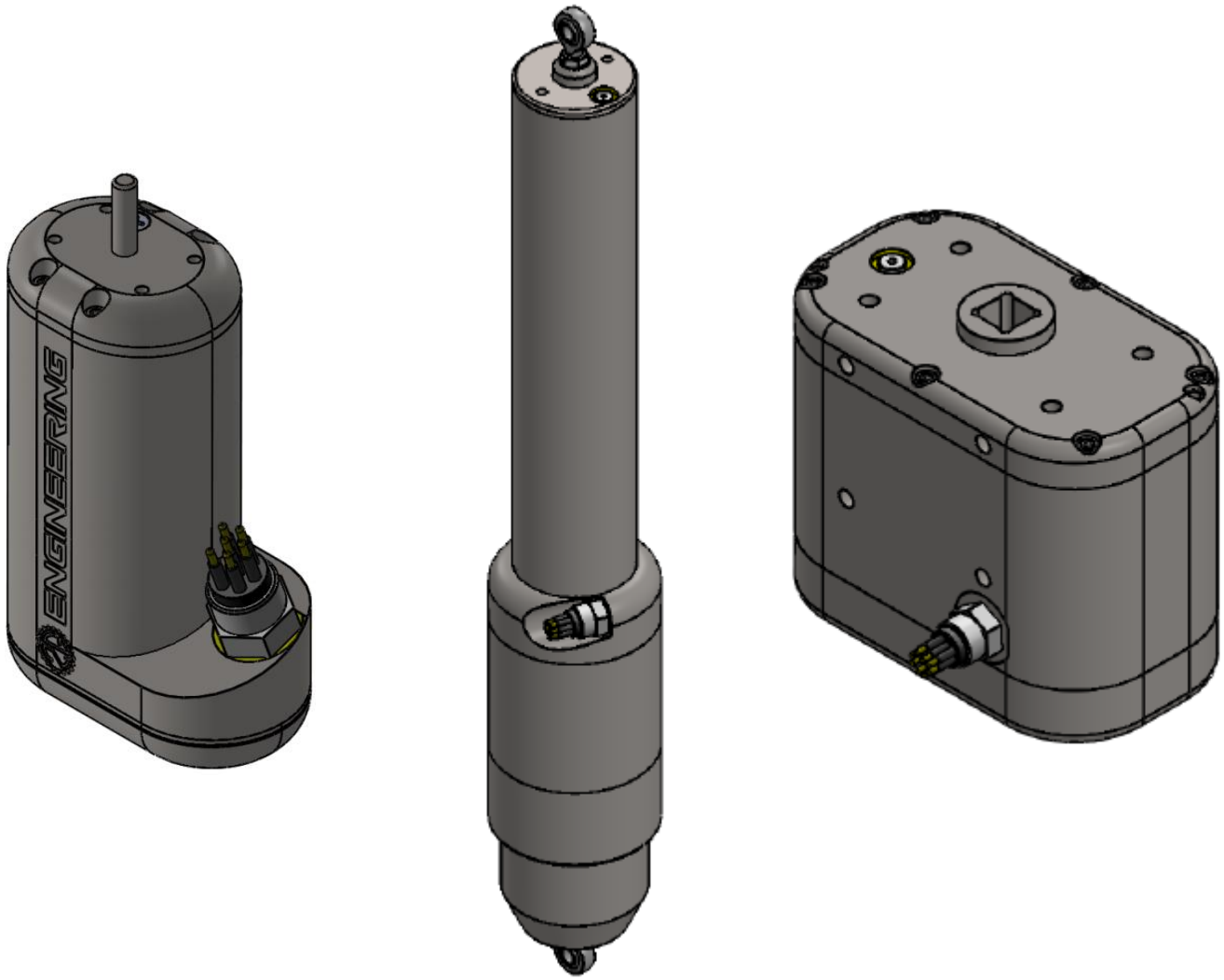
ACTUATOR OPERATING MANUAL

This manual provides installation, operation, and maintenance instructions for linear and rotary actuators.



DO NOT OPEN YOUR ACTUATOR

OPENING THE ACTUATOR WILL VOID WARRANTY

AND UNITS NEED TO BE SEALED WITH A VACUUM CHAMBER

Warranty

2G Engineering warrants that its product(s) shall be made in accordance with buyer's specifications which have been accepted in writing by 2G Engineering and shall be free from defects in material and workmanship for 1 Year after purchase. This warranty is provided to the original purchaser and in the case of original equipment manufacturers, to their original customer, and may not be transferred to any other person or entity. In no event shall 2G Engineering be liable or have any responsibility under such warranty if the products have been improperly stored, installed, used, or maintained, or if Buyer has permitted any modifications, adjustments, and/or repairs to such product(s) without 2G Engineering's prior written consent. The warranty is only valid if purchaser has paid all amounts due to 2G Engineering for the product and 2G Engineering has received written notice of the claim within 1 Year after purchase of the product.

The above warranty is the sole warranty provided by 2G Engineering. No other warranties, expressed or implied, are included in the purchase of the product(s) and 2G Engineering expressly disclaims all such other warranties, including without limitation, implied warranties of merchantability and fitness for a particular purpose.

Safety Considerations

As with any electro-mechanical device, safety must be considered during the installation and operation of your actuator. Throughout this manual you will see paragraphs marked with **CAUTION** and **WARNING** signs as shown below:

WARNING	"Warning" indicates the information following is essential to avoiding a safety hazard.
CAUTION	"Caution" indicates the information following is necessary for avoiding a risk of damage to the product or other equipment.

Pay particular attention to these paragraphs. They are intended to provide helpful information to ensure safe and trouble-free installation.

General Safety

Failure to follow safe installation guidelines can cause death or serious injury. The voltages used in the product can cause severe electric shock and/or burns and could be lethal. Extreme care is necessary at all times when working with or adjacent to the product. The forces created by the actuator could be lethal or cause severe injury if proper protection is not provided to keep personnel away from moving components.

Ensure that the product installation and use complies with all relevant safety legislation in the country of use.

System Design and Operational Safety for Personnel

The actuator is intended as a component for professional installation, incorporated into complete equipment or a system. If installed incorrectly, the actuator may present a safety hazard. The actuator uses high voltages and currents, carries a high level of stored electrical energy, and is used to control equipment which can cause injury. Close attention is required to the electrical installation and the system design to avoid hazards either in normal operation or in the event of equipment malfunction. System design, installation, and commissioning must be carried out by personnel who have the necessary training and experience. They must read this safety information and manual carefully. None of the functions or features of the actuator may be used to ensure safety of personnel, i.e. they must not be used for safety-related functions. Careful consideration must be given to the functions of the actuator which might result in a hazardous situation, either directly through intended operation or through incorrect operation due to a fault. In any application where a malfunction of the actuator or its control system could lead to or allow for damage, loss, or injury, a risk analysis must be

carried out, and where necessary, further measures taken to reduce the risk - for example a failsafe brake in case of loss of actuator braking power.

