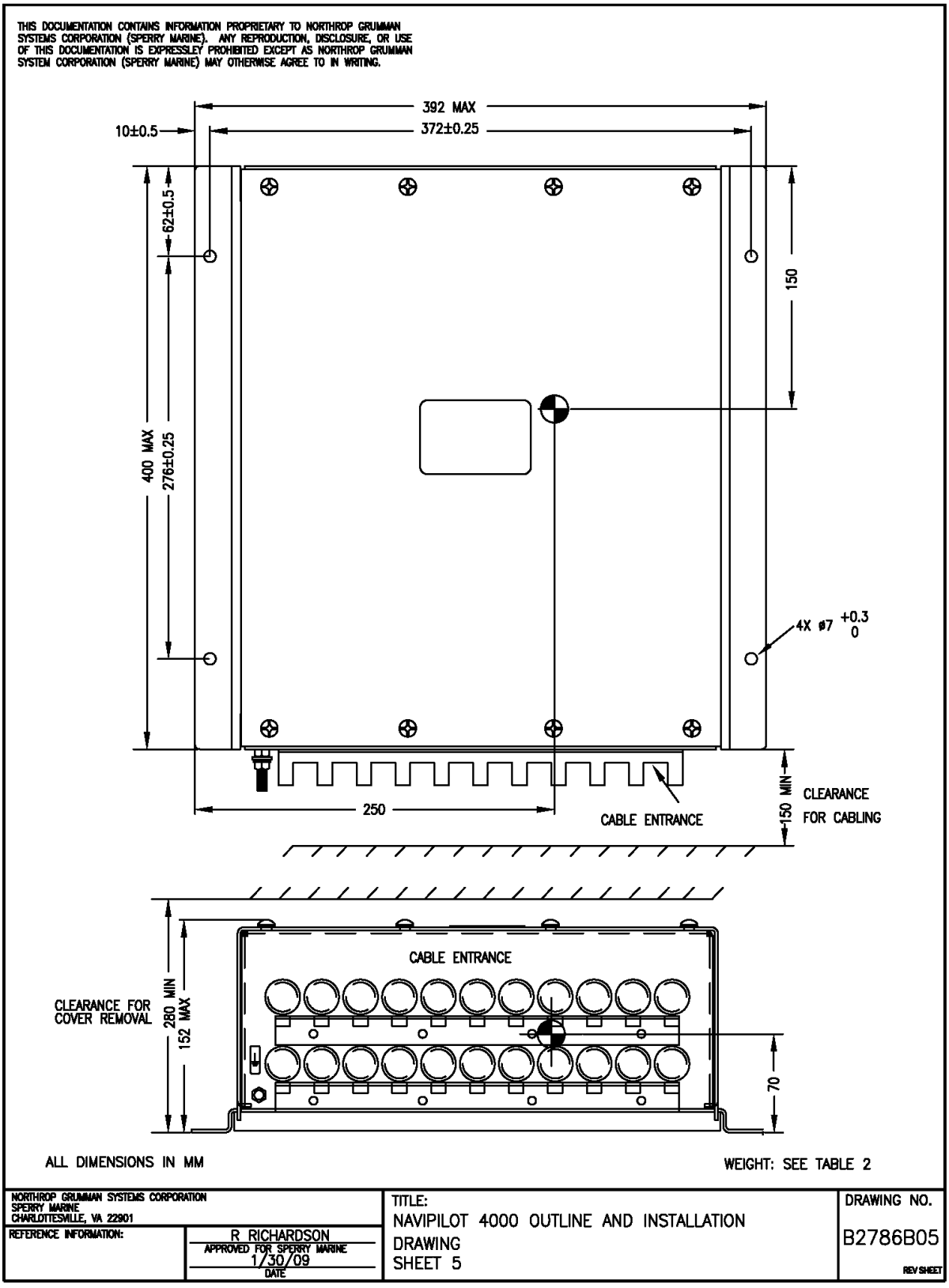


Figure 4-12. Outline and Installation Drawing (sheet 5 of 6)

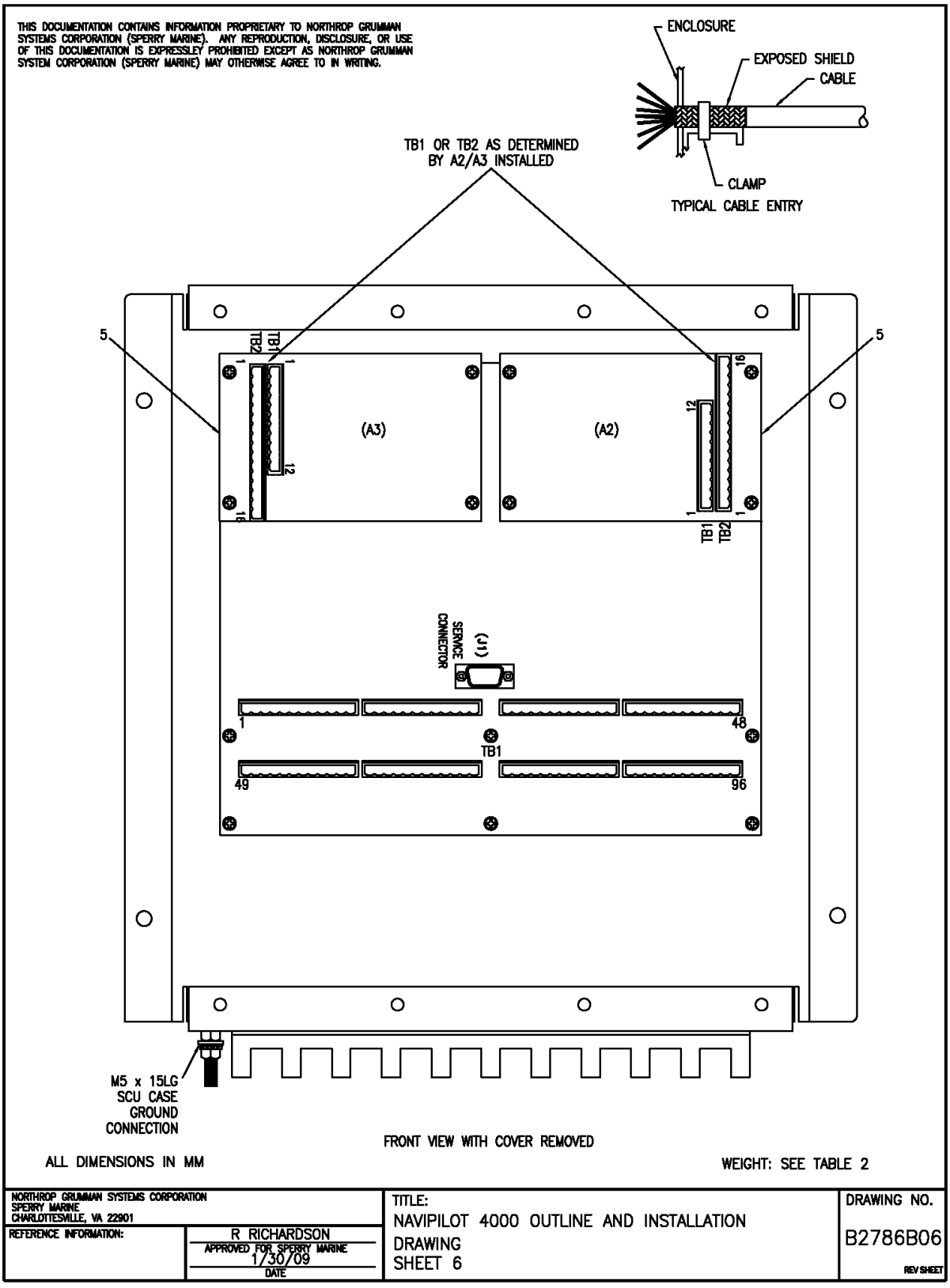


Figure 4-12. Outline and Installation Drawing (sheet 6 of 6)

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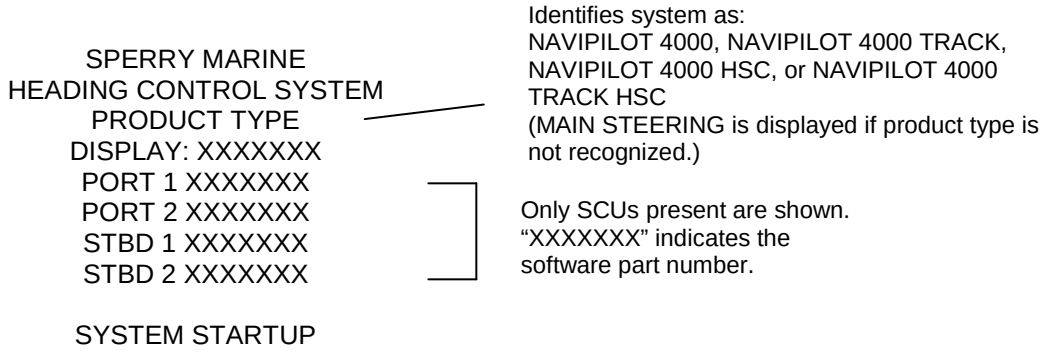
CHAPTER 5
ALARM SYSTEM

5.1 INTRODUCTION

This chapter provides information on the display and acknowledgement of system alarms, and provides a list (Table 5-1) of all alarm messages. Information in this chapter is applicable to all NAVIPILOT systems, including NAVIPILOT 4000, NAVIPILOT 4000 TRACK, NAVIPILOT 4000 HSC, and NAVIPILOT 4000 TRACK HSC.

5.2 POWER-UP SELF TEST

During power-up, the NAVIPILOT performs a self-test. After the self-test, the system beeps once and presents the following start-up screen:

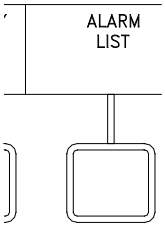


5.3 ALARM DISPLAY AND ACKNOWLEDGMENT.

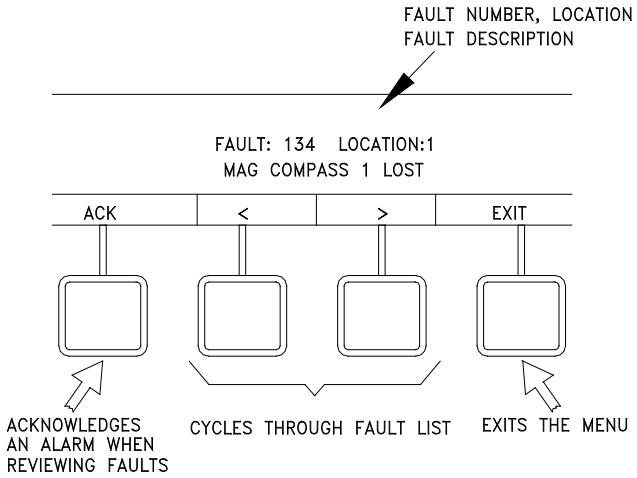
When the NAVIPILOT detects a new fault or alarm condition, the CDU will display ALARM and generate an audible tone. The ALARM indication is displayed in alternating normal and reverse video until the alarm is acknowledged.

Controls are provided at the CDU for display and acknowledgement of active alarms, as follows:

Press MENU until the ALARM LIST soft key is visible in the menu area.



Press the ALARM LIST soft key to display menu controls for the display and acknowledgement of system faults.



While any fault condition is detected, the alarm menu displays the number, location, and description of the fault. If more than one fault is detected, the < and > soft keys can be used to cycle through all faults in the active alarm list.

To acknowledge the displayed alarm, press the ACK soft key. When all active alarms have been acknowledged, the audible tone is silenced.

After acknowledgement, the alarm menu display responds as follows:

- **if the condition causing a fault is still detected, the fault will remain in the active alarms list and the ALARM indication** at the CDU **will** steadily be displayed in reverse video**.**
- **If the condition is no longer detected, the acknowledged alarm is cleared from the alarms list.**
- **When all faults have been cleared, "No Faults" is displayed, and the ALARM indication** at the CDU **is longer displayed.**

To clear the Alarm List menu, press the EXIT button.

At the CDU, the ACCEPT button can be used to quickly mute a new alarm.

NOTE: The ACCEPT button is also used to accept preset course changes. If a fault occurs while a preset course change is pending, the first press of ACCEPT will mute the fault/alarm. The user must press ACCEPT again after the fault/alarm is muted, in order to execute the preset course change.

After an alarm is accepted, it can be viewed in the alarm menu display as described above, if the fault condition causing the alarm is still detected. If the fault condition causing the alarm is no longer detected, accepting the alarm causes it to be removed from the alarm list, and display of the alarm number and description is not available.

5.4 FAULT CODES.

Table 5-1 provides the complete list of NAVIPILOT fault codes, with recommended corrective actions.

Table 5-1. Fault Codes

Fault No.	Description	Comments	Corrective Action
0	NO FAULT	No faults were detected.	
1	PARSE FAULT	Serial message parse fault.	Check cables.
2	PARITY ERROR	Serial message parity error.	Check cables.
3	FRAMING ERROR	Serial message framing error.	Check cables.
4	SERIAL ERROR	Serial message general error.	Check cables.
5	APB MSG MISSING	NMEA message missing.	Verify that navigator is operating. Check cables.
6	HTR MSG MISSING	NMEA message missing.	Verify that navigator is operating. Check cables.
7	HSC MSG MISSING	NMEA message missing.	Verify that navigator is operating. Check cables.
8	XTE MSG MISSING	NMEA message missing.	Verify that navigator is operating. Check cables.
9	HTC MSG MISSING	NMEA message missing.	Verify that navigator is operating. Check cables.
10	PROP HTC MSG MISSING	NMEA message missing.	Verify that navigator is operating. Check cables.
11	CTS MSG MISSING	NMEA message missing.	Verify that navigator is operating. Check cables.
12	VBW MSG MISSING	NMEA message missing.	Verify that speed log is operating. Check cables.
13	VHW MSG MISSING	NMEA message missing.	Verify that speed log is operating. Check cables.
14	VTG MSG MISSING	NMEA message missing.	Verify that speed log is operating. Check cables.
15	HDT 1 MSG MISSING	NMEA message missing.	Verify that compass is operating. Check cables.
16	HEHDT 1 MSG MISSING	NMEA message missing.	Verify that compass is operating. Check cables.
17	HCHDT 1 MSG MISSING	NMEA message missing.	Verify that compass is operating. Check cables.

Table 5-1. Fault Codes (continued)

Fault No.	Description	Comments	Corrective Action
18	HDG 1 MSG MISSING	NMEA message missing.	Verify that compass is operating. Check cables.
19	HDM 1 MSG MISSING	NMEA message missing.	Verify that compass is operating. Check cables.
20	NSD 1 MSG MISSING	NMEA message missing.	Verify that compass is operating. Check cables.
21	HDT 2 MSG MISSING	NMEA message missing.	Verify that compass is operating. Check cables.
22	HEHDT 2 MSG MISSING	NMEA message missing.	Verify that compass is operating. Check cables.
23	HCHDT 2 MSG MISSING	NMEA message missing.	Verify that compass is operating. Check cables.
24	HDG 2 MSG MISSING	NMEA message missing.	Verify that compass is operating. Check cables.
25	HDM 2 MSG MISSING	NMEA message missing.	Verify that compass is operating. Check cables.
26	NSD 2 MSG MISSING	NMEA message missing.	Verify that compass is operating. Check cables.
27	APB CHECKSUM FAULT	NMEA message missing.	Invalid navigator data. Check navigator for proper operation.
28	HTR CHECKSUM FAULT	NMEA message missing.	Invalid navigator data. Check navigator for proper operation.
29	HSC CHECKSUM FAULT	NMEA message missing.	Invalid navigator data. Check navigator for proper operation.
30	XTE CHECKSUM FAULT	NMEA message missing.	Invalid navigator data. Check navigator for proper operation.
31	HTC CHECKSUM FAULT	NMEA message missing.	Invalid navigator data. Check navigator for proper operation.
32	PROP HTC CHECKSUM FAULT	NMEA message missing.	Invalid navigator data. Check navigator for proper operation.
33	CTS CHECKSUM FAULT	NMEA message missing.	Invalid navigator data. Check navigator for proper operation.
34	VBW CHECKSUM FAULT	NMEA message missing.	Invalid speed log data. Check speed log for proper operation.
35	VHW CHECKSUM FAULT	NMEA message missing.	Invalid speed log data. Check speed log for proper operation.
36	VTG CHECKSUM FAULT	NMEA message missing.	Invalid speed log data. Check speed log for proper operation.
37	HDT 1 CHECKSUM FAULT	NMEA message missing.	Invalid compass data. Check compass for proper operation.

Table 5-1. Fault Codes (continued)

Fault No.	Description	Comments	Corrective Action
38	HEHDT 1 CHECKSUM FAULT	NMEA message missing.	Invalid compass data. Check compass for proper operation.
39	HCHDT 1 CHECKSUM FAULT	NMEA message missing.	Invalid compass data. Check compass for proper operation.
40	HDG 1 CHECKSUM FAULT	NMEA message missing.	Invalid compass data. Check compass for proper operation.
41	HDM 1 CHECKSUM FAULT	NMEA message missing.	Invalid compass data. Check compass for proper operation.
42	NSD 1 CHECKSUM FAULT	NMEA message missing.	Invalid compass data. Check compass for proper operation.
43	HDT 2 CHECKSUM FAULT	NMEA message missing.	Invalid compass data. Check compass for proper operation.
44	HEHDT 2 CHECKSUM FAULT	NMEA message missing.	Invalid compass data. Check compass for proper operation.
45	HCHDT 2 CHECKSUM FAULT	NMEA message missing.	Invalid compass data. Check compass for proper operation.
46	HDG 2 CHECKSUM FAULT	NMEA message missing.	Invalid compass data. Check compass for proper operation.
47	HDM 2 CHECKSUM FAULT	NMEA message missing.	Invalid compass data. Check compass for proper operation.
48	NSD 2 CHECKSUM FAULT	NMEA message missing.	Invalid compass data. Check compass for proper operation.
49	APB PARSE FAULT	NMEA message missing.	Check navigator for proper operation.
50	HTR PARSE FAULT	NMEA message missing.	Check navigator for proper operation.
51	HSC PARSE FAULT	NMEA message missing.	Check navigator for proper operation.
52	XTE PARSE FAULT	NMEA message missing.	Check navigator for proper operation.
53	HTC PARSE FAULT	NMEA message missing.	Check navigator for proper operation.
54	PROP HTC PARSE FAULT	NMEA message missing.	Check navigator for proper operation.
55	CTS PARSE FAULT	NMEA message missing.	Check navigator for proper operation.
56	VBW PARSE FAULT	NMEA message missing.	Check speed log for proper operation.
57	VHW PARSE FAULT	NMEA message missing.	Check speed log for proper operation.

Table 5-1. Fault Codes (continued)

Fault No.	Description	Comments	Corrective Action
58	VTG PARSE FAULT	NMEA message missing.	Check speed log for proper operation.
59	HDT 1 PARSE FAULT	NMEA message missing.	Check compass for proper operation.
60	HEHDT 1 PARSE FAULT	NMEA message missing.	Check compass for proper operation.
61	HCHDT 1 PARSE FAULT	NMEA message missing.	Check compass for proper operation.
62	HDG 1 PARSE FAULT	NMEA message missing.	Check compass for proper operation.
63	HDM 1 PARSE FAULT	NMEA message missing.	Check compass for proper operation.
64	NSD 1 PARSE FAULT	NMEA message missing.	Check compass for proper operation.
65	HDT 2 PARSE FAULT	NMEA message missing.	Check compass for proper operation.
66	HEHDT 2 PARSE FAULT	NMEA message missing.	Check compass for proper operation.
67	HCHDT 2 PARSE FAULT	NMEA message missing.	Check compass for proper operation.
68	HDG 2 PARSE FAULT	NMEA message missing.	Check compass for proper operation.
69	HDM 2 PARSE FAULT	NMEA message missing.	Check compass for proper operation.
70	NSD 2 PARSE FAULT	NMEA message missing.	Check compass for proper operation.
71	APB DATA FAULT	NMEA message missing.	Check navigator or track data source for proper operation.
72	XTE DATA FAULT	NMEA message missing.	Check navigator or track data source for proper operation.
73	XTRCK DATA FAULT	NMEA message missing.	Check navigator or track data source for proper operation.
74	WAYPOINT BEAR DATA FAULT	NMEA message missing.	Check navigator or track data source for proper operation.
75	HD STEER DATA FAULT	NMEA message missing.	Check navigator or track data source for proper operation.
76	TURN RATE DATA FAULT	NMEA message missing.	Check navigator or track data source for proper operation.
77	OVERRIDE DATA FAULT	NMEA message missing.	Check navigator or track data source for proper operation.
78	RUD ORD DATA FAULT	NMEA message missing.	Check navigator or track data source for proper operation.

