MicroCommander 9110X Installation, Operation and Troubleshooting Manual

MM9110-I Rev D.1 4/08

0 PREFACE

IMPORTANT: It is important to keep this Manual in a safe place for future reference. The manual contains answers to questions that may arise during operation or installation of the ZF Marine Electronics Control System and its options.

0-1 MicroCommander 9110X Series Processor

Table 1: MicroCommander 9110X

ZF Marine Electronics Processor Part No.	ENGINE	CLUTCH	REMOTE STATIONS	Optional TROLL (9001 Actuator)
9110X	Servo 2	Servo 1	X = No. of Pigtails	Servo 3

This manual is intended for use with the above Processors.

0-2 Conventional Symbols Used in the Manual

Throughout this manual special attention should be paid to the following:

NOTE: Contains helpful information

IMPORTANT: Contains helpful information.

CAUTION: Damage to the equipment may occur if these messages are not followed.

WARNING: Personal injury may result if these messages are not followed.

0-3 Important Information

WARNING: Personal Injury could occur if the following steps are not followed exactly.

CAUTION:

1. On MicroCommander systems utilizing more than one 585, 585CE, or 9110 Model Processors, ZF Marine Electronics highly recommends that ALL UNITS be upgraded to the latest Model 9110 Processor.
2. If you are planning to use the High/ Low Idle feature or Clutch Oil Pressure Interlock, Synchronization or Trolling options, DO NOT attempt to operate a 585 or 585CE Processor with the Model 9110 Processor.
3. Timing to engage control function (Button push, momentary hold for 2 seconds) is far different from older models.

CAUTION: On Control Systems utilizing more than one Processor, ZF Marine Electronics highly recommends that ALL UNITS be upgraded to the most current Processor.

CAUTION: Electro-static discharge can damage this equipment. Personnel working on this equipment must be grounded to the chassis with the Anti-static Wrist Strap provided.

CAUTION: Disconnect the Power Harness from the Power Pigtail whenever welding is being done on the vessel. Failure to do so can cause permanent damage.

CAUTION: This equipment is designed to work with other ZF Marine Electronics designed equipment. DO NOT operate this equipment with any other manufacturers equipment unless approved so in writing by ZF Marine Electronics Engineering Department.

This manual is written describing all possible options available for this Processor. Your vessel may not require all of these options. Refer to the System Drawing in Appendix C for specifics on what your vessel requires. Refer

only to the Sections that apply to your vessel. If you wish to use one of the available options listed, please contact a ZF Marine Electronics Representative for futher information.

SW15623.0

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REVISIONS LIST

Revision	Date	Revision Description
A	11/03	1. Preface-1 added last paragraph regarding hard-wiring per ELR 1099. 2. Section 4-3.2.2 Fig 4-3 revised per ELR 1099 to 5 amperes. 3. Section 8.1 Fig 8-1 & 8-2 revised per ELR 1099 to 0.5 amperes. CAUTION revised to 0.5 amperes and 100 volts.
B	4/04	Revised to new modular style.
C	2/05	1. Revised Company Name to "ZF Marine Electronics, LLC" 2. Updated all forms to current levels. 3. Corrected Cross-Referencing. 4. Added Language cross-referencing.
D	8/06	1. Revising to current modular and formatting. 2. Removed Battery Maintenance. 3. Added Engine Stop Switch Warning to Operation Section 4. Corrected Push-Pull Cable Instruction 5. Revised Control Head Pigtail Connections 6. Updated Appendix A Forms
D1	4/08	1. Replaced Forms: MMC123 FASSC List (North America and MMC172-FASSC List (International). 2. Replaced MMC-165 - Warranty Policy with currect Rev F, 6/07

1 INTRODUCTION

This manual is written to document every possible system option. Your system may not include every available option for single or multi-screw reverse reduction gear applications. Only those sections that apply to your specific installation are relevant to your vessel.

If additional options described within this manual are desired, contact your dealer for availability/compatibility with your system.

1-1 Manual Contents

This manual is divided into 12 Sections which cover, in detail, the features and operation of your system:

- Introduction (Section 1)
- Operation (Section 2)
- Plan the Installation (Section 3)
- Installation (Section 4)
- Set Up Procedures (Section 5)
- Dock Trials (Section 6)
- Sea Trials (Section 7)
- Control Options (Section 8)
- Periodic Checks and Maintenance (Section 9)
- ZF Marine Electronics Service Sheets (Appendix A)
- Troubleshooting (Appendix B)
- System Drawings (Appendix C)

1-2 Basic Theory of Operation

The MicroCommander Marine Propulsion Control System (hereafter referred to as MicroCommander or System) is designed for pleasure and light commercial marine vessels that require remote control of mechanically actuated engines and reverse reduction gears.

The System is electronic and requires a 12 or 24 VDC power supply, one Processor per engine/gear and one Control Head per remote station.

The MicroCommander commands the vessel's throttle and shift using a single Control Head lever.

The Processor is typically mounted in the engine room area and is connected mechanically to the vessel's main engine throttle and transmission with standard 33C type push-pull cables.

One wire harness/electric cable per Control Head lever connects the remote station(s) to the Processor(s). Only one remote station will have command at a given time and the Station-in-Command is indicated by a red light located on the Control Head. Station transfer is accomplished by pressing the Control Head mounted transfer button.

1-2.1 9110X Processor (Throttle - Servo, Shift - Servo, X = Number of Remote Station Pigtails)

The System is designed for pleasure and light commercial marine vessels that require remote control of:

- servo engine governors
- servo activated clutches

1-3 System Features

1-3.1 Standard Processor Features

Further information regarding the following features can be found in Section 2 - OPERATION.

- Sequencing of Clutch and Engine Speed.
- Station-in-Command indication.
- Up to five Remote Stations.
- Command of up to five screws.
- Single Control Head lever command of speed and direction.
- Start Interlock.
- Push Button Station Transfer.
- Proportional (Reversal) Pause on through Neutral Shifts.
- Warm-up Mode.

- High/Low Idle Selection.
- One Lever Mode.
- Engine Synchronization.

Further information regarding the following features can be found in Section 5 - SET UP PROCEDURES.

- Easily configured to a vessel's control requirements.
- Push Button Set Up.
- Pluggable Connections.

Further information regarding the following feature can be found in Appendix B4 - DIAGNOSTIC MENU.

- Visual system diagnostics, set up, and status indication.

Further information regarding the following feature can be found in Appendix B5 - AUDIBLE TONES.

- Audible system diagnostics and status indications.

1-3.2 Optional Processor Features

Further information regarding each optional feature can be found in Section 2 - OPERATION "Optional Features".

- System failure external alarm contact.
- Clutch pressure interlock.
- Multiple Screw Installations.
- Station Expander (SE).
- 9001 Trolling Valve Control

2 OPERATION

2-1 DC Power On

When DC power is turned ON to the Processor:

- A short steady tone, followed by an intermittent tone, will sound at all Remote Stations indicating that no station has command.
- The Start Interlock relay contact will remain open, preventing engine start.
- Throttle:
  Servo: The throttle servo will drive to Idle.
- Shift:
  Servo: The Shift servo will drive to Neutral.

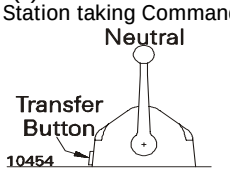
2-2 Taking Command

The Processor has zero (0) to five (5) Remote Station Pigtail connectors available for pluggable Remote Station Control Head connection. If more Remote Stations are required, refer to Section 8 - CONTROL OPTIONS "Station Expander".

To take command at any one of the Remote Stations:

- Ensure all Control Head's lever(s) at the Station are in the Neutral detent (vertical position).

Figure 1: Station taking Command



- Depress the transfer button for 1/2 second.

The Slow Repetitive tone will stop at all Stations, and the red LED indicator light will turn ON at the Control Head of the Station that had assumed command of the Control System.

NOTE: If Start Interlock is used: Once a Station is in command the Start Interlock relay contact will close, allowing the engine to start.

NOTE: Only one Station can have command at a time.

The Operator is now in control of the vessel's propulsion system.

WARNING: An Engine STOP Switch MUST be installed at every remote operating station. Refer to CFR 46, Section 62.35-5 (US Coast Guard) and ABYC P-24.5.8.

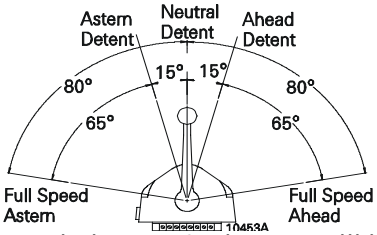
2-3 Basic Operation

2-3.1 Normal Operating Mode

A) The Control Head has three detents; Ahead, Astern and Neutral.

B) With the Control Head lever positioned in the Neutral (vertical) detent, the Processor will command Neutral and the throttle at Idle revolutions per minute (RPM).

Figure 2: Control Head Detents



C) Movement of the Control Head's lever 15 degrees to the Ahead or Astern detent will command Ahead or Astern clutch engagement, while the engine RPM remains at Idle.

D) Further movement of the Control Head lever through the next 65 degrees, will increase the engine RPM in proportion to the Control Head's lever position.

2-4 Start Interlock

The engine start signal is blocked unless all of the following are true:

- DC power has been turned ON to the Control System.
- A Remote Station is in command.
- The Control System is commanding Neutral.

2-5 Station Transfer

WARNING: Personal Injury could occur if the following steps are not followed exactly.

Command can be transferred as follows:

A) The Station-in-Command's lever(s) may be left in any position.

B) Place the Control Head's lever(s) of the receiving Station in the Neutral/Idle detent position (refer to Figure 3:).

Figure 3: Remote Stations Before Transfer of Command

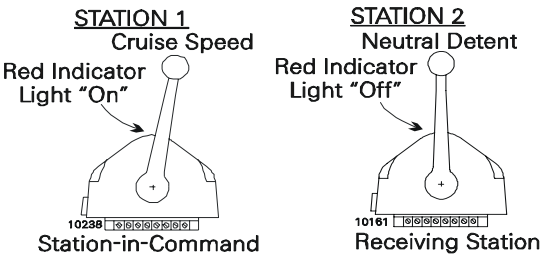
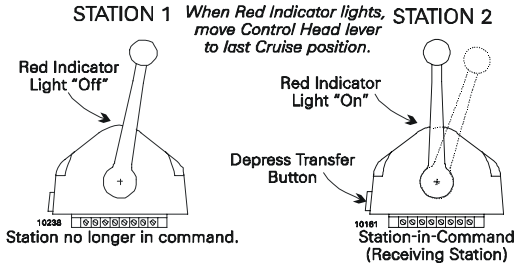


Figure 4: Remote Station Transfer after Transfer of Command



C) At the Station taking command (Receiving Station), depress and hold the transfer button for 1/2 second (refer to Figure 4:).

- The red LED indicator light at the receiving Station's Control Head will illuminate, indicating that the Station has taken command.
- The red LED indicator light will go OFF at the transferring Station's Control Head, indicating that the Station no longer is in command.

D) The commanded positions of the Throttle and Clutch will remain unchanged for one second after the red LED lights. This allows the operator time to move the Control Head's lever(s) to a position approximately matching the last Station, which will allow the vessel to maintain present speed and direction.

2-6 Emergency Reversal Protection (Proportional Pause)

The proportional pause provides a means of safely reversing the vessel's direction. A variable pause is introduced into the clutch command signal to allow time for the engine RPM's to drop to Idle and for the vessel's speed through the water to slow. This pause is set during Section 7 - SEA TRIALS.

2-7 Warm-up Mode (Throttle Only Mode)

WARNING: Personal Injury could occur if the following steps are not followed exactly.

This feature allows the operator to increase the engine's RPM, while the Clutch remains in Neutral. Warm-Up Mode is operational only when the Control Head lever is moved in the Ahead direction.

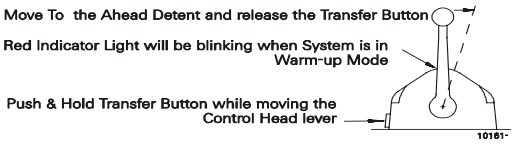
The system is placed into Warm-Up Mode as follows:

A) At the Station-in-Command, ensure that the Control Head's lever is in the Neutral detent position (refer to the following Figure).

B) Depress and hold the transfer button.

C) After one second, move the Control Head's lever to the Ahead detent, while continuing to hold the transfer button.

Figure 5: Control Head Warm-Up Mode

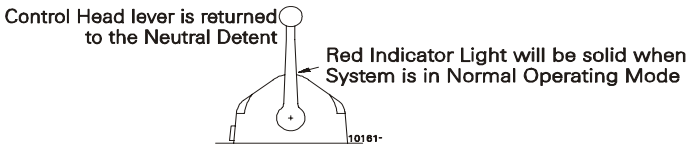


D) Now release the transfer button.
- The red LED indicator light will blink slowly, indicating Warm-Up Mode is activated and the Clutch has remained at Neutral.

E) The operator now can start the engine, if required, and increase the RPM through the entire throttle range by moving the Control Head's lever forward through the next 65 degrees.

F) When the Control Head's lever is returned to the Neutral detent, the red LED will discontinue blinking and remain lit steady. After one second in Neutral, the Processor will automatically reset to normal operation with full control of the clutches and engine.

Figure 6: Control Head Normal Operating Mode



G) The next movement of the Control Head's lever will engage the Ahead or Astern clutch (Normal Operation).

2-8 High/Low Idle

The Control System provides the input to the engine, so that it may run at the standard Idle speed (typically adjusted at the governor or carburetor), or it can provide a second elevated Idle speed.

2-8.1 Low Idle

- The factory default setting is for Low Idle Only.
- When the System is initially powered-up, it will always command Low Idle, even when High Idle is selected.

2-8.2 High Idle

- If High Idle is desired, it may be programmed during Dock Trials.
- High Idle is programmable up to a maximum setting of 20% of Full Throttle.
- High Idle is automatically selected when in Warm-Up Mode.

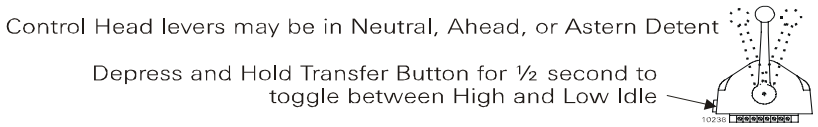
2-8.3 Selecting Between High and Low Idle

WARNING: Personal Injury could occur if the following steps are not followed exactly.

Refer to the following Figure when selecting between Low and High Idle (or vice versa) at the Station-in-Command.

A) The Control Head's lever(s) may be in the Neutral, Ahead or Astern detents when making a selection.

Figure 7: High/Low Idle Mode Selection



B) Depress and hold the transfer button for 1/2 second and then release.
- If the System was in Low Idle it will toggle to High Idle, and vice versa.

C) To return to the previous Idle setting, depress and hold the transfer button again for 1/2 second and then release.

NOTE: In Multiple Srew applications:
Always program all the Processors for the same amount of High Idle.
All Processors will be in High or Low Idle at the same time.

2-9 One Lever Mode (Multi Screw)

NOTE: One Lever Operation may be used in Troll Mode or in Non-Troll Mode.

NOTE: The Green LED will always be lit while in One Lever Operation, no matter which position the Master Control Head lever is in.

The system supports a mode of operation referred to as One Lever Mode.

One Lever Mode allows the operator to control two to five engines and transmissions with a single Control Head lever. Any of the Control Head levers at any Remote Station can be designated by the operator as the **Master lever**.

The designation can be changed by the operator at any time. Most of the features (synchronization, troll, etc.) available in normal operation are available while operating in One Lever Mode.

- The Processor defaults to One Lever Mode disabled.
- One Lever Mode can be disabled or enabled in the Set Up Procedures.
- When One Lever Mode is enabled, the operation must be turned ON and OFF as described below.

WARNING: Personal Injury could occur if the following steps are not followed exactly.

2-9.1 Turning ON One Lever Operation

Figure 8: Step A) One Lever Operation Mode

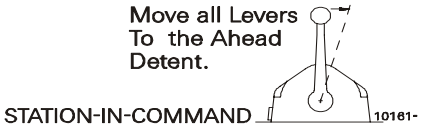
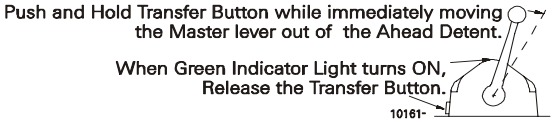


Figure 9: Step B) One Lever Operation Mode



A) At the Station-in-Command, move all the Control Head levers to the Ahead detent.

B) Depress and **Hold** the transfer button **while** moving one of the Control Head levers forward, out of the Ahead detent. **Do Not Release the Transfer Button** until the green LED turns ON, indicating One Lever Operation is now active.

- The Control Head lever which the operator chose to move out of the Ahead detent, becomes the **Master lever**.
- The Control Head lever which was left in the Ahead detent is now inactive.

NOTE: The Control Head lever(s) designated by the operator to be inactive in One Lever Operation, may be left in the Ahead detent or moved fully forward. Moving the lever fully forward is recommended, because it moves it out of the way and prevents accidental bumps while operating.

2-9.2 Turning OFF One Lever Operation

WARNING: It is strongly recommended that the Master lever be returned to the Neutral/Idle position prior to turning OFF One Lever Operation.
Do not attempt to transfer command from one Remote Station to another while in One Lever Operation.
Always turn One Lever Operation OFF prior to transferring.
Failure to observe these recommendations may result in a sudden change in the vessel's direction.

A) Place the **Master lever** into the Neutral detent.

B) Place all inactive Control Head levers into the Neutral detent.

- Whenever an inactive lever(s) is moved to the Neutral detent, One Lever Operation is turned OFF for that lever ONLY!
- In applications with three or more screws, the green LED will not turn OFF until all inactive Control Head levers are returned to the Neutral detent.

2-10 Engine Synchronization (Multi Screw)

NOTE: The Control System offers two types of synchronization, Active or Equal Throttle.

Synchronization is automatic and only operates when the Ahead clutch is engaged, consequently it can be left ON full time.

When synchronization has been selected during set up, the Control System will always power-up with synchronization ON.

In order for synchronization to become active (work toward synchronizing the engines' RPM's) the Synchronization Criteria listed below must be met.

2-10.1 Synchronization Criteria

Synchronization Criteria is met when all of the following are true:

- Both Control Heads must be commanding 5% or greater of the throttle range.
- The Control Head levers must be within 10% of one another (+/- approximately 6 degrees).
- Both Control Head levers are commanding Ahead clutch engagement.

NOTE: The use of Value 03 for Function Code E7 should be avoided in the 9000 Series Processors with mechanical throttle control.

SYMPTOM:

- When selected, Value 03 (Active Synchronization, no Synch if Tach signal lost) for Function Code E7 (Synchronization) may give the operator the appearance that synchronization is not functioning. This is due to the fact that the Control Head's green Synch indication LED does not light until both engine RPM's are within the "Active Synch Deadband". "Active Synch Deadband" is the maximum allowable difference in engine RPM where the Processors consider the system synchronized adequately. Once the allowable difference is obtained, the control system does not attempt to match the RPM's any closer.
- When in this Mode of Operation, there is no indication to the operator that the Control Head levers are matched close enough to start the synchronization process. Additionally, the green indication LED does not blink while working toward synchronization.

CAUSE:

- Function Code E7, Value 03, is operating as designed. Due to the imprecise positioning of mechanical push-pull cables, the ability to position the cables within the "Active Synch Deadband" is severely impaired.

SOLUTION:

- All Processors with mechanical throttle control, where synchronization is desired, must set the Value of Function Code E7 to Value 01 (Active Synchronization reverts to Equal Throttle Synchronization if Tach Signal is lost)

2-10.2 Synchronization Types

The following types of synchronization use the same criteria, indications, and are turned ON and OFF as described in following Sections.

2-10.2.1 Equal Throttle Servo Synchronization (default)

Equal Throttle synchronization simply positions the throttle push-pull cables to the same distance when the criteria has been met. With Equal Throttle Synchronization the Processors do not receive tachometer signals representative of the engines RPM's.

CAUTION: The Control System will remain synchronized as long as the Control Head's levers are in close proximity to one another. If a lever is moved to a point where the 10% throttle window is exceeded, a 10% increase or decrease in engine RPM would occur with one engine, resulting in a sudden change in the vessel's direction.

NOTE: In order for Equal Throttle Synchronization to work properly in Systems with mechanical Throttles, the bends in the push-pull cables must be kept to a minimum. There can be no back-lash in the linkage or cables. Both Governors or Carburetors must provide equal engine RPM with equal movement of their selector levers. If these conditions cannot be met, Active Synchronization is recommended.

2-10.2.2 Active Synchronization

Active Synchronization must be enabled during Set Up and a Tachometer Sensor Wire Harness must be used.

The Processors each receive a tachometer signal representing engine RPM from their respective engines. These signals are compared with one another over a serial communication line. If the Synchronization Criteria is met, the throttle command signal of the engine(s) running at the higher RPM is lowered, until the RPM's of all engines match.

2-10.3 Synchronization Indications

The green LED located on the Control Head indicates the status of synchronization.

- When the green LED is lit **steady**, the engines are synchronized.

- When the green LED is **not lit**, the engines are not synchronized and the Control System is not attempting to do so.
- In Active Synchronization the green LED **blinks** every time there is a change in the commanded throttle.

2-10.4 Turning Synchronization OFF/ON when Criteria is Met

2-10.4.1 Turning OFF:

When the Criteria is met, synchronization is automatic and does not need to be turned ON. If the operator elects to turn OFF synchronization, follow the steps below:

A) Ensure that the Control Head's levers are positioned to a point where Synchronization Criteria are met.

B) At the Station-in-Command, press and hold the transfer button until the green LED **blinks twice** and then goes out (approximately 2 seconds).

C) Synchronization is now OFF.

2-10.4.2 Turning ON:

Synchronization is automatic and does not need to be turned ON, unless previously turned OFF, as described in the previous Section.

A) Ensure that the Control Head's levers are positioned to a point where Synchronization Criteria are met.

B) At the Station-in-Command, press and hold the transfer button until the green LED **lights** (approximately 2 seconds).
- The green LED will blink as the system is working toward synchronization.
- The green LED will become solid when the engines are synchronized.

2-10.5 Turning Synchronization ON/OFF when Criteria is Not Met

The actual synchronizing of the engines occurs when the Control Head levers are within the 10% (approximately 6 degrees) window of one another. However, synchronization can be turned ON or OFF when the Control Head levers are apart more than the 10%.

At the Station-in-Command, press and hold the transfer button for at least two seconds:
- If synchronization is being turned ON, the green LED will light after two seconds and stay lighted as long as the transfer button is depressed. When transfer button is released the LED will go out.
- If synchronization is being turned OFF, after two seconds, the green LED will blink twice and then stay off.

2-11 Control Systems' Configurability

The Processor is designed in a way which allows it to be easily configured by the installer to meet the varying needs of a wide variety of vessels. Below you will find a list and a brief description of the groups of these functions.

2-11.1 Processor Functions

A0 Processor Identification - Assigns each Processor in multi screw applications a unique identifying number. **This function must be the second function set during Multi Screw Set Up.**

A1 Number of Engines - Lets the Processor know how many other Processors need to be communicated with. **This function must be the FIRST FUNCTION SET during Multi Screw Set Up.**

A2 One Lever Operation - Allows the installer to disable or enable One Lever Mode capability.

A3 Station Expander - Allows the Processor to communicate with the Station Expander (SE), which provides additional Remote Stations. **Contact the factory if this feature is required.**

A4 Neutral Indication Tone - When enabled, produces a short 200 Hz tone to indicate Neutral.

Detailed information on each Function is found in Section 5 - SET UP PROCEDURES.

2-11.2 Throttle Functions

2-11.2.1 Basic Throttle Functions

E1 Throttle in Neutral - Adjusts the Throttle when in Neutral, independent of the throttle output when the clutch is engaged.

E5 Throttle Pause following Shift - Allows the adjustment of time between clutch engagement command and when throttle begins to increase above Idle.

E6 High Idle - Programs a second/elevated Idle RPM.

E7 Synchronization - Allows the installer to select synchronization and select the type of synchronization.

Detail information on each function is found in Section 5 - SET UP PROCEDURES.

2-11.2.2 Servo Throttle Functions

This section along with "Basic Throttle Functions" allows the adjustment of the Servo Throttle:

E0 Throttle Servo Direction - Selects whether the Throttle Servo pushes or pulls to increase speed.

E2 Throttle Minimum - Once set mechanically at the Idle stop, this Function Code allows the position of the push-pull cable to be adjusted electrically in order to eliminate "dead lever". Dead lever in this case can be described as a movement of the Control Head lever without a change in the engine's RPM.

E3 Throttle Maximum - Adjusts the position or amount of travel of the push-pull cable at Full Throttle.

E4 Throttle Maximum Astern - Limits the amount of the Astern Throttle Servo movement.

Detail information on each function is found in Section 5 - SET UP PROCEDURES.

2-11.3 Clutch Functions

2-11.3.1 Basic Clutch Functions

The following functions are available for all types of clutches.

C0 Clutch Pressure Interlock - Selects the Clutch Oil Pressure Interlock option. The interlock prevents a throttle signal above Idle from being applied unless adequate clutch pressure is available.

C1 Clutch Interlock Delay - Determines when the Clutch Oil Pressure Interlock becomes active.

C2 Proportional (Reversal) Pause - Selects between an In-Gear, Neutral, or Fixed Neutral delay.

C3 Proportional (Reversal) Pause Time - Selects the maximum delay time during a full speed reversal.

C4 Proportional (Reversal) Pause Ratio - Determines if the Ahead and Astern reversal times are the same or if Astern is 1/2 of Ahead time.

Detail information on each function is found in Section 5 - SET UP PROCEDURES.

2-11.3.2 Clutch Servo Functions

This section along with the "Basic Clutch Functions" Section allows the adjustment of Clutch servo related items:

C5 Clutch Servo Direction - Determines if the servo pushes or pulls for Ahead and Astern.

C6 Clutch Ahead - Adjusts the amount of clutch servo travel in Ahead.

C7 Clutch Astern - Adjusts the amount of clutch servo travel in Astern.

Detail information on each function is found in Section 5 - SET UP PROCEDURES.

2-11.4 Troll Functions (Optional)

Refer to the 9001 Troll Actuator Manual (p/n MM9001) for detailed information on the Troll Functions and their operation.

2-11.5 Troubleshooting Functions

2-11.5.1 Basic Troubleshooting Functions

H0 Diagnostics - Allows the installer/technician to look at various inputs to the Processor.

H1 Return to Factory Defaults - Returns all settings to the factory default values.

Detail information on each function is found in Appendix B - DIAGNOSTIC MENU.

2-12 Audible Tones

Detailed information on the following tones are in Appendix B.

2-12.1 Basic Processor Tones

The Processor can produce numerous tones which inform the operator of the status of the system or if any faults were to occur. These tones are emitted from all Remote Stations regardless of whether they are in command or not.

2-12.1.1 Slow Repetitive Tone

This tone is normal when DC power is first applied to the System. This tone indicates that system initialization has occurred, no Remote Station has command, the operator can accept command at any Remote Station.

2-12.1.2 One Long, Three Short Tones

This tone indicates that the command signal from the Station-in- Command has gone out of the acceptable range.

2-12.1.3 Steady Tone

This tone indicates that the software program within the Processor has quit running, due to low voltage or component failure.

2-12.1.4 Five (5) Second Steady Tone

This tone indicates that there has been a loss of Serial Communication.

2-12.1.5 Three (3) Second Steady Tone

This tone is heard if there is a stuck transfer button, or when entering Back-up Mode, or if a Troll Solenoid error occurs. (Back-up Mode and Troll Solenoid is not available for all Processors.)

2-12.1.6 Five Seconds On, Five Seconds Off - High Repetitive Rate Tone

This tone indicates a loss of communication with the Station Expander.

2-12.2 Throttle (Servo 2) Tones

The following Tones are in addition to the Basic Processor Tones. Detailed information on each tone is in Appendix B.

2-12.2.1 One Long - Two Short Tones

This tone indicates that the feedback potentiometer signal from Servo 2 (Throttle) has gone out of range.

2-12.2.2 One Long, Two Short - High Repetitive Tone

This tone indicates that Servo 2 (Throttle) cannot reach the commanded position. This tone is also referred to as Servo 2 Jam Tone.

2-12.3 Clutch (Servo 1) Tones

2-12.3.1 One Long - One Short Tone

This tone indicates that the feedback potentiometer signal from Servo 1 (Clutch) has gone out of range.

2-12.3.2 One Long, One Short -High Repetitive Rate Tone

This tone indicates that Servo 1 (Clutch) cannot reach the commanded position. This tone is also referred to as Servo 1 Jam Tone.

2-12.4 9001 Trolling Actuator Tones (Servo 3)

Detailed information is found in the MM9001 Troll Acutator Manual.

2-12.4.1 One Long, Four Short Tones .

This tone indicates that there is a feedback error in the Trolling Actuator.

2-12.4.2 One Long, Four Short - High Repetitive Rate Tone

This tone indicates that Trolling Actuator Servo cannot reach the commanded position

2-13 Push Button Set Up

There are four push buttons mounted to the Processor's circuit board. These push buttons allow the installer/technician access to all of the Functions required for programming and troubleshooting the Processor.

A full description of their usage is provided in Section 5 - SET UP PROCEDURES.

2-14 Visual System Diagnostics, Set Up And Status Indication

There are four, seven segment LED's (hereafter referred to as the Display LED) mounted to the Processor's circuit board. The Display LED is visible through a transparent window in the Processor's cover. The information displayed is used in conjunction with the push buttons to program the Processor. The Display LED also displays Error Codes in the event that an anomaly is detected.

For a full description of the Display LED, its capability and usage, refer to Section 5 - SET UP PROCEDURES.

2-15 Pluggable Connections

2-15.1 Processor

The Processors come from the factory with enclosure mounted pigtail connectors for easy, mistake free installations.

Refer to Figure 10: for pigtail/servo locations:

Figure 10: Processor Connections View

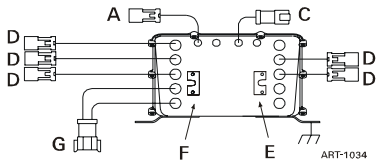


Table 2: Processor Connections List

FIGURE ID	QUANTITY	DESCRIPTION
A	1	Pigtail connector is provided for serial communication between multiple Processors.

C	1	Pigtail connector is provided for the Tachometer Sensor input used in multi screw Active Synchronization.
D	0 - 5	Pigtail connector provides the connections for Remote Station Control Heads..
E	0	No Pigtail - SERVO 1 entry point.
F	0	No Pigtail - SERVO 2 entry point.
G	1	Pigtail connector provides the connections for DC Power, Start Interlock, (optional)Clutch Oil Pressure Interlock and (optional) External Alarm contact.

2-16 Optional Features

2-16.1 External Alarm Capability

- This optional feature is designed to provide a status signal to an external visual or audible alarm circuit.
- The status signal is in the form of an OPEN or CLOSED relay contact. When the contact is CLOSED, the Processor is functioning normally. When the contact OPENS, this indicates the software program has quit running due to a component failure or loss of DC power.
- A full explanation is provided in Section 8 - CONTROL OPTIONS.

2-16.2 Clutch Pressure Interlock

- The purpose of the Clutch Pressure Interlock is to prevent high engine RPM when the Clutch is not fully engaged.
- A full explanation is provided in Section 8 - CONTROL OPTIONS.

2-16.3 Multiple Screw Installations

This Manual, as written, is intended for Single and Twin Screw applications only.

The Processor has the capability of controlling Triple, Quad and Quint Screw vessels.

If this option is going to be used, please contact a ZF Marine Electronics Representative for further information.

2-16.4 Station Expander (SE)

- The SE is a separate Processor housed in an enclosure that allows the connection of up to five additional Remote Control Stations.
- The SE communicates with the Processor over the serial communication line.
- A full explanation of the installation, operation and adjustment of the SE is provided in the Installation Manual provided with the SE.

If this option is going to be used, please contact a ZF Marine Electronics Representative for further information.

2-16.5 9001 Mechanically Actuated Trolling Valve Control

- The purpose of a Trolling Valve is to lower the Clutch pressure, which allows the Clutch Plate to slip.
- A full explanation is provided in the Installation Manual provided with the 9001 Trolling Actuator.

3 PLAN THE INSTALLATION

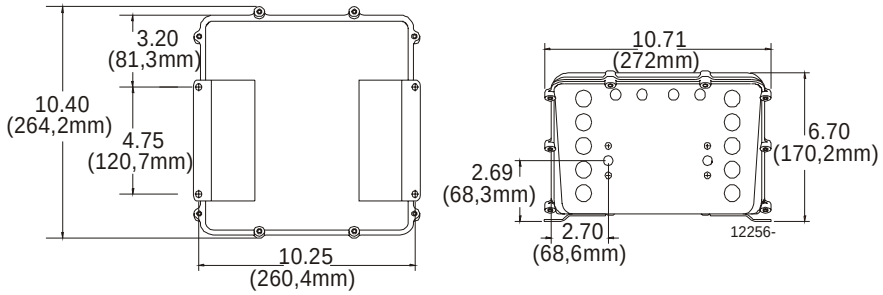
NOTE: ZF Marine Electronics recommends that the system be installed in accordance with ABYC, E-11 and P24.

3-1 System Requirements

The first step when installing a System is to carefully plan the installation. This includes finding proper mounting locations for the Processor(s) and Control Heads. The decision must be made on where power is going to be sourced and how the power will be routed to the Processor(s).

Once the locations have been decided, lengths of electrical wiring, harnesses and push-pull cables must be determined.

Figure 11: Processor Dimensions



- Grounding (Bonding) is required for maximum electromagnetic compatibility (EMC) performance. Refer to Appendix A - Grounding (Bonding).
- Locate the Processor such that the push-pull cables have the shortest, most direct path to the selector lever. The push-pull cable length should not exceed 20 feet (6,0m), the bend radius should not be less than 10 inches (254mm) and the total degrees of bends must be less than 270 degrees.

Only when the locations and lengths of wiring/harnesses have been determined, should you start the actual installation. The following sections describe the requirements for installing the components and selecting mounting locations.

3-1.1 Processor(s)

Processors required per engine:
Single Screw: One (1) Processor
Twin Screw: Two (2) Processors

Mounting Hardware is installer supplied.

Installation/Troubleshooting Manual is included with the Processor.

The following items must be taken into account when selecting the location for the Processor(s):

- The Processor is spray proof, but not water proof. Therefore, an area must be selected that typically stays dry.
- The engine room is the preferred location for mounting the Processor.
- If the engine room is too small, locate in any area where it is easily accessible, as long as all of the criteria listed are met.
- Bulkhead mounting is the preferred method due to ease of access for wiring and adjustments. However, the Processor can be mounted in any attitude as long as the Display LED window and push buttons are accessible.
- Do not mount the Processor on the engine, transmission, or in any location that will subject it to excessive vibration.
- Do not mount the Processor to the transom when the vessel is equipped with a surface piercing drive system (due to vibration concerns).
- Locate the Processor(s) away from sources of high heat, such as engine exhaust manifolds or turbochargers. Allow 4 feet (1,2m) of clearance or more.
- Do not mount the Processor(s) in close proximity to gas engine ignition systems, alternators, generators or any equipment producing strong magnetic fields. Allow 4 feet (1,2m) clearance or more.

CAUTION: Strong magnetic fields can influence the Processor's electronic circuits and void your warranty.

3-1.2 Control Head(s)

Refer to Appendix A - Control Head Variations Service Sheets for information on the various Control Heads available and their dimensions.

- Control Heads are available with pluggable pigtails or may be hard-wired (no pigtails).
- Retrofit applications may require an Adapter Pad to cover the old Control Head cutout. A variety of Adapters and Cover Pads are available. If an Adapter/Cover Pad is required, please contact a ZF Marine Electronics Representative for further information.
- The Control Head can be mounted at any location on the vessel, as long as all of the criteria listed above are met.
- A Handheld is available to use, instead of a mounted Control Head. Refer to the Installation Manual supplied with the Handheld for additional information on the planning of the installation.
- Ensure that the clearance is sufficient for the Control Head's lever to reach full Ahead and full Astern.
- The 400 and MC2000 Series Control Heads are spray proof from the top, but must be protected from the weather on the underside.
- When a 400 or MC2000 Series Control Head must be mounted in a location where the underside may be exposed to the weather, consider using a Weather Mount Enclosure. Refer to the Appendix A - Weather Mount for specific information.
- The 700 Series Control Heads are fully water proof.

3-1.3 Wire Harnesses

For further information regarding Wire Harness requirements, contact a ZF Marine Electronics Representative.

The following lists the various Harnesses that plug into the Processor:

3-1.3.1 Control Head Harnesses

- One Control Head Harness is required for every Control Head lever at every Remote Station.
- The Control Head Harnesses are available in various lengths.
- Harnesses are available with plugs on both ends or a plug on the Processor end only.
- The Harness from the Port side of a Control Head is always routed to the Port Processor.
- The Harness from the Starboard side of a Control Head is always routed to the Starboard Processor.

3-1.3.2 Power, Start Interlock, Clutch Pressure (optional), Alarm (optional) Harness

- One Harness required per Processor.
- The Harness is plugged at the Processor end only.
- In addition to the required DC power and Start Interlock, the Harness has options for Clutch Oil Pressure Switch and External Alarm Circuit that are available.
- All of the cables in the Harness are the same length. Therefore, order a length that will reach all of the previously mentioned items, if required.
- The Harness is available in lengths up to 30 feet (9,14m) for 12 VDC systems, and up to 60 feet (18,2m) for 24 VDC systems.

3-1.3.3 Serial Communication Harness

The Serial Communication Harness is only required in:

- Multi Screw applications,
- when an LCD Display is utilized,
- or an external trolling valve actuator (9001) is utilized.

The Harness interconnects the Processors to each other. A plug is attached at both ends of the Serial Harness.

Twin Screw:

One (1) Serial Harness (part no. 13316-X)

3-1.4 Additional Harnesses

For further information regarding Wire Harness requirements, contact a ZF Marine Electronics Representative.

The following lists the additional Harnesses that plug into the Processor:

3-1.4.4 Tach Sensor Harness

One Harness per Processor is required. The Harness is plugged on one end only. There are two types of Tach Sensor Harnesses available:

1. A AC Coupled Sensor Harness, which is designed for inputs from items such as Mechanical Senders, Magnetic Pickup Sensors, the Alternator AC Stator Terminal or the negative Coil Terminal.
2. A Harness designed for Active Sensors with an Open Collector output, such as Hall Effect Sensors. This Harness is only required when Active Synchronization is required.

Determine the source of the tachometer signal, which can be provided by a mechanical tachometer sender, magnetic pickup, alternator's pre-rectified output, the negative side of the coil (gasoline engine) or an engine's electronically produced signal. Refer to Engine Tachometer Sender Requirements located in Appendix A.

3-1.5 Electric Cables

For further information regarding Electric Cable requirements, contact a ZF Marine Electronics Representative.

The installation may use Harnesses, Electric Cables or a combination of both.

The following lists the various equivalent electric cables:

3-1.5.1 Control Head Electric Cable

If the Control Head is hard-wired (no plugs) the electric cable may be ordered from ZF Marine Electronics, or must meet the following specifications :

- Seven-conductor with shield, twisted.
- Color Code – black, brown, red, orange, green, blue, and violet.
- 18 AWG (nearest metric equivalent - #1).
- 300V, 105 degrees C, UL VW1, stranded tinned copper wire.
- Maximum outside diameter: 0.390 inch (9,9mm)

3-1.5.2 Power, Start Interlock, Clutch Pressure, Alarm Electric Cable

3-1.5.2.1 Power Electric Cable Requirements

If ***Power*** is hard-wired, (no plugs) the electric cable may be ordered from ZF Marine Electronics, or must meet the following specifications:

- Two-conductor, black and red with violet stripe, twisted.
- 14 AWG (#2,5 metric) or 12 AWG (#4 metric) may be used to crimp directly to the Processor terminals. Refer to Appendix A - Automatic Power Selector (APS) for cable length and additional wire size requirements.
- 300V, 105 degrees C, UL VW1, stranded tinned copper wire.
- Maximum outside diameter: 0.390 inch (9,9mm).

3-1.5.2.2 Start Interlock Electric Cable Requirements

If ***Start Interlock*** is hard-wired (no plugs) the electric cable may be ordered from ZF Marine Electronics, or must meet the following specifications:

- Two-conductor, both yellow with red stripe, twisted.
- 16 AWG (#1,5 metric).
- 300V, 105 degrees C, UL VW1, stranded tinned copper wire.
- Maximum outside diameter: 0.390 inch (9,9mm).

3-1.5.2.3 Clutch Pressure Interlock Electric Cable Requirements

When the ***Clutch Pressure Interlock*** option is utilized, a pressure switch with a normally open contact must be installed on the transmission, along with a Shuttle Valve

If the Clutch Pressure Switch is hard-wired (no plugs) the electric cable may be ordered from ZF Marine Electronics, or must meet the following specifications:

- Two-conductor, both light blue.
- 16 AWG (#1,5 metric).
- 300V, 105 degrees C, UL VW1, stranded tinned copper wire.
- Maximum outside diameter: 0.390 inch (9,9mm).

3-1.5.2.4 External Alarm Circuit Electric Cable Requirements

If the ***External Alarm Circuit*** is hard-wired (no plugs) the electric cable may be ordered from ZF Marine Electronics, or must meet the following specifications:

- Two-conductor, red and black, twisted.
- 16 AWG (#1,5 metric).
- 300V, 105 degrees C, UL VW1, stranded tinned copper wire.
- Maximum outside diameter: 0.390 inch (9,9mm).

3-1.5.3 Serial Communication

Serial Communication Harnesses are required in Multiple Screw applications. All Processors come equipped with Serial Communication Pigtail Plugs installed.

The Serial Communication Harness mates with these plugs. **It is strongly recommended** that only factory manufactured Harnesses are installed.

3-1.5.4 Tach Sensor Electric Cable Requirements

The cable selected depends on what type of Sensor is being used:

3-1.5.4.1 AC Tach Input

- Two-conductor, twisted, shielded.
- 20 AWG (#0,5 metric)
- 300 V, 165 C, UL VW1, stranded tinned copper
- Maximum outside diameter: 0.390 inches (9,9mm)

3-1.5.4.2 Open Collector (Active)

- Three-conductor, twisted, shielded
- 20 AWG (#0,5 metric)
- 300 V, 165 C, UL VW1, stranded tinned copper
- Maximum outside diameter: 0.390 inches (9,9mm)

3-2 Tachometer Sensors

There are two types of Tachometer Sensors available through ZF Marine Electronics, Mechanical (p/n 8902) and Magnetic Pickup (p/n 8912). Both types provide two separate outputs, one for the tachometer(s) and the second output provides the Processor's tachometer signal requirement. If a sensor other than one supplied by ZF Marine Electronics is used, it must meet the criteria provided below for each type:

3-2.1 AC Coupled Sensors

- The signal must have a minimum amplitude of +/- 1.5 V (3.0 V P-P).
- The signal's maximum amplitude must not exceed +/- 100 V (200 V P-P).
- The frequency of the signal must be no lower than 30 Hz at Idle.
- The signal's frequency may not exceed 8 KHz at Full Throttle.

