SPS-P232

Stabilized Pan and Tilt Platform System
Owner's Manual

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Watson Industries prides itself on solving customer problems and serving their needs in a timely fashion. This manual is intended to facilitate this goal and to provide written information about your product. We ask that you carefully read this manual. Becoming familiar with the manual will help you understand the product's capabilities and limitations, as well as provide you with a basic understanding of its operation. If, after reading the manual, you require further assistance, do not hesitate to call Watson Industries with your questions and comments.

CAUTION!

Watson Sensors are rugged devices that have been used successfully in a number of harsh environments. The components have been qualified to withstand a mechanical shock of 200g 's or greater, and most enclosures provide an added level of protection. However, dropping a sensor from waist height onto a hard floor can cause a shock level of 600g's. At this level, damage is likely to occur.

Introduction

This manual is intended to help in understanding the installation and operation requirements of the Watson Stabilized Pan & Tilt Platform System. This Platform employs gyros to stabilize the platform to allow devices to be accurately positioned on target irrespective of the motion of the vessels on which it is mounted. Details of the operation and adjustments are provided to allow the owner to obtain optimum performance from this product.

Watson Industries has many years of experience developing sensor packages for stabilized platforms for camera and antenna applications. Now we have taken the next step and are offering a complete system.

Watson Industries also provides custom systems for special requirements. Our system design is modular and configurable for economical and quick adaptation to a wide variety of hardware configurations. Watson Industries' excellent product support and applications engineering goes along with every product.

Product Description

Our gyro-stabilized platform system is built around a rugged pan and tilt mechanism. This is a high-resolution digital system that uses high quality, wide bandwidth, low noise, and solid-state gyros. The whole system is user configurable to adapt to a wide range of payloads and requirements.

This particular model of the Watson product line is intended to hold an up to a 99 pound (45 Kg) payload on a moving vessel.

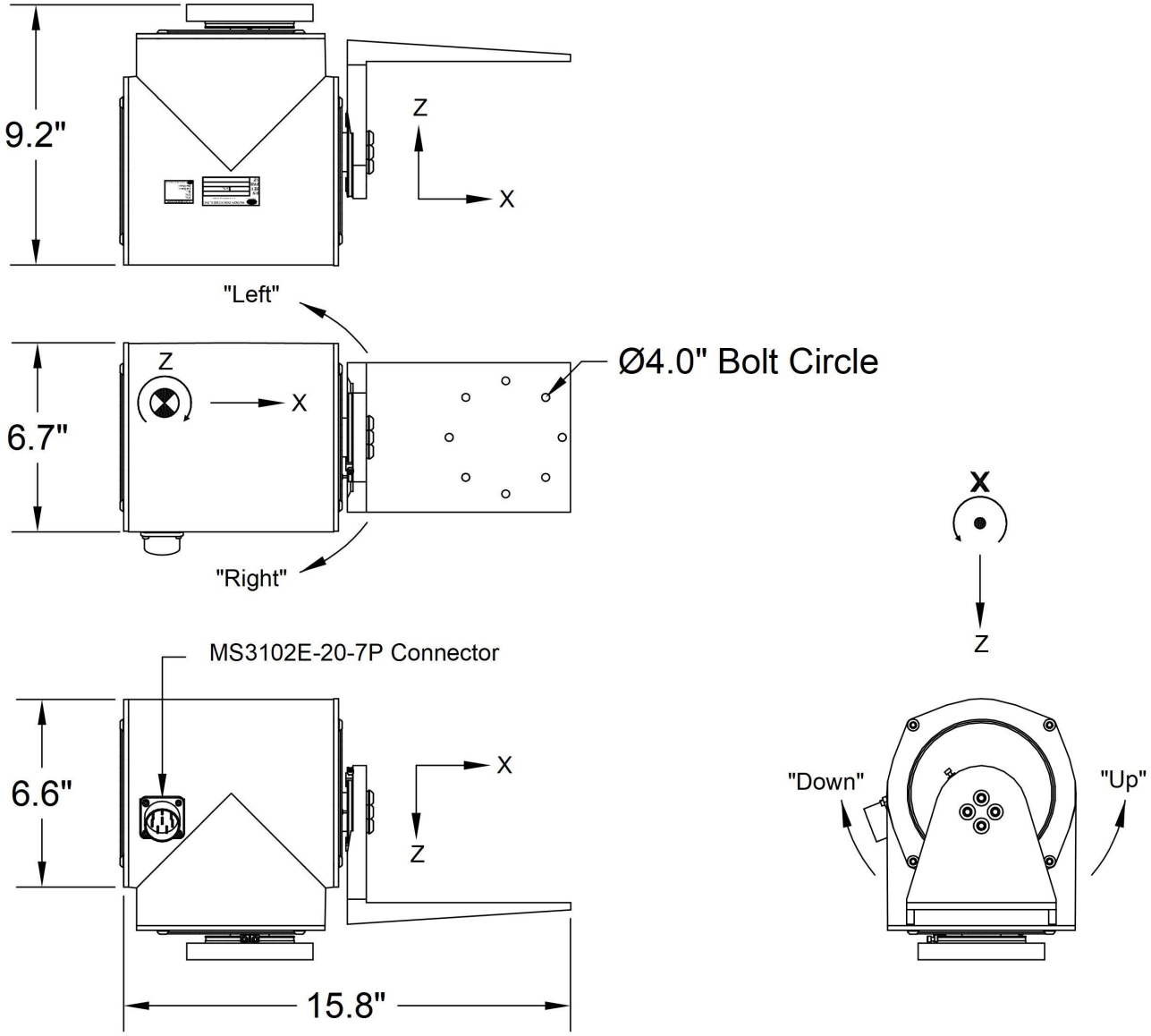


Figure 1 Two-axis gyro Stabilized Platform installation

Each axis uses a servomotor, which drives the platform through an anti-backlash gear, a precision potentiometer for positional measurements, and a pair of limit stops. The anti-backlash gear minimizes the backlash from platform motions to less than 10 Arc Seconds. Furthermore, Watson Industries has installed two gyros and a triaxial accelerometer that are used to calculate corrective commands to the drive motors.