Table 5-1. Fault Codes (continued)

Fault No.	Description	Comments	Corrective Action
79	STEER MODE DATA FAULT	NMEA message missing.	Check navigator or track data source for proper operation.
80	TURN MODE DATA FAULT	NMEA message missing.	Check navigator or track data source for proper operation.
81	RUD LIM DATA FAULT	NMEA message missing.	Check navigator or track data source for proper operation.
82	OFF CRS DATA FAULT	NMEA message missing.	Check navigator or track data source for proper operation.
83	TURN RAD DATA FAULT	NMEA message missing.	Check navigator or track data source for proper operation.
84	OFF TRK DATA FAULT	NMEA message missing.	Check navigator or track data source for proper operation.
85	HEAD REF DATA FAULT	NMEA message missing.	Check navigator or track data source for proper operation.
86	W SPD DATA FAULT	NMEA message missing.	Check speed log for proper operation.
87	B SPD DATA FAULT	NMEA message missing.	Check speed log for proper operation.
88	HDG GYRO DATA FAULT 1	NMEA message missing.	Check compass for proper operation.
89	HDG MAG DATA FAULT 1	NMEA message missing.	Check compass for proper operation.
90	HDG SRC DATA FAULT 1	NMEA message missing.	Check compass for proper operation.
91	HDG GYRO DATA FAULT 2	NMEA message missing.	Check compass for proper operation.
92	HDG MAG DATA FAULT 2	NMEA message missing.	Check compass for proper operation.
93	HDG SRC DATA FAULT 2	NMEA message missing.	Check compass for proper operation.
94	HEADING 1 RATE FAULT	---	Check compass for proper operation.
95	HEADING 2 RATE FAULT	---	Check compass for proper operation.
96	HEADING 3 RATE FAULT	---	Check compass for proper operation.
97	FLUXGATE VOLTAGE FAULT	---	Check compass for proper operation.
98	SPEED RANGE FAULT	---	Check speed log for proper operation.

Table 5-1. Fault Codes (continued)

Fault No.	Description	Comments	Corrective Action
99	BOTTOM SPD RANGE FAULT	---	Check speed log for proper operation.
100	CONTROL CHECKSUM FAULT	Some or all of the configuration data has been corrupted or reset to its default values.	Perform Service Setup 1 and 2 (see Appendix A).
101	INVALID MAC ADDRESS	---	EPROM Failure in SCU or CDU.
102	CONFIG DATABASE INIT FAULT	Some or all of the configuration data has been corrupted or reset to its default values.	Perform Service Setup 1 and 2 (see Appendix A).
103	DISPLAY FAULT FOR TEST	---	**---**
104	SPEED LOG LOST	Serial speed lost.	Verify speed log for proper operation. Check cables.
105	CONTROLLING STATION LOST	Steering station in control not responding.	Select new steering device.
106	STATION NOT ACCEPTED CONTROL	Desired steering station refused control.	Select new steering device.
107	ORDER LOST FAULT	The expected heading order message (APB, HSC, HTC, CTS) was not received within 15 seconds.	Verify navigator or track data for proper operation.
108	ORDER FORMAT FAULT	The message format does not match the NMEA 0183 format.	Verify navigator or track data for proper operation.
109	ORDER INVALID FAULT	The heading order data field is null or the validity field is set to invalid.	Verify navigator or track data for proper operation.
110	ORDER RANGE FAULT	The raw heading order is greater than 360.0° or less than 000.0° for 3 seconds.	Verify navigator or track data for proper operation.
111	RATE LOST FAULT	The expected heading rate order message (HTR) is not received within 15 seconds.	Verify navigator or track data for proper operation.
112	RATE FORMAT FAULT	The message format does not match the NMEA 0183 format.	Verify navigator or track data for proper operation.
113	RATE INVALID FAULT	The rate order data field is null or the validity field is set to invalid.	Verify navigator or track data for proper operation.
114	RATE RANGE FAULT	The raw rate order is greater than twice the configured maximum turn rate or less than 0 for 3 seconds.	Verify navigator or track data for proper operation.

Table 5-1. Fault Codes (continued)

Fault No.	Description	Comments	Corrective Action
115	WAYPOINT DATA LOST FAULT	The expected cross track error message (APB, XTE) is not received within 15 seconds.	Verify navigator or track data for proper operation.
116	WAYPOINT DATA FORMAT FAULT	The message format does not match the NMEA 0183 format.	Verify navigator or track data for proper operation.
117	WAYPOINT DATA INVALID FAULT	The cross-track error data field is null, or the validity field is set to invalid.	Verify navigator or track data for proper operation.
118	PROM CHECKSUM FAULT	**---**	
119	RAM READ WRITE FAULT	**---**	
120	NVRAM CHECKSUM FAULT	**---**	Perform service setup 1 and 2.
121	CONFIGURATION STORAGE	**---**	Perform service setup 1 and 2.
122	CONTROL STORAGE	**---**	Perform service setup 1 and 2.
123	SERIAL EEPROM STORAGE	**---**	
124	HELM WHEEL NOT ZEROED	Helm wheel has been moved from center position at least 5 degrees for 10 seconds.	Zero the helm wheel.
125	HELM UNIT NOT CALIBRATED	---	Calibrate helm unit.
126	RRB NOT CALIBRATED	---	Calibrate rudder repeatback.
127	EXTERNAL UNIT NOT CALIBRATED	---	Calibrate the external unit.
128	JOYSTICK IO FAULT	---	Future enhancement.
129	JOYSTICK NOT CENTERED	---	Future enhancement.
130	MODE SWITCH IO	Mode switch in invalid position.	Check mode switch.
131	DIAGNOSTIC PORT	---	Future enhancement.
132	ABS OVERRIDE	Activated ABS override function. When enabled, ABS Override activates if helm wheel position is greater than configured setting for 2 seconds.	Check helm wheel position.

Table 5-1. Fault Codes (continued)

Fault No.	Description	Comments	Corrective Action
133	GYRO COMPASS 1 LOST	---	Check compass.
134	MAG COMPASS 1 LOST	---	Check compass.
135	GYRO COMPASS 2 LOST	---	Check compass.
136	MAG COMPASS 2 LOST	---	Check compass.
137	ALARM NOT RECEIVED	---	Future enhancement.
138	SPEED LOG RANGE FAULT	200P/NM input.	Check speed log.
139	RUDDER LIMIT REACHED	---	---
140	TRACK HDG ERROR EXCEEDED	Operator advisory message.	Check track.
141	OFF HEADING FAULT	Operator advisory message.	Check course.
142	COMPASS SELECTED NOT CONFIGURED	---	Check compass selection.
143	NO STATION IN CONTROL	---	Select a steering station.
144	HEADING DIFF LIM EXCEEDED	Heading difference limit exceeded.	Check compass.
145	OFF TRACK FAULT	---	Check track.
146	GENERAL DEVICE FAULT	This is an all-purpose alarm for the Bus Interface Units (BIUs). (Table 1-5 lists the various types of BIUs.)	Check bus interface unit.
147	GENERAL CONFIGURATION FAULT	BIU fault indicating inconsistencies in the setup.	Reconfigure affected BIU.
148	ELECTRIC SHAFT TIMEOUT	Follow-Up Miniwheel/Display Unit motor cannot be moved.	Check Follow-Up Miniwheel/ Display Unit.
149	WHEEL POSITION INVALID	Follow-Up Miniwheel/Display Unit wheel position not reliable.	Check Follow-Up Miniwheel/ Display Unit.
150	DISPLAY CONTROLLER ERROR	General Bus Interface Unit (BIU) display error.	Check BIU.
151	STATION NOT AVAILABLE	The selected station cannot come into control.	Select new steering station.

Table 5-1. Fault Codes (continued)

Fault No.	Description	Comments	Corrective Action
152	USE LOG SPEED FOR RADIUS TURNS	The NAVIPILOT cannot perform accurate rate control turns without a speed log input.	Change to log speed.
153	NAV CONTROL MODE NOT AVAILABLE	Nav mode is not configured.	Check navigator configuration.
154	WAYPOINT CONTROL MODE NOT AVAILABLE	Waypoint mode is not configured.	Check track controller configuration.
155	AUTO DISABLED, HDG SRC SELECTED LOST	The heading source used for steering is lost – switch to manual steering.	Switch to manual mode and select another compass or repair lost compass.
156	NAV CRS CHG GREATER THAN 15 DEG	NAV mode course change is greater than 15 degrees. This alarm is generated only if NAV ACK is enabled in the SERVICE SETUP 2 - SCU CONFIGURATION menu, and the HTC message is available.	Verify that the course change is appropriate.
157	WAYPOINT CRS CHG GREATER THAN 15 DEG	WAYPOINT mode course change is greater than 15 degrees. This alarm is generated only if WAYPOINT ACK is enabled in the SERVICE SETUP 2 - SCU CONFIGURATION menu, and the HTC message is available.	Verify that the course change is appropriate.
158	LOST PORT SCU UNIT 1	Slave SCU times out in 30 seconds and never clears the fault.	Reboot PORT SCU UNIT 1 if SCU does not clear itself.
159	LOST PORT SCU UNIT 2	Slave SCU times out in 30 seconds and never clears the fault.	Reboot PORT SCU UNIT 2 if SCU does not clear itself.
160	LOST STBD SCU UNIT 1	Slave SCU times out in 30 seconds and never clears the fault.	Reboot STBD SCU UNIT 1 if SCU does not clear itself.
161	LOST STBD SCU UNIT 2	Slave SCU times out in 30 seconds and never clears the fault.	Reboot STBD SCU UNIT 2 if SCU does not clear itself.
162	RAM FAULT	RAM test failed.	Turn unit off and back on. If fault does not clear, contact Sperry Marine.
163	ROM FAULT	ROM test failed.	Turn unit off and back on. If fault does not clear, contact Sperry Marine.

Table 5-1. Fault Codes (continued)

Fault No.	Description	Comments	Corrective Action
164	POWER RESTORED IN AN AUTOMATIC MODE	Operator advisory message. The NAVIPILOT was powered up in AUTO mode.	Acknowledge alarm.
165	Not used	--	--
166	PSMI VMS STEERING MODE MSG MISSING	The system has been configured to receive the "$PSMI,STEERING MODE" message, but is not receiving this message from the VMS.	Confirm that the interface to the VMS is configured properly and that the VMS is outputting this message.
167	PSMI VMS STEERING MODE CHECKSUM FAULT	Steering mode message checksum is invalid.	Confirm that the format of the message being sent is correct.
168	PSMI VMS STEERING MODE PARSE FAULT	Steering mode message format is invalid.	Confirm that the format of the message being sent is correct.
169	NAV ALERT: TRACK CONTROL STOPPED	System has stopped VMS NAV (TRACK CONTROL) mode.	Check communications with NAV (VMS) system.
170	TRACK CONTROL FAILURE: CHECK NAV SYSTEM	NAV (VMS) system has forced system to downgrade to AUTO mode.	Check NAV system for the reason.
171	HEADING SOURCE CHANGED IN AUTO	The heading source changed while the system was in an automatic mode.	Do not allow the heading source to change while the system is in AUTO, NAV, or TRACK mode.
172	CAN BUS ERROR	This alarm is not posted on the display, but is output via the CAM interface and the RS-232 diagnostic interface, to provide status on CAN Bus errors. “CAN BUS ERROR 0 0” will be output for a normally functioning CAN bus. Non-zero values will be output if CAN bus errors are detected.	Refer to CAN bus documentation.
173	RATE TURN SELECTED FOR PRESENT SPEED	The NAVIPILOT has automatically changed the turn method from RADIUS to RATE, because RADIUS turns are not allowed at the current speed. The TURN METHOD indicator flashes (in addition to the ALARM indicator) until the alarm is acknowledged.	Avoid using radius orders near the allowable maximum. Increase speed in order to complete the turn at the desired radius, or continue to use the RATE turn method.

Table 5-1. Fault Codes (continued)

Fault No.	Description	Comments	Corrective Action
174	RATE TURN SELECTED FOR PRESENT TAU	The NAVIPILOT has automatically changed the turn method from RADIUS to RATE, because Tau has changed (due to a loading change) such that the turn radius exceeded the allowable maximum. The TURN METHOD indicator flashes (in addition to the ALARM indicator) until the alarm is acknowledged.	Avoid using radius orders near the expected maximum if there is a significant change in loading. Increase speed in order to complete the turn at the desired radius, or continue to use the RATE turn method.
175	RATE ORDER INCREASED FOR PRESENT TAU	The NAVIPILOT has automatically increased the RATE order, because Tau has changed (due to a loading change) such that the turn radius was below the allowable minimum. The TURN METHOD indicator flashes (in addition to the ALARM indicator) until the alarm is acknowledged.	Avoid using rate orders near the expected minimum if there is a significant change in loading, or use the RUDDER LIMIT turn method.
176	RAD ORDER DECREASED FOR PRESENT SPEED	The NAVIPILOT has automatically decreased the RADIUS order, because the turn radius exceeded the allowable maximum for the current speed. The TURN METHOD indicator flashes (in addition to the ALARM indicator) until the alarm is acknowledged.	Increase speed in order to complete the turn at the desired radius, or use the RATE turn method.
177-186	Not used	---	---
187	RRB RS-422 ERROR	Rudder repeatback Side Master/ Side Slave interface error.	Determine whether the RRB Side Master/Side Slave interface has been correctly configured (see Chapter 3 and Appendix A). Check for continuity on the RS-422 connection between each Side Master and its Side Slave.
188	CDU/SCU PORT 1 MISMATCH	Indicates a software mismatch between the CDU and Port SCU No. 1.	Select the SERVICE SETUP 2 menu, and check the CDU and SCU software revision letters on the MAIN SERVICE SETUP menu. (see Appendix A). If a mismatch does exist, contact Sperry Marine for the necessary firmware.

Table 5-1. Fault Codes (continued)

Fault No.	Description	Comments	Corrective Action
189	CDU/SCU PORT 2 MISMATCH	Indicates a software mismatch between the CDU and Port SCU No. 2.	Select the SERVICE SETUP 2 menu, and check the CDU and SCU software revision letters on the MAIN SERVICE SETUP menu. (see Appendix A). If a mismatch does exist, contact Sperry Marine for the necessary firmware.
190	CDU/SCU STBD 1 MISMATCH	Indicates a software mismatch between the CDU and Starboard SCU No. 1.	Select the SERVICE SETUP 2 menu, and check the CDU and SCU software revision letters on the MAIN SERVICE SETUP menu. (see Appendix A). If a mismatch does exist, contact Sperry Marine for the necessary firmware.
191	CDU/SCU STBD 2 MISMATCH	Indicates a software mismatch between the CDU and Starboard SCU No. 2.	Select the SERVICE SETUP 2 menu, and check the CDU and SCU software revision letters on the MAIN SERVICE SETUP menu. (see Appendix A). If a mismatch does exist, contact Sperry Marine for the necessary firmware.
192	MINIWHEEL OVERRIDE	Steering control has been overridden by actuation of a Follow-up Mini-Wheel (FMW).	Verify that the operator of the FMW did not inadvertently override steering control.
193	EXTERNAL OVERRIDE	Steering control has been overridden by actuation of an external device (other than a Follow-up Mini-Wheel).	Verify that the operator of the external device did not inadvertently override steering control.
194	AT RUD LIM IN NAV CONTROL MODE	The system provides a warning to the operator that the Rudder Limit was reached during Nav Mode. The rudder limit could interfere with the vessel from staying on track.	Change rudder limit.
195	AT RUD LIM IN WAYPOINT CONTROL MODE	The system provides a warning to the operator that the Rudder Limit was reached during Waypoint Mode. The rudder limit could interfere with the vessel from staying on track.	Change rudder limit.

Table 5-1. Fault Codes (continued)

Fault No.	Description	Comments	Corrective Action
196	KEY MISSING	At least one CDU does not have a Product Key installed, or baud rate of the CDU Service Interface port is set incorrectly (should be 4800). If the Product Key is missing at all CDUs, the system will revert to Main Steering mode after next SCU startup (see section 2.4 or 3.4). If a Product key is installed to at least one CDU, then that key is used at next SCU startup.	Verify visually that Product Key is installed, and check KEY TYPE and CONFIG ID displays (see section 2.19 or 3.19). Verify baud rate of CDU Service Interface port using Service Setup 2 menu (see section A.4.2, Table A-5 or B.4.2, Table B-5)
197	KEYS MISMATCH – PILOT TYPE	Indicates that Product Keys on two CDUs represent different pilot types (for example, one is NAVIPILOT 4000 HSC and the other is NAVIPILOT 4000). The system will revert to Main Steering mode after next SCU startup (see section 2.4 or 3.4).	Check KEY TYPE and CONFIG ID displays (see section 2.19 or 3.19). Remove mis-matched key and restart SCU.
198	KEYS MISMATCH – TRACK VS. BASIC	Indicates that Product Keys on two CDUs represent different functionality (for example, one is NAVIPILOT 4000 and the other is NAVIPILOT 4000 TRACK). In this example, the system will default to NAVIPILOT 4000 TRACK after next SCU startup.	Check KEY TYPE and CONFIG ID displays (see section 2.19 or 3.19). Remove mis-matched key and restart SCU.
199	PORT1 CONFIGURATION MISMATCH	Indicates that the SCU Port 1 configuration does not match the configuration of the other SCUs	Select DISPLAY OPTIONS to display the Master SCU, use the configuration upload/download tool to synchronize SCU configurations
200	PORT2 CONFIGURATION MISMATCH	Indicates that the SCU Port 2 configuration does not match the configuration of the other SCUs	Select DISPLAY OPTIONS to display the Master SCU, use the configuration upload/download tool to synchronize SCU configurations
201	STBD1 CONFIGURATION MISMATCH	Indicates that the SCU Stbd 1 configuration does not match the configuration of the other SCUs	Select DISPLAY OPTIONS to display the Master SCU, use the configuration upload/download tool to synchronize SCU configurations
202	STBD2 CONFIGURATION MISMATCH	Indicates that the SCU Stbd 2 configuration does not match the configuration of the other SCUs	Select DISPLAY OPTIONS to display the Master SCU, use the configuration upload/download tool to synchronize SCU configurations

Table 5-1. Fault Codes (continued)

Fault No.	Description	Comments	Corrective Action
203	SPEED INPUT – EXCESSIVE RATE OF CHANGE	Indicates an excessive rate of change of the speed input	Select the SERVICE SETUP 2 menu, and select MAX SHIP ACCELERATION for Maximum Ship Acceleration/Deceleration, and change MAX ACC

APPENDIX A
CONFIGURATION DATA
(NAVIPILOT 4000 / NAVIPILOT 4000 TRACK)

A.1 INTRODUCTION

This appendix provides information on configuration procedures for the NAVIPILOT 4000 and the NAVIPILOT 4000 TRACK.

A.2 RUDDER GAIN (RG) AND COUNTER RUDDER (CR) OPERATIONAL SETTINGS.

Use Table A-1 to record manually entered rudder gain (RG) and counter rudder (CR) values which are found to provide the best steering performance during sea trials. See chapter 2 for instructions for entering the gains manually.

NOTE: The *Medium* load condition is available only if the NAVIPILOT's Adaptive Self-Tuning feature is not enabled (that is, when the SYS TYPE in Service Setup 2 is set to PID. Service Setup 2 configuration settings are described in section A.4.2 of this appendix.

Table A-1. User Settings for Rudder Gain (RG) and Counter Rudder (CR)

Load	*Rudder Gain (RG)*	*Counter Rudder (CR)*	*Remarks*
Light			
Medium			
Loaded			

A.3 MAGNETIC FLUXGATE COMPASS CALIBRATION.

The Magnetic Fluxgate Compass Calibration function compensates for minor differences that occur between the magnetic fluxgate compass heading and the heading data transmitted by the gyrocompass. To perform this function, the maintenance technician enters correction factors for storage in the NAVIPILOT memory, using the SERVICE SETUP 1 menu.

NOTE: This calibration method is only used when the fluxgate compass is connected directly to the NAVIPILOT SCU. When a fluxgate compass is connected via a Navitwin III compass monitor unit, the calibration must be performed at the Navitwin III, which then provides the fluxgate heading to NAVIPILOT as serial data.

To enter the calibration data:

a. Verify that the magnetic fluxgate compass has been properly installed and calibrated, and **set the correct magnetic variation for the geographic location**. (Refer to Chapter 2 for instructions).

b. Select the manual steering mode.

c. Press MENU until the SERVICE SETUP 1 configuration menu appears. Select SERVICE SETUP 1.

d. Enter the access code for SERVICE SETUP 1. (Contact Sperry Marine for access codes.)

e. Select FLUXGATE CAL TABLE, and press the ACCEPT soft key.

f. Select SET UP CALIBRATION from the CALIBRATE FLUXGATE screen, and press the ACCEPT soft key.

g. Select CALIBRATE from the CALIBRATE FLUXGATE START screen, and press the ACCEPT soft key.

h. Operate the helm wheel until the heading indication on the magnetic fluxgate compass is 000°.

i. Record the gyrocompass heading indication in Table A-2.

j. Calculate the required correction value for each heading. Record the calculated value in Table A-2.

