1. Scope

This specification defines the Seakeeper gyro communication interface to enable a ship monitor system to:

1. Request power 'On' or 'Off' for each gyro
2. Request operation in 'Unlock' or 'Lock' modes for each gyro
3. Display gyro operational status for the gyro
4. Display gyro alarm information if a fault is detected
5. Display a chart with boat roll rate data
6. Configure the communication interface for a multiple gyro installation

2. System Overview

1. Proprietary CAN messages with J1939 style format are defined for communication between the gyro display and the ship monitor system.

2. The communication protocol consists of two CAN messages from the Gyro System – GS1 and GS2 and one CAN message from the Ship Monitor – SM1. These messages are defined in section 10 of this specification.

3. Each gyro has a 3.5" display with an optically isolated CAN bus that must be linked to the ship's monitor system. Each 3.5" display will have a unique CAN identifier that must be included in the CAN message from ship monitor system to control an individual gyro. For multi gyro installations, these CAN identifiers must be configured at commissioning to be unique for each gyro to use this communication interface. The procedure is described in section 9 of this specification.

4. 10-32V DC must be supplied by the ship monitor system to power the optically isolated CAN channel on each 3.5" display. Current draw is ~2 mA per display.

5. The gyro control interface requires two commands to enable stabilization.

    1. 'On' requests the gyro to turn on and spool the gyro up to operating speed. The gyro requires between 20 minutes and an hour to reach operating speed depending on model and conditions. A progress bar can be used to show spool up status. During the initial portion of spool up, the 'unlock' and 'lock' request is not available.
    2. 'Unlock' enables stabilization by allowing the gyro to precess. This command is only available when the gyro is at or near the operating speed.

6. The gyro control interface has two commands to disable stabilization:
    1. 'Off' – disables stabilization by locking the gyro to stop precession. Also allows the gyro to spool down to zero speed – It takes approximately 4.5+ hours for the speed to drop to zero RPM.
    2. 'Lock' – disables stabilization by locking the gyro to stop precession, but continues to maintain the gyro at operating speed.

7. Typical start up sequence: The ship monitor system will allow the user to request power 'On' via the SM1 message, then the gyro display will update the gyro operational mode from 0 to 1 via the GS1 message. The 'progress bar %' will also be transmitted to the ship monitor system via the GS1 message which can be displayed as a progress bar to the user. As the gyro spools up from zero RPM, the Unlock and Lock commands are not available. When the gyro gets close to its operating speed, the operational mode will change from 1 to 3 to indicate that the 'Unlock' and 'Lock' commands are now available. The 'progress bar %' value will continue to increase to indicate that the gyro speed is still increasing – the stabilization capability of the gyro increases with gyro speed, so some users may want to wait until the gyro is at operating speed before unlocking the gyro. When the 'progress bar

%' reaches 100, the progress bar should no longer be displayed. The ship monitor system will allow the user to request a gyro operational mode of 'Unlock' via the SM1 message, then the gyro display will update the gyro operational mode from 3 to 2 via the GS1 message. The progress bar should not be displayed when in mode 2.

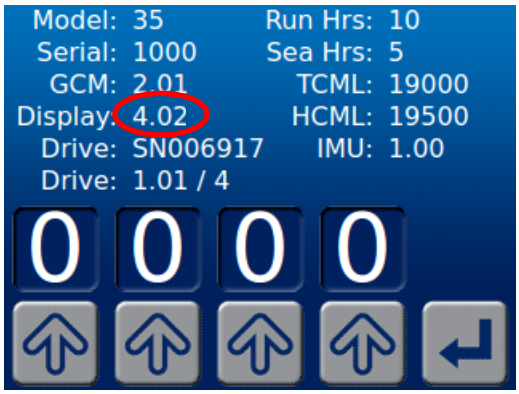
8. Locking and unlocking the gyro: The ship monitor system will allow the user to request the gyro operational mode to switch between 'Lock' and 'Unlock' via the SM1 message. The gyro display will update the operation mode to 3 for 'Lock' and 2 for 'Unlock' based on the commands. The gyro control will maintain operating speed during these transitions. The progress bar should not be displayed in either mode 2 or 3 after the initial transition into mode 2.