WARNING	The recommendations in this manual for installation, operation, and maintenance must be followed to ensure safe use. All persons responsible for the installation and use of 2G Engineering actuators must be familiar with the contents of this manual.

Customer is responsible for guards, gloves, personal protective equipment, and other protective devices. Customer is responsible for ensuring that the application of the actuator and usage conforms with local and national operating and safety codes appropriate to the class of equipment into which the actuator is being installed.

Table of Contents

1 SYSTEM DESCRIPTION

1.1 KEY FEATURES

- All 2G Engineering actuators are operational in air or submerged.
- Depending on the material option that is chosen, the model can be used in highly corrosive or acidic environments, such as sea water.
- All units are pressure compensated by the use of a pressure compensation diaphragm and filled with a biodegradable synthetic oil.
- All of the actuators covered in this manual contain a brushless DC motor.
- All units provide a fully closed loop servo motion system for precise position and velocity control.
    - The servo system provides trapezoidal, s-curve, and simple movement commands.
    - The unit is fully operational without calibration or “homing” as soon as the unit is powered on.
- Standard communication and control of the actuator is accomplished via RS-232 or RS-485.
- Isolated RS-232 communications is optional on all units.
- Firmware for processing of actuator control packets such as motor control, sensor data management, fault management, programmable events, and configuration options is built into the unit internally.
- See the specific product drawing for physical specifications and connection options.

1.2 OPERATION ENVIRONMENT

The intended use of the actuator is in submersed deep marine applications (salt water). All actuators are generally designed to operate at pressures of up to 5000 psi at temperatures from -20ºC to 65ºC. Please refer to your specific model’s specifications sheet for unit specific parameters.

1.3 SYSTEM OPERATIONS

The system must be properly installed and configured according to the installation section of this document. Once properly installed, operation of the actuator is accomplished by providing actuator movement data packets via the communications port that conform to the 2G Packet Protocol for Actuator Control (see the Communications Protocol document # 2150080). Control of the actuator and limits of its operation are detailed in the specifications section.

2 WIRING

This section describes how to electrically connect the actuator.

2.1 INTERFACE CONFIGURATION

Electrical connection and configuration:

Pinouts for your unit will list + VIN and GND pins. These are the positive and negative power inputs respectively. If your unit does not have an isolated communications port, the communications ground is shared with the power ground (typical on 2000 series units).

If the unit has 2 or more pairs of power pins, all must be connected.

CAUTION	**MAXIMUM VOLTAGE INPUT** Do not exceed the maximum rated voltage of the device! Motor back EMF, power supply ripple, and power line ringing and overvoltage must be taken into account when selecting a power supply to power the actuator. **Failure to follow these instructions may result in damage to system components!**

All actuators have an operating voltage range specified on their datasheet. The source of power for the units can be a device such as a battery or a power supply. The power source's output voltage must be able to sustain the current requirements of the actuator without dropping below the actuator's operational voltage range.

A fuse should be installed in line with the actuator. Typically this is done at the power source.

CAUTION	**HOT PLUGGING!** Do not connect or disconnect while the device is in a powered state. **Failure to follow these instructions may result in damage to system components!**

Depending on the model, there can be up to 1000µF of onboard capacitance that is connected at power on. Care must be taken with the power switch on system to avoid line ringing and it's associated over voltage spikes.

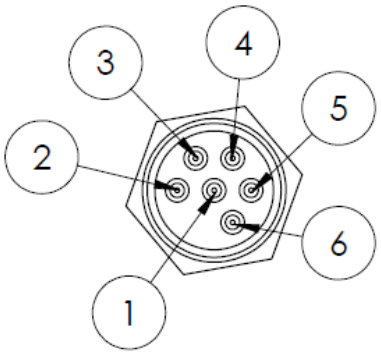
2.1.1 Pinouts

Depending on the model, there can be multiple pinout configurations. Please refer to your unit's specification sheet or model number for exact wiring.

The typical wiring options are listed below:

6-pin male MCBH "Micro Wet Pluggable" type. Three wiring options are available:

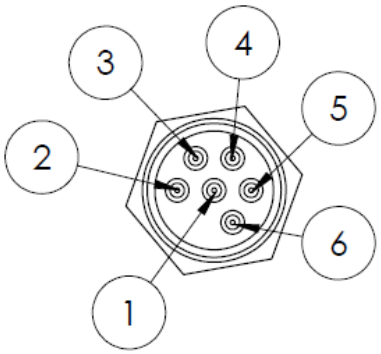
1. Dual "RS-485" and "RS-232" (Most Common)



Male Plug Face View

Pin Assignments:	
Pin #1	RS-232 TX (Out to Host)
Pin #2	RS-232 RX (In from Host)
Pin #3	RS-485 B
Pin #4	+Vin
Pin #5	GND
Pin #6	RS-485 A

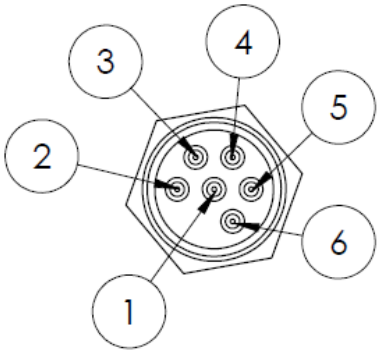
2. "Isolated RS-232" Option:



Male Plug Face View

Pin Assignments:	
Pin #1	RS-232 TX (Out to Host)
Pin #2	RS-232 RX (In from Host)
Pin #3	RS-232 RTN
Pin #4	+Vin
Pin #5	GND
Pin #6	No Connect

3. Analog Option:



Male Plug Face View

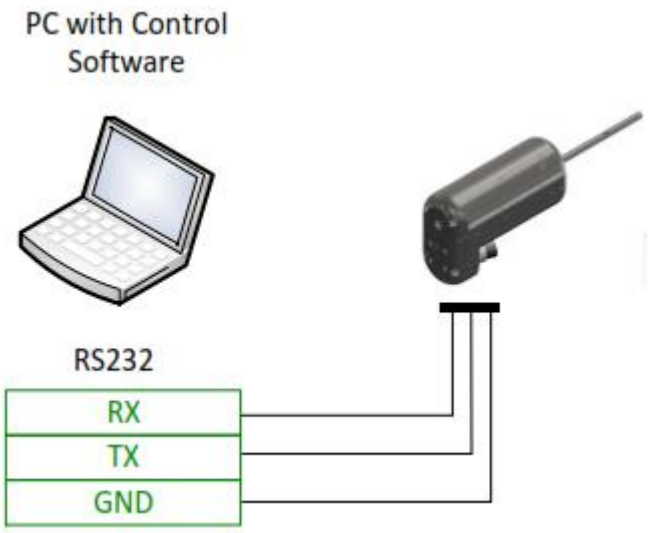
Pin Assignments:	
Pin #1	RS-232 TX (Out to Host)
Pin #2	RS-232 RX (In from Host)
Pin #3	Analog Position Feedback
Pin #4	+Vin
Pin #5	PWR GND
Pin #6	Analog Input / State Input