Example: The actual magnetic fluxgate compass heading is 010°. The actual gyrocompass heading is 011°. The required correction value is 1°.

k. Press the ∧ (up) or ∨ (down) soft key until the calculated value is displayed. Press the ACCEPT soft key.

l. Repeat steps h through k for each of the magnetic fluxgate compass headings listed in Table A-2.

Table A-2. Magnetic Fluxgate Compass Calibration Table

Magnetic Fluxgate Compass Heading	*Gyrocompass Heading*	*Correction Value*	*Magnetic Fluxgate Compass Heading*	*Gyrocompass Heading*	*Correction Value*
000°	_____	_____	180°	_____	_____
010°	_____	_____	190°	_____	_____
020°	_____	_____	200°	_____	_____
030°	_____	_____	210°	_____	_____
040°	_____	_____	220°	_____	_____
050°	_____	_____	230°	_____	_____
060°	_____	_____	240°	_____	_____
070°	_____	_____	250°	_____	_____
080°	_____	_____	260°	_____	_____
090°	_____	_____	270°	_____	_____
100°	_____	_____	280°	_____	_____
110°	_____	_____	290°	_____	_____
120°	_____	_____	300°	_____	_____
130°	_____	_____	310°	_____	_____
140°	_____	_____	320°	_____	_____
150°	_____	_____	330°	_____	_____
160°	_____	_____	340°	_____	_____
170°	_____	_____	350°	_____	_____

A.4 CONFIGURATION SETTINGS

Maintenance personnel can configure the NAVIPILOT for a variety of operating modes and Heading Control System (HCS) configurations, by using the SERVICE SETUP 1 and SERVICE SETUP 2 menus as described below.

IMPORTANT:

- **If all SCUs are powered on and communicating on the NAVINET 4000 Steering Control Network, the setup procedures described below will configure all SCUs simultaneously. Otherwise, the installer must repeat the configuration procedure each time a new SCU is powered on. The same configuration settings must be entered at each SCU to ensure consistent system performance and capabilities, regardless of which SCU is in use.**
- **For the configuration settings to take effect, the NAVIPILOT MUST be powered off and powered up again after completing service setup.**

A.4.1 Configuration Settings – SERVICE SETUP 1

To enter the SERVICE SETUP 1 configuration settings:

a. Select a non-automatic steering mode (follow-up or non follow-up).

b. Power-on all SCUs.

c. At a CDU, press MENU until the SERVICE SETUP 1 soft key appears. Press the SERVICE SETUP 1 soft key.

d. Enter the access code for SERVICE SETUP 1. (Refer to the latest Field Engineering Bulletin.)

e. From the SERVICE SETUP 1 menu, select HCS CONFIGURATION, and press the ACCEPT soft key.

f. Table A-3 lists each of the HCS CONFIGURATION parameters. Make the appropriate selections, and record the configuration settings in the table.

g. Press the EXIT key to exit the HCS CONFIGURATION menu.

h. Press the EXIT key again to exit the SERVICE SETUP 1 menu. The selected configuration settings will be stored in the NAVIPILOT memory.

A.4.2 Configuration Settings – SERVICE SETUP 2

To enter the SERVICE SETUP 2 configuration settings:

a. Select a non-automatic steering mode (follow-up or non follow-up).

b. Power-on all SCUs.

c. At a CDU, press MENU until the SERVICE SETUP 2 soft key appears. Press the SERVICE SETUP 2 soft key.

d. Enter the access code for SERVICE SETUP 2. (Refer to the latest Field Engineering Bulletin.)

e. At the MAIN SERVICE SETUP menu (Figure A-1), verify that all SCUs are reporting their part number and revision, and that the part numbers and revisions are all the same. (Figure A-1 shows a two-SCU configuration, with the SCUs identified as PORT 1 and STBD 1.)

f. To enter the SCU configuration settings:

   1) From the MAIN SERVICE SETUP menu, select SCU CONFIGURATION, then press the ACCEPT soft key.

   2) Table A-4 lists each of the SCU CONFIGURATION parameters. Make the appropriate selections, and record the configuration settings in the table.

3) Press the EXIT key to exit the SCU CONFIGURATION menu.

g. To enter the CDU configuration settings:

1) From the MAIN SERVICE SETUP menu, select CDU CONFIGURATION, then press the ACCEPT soft key.

2) Table A-5 lists each of the CDU CONFIGURATION parameters. Make the appropriate selections, and record the configuration settings in the table.

3) Press the EXIT key to exit the CDU CONFIGURATION menu.

4) If there are additional CDUs to be configured in the Heading Control System, repeat steps c, d, and g for each CDU. Verify that all CDU part numbers and revisions are the same. (Figure A-1 shows a single-CDU configuration, with the CDU identified as DISPLAY.)

h. To enter the SYS configuration settings:

1) From the MAIN SERVICE SETUP menu, select SYS CONFIGURATION, then press the ACCEPT soft key.

2) Table A-6 lists each of the SYS CONFIGURATION parameters. Make the appropriate selections, and record the configuration settings in the table.

3) Press the EXIT key to exit the SYS CONFIGURATION menu.

i. Press the EXIT key again to exit the MAIN SERVICE SETUP menu. The selected configuration settings will be stored in the NAVIPILOT memory.

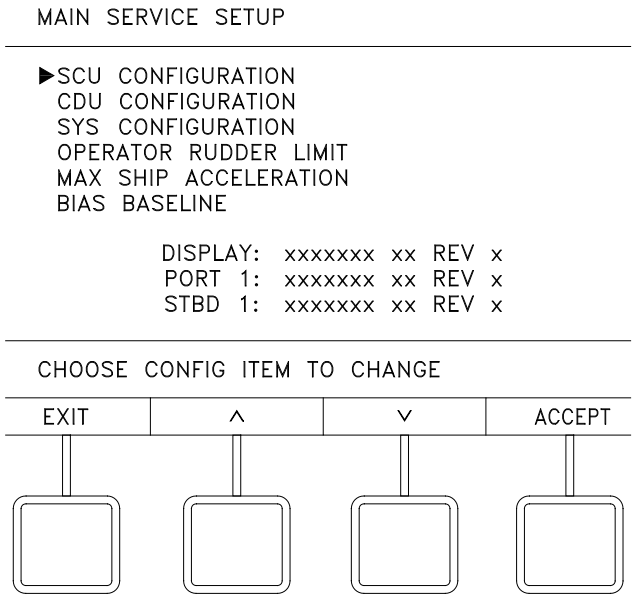


Figure A-1. Typical MAIN SERVICE SETUP Menu

Table A-3. Service Setup 1 – HCS Configuration Settings

Item	*Configuration Setting*	*Function*
NOTE: In the Tau, RG, and CR load settings below, the MEDIUM load condition is not available to the user if the Adaptive Self-Tuning feature is enabled. Refer to SYS Configuration (Table A-6).		
TAU:		
TAU LIGHT TAU MEDIUM TAU LOADED	_____ sec. _____ sec. _____ sec.	Sets the ship's time constant (tau) for each load condition setting. Tau is the time in seconds it takes for the ship to traverse a distance of its own length at service (cruising) speed. Ship length is defined as the length at the waterline, or the length between perpendiculars. See Appendix B for formulas. Range: 1 to 80 seconds. Default: 20 seconds.
SERVICE SPEED:		
SERV SPD	_____ kn.	Sets the ship's service (cruising) speed. Range: 5 to 35 knots. Default: 20 knots.
RG INIT:		
RG LIGHT RG MEDIUM RG LOADED	_____ _____ _____	Sets the initial rudder gain for each load condition setting. Also, if Adaptive Self-Tuning is enabled, the rudder gain is reset to these initial values if RESET TUNING is performed. Range: 0.3 to 3.0. Default: 1.4.
CR INIT:		
CR LIGHT CR MEDIUM CR LOADED	_____ _____ _____	Sets the initial counter rudder gain for each load c ondition setting. Also, if Adaptive Self-Tuning is enabled, the counter rudder gain is reset to these initial values if RESET TUNING is performed. Range: 0.3 to 3.0. Default: 1.0.
OVERRIDE RECOVERY: These settings dictate how the system responds when an override is cancelled by selecting PREV MODE (Previous Mode) at an ancillary unit. **Default settings are recommended.** These settings have no effect if the override capability is not available in the system.		
HEADING	☐ ACT HDG (default) ☐ LAST ORD	When an override is cancelled by selecting PREV MODE: ACT HDG (Actual Heading) – The set heading will be the same as the current actual heading, and the vessel will remain on its current course. LAST ORD (Last Order) – The previous heading order will go into effect. This may result in a significant change to set heading, depending on how far the vessel deviated from the previous order. In this mode, the override may be used to "jog" around an obstruction.

Table A-3. Service Setup 1 – HCS Configuration Settings (continued)

Item	*Configuration Setting*	*Function*
MODE	☐ AUTO (default) ☐ A/N/W	When an override is cancelled by selecting PREV MODE: AUTO – The system will drop from Nav or Waypoint to Auto mode. The user must take deliberate steps to resume Nav or Waypoint mode after an override. A/N/W (Auto/Nav/Waypoint) – the system will truly revert to the previous mode when PREV MODE is selected, including Nav or Waypoint if the override occurred in either of those modes.
CROSS TRACK: These settings are only used when the NAV interface uses APB or HSC/XTE messages for Waypoint mode at the NAVIPILOT.		
XT ERROR GAIN	_____ °/nm	Sets the amount of heading correction to make based on cross-track error. Range: 2 to 280 degrees per nautical mile. Default: 50°/nm.
XT RATE GAIN	_____ °/kn	Sets the amount of heading correction to make based on cross-track error rate. Range: 0.0 to 5.0 degrees per knot. Default: 0.0°/kn.
XT APPROACH ANGLE LIM	_____ °	Sets the maximum angle for regaining the track. Range: 20 to 60 degrees. Default: 20 degrees.
XT FILTER TC	_____ sec	Sets the time constant used to calculate cross-track rate. Range: 10 to 180 seconds. Default: 30 seconds.
XT BIAS ENABLE	☐ YES (default) ☐ NO	Allows the bias calculation to be disabled for tuning the track controller.
XT BIAS TC	_____ sec	Sets the time constant used in the bias calculation. Range: 50 to 500 seconds. Default: 300 seconds.
Speed Scaled Rudder Limit (SSRL):		
SS RUD	_____ °	Sets the maximum rudder angle allowed at service speed. Range: 5 to 45 degrees. Default: 20 degrees.
NOTE: The Speed Scaled Rudder Limit applies regardless of set rudder limit or rate/radius order. The selected limit is scaled to other speeds. For example, if the SSRL is set to 20 degrees, with a service speed of 20 kn: At 30 kn, the SSRL would stop the rudder at approximately 13 degrees. At 15 kn, the SSRL would allow approximately 27 degrees rudder.		
MINIMUM TURN RATE ORDER		
MIN RATE	_____ °/m	Sets the minimum turn rate order. Range 4 to 130 degrees. Default: Standard (7 degrees)

Table A-4. Service Setup 2 – SCU Configuration Settings

Item	Configuration Setting	Function
SERIAL INTERFACE:		
HEADING 1:		
GYRO	☐ NONE ☐ HDT ☐ HEHDT (default)	Determines the NMEA message type for a Gyrocompass input at the HDG 1 port in the SCU: HDT - True Heading HEHDT - North-Seeking Gyro, True Heading
MAGNETIC	☐ NONE (default) ☐ HCHDT ☐ HDG ☐ HDM	Determines the NMEA message type for a Magnetic Heading input at the HDG 1 port: HCHDT - Mag. Compass, True Heading HDG - Heading, Deviation, and Variation HDM - Magnetic Heading **WARNING:** Do NOT configure a NMEA message for a magnetic compass when a fluxgate compass is configured. Such a configuration error will cause the NAVIPILOT to toggle between the NMEA heading data and the heading data from the fluxgate compass, when magnetic is selected as the heading source.
NSD	☐ YES ☐ NO (default)	Sets up the HDG 1 port to receive the serial NSD (Navigation Status Data) message, from a connected Navitwin II compass monitor.
BAUD RATE	☐ 1200 ☐ 2400 ☐ 4800 (default) ☐ 9600 ☐ 14.4 ☐ 19.2 ☐ 28.8 ☐ 38.4	Sets the Baud Rate for HDG 1.
HEADING 2:		
GYRO	☐ NONE ☐ HDT ☐ HEHDT (default)	Determines the NMEA message type for a Gyrocompass input at the HDG 2 port in the SCU: HDT - True Heading HEHDT - North-Seeking Gyro, True Heading

Table A-4. Service Setup 2 – SCU Configuration Settings (continued)

Item	*Configuration Setting*	*Function*
MAGNETIC	☐ NONE (default) ☐ HCHDT ☐ HDG ☐ HDM	Determines the NMEA message type for a Magnetic Heading input at the HDG 2 port: HCHDT - Mag. Compass, True Heading HDG - Heading, Deviation, and Variation HDM - Magnetic Heading **WARNING:** Do NOT configure a NMEA message for a magnetic compass when a fluxgate compass is configured. Such a configuration error will cause the NAVIPILOT to toggle between the NMEA heading data and the heading data from the fluxgate compass, when magnetic is selected as the heading source.
NSD	☐ YES ☐ NO (default)	Sets up the HDG 2 port to receive the serial NSD message, from a connected Navitwin III compass monitor.
BAUD RATE	☐ 1200 ☐ 2400 ☐ 4800 (default) ☐ 9600 ☐ 14.4 ☐ 19.2 ☐ 28.8 ☐ 38.4	Sets the Baud Rate for HDG 2.
SPEED:		
MESSAGE TYPE	☐ NONE ☐ VHW ☐ VTG ☐ VBW (default) ☐ 200P/NM + ☐ 200P/NM -	Sets the speed message type: None VHW (Water Speed and Heading) VTG (Course Over Ground and Ground Speed) VBW (Dual Ground/Water Speed) 200 pulses per nautical mile, triggered on the rising edge of the pulse (+) 200 pulses per nautical mile, triggered on the falling edge of the pulse (-) For a VBW message, water speed has preference. Ground speed is used when water speed is not available. For a 200P/NM input, if the speed display is erratic with one of the two selections (+ or -), use the other selection.

Table A-4. Service Setup 2 – SCU Configuration Settings (continued)

Item	Configuration Setting	Function
BAUD RATE	☐ 1200 ☐ 2400 ☐ 4800 (default) ☐ 9600 ☐ 14.4 ☐ 19.2 ☐ 28.8 ☐ 38.4	Sets the Baud Rate expected for the Speed message.
NAV INTERFACE:		
MESSAGE TYPE	☐ NONE (default) ☐ APB ☐ HSC, XTE ☐ HSC, PROP-HTC, HTR	Sets the NMEA message used for the Nav interface: If the Nav interface is not used, select NONE. For interface to a GPS or a compatible non-Sperry chart system, select APB (Heading/Track Controller [Autopilot] Sentence "B") or HSC/XTE (Heading-to-Steer Command/Cross-Track Error), as appropriate for the system being used. This will enable WAYPOINT mode operation of the NAVIPILOT.
BAUD RATE	☐ 1200 ☐ 2400 ☐ 4800 (default) ☐ 9600 ☐ 14.4 ☐ 19.2 ☐ 28.8 ☐ 38.4	Sets the Baud Rate used for the Nav interface.
LOST NAV	☐ RES HDG (default) ☐ COMPL TURN	Determines the Set Heading to be used if communications are lost to the navigator during a VisionMaster FT-controlled turn in NAV mode: RES HDG – Resume on Heading. The current heading at the time that communications are lost becomes the set heading. COMPL TURN – Complete the Turn. The bearing of the next leg of the turn becomes the set heading. Use this mode on DNV Watch 1 vessels, and on other vessels when required.
WAYPOINT ACK	☐ YES ☐ NO (default)	Sets an alarm when WAYPOINT mode course change is >15 degrees.
NAV ACK	☐ YES ☐ NO (default)	Sets an alarm when NAV mode course change is >15 degrees.
NAV STATUS MSG	☐ YES ☐ NO (default)	Standby in non-master status.

Table A-4. Service Setup 2 – SCU Configuration Settings (continued)

Item	*Configuration Setting*	*Function*
NAV STEERING MODE MSG	☐ YES ☐ NO (default)	Selects whether the Nav Steering Mode Message from a Sperry VisionMaster FT is used. If YES is selected, the VisionMaster FT will automatically switch the NAVIPILOT from NAV mode to AUTO mode if a system failure makes NAV mode unavailable (such as loss of the necessary sensor data.)
NAV MSG TIMEOUT	☐ 5 (default) ☐ 10 ☐ 15	Sets the duration at which the Nav Steering Mode Message timeout alarm is triggered, in seconds.
REPEATER INTERFACE:		
REPEATER ENABLED	☐ YES ☐ NO (default)	Enables or disables the Serial Repeater.
BAUD RATE	☐ 4800 (default) ☐ 9600	Determines the Baud Rate output through the Serial Repeater channel.
CENTRAL ALARM INTERFACE		
CENTRAL ALARM PORT	☐ OFF (default) ☐ CAM ONLY ☐ RRB ONLY 38.4	Selects the function of the Central Alarm port: Off Central Alarm Manager (CAM) interface RRB Side Master/Slave interface (38.4k baud rate)
BAUD RATE	☐ 4800 (default) ☐ 9600 ☐ 19.2 K ☐ 38.4 K	If CAM ONLY is selected above, sets the baud rate for the Central Alarm Manager interface.
CENTRAL ALARM INTERFACE ON VMS PORT:		
ECHO TO VMS PORT	☐ YES ☐ NO (default)	Select YES to echo Central Alarm Manager (CAM) messages on the NAV interface port. (VMS is the name of the Sperry chart display and information system previous to VisionMaster FT. For the purpose of this configuration item, the two system names are interchangeable.) This configuration is used when: More than one output of CAM messages is required, or A CAM interface is required, but the Central Alarm Interface is configured for Rudder Repeatback (RRB 38.4) Side Master/Slave interface only.

Table A-4. Service Setup 2 – SCU Configuration Settings (continued)

Item	Configuration Setting	Function
ANALOG INTERFACE:		
HELM:		
HELM ENABLED	☐ YES ☐ NO (default)	Selects whether a helm analog input is used.
MAXIMUM ANGLE	_____ °.	Sets the maximum helm rudder angle. Range: 20 to 120 degrees. Default: 35 degrees.
MAXIMUM CAL ANGLE	_____ °.	Sets the maximum helm rudder angle. Range: 20 to 35 degrees, in 1 degree increments.
CALIBRATE	PORT HELM ☐ OK PORT HELM ☐ OK PORT HELM ☐ OK ZERO HELM ☐ OK STBD HELM ☐ OK STBD HELM ☐ OK STBD HELM ☐ OK	Sets the points for the 7 point calibration.
FEEDBACK:		
FEEDBACK ENABLED	☐ YES ☐ NO (default)	Enables or disables the rudder repeat-back function.
MAXIMUM ANGLE	_____ °.	Sets the maximum rudder repeat-back angle. Range: 20 to 120 degrees. Default: 35 degrees.
MAXIMUM CAL ANGLE (Note 1)	_____ °.	Sets the maximum helm rudder angle. Range: 20 to 35 degrees, in 1 degree increments.
CALIBRATE	PORT HELM ☐ OK PORT HELM ☐ OK PORT HELM ☐ OK ZERO HELM ☐ OK STBD HELM ☐ OK STBD HELM ☐ OK STBD HELM ☐ OK	Sets the points for the 7 point calibration.
EXTERNAL SYSTEM:		
EXTERNAL ENABLED	☐ YES ☐ NO (default)	Selects whether an external system input is used.
MAXIMUM ANGLE	_____ °.	Sets the maximum external system rudder angle. Range: 20 to 120 degrees. Default: 35 degrees.
POLARITY	☐ STBD POS (default) ☐ PORT POS	Sets the steering gear voltage polarity.

Table A-4. Service Setup 2 – SCU Configuration Settings (continued)

Item	*Configuration Setting*	*Function*
CALIBRATION:		
ZERO EXTERNAL	☐ OK	Calibrates the NAVIPILOT to read the current input from the external system as zero degrees when OK is selected.
EXTERNAL GRADIENT	_____ mV/°.	Sets the voltage scaling of the external system input. Range: 100 to 350 millivolts per degree. Default: 250 mV/°.
FLUXGATE:		
FLUXGATE	☐ YES ☐ NO (default)	Enables or disables fluxgate compass interface. Select YES only when a fluxgate compass is installed and connected using the SCU fluxgate ports.
PORTS:		
MODE PORTS (PINS 49-53):		
PORT 1 NFU	☐ STANDBY ☐ NFU (default)	Assigns the name to be displayed on the CDU when Port 1 is selected. This mode is selected using SCU Pin 49, or by a switch that closes pins 59/60.
PORT 2 FU	☐ NONE ☐ HELM ☐ FU (default) ☐ G/M ☐ 180 OFFSET GYRO 1 ☐ 180 OFFSET GYRO 2 ☐ 180 OFFSET MAG ☐ 180 PORT ☐ 180 STBD ☐ EN JOYSTICK ☐ MUTE	Assigns a function to Port 2 (SCU Pin 50). Normally FU or HELM is selected, and the name displayed on CDU will be either FU or HELM depending on selection. The functions 180 PORT, 180 STBD, and EN JOYSTICK have not yet been implemented in the NAVIPILOT software, and will not function if selected.
PORT 3 AUTO	☐ NONE ☐ AUTO (default) ☐ G/M ☐ 180 OFFSET GYRO 1 ☐ 180 OFFSET GYRO 2 ☐ 180 OFFSET MAG ☐ 180 PORT ☐ 180 STBD ☐ EN JOYSTICK ☐ MUTE	Assigns a function to Port 3 (SCU Pin 51). Normally AUTO is selected, unless the system is main steering only. The functions 180 PORT, 180 STBD, and EN JOYSTICK have not yet been implemented in the NAVIPILOT software, and will not function if selected.