9. Typical shut down sequence: The ship monitor system will allow the user to request power 'Off' via the SM1 message, then the gyro display will update the gyro operational mode from 1, 2 or 3 to 0 via the GS1 message. The there is no progress bar shown in mode 0. Mode 0 allows the gyro to spool down to zero speed – It takes approximately 4.5+ hours for the speed to drop to zero RPM.

10. If an alarm is detected in one of the gyros, the gyro display will indicate the number of active faults via the GS1 message. The fault codes for each active fault will also be included in the GS1 message. A table with a short text description of each fault code is included in Appendix 2 at the end of this specification so that both the Alarm Fault Code and description can be displayed to the user. To reset the alarm, the ship monitor system must send an 'On' request to the gyro that has reported the alarm. If no active fault is present, the content of the GS1 message for the number of active faults will be 0.

11. Loss of communications between the gyro display and the ship monitor system must be detected by the ship monitor system. The ship monitor system will determine if the periodic GS1 message is not being received from each gyro. If there is a loss of communication between the gyro display and the ship monitor system, the gyro will continue to operate normally, but will have to be controlled via the 3.5 gyro display. If there is a loss of communications between the gyro display and the gyro controller, the gyro display will report 1 active fault with a fault ID of 251 to the ship monitor system on GS1. All other fields on GS1 will be packed with 0xFF. GS2 will no longer transmit.

12. This interface will only work with Seakeeper gyros with display software version 4.02 or higher. Contact Seakeeper if the software requires updating.



3. **Images from the 3.5” display to illustrate the gyro operating modes:**

a. Mode 0 – System Off

b. Mode 1 – System On – display progress bar showing spool up status – ‘Unlock’ and ‘Lock’ commands not available during early spool up

c. Mode 3 – System On and Locked – display progress bar until it reaches 100% – ‘Unlock’ and ‘Lock’ commands are available because the gyro is near operating speed

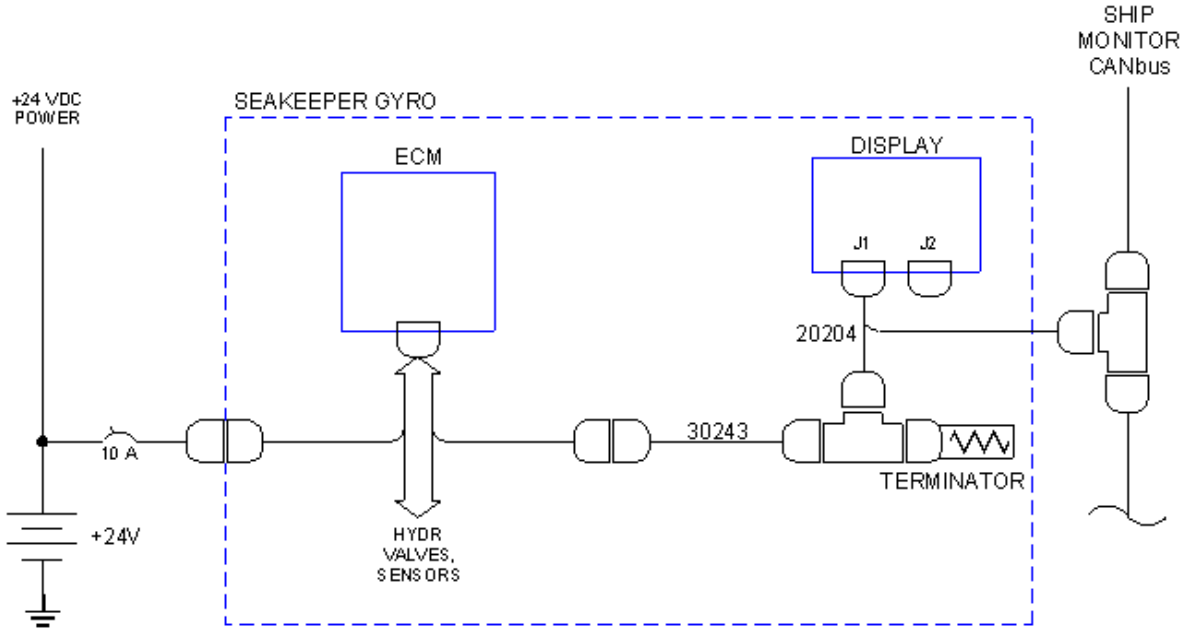
d. Mode 2 – System On and Unlocked – progress bar is not displayed