3 COMMUNICATION

3.1 SERIAL PORT

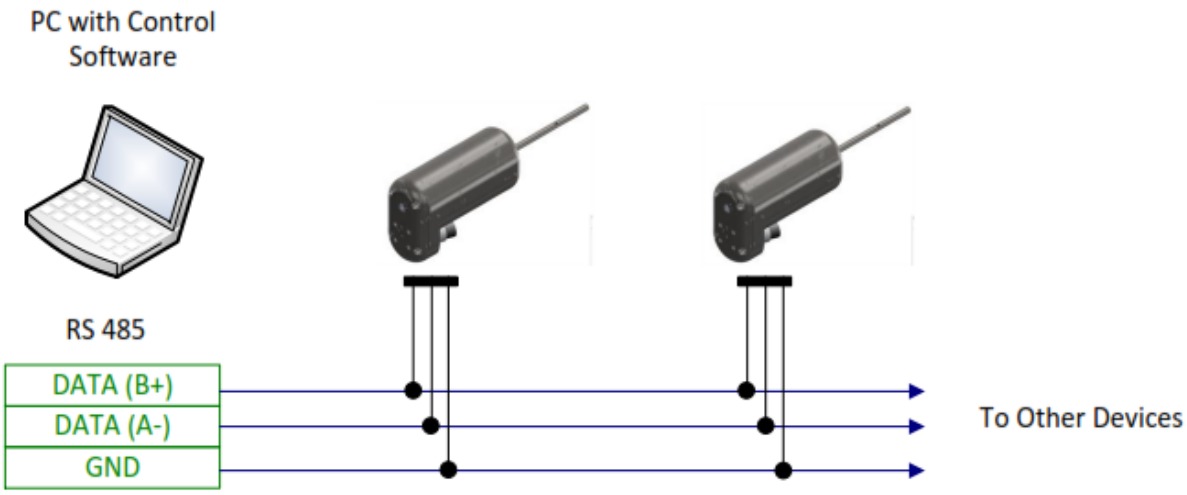
A serial port is typically used to control the actuator. The communications port is used to transfer data packets. The specific format is described in the Communications Protocol document (document # 2150080). Please consult 2G Engineering if a copy is not included with this document for the latest version.

RS-232 Wiring Configuration Example



RS-485 Wiring Configuration Example

(Commonly used with the addressed packet modes)



3.2 ANALOG CONTROL

If the unit is equipped with the analog control options, the RS-232 serial port is avalible for general configeration, but once the unit is configured as desired, an analog 0-5V input may be used to manipulate the unit. Please contact 2G Engineering for additional information about the usage of this option. Units with the Analog control option also produce a proportional 0-5 Signal relative to their absolute angle or linear position.

4 SOFTWARE FEATURES

All units can report back their operational status and move via motion control commands. They also have BIT's (built in self-tests) that are constantly run and their status can be checked for system faults.

All actuators monitor and report their operating voltage, current usage, and temperature in real time. Using a system status packet, this information can be read back.

Two current limits are provided for system protection:

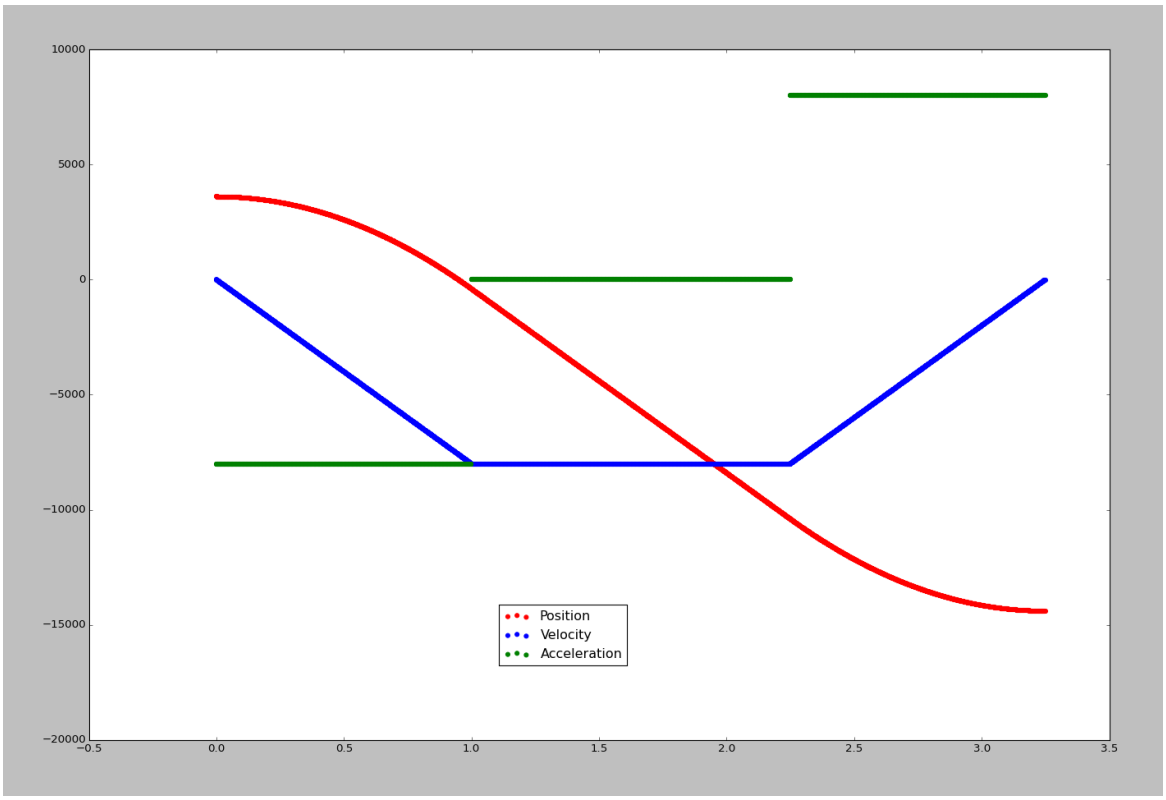
- Board current limit – When this limit is reached the unit will "throttle back" its output.