Table A-4. Service Setup 2 – SCU Configuration Settings (continued)

Item	*Configuration Setting*	*Function*
PORT 4 RMT	☐ NONE ☐ REMOTE (default) ☐ G/M ☐ 180 OFFSET GYRO 1 ☐ 180 OFFSET GYRO 2 ☐ 180 OFFSET MAG ☐ 180 PORT ☐ 180 STBD ☐ EN JOYSTICK ☐ MUTE	Assigns a function to Port 4 (SCU Pin 52). Normally REMOTE is selected, if the system includes remote locations. The functions 180 PORT, 180 STBD, and EN JOYSTICK have not yet been implemented in the NAVIPILOT software, and will not function if selected.
EXTERNAL SYSTEM NAME	☐ NONE (default) ☐ DPS ☐ AUTO ☐ BACK_UP ☐ PILOT ☐ TRACK ☐ RADAR ☐ CHART ☐ AUX	Sets the name to be displayed on the CDU when External mode has been selected. When a mechanical mode switch is used, SCU Pins 51 & 52 must be connected to select External mode.
JOYSTICK PORTS (PINS 54-58):		
PORT 1 UP	☐ NONE (default) ☐ JOY UP ☐ G/M ☐ 180 OFFSET GYRO 1 ☐ 180 OFFSET GYRO 2 ☐ 180 OFFSET MAG ☐ 180 PORT ☐ 180 STBD ☐ EN JOYSTICK ☐ MUTE ☐ FORCE MASTER	Assigns a function to Joystick Port 1. The functions JOY UP, 180 PORT, 180 STBD, and EN JOYSTICK have not yet been implemented in the NAVIPILOT software, and will not function if selected.
PORT 2 DOWN	☐ NONE (default) ☐ JOY DOWN ☐ G/M ☐ 180 OFFSET GYRO 1 ☐ 180 OFFSET GYRO 2 ☐ 180 OFFSET MAG ☐ 180 PORT ☐ 180 STBD ☐ EN JOYSTICK ☐ MUTE ☐ FORCE MASTER	Assigns a function to Joystick Port 2. The functions JOY UP, 180 PORT, 180 STBD, and EN JOYSTICK have not yet been implemented in the NAVIPILOT software, and will not function if selected.

Table A-4. Service Setup 2 – SCU Configuration Settings (continued)

Item	*Configuration Setting*	*Function*
PORT 3 RIGHT	☐ NONE (default) ☐ JOY RIGHT ☐ G/M ☐ 180 OFFSET GYRO 1 ☐ 180 OFFSET GYRO 2 ☐ 180 OFFSET MAG ☐ 180 PORT ☐ 180 STBD ☐ EN JOYSTICK ☐ MUTE ☐ FORCE MASTER	Assigns a function to Joystick Port 3. The functions JOY UP, 180 PORT, 180 STBD, and EN JOYSTICK have not yet been implemented in the NAVIPILOT software, and will not function if selected.
PORT 4 LEFT	☐ NONE (default) ☐ JOY LEFT ☐ G/M ☐ 180 OFFSET GYRO 1 ☐ 180 OFFSET GYRO 2 ☐ 180 OFFSET MAG ☐ 180 PORT ☐ 180 STBD ☐ EN JOYSTICK ☐ MUTE ☐ FORCE MASTER	Assigns a function to Joystick Port 4. The functions JOY UP, 180 PORT, 180 STBD, and EN JOYSTICK have yet not been implemented in the NAVIPILOT software, and will not function if selected.

Table A-4. Service Setup 2 – SCU Configuration Settings (continued)

Item	Configuration Setting	Function
OVERRIDE ACTIVE IN:		
OVERRIDE ACTIVE IN	☐ NONE ☐ AUTO/NAV/WPT ☐ EXT SYSTEM ☐ FU SYSTEM ☐ A/N/W/E ☐ A/N/W/FU (default) ☐ A/N/W/E/FU ☐ EXT SYST/FU	For any device which indicates override of steering control via a contact closure at the SCU's OVERRIDE input (pins 32 and 33), the NAVIPILOT will allow override by that device in the configured operating mode(s): None AUTO, NAV, and WAYPOINT EXTERNAL FU (Follow-Up) AUTO, NAV, WAYPOINT, and EXTERNAL AUTO, NAV, WAYPOINT, and FU AUTO, NAV, WAYPOINT, EXTERNAL, and FU EXTERNAL and FU For a Sperry Marine Follow-Up Mini-Wheel (FMW), which indicates override of steering control via the CAN bus: ❑ Override capability must be enabled at the FMW. Otherwise, it cannot override steering control in any mode. ❑ If override capability is enabled at the FMW, the FMW can override steering control in the configured modes, with the exception of FU.
RELAYS:		
RELAY 1 (TB 34-36)	☐ NONE ☐ OFF HDG ALARM ☐ HDG DIFFERENCE ☐ OVERRIDE (default) ☐ DEADMAN CONTACT ☐ EXT SYS ACTIVE ☐ HELM ADVISOR ☐ G/M ADVISOR ☐ MUTE ☐ AUTO (W/ OVR) ☐ NAV MODE ☐ WAYPOINT MODE	Assigns a function to Relay 1.

Table A-4. Service Setup 2 – SCU Configuration Settings (continued)

Item	*Configuration Setting*	*Function*
RELAY 2 (TB 73-75)	☐ NONE ☐ OFF HDG ALARM ☐ HDG DIFFERENCE ☐ OVERRIDE ☐ DEADMAN CONTACT ☐ EXT SYS ACTIVE ☐ HELM ADVISOR ☐ G/M ADVISOR ☐ MUTE ☐ AUTO (W/ OVR) (default) ☐ NAV MODE ☐ WAYPOINT MODE	Assigns a function to Relay 2.
RELAY 3 (TB 76-78)	☐ OFF HDG ALARM	Assigns a function to Relay 3. (Off Heading alarm is always assigned.)
RELAY 4 (TB 82-84)	☐ NONE ☐ OFF HDG ALARM ☐ HDG DIFFERENCE ☐ OVERRIDE ☐ DEADMAN CONTACT (default) ☐ EXT SYS ACTIVE ☐ HELM ADVISOR ☐ G/M ADVISOR ☐ MUTE ☐ AUTO (W/ OVR) ☐ NAV MODE ☐ WAYPOINT MODE	Assigns a function to Relay 4.
STEERING GEAR:		
MAXIMUM RUDDER:		
MAX RUD	_____°.	Sets the maximum rudder angle in NAVIPILOT steering mode. Range: 5 to 120 degrees. Default: 35 degrees. NOTE: Counter Rudder (CR) limit is 45 degrees or the MAX RUD setting, whichever is smaller.
STAGING THRESHOLDS:		
STAGE 1:		
ON	_____°.	Rudder error at which the solenoid for Stage 1 activates. Range: 0.1 to 7.3 degrees. Default: 0.8 degrees.

Table A-4. Service Setup 2 – SCU Configuration Settings (continued)

Item	*Configuration Setting*	*Function*
OFF	_____ °.	Rudder error at which the solenoid for Stage 1 de-activates. Range: 0.0 to 7.2 degrees. Default: 0.5 degrees.
STAGE 2:		
ON	_____ °.	Rudder error at which the solenoid for Stage 2 activates. Range: 1.4 to 8.4 degrees. Default: 3.1 degrees.
STAGE 3:		
ON	_____ °.	Rudder error at which the solenoid for Stage 3 activates. Range: 2.5 to 9.5 degrees. Default: 5.0 degrees.
STAGE 4:		
ON	_____ °.	Rudder error at which the solenoid for Stage 4 activates. Range: 3.6 to 10.6 degrees. Default: 7.0 degrees.
STAGE 5:		
ON	_____ °.	Rudder error at which the solenoid for Stage 5 activates. Range: 4.7 to 11.7 degrees. Default: 9.0 degrees.
STAGE 6:		
ON	_____ °.	Rudder error at which the solenoid for Stage 6 activates. Range: 5.8 to 12.8 degrees. Default: 11.0 degrees.
STAGE 7:		
ON	_____ °.	Rudder error at which the solenoid for Stage 7 activates. Range: 6.9 to 13.9 degrees. Default: 13.0 degrees.
STAGE 8:		
ON	_____ °.	Rudder error at which the solenoid for Stage 8 activates. Range: 8.0 to 15.0 degrees. Default: 15.0 degrees.
ANALOG OUTPUT:		
MODE	☐ PRO (default) ☐ PRE	Sets the analog output as proportional to the rudder order (PRO) or as proportional to the rudder error (PRE). PRO is selected in most cases.
TYPE	☐ VOLTAGE (default) ☐CURRENT	

Table A-4. Service Setup 2 – SCU Configuration Settings (continued)

Item		*Configuration Setting*	*Function*
POLARITY	Voltage	☐ STBD POS (default) ☐ PORT POS	Sets the steering gear voltage polarity.
	Current	☐ 20 mA STBD (default) ☐ 20 mA PORT	Sets the steering gear current polarity
CALIBRATION	Voltage	_____ mV/°.	Sets the voltage scaling of the steering gear analog output. Range: 80 to 350 millivolts per degree (PRO); 500 to 2000 mV/° (PRE). Default: 250 mV/° (PRO); 1000 mV/° (PRE).
	Current	_____ °/ 8 mA.	Sets the voltage scaling of the steering gear analog output. Range: 29 to 125 degrees per 8 milliamps (PRO); 5 to 20°/ 8 mA (PRE). Default: 40°/ 8 mA (PRO); 10°/ 8 mA (PRE)
AC SOLENOID BOARD 1:			
PUMP 1:			
SCU 1		☐ STAGE 1 (default) ☐ STAGE 2	Determines which stage of hydraulic flow control for a directional valve is performed by the Pump 1 section of AC solenoid board 1 in SCU 1.
SCU 2		☐ STAGE 1 ☐ STAGE 2 (default)	Determines which stage of hydraulic flow control for a directional valve is performed by the Pump 1 section of AC solenoid board 1 in SCU 2.
STATUS		☐ OFF (default) ☐ PUMP STAT	Determines whether the pump status (Pump On) signal is used by the Pump 1 section of AC solenoid board 1.
PUMP 2:			
SCU 1		☐ OFF ☐ STAGE 1 (default) ☐ STAGE 2 ☐ STAGE 3 ☐ STAGE 4 ☐ DUMP 2 ☐ DUMP 3 ☐ DUMP 4	Determines which stage of hydraulic flow control for a directional or dump valve is performed by the Pump 2 section of AC solenoid board 1 in SCU 1.
SCU 2		☐ OFF ☐ STAGE 1 ☐ STAGE 2 (default) ☐ STAGE 3 ☐ STAGE 4 ☐ DUMP 2 ☐ DUMP 3 ☐ DUMP 4	Determines which stage of hydraulic flow control for a directional or dump valve is performed by the Pump 2 section of AC solenoid board 1 in SCU 2.

Table A-4. Service Setup 2 – SCU Configuration Settings (continued)

Item	*Configuration Setting*	*Function*
PUMP 2:		
SCU 1	☐ OFF ☐ STAGE 1 (default) ☐ STAGE 2 ☐ STAGE 3 ☐ STAGE 4 ☐ DUMP 2 ☐ DUMP 3 ☐ DUMP 4	Determines which stage of hydraulic flow control for a directional or dump valve is performed by the Pump 2 section of AC solenoid board 1 in SCU 1.
SCU 2	☐ OFF ☐ STAGE 1 ☐ STAGE 2 (default) ☐ STAGE 3 ☐ STAGE 4 ☐ DUMP 2 ☐ DUMP 3 ☐ DUMP 4	Determines which stage of hydraulic flow control for a directional or dump valve is performed by the Pump 2 section of AC solenoid board 1 in SCU 2.
STATUS	☐ OFF (default) ☐ PUMP STAT	Determines whether the pump status (Pump On) signal is used by the Pump 2 section of AC solenoid board 1.
AC SOLENOID BOARD 2:		
PUMP 1:		
SCU 1	☐ STAGE 1 (default) ☐ STAGE 2	Determines which stage of hydraulic flow control for a directional valve is performed by the Pump 1 section of AC solenoid board 2 in SCU 1.
SCU 2	☐ STAGE 1 ☐ STAGE 2 (default)	Determines which stage of hydraulic flow control for a directional valve is performed by the Pump 1 section of AC solenoid board 2 in SCU 2.
STATUS	☐ OFF (default) ☐ PUMP STAT	Determines whether the pump status (Pump On) signal is used by the Pump 1 section of AC solenoid board 1.
PUMP 2:		
SCU 1	☐ OFF ☐ STAGE 1 (default) ☐ STAGE 2 ☐ STAGE 3 ☐ STAGE 4 ☐ DUMP 2 ☐ DUMP 3 ☐ DUMP 4	Determines which stage of hydraulic flow control for a directional or dump valve is performed by the Pump 2 section of AC solenoid board 2 in SCU 1.

Table A-4. Service Setup 2 – SCU Configuration Settings (continued)

Item	*Configuration Setting*	*Function*
SCU 2	☐ OFF ☐ STAGE 1 ☐ STAGE 2 (default) ☐ STAGE 3 ☐ STAGE 4 ☐ DUMP 2 ☐ DUMP 3 ☐ DUMP 4	Determines which stage of hydraulic flow control for a directional or dump valve is performed by the Pump 2 section of AC solenoid board 2 in SCU 2.
STATUS	☐ OFF (default) ☐ PUMP STAT	Determines whether the pump status (Pump On) signal is used by the Pump 2 section of AC solenoid board 2.
DC SOLENOID BOARD 1:		
PUMP 1:		
SCU 1	☐ STAGE 1 (default) ☐ STAGE 2	Determines which stage of hydraulic flow control for a directional valve is performed by the Pump 1 section of DC solenoid board 1 in SCU 1.
SCU 2	☐ STAGE 1 ☐ STAGE 2 (default)	Determines which stage of hydraulic flow control for a directional valve is performed by the Pump 1 section of DC solenoid board 1 in SCU 2.
STATUS	☐ OFF (default) ☐ PUMP STAT	Determines whether the pump status (Pump On) signal is used by the Pump 1 section of DC solenoid board 1.
PUMP 2:		
SCU 1	☐ OFF ☐ STAGE 1 (default) ☐ STAGE 2 ☐ STAGE 3 ☐ STAGE 4 ☐ DUMP 2 ☐ DUMP 3 ☐ DUMP 4	Determines which stage of hydraulic flow control for a directional or dump valve is performed by the Pump 2 section of DC solenoid board 1 in SCU 1.
SCU 2	☐ OFF ☐ STAGE 1 ☐ STAGE 2 (default) ☐ STAGE 3 ☐ STAGE 4 ☐ DUMP 2 ☐ DUMP 3 ☐ DUMP 4	Determines which stage of hydraulic flow control for a directional or dump valve is performed by the Pump 2 section of DC solenoid board 1 in SCU 2.

Table A-4. Service Setup 2 – SCU Configuration Settings (continued)

Item	*Configuration Setting*	*Function*
STATUS	☐ OFF (default) ☐ PUMP STAT	Determines whether the pump status (Pump On) signal is used by the Pump 2 section of DC solenoid board 1.
DC SOLENOID BOARD 2:		
PUMP 1:		
SCU 1	☐ STAGE 1 (default) ☐ STAGE 2	Determines which stage of hydraulic flow control for a directional valve is performed by the Pump 1 section of DC solenoid board 2 in SCU 1.
SCU 2	☐ STAGE 1 ☐ STAGE 2 (default)	Determines which stage of hydraulic flow control for a directional valve is performed by the Pump 1 section of DC solenoid board 2 in SCU 2.
STATUS	☐ OFF (default) ☐ PUMP STAT	Determines whether the pump status (Pump On) signal is used by the Pump 1 section of DC solenoid board 2.
PUMP 2:		
SCU 1	☐ OFF ☐ STAGE 1 (default) ☐ STAGE 2 ☐ STAGE 3 ☐ STAGE 4 ☐ DUMP 2 ☐ DUMP 3 ☐ DUMP 4	Determines which stage of hydraulic flow control for a directional or dump valve is performed by the Pump 2 section of DC solenoid board 2 in SCU 1.
SCU 2	☐ OFF ☐ STAGE 1 ☐ STAGE 2 (default) ☐ STAGE 3 ☐ STAGE 4 ☐ DUMP 2 ☐ DUMP 3 ☐ DUMP 4	Determines which stage of hydraulic flow control for a directional or dump valve is performed by the Pump 2 section of DC solenoid board 2 in SCU 2.
STATUS	☐ OFF (default) ☐ PUMP STAT	Determines whether the pump status (Pump On) signal is used by the Pump 2 section of DC solenoid board 2.

Table A-4. Service Setup 2 – SCU Configuration Settings (continued)

Item	*Configuration Setting*	*Function*
SIDE SLAVE RRB (RUDDER REPEATBACK) SOURCE		
SIDE SLAVE RRB SOURCE	☐ OWN (default) ☐ MASTER	For system configurations in which two SCUs control the same rudder, and the digital RRB Side Master/Slave interface between the two SCUs is enabled: Select MASTER at **both** SCUs to enable the Side Master/Slave RRB configuration. The Side Master SCU will use its analog RRB input as its RRB source. The Side Slave will use the digital RRB messages from the Side Master SCU, and ignore its analog RRB input. Select OWN at **both** SCUs to disable the Side Master/Slave RRB configuration. Each SCU will use its analog RRB input as its RRB source, and ignore the digital RRB messages from one SCU to the other. Press the ACCEPT softkey to accept the OWN or MASTER selection; press the CANCEL key to cancel the selection. For system configurations in which a single SCU controls a rudder, the configuration setting has no effect.
ABS OVERRIDE:		
ABS OVERRIDE	☐ NO (default) ☐ YES	Enables or disables ABS Override. If YES is selected, the main helm wheel will override Auto/Nav/Waypoint modes when the wheel is moved from the center position by a configured value for more than two seconds. **NOTE**: ABS Override is normally not enabled unless required by the inspecting agency.
ABS OVER	_____°.	If YES is selected above, allows input of the setting at which movement of the main helm wheel from the center position will override Auto/Nav/Waypoint modes. Range: 1 to 8 degrees. Default: 5 degrees.
HELM ADVISOR:		
HELM ADVISOR	☐ NONE ☐ AUTO ☐ EXT ☐ BOTH	Sets the Helm Advisor function. If enabled, an alarm is generated if the main helm wheel is moved from the zero position while in an automatic steering mode, an external steering mode, or both. **NOTE**: Helm Advisor should not be enabled if ABS override is enabled.

Table A-4. Service Setup 2 – SCU Configuration Settings (continued)

Item	Configuration Setting	Function
SERVICE INTERFACE:		
BAUD RATE	☐ 2400 ☐ 4800 ☐ 9600 (default) ☐ 19200	Sets the Baud Rate for the service interface.
PARITY	☐ NONE (default) ☐ EVEN ☐ ODD	Sets the Parity for the service interface.
DATA WIDTH	☐ 7 ☐ 8 (default)	Sets the Data Width for the service interface (future enhancement).
STOP BITS	☐ 1 (default) ☐ 2	Sets the Stop Bits for the service interface (future enhancement).
CAN INTERFACE:		
SIGNAL RATE	☐ 250K (default)	Sets the CAN baud rate.
MAIN MODE SWITCH:		
MODE SWITCH	☐ NONE ☐ MMS (default) ☐ SMS	Selects the type of main mode selection switch installed: MMS = Mechanical Mode Switch SMS = Steering Mode Selector (a Bus Interface Unit)
ALARM CONDITIONS:		
DEADMAN ALARM TIMEOUT	☐ DISABLE (default) ☐ ENABLE	Enables or disables alarm for no operator response.
DEAD TIME	_____ sec.	If ENABLE is selected above, allows input of the duration after which a Deadman alarm will occur. Range: 1 to 253 seconds. Default: 5 seconds
OFF HEADING ALARM DISABLE	☐ YES ☐ NO (default)	When YES is selected, the operator menu for OFF HEADING LIMIT allows selection of OFF as an option. When OFF is selected from that menu, the Off Heading alarm is disabled. When NO is selected, the OFF HEADING LIMIT operator menu does not allow the operator to disable the Off Heading alarm.
OFF HEADING DELAY	_____ sec.	Sets the delay time for the external Off Heading alarm. Range: 0 to 40 seconds. Default: 1 second.
MINIMUM SPEED	_____ kn.	Sets the minimum speed attainable without an alarm. Range: 1 to 10 knots. Default: 2 knots.