4. Roll Rate Graph

Information is provided in the GS2 message to make a chart of the boat's roll rate as shown below. Displaying this chart is optional, it is not necessary to control the operational modes of the gyro. The chart provides an indication of the effectiveness of the gyro by displaying a time history of the boat roll rate. 30 seconds of data is typically displayed with the graph scrolling across the screen. New data appears at the right side and older data scrolls to the left. Data older than 30 seconds is no longer displayed. The color of the roll rate line can be changed from red to green to indicate whether data was taken when all gyros were locked (red) or at least one gyro is unlocked (green.). Each gyro will report this data and the data from each gyro will be nearly identical, so it is only necessary to show a single chart with data from one gyro.

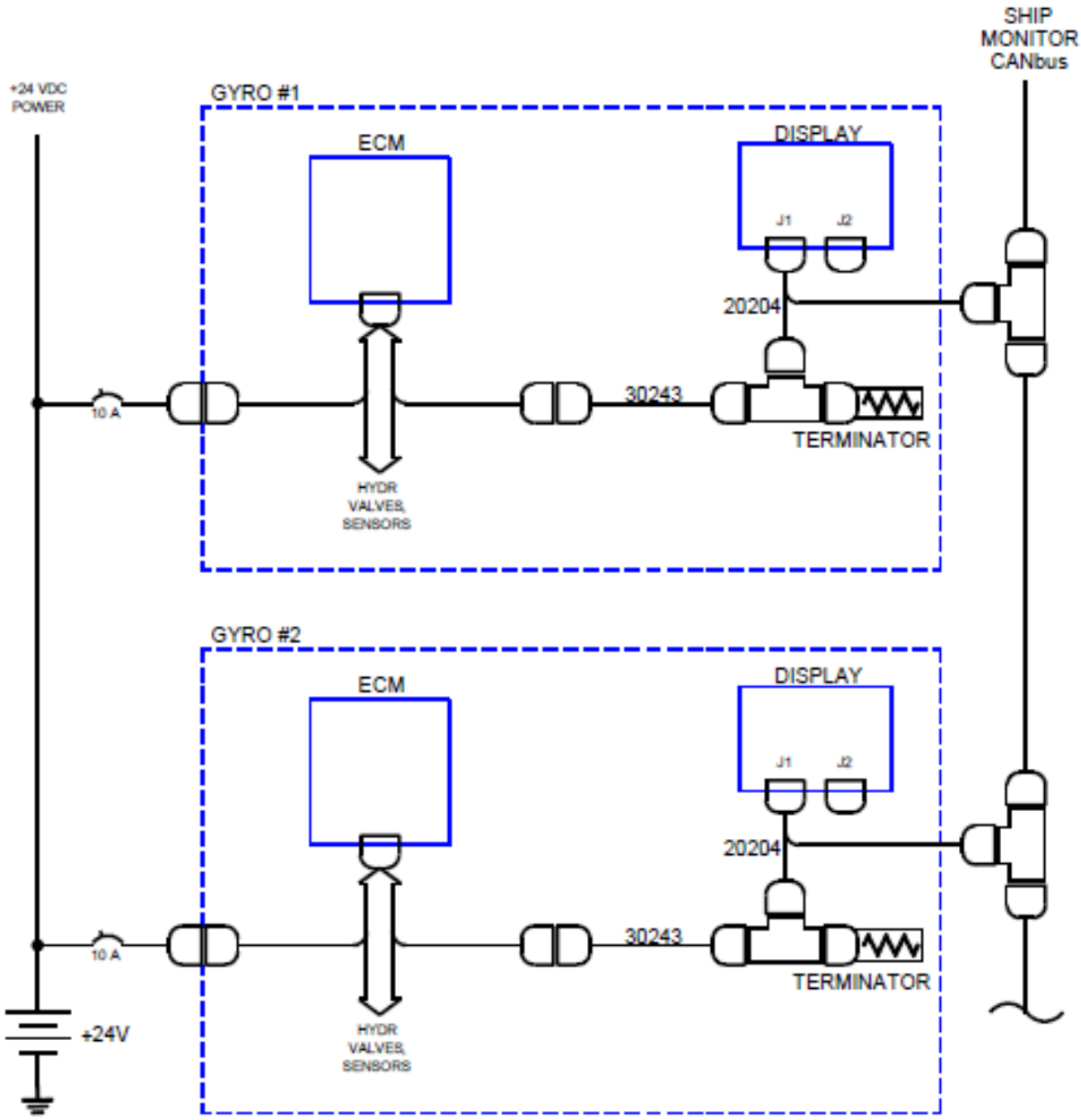
a. Roll rate graph –red line indicates all gyros are in mode 0, 1 or 3 and green line indicates one of more of the gyros are in mode 3.