3-2.2 Alternator

- The pre-rectified stator AC terminal may be used as the tach source.
- The signal is inputted to the AC Coupled Sensor input.
- The signal must meet the same criteria as any AC Coupled Sensor Signal (refer to Section 3-2.1).

3-2.3 Point side of the Coil

- When the signal is sourced from the coil or an electronically produced tach signal (used on some gasoline engines) the signal is connected to the AC Coupled Sensor input.
- The signal must meet the same criteria as any AC Coupled Sensor Signal (refer to Section 3-2.1).

3-2.4 Active Sensors (Open Collector Output)

- The sink current ability of the Sensor may be no lower than 2 mA.

- The operational current may not exceed 50 mA.
- The Sensor must have a maximum saturation voltage of 0.8 V.
- An operational voltage requirement of 9- 10 VDC.
- A minimum frequency of 5 Hz at Idle.
- A maximum frequency of 8 KHz at Full Throttle.

3-3 Installer Supplied Tools And Parts

3-3.1 Required Tools

Anti-static wrist strap (included with Processor).

Screwdriver – medium Phillips, #2.

Wire cutter, stripper & crimper (Thomas & Betts model WT-2000 or equivalent).

7/16 inch Nut Driver or Socket with ratchet & medium extension.

5/16 inch Wrench – open end.

Screwdriver – small straight slot.

Saw with blade suitable for Console Top Panel.

Drill Motor with 9/32 inch and 7/32 inch drill bits.

3-3.2 Optional Tools

Calibrated Digital Multimeter (Fluke 80 Series or equivalent).

Service Field Test Unit (P/N 13927, available through ZF Marine Electronics)

Field Test Control Head - Dual (P/N 14000)

3-3.3 Required Parts for Servo Processor's

- 33C type push-pull cables. The cables are measured from the end of the threads to the end of the threads. Available in 1 foot (0,3m) increments. (If 43C type push-pull cables are required, a 43C Conversion Kit is available from ZF Marine Electronics. Refer to Appendix A - 43C Cable Conversion Kit.)
- Many engines, transmissions and inboard/outboard (I/O) drives are delivered with mounting kits. If not, contact the engine/gear dealer/manufacturer for a factory Cable Connection Kit. Refer to Appendix A - Universal Mounting Kit, to show other connection options.

3-3.4 Engine Stop Switch

An engine STOP switch MUST be located at each Remote Station. The Installer supplies the switches. Refer to the installation instructions supplied with the switch and the engine installation instructions for manufacters recommendations.

WARNING: An Engine STOP Switch MUST be installed at every remote operating station. Refer to CFR 46, Section 62.35-5 (US Coast Guard) and ABYC P-24.5.8.

3-4 DC Power Source

One of the most important (and often overlooked) items for proper operation of your control system is a clean, dedicated, and reliable source of DC Power.

The wiring used to supply power from the power source (battery) through the various components (fuses, distribution panel, relays, etc.) to the Processors must be sized for a voltage drop of 10% or less using 10 amps as the maximum current draw. Refer to **ABYC** Standard E-11, Table X to determine the appropriate wire gauge for the necessary conductor length.

When using ZF Marine Electronics supplied 14 gauge power cable, and in accordance with **ABYC** Standard E-11, the distance from a 12 volt power source (battery or DC Distribution Panel) shall not exceed 30 feet (9,1m). In 24 volt systems, the maximum cable length is 60 feet (18,2m).

ZF Marine Electronics highly recommends using an Automatic Power Selector (APS) and a second power source (battery) to supply power to each Processor. Refer to Appendix A - Automatic Power Selector (APS) for examples of power supplies.

3-4.1 Processor Power

The items listed below will help ensure optimum performance from your control system.

- The Processor requires a battery source of 12 or 24 VDC.

- Two 5 ampere (when isolated power supplies are required) or one 10 ampere trip-free thermal circuit breaker(s) with manual ON/OFF actuation
- The use of an APS (Automatic Power Selector) is strongly recommended.
- Power should come from the vessel's DC Distribution Panel.
- The cables feeding power from the battery to the Processor must be sized large enough to keep voltage drop, due to current flow, below 10%. Reference Appendix A - Automatic Power Selector (APS) .

Contact a ZF Marine Electronics representative for the Processor's power cable(s) maximum lengths. Refer to Appendix A - Automatic Power Selector for examples of the various wiring options. Ultimately, it is the boat builder or installer's responsibility to ensure that the vessel's wiring meets the requirements of American Boating & Yachting Council standard E-11, for AC and DC Electrical Systems on Boats.

4 INSTALLATION

NOTE: Before starting the actual installation of the Control System, make sure you have the correct parts and tools on hand. Refer to Section 3 - PLAN THE INSTALLATION. Read ALL the instructions pertinent to each part before beginning the installation of the part.

CAUTION: Static electricity can destroy electronic components. Connect the wrist strap provided, to the Processor frame whenever working on the Processor with the enclosure cover open. This will drain any static charge you may have on your person.

4-1 Processor

A) Secure the Processor to the mounting surface with three 1/4 inch or M6 fasteners, leaving the fourth fastener unused at this time.

B) Connect the Processor to the Hull or Grounding Bus by running a 12 AWG or larger wire between the Processor's fourth mounting fastener and the Grounding Bus. (The Processor is bonded if mounted directly to a metallic surface that is connected to a metal hull) (Refer to Appendix A - Grounding)

4-2 Control Head(s)

4-2.1 400, MC2000 and 700 Series Control Heads

Refer to the appropriate Control Head Dimensions and Variations Service Sheet in Appendix A for installation.

4-2.2 500 Series Control Heads

Refer to the Installation Manual supplied with the 500 Series Control Head Assembly for installation instructions.

4-2.3 Handheld Remote Controls

Refer to the Installation Manual supplied with the Handheld Remote for installation instructions.

4-3 Wire Harness Installation

The standard Off-the-Shelf Processor has five Pigtails with connectors on the ends. Two of the Pigtails are for Remote Stations and one each for Power/Start Interlock, Serial Communication, and Tach Sensor. Additional Harnesses required will depend on the actual installation.

Four different styles of plugs and connectors are utilized but are inserted in an identical fashion as follows:

4-3.1 Harness Plug Insertion and Extraction

A) Prior to inserting the Harness plug, pay close attention to the number of pins and the keying of the plug. The plug is designed to be inserted one way only into the connector, but can be incorrectly forced together in the opposite orientation.

B) When connecting the plugs, ensure that the locking mechanisms are depressed and held until the plug is fully connected or disconnected.

Figure 12: Connector and Harness Plug Keying

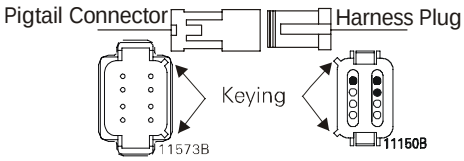
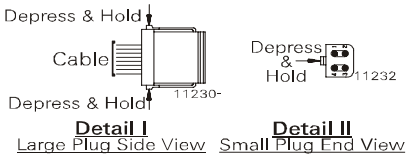


Figure 13: Harness Plug Locking Mechanism



4-3.2 Standard Power/Start Interlock Harness

The Power Harness has a minimum of two cables (DC Power and Start Interlock) and may have two more optional cables (Clutch Pressure Interlock and External Alarm Circuit).

4-3.2.1 DC Power Cable

(Refer to Appendix A - Automatic Power Selector)

A) Insert the Harness's black, twelve pin plug into the Processor's Power/Start Interlock Pigtail connector.

B) Run the cable to the DC Distribution Panel or the optional Power Relay.

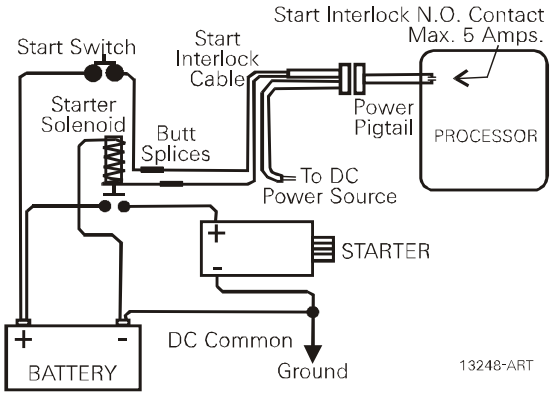
C) Strip back the appropriate amount of PVC jacketing and conductor insulation.

D) Crimp the appropriate connectors to the conductors.

E) Terminate the conductors to the DC Power Source.

4-3.2.2 Start Interlock Cable

Figure 14: Start Interlock Connections



A) Run the cable to the Engine's Starter Solenoid.

B) Disconnect the Starter Switch wire from the Solenoid.

C) Strip back the appropriate amount of PVC jacketing and conductor insulation.

D) Connect one of the conductors to the Solenoid's Starter Switch terminal.

E) Butt splice the second wire to Starter Switch wire.

4-3.2.3 External Alarm Circuit Cable (optional)

Refer to Section 8 - CONTROL OPTIONS, for installation information.

4-3.2.4 Clutch Pressure Switch Cable (optional)

Refer to Section 8 - CONTROL OPTIONS, for installation information.

4-3.3 Serial Communication Harness (Multi Screw)

4-3.3.1 Twin Screw

A) At the Processors, remove the watertight seals from the Serial pigtail connectors.

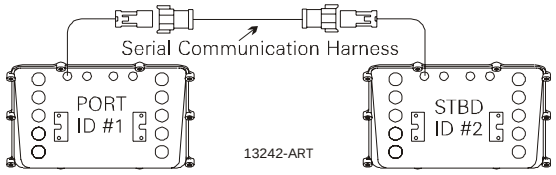
B) At the Port Processor, insert the Serial harness's grey, six pin plug into the Serial pigtail connector.

C) Run the harness to the Starboard Processor.

D) Insert the harness's grey, six pin plug into the Starboard Processor's Serial pigtail connector.

E) Secure the Serial Harness at least every 18 in. (45,72 cm).

Figure 15: Twin Screw Serial Harness Connections



4-3.4 Standard Control Head Harness

Depending on whether a pluggable or hard-wired (not pluggable) Control Head(s) is selected, will determine the procedure for terminating the Harness at the Remote Station.

- The first installation procedure is written for the pluggable Control Head(s).
- If a hard-wired Control Head(s) is selected, follow the information provided in the second procedure.

NOTE: Multi Screw Applications: Control Heads must be connected to the same numbered Station Pigtail or Circuit Board Station Terminal on ALL Processors.

4-3.4.1 Control Head Harness with Two Plugs

A) At the Port Processor, insert the harness's grey, eight pin plug into the Station 1 pigtail connector.

B) Run the cable to the Port side of the Control Head located at Station 1.
C) Insert the harness's grey, eight pin plug into the Control Head's Port pigtail connector.
D) Ensure that the cable has a strain relief close to the Control Head to relieve the strain on the connections.
E) Repeat Steps A) thru D) for all Processor's Station 1 connectors.
F) Repeat Steps A) thru E) for all required Stations (i.e. 2, 3, 4, 5).
- If Stations without pigtails are required to be installed, follow the Hard-Wire Control Head Installation Steps in Section 4 - INSTALLATION "Hard-wired Cable".

4-3.4.2 Control Head Harness with One Plug

A) At the Port Processor, insert the harness's grey, eight pin plug into the Station 1 pigtail connector.
B) Run the cable to the Port side of the Control Head located at Station 1.
C) Connect the conductors to the Control Head as described in the appropriate Control Head Dimensions and Variations Service Sheet in Appendix A.
D) Provide a strain relief in close proximity to the Control Head's terminal block.
E) Repeat Steps A) thru D) for all Processor's.
F) Repeat Steps A) thru E) for all required Stations (i.e. 2, 3, 4, 5).
- If Stations without pigtails are required to be installed, follow the Hard-Wire Control Head Installation Steps in Section 4 - INSTALLATION "Hard-wired Cable".

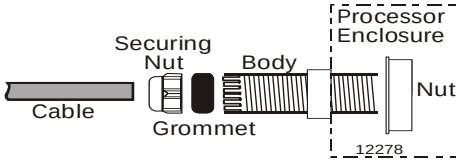
4-3.5 Tach Sensor Harness (required for Active Synchronization)

A) On all Processors, remove the watertight seals from the Tach Sender pigtail connectors.
B) Insert the harness's grey, four pin plug into the Tach Sender pigtail connector at each Processor.
C) Run the Tach Sensor Harness cables to the Tach signal source for each engine.
D) Connect the conductors to the Tach source in the appropriate manner, keeping in mind that some sources are polarity sensitive. **(black wire - negative, red wire - positive)**

4-4 Hard-Wired Cable

4-4.1 Liquid Tight Connector

Figure 16: Liquid Tight Installation

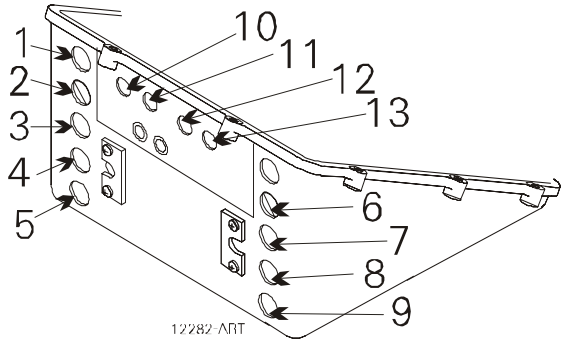


All cables that enter the Enclosure must go through a Liquid Tight Connector in order to maintain the moisture resistant integrity of the Processor. These connectors must be assembled as shown in Figure 16:

4-4.2 Processor Enclosure Cable Holes

When hard-wiring a Processor or installing additional Station pigtails, the cables must enter the enclosure through Liquid Tight Connectors in the appropriate holes.

Figure 17: Processor Enclosure Cable Holes



1. Station No.5
2. Station No.3
3. Station No.1
4. Alarm, Clutch Pressure, and Start Interlock
5. DC Power
6. Station No.4
7. Station No.2
8. Not Used
9. Not Used
10. Serial Communication
11. Not Used
12. Tachometer (optional)
13. Not Used

Figure 18: Processor Circuit Board Termination Points

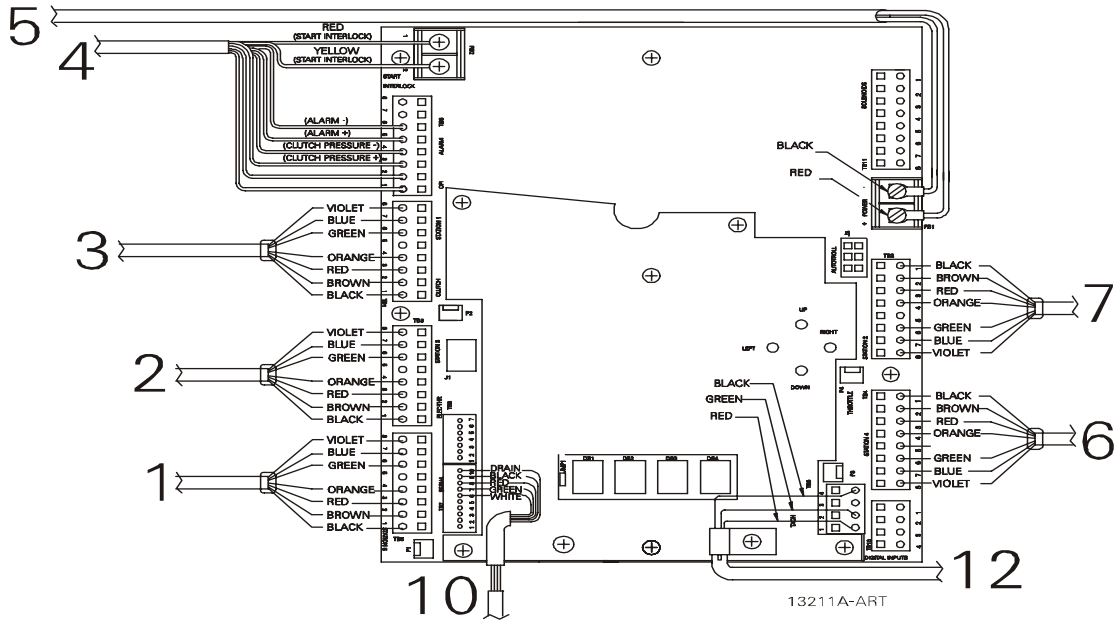


Table 3: Circuit Board Hardwire Termination Table

Hole # (Refer to Figure 17:)	Description and Terminal (Refer to Figure 18:)	Wire Cable Connections (Refer to Figure 18:)	
		Pin No.	Cable Color
1.	Station 5: TB5	1	Black
2.	Station 3: TB3	2	Brown
3.	Station 1: TB1	3	Red
6.	Station 4: TB4	4	Orange
7.	Station 2: TB2	6	Green
		7	Blue
		8	Violet
4.	Alarm: TB6	6	Brown
		5	Black
	Clutch Pressure: TB6	4	Green
		3	Blue
	Start Interlock: PB2	1	Red
		2	Yellow
	Ground: TB6	2	Orange
	Backup Input: TB6	1	White
5.	Power In: PB1	Negative	Black
		Positive	Red
10.	Serial Communication: TB7	6	White
		7	Green
		8	Red
		9	Black
		10	Drain
12.	Tachometer: TB9	1	Red
		2	Green
		4	Black

4-4.3 Hard-wire Installation

4-4.3.1 Seven-Conductor Control Head Cable (Locations 1, 2, 3, 6, and 7)

A) Run the seven-conductor cable from the Remote Station to the Processor.

B) Support the cables using clamps or straps not more than 18 inches (0,5m) apart if not contained in a conduit. Verify cable location protects the cable from physical damage.

C) Label each seven-conductor cable at both ends with the Station Number it connects, and Port or Starboard.

D) Place on your wrist the anti-static wrist strap provided, attach the strap to ground, and then remove the cover from the Processor.

E) Run the seven-conductor cable for each remote station through the corresponding liquid tight cable grip on the Processor to the appropriate Station terminal block. Do not tighten cable grip at this time.

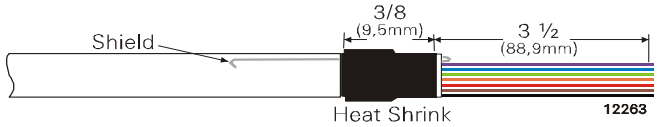
F) Strip the PVC jacket and shielding back approximately 4-1/2 inches (114,3mm) on the seven-conductor cable.

G) Strip the wire 3/8 inch (9,5mm) on each lead.

H) Pull the Shield wire back against the PVC jacket.

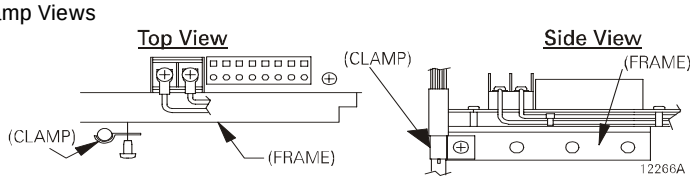
I) Slide and shrink a piece of 3/8 inch W. X 1 inch L. heat-shrink over the cable as shown in Figure 19:.

Figure 19: Seven-Conductor Control Head Cable Shield Wire and Heat-Shrink



J) Secure the seven-conductor cable to the frame using a conductive Clamp. Ensure that the Clamp and Shield wire come in contact with one another. Refer to Figure 20:.

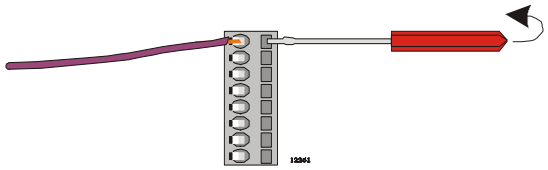
Figure 20: Clamp Views



K) Clip the Shield wire so that it is flush with the Clamp.

L) Connect the conductors to the appropriate pins as shown on Table 4:, using a small slotted screwdriver as shown in Figure 21:

Figure 21: Terminal Strip Cable Connections



M) Connect the other station's seven-conductor cables to the appropriate station terminal strips in the same way.

Table 4: Connections for Remote Stations (Refer to Appendix A - Control Head Sheets)

Circuit Board Termination	Conductor Color	Left Hand (Port) Control Head Lever	Right Hand (Stbd) Control Head Lever
TB1-1 thru TB5-1	**Black**	Pin 1	Pin 1
TB1-2 thru TB5-2	**Brown**	Pin 2	Pin 2
TB1-3 thru TB5-3	**Red**	Pin 3	Pin 3
TB1-4 thru TB5-4	**Orange**	Pin 4	Pin 4
TB1-6 thru TB5-6	**Green**	Pin 6	Pin 6
TB1-7 thru TB5-7	**Blue**	Pin 5	Pin 7
TB1-8 thru TB5-8	**Violet**	N/C	Pin 8
		Jumper between Pins 3 and 7	Jumper between Pins 3 and 5

4-4.3.2 Start Interlock Cable (Location 4)

4-4.3.2.1 Connection at the Starter Solenoid

A) Run the length of two-conductor cable between the Engine's Starter Solenoid and the Processor.

B) Disconnect the Starter Switch wire from the Solenoid.

C) Strip back the appropriate amount of PVC jacketing and conductor insulation.

D) Connect one of the conductors to the Solenoid's Starter Switch terminal.

E) Butt splice the second wire to Starter Switch wire.

4-4.3.2.2 Connection at the Processor

A) Install a liquid tight connector into entry hole (No. 4).

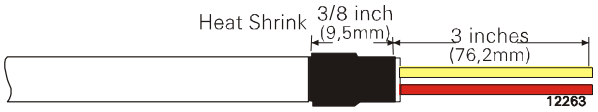
B) Run enough of the two-conductor power cable through the liquid tight cable grip so that it can be routed to PB2 on the Circuit Board as shown in the Processor Circuit Board Termination Points Figure.

C) Strip back 2 inches (50,8mm) of the PVC jacketing. Refer to Figure 22:

D) Strip each wire 3/8-inch (9,5mm).

E) Place a 3/8 inch (9,5mm) section of shrink tubing over the cable and heat.

Figure 22: Two-Conductor Start Interlock Cable



F) Crimp fork or ring terminals to the wires.

G) Connect the two-conductor cable to PB2, red lead to the terminal labeled (1) and yellow lead to the terminal labeled (2), as indicated on Processor Circuit board Termination Points Figure.

H) Tie wrap the start interlock cable to the Processor's frame.

4-4.3.3 Power Cable (Location 5)

A) Run the length of two-conductor power cable between the DC Power Source and the Processor.

B) Make the connections at the vessel's DC Power Source, but do not turn power ON.

C) Install a liquid tight connector into the DC POWER entry hole.

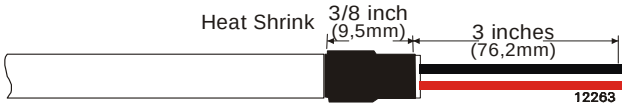
D) Run enough of the two-conductor power cable through the liquid tight cable grip so that it can be routed as shown in Processor Circuit board Termination Points Figure.

E) Strip back 3 inches (76,2mm) of the PVC jacketing. Refer to Figure 23:

F) Strip each wire 3/8-inch (9,5mm).

G) Place a 3/8 inch (9,5mm) section of shrink tubing over the cable and heat.

Figure 23: Two-Conductor Power Cable



H) Crimp fork or ring terminals to the wires.

I) Connect the two-conductor cable to PB1, red lead to the terminal labeled (+) and black lead to the terminal labeled (-), as indicated on Processor Circuit board Termination Points Figure.

J) Tie wrap the power cable to the Processor's frame.

4-4.3.4 Serial Communication Cable (Location 10)

A) Install 1/2 inch (12,7mm) liquid tight cable grips into appropriate hole of the Port and Starboard Processors.

B) Run a four-conductor, shielded cable from the Port to the Starboard Processors.

C) Strip back 3 inches (76,2mm) of PVC jacketing from both ends of the cable.

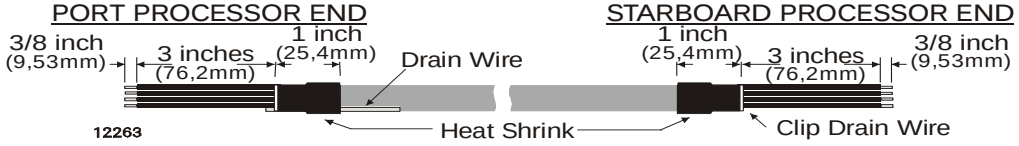
D) Strip each wire 3/8 inch (9,5mm).

E) Clip the drain wire flush with the PVC jacketing on the Starboard Processor only.

F) Place a 1 inch (25,4mm) section of shrink tubing over each end of the cable

G) On the Port end of the cable, bend the drain wire back and tuck it under the shrink tubing so that the drain wire end is exposed past the shrink tubing. (Refer to Figure 24:)

Figure 24: Four-Conductor Serial Communication Cable



H) Shrink the Tubing with a heat gun.

I) Insert the four-conductor cable through the liquid tight connectors and tighten the nuts

J) Secure the cables internally using a Clamp as shown in Figure 6:, Clamp Views. **Make certain that the drain wire makes contact with the Clamp's metallic surface.**

K) Clip the exposed drain wires flush with the Clamps.

L) Connect the conductors to the terminal block as listed in Table 5:

Table 5: Processor Circuit Board Connections for Serial Communication Cable

Conductor Color	Port Processor Termination A	Starboard Processor Termination B
White	TB7-6	TB7-6
Green	TB7-7	TB7-7
Red	TB7-8	TB7-8
Black	TB7-9	TB7-9
Silver (Drain Wire)	Clamp	No Connection

4-4.3.5 Tachometer Cable (Location 12)

A) Run a two- or three-conductor shielded cable from the Port Processor to the Port engine's tachometer source. (Refer to Section 3 - PLAN THE INSTALLATION)

NOTE: Three-conductor cable is required with Open Collector Type (Hall Effect) Tachometer Senders only.

B) Run a two- or three-conductor shielded cable from the Starboard Processor to the Starboard engine's tachometer source.

C) Install a 1/2 inch (12,7mm) liquid tight cable grip into the appropriate hole of the Port and Starboard Processors.

D) Strip back 2 inches (50,8mm) of PVC jacketing from both ends of the cable.

E) Strip the ends of each conductor back 3/8 inch (9,5mm).

F) Clip off the drain wire flush with the PVC jacketing at the Tachometer source side only.

G) Place a 7/8 inch (22,23mm) section of shrink tubing over each end of the cable.

H) At the Processor side, bend the drain wire back and tuck it under the shrink tubing so that the drain wire end is exposed past the shrink tubing. (Refer to Figure 25: and Figure 26:).

Figure 25: AC Type Tachometer Cable

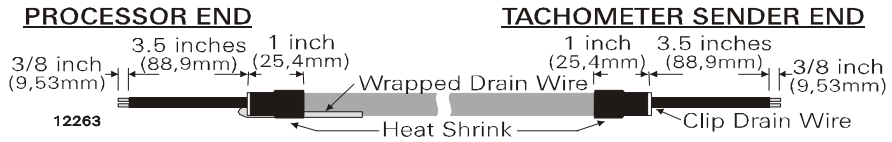
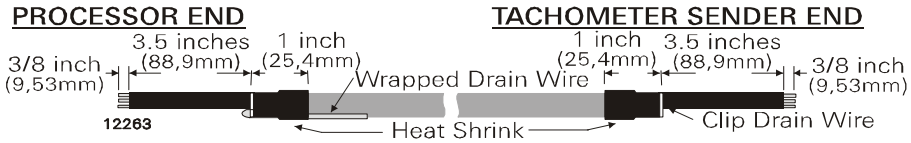


Figure 26: Open Collector Tachometer Cable



I) Shrink the tubing with a heat gun.

J) Insert the cable ends through the liquid tight connectors and tighten the nuts.

K) Secure the cables internally using a Clamp as shown in Figure 6:, Clamp Views. Make certain that the drain wire makes contact with the Clamp's metallic surface.

L) Clip the exposed drain wires flush with the Clamps.

M) Connect the conductors to the terminal block as listed in Table 6:.

Table 6: Processor Circuit Board Connections for Tachometer

Conductor Color	Processor Termination	Description	Notes
Red	TB9-1	Sensor Supply (+9VDC)	Required when Open Collector (i.e., Hall Effect Sensors) only
Green	TB9-2	AC Type Tachometer Input	The green wire connects here when AC Type Tach Sensors (i.e., Mechanical Senders, Magnetic Pickup, Alternator AC, etc.) are being used.
Green	TB9-3	Open Collector Tachometer Input	The green wire connects here when an Open Collector Type Tach Sender is used.

Table 6: Processor Circuit Board Connections for Tachometer

Conductor Color	Processor Termination	Description	Notes
Black	TB9-4	Return for Tachometer Input	Negative connection for both types of Senders.
Silver	Clamp	Drain Wire (Shield) connection	Connection made at Processor side only.

4-5 Engine Stop Switches

An engine stop switch(s) must be located at all Remote Stations and capable of stopping the engine at any RPM.

The Installer supplies the Stop Switches. Refer to the installation instruction supplied with the switch and the engine installation instructions for manufacturers recommendations.

WARNING: An Engine Stop Switch at each Remote Station is an absolute requirement. Refer to CFR 46, SEC. 62.35-5 and ABYC P-24.5.8.

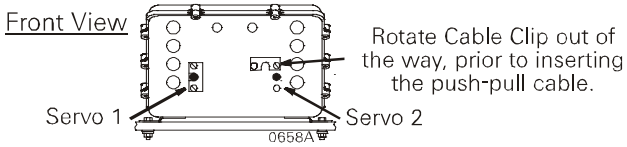
4-6 Push-Pull Cable Connections

4-6.1 Processor

A) Remove the #10-32 jam nut and the two rubber seals from the end of each push-pull cable that is to connect to the Processor(s) only; discard the seals, but save the nuts.

B) Remove one screw from each Cable Anchor Clip and loosen the other screw. Swing the two Clips clear.

Figure 27: Processor Cable Clamp Rotation

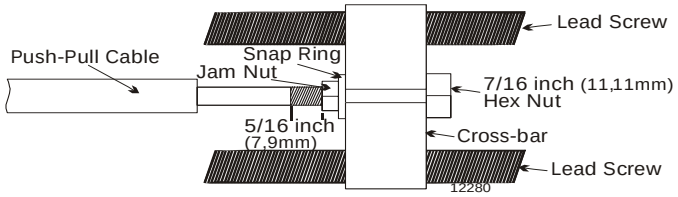


C) Insert the appropriate push-pull cable into the Processor according to the labels located above the cable clips on the Processor enclosure.

D) When the push-pull cable end is visible within the Processor interior, reinstall the #10-32 jam nut.

E) Connect the push-pull cables to the hex nuts (See Figure 28:). Use a 7/16 inch socket to turn the hex nut onto the cable rod end until there is approximately 5/16 inch (7,9mm) of thread showing beyond the jam nut.

Figure 28: Processor Push-Pull Cable Interior Connections



F) Use a 7/16 inch socket wrench and a 5/16-inch open end wrench to tighten the jam nuts.

G) Position the Cable Anchor Clips to secure the cables to the Processor housing.

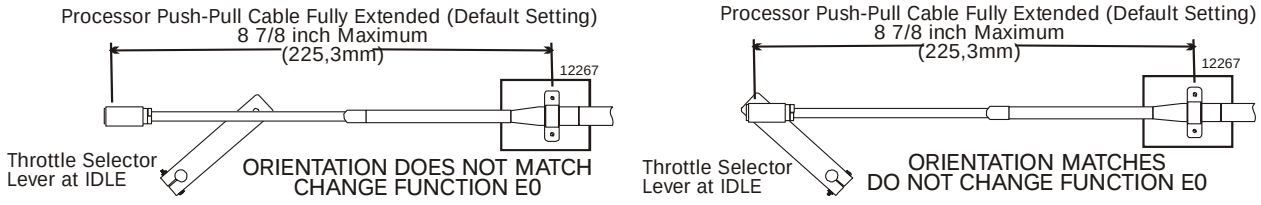
H) Install the screws removed in step B).

I) Tighten all Cable Anchor Clip screws.

4-6.2 Throttle Selector Lever

A) Ensure that the Throttle push-pull cable and the engine's throttle lever are in close proximity to one another at Idle. If so, proceed to step C) and if not continue with step B).

Figure 29: Throttle Push-Pull Idle Orientation to Selector Lever



B) If the throttle lever is at the opposite side from the push-pull cable, change the Throttle Servo Direction **E0** as described in Section 5 - SET UP PROCEDURES.
C) Adjust the ball joint on the Throttle cable to match the throttle lever at the Idle stop position.
D) Ensure that adequate cable threads are showing.
E) Tighten the jam nut.

4-6.3 Shift Selector Lever

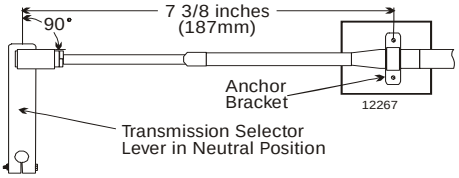
CAUTION: Misadjusted Shift Push-Pull Cables can cause damage to the Transmission's Clutch Pack. Ensure adjustments are made correctly and completely.

A) Check the engine and transmission to see if the push-pull cable anchor brackets have been installed. If the brackets are not on the transmission, select from the Appendix A - Morse Clutch and Throttle Kit Selection, or fabricate brackets as shown in Appendix A - Universal Mounting Kit.

B) Turn power ON to the Control System, to ensure that Neutral/Idle is commanded.

C) With the Shift Push-Pull cable disconnected at the clutch selector lever, adjust the Shift cable's ball joint at the transmission to align with the clutch selector lever at Neutral. The push-pull cable must form a 90 degree angle to the clutch selector lever.

Figure 30: Shift Push-Pull Cable Neutral Connection at Transmission



D) Connect the ball joint to the clutch selector lever.

5 SET UP PROCEDURE

The Processor utilizes push buttons in conjunction with Display LED's to program, adjust, calibrate and set up the various features. The push buttons also allow you to access and display information regarding the health of the System.

The following paragraphs explain how to locate and use the push buttons and Display LEDs:

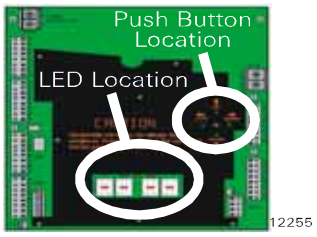
5-1 Processor Components Used In Set Up

- Each Processor has a Display LED and Push Buttons.
- The Display LED can be viewed through a window on the Processor's cover.

Figure 31: Typical Processor Cover

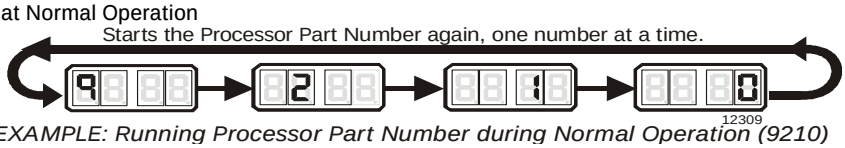
- The Processor enclosure cover must be removed to access the Push Buttons.
- The **Display LED** is used to view the Function Codes and the Values for those Functions.
- The **Push Buttons** are used to scroll through Function Codes, select Function Codes and set the Values of the Function Codes.

Figure 32: Processor Shield Push Button and Display LED Locations



5-1.1 Processor Display LED

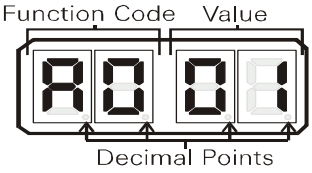
Figure 33: Display LED at Normal Operation



EXAMPLE: Running Processor Part Number during Normal Operation (9210)

- The Processor's Display LED has four 7-segment LED's, which light up to show either letters or numbers.
- The Display LED will have the Processor Part Number showing in a running pattern during Normal operation (Figure 33:)
- The first two digit Display LED's to the left, indicate the **Function Code**, which is alphanumeric.
- The second two digit Display LED's indicate the numeric **Value** that is programmed into the Processor for the Function Code displayed to the left.
- A **decimal point** indicator is located on the bottom right corner of each Display LED.

Figure 34: Display LED Designations



5-1.2 Push Buttons

The Processor has four Push Buttons located on the Circuit Board. They are identified by the words LEFT, RIGHT, UP and DOWN silk-screened on the Shield covering the Circuit Board.

Figure 35: Push Buttons

5-1.2.1 Up and Down Push Buttons

Pressing the Up or Down Push Buttons once has the following functions:

- Stops Normal Operation Display (running Processor Part Number) and activates the Function Menu.
- While in the Function Menu, scrolls through the Function Codes one at a time.
- When an Error Code is displayed, scrolls through the error messages one at a time. (Refer to Section B8 - ERROR CODES)
- When in Set Up Mode, increases (Up) or decreases (Down) the Value one digit at a time.

5-1.2.2 Left and Right Push Buttons

Pressing and holding the Left and Right Push Buttons simultaneously has the following functions:

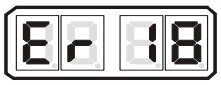
- Activates Set Up Mode as indicated by the blinking Display LED. (must hold the buttons until the blinking begins)
- While in Set Up Mode, deactivates Set Up Mode, saves the displayed Value to memory and returns to the Function Menu. (must hold the button until the blinking stops)

5-1.2.3 Left Push Button Only

Pressing the Left Push Button once has the following functions:

- Deactivates Set Up Mode without any changes to the Value being stored to memory. The Left Push Button must be held down until function code stops blinking. The default value will then be displayed.

Figure 36: Display LED Error Menu Example

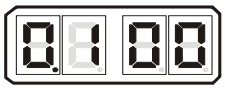


- While in Function Menu, changes the Display LED to the Error Menu, if any errors are present. (has no effect if there are no errors stored)
- While in the Error Menu, changes the Display LED back to the Function Menu.

5-1.2.4 Right Push Button Only

Pressing the Right Push Button once has the following functions:

Figure 37: Display LED Four Digit Value



- While in the Error Menu, clears inactive errors. (Active errors blink, inactive do not)
- While in Set Up Mode or Function Menu, allows the Value of the current Function Code to be displayed with all four Display LEDs.

5-2 Activating Set Up Mode

NOTE: To Escape from the Set Up procedure at any time without saving the changed value to memory, depress the Left Push Button. The Function Code will stop flashing and the Function will be saved with the original Value.

A) The Display LED is in Normal operating condition with the red running Processor Part Number.
B) Depressing either the Up or Down Push Button will activate the Function Menu.
C) Depressing the Up or Down Push Button will scroll through the Function Codes one at a time.
D) Once the desired Function Code is visible on the Display LED, press and hold down the Left and Right Push Buttons simultaneously, until the Function Code begins to blink.
E) Depressing the Up Push Button will increase the Value of the Function, while pressing the Down Push Button will decrease the Value of the Function. (Pressing and holding the Up or Down Push Button will increase or decrease the Value rapidly)

5-3 Storing Values To Memory

Once the desired Value has been reached in Set Up Mode, the Value is stored to memory as follows:

A) Depress and hold the right push button first. Then while still depressing the right button, depress and hold the Left push button until the Function Code stops blinking.
   - The new Value is now programmed into memory.
   - Set Up Mode is exited.
B) Depress the Up or Down Push Button until the next required Function Code is reached.
C) Reactivate Set Up Mode.

NOTE:
If no Push Buttons are pressed for five (5) minutes, the selected Mode of operation is automatically exited and the System returns to Normal Operating Mode.
If no Push Buttons are pressed for five (5) minutes while in Set Up Mode, it will be exited without the changes stored to memory

5-4 Function Codes And Values

The following tables list the Function Codes' Name, Default Value and Range or available Options. **Each of the Function Codes are explained in further detail in the following sections.**

NOTE:
SINGLE SCREW APPLICATIONS: The Function Values may be entered and stored in any order.
MULTI SCREW APPLICATIONS: The A1 Function must be set FIRST, and the A0 Function must be set SECOND. The rest of the Function Values may be entered and stored in any order.
Once these parameters are set, either cycle power to the Processors or wait five (5) minutes, before continuing set up.

Table 7: Processor Function Codes

Function Code	Function Name	Default Value	Value Range or Options
A0	Processor Identification	01	01, 02, 03, 04, 05
A1	Number of Engines	01	01, 02, 03, 04, 05
A2	One Lever Operation	00	00 - Disabled; 01 - Enabled
A3	Station Expander (SE)	00	00 - Disabled; 01 - Enabled
DO NOT ADJUST THE ABOVE FUNCTION! Leave at default Value set by the Factory. Contact a ZF Marine Electronics Authorized Technician if this Function requires adjustment.			
A4	Neutral Indication Tone	00	00 - No Tone 01 - Tone upon Control Head engaging Neutral 02 - Tone upon Transmission shifting to Neutral

Table 8: Throttle Servo Function Codes

Function Code	Function Name	Default Value	Value Range or Options
E0	Throttle Servo Direction	20	20 - Push (Extends) for Throttle Increase 21 - Pull (Retracts) for Throttle Increase
E1	Throttle in Neutral	00.0	00.0 to 25.0% of Throttle Range
E2	Throttle Minimum	00.0	00.0 to 20.0% Must be 10% or more below Throttle Maximum (E3).
E3	Throttle Maximum	33.0	10.0 to 100.0% of Maximum Throttle Allowable. Must be 10% or more above Throttle Minimum (E2)
E4	Throttle Maximum Astern	100.0	00.0 to 100.0% of Throttle Maximum (E3)
E5	Throttle Pause Following Shift	00.5	00.0 to 05.0 Seconds
E6	High Idle	00.0	00.0 to 20.0% of Throttle Range.
E7	Synchronization	00	00 - Equal Throttle (Open Loop) Synchronization 01 - Active (Closed Loop) Synchronization (reverts to Equal if Tach Signal lost) 02 - No Synchronization 03 - Active (Closed Loop) Synchronization (no synchronization if Tach Signal is lost)

Table 9: Solenoid Clutch Function Codes

Function Code	Function Name	Default Value	Value Range or Options
C0	Clutch Pressure Interlock	00	00 – Not Installed; 01 – Installed 02 – Throttle Clutch Pressure Interlock Mode
C1	Clutch Interlock Delay	00.5	00.5 to 10.0 Seconds
C2	Proportional (Reversal) Pause	00	00 – In-Gear; 01 – Neutral; 02 – Fixed Neutral Delay Enabled (NOTE: If C2 is set to 02, the setting of C3 will set Fixed Neutral Delay C8.)
C3	Proportional (Reversal) Pause Time	04	00 to 99 Seconds
C4	Proportional (Reversal) Pause Ratio	00	00 – 2:1 Ahead to Astern vs. Astern to Ahead 01 – 1:1 Ahead to Astern vs. Astern to Ahead
C5	Clutch Servo Direction	20	20 - Pull [Retracts for Ahead 21 - Push [Extends] for Ahead
C6	Clutch Ahead	80	00-100% of Maximum Ahead Travel from Neutral.
C7	Clutch Astern	80	00-100% of Maximum Astern Travel from Neutral.

Table 10: Trolling Valve Function Codes

Function Code	Function Name	Default Value	Value Range or Options
L0	Troll Enable and Control Head Troll Lever Range	00	00 – No Troll 01 – 20 Degrees- Type 1 02 – 35 Degrees- Type 2 03 – 45 Degrees- Type 3 (Throttle limited to 75% of Throttle Range) 04 – 55 Degrees- Type 4 (Throttle limited to 10% of Throttle Range)
Troll Functions are only available and displayed when a P/N 9001 Troll Actuator is connected to the Processor. Refer to MM9001 Manual for Functions.			