Table A-4. Service Setup 2 – SCU Configuration Settings (continued)

Item	*Configuration Setting*	*Function*
MAXIMUM SPEED	_____ kn.	Sets the maximum speed attainable without an alarm. Range: 1 to 99 knots. Default: 40 knots.
OVERRIDE ALARM	☐ NONE ☐ FMW ☐ EXT ☐ FMW+EXT (default)	Sets the conditions under which an alarm is generated if steering control is overridden by a Follow-Up Mini-Wheel or other external device: None Override by Follow-up Mini-Wheel Override by other external device, as indicated by a contact-closure at the SCU's OVERRIDE input (pins 32 and 33). Override by Follow-up Mini-Wheel or other external device

Table A-5. Service Setup 2 – CDU Configuration Settings

Item	Configuration Setting	Function
LOCATION:		
LOCATION	☐ 4: MAIN (default) ☐ 5: PORT WING ☐ 6: STBD WING ☐ 7: NAVSTATION ☐ 8: HELMSMAN STATION ☐ 9: MANEUVERING STATION ☐ 10: AFT BRIDGE ☐ 11: FORWARD BRIDGE ☐ 12: EMERGENCY STATION ☐ 13: FLY BRIDGE ☐ 14: PORT FLYBRIDGE ☐ 15: STBD FLYBRIDGE ☐ _____ [16 thru 31]	Identifies the control location associated with the device.
NAME:		
NAME	☐ 4: MAIN (default) ☐ 5: PORT WING ☐ 6: STBD WING ☐ 7: NAVSTATION ☐ 8: HELMSMAN STATION ☐ 9: MANEUVERING STATION ☐ 10: AFT BRIDGE ☐ 11: FORWARD BRIDGE ☐ 12: EMERGENCY STATION ☐ 13: FLY BRIDGE ☐ 14: PORT FLYBRIDGE ☐ 15: STBD FLYBRIDGE ☐ _____ [16 thru 255]	Identifies the display title associated with the device.
AUDIBLE OVERRIDE:		
OVERRIDE	☐ ALL ☐ A/N/W (default)	Beeps when an override condition occurs.
TENTH TIMEOUT:		
TENTH TIME	_____ sec.	Sets the duration of time following the last Set Heading change. Range: 10 to 60 seconds. Default: 10 seconds.

Table A-5. Service Setup 2 – CDU Configuration Settings (continued)

Item	*Configuration Setting*	*Function*
TAKEOVER METHOD:		
TAKEOVER METHOD	☐ NONE (default) ☐ CALL UP ☐ TAKEOVER	Sets the control acquisition method for the station. Refer to chapter 2.
AUDIBLE TAKEOVER:		
AUD TAKEOVER	☐ YES (default) ☐ NO	Determines if a beep is sounded when the station takes control.
AUDIBLE BUTTON:		
AUD BUTTON	☐ YES (default) ☐ NO	Determines if beep is sounded when a button is pressed.
SERVICE INTERFACE:		
BAUD RATE	☐ 2400 ☐ 4800 (default) ☐ 9600 ☐ 19200	Sets the Baud Rate for the diagnostic serial port. (This value should be set to 4800, or a Missing Key alarm will be issued.)
PARITY BITS	☐ NO PARITY (default) ☐ EVEN ☐ ODD	Sets the Parity Bits for the diagnostic serial port.
DATA BITS	☐ 7 ☐ 8 (default)	Sets the Data Width for the diagnostic serial port (future enhancement).
STOP BITS	☐ 1 (default) ☐ 2	Sets the number of Stop Bits for the diagnostic serial port (future enhancement).
CAN INTERFACE:		
BAUD RATE	☐ 250K (default)	Sets the Baud Rate on the NAVINET 4000 Steering Control Network bus for the unit.
KEYPAD CALIBRATION		
KEYPAD CAL	_____	Sets the CDU keypad backlighting to a level which does no interfere with night vision. Brightness is adjusted after 'Dim-' key on the CDU front panel is adjusted to dim down to the absolute minimum and up and down arrow keys are used to adjust the keypad calibration until the keypad backlight is barely visible. Range: 0 to 10.

Table A-6. Service Setup 2 – SYS Configuration Settings

Item	*Configuration Setting*	*Function*
SYSTEM	☐ PID (default) ☐ AD	Enables or disables the NAVIPILOT's Adaptive Self-Tuning feature (see Chapter 2, section 2.20): PID (Proportional Integral Derivative) - Adaptive Self-Tuning is disabled. AD (Adaptive) - Adaptive Self-Tuning is enabled.

A.5 SYSTEM CONFIGURATION

A number of important system characteristics are not configured via the service setup menus. Use Figure A-2 to record this information. The row of data entered becomes the System ID number, which is a useful record to assist with analysis if a problem is reported. It is recommended that the vessel keep a copy of the System ID number, and for the installing engineer to record the number to be kept with records of the installation.

A.6 OPERATOR RUDDER LIMIT

Select OPERATOR RUDDER LIMIT from the MAIN SERVICE SETUP menu and select either w/o RAD/RATE CTRL (without Radius/Rate Control) or w/ RAD/RATE CTRL (with Radius/Rate Control) as the turn method. Table A-7 is used to record the radius/rate control setting. If the system is configured without radius and rate control, the system uses either the rudder limit, the radius order, or the rate order as the turn method. When the system is configured for with radius and rate control, the system uses the rudder limit and either the radius order or the rate order.

Table A-7. Service Setup 2 – Operator Rudder Limit Settings

Item	***Configuration Setting***	***Function***
SYSTEM	☐ w/o RAD/RATE CTRL (default)	System uses either the rudder limit, the radius order, or the rate order as the turn method.
	☐ w/ RAD/RATE CTRL	System uses the rudder limit and either the radius order or the rate order.

A.7 MAX SHIP ACCELERATION

Select MAX SHIP ACCELERATION from the MAIN SERVICE SETUP menu and set the rate of change in knots per minute that the ship accelerates. Table A-8 is used to record the rate of acceleration.

Table A-8. Service Setup 2 – Maximum Ship Acceleration/Deceleration Setting

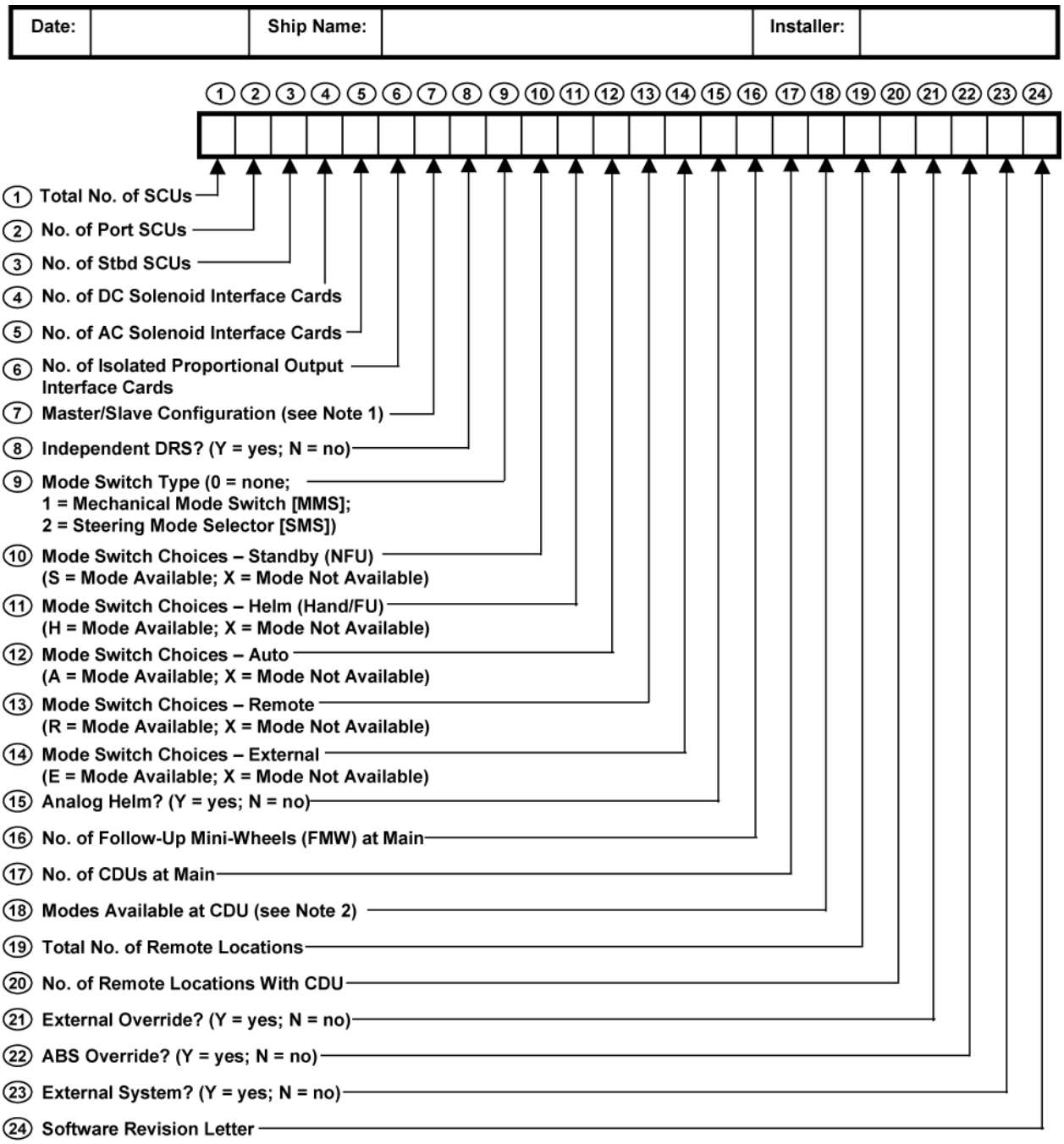
Item	*Configuration Setting*	*Function*
MAX ACC	_____ kts/min.	Sets the maximum ship acceleration/ deceleration rate. Range: 0.5 to 50 knots per minute. Default: 10

A.8 BIAS BASELINE

Select BIAS BASELINE from the MAIN SERVICE SETUP menu and set the baseline amount for rudder bias calculation. Table A-9 is used to record the baseline bias.

Table A-9. Service Setup 2 – Bias Baseline Setting

Item	*Configuration Setting*	*Function*
BIAS	_____ °.	Sets the baseline default for rudder bias. Range: -5 to +5 degrees. Default: 0



NOTES:

1. For Master/Slave Configuration, enter one of the following codes:
   - N1 - Only one SCU is powered on and on its own CAN bus, with no other SCU's connected
   - Y2 - Two SCUs on the same CAN bus are normally powered on at the same time, with master/slave relationship
   - Y3 - Three SCUs on the same CAN bus are normally powered on at the same time, with master/slave relationship
   - Y4 - Four SCUs on the same CAN bus are normally powered on at the same time, with master/slave relationship

2. For Modes Available at CDU, enter one of the following codes:
   - A – AUTO, NAV, and WAYPOINT
   - U – AUTO only
   - N – AUTO and NAV
   - T – AUTO and WAYPOINT

   NAV mode requires connection to Sperry VisionMaster FT. WAYPOINT mode requires connection to a compatible chart system or GPS.

Figure A-2. ***System ID Number***

APPENDIX B
CONFIGURATION DATA
(NAVIPILOT 4000 HSC / NAVIPILOT 4000 TRACK HSC)

B.1 INTRODUCTION

This appendix provides information on configuration procedures for the NAVIPILOT 4000 HSC and the NAVIPILOT 4000 TRACK HSC..

B.2 RUDDER GAIN (RG) AND COUNTER RUDDER (CR) OPERATIONAL SETTINGS.

Use Table B-1 to record the manually entered rudder gain (RG) and counter rudder (CR) values which are found to provide the best steering performance during sea trials. See chapter 3 for instructions for entering the gains manually.

Table B-1. User Settings for Rudder Gain (RG) and Counter Rudder (CR)

Gain Set	*Rudder Gain (RG)*	*Counter Rudder (CR)*	*Remarks*
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

B.3 MAGNETIC FLUXGATE COMPASS CALIBRATION.

The Magnetic Fluxgate Compass Calibration function compensates for minor differences that occur between the magnetic fluxgate compass heading and the heading data transmitted by the gyrocompass. To perform this function, the maintenance technician enters correction factors for storage in the NAVIPILOT memory, using the SERVICE SETUP 1 menu.

NOTE: This calibration method is only used when the fluxgate compass is connected directly to the NAVIPILOT SCU. When a fluxgate compass is connected via a Navitwin III compass monitor unit, the calibration must be performed at the Navitwin III, which then provides the fluxgate heading to NAVIPILOT as serial data.

To enter the calibration data:

a. Verify that the magnetic fluxgate compass has been properly installed and calibrated, and **set the correct magnetic variation for the geographic location**. (Refer to Chapter 3 for instructions).

b. Select the manual steering mode.

c. Press MENU until the SERVICE SETUP 1 configuration menu appears. Select SERVICE SETUP 1.

d. Enter the access code for SERVICE SETUP 1. (Contact Sperry Marine for access codes.)

e. Select FLUXGATE CAL TABLE, and press the ACCEPT soft key.

f. Select SET UP CALIBRATION from the CALIBRATE FLUXGATE screen, and press the ACCEPT soft key.

g. Select CALIBRATE from the CALIBRATE FLUXGATE START screen, and press the ACCEPT soft key.

h. Operate the helm wheel until the heading indication on the magnetic fluxgate compass is 000°.

i. Record the gyrocompass heading indication in Table B-2.

j. Calculate the required correction value for each heading. Record the calculated value in Table B-2.

Example: The actual magnetic fluxgate compass heading is 010°. The actual gyrocompass heading is 011°. The required correction value is 1°.

k. Press the $\wedge$ (up) or $\vee$ (down) soft key until the calculated value is displayed. Press the ACCEPT soft key.

l. Repeat steps h through k for each of the magnetic fluxgate compass headings listed in Table B-2.

Table B-2. Magnetic Fluxgate Compass Calibration Table

Magnetic Fluxgate Compass Heading	*Gyrocompass Heading*	*Correction Value*
000°	_____	_____
010°	_____	_____
020°	_____	_____
030°	_____	_____
040°	_____	_____
050°	_____	_____
060°	_____	_____
070°	_____	_____
080°	_____	_____
090°	_____	_____
100°	_____	_____
110°	_____	_____
120°	_____	_____
130°	_____	_____
140°	_____	_____
150°	_____	_____
160°	_____	_____
170°	_____	_____

Magnetic Fluxgate Compass Heading	*Gyrocompass Heading*	*Correction Value*
180°	_____	_____
190°	_____	_____
200°	_____	_____
210°	_____	_____
220°	_____	_____
230°	_____	_____
240°	_____	_____
250°	_____	_____
260°	_____	_____
270°	_____	_____
280°	_____	_____
290°	_____	_____
300°	_____	_____
310°	_____	_____
320°	_____	_____
330°	_____	_____
340°	_____	_____
350°	_____	_____

B.4 CONFIGURATION SETTINGS

Maintenance personnel can configure the NAVIPILOT for a variety of operating modes and Heading Control System configurations, by using the SERVICE SETUP 1 and SERVICE SETUP 2 menus as described below.

IMPORTANT:

- **If all SCUs are powered on and communicating on the NAVINET 4000 HSC Steering Control Network, the setup procedures described below will configure all SCUs simultaneously. Otherwise, the installer must repeat the configuration procedure each time a new SCU is powered on. The same configuration settings must be entered at each SCU to ensure consistent system performance and capabilities, regardless of which SCU is in use.**
- **For the configuration settings to take effect, the NAVIPILOT MUST be powered off and powered up again after completing service setup.**

B.4.1 Configuration Settings – SERVICE SETUP 1

To enter the SERVICE SETUP 1 configuration settings:

a. Select a non-automatic steering mode (follow-up or non follow-up).

b. Power-on all SCUs.

c. At a CDU, press MENU until the SERVICE SETUP 1 soft key appears. Press the SERVICE SETUP 1 soft key.

d. Enter the access code for SERVICE SETUP 1. (Refer to the latest Field Engineering Bulletin.)

e. From the SERVICE SETUP 1 menu, select HCS CONFIGURATION, and press the ACCEPT soft key.

f. Table B-3 lists each of the HCS CONFIGURATION parameters. Make the appropriate selections, and record the configuration settings in the table.

g. Press the EXIT key to exit the HCS CONFIGURATION menu.

h. Press the EXIT key again to exit the SERVICE SETUP 1 menu. The selected configuration settings will be stored in the NAVIPILOT memory.

B.4.2 Configuration Settings – SERVICE SETUP 2.

To enter the SERVICE SETUP 2 configuration settings:

a. Select a non-automatic steering mode (follow-up or non follow-up).

b. Power-on all SCUs.

c. At a CDU, press MENU until the SERVICE SETUP 2 soft key appears. Press the SERVICE SETUP 2 soft key.

d. Enter the access code for SERVICE SETUP 2. (Refer to the latest Field Engineering Bulletin.)

e. At the MAIN SERVICE SETUP menu (Figure B-1), verify that all SCUs are reporting their part number and revision, and that the part numbers and revisions are all the same. (Figure B-1 shows a two-SCU configuration, with the SCUs identified as PORT 1 and STBD 1.)

f. To enter the SCU configuration settings:

   1) From the MAIN SERVICE SETUP menu, select SCU CONFIGURATION, then press the ACCEPT soft key.

2) Table B-4 lists each of the SCU CONFIGURATION parameters. Make the appropriate selections, and record the configuration settings in the table.

3) Press the EXIT key to exit the SCU CONFIGURATION menu.

g. To enter the CDU configuration settings:

1) From the MAIN SERVICE SETUP menu, select CDU CONFIGURATION, then press the ACCEPT soft key.

2) Table B-5 lists each of the CDU CONFIGURATION parameters. Make the appropriate selections, and record the configuration settings in the table.

3) Press the EXIT key to exit the CDU CONFIGURATION menu.

4) If there are additional CDUs to be configured in the Heading Control System, repeat steps c, d, and g for each CDU. Verify that all CDU part numbers and revisions are the same. (Figure B-1 shows a single-CDU configuration, with the CDU identified as DISPLAY.)

h. To enter the SYS configuration settings:

1) From the MAIN SERVICE SETUP menu, select SYS CONFIGURATION, then press the ACCEPT soft key.

2) Table B-6 lists each of the SYS CONFIGURATION parameters. Make the appropriate selections, and record the configuration settings in the table.

3) Press the EXIT key to exit the SYS CONFIGURATION menu.

i. Press the EXIT key again to exit the MAIN SERVICE SETUP menu. The selected configuration settings will be stored in the NAVIPILOT memory.

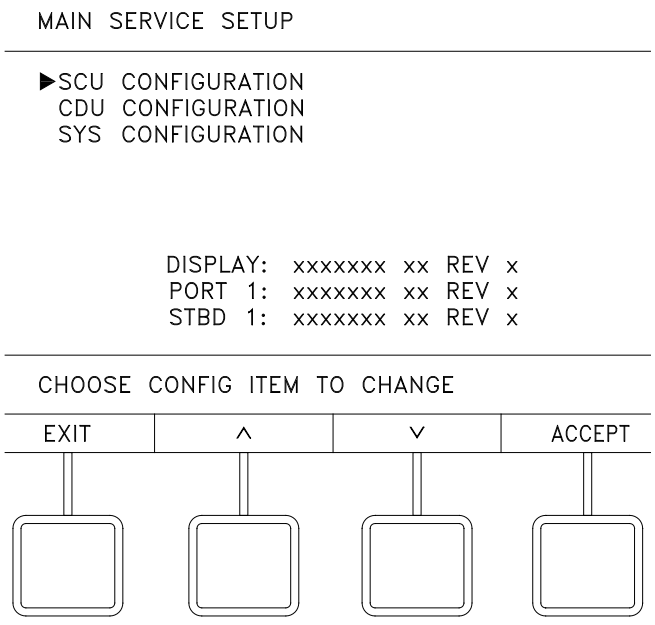


***Figure B-1*. Typical MAIN SERVICE SETUP Menu**

Table B-3. Service Setup 1 – HCS Configuration Settings

Item	*Configuration Setting*	*Function*
HCS CONFIGURATION		
TAU:		
TAU	_____ sec.	Sets the ship's time constant (tau). Tau is the time in seconds it takes for the ship to traverse a distance of its own length at service (cruising) speed. Ship length is defined as the length at the waterline, or the length between perpendiculars. See Appendix B for formulas. Range: 0.5 to 50 seconds. Default: 5 seconds.
SERVICE SPEED:		
SERV SPD	_____ kn.	Sets the ship's service (cruising) speed. Range: 5 to 60 knots. Default: 40 knots.
OVERRIDE RECOVERY: These settings dictate how the system responds when an override is cancelled by selecting PREV MODE (Previous Mode) at an ancillary unit. **Default settings are recommended.** These settings have no effect if the override capability is not available in the system.		
HEADING	☐ ACT HDG (default) ☐ LAST ORD	When an override is cancelled by selecting PREV MODE: ACT HDG (Actual Heading) – The set heading will be the same as the current actual heading, and the vessel will remain on its current course. LAST ORD (Last Order) – The previous heading order will go into effect. This may result in a significant change to set heading, depending on how far the vessel deviated from the previous order. In this mode, the override may be used to "jog" around an obstruction.
MODE	☐ AUTO (default) ☐ A/N/W	When an override is cancelled by selecting PREV MODE: AUTO – The system will drop from Nav or Waypoint to Auto mode. The user must take deliberate steps to resume Nav or Waypoint mode after an override. A/N/T (Auto/Nav/Waypoint) – the system will truly revert to the previous mode when PREV MODE is selected, including Nav or Waypoint if the override occurred in either of those modes.