5. **CAN Architecture - Single Gyro**



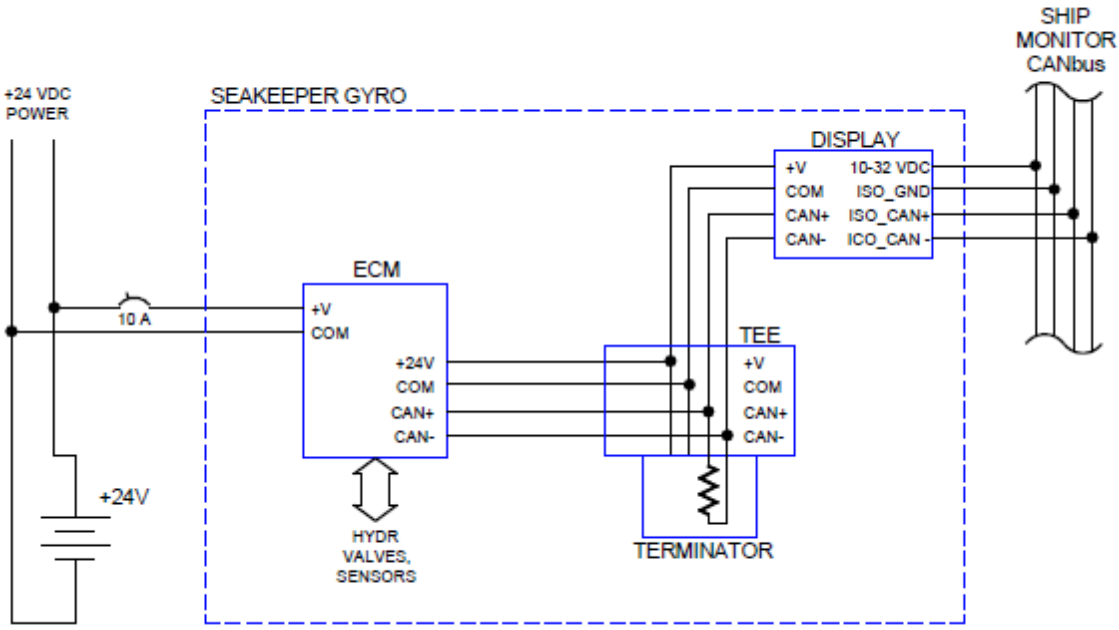
- Note: Seakeeper only provides cabling inside the blue dotted lines. The CAN bus between the ship monitor and gyros will be constructed with 5 pin conductor cables, tee's and terminators. The CAN bus design and construction is the responsibility of the boat builder. Note: Do not plug Seakeeper CAN connectors into an NMEA 2000 system.