The two gyros are rugged vibrating-structure gyroscopes, whose angular rate signals are converted from analog to 16-bit digital form. The effects of temperature variation on the DC bias of the gyros are digitally corrected.

The micro controller assesses the desired motion of the platform based on keyboard commands received through the RS-422 serial link. It then compares this desired motion against the real motion of the platform, sensed by the gyros and accelerometers, developing a rate error value. A servo-control system uses the angular rate and integral of the angular rate to derive a motor voltage that drives the error to zero. In other words, the servo-control system ensures that the motion of the platform matches that of the keyboard commands.

The servo driver module in the mount enclosure accepts commands from the micro controller in digital form, converts them to pulse-width modulation using two full-bridge switching motor drivers and then applies this to the two motors.

The platform is carefully designed to be rugged and reliable. Particular attention has been paid to minimizing the effects of noise at every point in the system. This ensures that full advantage can be taken of the low noise performance of the gyroscopes to achieve a highly stable platform.

Operation

Start-Up

The system is automatic. Once power is applied, the stabilized platform system will drive to its preset home position with any errors corrected by using a short time constant. The time constant of the corrections is increased in increments until it reaches the full operational time constant. The initialization mode has a 10 second duration. Please allow a 30 second warm-up before operating the unit.

Time Constant

The operational time constant of error correction is chosen for the predicted influences on the accuracy of the system. Chief among the sources of error are the dynamics of the vessel and the drift tendencies of the gyroscopes.

Vehicle dynamics are characterized as being violent when they exist for a short time and gentle when they are sustained over a long period. They are derivative in nature. In contrast, gyroscopes have little error in the short term, but these errors grow rapidly as they accumulate in the system. They are integral in nature. The time constant must be chosen to match the circumstances such that the least error is likely as shown in example the below:

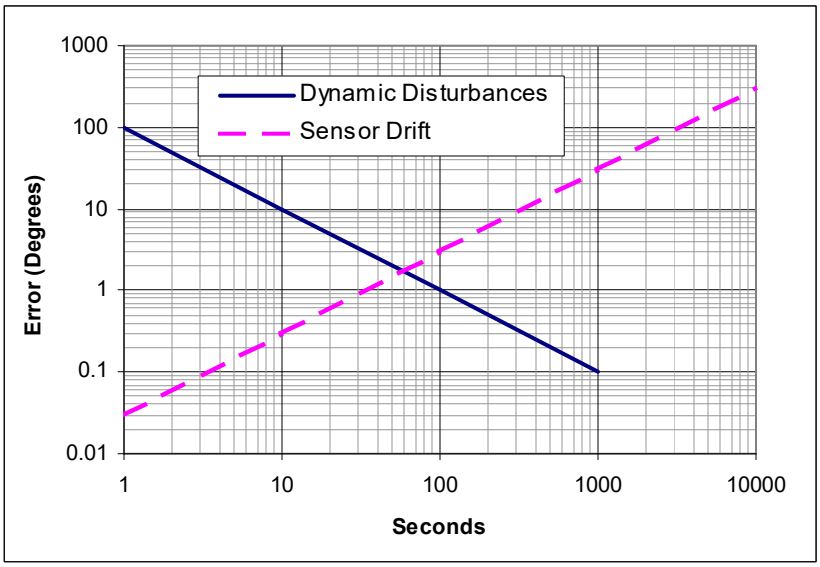


Figure 2 Errors versus Time Constant

The correction time constant for this system is adjustable based on the conditions detected by the system. When increasing errors are detected, the time constant is made longer so that the gyros are in more control of the angles. This is done on the assumption that short-term errors are more likely to be caused by vehicle dynamics.

The dynamics of aircraft, ships, or land vehicles all have individual patterns and intensities. Sometimes, only experience will expose the best time constant setting for lowest error. This is why the time constants are settable by the user through the RS-422 connections of the unit. Please consult with the Watson Industries before altering the time constants of the unit.

Pointing Angle

In initialization, the unit will drive to a preset "Home" pointing angle based on the potentiometer reading for each axis. After initialization, the unit can be commanded to return to this pointing angle by sending an "H" message. The stable platform will hold this angle until any other pointing command is received such as "Z", "U","D","L" or "R". Full ranges of offsets to this starting point (within mechanical limits) are settable by the user through the RS-422 connections of the unit (consult factory).

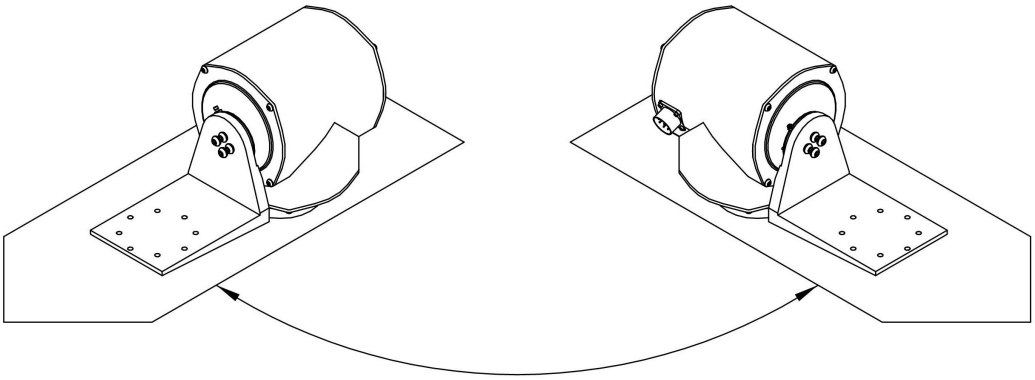
Inertial Mode

In this mode, the unit will stabilize both the pan and tilt axis of the platform. In "I" mode, the pan and tilt axis will compensate so that platform can stay pointed at a specific location regardless of the motions of the vehicle on which it is mounted. Any pointing commands to move the platform are relative to its stabilized position.