Table B-3. Service Setup 1 – HCS Configuration Settings (continued)

Item	*Configuration Setting*	*Function*
CROSS TRACK: These settings are only used when the NAV interface uses APB or HSC/XTE messages for Waypoint mode at the NAVIPILOT.		
XT ERROR GAIN	_____ °/nm	Sets the amount of heading correction to make based on cross-track error. Range: 2 to 280 degrees per nautical mile. Default: 50°/nm.
XT RATE GAIN	_____ °/kn	Sets the amount of heading correction to make based on cross-track error rate. Range: 0.0 to 5.0 degrees per knot. Default: 0.0°/kn.
XT APPROACH ANGLE LIM	_____ °	Sets the maximum angle for regaining the track. Range: 20 to 60 degrees. Default: 20 degrees.
XT FILTER TC	_____ sec	Sets the time constant used to calculate cross-track rate. Range: 10 to 180 seconds. Default: 30 seconds.
XT BIAS ENABLE	☐ YES (default) ☐ NO	Allows the bias calculation to be disabled for tuning the track controller.
XT BIAS TC	_____ sec	Sets the time constant used in the bias calculation. Range: 50 to 500 seconds. Default: 300 seconds.
DEAD BAND		
DEAD BAND	_____ °	Sets the jet dead band compensation. Range: 0 to 10 degrees. Default: 0 degrees. NOTE: For conventional rudder engine systems, the dead band should be set to 0 degrees. Other values should be selected only if dead band is actually present, i.e. with water jet propulsion/steering systems. The required dead band setting is usually obtained from the rudder engine manufacturer or from the shipyard. If necessary, the required setting may be determined during sea trials. Typical water jet propulsion/steering values are in the range of 1.5 to 2.0 degrees. Safety Note: An operator rudder limit is based on effective rudder limit and is not incorporated in the dead band calculation. For example, if a vessel has a dead band of 2 degrees and an operator rudder limit of 20 degrees, the maximum rudder is 22 degrees.

Table B-3. Service Setup 1 – HCS Configuration Settings (continued)

Item	*Configuration Setting*	*Function*
Relative Integrating Time Constant (CONST)		
ITPH	_____	Sets the maximum relative integrating time constant. Range: 0 to 300 %. Sets the time period which a heading offset is to be compensated by a corresponding rudder offset (integral component of rudder order). Increasing the time constant accelerates the compensation. Setting the time constant to 0% disables the drift compensation. NOTE: The optimum setting of the integration time may be determined during sea trials. A setting of 100% will provide satisfactory drift compensation with no further fine-tuning required. For mono-hulls, the value is typically set between 20% and 100%. For multi-hulls the value is typically 100%.

Table B-4. Service Setup 2 – SCU Configuration Settings

Item	*Configuration Setting*	*Function*
SERIAL INTERFACE:		
HEADING 1:		
GYRO	☐ NONE ☐ HDT ☐ HEHDT (default)	Determines the NMEA message type for a Gyrocompass input at the HDG 1 port in the SCU: HDT - True Heading HEHDT - North-Seeking Gyro, True Heading
MAGNETIC	☐ NONE (default) ☐ HCHDT ☐ HDG ☐ HDM	Determines the NMEA message type for a Magnetic Heading input at the HDG 1 port: HCHDT - Mag. Compass, True Heading HDG - Heading, Deviation, and Variation HDM - Magnetic Heading **WARNING:** Do NOT configure a NMEA message for a magnetic compass when a fluxgate compass is configured. Such a configuration error will cause the NAVIPILOT to toggle between the NMEA heading data and the heading data from the fluxgate compass, when magnetic is selected as the heading source.
NSD	☐ YES ☐ NO (default)	Sets up the HDG 1 port to receive the serial NSD (Navigation Status Data) message, from a connected Navitwin II compass monitor.
BAUD RATE	☐ 1200 ☐ 2400 ☐ 4800 (default) ☐ 9600 ☐ 14.4 ☐ 19.2 ☐ 28.8 ☐ 38.4	Sets the Baud Rate for HDG 1.
HEADING 2:		
GYRO	☐ NONE ☐ HDT ☐ HEHDT (default)	Determines the NMEA message type for a Gyrocompass input at the HDG 2 port in the SCU: HDT - True Heading HEHDT - North-Seeking Gyro, True Heading

Table B-4. Service Setup 2 – SCU Configuration Settings (continued)

Item	*Configuration Setting*	*Function*
MAGNETIC	☐ NONE (default) ☐ HCHDT ☐ HDG ☐ HDM	Determines the NMEA message type for a Magnetic Heading input at the HDG 2 port: HCHDT - Mag. Compass, True Heading HDG - Heading, Deviation, and Variation HDM - Magnetic Heading **WARNING:** Do NOT configure a NMEA message for a magnetic compass when a fluxgate compass is configured. Such a configuration error will cause the NAVIPILOT to toggle between the NMEA heading data and the heading data from the fluxgate compass, when magnetic is selected as the heading source.
NSD	☐ YES ☐ NO (default)	Sets up the HDG 2 port to receive the serial NSD message, from a connected Navitwin III compass monitor.
BAUD RATE	☐ 1200 ☐ 2400 ☐ 4800 (default) ☐ 9600 ☐ 14.4 ☐ 19.2 ☐ 28.8 ☐ 38.4	Sets the Baud Rate for HDG 2.
SPEED:		
MESSAGE TYPE	☐ NONE ☐ VHW ☐ VTG ☐ VBW (default) ☐ 200P/NM + ☐ 200P/NM -	Sets the speed message type: None VHW (Water Speed and Heading) VTG (Course Over Ground and Ground Speed) VBW (Dual Ground/Water Speed) 200 pulses per nautical mile, triggered on the rising edge of the pulse (+) 200 pulses per nautical mile, triggered on the falling edge of the pulse (-) For a VBW message, water speed has preference. Ground speed is used when water speed is not available. For a 200P/NM input, if the speed display is erratic with one of the two selections (+ or -), use the other selection.

Table B-4. Service Setup 2 – SCU Configuration Settings (continued)

Item	*Configuration Setting*	*Function*
BAUD RATE	☐ 1200 ☐ 2400 ☐ 4800 (default) ☐ 9600 ☐ 14.4 ☐ 19.2 ☐ 28.8 ☐ 38.4	Sets the Baud Rate expected for the Speed message.
NAV INTERFACE:		
MESSAGE TYPE	☐ NONE (default) ☐ APB ☐ HSC, XTE ☐ HSC, PROP-HTC, HTR* * Not available in waypoint control	Sets the NMEA message used for the Nav interface: If the Nav interface is not used, select NONE. For interface to a GPS or a compatible non-Sperry chart system, select APB (Heading/Track Controller [Autopilot] Sentence "B") or HSC/XTE (Heading-to-Steer Command/Cross-Track Error), as appropriate for the system being used. This will enable WAYPOINT mode operation of the NAVIPILOT.
BAUD RATE	☐ 1200 ☐ 2400 ☐ 4800 (default) ☐ 9600 ☐ 14.4 ☐ 19.2 ☐ 28.8 ☐ 38.4	Sets the Baud Rate used for the Nav interface.
LOST NAV	☐ RES HDG (default) ☐ COMPL TURN	Determines the Set Heading to be used if communications are lost to the navigator during a VisionMaster FT-controlled turn in NAV mode: RES HDG – Resume on Heading. The current heading at the time that communications are lost becomes the set heading. COMPL TURN – Complete the Turn. The bearing of the next leg of the turn becomes the set heading. Use this mode on DNV Watch 1 vessels, and on other vessels when required.
WAYPOINT ACK	☐ YES ☐ NO (default)	Sets an alarm when Waypoint control mode course change is >15 degrees.
NAV ACK	☐ YES ☐ NO (default)	Sets an alarm when NAV mode course change is >15 degrees.

Table B-4. Service Setup 2 – SCU Configuration Settings (continued)

Item	*Configuration Setting*	*Function*
NAV STATUS MSG	☐ YES ☐ NO (default)	Standby in non-master status.
NAV STEERING MODE MSG	☐ YES ☐ NO (default)	Selects whether the Nav Steering Mode Message from a Sperry VisionMaster FT is used. If YES is selected, the VisionMaster FT will automatically switch the NAVIPILOT from NAV mode to AUTO mode if a system failure makes NAV mode unavailable (such as loss of the necessary sensor data.)
NAV MSG TIMEOUT	☐ 5 (default) ☐ 10 ☐ 15	Sets the duration at which the Nav Steering Mode Message timeout alarm is triggered, in seconds.
REPEATER INTERFACE:		
REPEATER ENABLED	☐ YES ☐ NO (default)	Enables or disables the Serial Repeater.
BAUD RATE	☐ 4800 (default) ☐ 9600	Determines the Baud Rate output through the Serial Repeater channel.
CENTRAL ALARM INTERFACE		
CENTRAL ALARM PORT	☐ OFF (default) ☐ CAM ONLY ☐ RRB ONLY 38.4	Selects the function of the Central Alarm port: Off Central Alarm Manager (CAM) interface RRB Side Master/Slave interface (38.4k baud rate)
BAUD RATE	☐ 4800 (default) ☐ 9600 ☐ 19.2 K ☐ 38.4 K	If CAM ONLY is selected above, sets the baud rate for the Central Alarm Manager interface.
CENTRAL ALARM INTERFACE ON VMS PORT:		
ECHO TO VMS PORT	☐ YES ☐ NO (default)	Select YES to echo Central Alarm Manager (CAM) messages on the NAV interface port. (VMS is the name of the Sperry chart display and information system previous to VisionMaster FT. For the purpose of this configuration item, the two system names are interchangeable.) This configuration is used when: More than one output of CAM messages is required, or A CAM interface is required, but the Central Alarm Interface is configured for Rudder Repeatback (RRB 38.4) Side Master/Slave interface only.

Table B-4. Service Setup 2 – SCU Configuration Settings (continued)

Item	*Configuration Setting*	*Function*
ANALOG INTERFACE:		
HELM:		
HELM ENABLED	☐ YES ☐ NO (default)	Selects whether a helm analog input is used.
MAXIMUM ANGLE	_____ °.	Sets the maximum helm rudder angle. Range: 20 to 120 degrees. Default: 35 degrees.
MAXIMUM CAL ANGLE	_____ °.	Sets the maximum helm rudder angle. Range: 20 to 35 degrees, in 1 degree increments.
CALIBRATE	PORT HELM ☐ OK PORT HELM ☐ OK PORT HELM ☐ OK ZERO HELM ☐ OK STBD HELM ☐ OK STBD HELM ☐ OK STBD HELM ☐ OK	Sets the points for the 7 point calibration.
FEEDBACK:		
FEEDBACK ENABLED	☐ YES ☐ NO (default)	Enables or disables the rudder repeat-back function.
MAXIMUM ANGLE	_____ °.	Sets the maximum rudder repeat-back angle. Range: 20 to 120 degrees. Default: 35 degrees.
MAXIMUM CAL ANGLE	_____ °.	Sets the maximum helm rudder angle. Range: 20 to 35 degrees, in 1 degree increments.
CALIBRATE	PORT HELM ☐ OK PORT HELM ☐ OK PORT HELM ☐ OK ZERO HELM ☐ OK STBD HELM ☐ OK STBD HELM ☐ OK STBD HELM ☐ OK	Sets the points for the 7 point calibration.
EXTERNAL SYSTEM:		
EXTERNAL ENABLED	☐ YES ☐ NO (default)	Selects whether an external system input is used.
MAXIMUM ANGLE	_____ °.	Sets the maximum external system rudder angle. Range: 20 to 120 degrees. Default: 35 degrees.
POLARITY	☐ STBD POS (default) ☐ PORT POS	Sets the steering gear voltage polarity.

Table B-4. Service Setup 2 – SCU Configuration Settings (continued)

Item	*Configuration Setting*	*Function*
CALIBRATION:		
ZERO EXTERNAL	☐ OK	Calibrates the NAVIPILOT to read the current input from the external system as zero degrees when OK is selected.
EXTERNAL GRADIENT	_____ mV/°.	Sets the voltage scaling of the external system input. Range: 100 to 350 millivolts per degree. Default: 250 mV/°.
FLUXGATE:		
FLUXGATE	☐ YES ☐ NO (default)	Enables or disables fluxgate compass interface. Select YES only when a fluxgate compass is installed and connected using the SCU fluxgate ports.
PORTS:		
MODE PORTS (PINS 49-53):		
PORT 1 NFU	☐ STANDBY ☐ NFU (default)	Assigns the name to be displayed on the CDU when Port 1 is selected. This mode is selected using SCU Pin 49, or by a switch that closes pins 59/60.
PORT 2 FU	☐ NONE ☐ HELM ☐ FU (default) ☐ G/M ☐ 180 OFFSET GYRO 1 ☐ 180 OFFSET GYRO 2 ☐ 180 OFFSET MAG ☐ 180 PORT ☐ 180 STBD ☐ EN JOYSTICK ☐ MUTE	Assigns a function to Port 2 (SCU Pin 50). Normally FU or HELM is selected, and the name displayed on CDU will be either FU or HELM depending on selection. The functions 180 PORT, 180 STBD, and EN JOYSTICK have not yet been implemented in the NAVIPILOT software, and will not function if selected.
PORT 3 AUTO	☐ NONE ☐ AUTO (default) ☐ G/M ☐ 180 OFFSET GYRO 1 ☐ 180 OFFSET GYRO 2 ☐ 180 OFFSET MAG ☐ 180 PORT ☐ 180 STBD ☐ EN JOYSTICK ☐ MUTE	Assigns a function to Port 3 (SCU Pin 51). Normally AUTO is selected, unless the system is main steering only. The functions 180 PORT, 180 STBD, and EN JOYSTICK have not yet been implemented in the NAVIPILOT software, and will not function if selected.

Table B-4. Service Setup 2 – SCU Configuration Settings (continued)

Item	*Configuration Setting*	*Function*
PORT 4 RMT	☐ NONE ☐ REMOTE (default) ☐ G/M ☐ 180 OFFSET GYRO 1 ☐ 180 OFFSET GYRO 2 ☐ 180 OFFSET MAG ☐ 180 PORT ☐ 180 STBD ☐ EN JOYSTICK ☐ MUTE	Assigns a function to Port 4 (SCU Pin 52). Normally REMOTE is selected, if the system includes remote locations. The functions 180 PORT, 180 STBD, and EN JOYSTICK have not yet been implemented in the NAVIPILOT software, and will not function if selected.
EXTERNAL SYSTEM NAME	☐ NONE (default) ☐ DPS ☐ AUTO ☐ BACK_UP ☐ PILOT ☐ TRACK ☐ RADAR ☐ CHART ☐ AUX	Sets the name to be displayed on the CDU when External mode has been selected. When a mechanical mode switch is used, SCU Pins 51 & 52 must be connected to select External mode.
JOYSTICK PORTS (PINS 54-58):		
PORT 1 UP	☐ NONE (default) ☐ JOY UP ☐ G/M ☐ 180 OFFSET GYRO 1 ☐ 180 OFFSET GYRO 2 ☐ 180 OFFSET MAG ☐ 180 PORT ☐ 180 STBD ☐ EN JOYSTICK ☐ MUTE ☐FORCE MASTER	Assigns a function to Joystick Port 1. The functions JOY UP, 180 PORT, 180 STBD, and EN JOYSTICK have not yet been implemented in the NAVIPILOT software, and will not function if selected.
PORT 2 DOWN	☐ NONE (default) ☐ JOY DOWN ☐ G/M ☐ 180 OFFSET GYRO 1 ☐ 180 OFFSET GYRO 2 ☐ 180 OFFSET MAG ☐ 180 PORT ☐ 180 STBD ☐ EN JOYSTICK ☐ MUTE ☐FORCE MASTER	Assigns a function to Joystick Port 2. The functions JOY UP, 180 PORT, 180 STBD, and EN JOYSTICK have not yet been implemented in the NAVIPILOT software, and will not function if selected.

Table B-4. Service Setup 2 – SCU Configuration Settings (continued)

Item	*Configuration Setting*	*Function*
PORT 3 RIGHT	☐ NONE (default) ☐ JOY RIGHT ☐ G/M ☐ 180 OFFSET GYRO 1 ☐ 180 OFFSET GYRO 2 ☐ 180 OFFSET MAG ☐ 180 PORT ☐ 180 STBD ☐ EN JOYSTICK ☐ MUTE ☐FORCE MASTER	Assigns a function to Joystick Port 3. The functions JOY UP, 180 PORT, 180 STBD, and EN JOYSTICK have not yet been implemented in the NAVIPILOT software, and will not function if selected.
PORT 4 LEFT	☐ NONE (default) ☐ JOY LEFT ☐ G/M ☐ 180 OFFSET GYRO 1 ☐ 180 OFFSET GYRO 2 ☐ 180 OFFSET MAG ☐ 180 PORT ☐ 180 STBD ☐ EN JOYSTICK ☐ MUTE ☐FORCE MASTER	Assigns a function to Joystick Port 4. The functions JOY UP, 180 PORT, 180 STBD, and EN JOYSTICK have yet not been implemented in the NAVIPILOT software, and will not function if selected.

Table B-4. Service Setup 2 – SCU Configuration Settings (continued)

Item	*Configuration Setting*	*Function*
OVERRIDE ACTIVE IN:		
OVERRIDE ACTIVE IN	☐ NONE ☐ AUTO/NAV/WPT ☐ EXT SYSTEM ☐ FU SYSTEM ☐ A/N/W/E ☐ A/N/W/FU (default) ☐ A/N/W/E/FU ☐ EXT SYST/FU	For any device which indicates override of steering control via a contact closure at the SCU's OVERRIDE input (pins 32 and 33), the NAVIPILOT will allow override by that device in the configured operating mode(s): None AUTO, NAV, and WAYPOINT EXTERNAL FU (Follow-Up) AUTO, NAV, WAYPOINT, and EXTERNAL AUTO, NAV, WAYPOINT, and FU AUTO, NAV, WAYPOINT, EXTERNAL, and FU EXTERNAL and FU For a Sperry Marine Follow-Up Mini-Wheel (FMW), which indicates override of steering control via the CAN bus: ❑ Override capability must be enabled at the FMW. Otherwise, it cannot override steering control in any mode. ❑ If override capability is enabled at the FMW, the FMW can override steering control in the configured modes, with the exception of FU.
RELAYS:		
RELAY 1 (TB 34-36)	☐ NONE ☐ OFF HDG ALARM ☐ HDG DIFFERENCE ☐ OVERRIDE (default) ☐ DEADMAN CONTACT ☐ EXT SYS ACTIVE ☐ HELM ADVISOR ☐ G/M ADVISOR ☐ MUTE ☐ AUTO (W/ OVR) ☐ NAV MODE ☐ WAYPOINT MODE	Assigns a function to Relay 1.

Table B-4. Service Setup 2 – SCU Configuration Settings (continued)

Item	*Configuration Setting*	*Function*
RELAY 2 (TB 73-75)	☐ NONE ☐ OFF HDG ALARM ☐ HDG DIFFERENCE ☐ OVERRIDE ☐ DEADMAN CONTACT ☐ EXT SYS ACTIVE ☐ HELM ADVISOR ☐ G/M ADVISOR ☐ MUTE ☐ AUTO (W/ OVR) (default) ☐ NAV MODE ☐ WAYPOINT MODE	Assigns a function to Relay 2.
RELAY 3 (TB 76-78)	☐ OFF HDG ALARM	Assigns a function to Relay 3. (Off Heading alarm is always assigned.)
RELAY 4 (TB 82-84)	☐ NONE ☐ OFF HDG ALARM ☐ HDG DIFFERENCE ☐ OVERRIDE ☐ DEADMAN CONTACT (default) ☐ EXT SYS ACTIVE ☐ HELM ADVISOR ☐ G/M ADVISOR ☐ MUTE ☐ AUTO (W/ OVR) ☐ NAV MODE ☐ WAYPOINT MODE	Assigns a function to Relay 4.
STEERING GEAR:		
MAXIMUM RUDDER		
MAX RUD	_____ °.	Sets the maximum rudder angle in NAVIPILOT steering mode. Range: 5 to 120 degrees. Default: 35 degrees. NOTE: Counter Rudder (CR) limit is 45 degrees or the MAX RUD setting, whichever is smaller.
STAGING THRESHOLDS:		
STAGE 1:		
ON	_____ °.	Rudder error at which the solenoid for Stage 1 activates. Range: 0.1 to 7.3 degrees. Default: 0.8 degrees.