- Motor current limit – This is a rudimentary torque/force control limit. This control provides approximately +/- 30% control of torque output independent of system voltage.

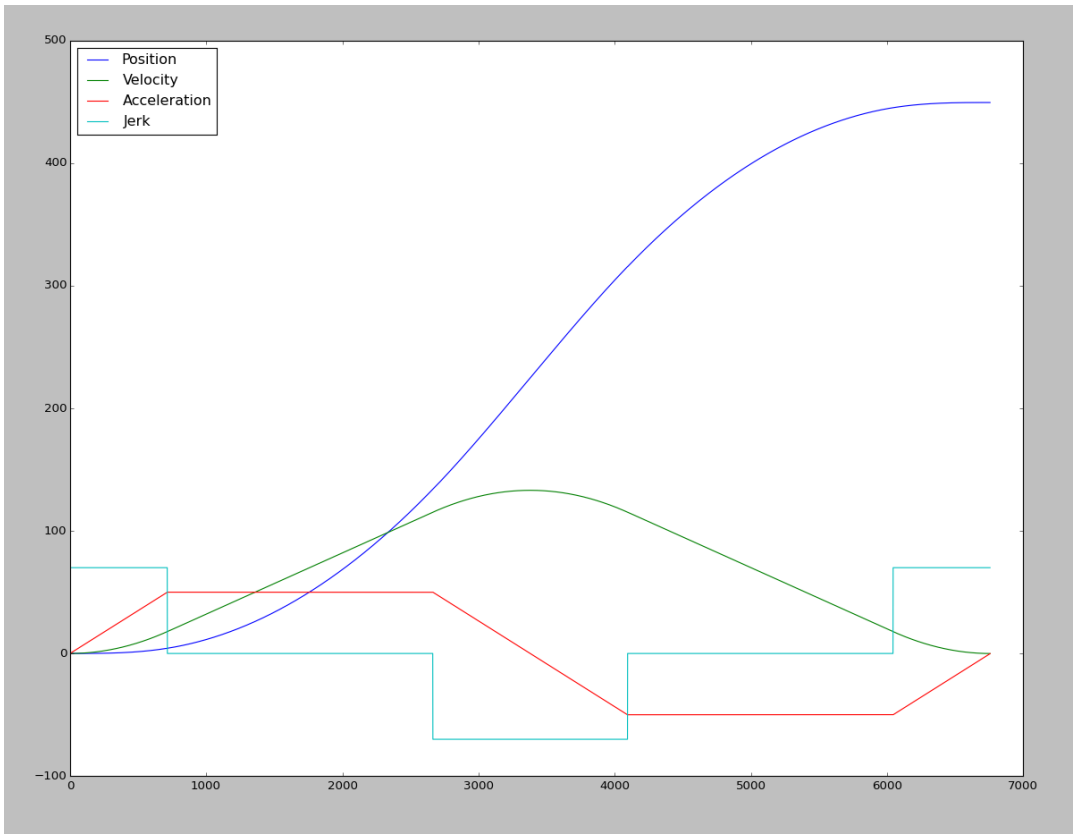
4.1 MOVEMENT COMMANDS

All actuators have the ability to perform passive, simple, and complex movement commands.

- The passive movement command is the “Duty Cycle” command:
  - Think of this command as a volume knob. It bypasses many of the internal states that are used for bounded motion (such as end stops) and should only be used as a basic system evaluation command. It is very useful as a troubleshooting tool, but is not intended to be used for a production system.
- Simple commands are “Move to Position” or “Move to Position at a fixed Velocity”:
  - These commands make use of the system’s two cascaded (position and velocity) PID control loops system for movement. See Sections 5 and 6 below on PID tuning for additional information.
  - When the commands complete, the unit has the following options:
    - Continue to track the set point
    - Turn off the motor and coast
    - Turn off the motor and engage the brake (Electrical or Mechanical)
- Complex movement commands include:
  - Trapezoidal moves to a fixed velocity or a fixed position.
    - In a trapezoidal move, a constant acceleration limit is in effect. This prevents step changes in velocity from occurring. Because of this, the change in position occurs in a smooth and controlled manner, reducing wear on the actuator as well as any mechanical systems driven by the actuator. For a position control profile, the profile contains three steps: acceleration, cruising, and deceleration. The cruising step is omitted for short movements. For a velocity control profile, the change in velocity occurs in a single constant-acceleration step. This type of profile is also known as a second-order profile.



- S-Curve moves to a fixed position. (Implementation currently incomplete).
  - In an s-curve move, a constant jerk limit is in effect. This prevents step changes in both velocity and acceleration. The change in position occurs even more smoothly than in a trapezoidal profile. An s-curve move will almost always take longer than the equivalent trapezoidal move. The reduction in jerk can further reduce mechanical wear in some systems, and is useful in systems where sudden changes in acceleration are undesirable (e.g. transport of liquids in containers). An s-curve profile typically contains 7 steps. Several of these steps may be automatically removed based on the specified velocity, acceleration, and jerk limits. This type of profile is also known as a third-order profile.



- Complex movement commands can be updated in real-time. The actuator will automatically blend the new motion profile into the currently running profile. This works for both position and velocity commands, both as the start and end conditions of a motion profile.
- The movement mode can be set independently for both position and velocity commands.
- The acceleration and jerk limits can be set separately for both position and velocity commands.
- To use complex movement modes, use the Motion Profile Config packet to set the position and/or velocity profile mode. Once this is set, you can use the standard “Setpoint Absolute” and “Setpoint Velocity” packets to trigger a complex movement profile.

4.2 BASIC SETTINGS

Other settings that are configurable as needed:

- Motor current limit:

  This value specified in mA in the packet parser system is directly related to the system's output torque or force. It can be set higher than the board current limit and only has an indirect relationship with it.

- Board current limit:

  This value specified in mA in the packet parser system is directly related to the system's input current. If the servo system detects that the system is using more than the set amount of current it will throttle back to a preset limit (typically 75% of current output) and slows creep back up to this limit. This is a simple hysteretic control on the system's maximum output power. This number correlates directly to peak power output, Power = Speed x Force.

- PID control values:

  Please see the section below on PID setup and controls.