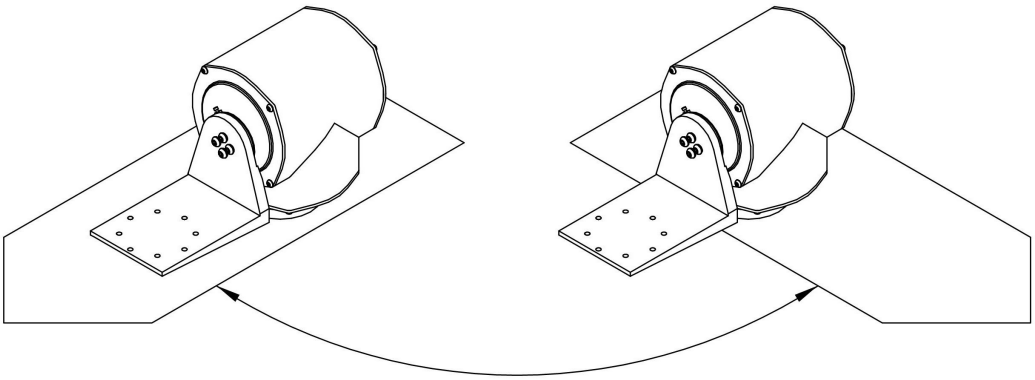
Position Mode

The unit starts up in this mode by default. Position or "P" mode is a relative positioning mode. It uses the rate gyros to detect motion on the pan axis and hold the platform in the last commanded position relative to the vehicle. The tilt axis operates differently. In Position mode, as well as Inertial Mode, the tilt axis stays stabilized and will maintain an inertial position irrespective of vehicle motions. The pan and tilt positions are set when a "Z" message is received.

Position Mode



Inertial Mode



Error Correction

Short-term disturbances will not affect the stable mount system, but as these errors become longer term, keyboard commands will become necessary to correct them. Two common sources of long-term errors for the "P" mode are discussed below.

Centrifugal Force:
The centrifugal force from turns at a significant speed could pull the pointing angle into error over time, depending on the pointing angle. If this is a problem, setting the system time constant to a higher time interval may help.

Delta Velocity (Acceleration):
The compensation for forward acceleration is for the same as for centrifugal force.

Safety Features

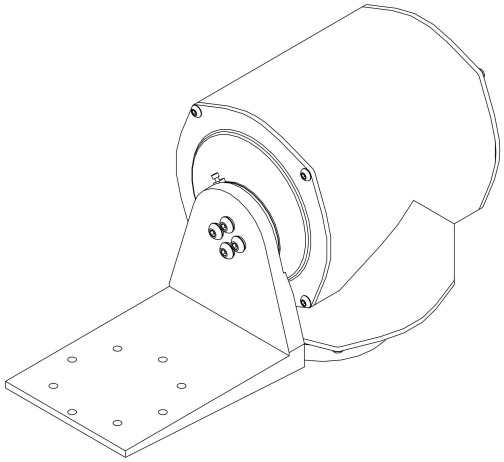
Over-current detection:
There is current sensing for each axis of this system that is connected to the micro controller. If sustained excessive motor current is detected (i.e. greater than one amp on either axis), the system will reduce the drive circuit gain by a factor of 4 to reduce the drive current. The gain will be held low for 2 seconds after the current is below the limit. Since the components of the system are balanced, the only regular cause of sustained over current is driving against resistance such as an obstruction. Such a load on the system could cause the motor to burn out and this must be prevented. If an obstruction causes an over current state, the obstruction should be identified and removed.

Electronic limit stop:
The system tracks the orientation of the mount by reading the potentiometer outputs and will prevent driving past a preset angle value held in the micro controller's non-volatile memory. Driving the mount away from this limit is not inhibited.

Mechanical limit stop:
This is a mechanical limit adjusted to keep the mount from colliding with its structure. It uses micro switches to turn off the ability to drive further into the stop by interrupting one side of the motor driver. This is a last line of defense from a system failure, as it is fully independent from the other safety systems. Driving the mount away from this limit is not inhibited.

Reverse power connection:
Power is diode protected from voltage polarity reversal. Recovery is immediate and without damage.

Installation



The servo system is mounted with careful alignment and bolted together. Additionally, the payload (supplied separately) must be attached to the SPS. The steps for this process are described below and should be read and understood before any installation or assembly begins.