Table 11: Servo Troubleshooting Function Codes

Function Code	Function Name	Default Value	Value Range or Options
H0	Diagnostic	00	Input Voltage (+/- 0.5VDC) Tachometer Sensor Frequency Lever A/D, Stations 1, 2, 3, 4, & 5 Servo 1 & 2 A/D Feedback Transfer Button, Stations 1, 2, 3, 4, & 5 Software Revision Level
H1	Erase EPROM	00	Store to Return to Factory Defaults; (For Authorized Personnel Only)

5-5 System Programming and Adjustments

NOTE:
SINGLE SCREW APPLICATIONS: The Function Values may be entered and stored in any order.
TWIN SCREW APPLICATIONS: The A1 Function must be set FIRST, and the A0 Function must be set SECOND. The rest of the Function Values may be entered and stored in any order.

NOTE: Power must be turned ON to the Processors when programming or making any adjustments to the System.

NOTE: In order to prevent nuisance alarms when first setting up a System, some Function Codes take up to 5 minutes to become ACTIVE. The Functions affected by this are the functions that rely on Serial Communication, such as A0, A1, A2, A3, E7, and L0. Cycling power OFF, then ON, expedites these features making the Functions available immediately.

5-5.1 Processor Functions

5-5.1.1 Function Code A0 – Processor Identification

NOTE: In twin screw or more applications, the Value of Function Code A0 must be changed AFTER the Value in Function Code A1 has been changed to 02 or higher on ALL Processors.

In applications where there is more than one screw, the system must know which Processor is where. Every Processor must have its OWN UNIQUE identifying number. At NO time can two or more Processors be identified by the same Processor Identification Number.

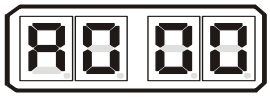
The available Values for this Function are:

00 (Default Value), **01, 02, 03, 04** and **05.**

NOTE: If Processors are not connected by a serial communication cable, leave the A0 Function Code at Default Value 00.

To change the Value (Refer to Sections 5-2 and 5-3):

Figure 38: Display LED Function A0



A) Scroll to Function Code **A0.**
B) Activate Set Up Mode.
C) Scroll Up or Down to the desired Value.
D) Store the Value to memory.
E) Repeat on all Processors BEFORE proceeding to the next Function.

NOTE: Before continuing set up, wait 5 minutes or cycle power.

5-5.1.1 Function Code A1 – Number of Engines

NOTE: If Processors are not connected by a serial communication cable, leave the A1 Function Code at Default Value 01.

The total number of engines must be entered into the memory of each of the Processors. All Processors in an installation must have the SAME VALUE entered.

The available Values for this Function are:

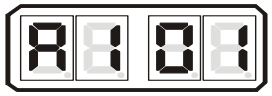
01 Single Screw (**Default Value)**
02 Twin Screw
03 Triple Screw (if required, contact a ZF Marine Technician.)
04 Quad Screw (if required, contact a ZF Marine Technician.)
05 Quint Screw (if required, contact a ZF Marine Technician.)

NOTE: Twin screw or more applications require Function Code A1 Value to be changed on ALL Processors prior to changing the Value of Function Code A0.

To change the Value (Refer to Sections 5-2 and 5-3):

A) Scroll to Function Code **A1.**
B) Activate Set Up Mode.
C) Scroll Up or Down to the desired Value.
D) Store the Value to memory.

Figure 39: Display LED Function A1



5-5.1.2 Function Code A2 – One Lever Operation

In Twin Screw or more applications, the System has the ability to command all engines and transmissions to the same speed and direction with a single Control Head lever. This Function allows this Feature to be enabled or disabled. (Refer to Section 2 - OPERATION, for operating instructions)

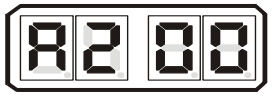
The available Values for this Function are:

00 Disabled **(Default Value)**
01 Enabled

To change the Value (Refer to Sections 5-2 and 5-3):

A) Scroll to Function Code **A2**.
B) Activate Set Up Mode.
C) Scroll Up or Down to the desired Value.
D) Store the Value to memory.

Figure 40: Display LED Function A2



5-5.1.3 Function Code A3 – SE (Station Expander)

NOTE: This Manual does not go into detail on the Station Expander installation and adjustments. For further information on the Station Expander, refer to Section 8 - CONTROL OPTIONS or contact your local ZF Marine Electronics Representative.

The SE is a separate unit, which gives the System the ability to increase the number of Remote Stations.

The available Values for this Function are:

00 Disabled **(Default Value)**
01 Enabled

Contact ZF Marine Electronics if this Function Code is going to be changed from the default setting.

5-5.1.4 Function Code A4 – Neutral Indication Tone

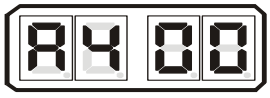
This Function allows the installer to turn ON a 1/2 second, low frequency tone to indicate Neutral.

The available Values for this Function are:

00 Disabled (**Default Value)**
01 Tone sounds when the Control Head's lever reaches Neutral.
02 Tone sounds when the Processor commands the Transmission to Neutral.

To change the Value (Refer to Sections 5-2 and 5-3):

Figure 41: Display LED Function A4



A) Scroll to Function Code **A4.**
B) Activate Set Up Mode.
C) Scroll Up or Down to the desired Value.
D) Store the Value to memory.

5-5.2 Throttle Functions

The following Throttle Functions are set up in Section 6 - DOCK TRIALS:

Table 12: Throttle Functions Performed during Dock Trials

Code	Function Name	Code	Function Name
E1	Throttle in Neutral	**E4**	Throttle Maximum Astern
E2	Throttle Minimum	**E5**	Throttle Pause Following Shift
E3	Throttle Maximum	**E6**	High Idle

5-5.2.1 Function Code E0 – Throttle Servo Direction

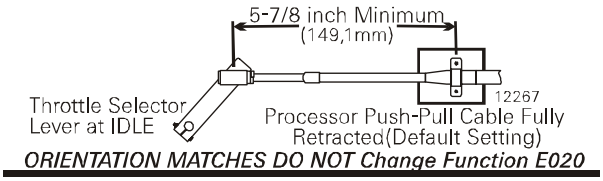
This Function determines if the Throttle Push-Pull cable is fully extended or retracted when at Idle.

The available Values for this Function are:

20 Fully Retracted at Idle, extends [Push] for Throttle increase **(Default Value)**
21 Fully Extended at Idle, retracts [Pull] for Throttle increase

To change the Value (Refer to Sections 5-2 and 5-3):

Figure 42: Throttle Push-Pull Cable Orientation



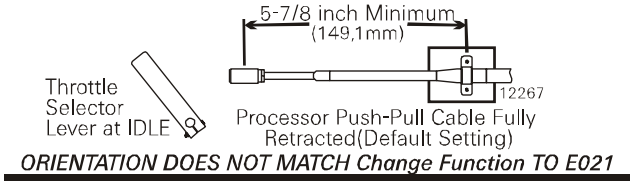
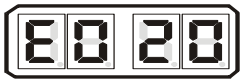


Figure 43: Display LED Function E0



A) Ensure that the engine's Governor or Carburetor lever is at the Idle position.
   - If the Throttle Push-Pull cable's ball joint is close to the Throttle lever's position, no change is required to this Function Code.
   - If the Throttle Push-Pull cable's ball joint is at the opposite side of the lever's position, continue with the next step.

B) Scroll to Function Code **E0**.
C) Activate Set Up Mode.
D) Scroll Up or Down until Value **21** is displayed.
E) Store the Value to memory.
   - The Throttle Push-Pull cable's ball joint should drive to the Throttle lever's Idle position.

F) Do <u>not</u> connect the ball joint to the throttle lever at this time.

5-5.2.2 Function Code E7 – Synchronization

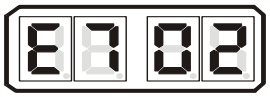
This Function Code selects the type of Synchronization, if Synchronization is required. The types are described in Section 2 - OPERATION .

The available Values for this Function are:

00 Equal Throttle (Open Loop) Synchronization
01 Active (Closed Loop) Synchronization (reverts to Equal Throttle Synch if there is no Tachometer Sensor signal)
02 No Synchronization **(DEFAULT VALUE)**
03 Active (Closed Loop) Synchronization (reverts to no Synchronization if there is no Tachometer Sensor signal)

To change the Value (Refer to Sections 5-2 and 5-3):

Figure 44: Display LED Function E7



A) Scroll to Function Code **E7**
B) Activate Set Up Mode.
C) Scroll Up or Down to the desired Value.
D) Store the Value to memory.

5-5.3 Clutch Functions

The following Clutch Functions are set up in Section 7 - SEA TRIALS:

Table 13: Basic Clutch Functions Performed during Sea Trials

Code	Function Name
C2	Proportional (Reversal) Pause

Code	Function Name
C3	Proportional (Reversal) Pause Time

5-5.3.1 Function Code C0 – Clutch Pressure Interlock

This adjustment is to be set to Enabled only if the optional Clutch Pressure Switch is being used with this application.

This Function enables or disables the feature and allows for two different modes of behavior when a Clutch Pressure Switch is used. Refer to Section 8 - CONTROL OPTIONS, for detailed information.

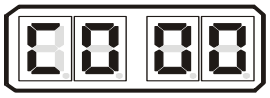
The available Values for this Function are:

00 Not Installed **(Default Value)**
01 Installed
02 Throttle Clutch Pressure Interlock Mode

NOTE: The C002 value is recommended in Gear Boxes that take longer than 10 seconds to reach operating pressure. Refer to Section 8 - CONTROL OPTIONS for more information on the settings.

To change the Value (Refer to Sections 5-2 and 5-3):

Figure 45: Display LED Function C0



A) Scroll to Function Code **C0**.
B) Activate Set Up Mode.
C) Scroll Up or Down to the desired Value.
D) Store the Value to memory.

5-5.3.2 Function Code C1 – Clutch Interlock Delay

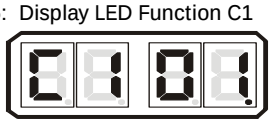
This adjustment is to be set to Enabled only if the optional Clutch Pressure Switch is being used with this application.

This Function works together with Function Code **C0** – Clutch Pressure Interlock. Refer to Section 8 - CONTROL OPTIONS, for further information.

The available Values are **00.5** to **10.0** seconds. The Default Value is **01.0** seconds.

To change the Value (Refer to Sections 5-2 and 5-3):

Figure 46: Display LED Function C1



A) Scroll to Function Code **C1**.
B) Activate Set Up Mode.
C) Scroll Up or Down to the desired Value.
D) Store the Value to memory.

5-5.3.3 Function Code C4 – Proportional (Reversal) Pause Ratio

This Function Code selects whether the Proportional (Reversal) Pause Time is the same in Ahead and Astern or whether the time in Ahead is twice that in Astern.

Standard vessels with a bow and a stern typically select a pause which is twice as much in Ahead compared to Astern. This is because much more speed is obtainable in Ahead, than Astern. Consequently, more time is required to slow down from Ahead as compared to Astern.

NOTE: When the Controls are installed on a vessel such as a double ended Ferry or the Controls are being used to control a thruster, the proportional pause should be the same in Ahead as Astern or Port and Starboard in the case of a Thruster.

The available Values for this Function are:

00 - 2:1 Ratio **(DEFAULT)**

- This is the default setting and determines how the value set in the Proportional (Reversal) Pause Time **C3** Function is applied.
- The number of seconds selected is for an Ahead to Astern maneuver only. An Astern to Ahead maneuver will be one-half of the **C3** - Proportional (Reversal) Pause Time selected. This is the typical selection since most vessels do not reach the same throttle in Astern as they would in Ahead.

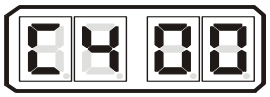
Therefore, the time required to get to a sufficient water speed for a safe reversal is significantly less.

01- 1:1 Ratio

- When this setting is selected, the value set in the Proportional (Reversal) Pause Time **C3** is the SAME for both Ahead to Astern, as with Astern to Ahead maneuvers.
- This may be selected when the vessel reaches the same water speed in both directions, as would be the case with a Double Ended Ferry. Another application where this option may be selected would be the control of a Bow or Stern Thruster.

To change the Value (Refer to Sections 5-2 and 5-3):

Figure 47: Display LED Function C4



A) Scroll to Function Code **C4.**
B) Activate Set Up Mode.
C) Scroll Up or Down to the desired Value.
D) Store the Value to memory.

5-5.3.4 Function Code C5 – Clutch Servo Direction

This Function allows the Processor to be programmed to retract the Push-Pull cable for Ahead or extend for Ahead.

The available Values are:

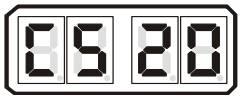
20 Pull [Retracts] for Ahead (**Default**)
21 Push [Extends] for Ahead

Figure 48: Clutch Push-Pull Cable Orientation

To change the Value (Refer to Sections 5-2 and 5-3):

A) Position the Clutch Selector Lever to the Ahead position.
B) Move a Control Head lever into the Ahead detent.
C) Check the Shift Push-Pull cable to see if it drove in the correct direction for Ahead.
   - If the cable drove in the correct direction, no change to this Function Code is required.
   - If the cable drove in the opposite direction, continue with the next step.

Figure 49: Display LED Function C5



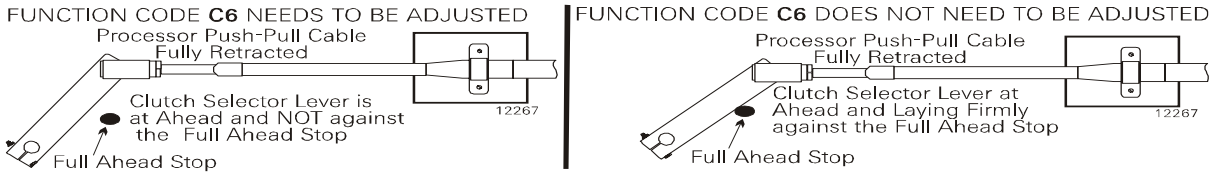
D) Scroll to Function Code **C5**.
E) Activate Set Up Mode.
F) Scroll Up to change the Value to **21**.
G) Store the Value to memory.

5-5.3.5 Function Code C6 – Servo Clutch Ahead Travel

This function adjusts the amount of Clutch push-pull cable travel in both the Ahead and the Astern directions.

The available Values are **00.0** to **100.0%** of the maximum available travel from Neutral to Ahead. The Default Value is **80**%.

Figure 50: Clutch Push-Pull Cable Ahead Position



To change the Value (Refer to Sections 5-2 and 5-3):

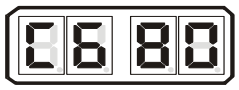
A) Move the Control Head lever to the Ahead detent.

B) Move the Clutch Selector Lever to the Ahead stop.

C) Does the cable's ball joint and lever align?
- If yes, no further adjustment of this Function is required.
- If no, continue with the next step.

D) Scroll to Function Code **C6**.

Figure 51: Display LED Function C6



E) Activate Set Up Mode.

F) Scroll Up or Down until the ball joint and lever align perfectly.

G) Store the Value to memory.

H) Return the Control Head lever to the Neutral/Idle position.

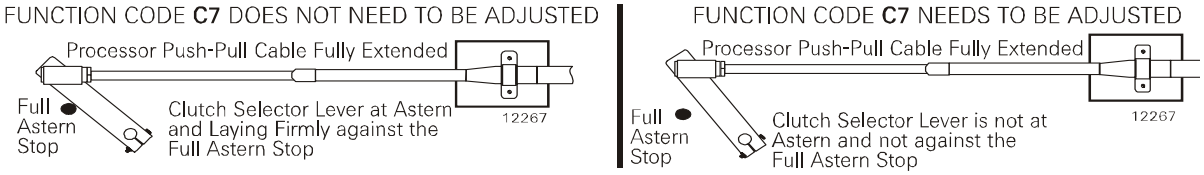
5-5.3.6 Function Code C7 – Clutch Astern Travel

This function is only required when the distance from Neutral to Astern differs from Neutral to Ahead.

This Function Code allows the independent adjustment of Astern travel. Otherwise, the Value selected in Function Code **C6** is automatically entered for Function Code **C7**.

The available Values are **00.0** to **100.0%** of the available travel from Neutral to Astern. The Default Value is **80**%.

Figure 52: Clutch Push-Pull Cable Astern Position



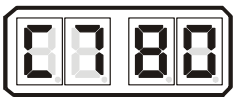
To change the Value (Refer to Sections 5-2 and 5-3):

A) Move the Control Head lever to the Astern detent.

B) Move the Clutch Selector Lever to the Astern stop.

C) Does the cable's ball joint and lever align?
- If yes, no further adjustment of this Function is required.
- If no, continue with the next step.

Figure 53: Display LED Function C7



D) Scroll to Function Code **C7**.

E) Activate Set Up Mode.

F) Scroll Up or Down until the ball joint and Clutch Selector lever aligns perfectly.

G) Connect the ball joint to the Clutch Selector lever.

H) Store the Value to memory.

I) Return the Control Head lever to the Neutral/Idle position.

5-5.4 Troll Functions

A 9001 Troll Actuator is required to offer Trolling Valve Control. Refer to the 9001 Troll Manual (p/n MM9001) for Installation and Set Up of the Troll Functions.

6 DOCK TRIALS

WARNING: It is imperative that the information provided in the previous Sections have been READ and FOLLOWED precisely, PRIOR to attempting a Dock Trial.

CAUTION: With I/O or Outboard applications, do not attempt to shift into or out of gear with engines stopped. This may cause a jam condition or damage to the linkage to some clutch configurations.

NOTE: On multiple screw applications, the following tests must be performed on all Processors. If any of the following tests fail, consult Appendix B Troubleshooting.

6-1 Control Heads (Engines Stopped)

A) Turn power ON to the Control System.

B) The Control Head at each Remote Station should produce an intermittent tone.

C) Take command at a Remote Station.

D) Perform each of the following steps on all Remote Stations.

1 Move the Control Head's lever(s) full Ahead and full Astern. Ensure that there are no obstructions to the movement, the Processor reacts to the lever movement, and that no tones are generated.

2 Place the Control Head's lever(s) in the Neutral position.

3 Depress and hold the Station transfer button while moving the Control Head's lever(s) to the Ahead detent. Release the transfer button.

- The red LED on the Control Head should blink, indicating Warm-up Mode has been entered. Warm-up Mode only operates in the Ahead direction. If the red indicator light BLINKS, continue with the testing.
- If the red indicator light DOES NOT BLINK, check connections as stated in the appropriate Appendix A - Control Head Service Sheet.

6-2 Start Interlock (Engines Stopped)

A) Turn the Processor DC power OFF.

- Verify that the engine(s) will not start.

B) Turn Processor DC power ON. Do not take command at a Remote Station.

- Verify that the engine(s) will not start.

C) Take command at a Remote Station. Place the Control Head's lever(s) to approximately 50% of the throttle range.

- Verify that the engine(s) will not start.

D) Place the Control Head's lever(s) in the Neutral/Idle position. Take command at a Remote Station.

- Verify that the engine(s) will start in this position.

If any of the above tests fail, verify Start Interlock installation and connections. Refer to Section 4 - INSTALLATION.

6-3 Servo Throttle Dock Settings (Engines Stopped)

6-3.1 Function Code E3 – Throttle Maximum

This Function adjusts the position of the Throttle Push-Pull cable at Full Throttle.

The available Values for this Function are **10.0**% to **100.0**%.

The Default Value is **33.0**%. This value will always be 10% or more above **E2** Throttle Minimum.

The Value entered is the percentage of the servo's maximum travel of 3.00 inches (76,2mm).

Example: A Value of **50.0**, will equal **1.50 inches (38,1mm)** of travel from Idle to Full Throttle.

Figure 54: Throttle Push-Pull Cable Full Throttle Position

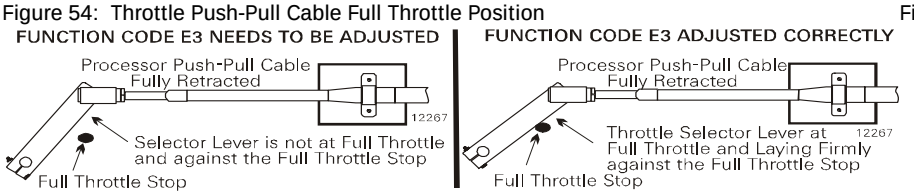
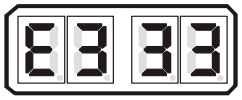


Figure 55: Display Function Code E3



To change the Value (Refer to Sections 5-2 and 5-3):

A) Take command at a Remote Station.
B) Move the Control Head lever to the Full Ahead position.
C) Check to see if the Throttle Push-Pull cable reaches the Full Throttle stop.
   - If the Throttle lever is firmly (not bound) against the Full Throttle stop, no adjustment to Function Code **E3** is required.
   - If the Throttle lever does not reach (or is bound against) the Full Throttle stop, continue with the next step.
D) Scroll to Function Code **E3**.
E) Activate Set Up Mode.
F) Scroll Up or Down until the Throttle lever is firmly (not bound) against the Full Throttle Stop.
G) Store the Value to memory.
H) Return the Control Head lever to the Neutral/Idle position.

6-3.1 Function Code E2 – Throttle Minimum

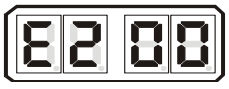
This Function further adjusts the Push-Pull cable's Idle position electronically. The primary purpose is to adjust the Push-Pull cable/Throttle Selector Lever's position is so that any further movement will result in an increase in engine RPM. (No Dead-band)

The available Values for this Function are **00.0** to **20.0**%. The Default Value is **00.0**%.

This value will always be **10%** or more below the **E3** Throttle Maximum setting.

To change the Value (Refer to Sections 5-2 and 5-3):

Figure 56: Display LED Function E2



A) Ensure that the Throttle push-pull cable is connected to the Throttle lever.
B) Scroll to Function Code **E2**.
C) Activate Set Up Mode.
D) Scroll Up until the engine RPM begins to increase above Idle.
E) Scroll Down until Idle RPM is reached.
F) Store the Value to memory.

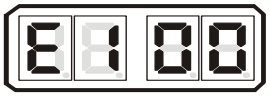
6-3.2 Function Code E1 – Throttle in Neutral

This Function allows the engine RPM at Neutral to be adjusted independently of the RPM at Idle Ahead and Astern.

The available Values for this Function are **00.0** to **25.0** percent of the Throttle Range. The Default Value is **00.0**%.

To change the Value (Refer to Sections 5-2 and 5-3):

Figure 57: Display LED Function E1



A) Scroll to Function Code **E1**.
B) Activate Set Up Mode.
C) Scroll Up or Down to the desired Value.
D) Store the Value to memory.

6-3.3 Function Code E4 – Throttle Maximum Astern

This Function limits the amount of Throttle permitted in Astern.

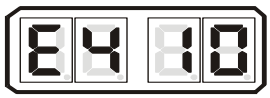
The available Values for this Function are **00.0**% to **100.0**%. The Default Value is **100.0**% of **E3** Throttle Maximum setting.

The Value selected is a percentage of the Value selected in Function Code **E3** – Throttle Maximum.

Example: A Value of **50.0** will allow **50%** of Throttle Maximum when commanding Astern. The Value selected is a matter of personal preference.

To change the Value (Refer to Sections 5-2 and 5-3):

Figure 58: Display LED Function E4



A) Scroll to Function Code **E4**
B) Activate Set Up Mode.
C) Scroll Up or Down to the desired Value.
D) Store the Value to memory.

6-3.4 Function Code E6 – High Idle

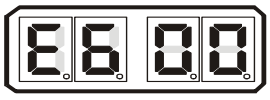
This Function Code Programs the RPM of the second, elevated Idle.

The available Values for this Function are **00.0** to **20.0**% of **E3** Throttle Maximum. The Default Value is **00.0**%.

The Value selected is a percentage of the Value selected in Function Code **E3** – Throttle Maximum.

To change the Value (Refer to Sections 5-2 and 5-3):

Figure 59: Display LED Function E6



A) Place the Station-in-Command Control Head into Warm-up Mode.
B) Scroll to Function Code **E6**.
C) Activate Set Up Mode.
D) Scroll Up or Down to the desired Value.
E) Store the Value to memory.
F) Return the Control Head levers to Neutral/Idle.

6-4 Servo Checks

6-4.1 Push-Pull Cables

A) Check that all Push-Pull cable connection fasteners are tightened securely.
B) Inside of the Processor(s) check that the Push-Pull cable jam nuts are securely tightened. A loose hex nut can back off the Push-Pull cable threaded end and effectively change the cable length.

6-5 Engine Stop Switches (Engines Running)

Start the engine(s) and verify that the Stop switches (normally push buttons) function correctly at all Remote Stations. Refer to the information supplied by the engine manufacturer or switch supplier for set up and adjustments.

CAUTION: An Engine Stop Switch at each station is an absolute requirement. Refer to CFR46, 62.35-5 and ABYC P-24.5.8.

WARNING: Do not attempt to continue tests until all Engine Stop Switches are functioning correctly!

6-6 Control Head Command Checks (Engines Running)

A) Start the engine(s) and let them run at Neutral/Idle.
B) Place one Control Head lever at a time into the Ahead detent, the Astern detent and then Neutral.
   - SERVO SHIFT: Confirm that the push-pull cable movement is in the direction commanded. If incorrect, perform the steps described in Section 5 - SET UP PROCEDURES "**C5** Clutch Servo Direction."
C) Place the Control System into Warm-Up Mode and confirm that there is control of speed.
D) Run the throttle up to approximately 20% of the throttle range for at least 10 seconds.
E) Return the lever to the Neutral/Idle position.
F) Repeat steps A) thru E) at the remaining Control Head levers.

6-7 Throttle Pause Following Shift (Engines Running)

6-7.1 Function Code E5 - Throttle Pause Following Shift

The available Values for this Function are **00.0** seconds to **05.0** seconds. The Default Value is **00.5** seconds.

This Function programs the amount of delay between the point that Clutch engagement is commanded and throttle is allowed to increase above Idle.

NOTE: A Test Control Head and a stop-watch are recommended to determine the correct setting for the Throttle Pause. If a Test Control Head is not available, a second person may be needed.

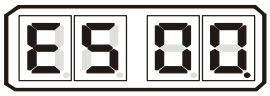
A) Move the Station in command's lever to the Ahead detent, while monitoring the Shaft.
   • SERVO THROTTLE: Start the stop-watch as soon as the Clutch Push-Pull cable stops moving.
B) When the Shaft begins to rotate, stop the stop-watch.
C) Record the time expired on the stop-watch..

NOTE: If the time recorded in step C) exceeds 5.0 seconds, a Clutch Pressure Interlock is required. Refer to Section 8 - CONTROL OPTIONS.

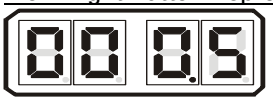
To change the Value (Refer to Sections 5-2 and 5-3, page 5-2):

Figure 60: Display LED Function E5

Default LED View



View Right Button Depressed.



A) Scroll to Function Code **E5.**
B) This Function can be set in tenths of a percent. To view the Value, depress the Right Push Button only.
C) Activate Set Up Mode.
D) Scroll Up or Down to the desired Value.
E) Store the Value to memory.

7 SEA TRIALS

WARNING: It is imperative that the information provided in the previous Sections has been read and followed precisely, prior to attempting a Sea Trial. If any of the following tests fail, discontinue the Sea Trial immediately and return to the dock. Consult Appendix B Troubleshooting Section or a ZF Facility prior to resuming the Sea Trial.

NOTE: On Multi Screw Applications, the following tests must be performed on all engines/transmissions. During the course of the Dock Trial and Sea Trials, fill out the Trial Report at the end of Section 7. Retain this information for future use.

7-1 Full Speed Setting

A) Warm-up the engine(s) and transmission(s) and slowly move into open water.

B) Gradually move the Control Head lever(s) to Full speed.

C) If synchronization is installed, disable synchronization as explained in Section 2 - OPERATION.

- SERVO THROTTLE: If the engine RPM is low, check whether the engine throttle lever is against the full speed stop. If it is not, adjust **E3** Throttle Maximum**,** as explained in Section 6 - DOCK TRIALS.
- If the engine RPM is high, decrease by using Function Code **E3** Throttle Maximum**,** as explained in Section 6 - DOCK TRIALS.

D) For multi screw applications, check that matching Idle, Mid-range and Full speed Control Head lever positions cause equal RPM on both engines.

- SERVO THROTTLE: If RPM's do not match, check push-pull cable travel. If travel does not match when the Control Head levers are side by side, adjust Function Code **E3** Throttle Maximum, refer to Section 6 - DOCK TRIALS.

7-2 Proportional (Reversal) Pause - C2

The proportional pause feature provides engine deceleration when making a direction change. The pause is variable and in proportion to:

- The Control Head's lever position prior to the reversal.
- How long the Control Head's lever has been in that position prior to the reversal.

7-2.1 Reversal Pause Type Sequences

The sequence of events, are as follows for the different Reversal Pause types: (Refer to the type being used on your vessel)

7-2.1.1 In-Gear Delay [C200]

1 The Throttle position drops to Idle.
2 The Transmission remains engaged in Ahead or Astern.
3 The Control System pauses at this position until the delay has timed out.
4 The Transmission shifts to the opposite gear (Astern or Ahead).
5 The Throttle position moves to the Control Head's present lever position.

7-2.1.2 Neutral Delay [C201]

1 The Throttle position drops to Idle.
2 The Tranmission shifts to Neutral.
3 The Control System pauses at this position until the delay has timed out.
4 The Transmission shifts to the opposite gear (Astern or Ahead).
5 The Throttle position moves to the Control Head's present lever position.

7-2.1.3 Fixed Neutral Delay [C202]

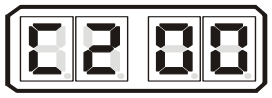
CAUTION: The Fixed Neutral Delay feature was added in order to accommodate Thruster Control installations. Damage to the drive train may occur when used for reverse reduction gear applications.

1 The Throttle position drops to Idle.
2 The Tranmission shifts to Neutral.
3 The Control System pauses at this position for the amount of time programmed (duration) with Function **C3** Proportional Pause Time (regardless of prior throttle setting).
4 The Transmission shifts to the opposite gear (Starboard or Port).
5 The Throttle position moves to the Control Head's present lever position.

7-2.2 Select Function Code C2 - Proportional (Reversal) Pause

To change the Value (Refer to Sections 5-2 and 5-3):

Figure 61: Display LED Function C2



A) Scroll to Function Code **C2.**
B) Activate Set Up Mode.
C) Scroll Up or Down to the desired Value.
D) Store the Value to memory.

7-3 Proportional (Reversal) Pause Time - C3

The Proportional Pause Time feature provides engine deceleration, followed by a pause in throttling to the commanded speed in the new desired direction, upon a Full-Speed Reversal. This pause time is proportional to how much throttle is being commanded and for how long.

In order to build up to the pause value set, the vessel must be at full throttle and Ahead six (6) times the pause set. The default pause from Astern to Ahead is 1/2 the Proportional Pause **C2** value set.

When **C2** Proportional Pause is set to **00**, the throttle position drops to Idle and the transmission remains engaged Ahead; the pause that follows is in proportion to the prior Control Head lever position and how long the lever had been in that position before the reversal.

NOTE: The pause on a through Neutral shift is proportional to the speed commanded and the time at that speed. The Values listed for Function Code C3 - Proportional (Reversal) Pause Time, are the maximum possible delays. When shifting from Idle Ahead to Idle Astern or vice-versa the delay is zero. The time required to build up to the maximum pause is six times the Value selected. In addition, in order to build up to the maximum delay Value, the System must be commanding Full Throttle. The Pause when shifting from Astern to Ahead is either half or the same as the Ahead to Astern delay depending on the Value selected for Function Code C4 - Proportional (Reversal) Pause Ratio.

7-3.1 Determine C3 Pause Requirement

NOTE: A stop-watch is required to accurately program the Proportional (Reversal) Pause Time.

The amount of pause required is determined as follows:

A) Place the Control Head lever(s) to the Full Ahead position.
B) Leave the Control Head lever(s) at this position for whichever of the following is longer:
   - Sixty seconds.
   - The vessel's speed through the water reaches maximum.
C) Quickly move the Control Head lever(s) to Ahead Idle or Neutral, (depending on Function Code **C4** setting stored during Set Up Procedures) while starting the stop-watch.
D) When the engine(s) RPM reaches Idle and the vessel's speed through the water is within two knots of the standard Idle Ahead speed, stop the stop-watch. Record Time_____.
E) Program Function Code **C3** to the time expired on the stop-watch.

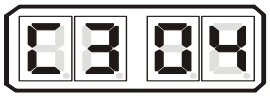
7-3.2 Store C3 - Proportional Pause Time Value

The available Values are **00** to **99** seconds. The default Value is **04** seconds.

To change the Value (Refer to Sections 5-2 and 5-3):

A) Scroll to Function Code **C3**.
B) Activate Set Up Mode.
C) Scroll Up or Down to the desired Value.
D) Store the Value to memory.

Figure 62: Display LED Function C2



7-3.3 Testing Proportional (Reversal) Pause Time

CAUTION: It is critical that the Proportional (Reversal) Pause is tested as outlined below, to ensure that is is properly programmed. Failure to do so could cause damage to the transmission.

A) Position the boat in open water and slowly increase the Throttle to 25% of the speed range.

B) Leave the Control Head lever(s) at this position for at least 60 seconds.

C) Quickly move the Control Head lever(s) to Idle Astern.
- The engine(s) RPM should drop to Idle.
- The Clutch should stay engaged or shift to Neutral for 25% of the time selected with Function Code **C3** Proportional Pause Time.
- Once the time has expired, the Clutch should Shift to Astern.
- The engine RPM will drop slightly when the Astern load is placed on the engine, but not to the point where it comes close to stalling.

D) Increase the Throttle slightly until the vessel starts moving in the opposite direction.
- If the engine stalled or came very close to stalling, increase the Value of Function Code **C3** by following the steps in the previous Section - "Program Function Code C3". Then repeat steps A) through C) of this Section.
- If the engine does not stall or come close to stalling, proceed with the next step.

E) Repeat steps A) through D) with the Throttle at 50%, 75%, and 100% of the speed range.
- If the engine stalls at any time, increase the Value of Function Code **C3** by one (1) second and repeat the steps A) through D) of this Section again.

F) Once a Full Speed Reversal is successful without coming close to stalling, the Proportional Pause is properly adjusted.

7-4 Synchronization Test

7-4.1 Equal Throttle Synchronization

A) Move both Control Head levers side by side to approximately 25% of the Throttle range.

B) If previously disabled, enable the synchronization by depressing the transfer button for two seconds.
- The green LED on the Control Head should illuminate, indicating synchronization.

C) Check the engine tachometers to see if they are within 1% of one another.

D) Move both Control Head levers side by side to approximately 50% of the Throttle range.

E) Check the engine tachometers to see if they are within 1% of one another.

F) Move both Control Head levers side by side to approximately 75% of the Throttle range.

G) Check the engine tachometers to see if they are within 1% of one another.

H) Move both Control Head levers side by side to 100% of the Throttle range.

I) Check the engine tachometers to see if they are within 1% of one another.
- While synchronized, if the tachometers have a greater than 1% difference at any engine RPM, Active Synchronization is recommended.

7-4.2 Active Synchronization

A) Move both Control Head levers side by side to approximately 25% of the Throttle range.

B) If previously disabled, enable the synchronization by depressing the transfer button for two seconds.
- The green LED on the Control Head may blink while driving toward synchronization.
- Once the engine RPM's are within 1% of one another, the green LED will remain solidly lit.

C) Check the engine tachometers to see if they are within 1% of one another.

D) Move both Control Head levers side by side to approximately 50% of the Throttle range.

E) Check the engine tachometers to see if they are within 1% of one another.

F) Move both Control Head levers side by side to approximately 75% of the Throttle range.

G) Check the engine tachometers to see if they are within 1% of one another.

H) Move both Control Head levers side by side to 100% of the Throttle range.

I) Check the engine tachometers to see if they are within 1% of one another.

While synchronized, if the tachometers have a greater than 1% percent difference at any engine RPM, or if they appear to be continually “hunting” for the correct RPM, refer to the Appendix B Troubleshooting Section.

7-5 Sea Trial Report

The purpose of this Sea Trial Report is to provide a convenient checklist and record of installation, dock trial set up, and sea trial performance of the ZF Marine Electronics Propulsion Control System. Please enter ALL of the information. We recommend that this form remains aboard the vessel, and a copy is sent to ZF Marine Electronics along with the Warranty Registration which is located at the end of Appendix A.

Table 14: Vessel Information

Vessel Name:		**Hull #**	**Trial Date:**
Vessel Type:		Dwg No.:	
Installing Yard/Project Manager:		Tel:	
Owner/Owner’s Representative:		Tel:	
ENGINE DATA:	MAKE:	MODEL:	HP(KW): RPM:
PROPELLER DATA:	No. of Screws:	Propeller Type:	Fixed Other
GEAR DATA:	MAKE:	MODEL:	RATIO:
NO. OF REMOTE STATIONS:	Locations:		

7-5.1 Control System Checks

Make the following checks prior to applying power to the Processor.

Table 15: Processor

	PORT		**STARBOARD**	
Processor Serial Number:				
Is the Processor subject to excessive heat? (Above 70 degrees C)	**YES**	**NO**	**YES**	**NO**
At least 4 feet (1,2m) from strong magnetic fields?	**YES**	**NO**	**YES**	**NO**
Accessible for checkout, adjustments, and maintenance?	**YES**	**NO**	**YES**	**NO**
Are the Processors grounded?	**YES**	**NO**	**YES**	**NO**
Are all Electric Cables supported every 18 inches (45,72cm)?	**YES**	**NO**	**YES**	**NO**
Are the electrical cable connections tight at the Processors and Control Heads?	**YES**	**NO**	**YES**	**NO**
Is the Processor’s Start Interlock Circuit being used? If NO, what type of start interlock is being utilized?	**YES**	**NO**	**YES**	**NO**
Is there an Engine Stop Switch installed at each Remote Station?	**YES**	**NO**	**YES**	**NO**
Does the Shift push-pull cable travel in the correct direction?	YES	NO	YES	NO
Is the amount of push-pull cable travel set properly for Shift?	YES	NO	YES	NO
Does the Throttle push-pull cable travel in the correct direction?	YES	NO	YES	NO
Is the amount of push-pull cable travel set properly for Throttle?	YES	NO	YES	NO
Are all of the push-pull cable fasteners tightened?	YES	NO	YES	NO
Are Control Head Harnesses Used?	**YES**	**NO**	**YES**	**NO**
Station 1 Length:				

Station 2 Length:
Station 3 Length:
Station 4 Length:
Station 5 Length:

Table 16: Power Supply

Processor Serial Number:	PORT	STARBOARD
What is the source of Processor power and how is it charged?		
Is there a backup power supply? APS or other, explain	**YES NO**	**YES NO**
Are the power cables protected by 10 Ampere Circuit Breakers?	**YES NO**	**YES NO**
If separate power supplies are used for each Processor, do they have a common ground?	**YES NO**	**YES NO**
What is the Voltage when not being charged?	**Battery_____ VDC** **Processor _____ VDC**	**Battery_____ VDC** **Processor _____ VDC**
What is the Voltage when connected to Shore Power?	**Battery_____ VDC** **Processor _____ VDC**	**Battery_____ VDC** **Processor _____ VDC**
What is the Voltage when the engines are running?	**Battery_____ VDC** **Processor _____ VDC**	**Battery_____ VDC** **Processor _____ VDC**

Table 17: Dock Trials

Processor Serial Number:	**PORT:**	**STARBOARD:**
Does the engine start when the Control System is turned OFF?	**YES NO**	**YES NO**
Does the Engine Stop Switch function at all Stations, regardless of RPM?	**YES NO**	**YES NO**
Can all Remote Stations take command?	**YES NO**	**YES NO**
Does the Warm-up Indicator Light blink in Ahead?	**YES NO**	**YES NO**
What is the Low Idle RPM?	**RPM**	**RPM**
High Idle RPM (optional)	**RPM**	**RPM**
Does the vessel surge forward with Control Head lever in the Ahead Detent?	**YES NO**	**YES NO**

Table 18: Sea Trials

Processor Serial Number:	**PORT:**	**STARBOARD:**
Do the Dual Control Head levers match position and RPM throughout the speed range?	YES NO	YES NO
The Full Speed Reversal Delay is set for how many seconds?	SECONDS	SECONDS

Table 18: Sea Trials

Processor Serial Number:	PORT:	STARBOARD:
Is Synchronization operational?	YES NO	YES NO
What is the Full Throttle RPM?	RPM	RPM

7-5.2 Record Parameters

Record information onto the following Tables only after ALL information has been recorded in the previous Section **Control System Checks.**

Table 19: Record Processor Functions

CODE:	FUNCTION NAME:		PORT:	STBD:
A0	**Processor Identification**			
A1	**Number of Engines**			
A2	**One Lever Operation**			
A3	**Station Expander (SE)**	Leave At Default. If Used, Contact A ZF Marine Electronics Representative		
A4	**Neutral Indication Tone**			

Table 20: Record Throttle Functions

CODE:	FUNCTION NAME:	PORT:	STBD:
E0	**Throttle Servo Direction**		
E1	**Throttle in Neutral**		
E2	**Throttle Minimum**		
E3	**Throttle Maximum**		
E4	**Throttle Maximum Astern**		
E5	**Throttle Pause Following Shift**		
E6	**High Idle**		
E7	**Synchronization**		

Table 21: Record Clutch Functions

CODE:	FUNCTION NAME:	PORT:	STBD:
C0	**Clutch Pressure Interlock**		
C1	**Clutch Interlock Delay**		
C2	**Proportional (Reversal) Pause**		
C3	**Proportional (Reversal) Pause Time**		
C4	**Proportional (Reversal) Pause Ratio**		
C5	**Clutch Servo Direction**		
C6	**Clutch Ahead**		
C7	**Clutch Astern**		

Table 22: Record Troll Functions

CODE:	FUNCTION NAME:	PORT:	STBD:
L0	Troll Enable and Control Head Troll Lever Range	LEAVE AT DEFAULT. IF REQUIRED, CONTACT A ZF MARINE ELECTRONICS REPRESENTATIVE TO PURCHASE A 9001 TROLL ACTUATOR. REFER TO THE MANUAL INCLUDED WITH THE 9001 FOR SET UP.		

7-5.3 Comments (Please use additional paper as necessary):

7-5.3.1 General Installation Condition

7-5.3.2 Any Irregularities:

INSPECTOR_____ DATE_____

8 CONTROL OPTIONS

8-1 External Alarm Capability

CAUTION: The Processor's Alarm circuit is limited to a maximum current of 0.5 Amperes and a maximum voltage of 100 Volts DC. Exceeding these limits will permanently damage the Alarm circuit.

The Processor comes equipped with a normally open relay contact for connection to an external Status Indication circuit. The relay energizes, closing the contact when the Circuit Board has power applied and the software program is running normally. In the event of a power loss or the software program detects an anomaly, the relay de-energizes and the contact opens.