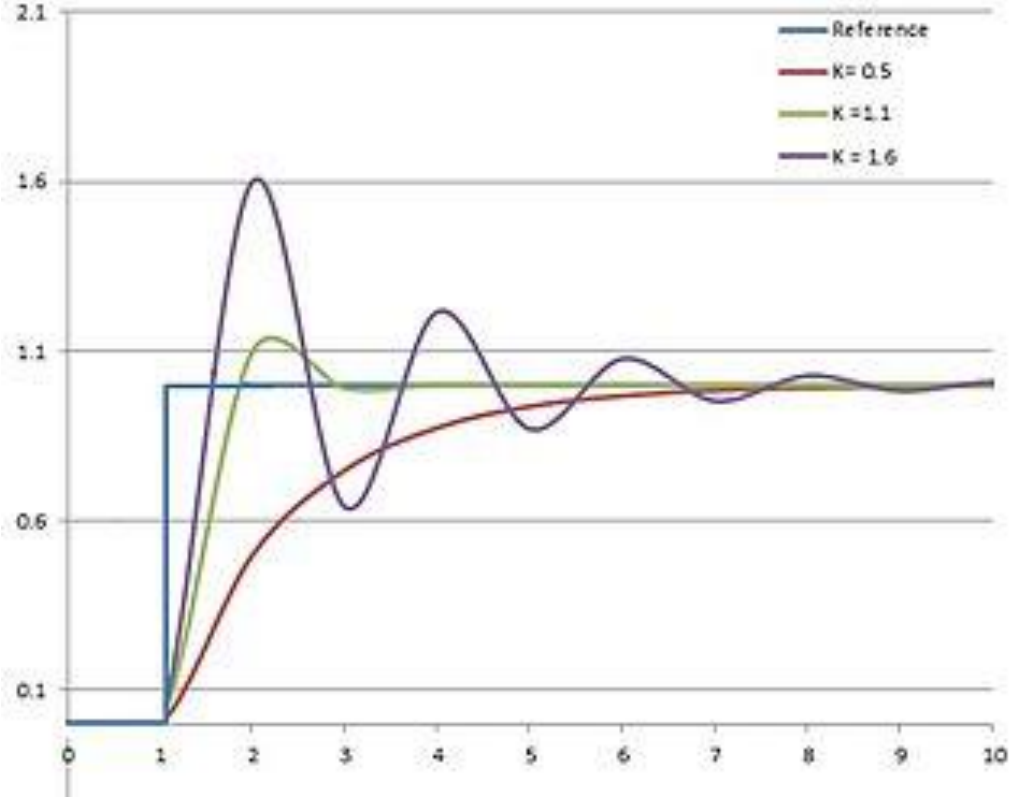
5 PID CONTROL PRIMER

The onboard servo system has two PID control loops that are used for velocity control and position control. Understanding the mechanics by which PID controls function is out of the scope of this document and there are several good references to this online. Just a short summary is given here as paraphrased from Wikipedia (https://en.wikipedia.org/wiki/PID_controller).

All units ship with a factory default set of values for the PID velocity and position parameters. They can be restored at any time by sending a “load defaults” command followed by a “Save to EEPROM” command. The “Save to EEPROM” makes the values persist between power cycles. All adjustments should be made in small steps starting from known good values.

The gains for velocity and position can be tested for stability independently by issuing velocity commands and position commands respectively.

5.1 PROPORTIONAL TERM

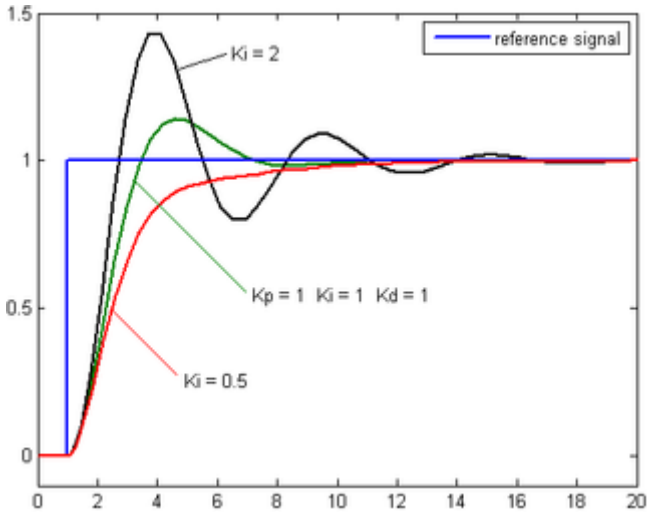


Above is a plot of the set point desired vs actual over time for three values of P gain. When adjusting the P gain one would typically set both the I gain and the D gain to 0.

The proportional term produces an output value that is proportional to the current error value. The proportional response can be adjusted by multiplying the error by a constant *K*, called the proportional gain constant.

A high proportional gain results in a large change in the output for a given change in the error. If the proportional gain is too high, the system can become unstable. In contrast, a small gain results in a small output response to a large input error and a less responsive or less sensitive controller. If the proportional gain is too low, the control action may be too small when responding to system disturbances.

5.2 INTEGRAL TERM

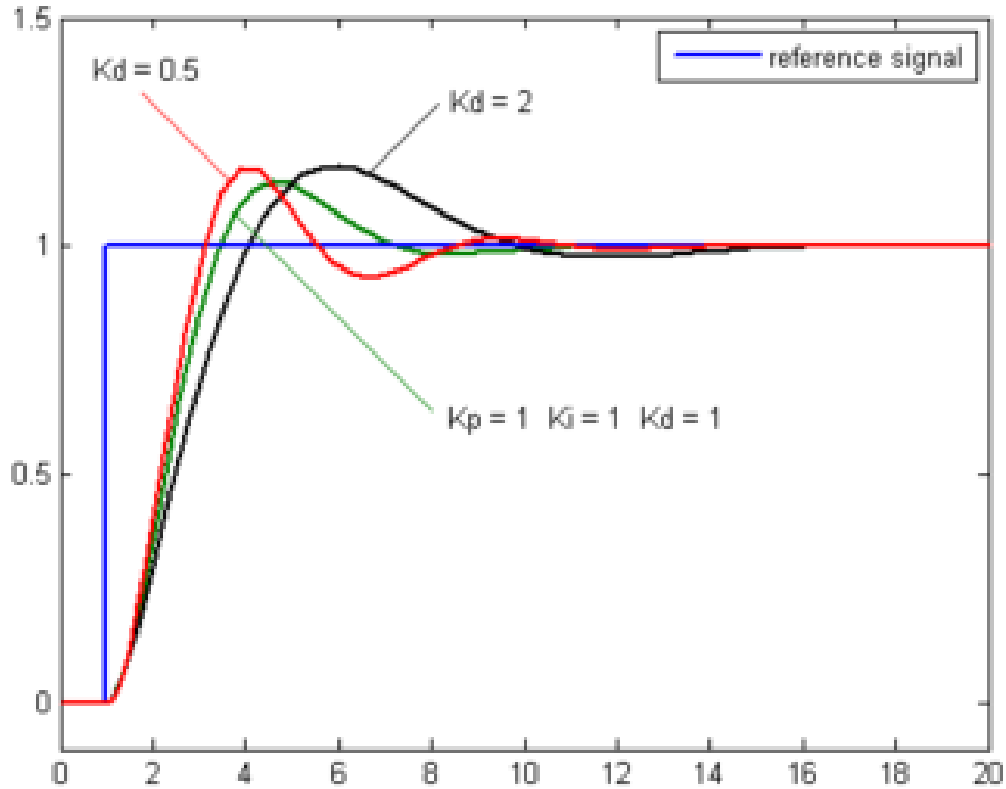


Above is a plot of the set point desired vs actual over time for three values of I gain. When adjusting the I gain one would typically leave the P gain constant and have the D gain set to 0.