6. **CAN Architecture - Multiple Gyro Installation**

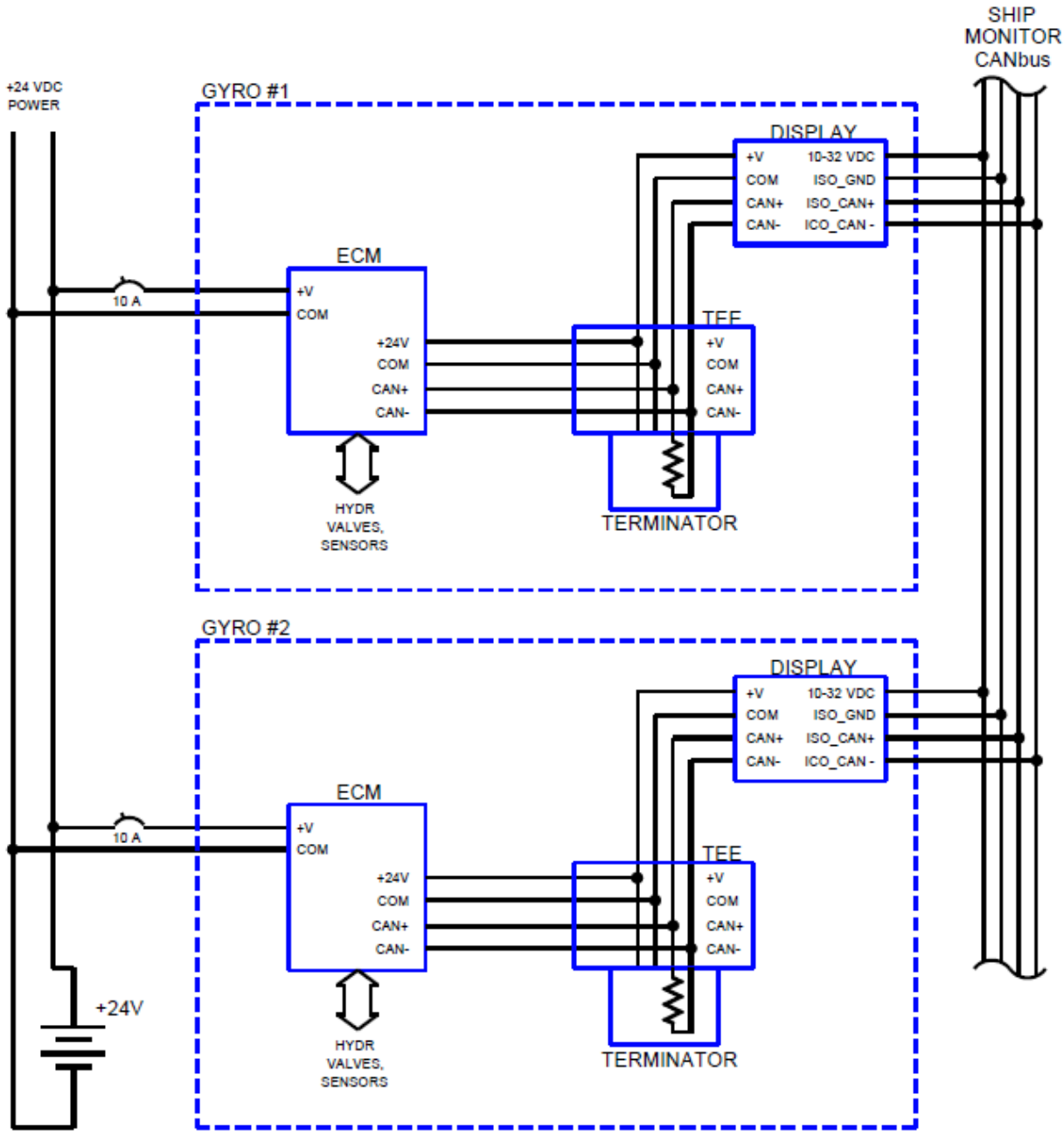


- Note: Seakeeper only provides cabling inside the blue dotted lines. The CAN bus between the ship monitor and gyros will be constructed with 5 pin conductor cables, tee's and terminators. The CAN bus design and construction is the responsibility of the boat builder. Note: Do not plug Seakeeper CAN connectors into an NMEA 2000 system.