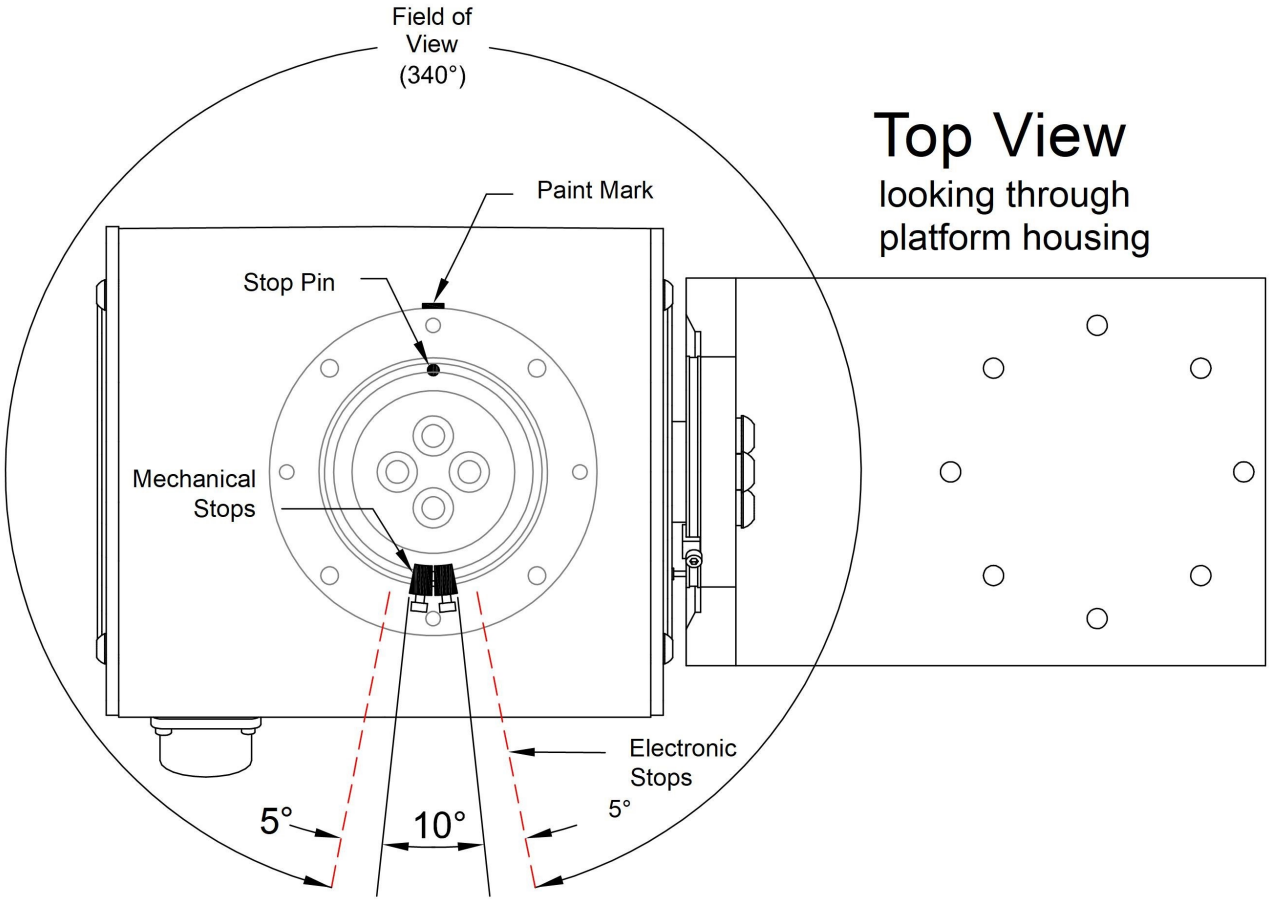
WARNING – Do not apply power until the installation is complete!

Mounting:

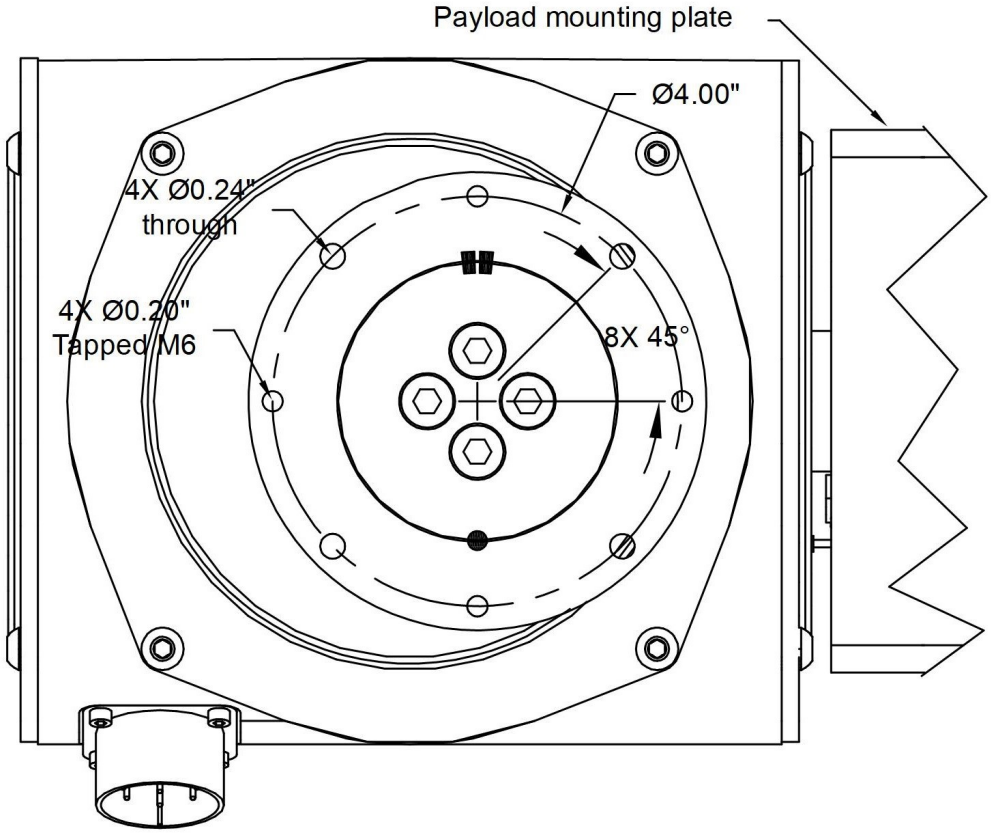
Servo System:
The servo system is the part of the SPS that will stabilize the payload. The servo system consists of the main servo housing and the payload mounting arm. The main servo housing has a circular plate with four M6 threaded holes and four #12 or M6 clearance holes for mounting. Several steps should be followed for a proper installation of the servo system:

1. The servo system is heavy and must be supported during installation to its mounting place.

2. Adjust the position of the mounting ring of the servo system so that the paint mark on the mounting ring will line up with aft of the center position of the intended field of view. The stop pin on the servo system needs to be aligned fore of the center position of intended field of view.