Table 23: Figure 63: and Figure 64: Designators

A	DC Power Source (12 or 24 VDC)
B	Fuse
C	Alarm Indication Circuit ON/OFF Switch
D	Relay with a Normally CLOSED Contact and a Diode across the Coil for Surge Suppression
E	Control System Fail Indicator Light (and/or Audio Alarm.
F	ZF Marine Electronics Processor
G	Maximum Current 0.5 A

For +V = 12 VDC R Load > 0.37 Ohm For +V = 24 VDC R Load > 0.18 Ohm

Figure 63: External Alarm Connections with Processor Harness Example

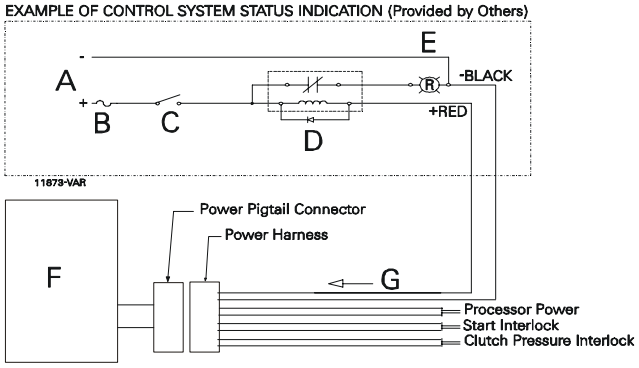
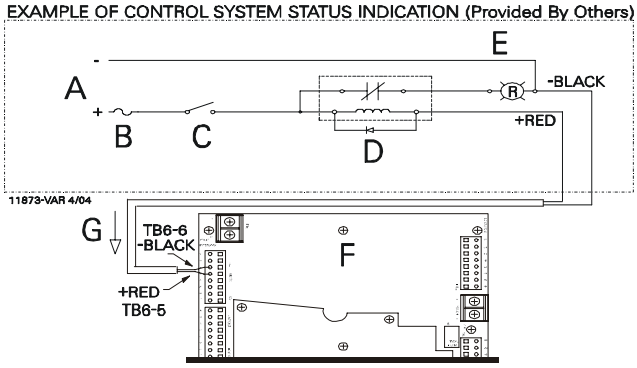


Figure 64: External Alarm Connections Processor Hard-Wired Example



8-1.1 Installation

The following items should be considered when designing and installing the Status Indication Panel:

- The Power Wire Harness (p/n 13631-#) must be used if an External Alarm is required.
- The Processor's Alarm Circuit uses a "dry" contact. Therefore, the polarity of the conductors is not a concern.
- The External Status Indication Circuit must not use the same power source as the Processor.
- Since the External Status Indication Circuit is activated on a loss of power to the Processor, an ON/OFF Switch is strongly recommended.
- Figure 63: and Figure 64: are examples of a suitable circuit, but are not necessarily the only acceptable circuit.

A) Plug the Power Wire Harness into the Processor's Power pigtail.

B) Run the Power Wire Harnesses's two-conductor Alarm cable to the location of the Status Indication Circuit.

C) Connect the black and red conductors to the Status Indication Circuit as shown in Figure 63: and Figure 64:.

8-2 Clutch Pressure Interlock

NOTE: The Clutch Pressure Interlock C0 must be set to be used. Refer to the Section 5 - SET UP PROCEDURES for information on setting Function Code C0.

The Clutch Pressure Interlock uses a Pressure Switch which monitors the Ahead and Astern Clutch pressures to prevent high engine RPM when the clutch is not fully engaged.

The Pressure Switch must have a Normally Open (N.O.) contact that closes when adequate Clutch pressure is reached. The primary function of the Interlock is to prevent high engine RPM when the Clutch is not fully engaged. The Interlock option must be selected with Function Code **C0**. There are two selectable methods of operation as described below:

8-2.1 C0 - Clutch Pressure Interlock Methods of Operation

8-2.1.1 01 - Installed

When selected, the Interlock will command the Throttle to Idle if low or a loss of pressure occurs while cruising. The Interlock is activated when the Pressure Switch's contact opens for the minimum period of time selected with Function Code **C1**.

If adequate Clutch pressure is not reached in the time programmed in Function Code **E5**, throttle will only be allowed to increase to this commanded speed for the time programmed in Function Code **C1** and then returned to Idle.

The Throttle will remain at Idle until the Control Head's lever is returned to Idle, the Pressure Switch contact closes and a speed command above Idle is commanded.

8-2.1.2 02 - Throttle Clutch Pressure Interlock

This option is typically selected when the Clutch takes longer than five seconds to reach full pressure. The Throttle will remain at Idle until there is a closure of the Pressure Switch's contact. This prevents speeds above Idle prior to full Clutch engagement.

In the event of a loss of Clutch pressure while cruising, the Throttle will be returned to Idle after the time selected with Function Code **C1** has expired. Once a closure of the Switch is sensed, indicating adequate pressure, the Throttle immediately returns to the commanded signal, without having to return the Control Head lever to Idle first, as is the case with Value **01**.

Table 24: Figure 65: and Figure 66: Designators

A	Shuttle Valve
B	Hydraulic Line
C	Pressure Switch
D	ZF Marine Electronics Processor
E	Ahead Clutch Pack
F	Astern Clutch Pack

Figure 65: Clutch Pressure Switch with Processor Harness

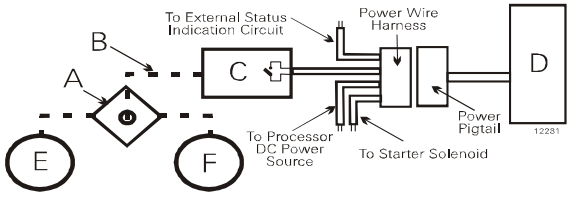
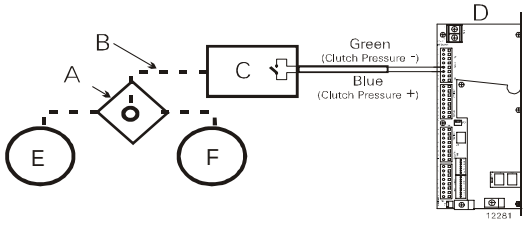


Figure 66: Clutch Pressure Switch with Processor Hard-Wired



8-2.2 Installation

The installation of the Clutch Pressure Switch is the same for both methods of operation. (Refer to the above Figures.)

A) Install a Shuttle Valve on or near the Transmission.

B) Connect hydraulic line from the Ahead and Astern Clutches.

C) Connect a hydraulic line that is no longer than 5 feet (1,524m)and at approximately the same height between the Shuttle Valve and the Pressure Switch.

D) Connect the Power Wire Harness's Clutch Pressure Interlock cable to the Pressure Switch's normally open contact.

E) Calibrate the Pressure Switch to close when adequate Clutch Pressure is reached. (Refer to the Transmission Manufacturers Installation Manual)

8-3 Station Expander (SE)

The Processor allows up to five Remote Stations. The SE allows up to an additional four Remote Stations for a total of nine Stations.

The SE and Processor communicate via the Serial Communication cable. Control Heads connected to the SE offer all of the functionality of a standard Remote Station.

For detailed information on the operation, installation and adjustment of the SE, refer to the Station Expander Installation Manual supplied with the Expander.

If this option is going to be used, please contact a ZF Marine Electronics Representative for further information.

8-4 9001 Actuator Trolling Valve Control

Most Marine Transmissions offer an optional Trolling Valve. A Trolling Valve controls the amount of pressure applied to the Clutch Plate. By doing so, the speed of the propeller can be reduced without decreasing engine RPM.

The Processor allows the operator to control, with a single lever, the Trolling Valve, Clutch and Throttle. In order to do so, a separate Trolling Actuator [p/n 9001] must be installed.

The Trolling Actuator and the main Processor(s) communicate with one another via the Serial Communication cable. The Trolling Actuator contains two Servos, which allows the control of two Trolling Valves with a single Actuator. This option is available only for Processors that do not have Integrated Servo or Solenoid Trolling.

For detailed information on the operation, installation and adjustment of the Trolling Actuator, refer to the Trolling Actuator Installation Manual supplied with the Actuator or contact ZF Marine Electronics.

9 PERIODIC CHECKS AND MAINTENANCE

The items listed below should be checked on an annual basis or less, when noted:

9-1 Control Heads

- Check the terminal strip for signs of corrosion or a loose connection.
- If used, disconnect the Deutsch connector and check the pins and sockets for signs of moisture and corrosion.

9-2 Processor

- Check all terminal connections for signs of corrosion or loose connections.
- Un-plug and inspect all Deutsch connectors for signs of moisture or corrosion.
- While in the vicinity of the Processor, move the Station-in-Command's lever. If the Servo's are excessively noisy, apply a light coating of silicone grease to the stainless steel lead screws. If there are no Stations in close proximity to the Processor(s), use a Field Service Control Head or have someone assist.

9-2.1 Throttle Servo Processor

- Check mechanical connections within the Processor and at the Throttle selector lever.
- Check the mechanical movement of the Throttle lever from Idle to Full. Ensure that the cable does not bind while positioning the Throttle at Idle or Full speed.

9-2.2 Clutch Servo Processor

- Check mechanical connections within the Processor and at the Transmission selector lever.
- Check the mechanical movement of the Clutch selector lever from Neutral to Ahead, and Neutral to Astern. Ensure that the cable does not bind while positioning the Control Head lever at Ahead or Astern. Ensure that the Clutch selector lever and the Push-Pull cable form a 90 degree angle at Neutral.

9-3 Power

- Check all of the connections from the battery to the DC Distribution Panel to the APS for loose or corroded connections.
- Measure the voltage at the battery and at the Processor while the Clutch or Throttle is driving. There should be no more than 10% difference between these two points. If so, check all devices and connections for excessive voltage drop

NOTE: If an APS is used in the circuit to supply power to the Processor, account for the 0.7V drop across the APS. Example: 12.6V @ battery – 1.26V (10% drop) – 0.7V (APS drop) = 10.64V (Minimum allowable voltage)

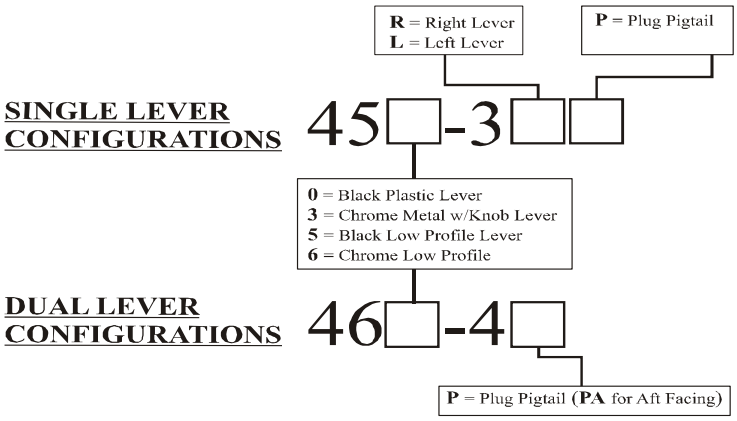
APPENDIX A

ZF Marine Electronics, LLC
Mukilteo Plant

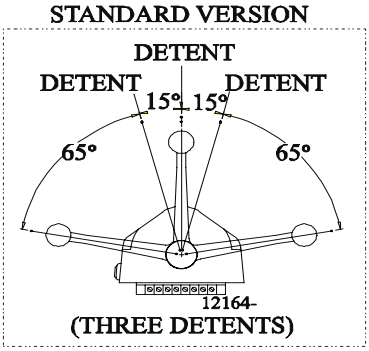
400 Series Standard Control Head Variations

This Service Sheet reflects all current variations of the standard 3-detent ZF Marine Electronics 400 Series Control Heads.

Part Numbering Configurations



Detents Available



REQUIREMENTS:

MicroCommander/ClearCommand: one (1) 8-Conductor Cable per Control Head lever.

Pluggable MicroCommander/ClearCommand: one (1) Control Head Harness per Control Head lever.

CruiseCommand: one (1) Control Head Harness per Control Head lever.

Included with the Control Head:

- Gasket
- Mounting screws and washers
- Terminals (For 8-Conductor or 1-Connector Harnesses)
- Watertight cable grip for the cable entrance on the Processor (For 8-Conductor)

When the Control Head is properly mounted on a console, it is spray proof from the top only. An adhesive gasket must be used to seal it to the mounting surface. However, below the mounting surface it needs protection from water or spray. Consider using a Weather Mount Enclosure, which is available from ZF Marine Electronics.

MOUNTING AND INSTALLATION:

Select the desired mounting locations and make cutouts per template. Refer to the Dimensions Diagram.

Check that the four mounting screws will start into the Control Head. Remove the Control Head from the cutout.

Remove the backing from the adhesive gasket and apply the gasket adhesive side to the console around the cutout.

Run cable/harnesses between Processor and Control Head. Label both ends with Station it connects (EXAMPLE: Port, Center, or Starboard; Port Thrust, Port Throttle; etc.)

There are two types of Control Head connections available: Plug or Terminal Connected. Both types may be used with MicroCommander, ClearCommand, or CruiseCommand using the appropriate cable or harness. Follow the appropriate steps for the Control Head that has been supplied for your system.

Type 1 - Pluggable

Plug Control Head cable into the pigtail at the Control Head. (Ensure the correct Processor Cable is being plugged into the corresponding Control Head lever pigtail).

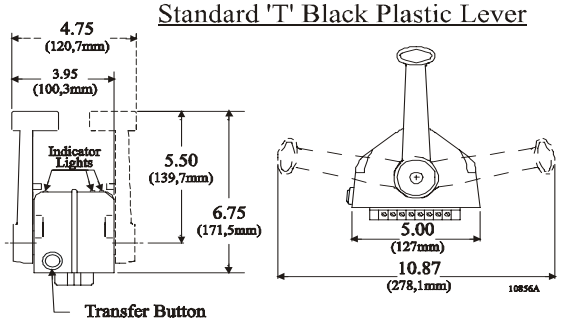
When connecting the plugs, ensure that the release button or buttons are depressed and held until plug is fully connected or disconnected. Connecting or disconnecting plugs without depressing and holding the release button or buttons will damage the plug.

Type 2 - Standard Cable

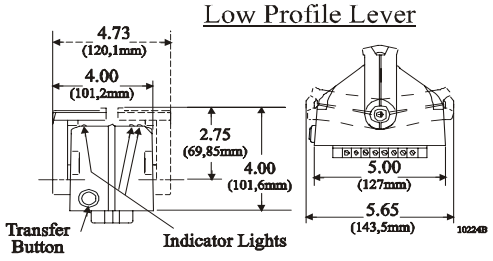
Strip back the PVC cover on the shielded cable approximately 2-1/2" (63,5mm) at the Control Head.
At the Control Head end of the cable strip and cut off the shielding and drain wire flush with the end of the PVC cover (the drain wire at the Control Head is not connected to ground).
Strip 3/8" (9,5mm) insulation off each wire.
Twist the individual strands of the wires to minimize fraying.
Crimp a locking fork terminal (included with each Control Head) to each of the conductors.
Make connections to the Control Head as indicated in the following TERMINAL CONNECTIONS diagrams.

Dimensions

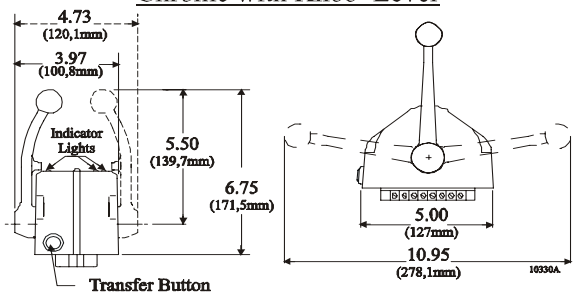
Standard 'T' Black Plastic Lever



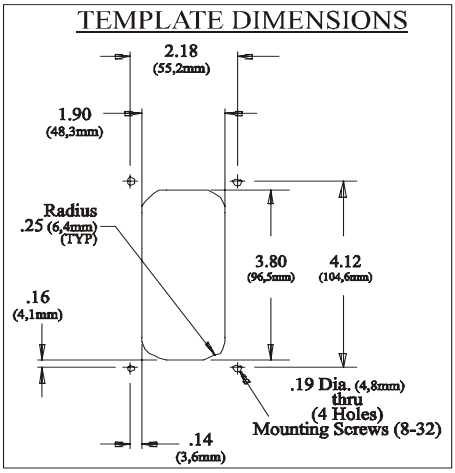
Low Profile Lever



Chrome with Knob Lever



TEMPLATE DIMENSIONS



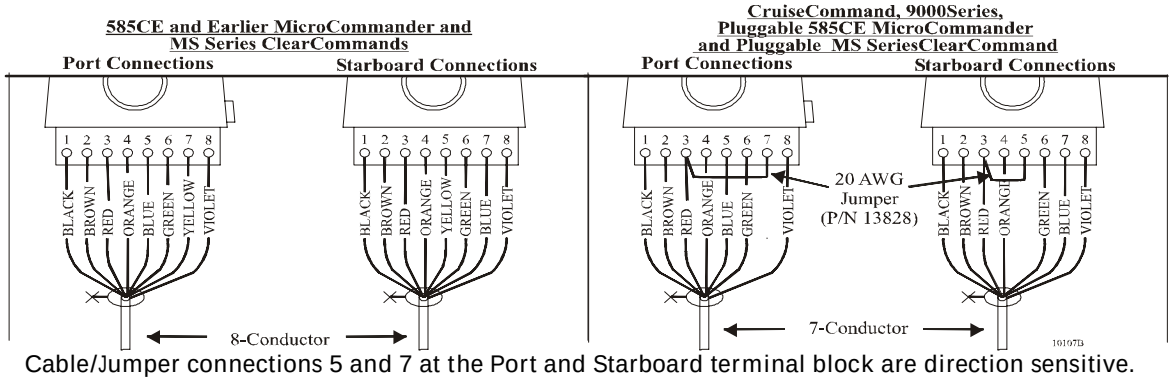
ALWAYS REFER TO THE MANUAL THAT IS SUPPLIED WITH THE CONTROL SYSTEM FOR ANY UNIQUE CONTROL HEAD CONNECTIONS FOR YOUR SYSTEM.

When cable connections are complete, MOUNT Control Head to the console using the four (4) mounting screws and washers supplied with the Control Head.

CABLE/HARNESS CONNECTIONS:

Dual Control Head Connections

TERMINAL CONNECTIONS



Cable/Jumper connections 5 and 7 at the Port and Starboard terminal block are direction sensitive.

MicroCommander/ClearCommand

Port Lever:
Terminal **3** Red
Terminal **5** Blue
Terminal **7** Yellow

Starboard Lever:
Terminal **3** Red
Terminal **5** Yellow
Terminal **7** Blue

CruiseCommand/9000 Series

Port Lever:
Terminal **3** Red & JUMPER
Terminal **5** Blue
Terminal **7** JUMPER

Starboard Lever:
Terminal **3** Red & JUMPER
Terminal **5** JUMPER
Terminal **7** Blue

PLUGGABLE CONNECTIONS

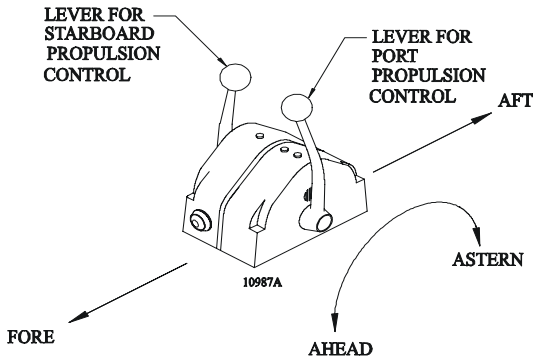
Pluggable Control Heads are supplied with a harness pigtail for each lever. When disconnecting/connecting the plugs, ensure that the release button or buttons are depressed and held until plug is fully disconnected or

connected. Disconnecting/connecting plugs without depressing and holding the release button or buttons WILL damage the plug.

Aft Facing Control Heads

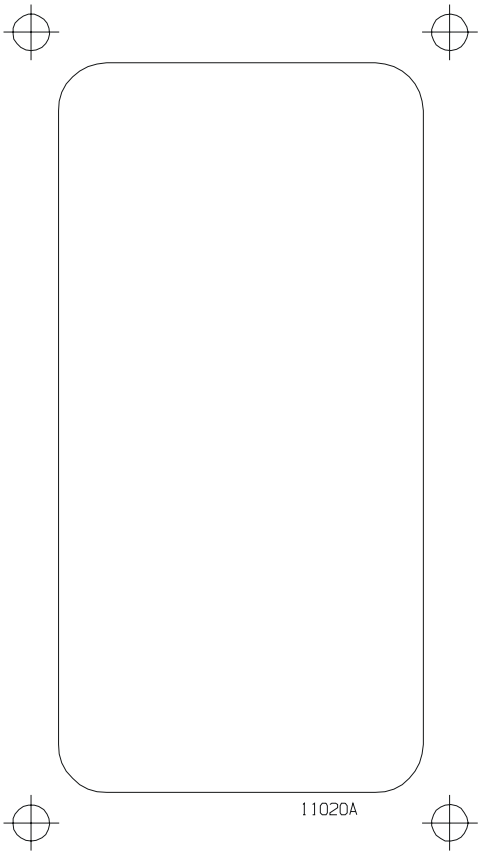
For dual lever Control Head Stations that have the user facing aft: Reverse connections 5 and 7.

For single lever Control Head Stations that have the user facing aft and the one Control Head lever on the user's right, reverse connections 5 and 7.



Handheld Control is a Station option. Contact your ZF Marine Electronics Dealer for further information on Handheld requirements and options.

0.19 Diameter (4,8mm) through Holes
(4 holes)

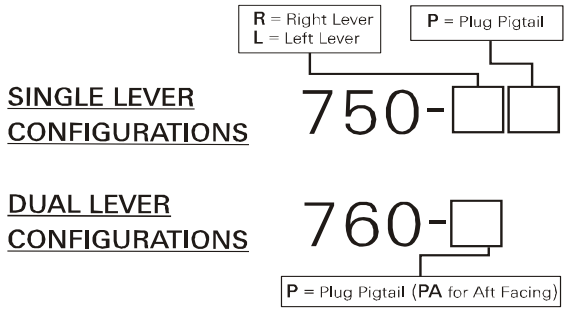


ZF Marine Electronics, LLC
Mukilteo Plant

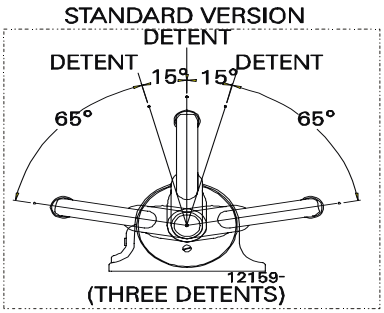
700 Series Standard Control Head Variations

This Service Sheet reflects all current variations of the standard 3-detent ZF Marine Electronics 700 Series Control Heads.

Part Numbering Configurations



Detents Available



REQUIREMENTS:

MicroCommander/ClearCommand: one (1) 8-Conductor Cable per Control Head lever.

Pluggable MicroCommander/ClearCommand: one (1) Control Head Harness per Control Head lever.

CruiseCommand: one (1) Control Head Harness per Control Head lever.

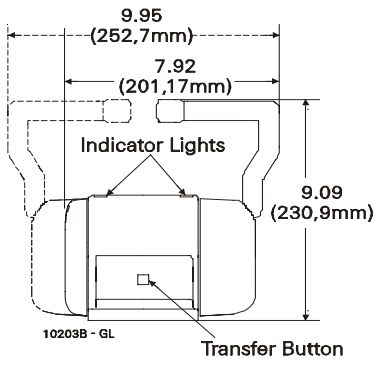
Included with the Control Head:

- (4) Flat-washer - Stainless Steel, 1/4 inch
- (4) Screw - Stainless Steel, Philip Pan Head, 1/4 inch-20 x 1-3/4 inch
- (4) Nut - Stainless Steel, 1/4 inch-20
- (14) Terminal - Flanged For, #6
- (2) Liquid Tight Connector (in addition to those installed at the factory)

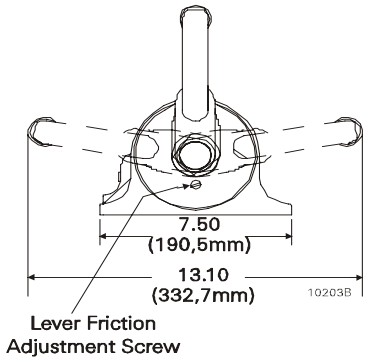
When the Control Head is properly mounted on a console, the Control Head is watertight.

Dimensions

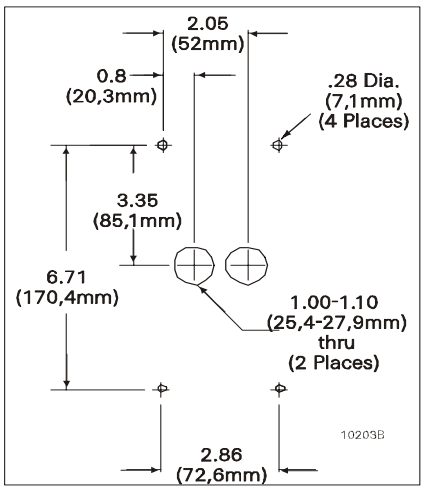
750 - 760 Series Front View



750 - 760 Series Side View



Template Dimensions



MOUNTING AND INSTALLATION:

Select the desired mounting locations and drill screw and cable holes as indicated on the template diagram. Refer to the Dimensions Diagram on the next page.

Run cable/harnesses between Processor and Control Head. Label both ends with the Station it connects (EXAMPLE: Port, Center, or Starboard; Port Thrust, Port Throttle; etc.)

There are two types of Control Head connections available: Plug or Terminal Connected. Both types may be used with MicroCommander, ClearCommand, or CruiseCommand using the appropriate cable or harness. Follow the appropriate steps for the Control Head that has been supplied for your system.

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Standard Cable

A) Remove the six screws holding the bottom cover of the Control Head housings and set aside.
B) Insert cable through the correct cable grip in the bottom cover.
C) Strip back the PVC cover on the shielded cable approximately 2-1/2" (63,5mm) at the Control Head.
D) At the Control Head end of the cable strip and cut off the shielding and drain wire flush with the end of the PVC cover (the drain wire at the Control Head is not connected to ground).
E) Strip 3/8" (9,5mm) insulation off each wire.
F) Twist the individual strands of the wires to minimize fraying.
G) Crimp a locking fork terminal (included with each Control Head) to each of the conductors.
H) Make connections to the Control Head as indicated in the following TERMINAL CONNECTIONS diagrams.

Pluggable

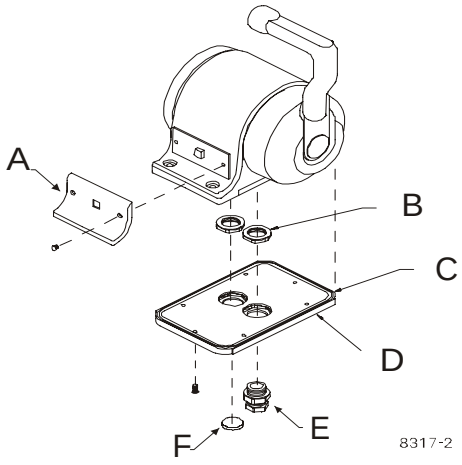
A) Plug Control Head cable into the pigtail at the Control Head. (Ensure the correct Processor Cable is being plugged into the corresponding Control Head lever pigtail).
B) When connecting the plugs, ensure that the release button or buttons are depressed and held until plug is fully connected or disconnected. Connecting or disconnecting plugs without depressing and holding the release button or buttons will damage the plug.

ALWAYS REFER TO THE MANUAL THAT IS SUPPLIED WITH THE CONTROL SYSTEM FOR ANY UNIQUE CONTROL HEAD CONNECTIONS FOR YOUR SYSTEM.

When cable connections are complete:

A) Replace Control Head bottom cover using the six (6) mounting screws removed earlier. Ensure seal is in place.
B) Tighten watertight cable grip(s).
C) Remove front cover from the Control Head
D) Mount Control Head with supplied hardware.
E) Replace front cover when mounting is complete.

Bottom Panel Assembly



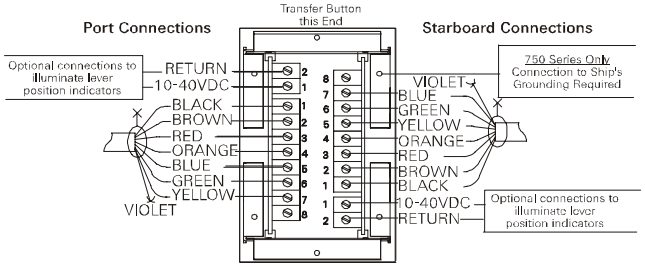
BOTTOM PANEL ASSEMBLY DESIGNATIONS	
A	Front Cover
B	Cable Grip Nut
C	Seal
D	Bottom Cover
E	750-R = Plug; 750-L & 760 = Watertight Cable Grip (Cable O.D. .275 - .393 [7mm - 10mm)
F	750-L = Plug; 750-R & 760 = Watertight Cable Grip (Cable O.D. .275 - .393 [7mm - 10mm)

CABLE/HARNESS CONNECTIONS:

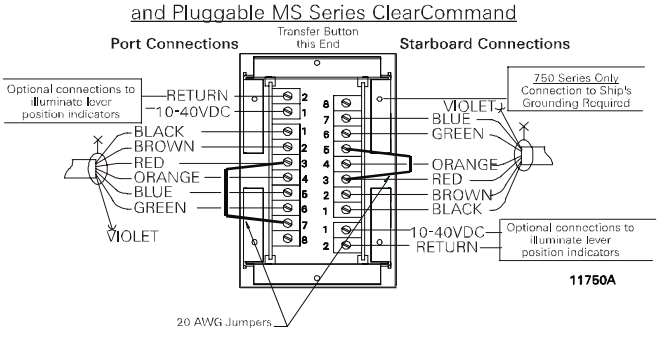
Dual Control Head Connections

750- 760 Series Connections

585CE and Earlier MicroCommander and MS Series ClearCommand



CruiseCommand, 9000 Series, Pluggable 585CE MicroCommander and Pluggable MS Series ClearCommand



TERMINAL CONNECTIONS

Cable/Jumper connections 5 and 7 at the Port and Starboard terminal block are direction sensitive.

585CE and Earlier MicroCommander and MS Series ClearCommand

Port Lever:	Starboard Lever:
Terminal **3** Red	Terminal **3** Red
Terminal **5** Blue	Terminal **5** Yellow
Terminal **7** Yellow	Terminal **7** Blue

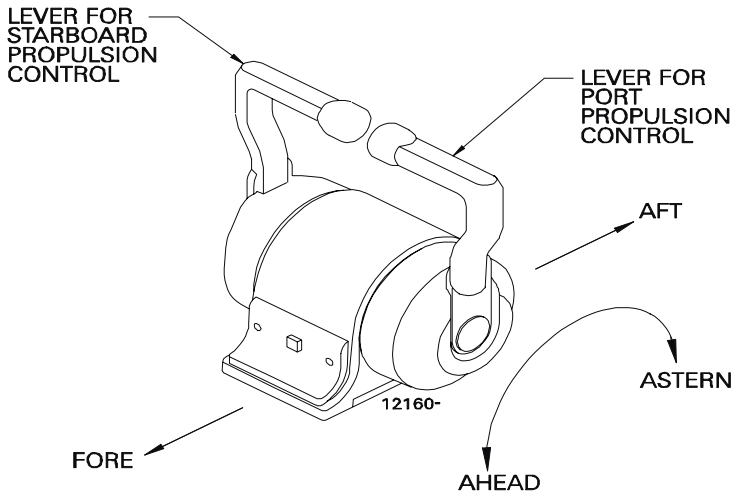
CruiseCommand, 9000 Series, Pluggable 585CE MicroCommander and Pluggable MS Series ClearCommand

Port Lever:	Starboard Lever:
Terminal **3** Red & JUMPER	Terminal **3** Red & JUMPER
Terminal **5** Blue	Terminal **5** JUMPER
Terminal **7** JUMPER	Terminal **7** Blue

PLUGGABLE CONNECTIONS

Pluggable Control Heads are supplied with a harness pigtail for each lever. When disconnecting/connecting the plugs, ensure that the release button or buttons are depressed and held until plug is fully disconnected or connected. Disconnecting/connecting plugs without depressing and holding the release button or buttons WILL damage the plug.

Aft Facing Control Head

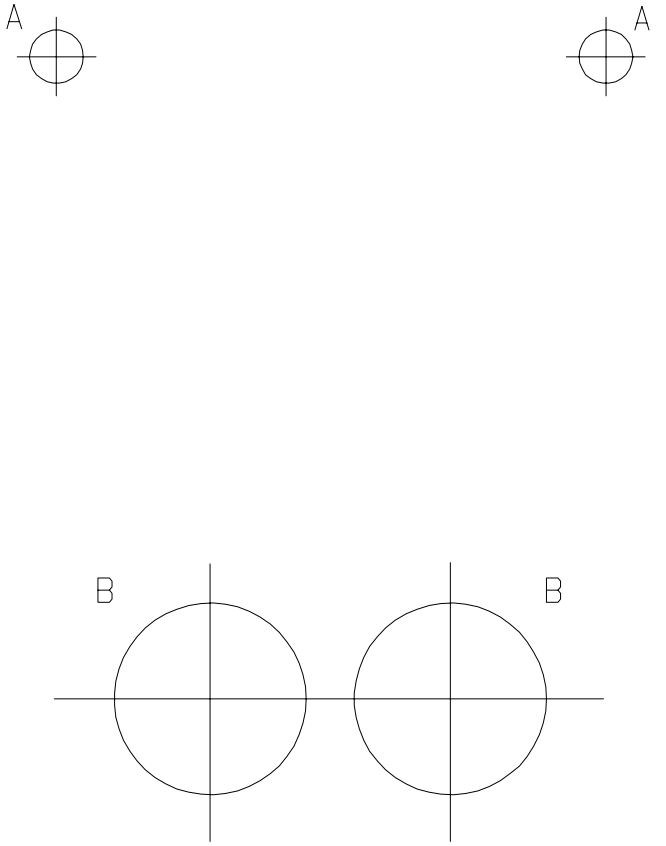


For dual lever Control Head Stations that have the user facing aft: Reverse connections 5 and 7.

For single lever Control Head Stations that have the user facing aft and the one Control Head lever on the user's right, reverse connections 5 and 7.

Handheld Control is a Station option. Contact your ZF Marine Electronics Dealer for further information on Handheld requirements and options.

TEMPLATE



"A" HOLES ∅ .28

"B" HOLES ∅ 1.00 - 1.10

11403-

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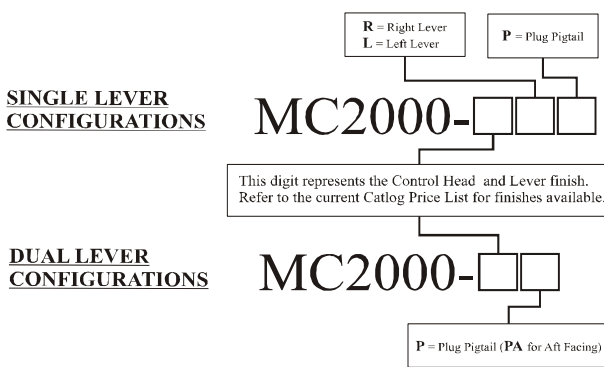
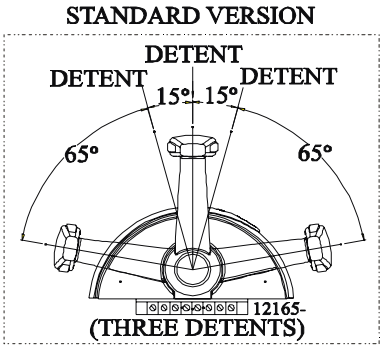
MC2000 Series Standard Control Head Variations

This Service Sheet reflects all current variations of the standard 3-detent ZF Marine Electronics MC2000 Series Control Heads

Part Numbering Configurations



Detents Available



REQUIREMENTS:

MicroCommander/ClearCommand: one (1) 8-Conductor Cable per Control Head lever.

Pluggable MicroCommander/ClearCommand: one (1) Control Head Harness per Control Head lever.

CruiseCommand: one (1) Control Head Harness per Control Head lever.

Included with the Control Head:

- Mounting screws
- Terminals (For 8-Conductor or 1-Connector Harnesses)
- Watertight cable grip for the cable entrance on the Processor (For 8-Conductor)

When the Control Head is properly mounted on a console, it is spray proof from the top only. An adhesive gasket is mounted on the bottom of the Control Head to seal it to the mounting surface. However, below the mounting surface it needs protection from water or spray. Consider using a Weather Mount Enclosure, which is available from ZF Marine Electronics.

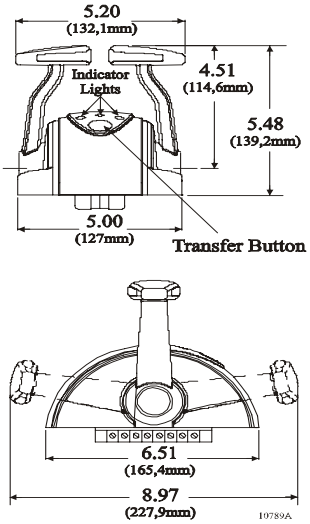
MOUNTING AND INSTALLATION:

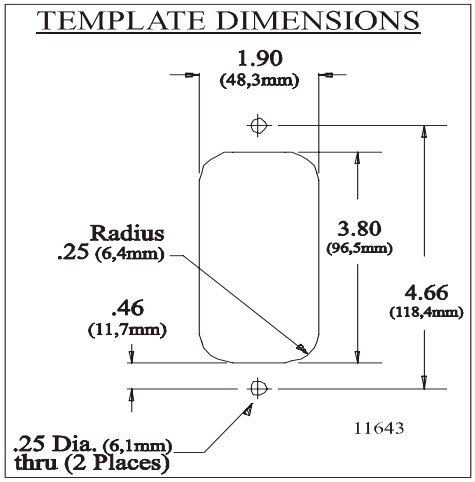
Select the desired mounting locations and make cutouts per template. Refer to the Dimensions Diagram.

Check that the two mounting screws will start into the Control Head. Remove Control Head from cutout.

Run cable/harnesses between Processor and Control Head. Label both ends with Station it connects (EXAMPLE: Port, Center, or Starboard; Port Thrust, Port Throttle; etc.)

Dimensions





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Telefax (425) 493-1569

There are two types of Control Head connections available: Plug or Terminal Connected. Both types may be used with MicroCommander, ClearCommand, or CruiseCommand using the appropriate cable or harness. Follow the appropriate steps for the Control Head that has been supplied for your system.

Standard Cable

A) Strip back the PVC cover on the shielded cable approximately 2-1/2" (63,5mm) at the Control Head.

B) At the Control Head end of the cable strip and cut off the shielding and drain wire flush with the end of the PVC cover (the drain wire at the Control Head is not connected to ground).

C) Strip 3/8" (9,5mm) insulation off each wire.

D) Twist the individual strands of the wires to minimize fraying.

E) Crimp a locking fork terminal (included with each Control Head) to each of the conductors.

F) Make connections to the Control Head as indicated in the following TERMINAL CONNECTIONS diagrams.

Pluggable

A) Plug Control Head cable into the pigtail at the Control Head. (Ensure the correct Processor Cable is being plugged into the corresponding Control Head lever pigtail).

B) When connecting the plugs, ensure that the release button or buttons are depressed and held until plug is fully connected or disconnected.

C) Connecting or disconnecting plugs without depressing and holding the release button or buttons will damage the plug.

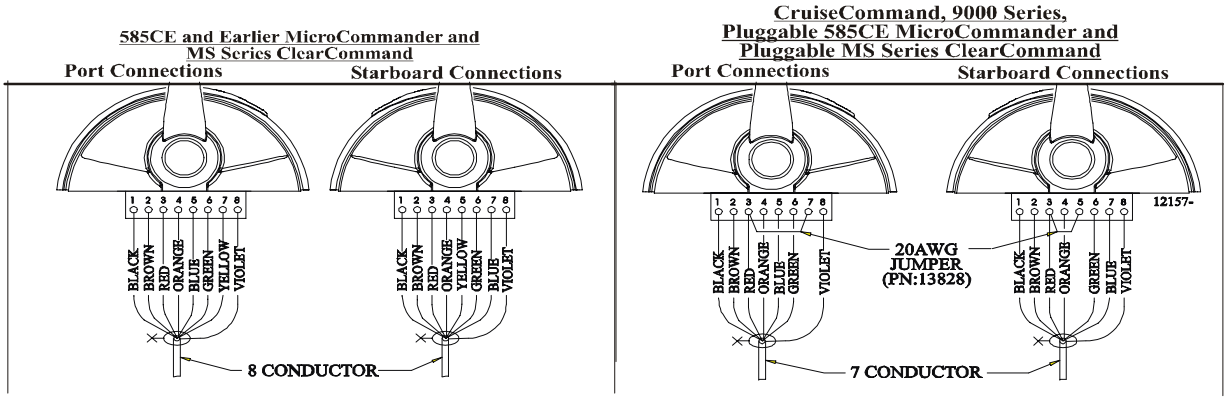
ALWAYS REFER TO THE MANUAL THAT IS SUPPLIED WITH THE CONTROL SYSTEM FOR ANY UNIQUE CONTROL HEAD CONNECTIONS FOR YOUR SYSTEM.

When cable connections are complete, MOUNT Control Head to the console using the two (2) mounting screws and washers supplied with the Control Head.

CABLE/HARNESS CONNECTIONS:

Dual Control Head Connections

TERMINAL CONNECTIONS



Cable/Jumper connections 5 and 7 at the Port and Starboard terminal block are direction sensitive.

MicroCommander/ClearCommand		CruiseCommand/9000 Series	
Port Lever:	Starboard Lever:	Port Lever:	Starboard Lever:
Terminal **3** Red	Terminal **3** Red	Terminal **3** Red & JUMPER	Terminal **3** Red & JUMPER
Terminal **5** Blue	Terminal **5** Yellow	Terminal **5** Blue	Terminal **5** JUMPER
Terminal **7** Yellow	Terminal **7** Blue	Terminal **7** JUMPER	Terminal **7** Blue

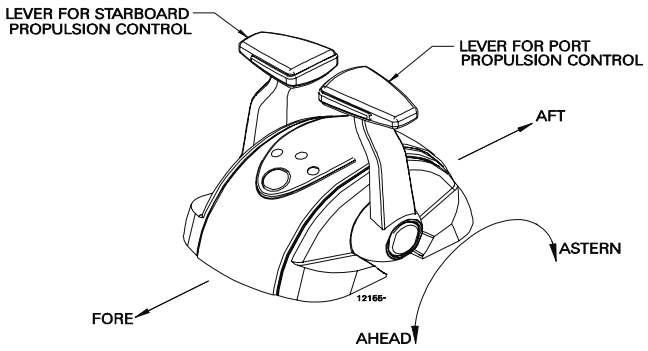
PLUGGABLE CONNECTIONS

Pluggable Control Heads are supplied with a harness pigtail for each lever. When disconnecting/connecting the plugs, ensure that the release button or buttons are depressed and held until plug is fully disconnected or connected. Disconnecting/connecting plugs without depressing and holding the release button or buttons WILL damage the plug.