Table B-4. Service Setup 2 – SCU Configuration Settings (continued)

Item	*Configuration Setting*	*Function*
OFF	_____°.	Rudder error at which the solenoid for Stage 1 de-activates. Range: 0.0 to 7.2 degrees. Default: 0.5 degrees.
STAGE 2:		
ON	_____°.	Rudder error at which the solenoid for Stage 2 activates. Range: 1.4 to 8.4 degrees. Default: 3.1 degrees.
STAGE 3:		
ON	_____°.	Rudder error at which the solenoid for Stage 3 activates. Range: 2.5 to 9.5 degrees. Default: 5.0 degrees.
STAGE 4:		
ON	_____°.	Rudder error at which the solenoid for Stage 4 activates. Range: 3.6 to 10.6 degrees. Default: 7.0 degrees.
STAGE 5:		
ON	_____°.	Rudder error at which the solenoid for Stage 5 activates. Range: 4.7 to 11.7 degrees. Default: 9.0 degrees.
STAGE 6:		
ON	_____°.	Rudder error at which the solenoid for Stage 6 activates. Range: 5.8 to 12.8 degrees. Default: 11.0 degrees.
STAGE 7:		
ON	_____°.	Rudder error at which the solenoid for Stage 7 activates. Range: 6.9 to 13.9 degrees. Default: 13.0 degrees.
STAGE 8:		
ON	_____°.	Rudder error at which the solenoid for Stage 8 activates. Range: 8.0 to 15.0 degrees. Default: 15.0 degrees.
ANALOG OUTPUT:		
MODE	☐ PRO (default) ☐ PRE	Sets the analog output as proportional to the rudder order (PRO) or as proportional to the rudder error (PRE). PRO is selected in most cases.
TYPE	☐ VOLTAGE (default) ☐CURRENT	

Table B-4. Service Setup 2 – SCU Configuration Settings (continued)

Item		*Configuration Setting*	*Function*
POLARITY	Voltage	☐ STBD POS (default) ☐ PORT POS	Sets the steering gear voltage polarity.
	Current	☐ 20 mA STBD (default) ☐ 20 mA PORT	Sets the steering gear current
CALIBRATION	Voltage	_____ mV/°.	Sets the voltage scaling of the steering gear analog output. Range: 80 to 350 millivolts per degree (PRO); 500 to 2000 mV/° (PRE). Default: 250 mV/° (PRO); 1000 mV/° (PRE).
	Current	_____ °/ 8 mA.	Sets the voltage scaling of the steering gear analog output. Range: 29 to 125 degrees per 8 milliamps (PRO); 5 to 20°/ 8 mA (PRE). Default: 40°/ 8 mA (PRO); 10°/ 8 mA (PRE)
AC SOLENOID BOARD 1:			
PUMP 1:			
SCU 1		☐ STAGE 1 (default) ☐ STAGE 2	Determines which stage of hydraulic flow control for a directional valve is performed by the Pump 1 section of AC solenoid board 1 in SCU 1.
SCU 2		☐ STAGE 1 ☐ STAGE 2 (default)	Determines which stage of hydraulic flow control for a directional valve is performed by the Pump 1 section of AC solenoid board 1 in SCU 2.
STATUS		☐ OFF (default) ☐ PUMP STAT	Determines whether the pump status (Pump On) signal is used by the Pump 1 section of AC solenoid board 1.
PUMP 2:			
SCU 1		☐ OFF ☐ STAGE 1 (default) ☐ STAGE 2 ☐ STAGE 3 ☐ STAGE 4 ☐ DUMP 2 ☐ DUMP 3 ☐ DUMP 4	Determines which stage of hydraulic flow control for a directional or dump valve is performed by the Pump 2 section of AC solenoid board 1 in SCU 1.
SCU 2		☐ OFF ☐ STAGE 1 ☐ STAGE 2 (default) ☐ STAGE 3 ☐ STAGE 4 ☐ DUMP 2 ☐ DUMP 3 ☐ DUMP 4	Determines which stage of hydraulic flow control for a directional or dump valve is performed by the Pump 2 section of AC solenoid board 1 in SCU 2.

Table B-4. Service Setup 2 – SCU Configuration Settings (continued)

Item	*Configuration Setting*	*Function*
STATUS	☐ OFF (default) ☐ PUMP STAT	Determines whether the pump status (Pump On) signal is used by the Pump 2 section of AC solenoid board 1.
AC SOLENOID BOARD 2:		
PUMP 1:		
SCU 1	☐ STAGE 1 (default) ☐ STAGE 2	Determines which stage of hydraulic flow control for a directional valve is performed by the Pump 1 section of AC solenoid board 2 in SCU 1.
SCU 2	☐ STAGE 1 ☐ STAGE 2 (default)	Determines which stage of hydraulic flow control for a directional valve is performed by the Pump 1 section of AC solenoid board 2 in SCU 2.
STATUS	☐ OFF (default) ☐ PUMP STAT	Determines whether the pump status (Pump On) signal is used by the Pump 1 section of AC solenoid board 1.
PUMP 2:		
SCU 1	☐ OFF ☐ STAGE 1 (default) ☐ STAGE 2 ☐ STAGE 3 ☐ STAGE 4 ☐ DUMP 2 ☐ DUMP 3 ☐ DUMP 4	Determines which stage of hydraulic flow control for a directional or dump valve is performed by the Pump 2 section of AC solenoid board 2 in SCU 1.
SCU 2	☐ OFF ☐ STAGE 1 ☐ STAGE 2 (default) ☐ STAGE 3 ☐ STAGE 4 ☐ DUMP 2 ☐ DUMP 3 ☐ DUMP 4	Determines which stage of hydraulic flow control for a directional or dump valve is performed by the Pump 2 section of AC solenoid board 2 in SCU 2.
STATUS	☐ OFF (default) ☐ PUMP STAT	Determines whether the pump status (Pump On) signal is used by the Pump 2 section of AC solenoid board 2.
DC SOLENOID BOARD 1:		
PUMP 1:		
SCU 1	☐ STAGE 1 (default) ☐ STAGE 2	Determines which stage of hydraulic flow control for a directional valve is performed by the Pump 1 section of DC solenoid board 1 in SCU 1.

Table B-4. Service Setup 2 – SCU Configuration Settings (continued)

Item	*Configuration Setting*	*Function*
SCU 2	☐ STAGE 1 ☐ STAGE 2 (default)	Determines which stage of hydraulic flow control for a directional valve is performed by the Pump 1 section of DC solenoid board 1 in SCU 2.
STATUS	☐ OFF (default) ☐ PUMP STAT	Determines whether the pump status (Pump On) signal is used by the Pump 1 section of DC solenoid board 1.
PUMP 2:		
SCU 1	☐ OFF ☐ STAGE 1 (default) ☐ STAGE 2 ☐ STAGE 3 ☐ STAGE 4 ☐ DUMP 2 ☐ DUMP 3 ☐ DUMP 4	Determines which stage of hydraulic flow control for a directional or dump valve is performed by the Pump 2 section of DC solenoid board 1 in SCU 1.
SCU 2	☐ OFF ☐ STAGE 1 ☐ STAGE 2 (default) ☐ STAGE 3 ☐ STAGE 4 ☐ DUMP 2 ☐ DUMP 3 ☐ DUMP 4	Determines which stage of hydraulic flow control for a directional or dump valve is performed by the Pump 2 section of DC solenoid board 1 in SCU 2.
STATUS	☐ OFF (default) ☐ PUMP STAT	Determines whether the pump status (Pump On) signal is used by the Pump 2 section of DC solenoid board 1.
DC SOLENOID BOARD 2:		
PUMP 1:		
SCU 1	☐ STAGE 1 (default) ☐ STAGE 2	Determines which stage of hydraulic flow control for a directional valve is performed by the Pump 1 section of DC solenoid board 2 in SCU 1.
SCU 2	☐ STAGE 1 ☐ STAGE 2 (default)	Determines which stage of hydraulic flow control for a directional valve is performed by the Pump 1 section of DC solenoid board 2 in SCU 2.
STATUS	☐ OFF (default) ☐ PUMP STAT	Determines whether the pump status (Pump On) signal is used by the Pump 1 section of DC solenoid board 2.

Table B-4. Service Setup 2 – SCU Configuration Settings (continued)

Item	*Configuration Setting*	*Function*
SCU 1	☐ OFF ☐ STAGE 1 (default) ☐ STAGE 2 ☐ STAGE 3 ☐ STAGE 4 ☐ DUMP 2 ☐ DUMP 3 ☐ DUMP 4	Determines which stage of hydraulic flow control for a directional or dump valve is performed by the Pump 2 section of DC solenoid board 2 in SCU 1.
PUMP 2:		
SCU 1	☐ OFF ☐ STAGE 1 (default) ☐ STAGE 2 ☐ STAGE 3 ☐ STAGE 4 ☐ DUMP 2 ☐ DUMP 3 ☐ DUMP 4	Determines which stage of hydraulic flow control for a directional or dump valve is performed by the Pump 2 section of DC solenoid board 2 in SCU 1.
SCU 2	☐ OFF ☐ STAGE 1 ☐ STAGE 2 (default) ☐ STAGE 3 ☐ STAGE 4 ☐ DUMP 2 ☐ DUMP 3 ☐ DUMP 4	Determines which stage of hydraulic flow control for a directional or dump valve is performed by the Pump 2 section of DC solenoid board 2 in SCU 2.
STATUS	☐ OFF (default) ☐ PUMP STAT	Determines whether the pump status (Pump On) signal is used by the Pump 2 section of DC solenoid board 2.

Table B-4. Service Setup 2 – SCU Configuration Settings (continued)

Item	*Configuration Setting*	*Function*
SIDE SLAVE RRB (RUDDER REPEATBACK) SOURCE		
SIDE SLAVE RRB SOURCE	☐ OWN (default) ☐ MASTER	For system configurations in which two SCUs control the same rudder, and the digital RRB Side Master/Slave interface between the two SCUs is enabled: Select MASTER at **both** SCUs to enable the Side Master/Slave RRB configuration. The Side Master SCU will use its analog RRB input as its RRB source. The Side Slave will use the digital RRB messages from the Side Master SCU, and ignore its analog RRB input. Select OWN at **both** SCUs to disable the Side Master/Slave RRB configuration. Each SCU will use its analog RRB input as its RRB source, and ignore the digital RRB messages from one SCU to the other. Press the ACCEPT softkey to accept the OWN or MASTER selection; press the CANCEL key to cancel the selection. For system configurations in which a single SCU controls a rudder, the configuration setting has no effect.
HYSTERESIS		
HYSTERESIS	_____ %	Range from 0 to 25%. Default: 2%. Hysteresis adds an additional dynamic dead band for dead band rudder systems to reduce wear. The Hysteresis setting corresponds to a percentage of set dead band. The rudder order will not cross the dead band unless the rudder order computation exceeds the dead band plus the Hysteresis setting times the dead band. A setting of 0% disables the Hysteresis. Example: If the system dead band is set to 2 degrees and the Hysteresis is set to 25%, the Navipilot will not order the rudder to cross the dead band unless the total rudder command is greater than 2.5 degrees in the opposite direction.
ABS OVERRIDE:		
ABS OVERRIDE	☐ NO (default) ☐ YES	Enables or disables ABS Override. If YES is selected, the main helm wheel will override Auto/Nav/Waypoint modes when the wheel is moved from the center position by a configured value for more than two seconds. **NOTE**: ABS Override is normally not enabled unless required by the inspecting agency.

Table B-4. Service Setup 2 – SCU Configuration Settings (continued)

Item	*Configuration Setting*	*Function*
ABS OVER	_____ °.	If YES is selected above, allows input of the setting at which movement of the main helm wheel from the center position will override Auto/Nav/Waypoint modes. Range: 1 to 8 degrees. Default: 5 degrees.
HELM ADVISOR:		
HELM ADVISOR	☐ NONE ☐ AUTO ☐ EXT ☐ BOTH	Sets the Helm Advisor function. If enabled, an alarm is generated if the main helm wheel is moved from the zero position while in an automatic steering mode, an external steering mode, or both. **NOTE**: Helm Advisor should not be enabled if ABS override is enabled.
SERVICE INTERFACE:		
BAUD RATE	☐ 2400 ☐ 4800 ☐ 9600 (default) ☐ 19200	Sets the Baud Rate for the service interface.
DATA WIDTH	☐ 7 ☐ 8 (default)	Sets the Data Width for the service interface (future enhancement).
PARITY	☐ NONE (default) ☐ EVEN ☐ ODD	Sets the Parity for the service interface.
STOP BITS	☐ 1 (default) ☐ 2	Sets the Stop Bits for the service interface (future enhancement).
CAN INTERFACE:		
BAUD RATE	☐ 250K (default)	Sets the CAN baud rate.
MAIN MODE SWITCH:		
MODE SWITCH	☐ NONE ☐ MMS (default) ☐ SMS	Selects the type of main mode selection switch installed: MMS = Mechanical Mode Switch SMS = Steering Mode Selector (a Bus Interface Unit)
ALARM CONDITIONS:		
DEADMAN ALARM TIMEOUT	☐ DISABLE (default) ☐ ENABLE	Enables or disables alarm for no operator response.
DEAD TIME	_____ sec.	If ENABLE is selected above, allows input of the duration after which a Deadman alarm will occur. Range: 1 to 253 seconds. Default: 5 seconds

Table B-4. Service Setup 2 – SCU Configuration Settings (continued)

Item	*Configuration Setting*	*Function*
OFF HEADING ALARM DISABLE	☐ YES ☐ NO (default)	When YES is selected, the operator menu for OFF HEADING LIMIT allows selection of OFF as an option. When OFF is selected from that menu, the Off Heading alarm is disabled. When NO is selected, the OFF HEADING LIMIT operator menu does not allow the operator to disable the Off Heading alarm.
OFF HEADING DELAY	_____ sec.	Sets the delay time for the external Off Heading alarm. Range: 0 to 40 seconds. Default: 1 second.
MINIMUM SPEED	_____ kn.	Sets the minimum speed attainable without an alarm. Range: 1 to 10 knots. Default: 2 knots.
MAXIMUM SPEED	_____ kn.	Sets the maximum speed attainable without an alarm. Range: 1 to 99 knots. Default: 40 knots.
OVERRIDE ALARM	☐ NONE ☐ FMW ☐ EXT ☐ FMW+EXT (default)	Sets the conditions under which an alarm is generated if steering control is overridden by a Follow-Up Mini-Wheel or other external device: None Override by Follow-up Mini-Wheel Override by other external device, as indicated by a contact-closure at the SCU's OVERRIDE input (pins 32 and 33). Override by Follow-up Mini-Wheel or other external device

Table B-5. Service Setup 2 – CDU Configuration Settings

Item	*Configuration Setting*	*Function*
LOCATION:		
LOCATION	☐ 4: MAIN (default) ☐ 5: PORT WING ☐ 6: STBD WING ☐ 7: NAVSTATION ☐ 8: HELMSMAN STATION ☐ 9: MANEUVERING STATION ☐ 10: AFT BRIDGE ☐ 11: FORWARD BRIDGE ☐ 12: EMERGENCY STATION ☐ 13: FLY BRIDGE ☐ 14: PORT FLYBRIDGE ☐ 15: STBD FLYBRIDGE ☐ _____ [16 thru 31]	Identifies the control location associated with the device.
NAME:		
NAME	☐ 4: MAIN (default) ☐ 5: PORT WING ☐ 6: STBD WING ☐ 7: NAVSTATION ☐ 8: HELMSMAN STATION ☐ 9: MANEUVERING STATION ☐ 10: AFT BRIDGE ☐ 11: FORWARD BRIDGE ☐ 12: EMERGENCY STATION ☐ 13: FLY BRIDGE ☐ 14: PORT FLYBRIDGE ☐ 15: STBD FLYBRIDGE ☐ _____ [16 thru 255]	Identifies the display title associated with the device.
AUDIBLE OVERRIDE:		
OVERRIDE	☐ ALL ☐ A/N/W (default)	Beeps when an override condition occurs.
TENTH TIMEOUT:		
TENTH TIME	_____ sec.	Sets the duration of time following the last Set Heading change. Range: 10 to 60 seconds. Default: 10 seconds.

Table B-5. Service Setup 2 – CDU Configuration Settings (continued)

Item	*Configuration Setting*	*Function*
TAKEOVER METHOD:		
TAKEOVER METHOD	☐ NONE (default) ☐ CALL UP ☐ TAKEOVER	Sets the control acquisition method for the station. Refer to chapter 3.
AUDIBLE TAKEOVER:		
AUD TAKEOVER	☐ YES (default) ☐ NO	Determines if a beep is sounded when the station takes control.
AUDIBLE BUTTON:		
AUD BUTTON	☐ YES (default) ☐ NO	Determines if beep is sounded when a button is pressed.
SERVICE INTERFACE:		
BAUD RATE	☐ 2400 ☐ 4800 (default) ☐ 9600 ☐ 19200	Sets the Baud Rate for the diagnostic serial port. (This value should be set to 4800, or a Missing Key alarm will be issued.)
DATA BITS	☐ 7 BITS ☐ 8 BITS (default)	Sets the Data Width for the diagnostic serial port (future enhancement).
PARITY BITS	☐ NO PARITY (default) ☐ EVEN ☐ ODD	Sets the Parity Bits for the diagnostic serial port.
STOP BITS	☐ 1 BIT (default) ☐ 2 BITS	Sets the number of Stop Bits for the diagnostic serial port (future enhancement).
CAN INTERFACE:		
BAUD RATE	☐ 250K (default)	Sets the Baud Rate on the NAVINET 4000 HSC Steering Control Network bus for the unit.
KEYPAD CALIBRATION		
KEYPAD CAL	_____	Sets the CDU keypad backlighting to a level which does no interfere with night vision. Brightness is adjusted after 'Dim-' key on the CDU front panel is adjusted to dim down to the absolute minimum and up and down arrow keys are used to adjust the keypad calibration until the keypad backlight is barely visible. Range: 0 to 10.

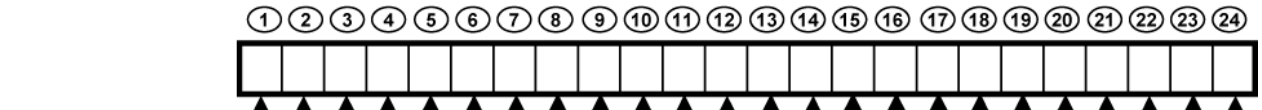
Table B-6. Service Setup 2 – SYS Configuration Settings

Item	*Configuration Setting*	*Function*
SYSTEM	☐ CR AUTO TUNE ON (default) ☐ CR AUTO TUNE OFF	Enables or disables the NAVIPILOT's CR Self-Tuning feature (see Chapter 3, section 3.20): CR AUTO TUNE ON - CR Self-Tuning is disabled. CR AUTO TUNE OFF – CR Self-Tuning feature is enabled.

B.5 SYSTEM CONFIGURATION

A number of important system characteristics are not configured via the service setup menus. Use Figure B-2 to record this information. The row of data entered becomes the System ID number, which is a useful record to assist with analysis if a problem is reported. It is recommended that the vessel keep a copy of the System ID number, and for the installing engineer to record the number to be kept with records of the installation.

Date:		Ship Name:		Installer:	



1. Total No. of SCUs
2. No. of Port SCUs
3. No. of Stbd SCUs
4. No. of DC Solenoid Interface Cards
5. No. of AC Solenoid Interface Cards
6. No. of Isolated Proportional Output Interface Cards
7. Master/Slave Configuration (see Note 1)
8. Independent DRS? (Y = yes; N = no)
9. Mode Switch Type (0 = none; 1 = Mechanical Mode Switch [MMS]; 2 = Steering Mode Selector [SMS])
10. Mode Switch Choices – Standby (NFU) (S = Mode Available; X = Mode Not Available)
11. Mode Switch Choices – Helm (Hand/FU) (H = Mode Available; X = Mode Not Available)
12. Mode Switch Choices – Auto (A = Mode Available; X = Mode Not Available)
13. Mode Switch Choices – Remote (R = Mode Available; X = Mode Not Available)
14. Mode Switch Choices – External (E = Mode Available; X = Mode Not Available)
15. Analog Helm? (Y = yes; N = no)
16. No. of Follow-Up Mini-Wheels (FMW) at Main
17. No. of CDUs at Main
18. Modes Available at CDU (see Note 2)
19. Total No. of Remote Locations
20. No. of Remote Locations With CDU
21. External Override? (Y = yes; N = no)
22. ABS Override? (Y = yes; N = no)
23. External System? (Y = yes; N = no)
24. Software Revision Letter

NOTES:

1. For Master/Slave Configuration, enter one of the following codes:
   - N1 - Only one SCU is powered on and on its own CAN bus, with no other SCU's connected
   - Y2 - Two SCUs on the same CAN bus are normally powered on at the same time, with master/slave relationship
   - Y3 - Three SCUs on the same CAN bus are normally powered on at the same time, with master/slave relationship
   - Y4 - Four SCUs on the same CAN bus are normally powered on at the same time, with master/slave relationship

2. For Modes Available at CDU, enter one of the following codes:
   - A – AUTO, NAV, and WAYPOINT
   - U – AUTO only
   - N – AUTO and NAV
   - T – AUTO and WAYPOINT

   NAV mode requires connection to Sperry VisionMaster FT. WAYPOINT mode requires connection to a compatible chart system or GPS.