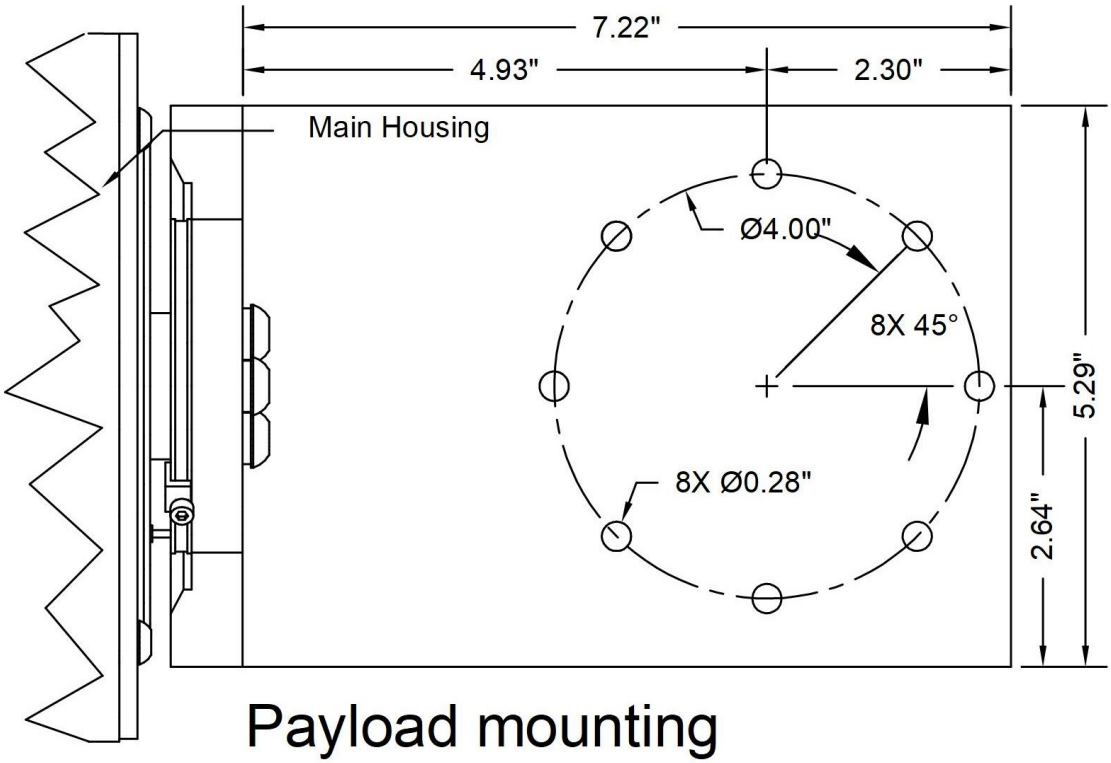
3. Loosely attach the servo system to the mounting position using four mounting bolts, washers and possibly nuts. Use bolts that do not protrude beyond the mounting ring.



Platform mounting dimensions

4. Once the servo system is aligned, secure the four mounting bolts.

User Payload:
Once the servo system is correctly installed, a payload may be installed on the arm of the servo system. The SPS has no counterweight and is limited by this load imbalance to a 99 lb (45 Kg) payload. WARNING – Do not apply power until the installation is complete!



Payload mounting plate dimensions

Environment:

This product has been surface treated for resistance to salt air and precipitation. This resistance is limited however, and the system should be kept clean and should be inspected for signs of corrosion damage regularly.

As in all moving mechanisms there is concern about ice interfering with operation. The system has internal protection against damage from stalling the motors, but performance may be reduced.

The system should be considered fragile:
DO NOT APPLY LOADS OR FORCES TO THE PAYLOAD.

Connections:

This product has one connector (MS3102E-20-7P) for all system connections. The user mating connector is Amphenol part number MS3106E-20-7S (included with the system). The connections are:

Pin	Function	
A	Power Return	
B	+28 Volt Power	
C	RS-422 TX+	Transmit from SPS-P232
D	RS-422 TX-	
E	Signal Ground (connected internally to Power Return)	
F	RS-422 RX-	Receive to SPS-P232
G	RS-422 RX+	
H	Case Ground	

Power:

This unit has an internal regulator to allow operation over a moderate voltage input range. Best operation is obtained at 28 VDC level, although operation is fully satisfactory down to 18 VDC and up to 30 VDC. Current draw of the unit is about 3 amperes peak. Internal capacitors are provided to remove a reasonable level of power line noise, however, capacitors should be added for long power line wiring or if noise is induced from other loads on the circuit.

Specifications

Platform

Range: Pan	±170° (Electronic)	±175° (Mechanical)
Range: Tilt	±90° (Electronic)	±95° (Mechanical)
Slew Rate: Bank, Elevation	±45°/sec	
Tilt Accuracy: Static	±1.5°	
Tilt Accuracy: Dynamic	±3.0°	
Noise:	0.1° rms	
Stability:	±1.5°	Over 20 minutes

Environmental

Temperature: Operating	-20°C to +50°C	
Temperature: Storage	-50°C to +80°C	
Vibration: Operating	0.5 g rms	100 Hz to 1 KHz
Vibration: Survival	2 g rms	100 Hz to 1 KHz

Electrical

Startup Time: Operational	10 seconds	
Startup Time: Full Performance	90 seconds	
Input Power:	18 to 30 VDC	
Input Current:	2A @ 28VDC	6A Peak

Physical

Size: Including Mounting Flanges	6.7"W x 15.8"L x 9.2"H	17.0 x 40.1 x 23.4 (cm)
Weight:	28lb (12.7Kg)	Not including payload
Connection	MS3102E-20-7P	Mating connector included
Capacity:	45 Kg	
Base Mounting Holes:	Qty 8 (4 x M6 Threaded; 4 x #12 or M6 clearance)	4” dia. bolt circle
Payload Mounting Holes:	Qty 8 #12 (M6 clearance)	4” dia. bolt circle

- Specifications are subject to change without notice.
- This product may be subject to export restrictions. Export Classification ECCN EAR99.

RS-422 Output Format

The nominal RS-422 output consists of a string of decimal ASCII characters sent asynchronously at regular intervals at about 10 strings per second. The string is set to be sent at 9600 baud with eight data bits, one stop bit, no parity, and no handshaking. The factory set for the contents of the string is formed as follows:

1. A six character string representing the tilt angle starting with a space, then a "+" or a "-", followed by two digits, a decimal point, and one digit for up to ±89.9 degrees.

2. A six character string representing the pan angle starting with a space, then a "+" or a "-", followed by three digits, a decimal point, and one digit for up to ±179.9 degrees.