The contribution from the integral term is proportional to both the magnitude of the error and the duration of the error. The integral in a PID controller is the sum of the instantaneous error over time and gives the accumulated offset that should have been corrected previously. The accumulated error is then multiplied by the integral gain and added to the controller output.

The integral term accelerates the movement of the process towards set point and eliminates the residual steady-state error that occurs with a pure proportional controller. However, since the integral term responds to accumulated errors from the past, it can cause the present value to overshoot the set point value.

5.3 DERIVATIVE TERM



Above is a plot of the set point desired vs actual over time for three values of D gain. When adjusting the D gain one would typically leave the P and I gain constant.

The derivative of the process error is calculated by determining the slope of the error over time and multiplying this rate of change by the derivative gain. The magnitude of the contribution of the derivative term to the overall control action is termed the derivative gain.

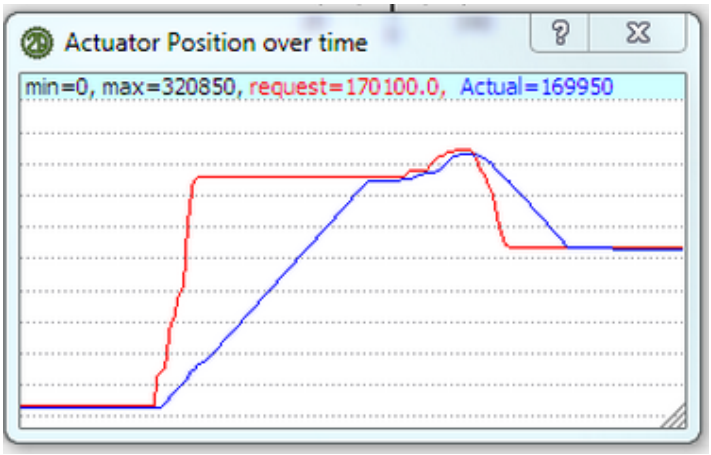
Derivative action predicts system behavior and thus improves settling time and stability of the system.

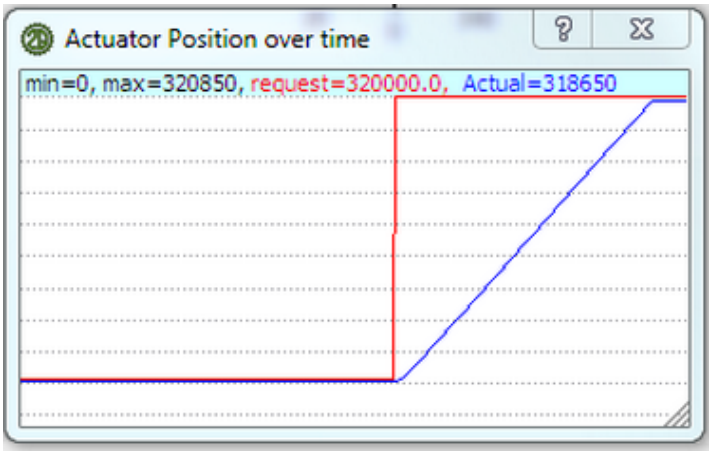
6 ACTUATOR TUNING

6.1 TOOLS

The 2G Actuator Control GUI's graph display and data logging features will help the user to verify the proper operation of the servo control system. Please contact 2G Engineering for a copy of the Windows application that will allow tuning and configuration of the unit's internal PID gains. The current version will be available on the 2G website.

The application has the ability to log and export all the data from the actuator. It also has the ability to display time domain graphs of all parameters to check the operation of tracking of the unit's actual position vs designed position in real time.





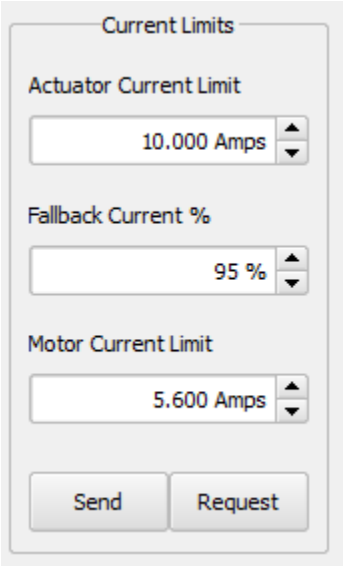
6.2 IMPORTANT TUNING PARAMETERS

6.2.1 Actuator Current Limit

(Note that the factory default settings can be restored by sending a "Load Defaults" command.)

There are 2 parameters related to actuator current:

- Actuator Current limit
  - Used to keep the total current used by the actuator under the customer's wiring or power supply limitations.
  - Also used to limit the amount of work an actuator can do. As the limit directly relates to the system's input power at a given voltage, it will limit the amount of mechanical output power the unit generates.
- Fallback Current %
  - When the system current limit is reached (checked at ~1000Hz), the output of the motor is reduced to the percentage set.
  - After this limit is hit, the unit will ramp back up to the maximum output at a fixed rate. This forms a basic control loop keeping the unit's output power and input current within the desired safe operating parameters of the customer's system.



6.2.2 Motor Current Limit

The motor current setting directly controls the unit's output force or torque. This parameter adjusts the maximum current that is built up in the actuator's motor stator winding. Stator winding current is, for the purposes of this discussion, linearly related to motor torque.

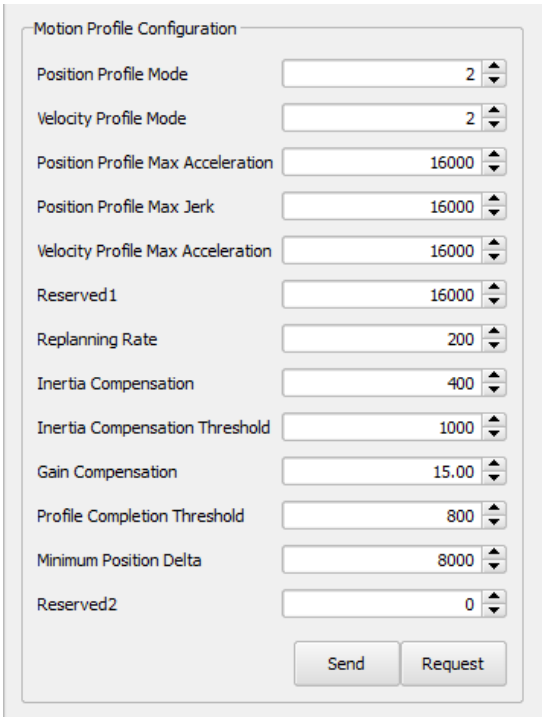
This parameter is independent of actuator operating voltage or speed; the output force will be the same. At higher rates of speed, to maintain a given force, the parameter may have to be increased because the windage losses of the system may also increase.