Figure B-2. System ID Number

APPENDIX C
SERVICE SETUP CONSIDERATIONS – TUNING
(NAVIPILOT 4000 / NAVIPILOT 4000 TRACK)

C.1 INTRODUCTION

The NAVIPILOT 4000/NAVIPILOT 4000 TRACK must be properly tuned in order to steer the ship effectively and efficiently. Tuning procedures are described in section 2.20 of this manual. However, before the NAVIPILOT can be successfully tuned, the Service Setup parameters for the specific application must be configured correctly, as described in Appendix A. The following setup parameters are particularly critical to successful tuning:

- **Ship's Time Constant (Tau)** – Time (in seconds) that it takes the vessel to sail its own length (length at waterline) at its service speed.
- **Rudder Gain (RG).** Sensitivity of the NAVIPILOT's response to heading errors. RG is also referred to as Proportional Gain, because it generates rudder orders proportional to the heading error. Increasing the RG value increases the sensitivity.
- **Counter Rudder (CR)**. Sensitivity of the NAVIPILOT's response to turn rate. CR is also referred to as Rate Gain, because it generates rudder order in direct response to the turn rate of the ship. Increasing the CR value increases the amount of counter rudder, and hence reduces the tendency for the ship to overshoot the desired heading.

The tuning process does not affect the Tau value. **Therefore, before tuning is performed, it is critical that the Tau value be set accurately, based on vessel length at the waterline and service speed.** Filtering and timing within the NAVIPILOT is speed-scaled from the Tau value. If the Tau value is not accurate, it will be difficult or impossible to achieve good performance.

RG and CR are adjusted during the tuning process to their proper values. However, it is important to consider the following:

- The tuning process is facilitated by initial RG and CR settings which are appropriate for the vessel. When appropriate values are used, initial overshoot/undershoot is reduced, the time required for tuning is reduced, and the quality of the tuning level achieved may be significantly improved.
- If Tuning is reset, RG and CR will be reset to the initial values entered in the Service Setup menus. If the initial RG and CR values are not appropriate, the NAVIPILOT may be unable to steer the ship effectively.

This Appendix contains instructions for calculating Tau, and for selecting the appropriate default values for RG and CR.

C.2 CALCULATING TAU

The value of Tau is entered using the SERVICE SETUP 1 menu, as described in Appendix A. Calculate the value of Tau as follows:

$$\text{Tau (seconds)} = \frac{\text{Ship Length (meters)}}{\text{Service Speed (knots)}} \times 1.94$$

or

$$\text{Tau (seconds)} = \frac{\text{Ship Length (feet)}}{\text{Service Speed (knots)}} \times 0.592$$

Length is ship length between perpendiculars (Lpp), or design waterline length. Service speed is the typical

operating speed of the vessel. Calculated Tau will range from low values (4 or less) for small vessels with high service speeds, to high values (36 or more) for large super-tankers with relatively low service speeds.

Figure C-1 is a nomogram illustrating the Tau formula. In the example shown in Figure C-1:

Vessel length between perpendiculars = 225 meters

Vessel service speed = 18 knots

$$\text{Tau (seconds)} = \frac{225}{18} \times 1.94 = 24.25 \approx 24 \text{ seconds}$$

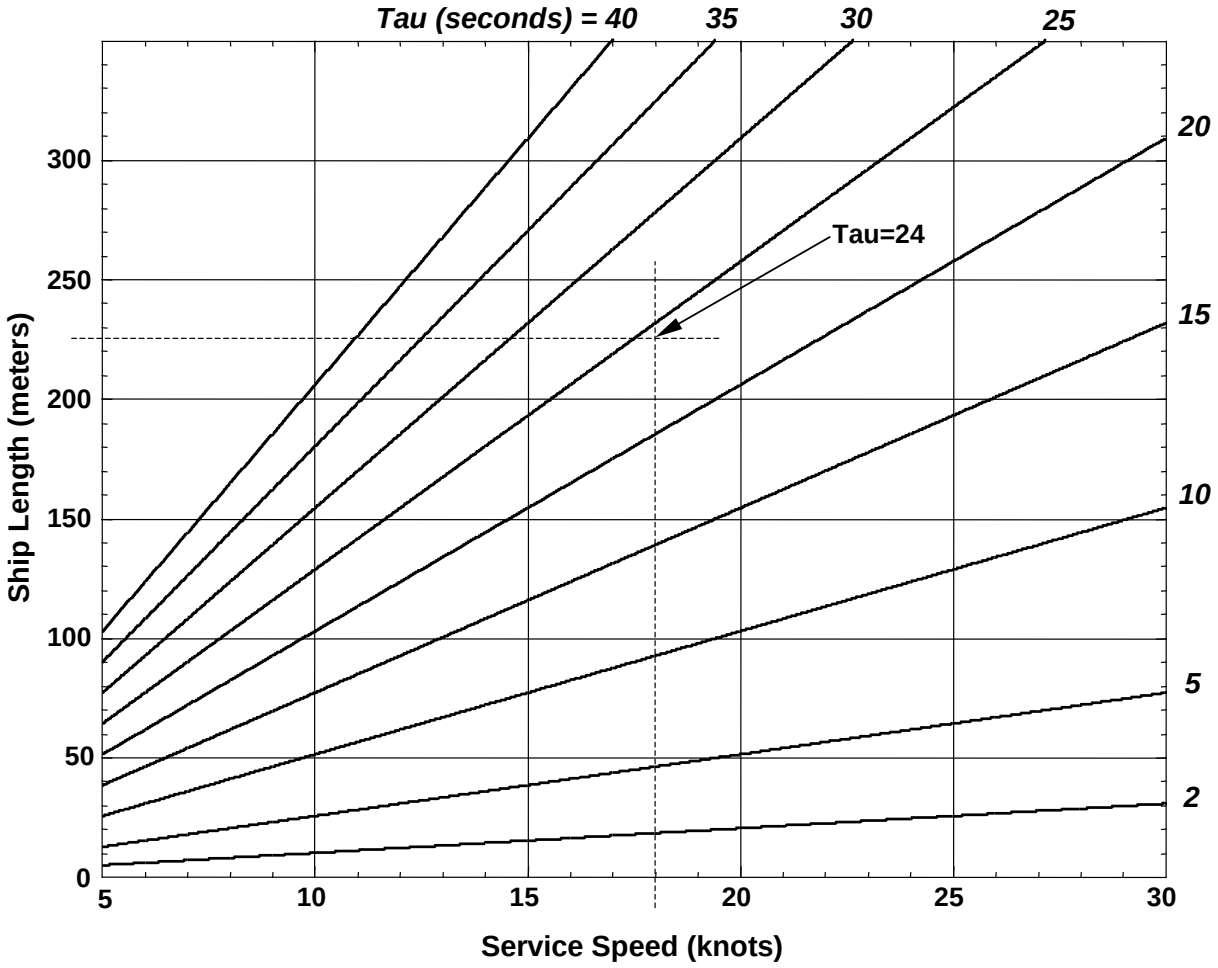


Figure C-1. ***Tau Formula Nomogram***

Also note that the appropriate value of Tau must be input for each of the NAVIPILOT's operator-selectable loading conditions. For Adaptive Self-Tuning operation, two separate tunings are maintained: *Light* (for use when the ship is lightly loaded), and *Loaded* (for use when the ship is heavily loaded). For Manual Tuning operation, three separate tunings are maintained: *Light*, *Medium*, and *Loaded*. For each loading condition, a different Tau value may be entered in the SERVICE SETUP Menu. **Normally, Tau should be set to the same value for all load conditions.** The exception is the case of Notch Tugs, where two Tau settings can be used for the two operating conditions of the vessel: (1) When the Notch Tug is operating as an unattached tugboat (in which case the ship length is short, producing a small Tau), and (2) When the Notch Tug is docked into a ship-shaped hull (producing a much longer ship length, and thus a large Tau).

C.3 SELECTING INITIAL VALUES FOR RUDDER GAIN (RG) AND COUNTER RUDDER (CR)

The initial values of Rudder Gain (RG) and Counter Rudder (CR) are entered using the SERVICE SETUP 1 Menu, as described in Appendixes A and B. These values are retained in memory, and are the initial RG and CR values for the Adaptive Self-Tuning procedure when the user selects RESET TUNING. The current RG and CR may differ from the initial values, due to adjustments made during Adaptive Self-Tuning, or due to adjustments made manually. *Note: the initial RG and CR values have no consequence when Adaptive Self-Tuning is NOT enabled.*

Before performing an initial tuning sequence, the initial RG and CR values should be set as follows:

RG - Normal configurations	**1.4**
RG - High-lift rudder configurations	**0.7**
CR	**1.0**

Normally, the initial values will require no further changes. The user may select manual tuning if it becomes necessary to modify the RG and/or CR values in use. This will not change the stored initial values for RG and CR.

The RG and CR settings shown above work well for most vessels. However, there may be special cases for which these initial values do not result in acceptable tuning. In such a case, manually tune to determine the best final tune settings for the vessel and for the vessel's loading condition. If the manual tuning indicates that the appropriate RG and CR values are significantly different from the default values shown above, request that Sperry Field Service update the initial values of RG and CR in the Service Setup menus accordingly. Thereafter, allow Adaptive Self-Tuning to continue to adjust to loading changes over time and usage.

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APPENDIX D
SERVICE SETUP CONSIDERATIONS – TUNING
(NAVIPILOT 4000 HSC / NAVIPILOT 4000 TRACK HSC)

D.1 INTRODUCTION

The NAVIPILOT 4000 HSC / NAVIPILOT 4000 TRACK HSC must be properly tuned in order to steer the ship effectively and efficiently. Tuning procedures are described in section 3.20 of this manual. However, before the NAVIPILOT can be successfully tuned, the Service Setup parameters for the specific application must be configured correctly, as described in Appendix B. The following setup parameters are particularly critical to successful tuning:

- **Ship's Time Constant (Tau)** – Time (in seconds) that it takes the vessel to sail its own length (length at waterline) at its service speed.
- **Rudder Gain (RG)** – Sensitivity of the NAVIPILOT's response to heading errors. RG is also referred to as Proportional Gain, because it generates rudder orders proportional to the heading error. Increasing the RG value increases the sensitivity.
- **Counter Rudder (CR)** – Sensitivity of the NAVIPILOT's response to turn rate. CR is also referred to as Rate Gain, because it generates rudder order in direct response to the turn rate of the ship. Increasing the CR value increases the amount of counter rudder, and hence reduces the tendency for the ship to overshoot the desired heading.
- **Relative Integration Time Constant (RITC)** – Sensitivity factor on the heading bias integrator. Initial setting should be 100% which is to then be tuned at sea for its proper speed of response for increasing weather helm (steady state rudder order) to eliminate long term heading bias. Smaller RITC slows the rate of integration, while larger RITC speeds the rate of integration. An RITC which is too large causes low frequency heading oscillation around set heading, while an RITC which is too small causes a very slow elimination of long term heading bias. This is a very important value to get at least approximately accurate.
- **Dead Band Compensation (Dead Band)** – Compensation for the steering dead zone effect of water jets. If this value is too small then excessive heading wander will result, and if too large then excessive back and forth water jet steering actuation results.
- **Hysteresis** – This setting is included in order to prevent the steering jet angle activity from excessively going back and forth across the Dead Band in order to maintain an approximate zero steering angle effect. The Hysteresis inhibits the steering jet angle command from jumping across the band until the steering angle reaches a value of the Hysteresis (as a % of Dead Band) on the other side of the Dead Band.

An HSC vessel has various regimes of steering which can require different autopilot tuning values. Typical variations are load conditions, high speed planeing vs. low speed non-planeing, speed variation while on-plane, powering variation (such as 2 jets powered vs 4 jets but at similar speed), variations of desired heading control accuracy in confined water vs. open sea, and possibly some variations with sea conditions.

To aid the operator with adapting the Navipilot for the relevant operational variations of his vessel, the following features are incorporated for his use:

- Ten operator selectable and changeable gain sets for storing these sets of RG and CR which have been determined appropriate for specific variations of operation, and
- CR automatic self-tuning, which the operator can selectively choose as automatic or manual. When automatic, it aids in tuning to a value for achieving the operator set turn rate/turn radius.

This Appendix contains the instructions for calculating Tau, and for selecting the appropriate initial values for RG, CR, Dead Band, and RITC.

D.2 CALCULATING TAU

The value of Tau is entered using the SERVICE SETUP 1 menu, as described in Appendix B. Calculate the value of Tau as follows:

$$\text{Tau (seconds)} = \frac{\text{Ship Length (meters)}}{\text{Service Speed (knots)}} \times 1.94$$

or

$$\text{Tau (seconds)} = \frac{\text{Ship Length (feet)}}{\text{Service Speed (knots)}} \times 0.592$$

Length is ship length between perpendiculars (Lpp), or design waterline length. Service speed is the typical operating speed of the vessel. Calculated Tau will range from low values (4 or less) for small vessels with high service speeds, to high values (36 or more) for large super-tankers with relatively low service speeds.

Figure D-1 is a nomogram illustrating the Tau formula. In the example shown in Figure D-1:

Vessel length between perpendiculars = 60 meters

Vessel service speed = 42 knots

$$\text{Tau (seconds)} = \frac{60}{42} \times 1.94 = 2.8 \text{ seconds}$$

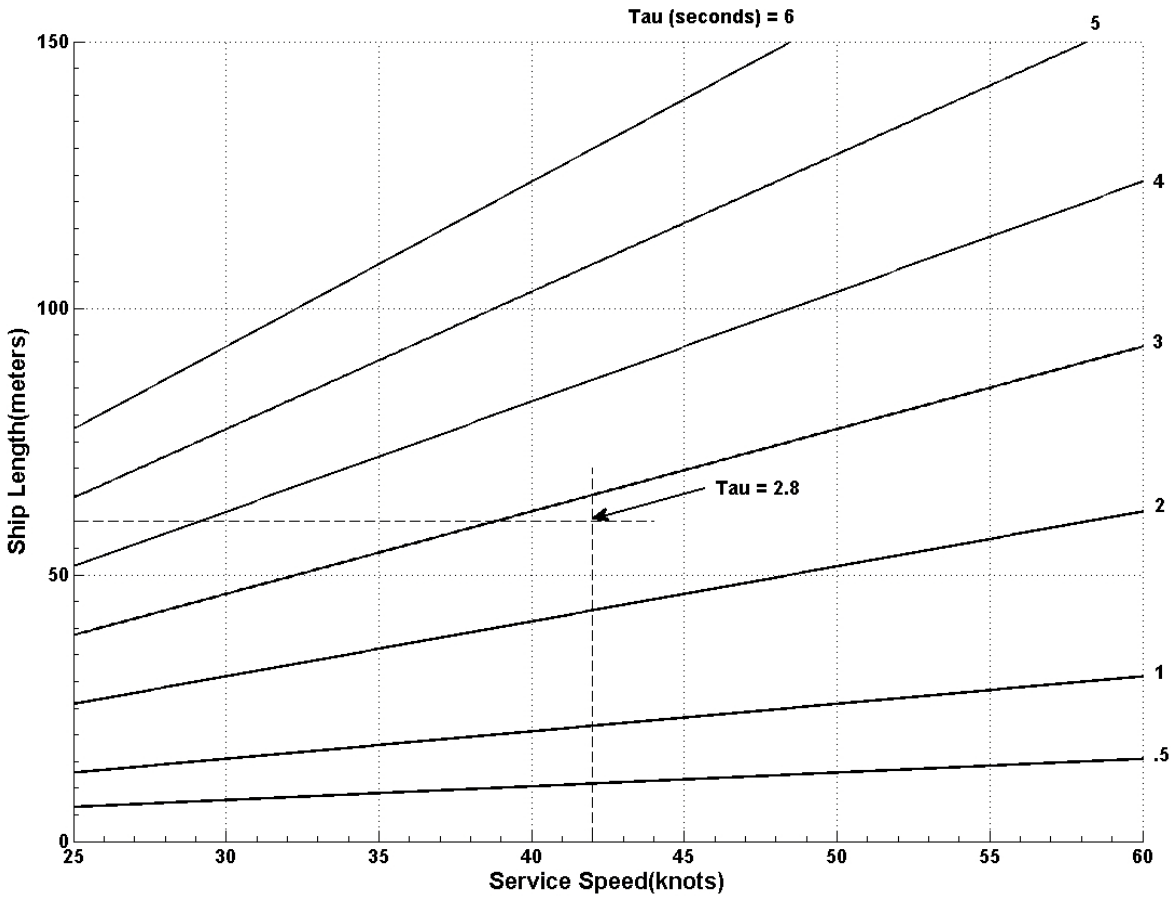

Figure D-1. Tau Formula Nomogram

APPENDIX E
ACRONYMS AND ABBREVIATIONS

ABS	American Bureau of Shipping
AC	Alternating Current
ACT HDG	Actual Heading
AD	Adaptive
ADG	Adaptive Digital Gyropilot
A/N/W	Auto/Nav/Waypoint
A/N/W/E	Auto/Nav/Waypoint/External
AUTO	Automatic
Aux	Auxiliary
BEAR	Bearing
BIAS	Rudder Order Bias
BIU	Bus Interface Unit
BPS	Bits Per Second
CAGE	Commercial and Government Entity
CAL	Calibration
CAN	Controller Area Network
CDU	Control and Display Unit
CHG	Change
CIU	CAN Interface Unit
COMP MAN	Complete Maneuver
CR	Counter Rudder
CRS	Course
DC	Direct Current
DEG	Degree
DISP OPT	Display Option
DNV	Det Norske Veritas
DPS	Dynamic Positioning System
DRS	Dual Rudder Sync Selector
E	East
ECDIS	Electronic Chart Display and Information System
EMF	Electromotive Force
En	Enable
Err	Error
Ext	External
FID	Follow-Up Interface/Display Unit
FU	Follow-Up
FMW	Follow-Up Mini-Wheel/Display Unit
G/M	Gyro/Magnetic
GPS	Global Positioning System
HCS	Heading Control System
HDG	Heading
HDG DIFF	Heading Difference
HSC	Heading to Steer Command
HSC	High Speed Craft
HTC	Heading To Complete
HTD	Heading Track Control Data
IMO	International Maritime Organization
INF	Seaway Influence
INIT	Initialization
IO	Input Output
Kn	Knot
Kbps	Kilobits Per Second
L	Log
LCD	Liquid Crystal Display
LIM	Limit
LVL	Tune Level
MAG	Magnetic
MAG VAR	Magnetic Variation
MIN	Minute
MMS	Mechanical Mode Switch
MOSFET	Metal Oxide Semiconductor Field-Effect Transistor
MSG	Message
MSU	Manual Steering Unit
NAD	Network Address

NAV	Navigation
NC	Normally Closed
NFU	Non Follow-Up
NM	Nautical Mile
NMEA	National Marine Electronics Association
NO	Normally Open
Ord	Order
PCB	Printed Circuit Board
PID	Proportional Integral Derivative
PRE	Proportional to Rudder Error
PRO	Proportional to Rudder Order
PROM	Programmable Read Only Memory
PROP	Proportional
PROP-HTC	Proprietary Heading-To-Complete
RAD ORD	Radius Order
RAM	Random Access Memory
RG	Rudder Gain
RITC	Relative Integration Time Constant
RRB	Rudder Repeatback
RSA	Rudder Sensor Angle
RUD	Rudder
RUD ANG	Rudder Angle
RUD LIM	Rudder Limit
RUD ORD	Rudder Order
SAM	Steering Alarm Module
SCR	Silicon-Controlled Rectifier
SCU	Steering Control Unit
SEC	Second
SMS	Steering Mode Selector
SMN/NFU	Steering Mode Selector/ Non-Followup Tiller
SOG	Speed Over Ground
SPD	Speed
SPST	Single-Pole, Single-Throw
SRC	Source
Stat	Status
SPS	Steering Position Selector
Stbd	Starboard
STW	Speed Through Water
SYNC	Synchronize
TRK	Track
VAC	Volts Alternating Current
VDC	Volts Direct Current
VDR	Voyage Data Recorder
VMFT	VisionMaster FT
VMS	Voyage Management System
W	West
WCU	Wheel Control Unit
WPT	Waypoint
XT	Cross Track
XTE	Cross Track Error