3. A six character string representing the tilt axis angular rate starting with a space, then a "+" or a "-", followed by two digits, a decimal point and one digit for up to ±99.9 degrees/second.

4. A six character string representing the pan axis angular rate starting with a space, then a "+" or a "-", followed by two digits, a decimal point and one digit for up to ±99.9 degrees/second.

5. A five character string representing the power supply voltage starting with a space, followed by two digits, a decimal point, and one digit for up to 35.0 VDC.

6. .A six character string representing the tilt axis motor current starting with a space, then a "+" or a "-", followed by one digit, a decimal point and two digits for up to ±9.99 Amps.

7. A six character string representing the pan axis motor current starting with a space, then a "+" or a "-", followed by one digit, a decimal point and two digits for up to ±9.99 Amp.

8. A three character string representing the Status Bits starting with a space, followed by two ASCII characters representing Octal digits.

9. A seven character string representing the Flag Bits starting with a space, followed by two ASCII characters (Flag Bits1) representing Octal digits, a space, followed by three ASCII characters (Flag Bits2) representing Octal digits.

10. The string is terminated by a carriage return. There will then be a short interval with no data transmission before the next string begins.

Example:

+02.5	-001.5	+02.5	-05.0	24.5	+0.25	-0.22	64	04 000	<CR>
Tilt Angle (1)	Pan. Angle (2)	Tilt Rate (3	Pan Rate (4)	Power Supply Voltage (5)	Tilt Current (6)	Pan Current (7)	Status Bits (8)	Flag Bits (9)	(10)
↑ space	↑ space	↑ space	↑ space	↑ space	↑ space	↑ space	↑ space		

The output message and baud rate can be configured by the user. See Appendix B for more information.

A text header is sent by the SPS during initialization that identifies the unit by part number and serial number and gives the date of last calibration. Additionally, a line of text characters that identifies the data channel columns is sent if the serial output is set to ASCII decimal. This header message can be suppressed or restored by sending a "*" command from the interfacing computer. This change can also be made the default by sending a quote (") command.

Data transmission sent by the SPS-P232 can also be suppressed or restored by sending a "+" command from the interfacing computer. This change can be made the default setting by sending a quote (") command.

RS-422 Keyboard Input Commands

The movement, positioning, and settings of the platform are controlled by keystroke commands transmitted by RS-422. These input commands use the same communication parameters that the output data uses (9600 baud 8 data bits, 1 stop bit, no parity, and no handshaking). There are seven keyboard commands. More detail is given below:

There are four positioning commands:

- Each command starts with a letter (U for Tilt up, D for tilt Down, L for pan left, R for pan right).
- The commands are case insensitive.
- The command letter is followed by 1 or 2 digits which indicate the rate (in degrees per second) at which the platform should move.
- Optionally, a third digit preceded by a decimal point can be included.
- Any extra digits will be ignored.
- The maximum input value allowed is 49.9, representing 49.9 degrees/second.
- The command is ended by a <CR> (i.e. The "Enter" key)
- To Abort the command entry, use <ESC> (i.e. The "Escape" key)
- Examples:
    - "U22<CR>"
    - "D22.1<CR>"
    - "L5<CR>"
    - "r5.1<CR>"

There also three control commands:

- Set to zero on "Z" or "z" message
    - When the tilt command of zero is set, the tilt reference is offset to the current reference angle
- Platform sent to 'Home' position by sending an "H" or "h" message
    - During startup initialization the SPS automatically goes to 'Home" position.
    - Released by any keyboard command or "Z" message.

- Platform pan axis holds a position relative to the vehicle by sending a "P" or "p" message

- Holds at the last zero position (see the z command above).
- May be offset by positioning commands (see above).
- Releases to stabilized “Inertial Mode” by “I” or “i” message.

RS-422 Input Commands

The RS-422 input commands are provided for the purpose of unit test and installation set-up. These input commands use the same communication parameters that the output data uses (9600 baud ASCII nominal, or as reset in the units EEPROM).

Note: Many commands require Command Mode or “Double spacebar mode” in order to access them. For more information on how to activate Command Mode, see the instructions in Appendix B.

These commands are available to the user (others are used at the factory for alignment and calibration).

1. An exclamation point “!” will reinitialize the unit just as re-powering the unit would. Further, the access to initialization is inhibited such that a spacebar command must be sent within 2.5 seconds of the “!” command for initialization to be engaged. This command does not require command mode, it may be used at any time.

2. A “:” command will toggle the output to send a frame of data upon receiving any non-command character (On to Off; Off to On). This change is made non-volatile in the unit on EEPROM by keying in the quote (“) character. Command mode is required for access to this command.

   Note: To test if this command is active when the unit is not flowing data, send a carriage return (or any other non-command character) to the sensor, and observe if there is any output.

   Important Note: The “:” setting will cause the mechanical brake to be engaged between frames. This is not intended to be an operational mode.

3. A “+”command will suppress or restore the transmission of data. This command will toggle the data transmission (On to Off; Off to On).. This change is made non-volatile (default) in the unit on EEPROM by keying in the quote (“) character. Command Mode is required for access to these commands.

   Note: It is possible for both the “:” and the “+” commands to be active at the same time. The “+” command determines whether the sensor is allowed to transmit data. So in this case, the “:” command must also be turned off to allow the free flow of data.

4. An “*” command will suppress or restore the initialization message. This command will toggle the transmitting of the text header during initialization (On to Off; Off to On). This change is made non-volatile in the unit on EEPROM by keying in the quote (“) character. Command mode is required for access to this command.

5. The “&” command calls a menu which allows any of several parameters to be set. These are system time constants, selection of data channels for serial output, listing current serial channels and baud rate. Command Mode is required for access to this command.

The commands “~”, “@”, “#”, “$”, “(“, “)”, “{“, “}”, “|”, “<”, “>” and “?” are used by the Watson factory to calibrate the unit and should be used only with the assistance of the factory. If an undesired function is called, a “Q”, and sometimes the Escape or Delete key will interrupt the command and return to operation with the least disturbance to the system. All other unspecified characters such as carriage return, line feed and space are ignored by the system.