Aft Facing Control Heads

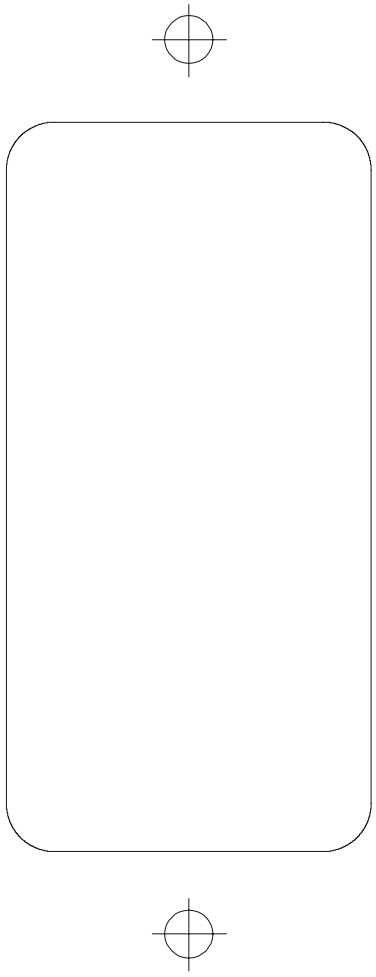
For dual lever Control Head Stations that have the user facing aft: Reverse connections 5 and 7.

For single lever Control Head Stations that have the user facing aft and the one Control Head lever on the user's right, reverse connections 5 and 7.



Handheld Control is an option. Contact your ZF Marine Electronics Dealer for further information on Handheld requirements and options.

0.25 Diameter (6,1mm) through Holes
(2 Holes)



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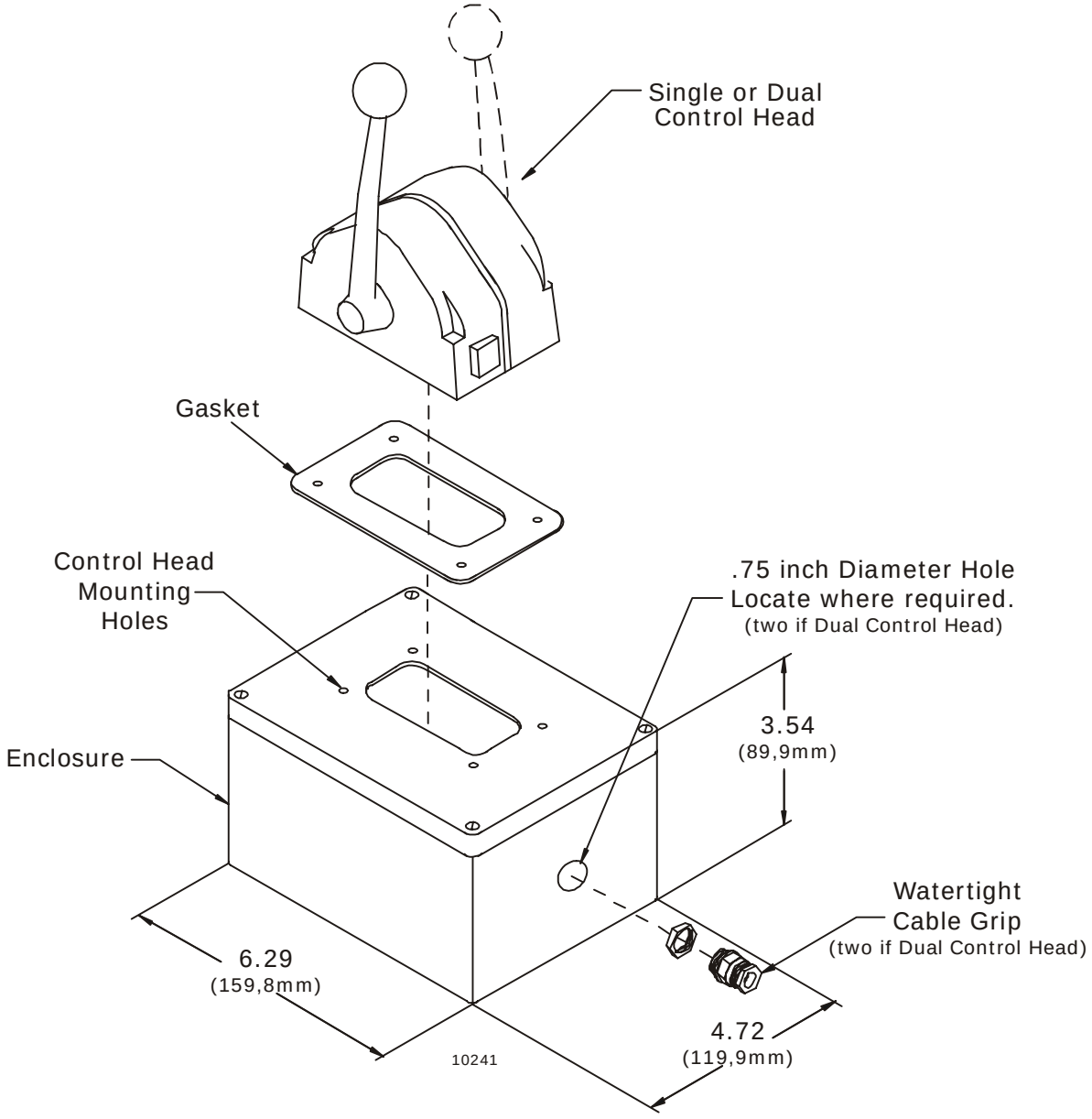
400 Series Weather Mount Enclosure



Deck Mount or Exposed Mount

Ideal for outside Weather Mount

To prevent internal condensation and moisture build up the mount is drilled to allow air circulation.

Part No. 12110

.

Deutsch Connector Assembly

DT Type

Step 1: Contact Removal

1. Remove wedgelock using needlenose pliers or a hook shaped wire. Pull wedge straight out.

2. To remove the contacts, gently pull wire backwards, while at the same time releasing the locking finger by moving it away from the contact with a screwdriver.

3. Hold the rear seal in place, as removing the contact may displace the seal.

Step 2: Wire Stripping

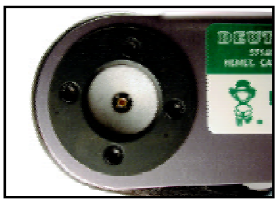
Solid Contacts

Contact Part Number	Wire Gauge Range	Strip Length (inches)
0460-202-20141 0462-201-20141	20 AWG 20 AWG	.156-.218 .156-.218
0460-202-16141 0462-201-16141	16, 18 & 20 AWG 16, 18 & 20 AWG	.250-.312 .250-.312
0460-215-16141 0462-209-16141	14 AWG 14 AWG	.250-.312 .250-.312
0460-204-12141 0462-203-12141	12 & 14 AWG 12 & 14 AWG	.222-.284 .222-.284
0460-204-08141 0462-203-08141	8 & 10 AWG 8 & 10 AWG	.430-.492 .430-.492
0460-204-0490 0462-203-04141	6 AWG 6 AWG	.430-.492 .430-.492

Step 3: Contact Crimping

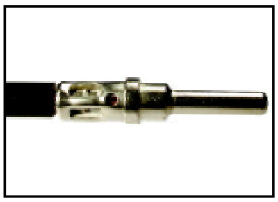
Use Crimp Tool #HDT48-00

1. Strip insulation from wire. (See Step 2).
2. Raise selector knob and rotate until arrow is aligned with wire size to be crimped.
3. Loosen locknut, turn adjusting screw in until it stops.



4. Insert contact with barrel up. Turn adjusting screw counter–clockwise until contact is flush with indentor cover. Tighten locknut.

5. Insert wire into contact. Contact must be centered between indicators. Close handles until crimp cycle is completed.
6. Release handles and remove crimped contact.



7. Inspect terminal to ensure that all strands are in crimp barrel.**NOTE:** Tool must be readjusted for each type/size of contact. Use HDT04-08 for size 8 and 4 contacts.

Step 4: Contact Insertion

1. Grasp crimped contact approximately (25.2 mm) one inch behind the contact barrel.

2. Hold connector with rear grommet facing you.

3. Push contact straight into connector grommet until a click is felt. A slight tug will confirm that contact is properly locked in place.

4. Once all contacts are in place, insert wedgelock with arrow pointing toward exterior locking mechanism. The wedgelock will snap into place. Rectangular wedges are not oriented. They may go in either way.
NOTE: The receptacle is shown –use the same procedure for plug.

ZF Marine Electronics, LLC
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Automatic Power Selector (APS) Model: 13505

A) GENERAL INFORMATION

The APS (Automatic Power Selector), Model 13505, provides a simple, solid state solution to the need for routing redundant DC power sources for vital electronic equipment while maintaining isolation of the DC power sources.

Two independent batteries rated at the same nominal voltage are wired to separate terminals on the APS and internal diodes maintain total isolation between them. A single output terminal is wired to the ZF Marine Electronics Propulsion Control System.

The APS is rated for loads of up to 70 Amps on 12-24V systems. The unit is ruggedly constructed with heavy-duty wiring studs and epoxy-potted components in an anodized aluminum case.

B) APS SPECIFICATIONS

Model: 13505

Maximum Load Current: 70 amps

Operating Temperature: -40 degrees C to +80 degrees C; derate linearly from 100% @ 50 degrees C to 70% @ 80 degrees C

Voltage Drop: 0.7 VDC @ 50% load; 0.9 VDC @ full load

Dimensions: 3.25" x 4.5" x 3.1" (8,3 x 11,4 x 7,9 cm)

C) MATERIALS PROVIDED

The **single** APS is supplied with a hardware packet containing (6) hex nuts, (3) lock washers, (4) self-tapping mounting screws, (1) instructions diagram.

NOTE: Not all of the hardware will be used in the installation; some spares are provided. Nut size is M-6.

The **twin** APS is supplied with (2) single APS hardware packets.

D) INSTALLATION

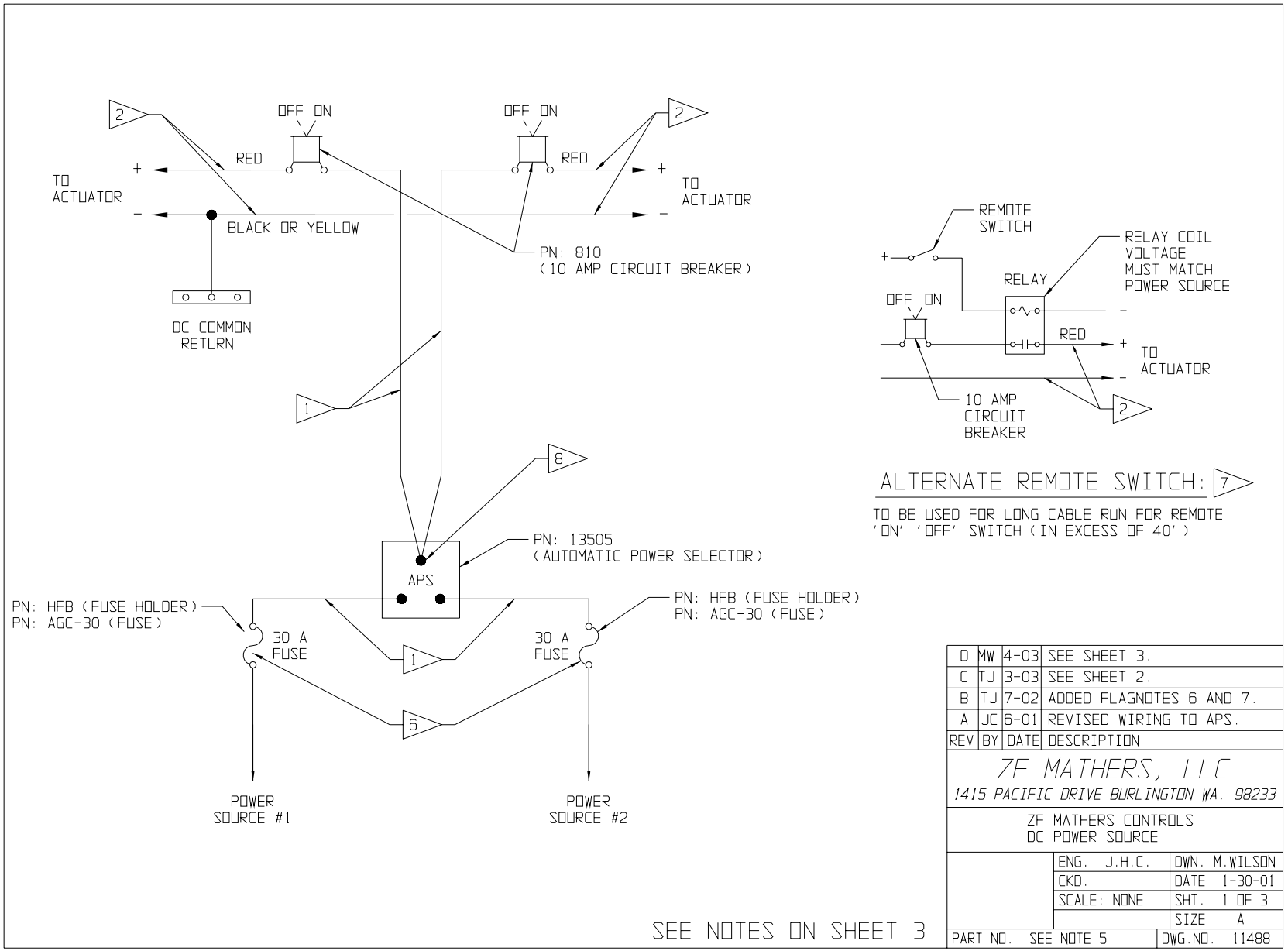
Refer to the installation Drawing 11488D.

1. Shut off all charging sources and disconnect the negative (ground) side of each battery which will be wired to the APS.
2. Mount the APS(s) in a suitable location which will keep wire runs to a minimum length, and is (preferably) ventilated, for cooler operation. The case of the APS is electrically isolated from the internal diodes, so mounting on either a metal or non-metal surface is acceptable.
3. Complete the wiring as indicated on either Drawing 11488D-1 or 11488D-2.
4. Reconnect the negative battery posts.

E) IMPORTANT NOTE ABOUT BATTERY SOURCES

Whenever the load is turned on, it can be drawing power from the batteries. Therefore, if the batteries are not simultaneously being recharged, or if charging will not be available for an extended period, it is recommended that the load be shut off to prevent complete discharge of batteries.

Drawing 11488D-1 Twin Screw Single APS Connection & Alternate Remote Switch



REV	BY	DATE	DESCRIPTION
D	MW	4-03	SEE SHEET 3.
C	TJ	3-03	SEE SHEET 2.
B	TJ	7-02	ADDED FLAGNOTES 6 AND 7.
A	JC	6-01	REVISED WIRING TO APS.

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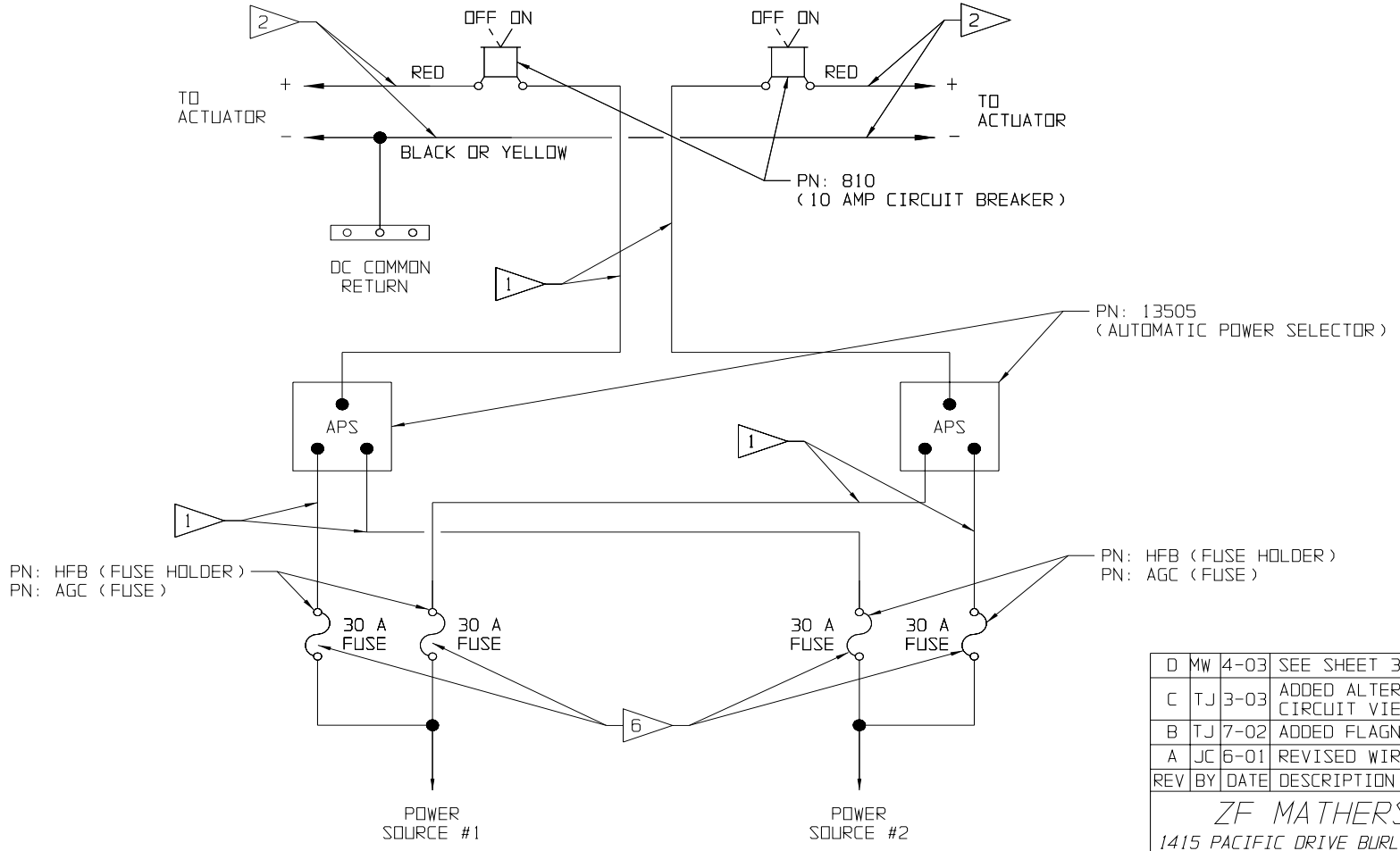
1415 PACIFIC DRIVE BURLINGTON WA. 98233

ZF MATHERS CONTROLS
DC POWER SOURCE

	ENG. J.H.C.	DWN. M.WILSON
	CKD.	DATE 1-30-01
	SCALE: NONE	SHT. 1 OF 3
		SIZE A
PART NO. SEE NOTE 5		DWG.NO. 11488

Drawing 11488D-2 Twin Screw Dual APS Connections



ALTERNATE APS CIRCUIT:

SEE NOTES ON SHEET 3

REV	BY	DATE	DESCRIPTION
D	MW	4-03	SEE SHEET 3.
C	TJ	3-03	ADDED ALTERNATE APS CIRCUIT VIEW.
B	TJ	7-02	ADDED FLAGNOTES 6 AND 7.
A	JC	6-01	REVISED WIRING TO APS.

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ZF MATHERS CONTROLS
DC POWER SOURCE

	ENG. J.H.C.	DWN. M.WILSON
	CKD.	DATE 1-30-01
	SCALE: NONE	SHT. 2 OF 3
		SIZE A
PART NO. SEE NOTE 5		DWG.NO. 11488

Drawing 11488D-3 APS Notes Page

NOTES:

1. WIRE SIZE (REF ABYC E9.15.9 10%)

12VDC POWER SYSTEMS:

0-15' (0-4,6M)	12 AWG (#4 METRIC EQUIVALENT)	
15'-25' (4,6-7,6M)	10 AWG (#6 " ")	
25'-40' (7,6-12,2M)	8 AWG (#10 " ")	
40'-70' (12,2-21,3M)	6 AWG (#16 " ")	

24VDC POWER SYSTEMS:

0-20' (0-6,1M)	14 AWG (#2,5 METRIC EQUIVALENT)	
20'-30' (6,1-9,1M)	12 AWG (#4 " ")	
30'-50' (9,1-15,2M)	10 AWG (#6 " ")	
50'-80' (15,2-24,3M)	8 AWG (#10 " ")	

2. WIRE SIZE. (RECOMMENDED TWISTED PAIR)

12VDC POWER SYSTEMS:

0-20' (0-6,1M)	14 AWG (#2,5 METRIC EQUIVALENT)	
20'-30' (6,1-9,1M)	12 AWG (#4 " ")	

24VDC POWER SYSTEMS:

0-40' (0-12,2M)	14 AWG (#2,5 METRIC EQUIVALENT)	
40'-65' (12,2-19,8M)	12 AWG (#4 " ")	

3. APS OUTPUT IS STRICTLY FOR ZF MATHERS CONTROLS.

4. POWER SOURCES MAY BE 12 OR 24 VOLTS DC.

5. SINGLE SCREW KIT - PN: 13983.

PN: 13505 (AUTOMATIC POWER SELECTOR)	QTY 1
PN: 810 (10 AMP CIRCUIT BREAKER)	QTY 1
PN: AGC-30 (30 AMP FUSE)	QTY 2
PN: HFB (FUSE HOLDER)	QTY 2

TWIN SCREW KIT - PN: 13984.

PN: 13505 (AUTOMATIC POWER SELECTOR)	QTY 1
PN: 810 (10AMP CIRCUIT BREAKER)	QTY 2
PN: AGC-30 (30 AMP FUSE)	QTY 2
PN: HFB (FUSE HOLDER)	QTY 2

6. MAXIMUM WIRE SIZE ALLOWED IN FUSEHOLDER IS 12 AWG. IF A LARGER WIRE SIZE IS REQUIRED FOR INSTALLATION, THE CUSTOMER SHALL PROVIDE AN APPROPRIATE FUSE AND FUSE HOLDER. (SUGGESTED MANUFACTURER BLUE SEA SYSTEMS, MAXI FUSE BLOCK SERIES).

7. IF THIS CONFIGURATION IS USED WITH AN ELECTRONIC ENGINE THE CIRCUIT BREAKER MUST BE TURNED ON PRIOR TO APPLYING POWER TO THE REMOTE SWITCH.

8. SEE FIGURE 1 BELOW FOR THE SUGGESTED HARDWARE STACK FOR SYSTEMS UTILIZING MULTIPLE OUTPUTS FROM THE PN: 13505 (AUTOMATIC POWER SELECTOR).

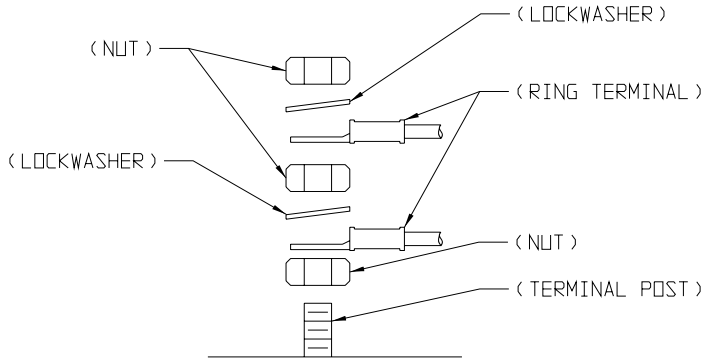

FIGURE 1

REV	BY	DATE	DESCRIPTION
D	MW	4-03	REVISED FLAGNOTES 1 & 2.
C	TJ	3-03	ADDED FLAGNOTE 8. REVISED FLAGNOTE 6.
B	TJ	7-02	ADDED FLAGNOTES 6 AND 7.
A	JC	6-01	SEE SHEET 1.

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ZF MATHERS CONTROLS
DC POWER SOURCE

	ENG. J.H.C.	DWN. M.WILSON
	CKD.	DATE 1-30-01
	SCALE: NONE	SHT. 3 OF 3
		SIZE A
PART NO. SEE NOTE 5		DWG.NO. 11488

Grounding (Bonding)

Grounding (Bonding) - 46 CFR 111.05 and ABYC Section E-11

Grounding (Bonding) should be done according to ABYC Section E-11 and Code of Federal Regulations 46 CFR 111.05.

Each grounded system must have only one point of connection to ground regardless of the number of power sources operating in parallel in the system

A vessel's hull must not carry current as a conductor. A metallic hull, or the bonding and DC grounding systems, shall not be used as a return conductor.

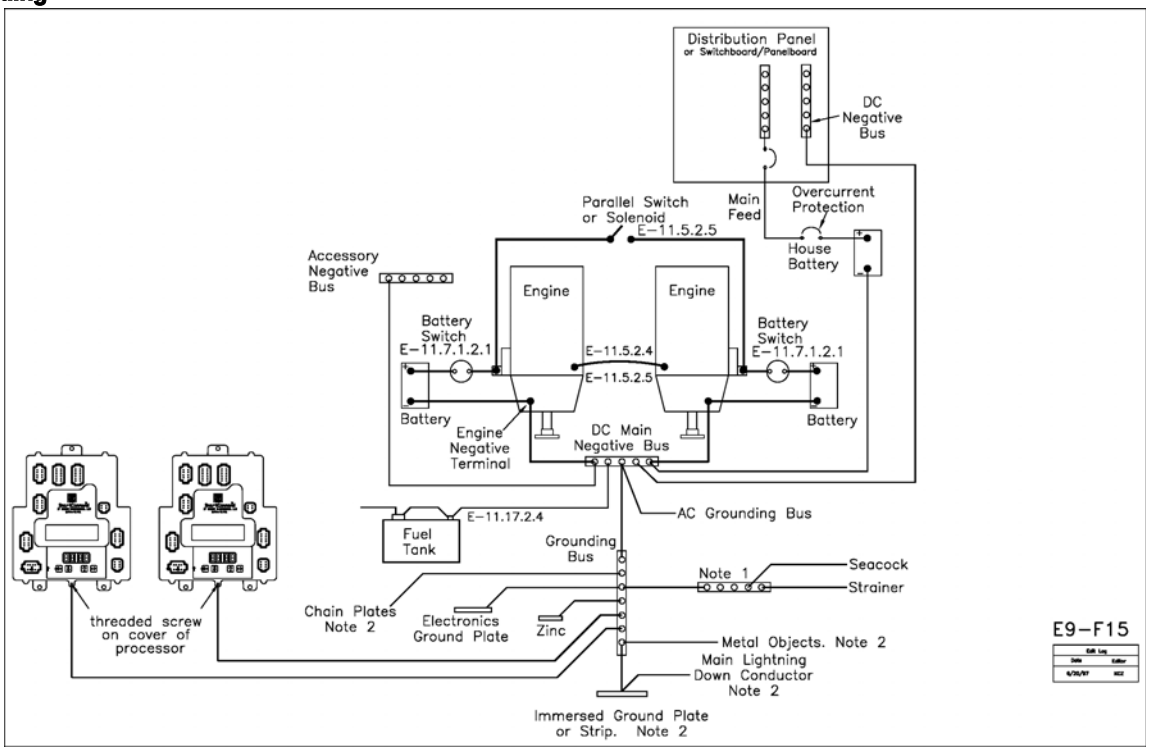
There are some limited exceptions: (1) Impressed current cathodic protection systems. (2) Limited and locally grounded systems, such as a battery system for engine starting that has a one-wire system and the ground lead connected to the engine. (3) Insulation level monitoring devices if the circulation current does not exceed 30 milliamperes under the most unfavorable conditions. (4) Welding systems with hull return except vessels subject to 46 CFR Subchapter D.

Grounding conductors should be green or green with a yellow stripe.

References:

CFR Sec. 111.05-13, Sec. 111.05-11
ABYC E-11 11.5.2.2, ABYC E-11.4, ABYC 11-18.

Grounding[a]



[a] **Grounding** is used courtesy of American Boat and Yacht Council.
All parts of figure except processors and processor connection ©
2003 American Boat and Yacht Council

Metal - Hull Vessels

The hull of a metal hull vessel may serve as the common grounding conductor. If it is desirable for the item being installed to be bonded to the vessel grounding system, and the installation or mounting method does not provide the desired path, a separate grounding conductor may be required.

References and Parts Source

A) REFERENCES

1. American Boat & Yacht Council (ABYC)
   3069 Solomons Island Road
   Edgewater, MD 21037-1416
   - E-3 Wiring Identification on Boats
   - E-11 AC and DC Electrical Systems on Boats
   - H-2.4e or 32.4g Ambient Temp. 50 degrees C
   - P-24 Electric/Electronic Propulsion Controls
2. Code of Federal Regulations
   33 CFR 183 Subpart I - Electrical Systems
   33 CFR 183.410 Ignition protection
   33 CFR 183.415 Grounding
   33 CFR 183.425 Conductors: General
   33 CFR 183.430 Conductors in circuit of less than 50 Volts
   33 CFR 183.445 Conductors: Protection
   33 CFR 183.455 Over-current and Protection: General
   46 CFR 111.01 - 15(b) Ambient Temp. Machinery Spaces 50 degrees C
   46 CFR 111.05- System Grounds
3. Society of Automotive Engineers
   400 Commonwealth Drive
   Warrendale, PA 15096
   - J1171 External Ignition Protection
   - J1428 Marine Circuit Breakers
   - J378 Marine Engine Wiring
4. National Marine Manufacturers Association
   401 North Michigan Avenue
   Chicago, IL 60611
5. Underwriters Laboratories

B) PARTS SOURCE

Anti-Static Wrist Strap	P/N 517 [Thomas & Betts (P/N AWCC)]
Automatic Power Selector	P/N 13505
Circuit Breaker- UL Approved	P/N 810 [E-T-A (P/N 41-2-514-LN2-10)]
Fuse	P/N 1030 [Bussman (P/N. GDC-1A)]
Relay 12 VDC	P/N 1114 [Potter-Brumfield (P/N KRPA5D6-12)]
Relay 24 VDC	P/N 1122 [Potter-Brumfield (P/N KRPA5D6-24)]
Service Field Test Unit (Break-out Box)	P/N 13927
WAGO Tool	P/N 397 [WAGO (P/N 236-332)]
Field Test Control Head - Dual	P/N 14000

Engine Tachometer Sender Requirements

Engine Type	Engine	Model	Sender	Comments
Gasoline	Inboard	3, 4, 6, 8 Cylinder	Alternator's Stator AC Terminal or Point Side of the Coil	N/A
Gasoline	Outboard	4, 6, 8, 14 Pole	Alternator's Stator AC Terminal or Point Side of the Coil	N/A
Diesel	Caterpillar	Most Older & 3208, D336, D346, D348, D398, D399 & D334	8902	N/A
Diesel	Caterpillar	3116, 3126, 3176, 3196, 3406, 3408, 3306, 3412, 3056, 3512 & 3516	8922	Some use 8912. New engines have Magnetic Pickup already installed on flywheel.
Diesel	Caterpillar	All Electronic	N/A	Use ECM output. Outputs 12 PPR.
Diesel	Cummins	Most Older & 555	8902	N/A
Diesel	Cummins	B & C Series, KTA19M3, MTA855, * KTA1150M	8912	Most have Magnetic Pickup already installed on flywheel.
Diesel	Detroit	DDEC Electronic System	8902	Must have Detroit data-link output module.
Diesel	Detroit	53, 71, & 92 Series	8902	Engines manufactured before 1976 use Aetna Part No. 8152 drive key with Sender.
Diesel	Detroit	8.2 Liter 2 Cycle, Some 71 & 92 Series	8912	N/A
Diesel	EMD	Mechanical Sender Applications	8902	N/A
Diesel	EMD	Flywheel Applications	8912	N/A
Diesel	Hino	All Engines	8902	250 HP: Tach drive on front Port side of engine. 310HP: Tach drive on rear center, just below the head.
Diesel	John Deere	Older Engines	8902	Tach drive usually at rear Starboard side of engine.
Diesel	John Deere	Newer Engines	8912	Magnetic Pickup usually already installed.
Diesel	Lehman (Ford)	All Engines	8902	Engine built after 1977 require the Aetna Part No. 8619 tachometer drive adapter.
Diesel	Lugger	All Engines	8912	N/A
Diesel	MAN	In-line	8902	N/A
Diesel	MAN	V-Engines	8902	An extension tachometer cable Aetna Part No. 9212 is usually required.

12125 Harbour Reach Drive, Suite B
Mukilteo, WA 98275
Telephone (425) 583-1900
Telefax (425) 493-1569

Engine Type	Engine	Model	Sender	Comments
Diesel	MAN	826	8912	It may be necessary to manufacture a mounting plate for the magnetic pickup.
Diesel	MAN	2840, 2842, 2848, 2866 & 2886	8912	N/A
Diesel	MTU	All Engines	8902	N/A
Diesel	Perkins	1980 and earlier	8902	N/A
Diesel	Perkins	4-236 & 6-354	8902	Perkins Part No. 8875 drive adapter needed on 1980 and newer engines.
Diesel	Perkins	4-107, 4-108 & M-800TI	8902	N/A
Diesel	Perkins	4-154	N/A	Aetna Part No. 8709 Magnetic Sensor must be used in lieu of SAE drive.
Diesel	Perkins	M-135, M225, M-300 & M30	8912	N/A
Diesel	Volvo	70, 100 & 120 A or B Series	8902	N/A
Diesel	Volvo	3, 6A, 17 & 30	8912	N/A
Diesel	Volvo	31 & Up, 41	N/A	Aetna Part No. 8709 Magnetic Sensor must be used in lieu of SAE drive.
Diesel	Volvo	40, 60, 61 & Up, 71 & Up, 100C & Up, 102, 121C & Up, 122, 2010 & 2020	N/A	Magnetic pickup already installed on cam gear.
Diesel	Volvo	42 & 43	N/A	Connect at blower box. Black wire is ground and grey is signal
Diesel	Volvo	2030 & 2040	N/A	Magnetic pickup already installed on cam gear.
Diesel	Yanmar	All Engines	N/A	A metric Magnetic pickup is already installed on all engines.

P/N 8902 Dual Mechanical Sender
P/N 8912 Dual Magnetic Pickup (3/4-16)
P/N 8922 Single Magnetic Pickup (5/8-18) Available through Aetna Engineering only.

Morse Clutch and Throttle Kit Selection

Pre-Engineered Throttle Connection Kits

MAKE	ENGINE MODEL	KIT NO.
Caterpillar	3208NA 3208TA 334, 3304, 3306 3406 & 343 3408	300172 305403 36680 36680 36680
Cummins	A11 w/MVSGOV AFC Fuel Pump V504M, V555M, V903M, VT903M, VTA903M, NT855M, VT171OM, VTA171OM, KT & KTA 1150M, KT & KTA 2300M, 1975 and later	36680 300580
General Motors	3, 4, & 6-71 w/var.sp.gov. 6, 8, 12 V-71 & 6, 8 V-92 w/var.sp.gov. 6-71 inclined 2, 3, 4-53 w/left hand gov. Right hand gov. 6V-53 Rear entry 6V-53 Front entry 6, 8V-71 Front entry 12, 16V-149	41736 41736 36680 36680 36680 36680 36680 36680 36680
Perkins	4, 236M 6, 3544M; T6, 3544M; ST6, 3544M; SST6, 3544M 4, 108 W/shut off	48931 302026 303878

Pre-Engineered Clutch Connection Kits

MAKE	TRANSMISSION MODEL	KIT NO.
Allison	M & MH	41482
Borg Worner	70, 71, 72 In line w/red gear rear entry	301474
Capital	12400 2, 3, & 4 HD & HE	36680 36680
MerCruiser	Inboard w/o Warner red gear	62355
Paragon	HF-7	36680
Twin Disc	MG508, 509, 510, 510A, 512, 514C, 514CHP, 518, 521, 527, 530, 540 MG502, 506, 507, W/x9994, xA7022, A7048 Valves	42577 63696
Twin Disc Trolling Valve	MG509, 510A, 511A, 514C	307171

Outboard and I/O Cable Connection Kits

ENGINE MAKE	KIT NO.
Chrysler 1975 & later	300465
Evinrude/Johnson 55-235 H.P. 1978 to date	301729
Mercury 40-300 H.P.	301901
Mercruiser I/O	302123
OMC Sterndrive I/O	300557
Volvo I/O Engine and out drive brackets are provided by Volvo	

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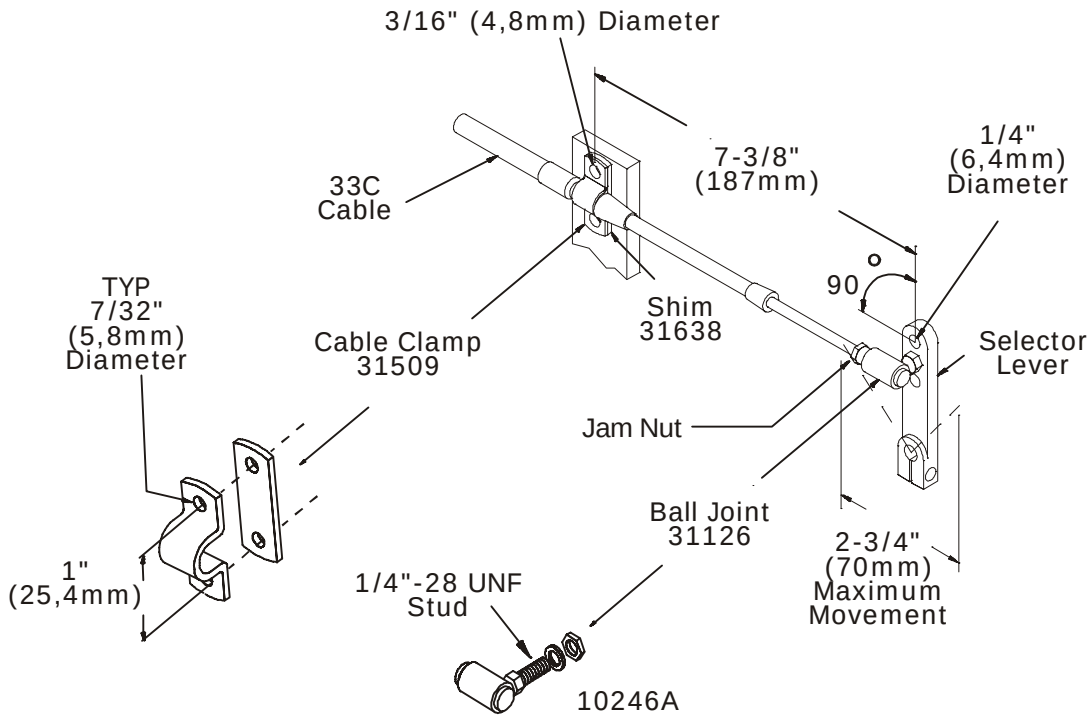
Universal Mounting Kit

Fabricate Bracket to match dimensions shown



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43C Cable Conversion Kit

9000 Series Processors and Actuators
585CE Actuator (Serial Number B06500 and up)
813CE Actuator (Serial Number C01150 and up)
ClearCommand Processors (Serial Number D02100 and up)

Revisions List

Rev	Date	Revision Description
A	**8/03**	**Added 9000 Series.**

This procedure is to be used in conjunction with the technical manual supplied with the System's Actuator/Processor.

A) Parts Required:
One 43C Conversion Kit (P/N 13821) for each cable. Kit includes the following:
- 43C cable nut (P/N MS12820)
- 43C cable retainer (P/N 13694)
- Cable retainer screws (P/N 00791)

B) Tools Required:
- Snap Ring Tool or Small Slotted Screwdriver
- Phillips Screwdriver
- 7/16 Nut Driver or Socket
- 7/16 Open End Wrench

C) Actuator/Processor Preparation [Refer to Figure 1:]

D) Remove cover to Actuator/Processor.

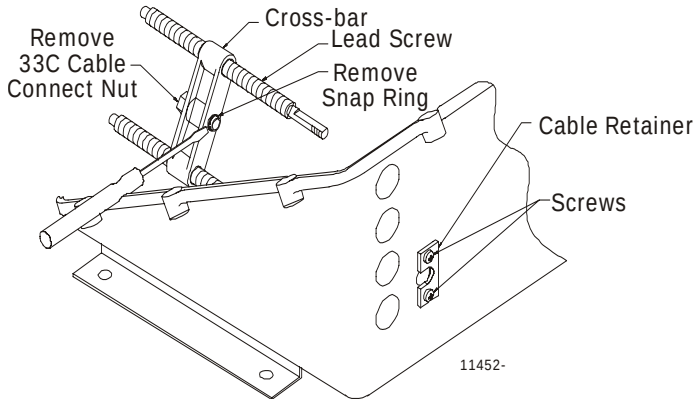


Figure 1: Actuator/Processor Preparation

CAUTION: Static electricity can destroy electronic components. Anytime the Actuator/Processor cover is off, use an anti-static wrist strap and connect it to the Actuator/Processor frame. This will drain any static charge you may have on your person.

E) Remove screws holding Cable Retainer in place.

F) Remove and discard Cable Retainer.

G) Remove the Snap Ring holding the Cable Connect Nut in the cross-bar using a snap ring tool or small screwdriver.

H) Remove and discard Cable Connect Nut and Snap Ring.

I) Cable Installation [Refer To Figure 2:]

NOTE: 43C cable and jam nut are supplied by others.

1. Remove and retain the jam nut from the end of the 43C cable to be installed in the Actuator/ Processor.

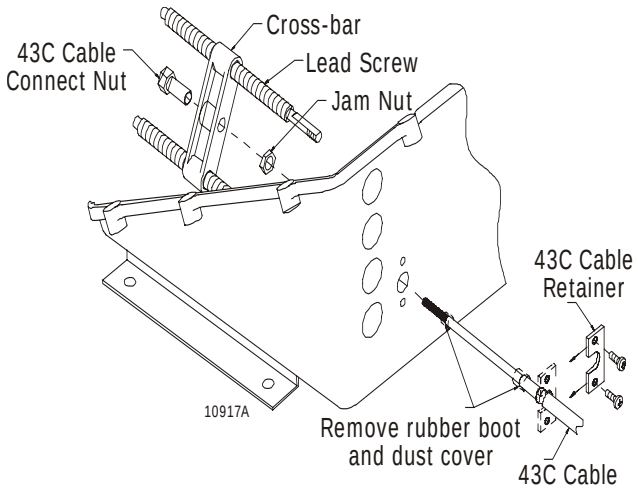


Figure 2: Actuator/Processor Cable Installation

2. Remove and discard the rubber boot and the rubber dust cover from the end of the 43C cable to be installed in the Actuator/Processor.
3. Insert the end of the cable through the hole in the Actuator/Processor.
4. Thread the jam nut onto the end of the cable inside the Actuator/Processor.
5. On the outside of the Actuator/Processor, press the 43C Cable Retainer over the notch in the 43C cable. This is intended to be a snug fit and may require some force.
6. Install two screws through the 43C Cable Retainer and into the Actuator/Processor.
7. Tighten the two screws securely with a Phillips Screwdriver.
8. Insert the 43C Cable Connect Nut through the cross-bar.
9. Thread the 43C Cable Connect Nut onto the end of the 43C cable.
10. After the cable connect nut is threaded onto the cable, tighten the jam nut against the cross-bar using a 7/16 nut driver or socket and 7/16 open end wrench.
11. Replace cover to Actuator/Processor. Refer to technical manual supplied with the Actuator/ Processor for any other required set up or adjustment.