7. CAN Wiring Detail – Single Gyro Installation



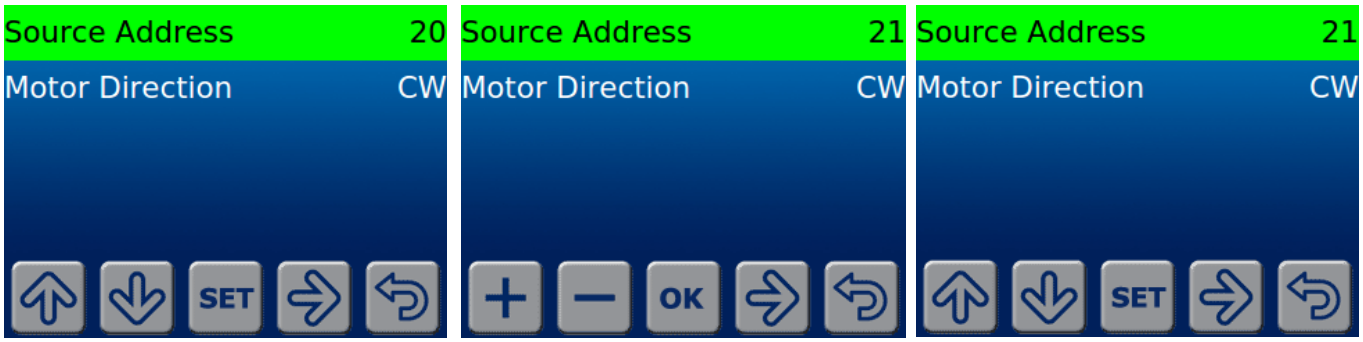
8. **CAN Architecture – Multiple Gyro Installation**



9. Configuration of Multi Gyro Installations

Configuration of the Display for multi gyro installations requires the entering the password to enter the Service screens and paging to the Display Source Address Screen

- The display source address selection screen must be utilized in multi-gryo installations where a central display panel is utilized to control all gyros.
- In this case, each gyro must be given a unique source address
- This can be accomplished by hitting the set button, which will expose the + - and OK buttons. Once the desired source address has been selected hit OK to confirm the selection



10. CAN Message Protocol

PGN 65293 Ship Monitor 1 SM1

Used by the ship system monitor to:

- address individual gyros based on unique CAN IDs
- request changes to gyro operational mode control (On or Off and Unlock or Lock)

Transmission Repetition Rate:	Asynchronous – only when a change in mode is requested.
Data Length:	8
Extended Data Page:	0
Data Page:	0
Single Frame	Yes
Little Endian:	Yes
Destination	Global
Query Support	No
Ack Request	No
PDU Format:	255
PDU Specific:	13
Default Priority:	6

Byte	Bits	Parameter
1-2	All	Reserved
3	8-1	Gyro Destination Address Resolution: Enumeration – gain of 1 and offset of 0 20, 21, 22, or 23 = Gyro Destination
4	8-7	Stop/Run State Request Resolution: Enumeration – gain of 1 and offset of 0 0 = Stop 1 = Run
4	6-5	Stabilization State Request Resolution: Enumeration – gain of 1 and offset of 0 0 = Lock 1 = Unlock
4	4-1	Reserved
5-8	All	Reserved

PGN 65294 Gyro Status 1 GS1

Used to communicate the Seakeeper Gyro operational mode and active alarms (if present). This periodic message also acts as a heartbeat to confirm communication from the Gyro. Source address from gyros will be 20, 21, 22, or 23 to differentiate messages from each gyro. The source address will be contained in the message frame.

Transmission Repetition Rate:	100ms
Data Length:	8
Extended Data Page:	0
Data Page:	0
Single Frame	Yes
Little Endian:	Yes
Destination	Global
Query Support	No
Ack Request	No
PDU Format:	255
PDU Specific:	14
Default Priority:	6

Byte	Bits	Parameter
1-2	All	Reserved
3	8-5	Gyro Operational Mode Resolution: Enumeration – gain of 1 and offset of 0 0=Stop 1=On (waiting with 'red' progress bar)(Lock and Unlock not Available) 2=On and Unlock Mode 3=On and Lock Mode (waiting with 'green' progress bar if <100%)(Lock and Unlock are Available)
3	4-1	Number of Active Faults Resolution: Enumeration – gain of 1 and offset of 0 0-4: Total number of active faults.
4	8-1	Progress Bar Percent Resolution: 1 %/bit , 0 % offset Data Range: 0 to 100 %
5	8-1	Active Fault Code #1 Resolution: Enumeration – gain of 1 and offset of 0 Data Range: 0 to 250
6	8-1	Active Fault Code #2 Resolution: Enumeration – gain of 1 and offset of 0 Data Range: 0 to 250
7	8-1	Active Fault Code #3 Resolution: Enumeration – gain of 1 and offset of 0 Data Range: 0 to 250
8	8-1	Active Fault Code #4 Resolution: Enumeration – gain of 1 and offset of 0 Data Range: 0 to 250