Warning

Rough handling or dropping of this unit is likely to cause damage. Over-voltage and/or miswiring of this unit will cause damage. This unit should be inspected regularly when exposed to prolonged exposure to high humidity and/or salt air environments.

DISCLAIMER

The information contained in this manual is believed to be accurate and reliable; however, it is the user's responsibility to test and to determine whether a Watson Industries' product is suitable for a particular use.

Suggestion of uses should not be taken as inducements to infringe upon any patents. This product is not to be used as a primary instrument for life critical use.

WARRANTY

Watson Industries, Inc. warrants, to the original purchaser, this product to be free from defective material or workmanship for a period of two full years from the date of purchase. Watson Industries' liability under this warranty is limited to repairing or replacing, at Watson Industries' sole discretion, the defective product when returned to the factory, shipping charges prepaid, within two full years from the date of purchase. All sensors returned under warranty will be repaired (or replaced at the sole option of Watson Industries) at no cost to the customer other than shipping charge from customer to Watson Industries (plus any export and transportation charges outside the United States). The warranty described in this paragraph shall be in lieu of any other warranty, express or implied, including but not limited to any implied warranty of merchantability or fitness for a particular purpose.

Excluded from any warranty given by Watson Industries are products that have been subject to abuse, misuse, damage or accident; that have been connected, installed or adjusted contrary to the instructions furnished by seller; or that have been repaired by persons not authorized by Watson Industries.

Watson Industries reserves the right to discontinue models, to change specifications, price or design of this product at any time without notice and without incurring any obligation whatsoever.

The purchaser agrees to assume all liabilities for any damages and/or bodily injury, which may result from the use, or misuse, of this product by the purchaser, his employees or agents. The purchaser further agrees that seller shall not be liable in any way for consequential damages resulting from the use of this product.

No agent or representative of Watson Industries is authorized to assume, and Watson Industries will not be bound by any other obligation or representation made in connection with the sale and/or purchase of this product.

PRODUCT LIFE

The maximum expected life of this product, other than wear out, is 20 years from the date of purchase. Watson Industries, Inc. recommends the replacement of any product that has exceeded the product life expectation.

Customer Service

All repairs, calibrations and upgrades are performed at the factory. Before returning any product, please contact Watson Industries to obtain a Returned Material Authorization number (RMA).

Return Address & Contact Information

Watson Industries, Inc.
3035 Melby Street
Eau Claire, WI 54703
ATTN: Service Department
Telephone: (715) 839-0628 Fax: (715) 839-8248 email: support@watson-gyro.com

Returning the Product

Product shall be packaged making sure there is adequate packing around all sides. Correspondence shall include:

- Customer's Name and Address
- Contact Information
- Equipment Model Number
- Equipment Serial Number
- Description of Fault

It is the customer's responsibility to pay all shipping charges from customer to Watson Industries, including import and transportation charges.

Appendix A

The following outputs are available via the RS-422 serial link. Their full-scale ranges are listed for decimal format.

Inertial Output	Label	Decimal Range
Time	TM	000.1 to 999.9 s
Tilt Angle	TA	±89.9º
Pan Angle	PA	±179.9º
X Accelerometer	XA	±9.99 g
Y Accelerometer	YA	±9.99 g
Z Accelerometer	ZA	±9.99 g
Tilt Axis Angular Rate	TR	±99.9 º/s
Pan Axis Angular Rate	PR	±99.9 º/s
Power Supply Voltage	PS	00.0 to 35.0 VDC
Tilt Current	TC	±9.99 Amps
Pan Current	PC	±9.99 Amps
Temperature	TP	-40º to 88ºC
Status Bits	ST	2 ASCII chars representing Octal digits
Flag Bits 1	F1	2 ASCII chars representing Octal digits
Flag Bits 2	F2	3 ASCII chars representing Octal digits

Status Bits:

The status bits provide operational information that is presented as two ASCII octal digits. The first digit is made from three bits as follows:

1) Initialization mode equals a value of 1 during start up.
2) Tilt Stop bit equals a value of 2 when no Tilt ("U" or "D") command (ie zero)
3) Pan Stop bit equals a value of 4 when no Pan ("L" or "R") command (ie zero)

First Digit	Pan Stop	Tilt Stop	Initialization	
7	Yes	Yes	Yes	4 + 2 + 1
6	Yes	Yes	No	4 + 2
5	Yes	No	Yes	4 + 1
4	Yes	No	No	4
3	No	Yes	Yes	2 + 1
2	No	Yes	No	2
1	No	No	Yes	1
0	No	No	No	

"4" Pan Stop
"2" Tilt Stop
"1" In Initialization

The second digit represents the current time constant as a power of two:

$TC = 2^X$ Seconds

The nominal time constant is 16 seconds which would display the octal value of X as "4".

Second Digit	Time Constant (seconds)
7	128
6	64
5	32
4	16
3	8
2	4
1	2
0	1

Flag Bits 1:

The flag bits present warning information. The first digit is made from three bits:

1) Pan angle negative stop limit equals a value of 1 when the Pan potentiometer reaches a preset limit.
2) Pan angle positive stop limit equals a value of 2 when the Pan potentiometer reaches a preset limit.
3) Position mode bit equals a value of 4 when the Position mode active ('P' command)

First Digit	Position Mode	Pan Angle Positive Stop Limit	Pan Angle Negative Stop Limit	
6	Yes	Yes	No	4 + 2
5	Yes	No	Yes	4 + 1
4	Yes	No	No	4
2	No	Yes	No	2
1	No	No	Yes	1

"4" In Position Mode
"2" Pan Positive Stop Limit
"1" Pan Negative Stop Limit

The second digit is made from three bits as follows:

1) Tilt angle negative stop limit equals a value of 1 when the Tilt potentiometer reaches a preset limit.
2) Tilt angle positive stop limit equals a value of 2 when the Tilt potentiometer reaches a preset limit.
3) Home mode bit equals a value of 4 when the Home mode active ('H' command)

First Digit	Home Mode	Tilt Angle Positive Stop Limit	Tilt Angle Negative Stop Limit	
6	Yes	Yes	No	4 + 2
5	Yes	No	Yes	4 + 1
4	Yes	No	No	4
2	No	Yes	No	2
1	No	No	Yes	1

"4" In Home Mode
"2" Tilt Positive Stop Limit
"1" Tilt Negative Stop Limit

Flag Bits 2:

The flag bits present warning information. Flag Bits 2 is made from three digits as follows:

The first digit is made from two bits as follows:

1) Input Power greater than 30 Volts equals a value of 2.
2) Input Power less than 18 Volts equals a value of 1.