ZF Marine Electronics, LLC
Mukilteo Plant

Electronic Propulsion Control Systems Limited Warranty

A. Limited Warranty: Your ZF Marine Electronics product has been designed and manufactured by experienced engineers and craftsmen. ZF Marine Electronics LLC warrants for the period indicated below, each product manufactured by ZF Marine Electronics LLC, to be free from defects in materials and workmanship. If during the applicable warranty period a product is determined by ZF Marine Electronics LLC to be in breach of this limited warranty, ZF Marine Electronics LLC, at its option will repair or replace the defective product. ,

B. Warranty Exclusions: This warranty covers only failures due to defects in materials or workmanship that occur during normal use. This warranty does not cover damage that occurs in shipment, failures that are caused by products not supplied by ZF Marine Electronics, failures that result from installation that is not in compliance with ZF Marine Electronics specifications, accident, misuse, abuse, neglect, water damage, mishandling, misapplication, set-up adjustments, improper maintenance, alteration, modification or service by anyone other than a ZF Marine Electronics Authorized Service Center, damage that is attributable to acts of God or other causes unrelated to defects in materials and workmanship.

C. Warranty Period: The length of the applicable warranty period will depend on the use of your vessel.
For Commercial Craft the standard warranty period is for 24 months from the date of original shipment by ZF ME or 12 months after commissioning of the craft, whichever occurs first. A commercial craft is defined as, any vessel used for any commercial purpose including but not limited to any use as a workboat, passenger vessel, charter or rental fleet.

For Pleasure Craft the warranty period is 36 months from the date of original shipment by ZF ME or 24 months after commissioning of the craft whichever occurs first. A Pleasure Craft is any vessel that is or has not been used for any commercial purpose including but not limited to any use as a workboat, passenger, charter or rental fleet.

Repair or replacement parts provided under this Warranty will be covered by the remainder of the unexpired warranty in effect on the complete unit.

D. No Coverage Under Warranty The exclusive remedy under this Warranty is the repair or replacement of the defective component and this warranty specifically does not provide coverage for:

1) Towing or transportation of the vessel, or travel to and from the job site or vessel.
2) Original installation charges or start-up costs.
3) Loss of use or income from the vessel and/or rental of equipment during the performance of warranty repairs.

E. To Obtain Warranty Service

Please go to www.zf-marine.com or Call 1-425-583-1900 or (U.S. only) 1-800-546-5455 for your nearest ZF Marine Electronics Factory Authorized Service Center.

1) The Service Center will contact ZF Marine Electronics Service Department for a Service Return Authorization (SRA) number. Return the product freight prepaid, marked clearly with the SRA number and a description of the malfunction.
2) If there are defects covered by this warranty, ZF Marine Electronics will, at its option, either repair or replace the defective part or product. If after inspection, ZF Marine Electronics determines that the product is not defective; ZF Marine Electronics will charge a testing fee and return the product to the sender, freight collect.
3) Repair or replacement during the warranty period will not extend the warranty period.
4) All SRA claims must be requested and submitted within 30 days from date of repair service.
5) Claims for over 3 hours labor must be pre-approved by the ZF Marine Electronics Service Department.

This Warranty is expressly in lieu of all other warranties, express or implied. Except to the extent prohibited by applicable law, ZF Marine Electronics hereby disclaims all other implied or express warranties of any kind, including warranties of merchantability and fitness for a particular purpose. Under no circumstances shall ZF Marine Electronics be liable for any incidental or consequential damages sustained in connection with the product or its use, including any costs or damages which result from loss of use of the product or any engine or boat with which it is used. ZF Marine Electronics does not authorize any representative or agent to assume for it any obligation or liability other than those expressly set forth above. Some States and other jurisdictions do not allow limitations on how long an implied warranty lasts or the exclusion or limitation of incidental or consequential damages, so the above limitations may not apply to you. All implied warranties, if any, are limited to the duration of this express warranty. This warranty gives you legal rights, and you may have other rights which may vary from State to State.

ZF MARINE ELECTRONICS, L.L.C.

12125 Harbour Reach Drive, Suite B
Mukilteo, WA 98275
Telephone (425) 583-1900
Telefax (425) 493-1569

ZF Marine Electronics, LLC
Mukilteo Plant

Warranty Registration

Processor, Serial #_____ Serial #_____

Number of Remote Stations_____

Purchase Date_____

Dealer's Name_____

Installer's Name_____

Phone Number (___) _____

Cell Number (___) _____

Fax Number (___) _____

E-Mail Address_____

Purchaser's Name_____

Street Address_____

City, State, Zip_____

Phone Number (___) _____

YOUR VESSEL:

Engine, Make & Model_____

Length_____

Manufacturer_____

ZF Marine Electronics, LLC. Product First Seen At:

Boat Show Dealer Magazine Friend

ZF Marine Electronics, LLC.
12125 Harbour Reach Drive, Suite B
Mukilteo, WA 98275

APPENDIX B

B1 TROUBLESHOOTING GENERAL

The ZF Marine Electronics Control System consists of one Processor per engine, typically mounted in the engine room, and one to five Control Heads located at the vessel's Remote Stations.

In the event that a malfunction occurs, review the appropriate System Diagram and become familiar with the various components, their functions and locations on the vessel.

The following Sections are a list of the main components that make up a typical system, along with a brief description of their functions:

B1-1 Control System Examples

B1-1.1 9110X (Throttle Servo, Clutch Servo, X = Pluggable Remote Stations) Processor

The **9110X** is designed to precisely control speed and direction on vessels equipped with servo Throttle and servo Clutch selection.

B1-2 Typical System Main Components

B1-2.1 Control Head

The primary function of the Control Head is to send out a variable DC voltage to the Processor. This DC voltage is representative of the Control Head's present lever position. In addition to the primary function, the Control Head also has audible (Sound Transducer) and visual (LED) status indications, along with a Transfer Button for taking command and performing other system functions.

B1-2.2 Processor

The Processor receives the variable DC voltage from the Control Head(s) and converts these inputs to the appropriate electronic or electric outputs at the correct time and sequence to the Governor and Gear Box. The information regarding throttle type, throttle/ clutch sequencing, etc., are all stored on memory within the Processor.

B1-2.3 Power Source

All electronic equipment must have power in order to operate. Ensuring a properly charged reliable power source is available and cruicial.

The Processor requires a 12 or 24 VDC power system.

The minimum voltage at which the Processor will continue to operate is 8.00 VDC. The maximum allowable voltage is 30 VDC. Exceeding these limits will not damage the Processor, but will render it unusable temporarily. The power supply must be capable of delivering 10 amperes to each Processor on a continual basis and current surges up to 20 amperes.

All cable calculations should be based on a 10 ampere draw with no more than 10% voltage drop.

B1-2.4 Electrical Cables and Harnesses

The function of the Electrical Cables and Harnesses are to move electrical information from one point to another. The ZF Marine Electronics' System requires electrical cables and/or pluggable Harnesses. These Harnesses may have plugs on one end or both, depending on its purpose.

There are Harnesses available for Control Head Interface, DC Power, Start Interlock, Clutch Oil Pressure Interlock and External System Status Indication Circuit.

In addition, the application may require Harnesses for one or more of the following:

- Serial Communication
- Tachometer Sensor Signal

B1-2.5 Push-Pull Cables

The primary function of a Push-Pull cable is to allow a physical movement on one end to be felt at the opposite end with a minimum of back-lash.

The Push-Pull cables are mechanically connected on one end to the Processor's cross-bars and the governor and/or transmission selector levers on the other end. The Processor uses the 33C Type push-pull cable as standard, or 43C Type with a special adapter. (Refer to Appendix A - 43C Cable)

Prior to attempting to troubleshoot the System, get as much information as possible from the owner or operator. Inspect the System for signs of misadjustments, loose connections, physical damage or water incursion.

Pay special attention to the following items:

- DC Power Source
- Component Location
- Component Condition
- Interconnecting Wiring and Harnesses
- Wire Terminations
- Plug and Connector Socket Pins
- Mechanical connections at the Selector Levers
- Mechanical connections within the Processor

B2 TROUBLESHOOTING QUESTIONS

Prior to lifting a tool or stepping on board the vessel, many problems can be resolved by asking the customer the following basic questions:

A) Is the System installed on a Single, Twin or Multiple Screw vessel?
- If the System is installed on a Single Screw vessel, this question does not have much value in narrowing down the source of the problem.
- If the System is installed on a Twin or more Screw application, this question is quite useful, if you ask the following question.

1 Does the problem or symptom occur on the Port, Starboard or both sides?
- If the problem or symptom occurs on one side only, you have effectively eliminated 50% of the possible causes. For example, the symptom only occurs on the Port side. All of the components on the Starboard side have been eliminated as potential causes.
- If the problem occurs on both the Port and Starboard sides, you must ask yourself: What do both sides have in common? Most likely answer to your question would be the DC Power source.

B) What is the Part Number and Serial Number of the Processor?
- Whenever the factory is called for technical assistance, the part number and serial number will be required. These numbers provide the Service Technician information about the operating characteristics of the Processor. The numbers are located on the Processor's front cover.

C) How many Remote Stations are there? (If only one Remote Station is present, not much will be gained by asking this question. However, if more than one Remote Station is being used, command should be taken from one of the other Sta0tions to see if the problem occurs from another Station.)
- If the problem occurs from more than one Remote Station, the odds are that the Control Heads are not the cause of the trouble.
- If the problem occurs at one Remote Station only, there is a greater chance of the Control Head or the Control Head Harness of being the cause.

D) Are any tones generated when the problem occurs?

The tones are used to bring the operator's attention to a possible condition or problem. The following basic tones can be produced on all Systems (refer to Section B5 - AUDIBLE TONES):
- **Slow Repetitive Tone**
- **One Long- Three Short Tones**
- **Steady Tone**
- **Three Second Steady Tone**
- **Five Seconds On, Five Seconds Off - High Repetitive Rate Tone**
- **Five Second Steady Tone** .

The following tones can be produced on all Systems using Servo 2:
- **One Long - Two Short Tones**
- **One Long, Two Short - High Repetitive Rate Tones**

The following tones can be produced on all Systems using Servo 1:
- **One Long, One Short - High Repetitive Rate Tone**
- **One Long - One Short Tone**

E) Are there any Error Messages displayed on the Processor's Display LED?
- In addition to generating a tone, at any time the system detects a malfunction or fault, an error message will be displayed at the Processor. Refer to Section 8 - Table B8-1 "Basic Control System Error Codes", for an explanation of the errors.

F) What is the status of the Control Head in command's red LED?
- The red LED(s) will be in one of the following states:

Lit Steady
When the red LED is **Lit Steady**, this indicates that the Station is in command and in Normal operative mode.

Not Lit
When the red LED is **Not Lit**, that Station is not in command, or there is no power to the Control System.

Blinking Slowly
A **Slow Blinking** red LED indicates that the Control Head is in Throttle Only Mode (Warm-up Mode).

Blinking Rapidly
A red LED that is **Blinking Rapidly** indicates that the System is in Troll Mode.

G) Has anything on the vessel changed shortly prior to or when the problem arose?

This question is often overlooked, but should be considered. Obvious changes such as additions or changes to the electrical/ electronic equipment onboard can affect the electrical load and in turn the Processor's power supply.

Ask the operator if any changes or maintenance to the vessel's machinery have occurred lately. Items which are significant to you, the technician, may not seem so to the casual owner or operator. An example would be changes to the engine's fuel system.

Ask about changes, that when initially considered, appear to have nothing to do with the Control System. An example where this really occurred was on a vessel which had recently been repainted. For unknown reasons, the painter took it upon himself to disconnect the connections at a Control Head and then reconnected it incorrectly.

In many cases, these simple questions can resolve a problem with no further action from you, the technician. Take the time to consider these questions. In the long run, you will save yourself and the customer a lot of time and money.

B3 TROUBLESHOOTING PROBLEM RESOLUTION

If the problem could not be resolved by asking the questions in the previous section, a careful inspection of the Control System may be the next step. Even in situations where the problem was found and corrected, it is good practice to always perform a careful inspection of the entire Control System each and every time you are asked aboard a boat.

Always verify that the installation of the System is in compliance with the Installation Manual by carefully inspecting the following:

B3-1 DC Power

A) Ensure that the Processor(s) is connected to a properly charged 12 or 24 VDC battery through a 10 Ampere circuit breaker.

B) To ensure reliable power to the Processors an APS (Automatic Power Selector) is strongly recommended. The APS take inputs from two separate power sources. Whichever power source is at the higher voltage level, will be automatically switched through.

C) Refer to Automatic Power Selector information in Appendix A.

B3-2 Component Location

B3-2.1 Control Heads

There are virtually no restrictions regarding the location of the 400 Series and MC2000 Series Control Heads, as long as the bottom is protected from the environment. The 500 Series Control Heads must be mounted to a console and the 700 Series are waterproof from top to bottom.

Refer to Appendix A - Control Head Reference Sheet for Installation requirements.

B3-2.2 Processors

The Processors are typically mounted in the engine room, while maintaining a minimum distance of 4 feet (1,22m) from sources of high heat and EMI (Electro Magnetic Interference) or RFI (Radio Frequency Interference).

Refer to Section 3 - PLAN THE INSTALLATION for requirements.

B3-3 Component Condition

B3-3.1 Control Heads

Inspect for any signs of corrosion due to water incursion. If hard-wired, ensure that all the fork connectors are properly secured to the terminal. Verify all wires are fully crimped and do not pull loose.

B3-3.2 Processors

Inspect the Processor for any signs of physical damage.

B3-4 Interconnecting Wiring and Harnesses

A) Inspect the wire terminations for loose connections, corrosion or wire strands.

B) Inspect the Harness's pins and sockets for bent pins, torn boots or any signs of corrosion.

The first step in troubleshooting a problem with the Propulsion System is to determine if the problem is with the Control System or something external to the System. In all cases a Control System malfunction will alert the operator of the potential problem. This is accomplished through the audible tone emitted at all Remote Stations. When an audible tone is emitted, it will be accompanied by an Error Message at the Processor. Also, in many cases, the Control System will alert the operator to a problem external to the Control System.

The following are examples of components both internal and external to the Control System which could be a source of trouble:

Table B1: Examples of Components (Internal/External)

Internal	External
Processor	DC Power Source
Control Head	Engine
Interconnecting Wiring (Harnesses)	Transmission

Table B1: Examples of Components (Internal/External)

Internal	External
Push-Pull Cable	Push-Pull Cable

The following pages should give you a good guideline for making this determination. There is no need to troubleshoot the system to any point further than one of the main components listed above. If the fault is found to be with a Control System component, that component is simply replaced. If the fault is found to be with one of the external components, replace or repair the defective component or contact a qualified mechanic.

B4 TROUBLESHOOTING DIAGNOSTIC MENU

The Processor has built in diagnostics designed to assist the technician in determining the cause of a problem. The following information is available to view at any time:

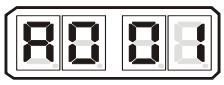
- Applied Battery Voltage
- Tachometer Sender Frequency
- Stations 1- 5 A/D's
- Stations 1- 5 Transfer Button Status
- Servo 2 Feedback A/D's (if applicable)
- Servo 1 Feedback A/D's (if applicable)
- Software Revision Level

In order to access this information, follow the steps below:

A) Locate the Display LED on the Port or Starboard Processor. The Display LED will have the Processor Part Number displayed in a running pattern moving from left to right while the program is running in Normal Operation.

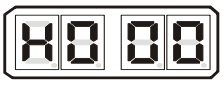
B) Depress the Up or Down Push Button to activate the Function Code List. The characters **A001** will be shown on the Display like Figure B1:

Figure B1: Display Function Code



C) Depress the Up or Down Push Button repeatedly until **H000** is displayed like Figure B2:.

Figure B2: Display Troubleshooting Function

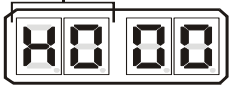


D) Depress and hold the Left and Right Push Buttons simultaneously until the **H0** begins to blink. (Figure B3:) Release the Push Buttons; the applied battery voltage will now be displayed:

- The displayed value is in "real time" and provides a rough estimate of the DC voltage applied to the Processor. The reading is accurate to within 0.50 DC. Refer to Figure B4:

Figure B3: Display Function Blinking

Function Code is Blinking



E) In addition to the applied battery voltage, scrolling through the **Diagnostics Menu** by pressing the Up or Down Push Button can also show the Tachometer Sender Frequency (Figure B5:):

- The information shown is the actual frequency output by the Tachometer Sender. This signal is utilized in "Closed Loop" Synchronization or "Closed Loop" Troll (future) systems
- The Control Head's lever position, and the resulting output of the Station's Control Heads can always be monitored. This is regardless of whether that Station is in command or not. Note the placement of the decimal points in the following examples, which show all Stations with the lever positioned at the Neutral/Idle position. This will be covered in further detail later.

Figure B4: Example Display of Applied Battery Voltage

Figure B5: Example Display of Tach Sensor Frequency

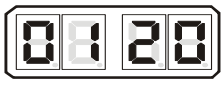
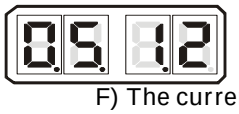


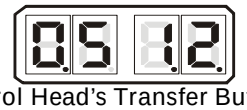
Figure B6: Example Display Control Head Lever Current Positions

Station #1

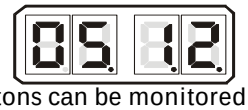


Station #2

Station #3



Station #4

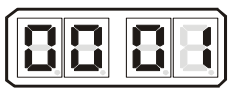


Station # 5

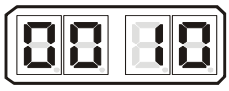
F) The current status of all the Control Head's Transfer Buttons can be monitored within the **Diagnostic Menu.** A **1** indicates a closure (depressed Transfer Button) of the switch, while a **0** indicates an open switch.

Figure B7: Example Display Control Head Transfer Button Status View

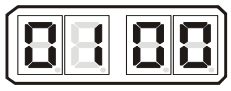
Station #1



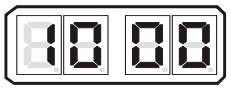
Station #2



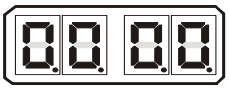
Station #3



Station #4d

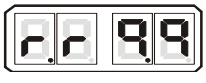


Station # 5d



G) Depressing the Up or Down Push Button one more time will show the current revision level of the software. This feature will provide invaluable information in the years to come. Determining the characteristics or capabilities of a certain Processor will be as simple as selecting this feature.

Figure 1: Example Display of Software Revision Level View



H) Pressing the Up or Down (Scroll) Push Button once more, returns you to the Applied Battery Voltage.

I) The Diagnostic Menu can be exited two ways:

- Do not touch any Push Buttons for 5 minutes. The system will automatically exit.

- Depress the Left Push Button until **H000** appears. You may now scroll through the Set Up Menu.

B5 TROUBLESHOOTING AUDIBLE TONES

As mentioned previously, there are various tones emitted from the Control Head if an error were to occur.

B5-1 Basic Control System Tones

These basic tones are as follows:

B5-1.1 Slow Repetitive Tone

The Slow Repetitive Tone, also referred to as the "Initialization Tone" is the tone you hear at all Remote Stations when power is initially applied to the control system. When this tone is heard, you know for a fact that the following are true:

- Power has just been applied to the system.
- The Software Program is running normally.
- The Processor is commanding the throttle to Idle.
- The Processor is commanding the clutch to Neutral.

This is a normal tone when power has first been applied to the Processor and no Control Head has taken command. However, if during normal operation the engine's throttle drops to Idle, followed by the clutch to Neutral, the Control Head's red LED goes out and a slow repetitive tone is heard at all remote stations, the tone may be an indication of a problem. This indicates that the voltage at the Processor has momentarily dropped below 8 VDC and then returned to a normal operational level. This could be due to:

- Loose battery power cable connection.
- Under-charged or defective battery.
- Voltage drop due to current flow.

In order to pinpoint the exact cause of the low voltage at the Processor, perform the following checks:

A) Check the Display on the Processor for Error Messages. Error Message **57** may appear indicating Under Voltage. One or more of Error Messages **43** through **54** may also be displayed. This is due to the momentary loss of serial communication between the two Processors. Take note that the Under Voltage error is not only dependent on low voltage, it is also dependent on the duration of the low voltage. The possibility exists that an error message would not be displayed if the duration of the low voltage was short enough. However, the other symptoms mentioned above still occur.

B) In either case, follow the procedure listed under Section B4 - DIAGNOSTIC MENU until the Applied Battery Voltage is displayed. Take note of the applied voltage.

C) Go to the battery or Main Distribution Panel which is feeding power to the Processor. With a DC Voltmeter, measure the voltage at this power source. The battery voltage should be greater than 12.4 Volts in 12 VDC systems and 24.8 Volts in 24 VDC systems. If not, the battery or it's charging system needs servicing.

D) The voltage differential between the power source and the Processor should not exceed 1.2 Volts in 12 VDC systems and 2.4 Volts in 24 VDC systems. If so, there is high resistance somewhere between the battery and Processor.

NOTE: If an APS is being utilized in the power circuit, take into account the 0.7 VDC forward voltage drop of the diodes. This would increase the permissible differential between power source and Processor from 1.2 to 1.9 VDC in 12 VDC circuits and 2.4 to 3.1 VDC in 24 VDC circuits.

E) High resistance, resulting in a differential voltage of 1.2 Volts (12 VDC Systems) or 2.4 Volts (24 VDC Systems) or greater, may be the result of corroded or tarnished connections, dirty or pitted relay contacts or an improperly sized power cable.

F) If the voltage differential is less than 1.2 Volts (12 VDC Systems) or 2.4 Volts (24 VDC Systems), which is what you would typically expect, a loose connection may exist between the power source and the Processor. The vibration experienced while the vessel is underway may intermittently cause the circuit to open. Check all the connections between the power source and the Processor for loose bolts, nuts, etc.

B5-1.2 One Long - Three Short Tones

This tone indicates that there is an invalid command signal at the Station-in-Command.

The Processor expects a DC voltage, representative of the Control Head's present lever position.

This voltage is referred to as the "**Command Signal**". In normally functioning Control Heads, the command signal is between approximately 0.8VDC at Full Astern to 4.10 VDC at Full Ahead.

The command signal is converted by the Processor to a digital representation, referred to as an A/D (Analog/Digital) Count. More on A/D Counts later. If the command signal drops below 0.6 VDC or exceeds 4.40 VDC, the tone will be generated.

At the same time the tone is heard, throttle command drops to Idle and the clutch will be commanded to Neutral. The following items will cause this to occur:

- An open or high resistance connection between the Control Head and Processor.
- Out of calibration Control Head.
- A defective Control Head.

The exact cause of the malfunction can be found as follows:

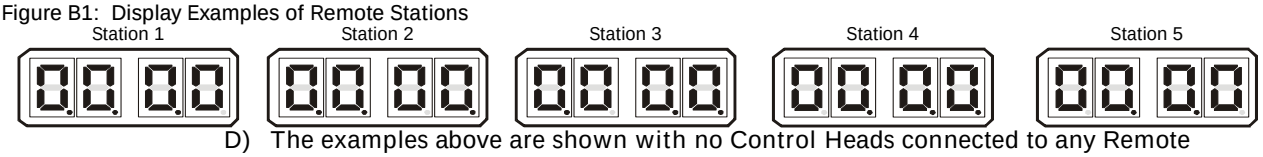
A) Check the Processor's Display for error messages. Most likely, one of error messages **13** thru **32** will be shown. The exact number shown depends on which remote station is experiencing the problem and whether the command signal was too high or too low.

B) Enter the **Diagnostic Menu** as outlined in Section B4 - DIAGNOSTIC MENU.

C) Depress the Up or Down (Scroll) Push Button until the appropriate Remote Station is displayed.

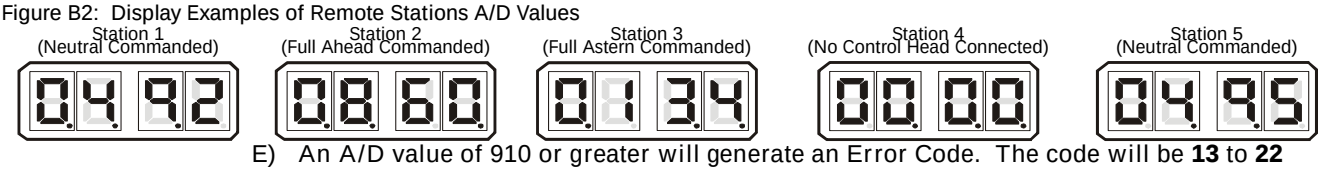
- The Remote Station are identified by the position of the decimal points.
- Station 1 has no decimal point after the first digit to the far right. The remaining three digits all have decimal points.
- If the digit to the far left had no decimal point following it, but the remaining three do, this would represent Station 4.

Figure B1: Display Examples of Remote Stations



D) The examples above are shown with no Control Heads connected to any Remote Stations. When a Control Head is connected, the appropriate A/D (Analog/Digital) value for the present position of the Control Head's lever will be shown, as in the following examples:

Figure B2: Display Examples of Remote Stations A/D Values



E) An A/D value of 910 or greater will generate an Error Code. The code will be **13** to **22** (Control Head # Faulted High), depending on which Station has the high Command Signal.

- If the A/D value is greater than 910, but less than 990, one of the following may be the cause:
  1. The Control Head's potentiometer is out of calibration.
  2. The potentiometer is defective.

  In either case, it is recommended that the Control Head is replaced.
- If the A/D value is 995 or higher, most likely the potentiometer's ground has been lost.
- Right hand Control Heads have a jumper between pins 3 and 5 if a Harness is used. This jumper provides the potentiometers ground.
- Left hand Control heads have a jumper between pins 3 and 7 if a Harness is used. This jumper provides the potentiometers ground.
- The potentiometer ground connection for Control Heads are hard-wired to the Processor through the yellow wire (pin 5 on right hand and pin 7 on left hand).

F) If the A/D value is 100 or less, one of Error Codes **23**- **32** (Control Head # Faulted Low) will be shown.

- If the A/D value is less than 100, but greater than 75, the following may be the cause:
  1. The Control Head's potentiometer is out of calibration.
  2. The potentiometer is defective.
  3. A high resistance connection exists on pin 6 (green wire) between the Control Head and Processor.
- If the A/D value is less than 75:
  1. There is an open wire between pin 6 (green wire) of the Control Head and the Processor.
  2. There is an open wire between pin 7 (blue wire) of a right hand Control Head and the Processor.
  3. There is an open wire between pin 5 (blue wire) of a left hand Control Head and pin 7 (blue wire) of the Processor.

B5-1.3 Steady Tone

The Steady Tone is an indication to the operator that something has gone wrong within the Control System. The Steady Tone will typically be accompanied by an Error Message on the Processor's Display. If the tone is heard, the Processor's Display must be referred to in order to further diagnosis the problem.

If the Transfer Button is shorted - Tone will cease when command is taken at another Station.

If the Transfer Button becomes shorted for 12 seconds or more during Normal Operation, a steady tone will be produced at all Remote Stations as long as the Transfer Button remains shorted. Full System control remains. Transferring to another Remote Station silences the Steady Tone. Command cannot be regained at the (shorted) Station until the problem is rectified.

B5-1.4 Three Second Steady Tone

This tone could indicate one of three things:

- Transfer Button on the Control Head in command is stuck.
- If the Processor for this System includes the use of Back-up Mode, this tone would indicate that there has been a switch closure requesting Back-up Mode.
- If the Processor for this System includes Integrated Solenoid Trolling Valve control, this tone would indicate that there has been a Troll Solenoid error. Refer to the Error Code displayed.

B5-1.5 Three Second Steady Tone, followed by a Slow Repetitive Tone

This tone indicates that there has been a shorted Transfer Button on power-up. Command can be gained at any other Remote Station, which silences the Slow Repetitive Tone.

B5-1.6 Five Seconds On, Five Seconds Off - High Repetitive Rate Tone

Loss of communication with Station Expander (SE) or the Troll Actuator (p/n 9001). This tone cannot be cleared unless all Error Codes (Active and In-Active) have been cleared.

B5-1.7 Five Second Steady Tone

Loss of Serial Communication.

B5-2 Servo 2 Control System Tones

B5-2.1 One Long - Two Short Tones

This tone indicates that the feedback signal, which represents the position of the Servo 2 cross-bar, is out of expected range.

This tone will be accompanied by Error Code **66** or **67**.

- If Error Code **66** is displayed, the signal received from the feedback potentiometer is higher than expected. This is due to one of the three following reasons:
  1 The orange wire (ground) between the potentiometer and plug are not making contact, or have a high resistance contact.
  2 The potentiometer is out of calibration.
  3 The potentiometer is defective.
- If Error Code **67** is displayed, the signal received from the feedback potentiometer is lower than expected. This is due to one of the following reasons:
  1 The green (signal) or orange (reference voltage) wires between the potentiometer and plug are not making contact or have a high resistance contact.
  2 The potentiometer is out of calibration.
  3 The potentiometer is defective.
  4 The Control Circuit is defective.

The Servo 2 feedback signal can be viewed within the Diagnostic Menu. The Value displayed depends on the direction and amount of push-pull cable travel. As a general rule:

- When the Value displayed is **1023** or **0**, the problem is with the wiring between the potentiometer and plug.
- If the displayed Value varies, the potentiometer is defective.
- When the Value is too high or too low when fully extended, the potentiometer requires calibration.

B5-2.2 One Long, Two Short - High Repetitive Rate Tones

This tone is also referred to as a **Jam Tone**. When sounded, Servo 2 is unable to reach the commanded position. In most cases when a **Jam Tone** is encountered, it can be cleared by moving the Control Head lever back to the point prior to where the tone was first encountered.

The tone will be accompanied by Error Code **65** and is typically caused by one of the following reasons:

- Stiff or frozen selector lever.
- Misadjusted push-pull cable.
- Defective push-pull cable.
- Low battery voltage.
- Defective Processor.

In order to isolate the cause to one of these five items, follow the steps below:

A) Turn the power ON to the Processor.
   - If the tone is not present continue with step C)
   - If the tone is present, check the DC voltage to the Processor by accessing the Diagnostic Menu **H0**. If the voltage is adequate continue with step B.

B) Disconnect the push-pull cable from the selector lever.
   - If the tone is still present after cycling power, replace the Processor.
   - If the tone is no longer present, continue with step C)

C) If disconnected, reconnect the push-pull cable.

D) Depress the Transfer Button while moving the Control Head lever to the Ahead detent.

E) Release the transfer button and continue to move the Control Head lever through the speed range.
   - If the tone does not sound until the Control Head lever is close to full throttle, Function Code **E3** Throttle Maximum is misadjusted.
   - If the tone sounds earlier than full throttle, continue with step F).

F) Disconnect the push-pull cable from the selector lever.

G) Manually reposition the selector lever (Idle to Full).
   - If the selector lever is very stiff it needs to be serviced.
   - If the selector lever moves freely, the push-pull cable is defective and needs replacing.

B5-3 Servo 1 Control System Tones

B5-3.1 One Long - One Short Tone

This tone indicates that the feedback signal, which represents the position of the Servo 1 cross-bar, is out of the expected range.

This tone will be accompanied by Error Code **63** or **64**.

- If Error Code **63** is displayed, the signal received from the feedback potentiometer is higher than expected. This is due to one of the three following reasons:
  1. The orange wire (ground) between the potentiometer and plug are not making contact, or have a high resistance contact.
  2. The potentiometer is out of calibration.
  3. The potentiometer is defective.
- If Error Code **64** is displayed, the signal received from the feedback potentiometer is lower than expected. This is due to one of the following reasons:
  1. The green (signal) or orange (reference voltage) wires between the potentiometer and plug are not making contact or have a high resistance contact.
  2. The potentiometer is out of calibration.
  3. The potentiometer is defective.
  4. The Control Circuit is defective.

The Servo 1 feedback signal can be viewed within the Diagnostic Menu. The Value displayed depends on the direction and amount of push-pull cable travel. As a general rule:

- When the Value displayed is **1023** or **0**, the problem is with the wiring between the potentiometer and plug.
- If the displayed Value varies, the potentiometer is defective.
- When the Value is slightly too high or too low when fully extended, the potentiometer requires calibration.

B5-3.2 One Long, One Short - High Repetitive Rate Tones

This tone is also referred to as a **Jam Tone**. When sounded, Servo 1 is unable to reach the commanded position. In most cases when a **Jam Tone** is encountered, it can be cleared by moving the Control Head lever back to the point prior to where the tone was first encountered.

The tone will be accompanied by Error Code **62** and is typically caused by one of the following reasons:

- Stiff or frozen selector lever.
- Misadjusted push-pull cable.
- Defective push-pull cable.
- Low battery voltage.
- Defective Processor.

In order to isolate the cause to one of these five items, follow the steps below:

A) Disconnect the push-pull cable from the selector lever.

B) Move the Control Head lever to Ahead, Astern, and back to Neutral.
   - If the tone ceases continue with step C).
   - If the tone is still present, skip ahead to step D).

C) Grab a hold of the selector lever and manually reposition the lever.
   - If the selector lever is very stiff it needs servicing.
   - If the selector lever moves freely, the push-pull cable's travel is misadjusted and needs to be corrected.

D) If the tone did not cease in step B), remove the push-pull cable from the Processor.

E) Move the Control Head lever back and forth from Neutral to Ahead to Astern.
   - If the tone ceases, the push-pull cable is defective and needs to be replaced.
   - If the tone did not cease, check the DC Voltage to the Processor by accessing the Diagnostic Menu **H0**. If the voltage is adequate, replace the Processor.

B6 TROUBLESHOOTING STATION TRANSFER

In order to transfer command from one Remote Station to another, the following must occur:

- There must be a valid "Command Signal" at the Station being transferred to.
- The "Command Signal" must indicate that the Control Head's lever(s) is at the Neutral/Idle position.
- The Transfer Button must be depressed which takes the "Station Select" signal from 5.00 VDC to 0.00 VDC.

If a transfer from one Remote Station to another is requested, but does not take place; the items required for successful transfer can be tested as follows:

B6-1 Command Signal

- The Command Signal is a DC voltage which varies in relationship to the Control Head's lever position.
- The Processor provides each Control Head 5.00 +/- 0.20VDC, which is referred to as the "Reference Voltage".
- The Reference Voltage is applied to a 5K Ohm Potentiometer in the Control Head.
- The potentiometer's "Wiper" taps off a portion of the Reference Voltage and sends it back to the Processor.
- The amount of DC voltage which is tapped off, is dependant on the position of the Control Head's lever.
- When the lever is fully Astern, a small portion of the Reference Voltage is tapped off by the wiper, and therefore, the voltage is at its lowest point (approximately 0.80 VDC).
- When the lever is positioned fully Ahead, a larger portion is tapped off and the voltage is at its highest point (approximately 4.10 VDC).

B6-2 Analog to Digital (A/D) Counts

Since all the calculations within the control system are performed digitally, these DC voltages are expressed as and converted to a digital representation.

- The "Reference Voltage" (approximately 5.00 VDC) by which all analog inputs are based, is represented as 1023 A/D (Analog to Digital) Counts.
- This allows for the possibility of a 1024 possible positions when 0 is included in the count.
- The value of the Command Voltage with the lever at the Neutral/Idle position is 49- 51% of the Reference Voltage when measured at the Station terminal block. The actual value read by the Processor is 2% below that value or 47% to 49% of 1023 A/D Counts (485- 505 A/D).

NOTE: The A/D values listed for Full Ahead and Full Astern represent the point where maximum throttle is reached. The A/D count when the Control Head lever is physically at it's maximum point will be higher, but may not exceed the out-of-range values listed in Table B2:, page B6-15.

- The Command Signal at Full Ahead is 82- 84% of the Reference Voltage when measured at the Station terminal block. The actual value read by the Processor is 2% below that value or 80- 82% of 1023 A/D Counts (821- 841 A/D).
- The Command Signal at Full Astern is 17 - 19% of the Reference Voltage when measured at the Station terminal block. The actual value read by the Processor is 2% below that value or 15- 17% of 1023 A/D Counts (153- 173 A/D).
- Since the Command Signal is based on a percentage of the Reference Voltage, the distance of the Control Head from the Processor has no impact on the performance of the system.
- The amount of voltage drop, due to current flow, is the same for both the Reference and Command Voltages.
- The relationship between the Reference and Command Voltages when thought of as a percentage, will remain the same regardless of distance. For instance, here are two examples.

Example 1:

Reference Voltage	5.00 VDC	1023 A/D Counts
Command Voltage	2.45 VDC	501 A/D Counts

Example 2:

Reference Voltage	4.80 VDC	1023 A/D Counts
Command Voltage	2.35 VDC	501 A/D Counts

As you can see by the examples, even though the Command Voltages are different between Examples 1 and 2, the resulting A/D counts, are the same because of the different Reference Voltages. This would result in the Processor commanding the identical outputs (Clutch & Throttle) in both cases.

A) The A/D count for a specific Control Head's lever can be seen on the Processor's Display by following the steps outlined in Section B4 - TROUBLESHOOTING DIAGNOSTIC MENU.

B) Once the appropriate remote station is reached, ensure that the displayed A/D Count represents the Neutral/Idle position (485- 505 A/D counts). Command will not be accepted unless the Control Head's lever is at the Neutral/Idle position.

The following table shows the appropriate A/D Counts for various Control Head lever positions:

Table B2: Control Head Lever A/D Counts

Control Head Lever Position	A/D Count
Lever Out of Range Low	100
Full Astern	153 - 173
Neutral/ Idle	485 - 505
Ahead Shift Point	537
Full Ahead	821 - 841
Lever Out of Range High	910

B6-3 Remote Station Select

The second required item for taking command is "Station Select" or depressing of the Transfer Button. The Transfer Button can be tested by entering the Diagnostic Menu H0.

Figure B3: No Station Transfer Button Depressed

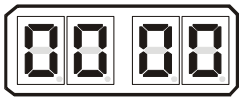


Figure B4: Transfer Button Depressed for Stations 1 - 4

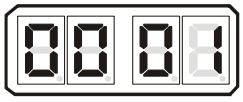
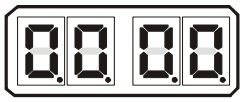


Figure B5: Transfer Button Depressed for Station 5



A) Depress the Up or Down (scroll) Push Button until four zeroes are displayed without decimal points as shown in Figure B3:.

B) For Stations 1 - 4 when the Transfer Button is depressed, the **0** which represents that remote station, will change to a **1** as shown in Figure B4:. For Station 5 when the Transfer Button is depressed, all four decimal points will light as shown in Figure B5:

- Whenever command cannot be gained at a particular remote station, the Station Select and Command Signals are the first to be investigated. If either the Command Signal is out of range or the Station Select is inoperable, command will not be accepted at that remote station.

B6-4 Stuck Transfer Button

The Transfer Button is a normally open, momentary switch. The only time the switch should close is when it is depressed to take command or when entering or departing various other functions. In the event that the Transfer Button became stuck in the closed position, the following will occur:

- The Transfer Button would have to be closed for 15 seconds or more.
- The throttle and clutch are not affected.
- A solid tone is heard from all remote stations, until the button's contact opens or transfer to another remote station has taken place.

If a Control Head that is not in command has a stuck transfer button, the following will happen:

- If Control Head levers are positioned at Neutral/Idle, a solid tone is heard from all remote stations.
- If Control Head levers are positioned other than Neutral/Idle, a three (3) second tone is heard from all remote stations.
- Error Code **33** - **42**, depending on which remote station, will be shown on the Processor Display.
- Command can be taken at any other operational remote station.
- After one (1) second command can be regained at the remote station with the stuck button as long as the problem has been corrected by depressing the transfer button.

If a stuck Transfer Button is suspected, this can be verified by looking at the Station Select status (**1** or **0**) as outlined in Section B6-4 - "Remote Station Select".

- An Error Code **33** - **42** will be shown on the Display, depending on which Station is experiencing the problem.

B7 TROUBLESHOOTING ERROR CODES

As stated previously, if a problem with the Control System is detected, the Processor is programmed to display numerous Error Codes to aid in the isolation of the cause. The following tables list these Error Codes, along with a brief description.

Table B3: Basic Error Codes

Error #	Title	Description
13	Station No.1 Faulted High	Station No.1 Control Head's lever position is out of range. The input appears to be too high.
14	Station No.2 Faulted High	Station No.2 Control Head's lever position is out of range. The input appears to be too high.
15	Station No.3 Faulted High	Station No.3 Control Head's lever position is out of range. The input appears to be too high.
16	Station No.4 Faulted High	Station No.4 Control Head's lever position is out of range. The input appears to be too high.
17	Station No.5 Faulted High	Station No.5 Control Head's lever position is out of range. The input appears to be too high.
18	Station No.6 Faulted High	Station No.6 Control Head's lever position is out of range. The input appears to be too high.
19	Station No.7 Faulted High	Station No.7 Control Head's lever position is out of range. The input appears to be too high.
20	Station No.8 Faulted High	Station No.8 Control Head's lever position is out of range. The input appears to be too high.
21	Station No.9 Faulted High	Station No.9 Control Head's lever position is out of range. The input appears to be too high.
22	Station No.10 Faulted High	Station No.10 Control Head's lever position is out of range. The input appears to be too high.
23	Station No.1 Faulted Low	Station No.1 Control Head's lever position is out of range. The input appears to be too low.
24	Station No.2 Faulted Low	Station No.2 Control Head's lever position is out of range. The input appears to be too low.
25	Station No.3 Faulted Low	Station No.3 Control Head's lever position is out of range. The input appears to be too low.
26	Station No.4 Faulted Low	Station No.4 Control Head's lever position is out of range. The input appears to be too low.
27	Station No.5 Faulted Low	Station No.5 Control Head's lever position is out of range. The input appears to be too low.
28	Station No.6 Faulted Low	Station No.6 Control Head's lever position is out of range. The input appears to be too low.
29	Station No.7 Faulted Low	Station No.7 Control Head's lever position is out of range. The input appears to be too low.
30	Station No.8 Faulted Low	Station No.8 Control Head's lever position is out of range. The input appears to be too low.
31	Station No.9 Faulted Low	Station No.9 Control Head's lever position is out of range. The input appears to be too low.
32	Station No.10 Faulted Low	Station No.10 Control Head's lever position is out of range. The input appears to be too low.
33	Station No.1 Button Stuck Closed	Station No.1 Control Head's Transfer Button has either been closed too long or has been closed since power-up.
34	Station No.2 Button Stuck Closed	Station No.2 Control Head's Transfer Button has either been closed too long or has been closed since power-up.
35	Station No.3 Button Stuck Closed	Station No.3 Control Head's Transfer Button has either been closed too long or has been closed since power-up.