6.2.3 Motion Profiler

The motion profiler system allows for controlling the acceleration and deceleration of the actuator. With the motion profiler disabled, when a new setpoint is provided, the actuator's PID control system will immediately attempt to seek it. This may result in large acceleration of the actuator output shaft. When the motion profiler is turned

on, the actuator will ramp the velocity of the output shaft up and down in a controlled manner in order to reach the desired setpoint. The acceleration is constrained to a user-defined limit. This can reduce stress and wear in applications that are acceleration-sensitive. For applications in which positioning speed is critical, it is recommended that the motion profiler be disabled. An unprofiled move will always reach the position target faster than a profiled one, in some cases significantly so.

There are a number of tunable parameters related to motion profiling:



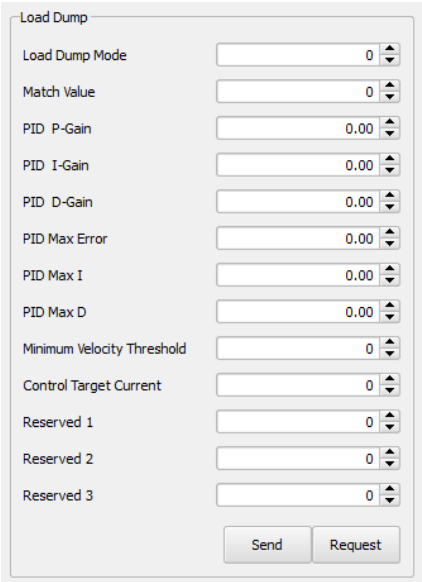
- Position Profile Mode
  - Controls if the motion profiler is enabled for position-to-position or velocity-to-position moves. A value of 0 disables the motion profiler, and a value of 2 enables the profiler in trapezoidal (constant acceleration) mode.
- Velocity Profile Mode
  - Controls if the motion profiler is enabled for velocity-to-velocity or position-to-velocity moves. A value of 0 disables the motion profiler, and a value of 2 enables the profiler in trapezoidal (constant acceleration) mode.
- Position Profile Max Acceleration
  - Sets the maximum acceleration for the position profiler. For rotary actuators, this is in units of milli-RPM per second. For linear actuators, this is in units of milli-inches per minute per second.
- Position Profile Max Jerk
  - This function is not currently implemented.
- Velocity Profile Max Acceleration
  - Sets the maximum acceleration for the velocity profiler. For rotary actuators, this is in units of milli-RPM per second. For linear actuators, this is in units of milli-inches per minute per second.
- Reserved 1
  - This function is not currently implemented.
- Replanning Rate
  - The actuator periodically re-plans the optimal motion profile to reach the target position or velocity given its current state. This field controls

how often (in milliseconds) this re-planning occurs. For applications with rapidly-changing or non-constant loads, performance may be improved by reducing this value. It is recommended that this field is set to a value ≥ 10.

- Inertia Compensation
  - This field allows adding a time offset (in milliseconds) to the internal profile time calculations. This can be used to correct for the physical response time of the system the actuator is installed in. Large values here may result in poor performance and instability.
- Inertia Compensation Threshold
  - Near the end of a profile, the inertia compensation is automatically disabled, ensuring that the profile ends at the desired position. This field specifies the time remaining in the profile (in milliseconds) at which the inertia compensation is disabled.
- Gain Compensation
  - In order to allow the PID system to accurately track the desired profile, the position P-gain is temporarily boosted while a position profile is active. This field specifies the gain multiplier that is used. Setting a value here that is too large will result in control loop instability.
- Profile Completion Threshold
  - When using the position profiler, the profiler will hand off control of the actuator position near the end of the profile to the standard PID control loop to allow tracking the setpoint. This field specifies the time remaining in the profile (in milliseconds) at which this occurs. Large values in this field will reduce the motion profiler's ability to limit actuator acceleration. Values in this field that are too small may prevent the actuator from reaching its target position.
- Minimum Position Delta
  - For small changes in position setpoint, it is typically more efficient to use the PID control loop directly rather than the motion profiler. This field specifies the minimum requested change in position (milli-degrees for rotary actuators, milli-inches for linear actuators) required before the motion profiler will be active. If the requested change in position is less than this value, the PID control loop will be used directly instead of through the motion profiler. Set to 0 to disable this function, but note that commands intended to produce small changes in position may perform poorly.
- Reserved 2
  - This function is not currently implemented.

6.2.4 Load Dump (If Equipped)

When an actuator is driven in the same direction as an applied mechanical load, the actuator will function as a generator and will produce electric power. Depending on the characteristics of the supply powering the actuator, this may result in a negative current flow out of the actuator and/or an increase in voltage on the actuator supply lines. Because this behavior may be undesirable, some actuators are equipped with an internal resistive load bank to dissipate excess power generated in this fashion. The load bank is equipped with a PID load control system which will adjust the power dissipated to maintain a target current into the actuator. There are a number of settings which can be adjusted in order to control the load dump system:



- Load Dump Mode
  - Selects the mode of operation for the load dump. If set to 0, the load dump is completely disabled. If set to 1, the load dump is set to manual mode and the amount of power dissipated is proportional to the value set in the match value field. Operation in manual mode is recommended for testing purposes only, and extended operation at high power may damage the internal load bank. If set to 2, the internal current PID control loop will adjust the power into the load bank to maintain a certain amount of current according the following settings.
- Match Value
  - Sets the amount of power the load bank will dissipate. 0 indicates full power, and the maximum value indicates no power. The maximum value of this field may vary depending on actuator and firmware version, but it can be determined by setting the Load Dump Mode to 0 and reading the match value.
- PID P-Gain
  - Specifies the proportional gain for the load dump current control loop.
- PID I-Gain
  - Specifies the integral gain for the load dump current control loop.
- PID D-Gain