First Digit	Input Power
2	Greater than 30 VDC (Over voltage)
1	Less than 18 VDC (Under voltage)
0	Between 18 & 30 VDC (Acceptable)

The second digit is made from two bits as follows:

1) Tilt over current limit equals a value of 2 when the Tilt motor is overloaded.
2) Pan over current limit equals a value of 1 when the Pan motor is overloaded.

Second Digit	Tilt Motor Overload	Pan Motor Overload	
3	Yes	Yes	2 + 1
2	Yes	No	2
1	No	Yes	1
0	No	No	

"2" Tilt Motor Overload
"1" Pan Motor Overload

The third digit is made from two bits as follows:

1) Tilt Rate limit equals a value of 2 when the Tilt axis angular rate exceeds 25 degrees per second.
2) Pan Rate limit equals a value of 1 when the Pan axis angular rate exceeds 25 degrees per second.

Third Digit	Tilt Axis Rate Limit Exceeded	Pan Axis Rate Limit Exceeded	
3	Yes	Yes	2 + 1
2	Yes	No	2
1	No	Yes	1
0	No	No	

"2" Tilt Rate Limit Exceeded
"1" Pan Rate Limit Exceeded

Appendix B

Activating Command Mode (Double Spacebar Mode)

1) Connect the unit to a DC power source that is off.
2) The viewing computer needs a valid bi-directional RS-232 serial port. Connect the serial port of the Watson sensor to the computer's serial port.
3) Open a terminal program (such as HyperTerminal) to interface with the unit. The default baud rate of the unit is 9600 baud. Make sure the computer's serial port is open.
4) Power-on the unit. A startup message will be transmitted by the unit and will appear in the terminal window unless it has been suppressed (See RS-232 Input Commands above).
5) During initialization, hit the space bar twice within close succession.

   Note: The sensor initialization time begins after the startup message is transmitted. Typically, this time period lasts 5 seconds, but could be as long as 127 seconds depending on your sensor.

6) Wait until after initialization is finished. At this point, command mode will be activated and the unit will accept keyboard commands.

   Note: Most Watson sensors have initialization times that are shorter than 30 sec. Any extra keystrokes (other than two spacebars) sent during initialization will deactivate command mode.

**It can often take a few attempts to get the hang of step 5. Repeat steps 4-6 until successful.

Determining Output Channels

1) Activate Command Mode (See above).
2) To determine which channel present, first type '&'.
   This will bring up the menu:

```
TYPE IN THE NUMBER OF YOUR SELECTION (OR 'Q' TO QUIT):
  1 = ADJUST TIME CONSTANTS
  2 = SET OUTPUT CHANNELS
  3 = LIST CURRENT OUTPUT CHANNEL SELECTION
  4 = SET NEW BAUD RATE
```

3) Typing in '3' will show which channels are currently active.

Setting Output Channels

1) Activate Command Mode (See above).
2) To change which channels are output type '&'(this will bring up the main menu again)
3) Type '2' to set up the channels.

The following message will appear:

```
TO SET FOR OUTPUT FOR ANY OF THE FOLLOWING DATA ITEMS, PRESS Y
TO AVOID ANY OF THE FOLLOWING DATA ITEMS, PRESS N
TO QUIT AND DISREGARD ANY OTHER DATA, PRESS Q

*** DO YOU WANT TO PROCEED?  (Y/N/Q)
```

4) To proceed type 'Y'.
Stop this process by typing either ‘N’ or ‘Q’.
If ‘Y’ is pressed, each channel will come up one at a time

For example:

```
DO YOU WANT OUTPUT OF TIME SINCE RESET?  N
DO YOU WANT OUTPUT OF TILT ANGLE?  Y
DO YOU WANT OUTPUT OF PAN ANGLE?
```

5) Type 'Y' to output the channel, type 'N' to remove the channel.

After the last data channel is listed, this message will appear:

```
Y = GOBACK, N = INSTALL DATA & QUIT, Q = QUIT
  DO YOU WANT TO TRY TO SET DATA AGAIN?
```

6) To accept the new channels, type 'N'. Typing a ‘Y’ will start the command menu sequence over.
Typing a ‘Q’ at any time in the sequence will quit without updating the channels.
Changes made will not change the non-volatile settings. To make these new settings the default value, send a Quotation Mark (“).

7) Press the space bar after quitting or updating the new channels to restart the data flow.

Adjust Time Constant

1) Activate Command Mode (See above).
2) Type '&'(this will bring up the main menu again).
3) Type '1' to show the current time constants.

   The Nominal Time Constant is set at the factory to a value of 64 seconds. This is the main setting.

   Consult the factory for recommendations before adjusting these values.
4) Press the spacebar after changing the time constant to resume data transmission.

Set Baud Rate

1) Activate Command Mode (See above).
2) Type '&'(this will bring up the main menu again).
3) Typing in '4' will allow the user to change the baud rate.
4) Change the baud rate to a new setting.

   To change to 38,400 Baud, type ‘1’.
   To change to 19,200 Baud, type ‘2’.
   To change to 9,600 Baud, type ‘3’.
   To change to 4,800 Baud, type ‘4’.

The baud rate change will take effect immediately. To make the new baud rate the default setting, send a quote symbol (“) using the new baud rate. Otherwise the old baud rate will return the next time the unit is powered up.

Note: The baud rate of the software that is communicating to the sensor will need to be changed to match the new setting.

5) Press the space bar to resume data transmission.

The factory settings for serial communications are 9.6K baud with 8 bits and one stop bit, no parity.