PGN 65295 Gyro Status 2 GS2

Used to communicate Boat Roll Rate as measured by the Gyro. Source address from gyros will be 20, 21, 22, or 23 to differentiate messages from each gyro. The source address will be contained in the message frame.

Transmission Repetition Rate:	100 ms (updated from previous specification)
Data Length:	8
Extended Data Page:	0
Data Page:	0
Single Frame	Yes
Little Endian:	Yes
Destination	Global
Query Support	No
Ack Request	No
PDU Format:	255
PDU Specific:	15
Default Priority:	6

Byte	Bits	Parameter
1-2	All	Reserved
3	8-1	Boat Roll Rate Resolution: 0.25 dps/bit, -30 dps offset Data Range: -30 to 30 dps
4-8	All	Reserved

Appendix 1: Expected RAW CAN Messaging Sequences

Initial raw CAN traffic without faults and gyro turned off / at zero speed.

Identifier	Flg	DLC	D0	1	2	3	4	5	6	D7	Time	Dir
18FF0E14	X	8	FF	FF	00	00	FF	FF	FF	FF	1742.833620	R
18FF0F14	X	8	FF	FF	78	FF	FF	FF	FF	FF	1742.901050	R

Stabilization Request of 0x03, Stop/Run state request of 0x00. No change on GS1 as it was already in this state:

Identifier	Flg	DLC	D0	1	2	3	4	5	6	D7	Time	Dir
06FF0D63	X	8	FF	FF	14	3F	FF	FF	FF	FF	1991.443730	R
18FF0E14	X	8	FF	FF	00	00	FF	FF	FF	FF	2025.166990	R
18FF0F14	X	8	FF	FF	78	FF	FF	FF	FF	FF	2025.212550	R

Stabilization Request of 0x03, Stop/Run State request of 0x01. Request is successful, progress bar percent begins to iterate up (at 1 in the below).

Identifier	Flg	DLC	D0	1	2	3	4	5	6	D7	Time	Dir
06FF0D63	X	8	FF	FF	14	7F	FF	FF	FF	FF	2105.170150	R
18FF0E14	X	8	FF	FF	10	01	FF	FF	FF	FF	2161.791740	R
18FF0F14	X	8	FF	FF	78	FF	FF	FF	FF	FF	2161.797500	R

Both Stop/Run State request = 0x03 and Stabilization Request = 0x03. A new message is received and stop/run request is out of range, therefore the display chooses to shut off the gyro.

Identifier	Flg	DLC	D0	1	2	3	4	5	6	D7	Time	Dir
06FF0D63	X	8	FF	FF	14	FF	FF	FF	FF	FF	2793.150450	R
18FF0E14	X	8	FF	FF	00	00	FF	FF	FF	FF	3230.509990	R
18FF0F14	X	8	FF	FF	78	FF	FF	FF	FF	FF	3230.523410	R

Once the gyro is up to speed, the operational mode will change to ‘On and Lock’ (decimal value 3) and the progress bar should change to green. An unlock request will now be passed through from the shipmaster to the GCM if it is requested:

Identifier	Flg	DLC	D0	1	2	3	4	5	6	D7	Time	Dir
06FF0D63	X	8	FF	FF	14	7F	FF	FF	FF	FF	3401.114910	R
18FF0E14	X	8	FF	FF	30	5D	FF	FF	FF	FF	3481.343910	R
18FF0F14	X	8	FF	FF	78	FF	FF	FF	FF	FF	3481.433080	R

To unlock the gyro, pass through a Stop Run state request of 0x01 and a stabilization state request of 0x01. The gyro operational mode will change to ‘On and Sea’ (decimal value 2):