36	Station No.4 Button Stuck Closed	Station No.4 Control Head's Transfer Button has either been closed too long or has been closed since power-up.
37	Station No.5 Button Stuck Closed	Station No.5 Control Head's Transfer Button has either been closed too long or has been closed since power-up.
38	Station No.6 Button Stuck Closed	Station No.6 Control Head's Transfer Button has either been closed too long or has been closed since power-up.
39	Station No.7 Button Stuck Closed	Station No.7 Control Head's Transfer Button has either been closed too long or has been closed since power-up.
40	Station No.8 Button Stuck Closed	Station No.8 Control Head's Transfer Button has either been closed too long or has been closed since power-up.
41	Station No.9 Button Stuck Closed	Station No.9 Control Head's Transfer Button has either been closed too long or has been closed since power-up.
42	Station No.10 Button Stuck Closed	Station No.10 Control Head's Transfer Button has either been closed too long or has been closed since power-up.
43	CAN Communication Stuffing Error	The Control-Area-Network protocol has detected an error in communication with other devices on the network. The error type is a stuffing error.
44	CAN Communication Form Error	The Control-Area-Network protocol has detected an error in communication with other devices on the network. The error type is a form error.
45	CAN Communication Acknowledge Error	The Control-Area-Network protocol has detected an error in communication with other devices on the network. The error type is an acknowledge error.
46	CAN Communication Bit 1 Error	The Control-Area-Network protocol has detected an error in communication with other devices on the network. The error type is a Bit 1 error.
47	CAN Communication Bit 0 Error	The Control-Area-Network protocol has detected an error in communication with other devices on the network. The error type is a Bit 0 error.
48	CAN Communication CRC Error	The Control-Area-Network protocol has detected an error in communication with other devices on the network. The error type is a CRC error.
49	CAN Communication Bus Error	The Control-Area-Network protocol has detected an error in communication with other devices on the network. The error type is a Bus failure error. The error cannot be recovered from without cycling power to the Processor.
50	Comm. Error Time-out System 1	Communication with System 1 has been too long without a Refresh message
51	Comm. Error Time-out System 2	Communication with System 1 has been too long without a Refresh message
52	Comm. Error Time-out System 3	Communication with System 1 has been too long without a Refresh message
53	Comm. Error Time-out System 4	Communication with System 1 has been too long without a Refresh message
54	Comm. Error Time-out System 5	Communication with System 1 has been too long without a Refresh message
55	SE Communication Error	Communication with the Station Expander has been too long without a Refresh message.
56	High Battery Voltage Fault	The applied battery voltage is 30VDC or higher for at least two seconds.
57	Low Battery Voltage Fault	The applied battery voltage is 10VDC or lower for at least two seconds.

58	Reset Due to Software Watchdog	The system has had an unexpected Reset, due to a software problem.
59	Reset Due to Software Fault	The system has had an unexpected Reset, due to a softwareproblem.
60	Reset Due to Hardware Watchdog	The system has had an unexpected Reset, due to a hardware problem.
61	Oscillator Watchdog	The system Oscillator has experienced a malfunction.

Table B4: Servo 1 Error Codes

Error #	Title	Description
62	Servo 1 Jam	Servo one is unable to make any progress toward its commanded position
63	Servo 1 Feedback High	Servo one's position feedback voltage is higher than the acceptable range.
64	Servo 1 Feedback Low	Servo one's position feedback voltage is lower than the acceptable range.

Table B5: Servo 2 Error Codes

Error #	Title	Description
65	Servo 2 Jam	Servo two is unable to make any progress toward its commanded position
66	Servo 2 Feedback High	Servo two's position feedback voltage is higher than the acceptable range.
67	Servo 2 Feedback Low	Servo two's position feedback voltage is lower than the acceptable range.

B8 PROBLEM CAUSES AND SOLUTIONS

The following table lists the various Error Codes and provides possible causes and solutions. Error Codes appearing on the Port side Processor's Display LED are port side errors and vice versa. The Causes and Solutions provided are the most likely, but are not the only possible causes for the Errors Codes listed.

Table 1: Basic Control System Problem Causes and Solutions

Error #	CAUSE	SOLUTION
13	a. Station No.1 Control Head is defective.	a. Replace Station No.1 Control Head.
	b. No continuity between pin 5's of the Control Head Harness connectors.	b. Ensure that the red conductor is properly crimped to pin 5 at both connectors.
	c. Control Head jumper (pin 3 to 5 or 7) is missing.	c. Install a jumper from pin 3 to 5 on right hand and 3 to 7 on left hand Control Heads
14	a. The Station No.2 Control Head is defective.	a. Replace Station No.2 Control Head.
	b. No continuity between pin 5's of the Control Head Harness connectors.	b. Ensure that the red conductor is properly crimped to pin 5 at both connectors.
	c. Control Head jumper (pin 3 to 5 or 7) is missing	c. Install a jumper from pin 3 to 5 on right hand and 3 to 7 on left hand Control Heads.
15	a. The Station No.3 Control Head is defective.	a. Replace Station No.3 Control Head.
	b. o continuity between pin 5's of the Control Head Harness connectors.	b. Ensure that the red conductor is properly crimped to pin 5 at both connectors.
	c. Control Head jumper (pin 3 to 5 or 7) is missing.	c. Install a jumper from pin 3 to 5 on right hand and 3 to 7 on left hand Control Heads.
16	a. The Station No.4 Control Head is defective.	a. Replace Station No.4 Control Head.
	b. No continuity between pin 5's of the Control Head Harness connectors.	b. Ensure that the red conductor is properly crimped to pin 5 at both connectors.
	c. Control Head jumper (pin 3 to 5 or 7) is missing.	c. Install a jumper from pin 3 to 5 on right hand and 3 to 7 on left hand Control Heads.
17	a. The Station No.5 Control Head is defective.	a. Replace Station No.5 Control Head.
	b. No continuity between pin 5's of the Control Head Harness connectors.	b. Ensure that the red conductor is properly crimped to pin 5 at both connectors.
	c. Control Head jumper (pin 3 to 5 or 7) is missing.	c. Install a jumper from pin 3 to 5 on right hand and 3 to 7 on left hand Control Heads.
18	a. The Station No.6 Control Head is defective.	a. Replace Station No.6 Control Head.
	b. No continuity between pin 5's of the Control Head Harness connectors.	b. Ensure that the red conductor is properly crimped to pin 5 at both connectors.
	c. Control Head jumper (pin 3 to 5 or 7) is missing.	c. Install a jumper from pin 3 to 5 on right hand and 3 to 7 on left hand Control Heads.
19	a. The Station No.7 Control Head is defective.	a. Replace Station No.7 Control Head.
	b. No continuity between pin 5's of the Control Head Harness connectors.	b. Ensure that the red conductor is properly crimped to pin 5 at both connectors.
	c. Control Head jumper (pin 3 to 5 or 7) is missing.	c. Install a jumper from pin 3 to 5 on right hand and 3 to 7 on left hand Control Heads.
20	a. The Station No.8 Control Head is defective.	a. Replace Station No.8 Control Head.
	b. No continuity between pin 5's of the Control Head Harness connectors.	b. Ensure that the red conductor is properly crimped to pin 5 at both connectors.
	c. Control Head jumper (pin 3 to 5 or 7) is missing.	c. Install a jumper from pin 3 to 5 on right hand and 3 to 7 on left hand Control Heads.
21	a. The Station No.9 Control Head is defective.	a. Replace Station No.9 Control Head.
	b. No continuity between pin 5's of the Control Head Harness connectors.	b. Ensure that the red conductor is properly crimped to pin 5 at both connectors.
	c. Control Head jumper (pin 3 to 5 or 7) is missing.	c. Install a jumper from pin 3 to 5 on right hand and 3 to 7 on left hand Control Heads.

Table 1: Basic Control System Problem Causes and Solutions

Error #	CAUSE	SOLUTION
22	a. The Station No.10 Control Head is defective.	a. Replace Station No.10 Control Head.
	b. No continuity between pin 5's of the Control Head Harness connectors.	b. Ensure that the red conductor is properly crimped to pin 5 at both connectors.
	c. Control Head jumper (pin 3 to 5 or 7) is missing.	c. Install a jumper from pin 3 to 5 on right hand and 3 to 7 on left hand Control Heads.
23	a. The Station No.1 Control Head is defective.	a. Replace Station No.1 Control Head.
	b. No continuity between pin 6's of the Control Head Harness connectors.	b. Ensure that the green conductor is properly crimped to pin 6 at both connectors and there is continuity.
	c. No continuity between pin 7's of the Control Head Harness connectors.	c. Ensure that the blue conductor is properly crimped to pin 7 at both connectors and there is continuity.
24	a. The Station No.2 Control Head is defective.	a. Replace Station No.2 Control Head.
	b. No continuity between pin 6's of the Control Head Harness connectors.	b. Ensure that the green conductor is properly crimped to pin 6 at both connectors and there is continuity.
	c. No continuity between pin 7's of the Control Head Harness connectors.	c. Ensure that the blue conductor is properly crimped to pin 7 at both connectors and there is continuity.
25	a. The Station No.3 Control Head is defective.	a. Replace Station No.3 Control Head.
	b. No continuity between pin 6's of the Control Head Harness connectors.	b. Ensure that the green conductor is properly crimped to pin 6 at both connectors and there is continuity.
	c. No continuity between pin 7's of the Control Head Harness connectors.	c. Ensure that the blue conductor is properly crimped to pin 7 at both connectors and there is continuity.
26	a. The Station No.4 Control Head is defective.	a. Replace Station No.4 Control Head.
	b. No continuity between pin 6's of the Control Head Harness connectors.	b. Ensure that the green conductor is properly crimped to pin 6 at both connectors and there is continuity.
	c. No continuity between pin 7's of the Control Head Harness connectors.	c. Ensure that the blue conductor is properly crimped to pin 7 at both connectors and there is continuity.
27	a. The Station No.5 Control Head is defective.	a. Replace Station No.5 Control Head.
	b. No continuity between pin 6's of the Control Head Harness connectors.	b. Ensure that the green conductor is properly crimped to pin 6 at both connectors and there is continuity.
	c. No continuity between pin 7's of the Control Head Harness connectors.	c. Ensure that the blue conductor is properly crimped to pin 7 at both connectors and there is continuity.
28	a. The Station No.6 Control Head is defective.	a. Replace Station No.6 Control Head.
	b. No continuity between pin 6's of the Control Head Harness connectors.	b. Ensure that the green conductor is properly crimped to pin 6 at both connectors and there is continuity.
	c. No continuity between pin 7's of the Control Head Harness connectors	c. Ensure that the blue conductor is properly crimped to pin 7 at both connectors and there is continuity.

Table 1: Basic Control System Problem Causes and Solutions

Error #	CAUSE	SOLUTION
29	a. The Station No.7 Control Head is defective.	a. Replace Station No.7 Control Head.
	b. No continuity between pin 6's of the Control Head Harness connectors.	b. Ensure that the green conductor is properly crimped to pin 6 at both connectors and there is continuity.
	c. No continuity between pin 7's of the Control Head Harness connectors.	c. Ensure that the blue conductor is properly crimped to pin 7 at both connectors and there is continuity.
30	a. The Station No.8 Control Head is defective.	a. Replace Station No.8 Control Head.
	b. No continuity between pin 6's of the Control Head Harness connectors.	b. Ensure that the green conductor is properly crimped to pin 6 at both connectors and there is continuity.
	c. No continuity between pin 7's of the Control Head Harness connectors.	c. Ensure that the blue conductor is properly crimped to pin 7 at both connectors and there is continuity.
31	a. The Station No.9 Control Head is defective.	a. Replace Station No.9 Control Head.
	b. No continuity between pin 6's of the Control Head Harness connectors.	b. Ensure that the green conductor is properly crimped to pin 6 at both connectors and there is continuity.
	c. No continuity between pin 7's of the Control Head Harness connectors	c. Ensure that the blue conductor is properly crimped to pin 7 at both connectors and there is continuity.
32	a. The Station No.10 Control Head is defective.	a. Replace Station No.10 Control Head.
	b. No continuity between pin 6's of the Control Head Harness connectors.	b. Ensure that the green conductor is properly crimped to pin 6 at both connectors and there is continuity.
	c. No continuity between pin 7's of the Control Head Harness connectors.	c. Ensure that the blue conductor is properly crimped to pin 7 at both connectors and there is continuity.
33	a. The Station No.1 transfer button was held down for 15 seconds or longer	a. Clear the Error Code from memory
	b. The Station No.1 Control Head transfer button is defective	b. Replace the Control Head
	c. The Control Head Harness is miswired.	c. Ensure that the orange conductor is crimped to pin 4 at both ends and the red wire is crimped to pin 5 at both ends of the Harness.
	d. The Control Head's Pigtail is miswired.	d. Ensure that the orange conductor is crimped to pin 4 of the connector and connected to pin 4 of the Control Head's terminal block. In addition, ensure that the red conductor is crimped to pin 5 of the connector and connected to pin 3 of the Control Head's terminal block.
34	a. The Station No.2 transfer button was held down for 15 seconds or longer.	a. Clear the Error Code from memory.
	b. The Station No.2 Control Head transfer button is defective.	b. Replace the Control Head.
	c. The Control Head Harness is miswired.	c. Ensure that the orange conductor is crimped to pin 4 at both ends and the red wire is crimped to pin 5 at both ends of the Harness.
	d. The Control Head's Pigtail is miswired.	d. Ensure that the orange conductor is crimped to pin 4 of the connector and connected to pin 4 of the Control Head's terminal block. Ensure that the red conductor is crimped to pin 5 of the connector and connected to pin 3 of the Control Head's terminal block.

Table 1: Basic Control System Problem Causes and Solutions

Error #	CAUSE	SOLUTION
35	a. The Station No.3 transfer button was held down for 15 seconds or longer.	a. Clear the Error Code from memory.
	b. The Station No.3 Control Head transfer button is defective.	b. Replace the Control Head.
	c. The Control Head Harness is miswired.	c. Ensure that the orange conductor is crimped to pin 4 at both ends and the red wire is crimped to pin 5 at both ends of the Harness.
	d. The Control Head's Pigtail is miswired.	d. Ensure that the orange conductor is crimped to pin 4 of the connector and connected to pin 4 of the Control Head's terminal block. Ensure that the red conductor is crimped to pin 5 of the connector and connected to pin 3 of the Control Head's terminal block.
36	a. The Station No.4 transfer button was held down for 15 seconds or longer.	a. Clear the Error Code from memory.
	b. The Station No.4 Control Head transfer button is defective.	b. Replace the Control Head.
	c. The Control Head Harness is miswired.	c. Ensure that the orange conductor is crimped to pin 4 at both ends and the red wire is crimped to pin 5 at both ends of the
	d. The Control Head's Pigtail is miswired.	d. Ensure that the orange conductor is crimped to pin 4 of the connector and connected to pin 4 of the Control Head's terminal block. Ensure that the red conductor is crimped to pin 5 of the connector and connected to pin 3 of the Control Head's terminal block.
37	a. The Station No.5 transfer button was held down for 15 seconds or longer.	a. Clear the Error Code from memory.
	b. The Station No.5 Control Head transfer button is defective.	b. Replace the Control Head.
	c. The Control Head Harness is miswired.	c. Ensure that the orange conductor is crimped to pin 4 at both ends and the red wire is crimped to pin 5 at both ends of the Harness.
	d. The Control Head's Pigtail is miswired.	d. Ensure that the orange conductor is crimped to pin 4 of the connector and connected to pin 4 of the Control Head's terminal block. Ensure that the red conductor is crimped to pin 5 of the connector and connected to pin 3 of the Control Head's terminal block.
38	a. The Station No.6 transfer button was held down for 15 seconds or longer.	a. Clear the Error Code from memory.
	b. The Station No.6 Control Head transfer button is defective.	b. Replace the Control Head.
	c. The Control Head Harness is miswired.	c. Ensure that the orange conductor is crimped to pin 4 at both ends and the red wire is crimped to pin 5 at both ends of the Harness.
	d. The Control Head's Pigtail is miswired.	d. Ensure that the orange conductor is crimped to pin 4 of the connector and connected to pin 4 of the Control Head's terminal block. Ensure that the red conductor is crimped to pin 5 of the connector and connected to pin 3 of the Control Head's terminal block.

Table 1: Basic Control System Problem Causes and Solutions

Error #	CAUSE	SOLUTION
39	a. The Station No.7 transfer button was held down for 15 seconds or longer.	a. Clear the Error Code from memory.
	b. The Station No.7 Control Head transfer button is defective.	b. Replace the Control Head.
	c. The Control Head Harness is miswired.	c. Ensure that the orange conductor is crimped to pin 4 at both ends and the red wire is crimped to pin 5 at both ends of the Harness.
	d. The Control Head's Pigtail is miswired.	d. Ensure that the orange conductor is crimped to pin 4 of the connector and connected to pin 4 of the Control Head's terminal block. Ensure that the red conductor is crimped to pin 5 of the connector and connected to pin 3 of the Control Head's terminal block.
40	a. The Station No.8 transfer button was held down for 15 seconds or longer.	a. Clear the Error Code from memory.
	b. The Station No.8 Control Head transfer button is defective.	b. Replace the Control Head.
	c. The Control Head Harness is miswired.	c. Ensure that the orange conductor is crimped to pin 4 at both ends and the red wire is crimped to pin 5 at both ends of the Harness.
	d. The Control Head's Pigtail is miswired.	d. Ensure that the orange conductor is crimped to pin 4 of the connector and connected to pin 4 of the Control Head's terminal block. Ensure that the red conductor is crimped to pin 5 of the connector and connected to pin 3 of the Control Head's terminal block.
41	a. The Station No.9 transfer button was held down for 15 seconds or longer.	a. Clear the Error Code from memory.
	b. The Station No.9 Control Head transfer button is defective.	b. Replace the Control Head.
	c. The Control Head Harness is miswired.	c. Ensure that the orange conductor is crimped to pin 4 at both ends and the red wire is crimped to pin 5 at both ends of the Harness.
	d. The Control Head's Pigtail is miswired.	d. Ensure that the orange conductor is crimped to pin 4 of the connector and connected to pin 4 of the Control Head's terminal block. Ensure that the red conductor is crimped to pin 5 of the connector and connected to pin 3 of the Control Head's terminal block.
42	a. The Station No.10 transfer button was held down for 15 seconds or longer.	a. Clear the Error Code from memory.
	b. The Station No.10 Control Head transfer button is defective.	b. Replace the Control Head.
	c. The Control Head Harness is miswired.	c. Ensure that the orange conductor is crimped to pin 4 at both ends and the red wire is crimped to pin 5 at both ends of the Harness.
	d. The Control Head's Pigtail is miswired.	d. Ensure that the orange conductor is crimped to pin 4 of the connector and connected to pin 4 of the Control Head's terminal block. Ensure that the red conductor is crimped to pin 5 of the connector and connected to pin 3 of the Control Head's terminal block.

Table 1: Basic Control System Problem Causes and Solutions

Error #	CAUSE	SOLUTION
43	a. The Serial Harness is in excess of 120 feet (37m).	a. Reposition the Processor(s) so that the Serial Harness is less than 120 feet (37m).
	b. The Processor is defective.	b. Replace the faulty Processor.
	c. The Serial Harness's shield is not properly terminated.	c. Ensure that the shield is terminated and the termination is at one side only.
44	a. The Serial Harness is in excess of 120 feet (37m).	a. Reposition the Processor(s) so that the Serial Harness is less than 120 feet (37m).
	b. The Processor is defective.	b. Replace the faulty Processor.
	c. The Serial Harness's shield is not properly terminated.	c. Ensure that the shield is terminated and the termination is at one side only.
45	a. The Serial Harness is not connected at one or more Processors.	a. Ensure that the Serial Harness is properly seated at all Processors.
	b. The Serial Harness is incorrectly wired.	b. Refer to the Serial Plug pin-out in Appendix B. Correct or replace the Harness.
	c. Loss of power to one of the Processorr.	c. Restore Power to the Processor.
46	a. The Serial Harness is in excess of 120 feet (37m)	a. Reposition the Processor(s) so that the Serial Harness is less than 120 feet (37m).
	b. The Processor is defective.	b. Replace the faulty Processor.
	c. The Serial Harness's shield is not properly terminated.	c. Ensure that the shield is terminated and the termination is at one side only.
47	a. The Serial Harness is in excess of 120 feet (37m).	a. Reposition the Processor(s) so that the Serial Harness is less than 120 feet (37m).
	b. The Processor is defective.	b. Replace the faulty Processor.
	c. The Serial Harness's shield is not properly terminated	c. Ensure that the shield is terminated and the termination is at one side only.
48	a. The Serial Harness is in excess of 120 feet (37m).	a. Reposition the Processor(s) so that the Serial Harness is less than 120 feet (37m).
	b. The Processor is defective.	b. Replace the faulty Processor.
	c. The Serial Harness's shield is not properly terminated.	c. Ensure that the shield is terminated and the termination is at one side only.
49	a. The Serial Harness is in excess of 120 feet (37m).	a. Reposition the Processor(s) so that the Serial Harness is less than 120 feet (37m).
	b. The Processor is defective.	b. Replace the faulty Processor.
	c. The Serial Harness's shield is not properly terminated.	c. Ensure that the shield is terminated and the termination is at one side only.
50	a. The Serial Harness is not connected at Processor ID No.1.	a. Connect the Serial Harness into Processor ID No.1.
	b. None of the Processors has ID No. 1 selected.	b. Identify one of the Processors as ID No.1 with the A0 function.
	c. Loss of power to Processor ID No.1.	c. Restore power to Processor ID No.1.
51	a. The Serial Harness is not connected at Processor ID No.2.	a. Connect the Serial Harness into Processor ID No.2.
	b. None of the Processors has ID No.2 selected.	b. Identify one of the Processors as ID No.2 with the A0 function.
	c. Loss of power to Processor ID No.2	c. Restore power to Processor ID No.2.
52	a. The Serial Harness is not connected at Processor ID No.3.	a. Connect the Serial Harness into Processor ID No.3.
	b. None of the Processors has ID No.3 selected.	b. Identify one of the Processors as ID No.3 with the A0 function.
	c. Loss of power to Processor ID No.3.	c. Restore power to Processor ID No.3.

Table 1: Basic Control System Problem Causes and Solutions

Error #	CAUSE	SOLUTION
53	a. The Serial Harness is not connected at Processor ID No.4.	a. Connect the Serial Harness into Processor ID No.4.
	b. None of the Processors has ID No.4 selected.	b. Identify one of the Processors as ID No.4 with the A0 function.
	c. Loss of power to Processor ID No.4.	c. Restore power to Processor ID No.4.
54	a. The Serial Harness is not connected at Processor ID No.5.	a. Connect the Serial Harness into Processor ID No.5.
	b. None of the Processors has ID No.5 selected.	b. Identify one of the Processors as ID No.5 with the A0 function.
	c. Loss of power to Processor ID No.5.	c. Restore power to Processor ID No.5.
55	a. The Serial Harness is not connected to the SE.	a. Connect the Serial Harness to the SE.
	b. The Serial Harness is not connected to the Processor reporting the fault.	b. Connect the Serial Harness to the Processor reporting the fault.
	c. No power to the SE.	c. Turn power 'On' to the SE.
56	a. The battery is being overcharged.	a. Repair or replace the charging system.
	b. There's a loose terminal on the battery while being charged.	b. Clean and tighten the battery posts and terminals.
57	a. Battery will not take a charge and is defective.	a. Replace the battery.
	b. The battery is not being properly charged	b. Repair or replace the charging system.
	c. There's a high resistance connection between the battery and the Processor.	c. Locate and repair the high resistance connection
58	a. External Interference, such as a lightning strike.	a. If the error message is displayed once and you are able to clear the error, take no further actions at this time. If the error cannot be cleared, replace the Processor.
	b. Component failure.	b. Replace the Processor.
59	a. External Interference, such as a lightning strike.	a. If the error message is displayed once and you are able to clear the error, take no further actions at this time. If the error cannot be cleared, replace the Processor.
	b. Component failure.	b. Replace the Processor.
60	a. External Interference, such as a lightning strike.	a. If the error message is displayed once and you are able to clear the error, take no further actions at this time. If the error cannot be cleared, replace the Processor.
	b. Component failure.	b. Replace the Processor.
61	a. External Interference, such as a lightning strike.	a. If the error message is displayed once and you are able to clear the error, take no further actions at this time. If the error cannot be cleared, replace the Processor.
	b. Component failure.	b. Replace the Processor.

Table B1: Servo 1 Clutch Problem Causes and Solutions

Error #	CAUSE	SOLUTION
62	a. Excessive Clutch Push-Pull cable travel.	a. Readjust Function Code C6 and or C7.
	b. The load on the Push-Pull cable exceeds 40 Lbs.	b. Contact a certified Marine Transmission technician to determine the cause of the excessive load.
	c. The Push-Pull cable is defective.	c. Replace the Push-Pull cable
	d. The Processor's Clutch Servo (Servo 1) is defective.	d. Replace the Processor.
	e. Low battery voltage.	e. Charge, repair or replace the battery, charging system or power distribution system.

Table B1: Servo 1 Clutch Problem Causes and Solutions

Error #		CAUSE		SOLUTION
63	a.	The Clutch Servo's feedback potentiometer is out of calibration.	a.	Replace the Processor or calibrate the potentiometer.
	b.	The Clutch Servo's feedback potentiometer is defective.	b.	Replace the Processor or replace the potentiometer.
	c.	The Processor's Circuit Board is defective.	c.	Replace the Processor or the Circuit Board.
64	a.	The Clutch Servo's feedback potentiometer is out of calibration.	a.	Replace the Processor or calibrate the potentiometer.
	b.	The Clutch Servo's feedback potentiometer is unplugged from the Circuit Board.	b.	Plug the feedback potentiometer's brown plug into the Circuit Board.
	c.	The Clutch Servo's feedback potentiometer is defective.	c.	Replace the Processor or the feedback potentiometer
	d.	The Processor's Circuit Board is defective.	d.	Replace the Processor or the Circuit Board.

Table B2: Servo 2 Throttle Problem Causes and Solutions

Error #		CAUSE		SOLUTION
65	a.	Excessive Throttle Push-Pull cable travel.	a.	Readjust Function Code E2 and or E3.
	b.	The load on the Push-Pull cable exceeds 40 Lbs.	b.	Contact a certified Marine Transmission technician to determine the cause of the excessive load..
	c.	The Push-Pull cable is defective.	c.	Replace the Push-Pull cable
	d.	The Processor's Throttle Servo (Servo 2) is defective.	d.	Replace the Processor.
	e.	Low battery voltage.	e.	Charge, repair or replace the battery, charging system or power distribution system.
66	a.	The Throttle Servo's feedback potentiometer is out of calibration.	a.	Replace the Processor or calibrate the potentiometer.
	b.	The Throttle Servo's feedback potentiometer is defective.	b.	Replace the Processor or replace the potentiometer.
	c.	The Processor's Circuit Board is defective.	c.	Replace the Processor or the Circuit Board.
67	a.	The Throttle Servo's feedback potentiometer is out of calibration.	a.	Replace the Processor or calibrate the potentiometer.
	b.	The Throttle Servo's feedback potentiometer is unplugged from the Circuit Board.	b.	Plug the feedback potentiometer's brown plug into the Circuit Board.
	c.	The Throttle Servo's feedback potentiometer is defective.	c.	Replace the Processor or the feedback potentiometer
	d.	The Processor's Circuit Board is defective.	d.	Replace the Processor or the Circuit Board.

B9 TROUBLESHOOTING PROBLEMS WITHOUT ERROR CODES

In addition to the Error Codes listed above, some problems may not necessarily generate Error Codes. The following give some examples where the Processor may not detect a fault, though the operation may not be perfect:

B9-1 Basic without Error Codes

SYMPTOM:	CAUSE	REMEDY
No audible tones heard at one Control Station when power is first applied to the Processor. All other features function normally.	a. Incorrectly wired Station Harness/ Cable.	a. Verify that the black wire is properly connected to pin 1 on the Control Head and Pin 8 at the Processor.
	b. The Control Head's Sound Transducer is defective.	b. Measure the AC voltage at pins 1 & 3 of the Control Head. If 20- 25 VAC is present, replace the Control Head.
SYMPTOM	**CAUSE**	**REMEDY**
The Control Head's red LED doesn't light when in command, but otherwise functions properly	a. Incorrectly wired Station Harness/ Cable.	a. Verify that the brown wire is properly connected to pin 2 on the Control head and pin 2 at the Processor.
	b. The Control Head's red LED or circuit is open.	b. Measure the DC voltage at pins 2 & 3 at the Control Head. The measurement will be approximately 2.20 VDC when the red LED is lit. If 4.00 VDC is measured, the red LED or its circuit is open. Replace the Control Head.
SYMPTOM	**CAUSE**	**REMEDY**
The engine begins to turn-over while starting and then stops. A slow repetitive tone is heard from all Remote Stations	a. The voltage available at the Processor has dropped too low, due to the starter's current requirement	a. Supply power to the Processor from a battery other than the starting battery or supply power from two sources through an APS (Automatic Power Selector).
	b. Battery charge is too low	b. Recharge/ replace the battery or supply battery power from two sources through an APS.
SYMPTOM	**CAUSE**	**REMEDY**
When power is turned ON to the Processor, there are no tones from any of the Remote Stations, the Control Head red LED does not light when the Transfer Button is pressed, and the Display is not lit at the Processor.	a. No power to the Processor.	a. Disconnect the Power Harness from the Processor. Measure the DC voltage at pins 10 (+) and 11 (-) of the Harness plug. If 12 or 24 VDC is not present, check the circuit breakers, switches and cables feeding power to the Processor. Correct the power source as required.
	b. The battery's polarity is reversed at the Processor.	b. Disconnect the Power Harness from the Processor. Connect a voltmeter's red lead to pin 10 and the black lead to pin 11 of the Harness's plug. If negative voltage is measured, reverse the wires.
	c. Defective Processor.	c. If Causes a. and b. were not the fault, replace the Processor.

SYMPTOM	CAUSE	REMEDY
Active Synchronization is inoperable.	a. There is no Tachometer Sensor signal at the Port or Starboard Processor.	a. The Tachometer Sensor frequency can be seen on the Processor's Display by accessing the Diagnostic Menu H0. If the frequency is not measured, check the Tachometer Sensor and the wiring.
	b. Loss of Serial Communication between the Processors.	b. If Active Synchronization is inoperative due to a lack of Serial Communications, one or more Error Codes will be displayed indicating the loss of communication.
	c. The Processor's Identification number(s) have not been set properly.	c. All Processors must have a unique identification number as set with Function Code A0. Refer to Section 5- SET UP PROCEDURES.
	d. The correct number of engines has not been set.	d. All Processor must have the same number of engines selected as programmed with Function Code A1. Refer to Section 5- SET UP PROCEDURES.

B9-2 Servo Clutch Control System Problems Without Error Codes

SYSMPTOM	CAUSE	REMEDY
Cannot obtain Warm-up Mode while moving the Control Head lever in the Ahead direction, only in the Astern direction.	a. The Processor is sensing that the Control Head's lever is moving in the Astern direction	a. Depress the Transfer Button while moving the Control Head lever in the Astern direction. If the LED begins to blink, the Control Head is incorrectly wired. • Check the colors of the wires at pins 5 and 7. • A right hand Control Head should have yellow at pin 5 and blue at pin 7. • A left hand Control Head should have blue at pin 5 and yellow at pin 7. • The Clutch Servo's direction of travel must be changed with Function Code C5 if the yellow and blue wires are reversed.

B9-3 Servo Throttle Control System Problems Without Error Codes

SYMPTOM	CAUSE	REMEDY
The engine RPM's vary, without moving the Control Head lever (synchronization disabled).	a. Problem with the Governor or Carburetor.	a. Observe the Throttle push-pull cable. If variations are seen, proceed to Step b.
	b. Erratic Command Signal.	b. Refer to Command Signal testing in Section B5 . If variations of the A/D counts occur, connect the Control Head to another Station (if available) on the Processor. If variations persist, replace the Control Head.

SYMPTOM	CAUSE	REMEDY
The engine's Idle speed is too high.	a. Idle was not adjsuted mechanically correct at the Idle stop.	a. Adjust the throttle Push-Pull cable as specified in Section 5 - SET UP PROCEDURES.
	b. Function Code E2 Throttle Minimum is incorrectly set.	b. Adjust Throttle Minimum as specified in Section 5 - SET UP PROCEDURES.
	c. The Governor or its Control Module is incorrectly adjusted or faulty.	c. After Causes a. and b. have been eliminated, contact a certified engine mechanic to properly adjust.

B10 SYNCHRONIZATION TROUBLESHOOTING

If you encounter a problem with Synchronization, it will more than likely one of the following; failure to attempt to synchronize, synchronizing at different RPM's or RPM variations of one or both engines while synchronized. Each problem is distinct and the cause may differ depending on the type of Synch. Therefore, each type is discussed individually.

B10-1 Equal Throttle Synchronization

B10-1.1 Basic Troubleshooting

SYMPTOM	CAUSE	SOLUTION
Will not synchronize.	a. Synchronization is Disabled	a. At the Station-in-Command, move both Control Head levers to more than 5% of the speed range. Press and hold the transfer button for 5 seconds. If synch is disabled, the green LED will light as long as the button is pressed. If synch was enabled, the green LED would have blinked twice.
	b. The Serial Communication Harness is not plugged into both Processors.	b. Plug the Serial Communication Harness into both Processors.
	c. The Port and Starboard Processors are not set up for Twin Screw operation.	c. Plug the Serial Communication Harness into both Processors.
	d. The Port and Starboard Processors have the same ID number.	d. On the Port Processor, scroll to Function A0 and enter a Value of 01. On the Starboard Processor, scroll to Function A0 and enter a Value of 02.

B10-1.2 Servo Clutch Troubleshooting

SYMPTOM	CAUSE	SOLUTION
Will not synchronize.	The Processor(s) think Astern is being commanded.	Place both the Port and Starboard Processors into Warm-up Mode by pressing the transfer button while moving the Control Head levers to the Ahead detent. Both red LED's on the Control Head should be blinking. If not, reverse the wires at pins 5 and 7 at the Control Head. Change the Clutch direction with Function Code C5.

B10-1.3 Servo Throttle Troubleshooting

SYMPTOM	CAUSE	SOLUTION
One or both of the engines continually changes RPM (hunts). Will not synchronize properly.	a. A Control Head's Command Signal is varying.	a. Scroll to the Diagnostic Menu Function Code H0. Go to the appropriate Station A/D Count's display. The Value should not change by more than +/- 1 A/D Count. If so, check the connections and if good, replace the Control Head.
	b. The push-pull cable's travel from Idle to Full is too short.	b. Lengthen the Governor or Carburetor's selector lever and attach the push-pull cable to a point where the travel is in excess of 2.00 inches (50,8mm).
SYMPTOM	**CAUSE**	**SOLUTION**
Will not synchronize.	Excessive bends in the push-pull cable(s).	Reroute the push-pull cable(s) or install Tach Sender and enable Active Synchronization with Function Code E7.

SYMPTOM	CAUSE	SOLUTION
The green LED is lit solid, though the Engine RPM's differ by a significant amount.	a. The throttle travel from Idle to Full is set differently on the Port and Starboard Processors.	a. Scroll to Function Codes E2 and E3 on both Processors and compare the Values. The Values of E2 and E3 must be the same for both Processors.
	b. The engines run at different RPM's with equal travel of the Governors'/ Carburetors' selector lever.	b. While underway at cruising speed, decrease the Value of Function Code E3 on the Processor running at the higher RPM until both engine are at the same RPM. This is not a normal condition and is masking the actual problem with the engine. Top speed may be sacrificed by doing so. Install Tach Senders and enable Active Synchronization with Function Code E7
	c. Excessive back-lash in the push-pull cable(s) or linkage.	c. Remove the excessive back-lash or install Tach Senders and enable Active Synchronization with Function Code E7.
	d. Excessive bends in the push-pull cable(s).	d. Reroute the push-pull cable(s) or install Tach Sender and enable Active Synchronization with Function Code E7.

B10-2 Active Synchronization

B10-2.1 Basic Troubleshooting

SYMPTOM	CAUSE	SOLUTION
The green LED is lit solid, though the Engine RPM's differ by a significant amount.	The Tach Sender signal has been lost by one or both Processors.	Scroll to Function Code H0. Go to the Value for the Tach Sender's input frequency. If the frequency displayed is 0000, the signal has been lost and the system diverted to Equal Throttle Synch. Correct the wiring or replace the Sender.

SYMPTOM	CAUSE	SOLUTION
Will not synchronize.	a. Synchronization is Disabled	a. At the Station-in-Command, move both Control Head levers to more than 5% of the speed range. Press and hold the transfer button for 5 seconds. If synch is disabled, the green LED will light as long as the button is pressed. If synch was enabled, the green LED would have blinked twice.
	b. The Serial Communication Harness is not plugged into both Processors.	b. Plug the Serial Communication Harness into both Processors.
	c. The Port and Starboard Processors have the same ID number.	c. On the Port Processor, scroll to Function Code A0 and enter a Value of 01. On the Starboard Processor, scroll to Function Code A0 and enter a Value of 02.
	d. The Port and Starboard Processors are not set up for twin screw operation	d. Scroll to Function Code A1, on the Port and Starboard Processor. Enter a Value of 02 into both Processors.

B10-2.2 Servo Throttle Troubleshooting

SYMPTOM	CAUSE	SOLUTION
One or both of the engines continually changes RPM. Will not synchronize properly.	a. A Control Head's Command Signal is varying.	a. Scroll to the Diagnostic Menu Function Code H0. Go to the appropriate Station A/D Count's display. The Value should not change by more than +/- 1 A/D Count. If so, check the connections and if good, replace the Control Head.
	b. The engine(s) is not running smoothly.	b. Increase the engines' RPM's in Warm-up Mode. Scroll to Function Code H0 and display the Tach Sender's input frequency. If the frequency is varying, check the push-pull cable for movement. If the push-pull cable is not moving, swap the Port and Starboard Tach Senders. If the frequency still varies on the same side, the engine needs servicing.
	c. Defective Tach Sender	c. Same procedure as b. However, if the frequency variations move to the opposite side, replace that Tach Sender.

B10-2.3 Servo Clutch Troubleshooting

SYMPTOM	CAUSE	SOLUTION
Will not synchronize properly	The Processor(s) think Astern is being commanded.	Place both the Port and Starboard Processors into Warm-up Mode by pressing the transfer button while moving the Control Head levers to the Ahead detent. Both red LED's on the Control Head should be blinking. If not, reverse the wires at pins 5 and 7 at the Control Head. Change the Clutch direction with Function Code C5.

B11 TROUBLESHOOTING WIRE HARNESSES

The following Sections list the various Harnesses manufactured for use with the Processor. These tables are invaluable when troubleshooting a suspected interface problem or when manufacturing your own Harnesses.

The Wire Harness Plug figures below indicators:

- SOLID BLACK circles wire termination
- MEDIUM GRAY circles variation in terminations (refer to Table for information)
- WHITE circles indicate no wire termination.

B11-1Basic Control System Harnesses

Table B3: Power, Start Interlock Harness Pin-Out

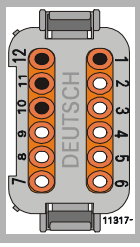
Plugs into Processor POWER Connector	HARNESS PLUG Termination A	HARNESS PLUG Conductor Color	ENGINE & BATTERY Termination B	ENGINE & BATTERY Description
Termination A 	1	Yellow w/ Red Trace	Starter Solenoid	Closed contact when In-Command and at Neutral.
	10	Red	Battery (+)	+ 24 VDC
	11	Black	Battery (-)	- DC Return
	12	Yellow w/ Red Trace	Starter Switch Wire at the Starter Solenoid	Closed contact when In-Command and at Neutral.

Table B4: Power, Start Interlock , Clutch Pressure Switch Harness Pin-Out

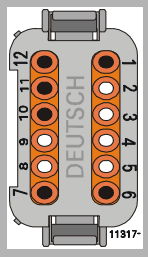
Plugs into Processor POWER Connector	HARNESS Termination A	HARNESS Conductor Color	ENGINE/GEAR/BATTERY Termination B	ENGINE/GEAR/BATTERY Description
Termination A 	1	Yellow w/ Red Trace	Starter Solenoid	Closed Contact when In-Command and at Neutral
	6	Light Blue	Clutch Pressure Switch	Normally Open contact that closes when transmission manufacturer's minimum safe operating pressure is reached.
	7	Light Blue	Clutch Pressure Switch	Normally Open contact that closes when transmission manufacturer's minimum safe operating pressure is reached.
	10	Red	Battery (+)	24 VDC
	11	Black	Battery (-)	- DC Return
	12	Yellow w/ Red Trace	Starter Switch Wire at the Starter Solenoid	Closed contact when In-Command and at Neutral

Table B5: Power, Start Interlock, Clutch Pressure Switch, and Alarm Harness Pin-Out

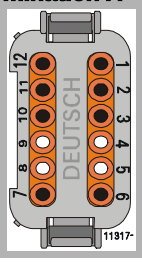
Plugs into Processor POWER Connector	HARNESS Termination A	HARNESS Conductor	ENGINE/GEAR/ALARM/ BATTERY Termination B	ENGINE/GEAR/ALARM/BATTERY Description
Termination A 	1	Yellow w/ Red Trace	Start Solenoid	Closed Contact when In-Command and at Neutral
	2	Red	External Alarm Circuit	Normally Open contact opens with fault or loss of power.
	3	Black	External Alarm Circuit	Normally Open contact opens with fault or loss of power
	6	Light Blue	Clutch Pressure Switch	Normally Open contact that closes when transmission manufacturer's minimum safe operating pressure is reached.
	7	Light Blue	Clutch Pressure Switch	Normally Open contact that closes when transmission manufacturer's minimum safe operating pressure is reached.
	10	Red	Battery (+)	+ 24 VDC

Table B5: Power, Start Interlock, Clutch Pressure Switch, and Alarm Harness Pin-Out

Plugs into Processor POWER Connector	HARNESS Termination A	HARNESS Conductor	ENGINE/GEAR/ALARM/ BATTERY Termination B	ENGINE/GEAR/ALARM/BATTERY Description
	11	Black	Battery (-)	- DC Return
	12	Yellow w/ Red Trace	Starter Switch Wire at the Starter Solenoid	Closed contact when In-Command and at Neutral

Table B6: Serial Communication Harness Pin-Out

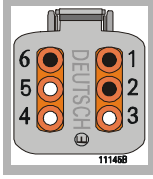
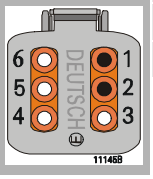
Plugs into each Processor's SERIAL Connector		HARNESS PLUG Termination End A	HARNESS PLUG Conductor Color	HARNESS PLUG Termination End B	HARNESS PLUG Description
Termination A	Termination B	1	Black	1	CAN Low
		2	Red	2	CAN High
		6	Yellow/Green	N/C	N/A

Table B7: Control Head Harness Pin-Out

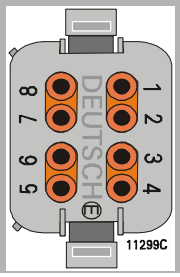
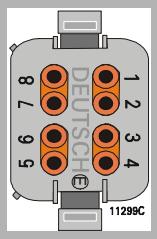
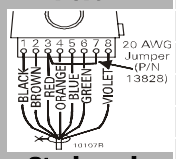
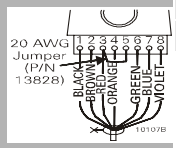
Plugs into Processor STATION Connectors	Plugs into Control Head Pigtail Connector	Termination A and B	Conductor Color	Description
Termination A and Termination B		1	Green/Yellow	Shield
		2	Brown	Red LED (+)
		3	Violet	Green LED (-)
		4	Orange	Transfer Button (+)
		5	Red	Ground
		6	Green	Lever Command Signal
		7	Blue	VREF + 5 VDC
		8	Black	Tone (+)

Table B8: Control Head Harness Hard-Wire

Plugs into Processor STATION Connectors	Hard-wires to Control Head	Termination A	Conductor Color	Termination B	Description
Termination A	Termination B	1	Green/Yellow	N/C	Shield
	Port 	2	Brown	2	Red LED (+)
		3	Violet	8	Green LED (-)
		4	Orange	4	Transfer Button (+)
		5	Red	3	Ground
		6	Green	6	Lever Command Signal
	Starboard 	7	Blue	5 (Port); 7 (Stbd)	VREF (+5VDC)
		8	Black	1	Tone (+)

NOTE: Starboard Side of Control Head - Jumper Pins 3 to 5;
Port Side of Control Head - Jumper Pins 3 to 7

TableB 9: Tachometer Sensor Harness Pin-Out

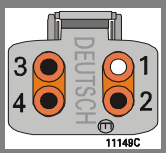
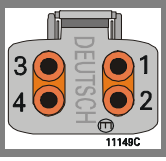
Plugs into Processor TACH Connector	Termination A	Conductor Color	TACH SENSOR Termination B	TACH SENSOR Description
Termination A 	2	Red	Pin B	Tachometer (+)
	3	Black	Pin C	Tachometer (-)
	4	Green/Yellow	N/C	N/A

Table B10: Tachometer Sensor Harness with Power Pin-Out

Plugs into Processor TACH Connector	Termination A	Conductor Color	TACH SENSOR Termination B	TACH SENSOR Description
Termination A 	1	Red	As Required	Sensor Supply (+9 VDC)
	2	Green	As Required	Tachometer (+)
	3	Black	As Required	Tachometer (-)
	4	Green/Yellow	N/C	N/A

B12 PROCESSOR PIGTAILS

The number and types of Pigtails used varies with the different Processors and their configurations. The basic off-the-shelf Processors are available with no Pigtails (hard-wired) or pre-wired for for up to a total of eight Pigtails when all five Remote Stations are being used.

The following Tables describe the pin outs and functions of the conductors within the various Pigtails.

B12-1Basic Processor Pigtails

Table 1: Power, Start Interlock, Clutch Pressure Switch, Alarm Processor Pigtail Pin-Out

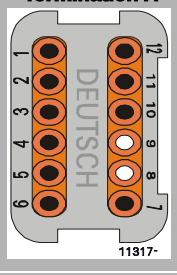
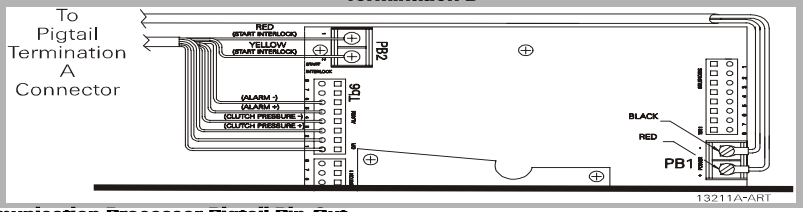
Processor Pigtail Connector	Termination A	Conductor Color	Description	Termination B
Termination A 	1	Yellow	Start Interlock	PB2-2
	2	Brown	Alarm (N.O.)	TB6-6
	3	Black	Alarm (Common)	TB6-5
	4	Orange	Back-up Control (Ground)	TB6-2
	5	White	Back-up Control Input	TB6-1
	6	Blue	Clutch Pressure Switch	TB6-3
	7	Green	Clutch Pressure Switch (Ground)	TB6-4
	10	Red	DC Power (+)	PB1 (+)
	11	Black	DC Power (-)	PB1 (-)
	12	Red	Start Interlock	PB2-1
Termination B 				

Table 2: Serial Communication Processor Pigtail Pin-Out

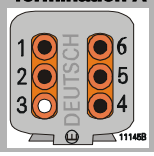
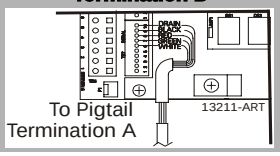
Pigtail Connector Serial Harness	Termination A	Conductor Color	Description	Termination B	Processor Circuit Board Connections
Termination A 	1	Green	CAN Low	TB7-7	Termination B 
	2	White	CAN High	TB7-6	
	4	Red	CAN High	TB7-8	
	5	Black	CAN Low	TB7-9	
	6	Black	Shield	TB7-10	

Table 3: Control Head Pigtail Pin-Out (Up to 5 Stations)

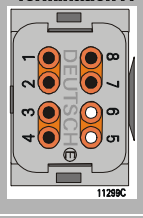
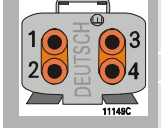
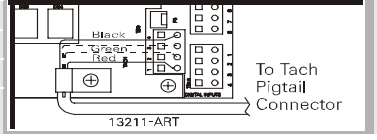
Pigtail Connector	Termination A	Conductor Color	Description	Termination B
Termination A 	1	Non-insulated to Green/Yellow	Shield	Frame
	2	Brown	Red LED (+)	TB1-2 thru TB5-2
	3	Violet	Green LED (-)	TB1-8 thru TB5-8
	4	Orange	Transfer Button	TB1-4 thru TB5-4
	5	Red	Ground	TB1-3 thru TB5-3
	6	Green	Lever Command Signal	TB1-6 thru TB5-6
	7	Blue	VREF (+5VDC)	TB1-7 thru TB5-7
	8	Black	Tone (+)	TB1-1 thru TB5-1
Termination B (Up to 5 Stations) 				

Table 4: Tachometer Processor Pigtail Pin-Out

Pigtail Connector	Termination A	Conductor Color	Description	Termination B	Processor Circuit Board Connections
Termination A 	1	Red	Sensor Supply (+9 VDC)	TB9-1	Termination B 
	2	Green	AC Type Tach Input	TB9-2	
			Open Collector Tach	TB9-3	
	3	Black	Return for Tach Input	TB9-4	
	4	Drain	Shield	Grounding Screw	

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MicroCommander 9110 Series
Servo Throttle – Servo Clutch
Qualitative Failure Analysis & Design
Verification Test Procedure

Revision A

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Qualitative Failure Analysis

The following qualitative failure analysis is provided to show compliance with:

- Subchapter K Small Passenger Vessels, 46 CFR 121.620
- Subchapter L Offshore Supply Vessels, 46 CFR 130.120
- Subchapter T Small Passenger Vessels, 46 CFR 184.620:

121.620 Propulsion engine control systems.

(a) A vessel must have two independent means of controlling each propulsion engine. Control must be provided for the engine speed, direction of shaft rotation, and engine shutdown.

(1) One of the means may be the ability to readily disconnect the remote engine control linkage to permit local operation.

(2) A multiple engine vessel with independent remote propulsion control for each engine need not have a second means of controlling each engine.

(b) In addition to the requirements of paragraph (a) of this section, a vessel must have a reliable means for shutting down a propulsion engine, at the main pilot house control station, which is independent of the engine's speed control.

(c) A propulsion engine control system, including pilothouse control, must be designed so that a loss of power to the control system does not result in an increase in shaft speed or propeller pitch.

(d) All microprocessor or computer based systems must meet the requirements of part 62 in subchapter F of this chapter.

130.120 Propulsion control.

(a) Each vessel must have--

(1) A propulsion-control system operable from the pilothouse; and

(2) A means at each propulsion engine of readily disabling the propulsion-control system to permit local operation.

(a) Each propulsion-control system operable from the pilothouse must enable--

(1) Control of the speed of each propulsion engine;

(2) Control of the direction of propeller-shaft rotation;
(3) Control of propeller pitch, if a controllable-pitch propeller is fitted; and
(4) Shutdown of each propulsion engine.

(a) The propulsion-control system operable from the pilothouse may constitute the remote stopping-system required by Sec. 129.540 of this subchapter.

(b) Each propulsion-control system, including one operable from the pilothouse, must be designed so that no one complete or partial failure of an easily replaceable component of the system allows the propulsion engine to over-speed or the pitch of the propeller to increase.

184.620 Propulsion engine control systems.

(a) A vessel must have two independent means of controlling each propulsion engine. Control must be provided for the engine speed, direction of shaft rotation, and engine shutdown.

(1) One of the means may be the ability to readily disconnect the remote engine control linkage to permit local operation.

(2) A multiple engine vessel with independent remote propulsion control for each engine need not have a second means of controlling each engine.

(a) In addition to the requirements of paragraph (a), a vessel must have a reliable means for shutting down a propulsion engine, at the main pilothouse control station, which is independent of the engine's speed control.

(b) A propulsion engine control system, including pilothouse control, must be designed so that a loss of power to the control system does not result in an increase in shaft speed or propeller pitch.

The ZF Marine Electronics MicroCommander 9110 Series (servo throttle, servo clutch version) marine engine controls offer single lever control of speed and direction. Each enclosure houses an independent Control Processor and requires separate power supplies. The system operates on 12 or 24VDC power and can have up to five remote stations depending on the application. The system sequences the operation of speed and shift in order to prevent an inexperienced operator from mishandling the engine or transmission.

A requirement of the ZF Marine Electronics MicroCommander system is that there be an engine ’STOP’ button at each remote station.

A standard feature is an alarm contact (normally open) to interface with the main alarm system of the vessel. This switch will open and activate the alarm system with a power loss or CPU failure. In addition, ZF Marine Electronics provides audible tones at the Control Head locations to indicate system faults.

ITEM NUMBER	FAILED COMPONENT	ALARM STATUS	INITIAL RESULT	FINAL OUTCOME
1	ZF MARINE ELECTRONICS CONTROL HEAD	AUDIBLE TONE WILL SOUND AT CONTROL HEAD	THROTTLE RESETS TO IDLE	NO INCREASE IN ENGINE RPM
			CLUTCH SHIFTS TO NEUTRAL	NO INCREASE IN SHAFT SPEED
2	LOSS OF POWER SUPPLY	ALARM CIRCUIT WILL OPEN	THROTTLE REMAINS AT LAST COMMANDED POSITION	NO INCREASE IN ENGINE RPM
			CLUTCH REMAINS AT LAST COMMANDED POSITION	NO INCREASE IN SHAFT SPEED
3	ZF MARINE ELECTRONICS THROTTLE FEEDBACK POTENTIOMETER	AUDIBLE TONE WILL SOUND AT CONTROL HEAD	THROTTLE RESETS TO IDLE	NO INCREASE IN ENGINE RPM
			CLUTCH REMAINS AT LAST COMMANDED POSITION	NO INCREASE IN SHAFT SPEED
4	ZF MARINE ELECTRONICS CLUTCH FEEDBACK POTENTIOMETER	AUDIBLE TONE WILL SOUND AT CONTROL HEAD	THROTTLE RESETS TO IDLE	NO INCREASE IN ENGINE RPM
			CLUTCH REMAINS AT LAST COMMANDED POSITION	NO INCREASE IN SHAFT SPEED

Design Verification Test Procedure

The MicroCommander 9110 Series (servo throttle, servo clutch version) Propulsion Control System is compliant to the environmental design standards in 46 CFR 62.25-30.

The following test procedure covers the 4 items included in the Qualitative Failure Analysis; 1) Control Head Potentiometer failure, 2) Loss of power supply, 3) Throttle Feedback Potentiometer failure, and 4) Clutch Feedback Potentiometer failure.

1) **Failure: Control Head Potentiometer failure**.
   a) Results: The Processor will shift to Neutral (if needed) and throttle will go to Idle, (if needed).
   b) Test Procedure
      i) Turn power ON to both Port and Starboard Processors. Take command at a Control Head.
      ii) Move the Port and Starboard Control Head levers to approximately ½ Ahead.
      iii) Locate the green wire coming from the Port Control Head in command, connecting to pin 6 of the respective terminal block on the Processor circuit board. Disconnect it from the Processor circuit board.
         (1) The Port Processor will shift to Neutral (if needed) and throttle will go to Idle (if needed).
         (2) The Port Control Head will give an alarm tone indicating a faulty potentiometer.
      iv) Move the Port and Starboard Control Head levers back to Neutral. Reconnect the green wire.

v) Take command at the Control Head
vi) Repeat for Starboard side.

2) Failure: Power failure to MicroCommander 9110 Series

(A power failure to the MicroCommander 9110 Series circuit board will have the same results as a failed microprocessor)

a) Results
   i) Throttle and clutch will remain at last commanded position.
   ii) LED at Control Heads will not be lit.
   iii) Opposite engine still under power has full control.

b) Test Procedure.
   i) Turn power ON to both Port and Starboard Processors. Take command at a Control Head.
   ii) Move the Port and Starboard Control Head levers to approximately ½ Ahead.
   iii) Turn power OFF to the Port side only.
      (1) Port side throttle and clutch will remain at last commanded position.
      (2) LED on the Port side of the Control Head in command will go OFF.
      (3) The Port Control Head will no longer have command of the engine and gear.
      (4) The Starboard Control Head will still have full command of the Starboard engine and gear.
   iv) Turn power ON to the Port Processor. Return Control Head lever to Neutral. Take command of the Port side.
      (1) The Port Control Head will operate as usual-(Non-volatile memory)
   v) Repeat test for Starboard Processor.

3) Failure: Throttle Feedback Potentiometer failure

a) Results: Throttle will go to Idle (if needed).

b) Test Procedure.
   i) Turn power ON to both Port and Starboard Processors. Take command at a Control Head.
   ii) Move the Port and Starboard Control Head levers to approximately ½ Ahead.
   iii) On the Port Processor, locate the 3-pin plug above the throttle servo on the Processor's main circuit board. Disconnect the plug from the circuit board.
      (1) The Port Processor will move the throttle to Idle.
      (2) The Port Control Heads will give an alarm tone indicating a faulty throttle feedback potentiometer.
   iv) Move the Port and Starboard Control Head levers back to Neutral.
   v) Replace the 3-pin plug.
   vi) Acknowledge the error by pressing the transfer button.
   vii) Repeat test for Starboard Processor.

4) Failure: Clutch Feedback Potentiometer failure

a) Results: Clutch will remain at last commanded position. Throttle will go to Idle (if needed).

b) Test Procedure.

i) Turn power ON to both Port and Starboard Processors. Take command at a Control Head.

ii) Move the Port and Starboard Control Head levers to approximately ½ Ahead.

iii) On the Port Processor, locate the 3-pin plug above the clutch servo on the Processor's main circuit board. Disconnect the plug from the circuit board.

(1) The Port Processor clutch servo will remain at last commanded position. Throttle servo will drive to Idle.

(2) The Port Control Heads will give an alarm tone indicating a faulty clutch feedback potentiometer.

iv) Move the Port and Starboard Control Head levers back to Neutral.

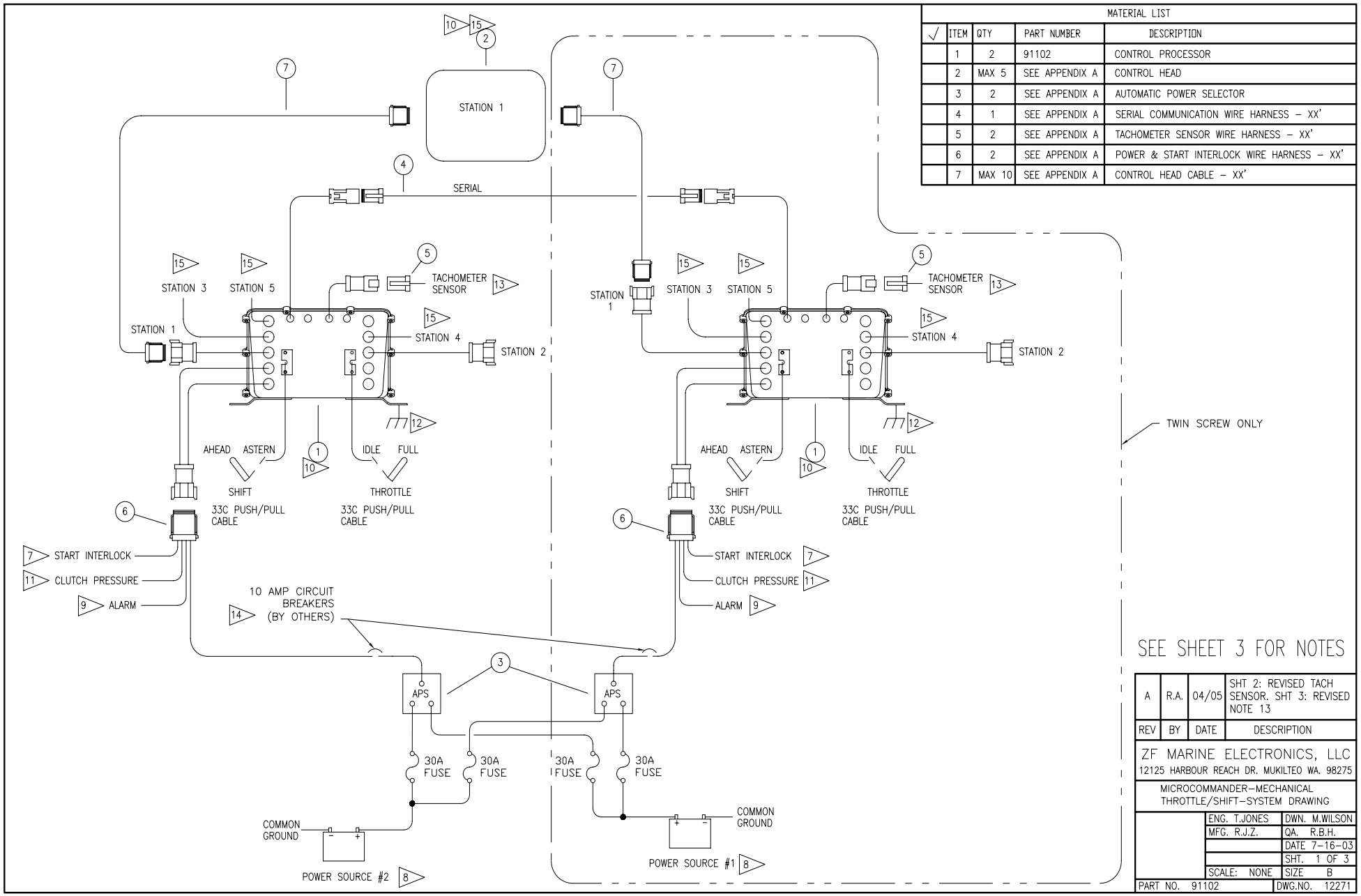
v) Replace the 3-pin plug.

vi) Acknowledge the error by pressing the transfer button.

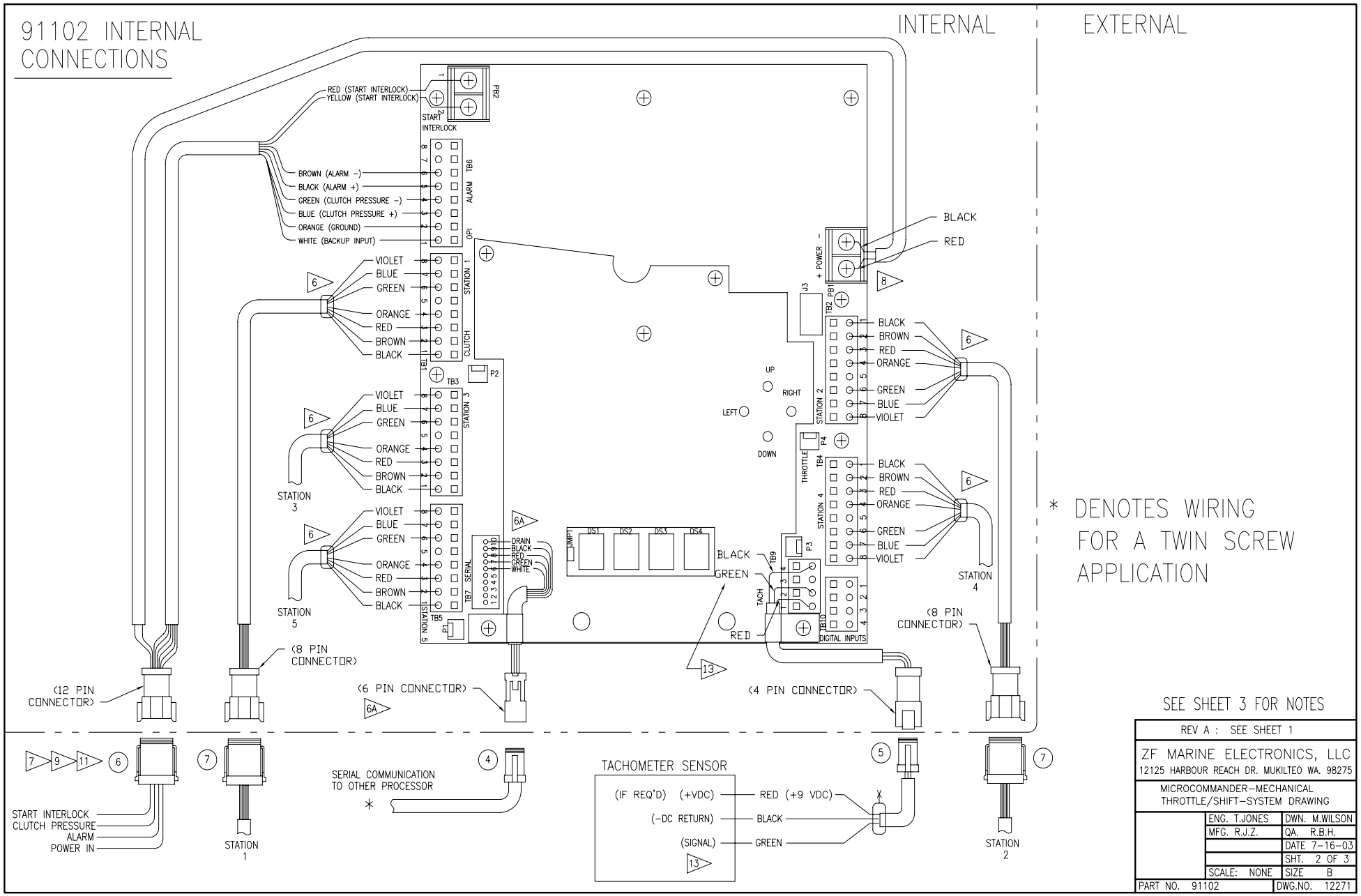
vii) Repeat test for Starboard Processor.

APPENDIX C

C1 Drawing 12271A-1 Basic Pluggable System Diagram



C2 Drawing 12271A-2 Basic Pluggable Processor Connections



C3 Drawing 12271A-3 Basic Pluggable Notes Page

– NOTES –

1. DO NOT MOUNT CONTROL SYSTEM COMPONENTS ON ENGINE OR REDUCTION GEAR.
2. DO NOT MOUNT CONTROL COMPONENTS NEAR SOURCES OF HIGH HEAT. (EXHAUST DUCTS, ETC.)
3. DO NOT MOUNT CONTROL COMPONENTS NEAR SOURCES OF STRONG ELECTROMAGNETIC FIELDS. (STARTERS, GENERATORS,ETC.)
4. MOUNT CONTROL COMPONENTS IN A LOCATION ACCESSIBLE FOR CHECKOUT, MONITORING AND MAINTENANCE.
5. ALL ELECTRICAL CABLES ARE TO BE SUITABLE FOR MARINE APPLICATION AND MEET ALL APPLICABLE REGULATORY REQUIREMENTS.

6> INSURE THAT SHIELD ON THE SHIELDED CABLE IS CONNECTED ONLY AT ONE END TO THE CHASSIS AND THAT THE DRAIN WIRE DOES NOT TOUCH ANY OTHER CONDUCTIVE SURFACE.

6A> INSURE THAT DRAIN WIRE ON SHIELDED CABLE IS CONNECTED ONLY WHERE INDICATED INSIDE HOUSING AND THAT DRAIN WIRE DOES NOT TOUCH ANY OTHER CONDUCTIVE SURFACE. FOR OPTIMAL SCREENING THE SERIAL WIRE HARNESS SHIELD SHOULD BE CONNECTED TO "EARTH" AT ONE POINT IN THE VESSEL. (NOT INSIDE THE UNIT)

7> START INTERLOCK RELAY WITH NORMALLY OPEN CONTACTS. CONTACTS ARE CLOSED WHEN SYSTEM IS OPERATING AND COMMANDING NEUTRAL. MAXIMUM OF 5 AMP, MAXIMUM OF 30V.

8> THE CONTROL PROCESSOR WILL BE PROVIDED SHIPS SUPPLY OF 12 OR 24 VDC, PROTECTED BY A 10 AMP RATED CIRCUIT BREAKER PROVIDED BY THE SHIPYARD.

9> CONTROL FAILURE ALARM RELAY CONTACTS RATED FOR A MAXIMUM OF 0.5A, MAXIMUM CONTACT DRY RATING OF 100V. DO NOT EXCEED THIS RATING. IT IS THE SHIPYARDS RESPONSIBILITY TO UTILIZE THE ALARM CONNECTION IN AN APPROPRIATE ALARM CIRCUIT.

10> CAUTION:
THIS PART CONTAINS ELECTRONIC COMPONENTS WHICH CAN BE DESTROYED BY STATIC ELECTRICITY. PERSONNEL SHOULD GROUND THEMSELVES TO DISSIPATE ANY STATIC ELECTRICITY PRIOR TO WORKING INSIDE THE PART.

11> PRESSURE SWITCH SETPOINT (N.O. CONTACTS) MUST BE SET AT 150 PSI OR AS AS RECOMMENDED BY TRANSMISSION MANUFACTURER. WHEN CONTACTS CLOSE THIS INDICATES TO THE CONTROL PROCESSOR WHEN THE CLUTCH IS SUFFICIENTLY ENGAGED TO ALLOW A SPEED COMMAND ABOVE IDLE SPEED. IT IS A SAFETY FEATURE THAT PROTECTS THE CLUTCH AND ITS USE IS RECOMMENDED.

– NOTES –

12> THE CONTROL PROCESSOR'S MOUNTING FEET MUST BE CONNECTED TO THE VESSELS BONDING SYSTEM.

13> FREQUENCY INPUT FOR ENGINE SYNCHRONIZATION:
(INPUT PULSES EITHER AC TYPE TACH INPUT OR OPEN COLLECTOR TYPE INPUT)

AC COUPLED INPUT (TB9–2): MINIMUM FREQUENCY 30Hz – MAXIMUM FREQUENCY 8000Hz.
MINIMUM VOLTAGE 3V – MAXIMUM VOLTAGE 200V, PEAK TO PEAK.

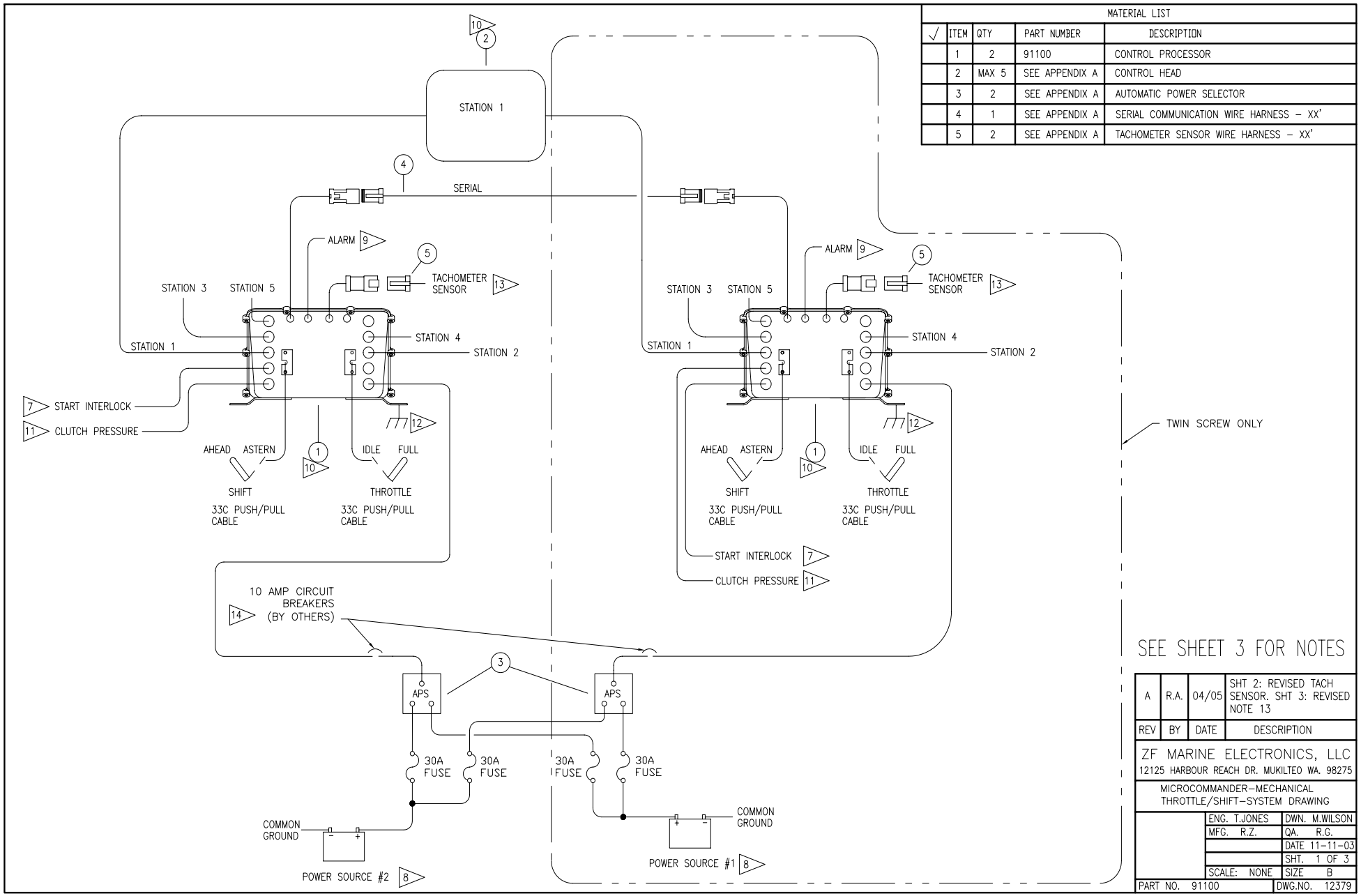
OPEN COLLECTOR INPUT (TB9–3): MINIMUM FREQUENCY 5Hz – MAXIMUM FREQUENCY 8000Hz.
MINIMUM SINK CURRENT 2mA. MAX SENSOR OUTPUT SATURATION VOLTAGE 0.8V.

14> REFER TO DRAWING 11488 FOR ADDITIONAL POWER OPTIONS.

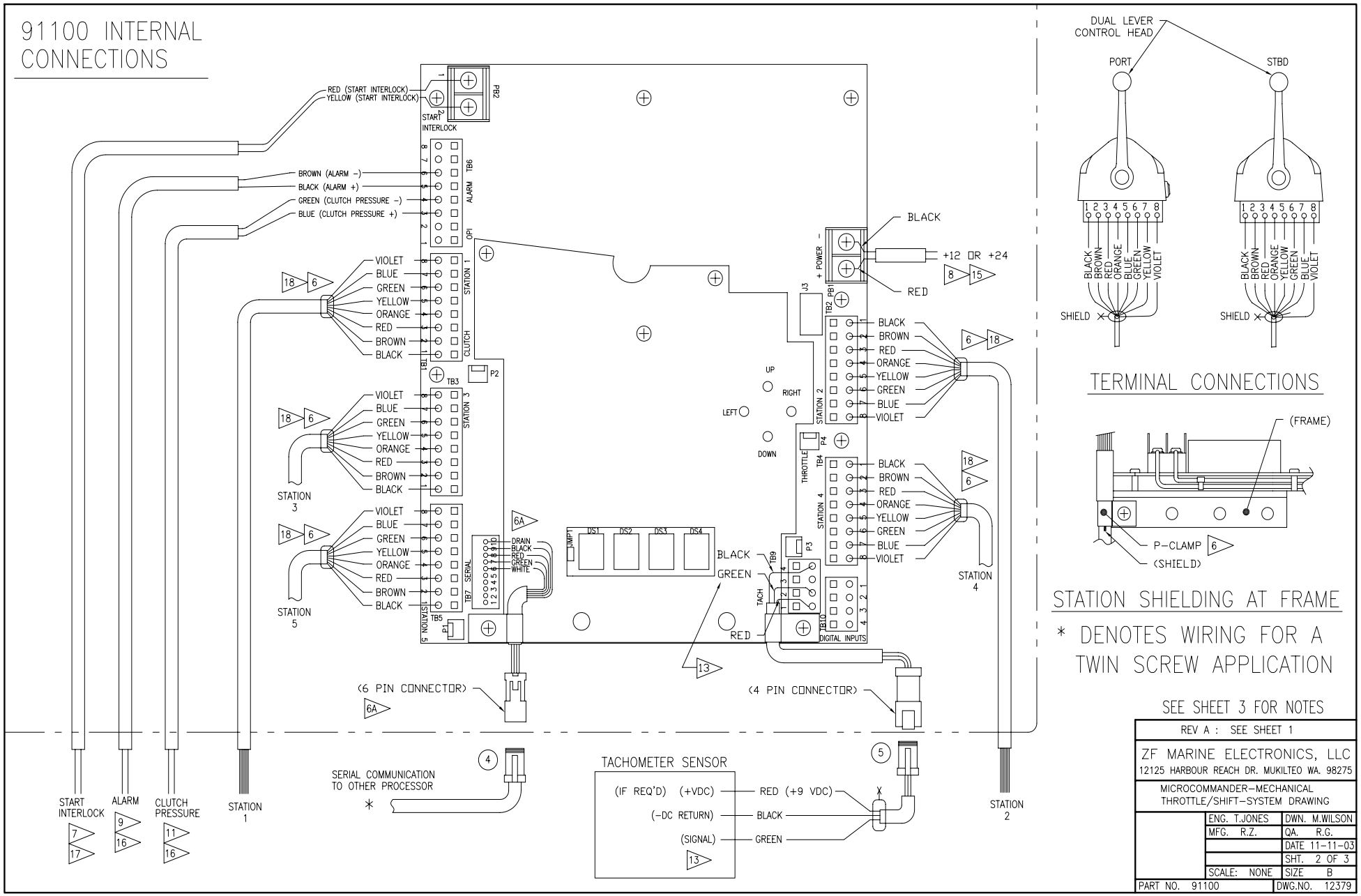
15> THIS PROCESSOR COMES EQUIPPED WITH TWO STATIONS PRE–WIRED. THREE ADDITIONAL STATIONS MAY BE ADDED BY EITHER HARD CABLE WIRING INTO THE LOCATIONS SHOWN ON SHEET TWO OF THIS DRAWING OR BY ACQUIRING THE # OF ADDITIONAL PIGTAILS AND WIRE HARNESS'S REQUIRED FROM ZF MATHERS.

REV A : SEE SHEET 1		
ZF MARINE ELECTRONICS, LLC 12125 HARBOUR REACH DR. MUKILTEO WA. 98275		
MICROCOMMANDER–MECHANICAL THROTTLE/SHIFT–SYSTEM DRAWING		
	ENG. T.JONES	DWN. M.WILSON
	MFG. R.J.Z.	QA. R.B.H.
		DATE 7–16–03
		SHT. 3 OF 3
	SCALE: NONE	SIZE B
PART NO. 91102		DWG.NO. 12271

C4 Drawing 12379A-1 Basic Hard-wired System Diagram



C5 Drawing 12379A-2 Basic Hard-wired Processor Connections



C6 Drawing 12379A-3 Basic Hard-wiring Notes Page

– NOTES –

1. DO NOT MOUNT CONTROL SYSTEM COMPONENTS ON ENGINE OR REDUCTION GEAR.
2. DO NOT MOUNT CONTROL COMPONENTS NEAR SOURCES OF HIGH HEAT. (EXHAUST DUCTS, ETC.)
3. DO NOT MOUNT CONTROL COMPONENTS NEAR SOURCES OF STRONG ELECTROMAGNETIC FIELDS. (STARTERS, GENERATORS,ETC.)
4. MOUNT CONTROL COMPONENTS IN A LOCATION ACCESSIBLE FOR CHECKOUT, MONITORING AND MAINTENANCE.
5. ALL ELECTRICAL CABLES ARE TO BE SUITABLE FOR MARINE APPLICATION AND MEET ALL APPLICABLE REGULATORY REQUIREMENTS.

6> INSURE THAT SHIELD ON THE SHIELDED CABLE IS CONNECTED ONLY AT ONE END TO THE CHASSIS AND THAT THE DRAIN WIRE DOES NOT TOUCH ANY OTHER CONDUCTIVE SURFACE. USE THE P–CLAMP TO CONNECT THE SHIELD TO THE CHASSIS AS SHOWN IN THE "STATION SHIELDING AT FRAME" DETAIL, ON SHEET 2.

6A> INSURE THAT DRAIN WIRE ON SHIELDED CABLE IS CONNECTED ONLY WHERE INDICATED INSIDE HOUSING AND THAT DRAIN WIRE DOES NOT TOUCH ANY OTHER CONDUCTIVE SURFACE. FOR OPTIMAL SCREENING THE SERIAL WIRE HARNESS SHIELD SHOULD BE CONNECTED TO "EARTH" AT ONE POINT IN THE VESSEL. (NOT INSIDE THE UNIT)

7> START INTERLOCK RELAY WITH NORMALLY OPEN CONTACTS. CONTACTS ARE CLOSED WHEN SYSTEM IS OPERATING AND COMMANDING NEUTRAL. MAXIMUM OF 5 AMP, MAXIMUM OF 30V.

8> THE CONTROL PROCESSOR WILL BE PROVIDED SHIPS SUPPLY OF 12 OR 24 VDC, PROTECTED BY A 10 AMP RATED CIRCUIT BREAKER PROVIDED BY THE SHIPYARD.

9> CONTROL FAILURE ALARM RELAY CONTACTS RATED FOR A MAXIMUM OF 0.5A, MAXIMUM CONTACT DRY RATING OF 100V. DO NOT EXCEED THIS RATING. IT IS THE SHIPYARDS RESPONSIBILITY TO UTILIZE THE ALARM CONNECTION IN AN APPROPRIATE ALARM CIRCUIT.

10> CAUTION:
THIS PART CONTAINS ELECTRONIC COMPONENTS WHICH CAN BE DESTROYED BY STATIC ELECTRICITY. PERSONNEL SHOULD GROUND THEMSELVES TO DISSIPATE ANY STATIC ELECTRICITY PRIOR TO WORKING INSIDE THE PART.

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OPEN COLLECTOR INPUT (TB9–3): MINIMUM FREQUENCY 5Hz – MAXIMUM FREQUENCY 8000Hz.
MINIMUM SINK CURRENT 2mA. MAX SENSOR OUTPUT SATURATION VOLTAGE 0.8V.

14> REFER TO DRAWING 11488 FOR ADDITIONAL POWER OPTIONS.

15> ELECTRICAL CABLING MUST BE 14 AWG OR LARGER.

16> ELECTRICAL CABLING MUST BE 16–20 AWG.

17> ELECTRICAL CABLING MUST BE 14–16 AWG.

18> 8 CONDUCTOR 20 AWG SHIELDED CABLE (PN: 00350)
WITH COLOR CODE AS SHOWN.

REV A : SEE SHEET 1		
ZF MARINE ELECTRONICS, LLC 12125 HARBOUR REACH DR. MUKILTEO WA. 98275		
MICROCOMMANDER–MECHANICAL THROTTLE/SHIFT–SYSTEM DRAWING		
	ENG. T.JONES	DWN. M.WILSON
	MFG. R.Z.	QA. R.G.
		DATE 11–11–03
		SHT. 3 OF 3
	SCALE: NONE	SIZE B
PART NO. 91100		DWG.NO. 12379

C7 Language Translation Reference

Table C1: Color Codes

ENGLISH	FRENCH	GERMAN	ITALIAN	SPANISH	SWEDISH
Black	Noir	Schwarz	Nero	Negro	Svart
Blue	Bleu	Blau	Blu	Azul	Blå
Brown	Marron	Braun	Marrone	Marrón	Brun
Drain	Masse	Erdung	Terra	Malla	Jord
Green	Vert	Grün	Verde	Verde	Grön
Light Blue	Bleu Clair	Hellblau	Bi Azzurri	Azul Claro	Ljusblå
Orange	Orange	Orange	Arancione	Naranja	Orange
Red	Rouge	Rot	Rosso	Rojo	Röd
Silver	Argent	Silber	Argento	Plateada	Silver
Violet	Violet	Violett	Viola	Violeta	Violett
Yellow	Jaune	Gelb	Giallo	Amarillo	Gul
White	Blanc	Weiß	Bianco	Blanco	Vit

English	French	German	Italian	Spanish	Swedish
Appendix	Annexe	Anhang	Appendice	Apéndice	bilaga
CAUTION	ATTENTION	ACHTUNG	ATTENZIONE	PRECAUCÓN	SE UPP!
Figure	Figure	Abbildung	Figura	Figura	Figur
Function	fonction	Funktion	funzioni	función	funktion
IMPORTANT	IMPORTANT	WICHTIG	IMPORTANTE	IMPORTANTE	VIKTIGT!
Installation and Troubleshooting Manual		Handbuch zur Installation und Fehlersuche			
NOTE	REMARQUE	HINWEIS	NOTA	NOTA	OBS!
P/N	No. de réf.	Teil-Nr	Numero pezzo	Nº de pieza	artikelnr
Page	Page	Seite	Pagina	Página	Sida
Section	Section	Abschnitt	Sezione	Sección	avsnitt
Table	Tableau	Tabelle	Tabella	Tabla	Tabell
Table of Contents	Table des matières	INHALTSVERZEICHNIS	Indice	Contenido	Innehållsförteckning
WARNING	AVERTISSEMENT	WARNUNG	AVVERTENZA	ADVERTENCIA	VARNUNG!
Port	bâbord	Backbord	Sinistra lato sinistro	Babor	babord
Starboard	Triboard	Steuerbord	Destra lato destro	Estribor	styrbord
Neutral	point mort	Neutral	folle	punto muerto	Friläge
Ahead	marche avant	Voraus	Avanti	Avante	Framåt
Astern	marche arrière	Zurück	Indietro	Atrás	back
Negative	négatif	Negativ	Negativo	Negativa	Negativ
Positive	positif	Positiv	Positivo	Positiva	Positiv
Autotroll	traîne automatique	Auto- Trolling	Autotroll	ralentización mecánica	Autotroll
Power In		Stromversorgung	Ingresso alimentazione	Entrada de alimentación	Inkommande spänning
Station	postes	Steuerstand	stazioni	Estaciones	stationer
SS [Single Screw]	Un seul moteur	Einzelschraube	Elica singola	Rosca única	En propeller
OR	OU		O		
	Un seul moteur	Einzelmotor	Motore singolo	UN MOTOR	En motor
TS [Twin Screw]	Deux moteurs	Doppelschraube	Due motori		Två propellrar
OR	OU		O		
	Deux moteurs avec synchronisation	Zwei Motoren mit Synchronisierung	Due motori con sincronizzazione	DOS MOTORES CON SINCRONIZACIÓN	Två propellrar (Två motorer med synkronisering)
Typical Actuator Connections	Connexions typiques des Servomoteursactionneurs	Typische Stellerverbindung	Collegamenti tipici dell' attuatore	Conexiones comunes del actuador	Typiska anslutningar av manöverenheter
Actuator	Actionneur	Aktuator	Attuatore	Actuador	Manöverenhet
Processor	processeur	Prozessor	processore	procesador	Processorns