Identifier	Flg	DLC	D0	1	2	3	4	5	6	D7	Time	Dir
06FF0D63	X	8	FF	FF	14	5F	FF	FF	FF	FF	4163.408590	R
18FF0E14	X	8	FF	FF	20	64	FF	FF	FF	FF	4175.436450	R
18FF0F14	X	8	FF	FF	78	FF	FF	FF	FF	FF	4175.435830	R

To lock the gyro, pass through a Stop Run state request of 0x01 and a stabilization state request of 0x00. The gyro operational mode will change back to ‘On and Locked’ (decimal value 3):

Identifier	Flg	DLC	D0	1	2	3	4	5	6	D7	Time	Dir
06FF0D63	X	8	FF	FF	14	1F	FF	FF	FF	FF	4463.324440	R
18FF0E14	X	8	FF	FF	00	63	FF	FF	FF	FF	4473.157360	R
18FF0F14	X	8	FF	FF	78	FF	FF	FF	FF	FF	4473.224220	R

To shut off the gyro, pass through a Stop Run state request of 0x00. Gyro operational mode will change to ‘stop’ decimal ID 0.

Identifier	Flg	DLC	D0	1	2	3	4	5	6	D7	Time	Dir
06FF0D63	X	8	FF	FF	14	1F	FF	FF	FF	FF	4735.991590	R
18FF0E14	X	8	FF	FF	00	55	FF	FF	FF	FF	4751.116790	R
18FF0F14	X	8	FF	FF	78	FF	FF	FF	FF	FF	4751.126070	R

Appendix 2: Alarm ID and Associated Descriptions

Code	Alarm Description
6	Alarm: Drive Temp High
8	Alarm: Coolant Pump 1 Fault
9	Alarm: Coolant Pump 2 Fault
12	Alarm: Brake Pressure 1 Low
13	Alarm: Brake Pressure 2 Low
19	Alarm: Angle Sensor Fault
26	Alarm: Valve 1 Fault
27	Alarm: Valve 2 Fault
32	Alarm: Vertical Accel High
35	Alarm: Display Fault
36	Alarm: Motor Fault
37	Alarm: Gyro Travel Fault
38	Alarm: Gyro Motion Fault
40	Alarm: DC Input Voltage High
41	Alarm: DC Input Voltage Low
43	Alarm: Power Relay
44	Alarm: Sensor Power High
45	Alarm: Sensor Power Low
50	Alarm: Angle Sensor Fault
55	Alarm: Angle Sensor Fault
72	Alarm: Motor Underspeed
73	Alarm: Bearing Temp High
74	Alarm: Bearing Temp High
75	Alarm: IMU Fault
76	Alarm: Roll Rate Fault
77	Alarm: Yaw Rate Fault
78	Alarm: Brake Valve Fault
79	Alarm: Valve 3 Fault
80	Alarm: Valve 4 Fault
81	Alarm: Bearing Temp
82	Alarm: Drive Age Count
83	Alarm: Drive Voltage Fault
84	Alarm: Drive CANBus
85	Alarm: Drive Software
86	Alarm: Drive Memory
87	Alarm: Drive Configuration
88	Alarm: Drive Wiring
89	Alarm: Drive Motor Control
90	Alarm: Drive Motor Fault
91	Alarm: Drive Hardware

92	Alarm: Drive MOSFET
93	Alarm: Drive IGBT
94	Alarm: Drive Preoperational
95	Alarm: Drive Hardware
96	Alarm: Drive Fault
97	Notice: AC Power low
98	Alarm: AC Mains Low
99	Alarm: Motor Fault
100	Alarm: Drive DSPPF Fault
101	Alarm: Drive Pulsing Error
102	Alarm: Drive OP Circuit
103	Alarm: Drive Sensorless
104	Alarm: Drive Temperature
105	Notice: Heater On
106	Alarm: Angle Sensor Fault
107	Alarm: Display Incompatible
108	Alarm: Drive Incompatible
109	Alarm: Drive Incompatible
110	Alarm: IMU Incompatible
111	Alarm: DC Input Voltage Low
112	Alarm: DC Input Voltage Low
113	Notice: Check and Replace Zinc Anode