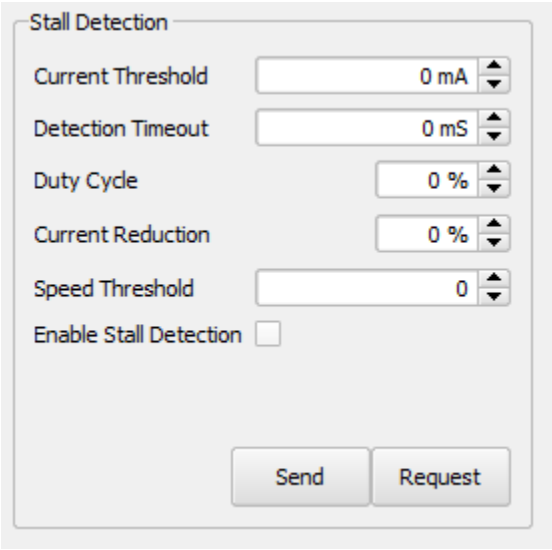
  - Specifies the derivative gain for the load dump current control loop.
- PID Max Error
  - Specifies the scaling factor for the load dump current control loop.
- PID Max I
  - Specifies the maximum amount of error that can be accumulated under the integral term for the load dump current control loop.
- PID Max D
  - Specifies the maximum error contribution of the derivative term for the load dump current control loop.
- Minimum Velocity Threshold
  - Specifies the minimum velocity required for the load dump to engage. Below this velocity (in either direction), the load dump will be disabled. For rotary actuators, this is in milli-RPM. For linear actuators, this is in milli-inches per minute.
- Control Target Current
  - Sets the amount of current (in mA) that the load dump system will attempt to draw in automatic mode. This should be set to a value approximately equal to the amount of power that the actuator would typically generate while driven under load, plus a small margin to account for current spikes. A typical value for a 3500 series rotary actuator might be around 1500 mA.
- Reserved 1 (Load Dump Load Direction)
  - Sets the active direction of the load dump. Set to 0 to allow the load dump to operate the load dump when the actuator is moving in both the forward and reverse directions. Set to 1 to only enable the load dump when moving in the forward direction. Set to 2 to only enable the load dump when moving in the reverse direction. This is useful for applications such as moving a load against gravity, where the load will be with the actuator's direction of travel in one direction, and against it in the other direction.

6.2.5 Stall Detection

If the actuator is installed in a system which mechanically constrains the range of motion of the actuator and the unit stalls against one of these constraints, it may become damaged due to high static motor winding currents. The best way to prevent damage is to ensure that the actuator is not stalled during normal operation. However, in the event that the actuator does become stalled, the stall detection feature can significantly reduce the chance of damage to the actuator occurring. The feature works by periodically reducing the actuator's motor current limit when a combination of current and velocity threshold conditions are met. This will continue

until the actuator has started moving again or the motor is turned off. Note that this is a safety feature only and it is never recommended to stall the actuator as part of operation in a customer's system. The stall detection feature can be configured using the following options:

- Current Threshold
  - Specifies the value of actuator current above which a stall may be detected. This should be set high enough that the stall detection will not trip while the motor is starting.
- Detection Timeout
  - Specifies the amount of time that the current and speed conditions must be met for a stall to be detected. Also sets the frequency at which the actuator's motor current limit will be cycled after a stall has been detected.



- Duty Cycle
  - Specifies the percentage of time the actuator will spend in the high motor current limit state once a stall has been detected. The balance of the time will be spent in the reduced motor current limit state.
- Current Reduction
  - Specifies the percentage by which the motor current limit will be reduced once a stall has been detected.
- Speed Threshold
  - Specifies the maximum speed at which the system may detect a stall. This distinguishes a stall condition from a normal high-load operating condition. This should be set to a fairly low value. For rotary actuators, this is in milli-RPM. For linear actuators, this is in milli-inches per minute.
- Enable Stall Detection
  - Controls whether or not the stall detection system is enabled. When it is disabled, the system will never attempt to detect stall conditions.

7 APPLICATION INSTALLATION

7.1 INITIAL SET-UP

Initial testing of the actuator should be performed on a test bench. With the actuator on a test bench, ensure movement of the actuator is not impeded. Ensure wires connecting to the actuator have a clear path leading up to the actuator and avoid crossing over the shaft and their moving and mounting components.

The actuator unit does not require calibration before use. It is fully assembled and calibrated from production.

CAUTION	Always make sure power is off before attempting to work on or near the actuator and its electrical controls.
WARNING	The actuator is factory lubricated for life. No disassembly is ever required for routine maintenance. The actuator is a non-serviceable device by anyone other than 2G Engineering. **Attempts at opening or tampering with components internal to the device may damage system components and will void all warranties on the device.**

7.2 CONFIGURATION OF UNIT ADDDRES

When the unit is used with addressed packet commands (Typical over RS-485) you will have to first set the address of each unit to be connected on the same bus. The application “Actuator Universal” from 2G can help with this. You can also set the address using the standard 2G packet “Y” command.

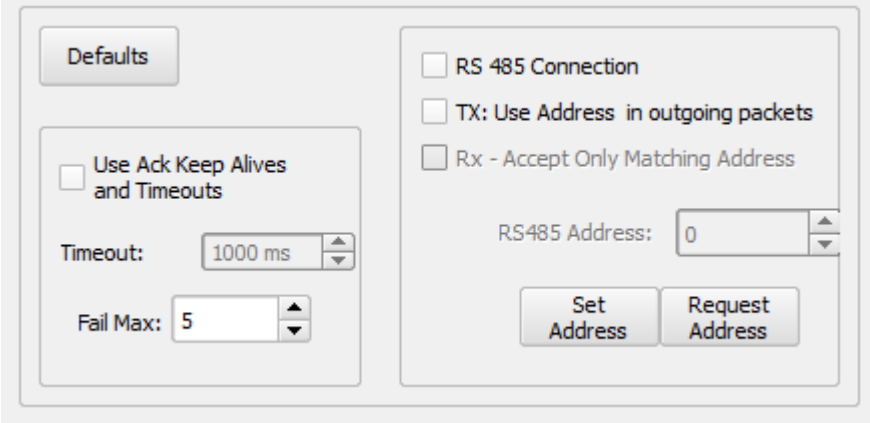
After a new address is sent to the unit a save to EEPROM command will have to be issues to make the update persistent across power cycles.

From the 2G packet protocol document section 4:

Units will only respond to addressed packets (with "[“/”]" delimiters and unit address field) with a matching address or broadcast address (0). Units responding to broadcast packets will respond with their own address in the return packet.

*Note: To avoid packet collisions, broadcast addressing shall only be used on busses with one actuator present (point-to-point topology). If multiple units are on a bus (multi-drop topology), actuator units must be individually addressed.

When using the Actuator Universal software package from 2G. If you select to use addressed packets under the advanced communications section, you can talk with specific units on the RS-485 bus.



Or send commands to receive the address of a single unit on the bus or set the address of the unit.

Make sure issue a save to EEPROM command after setting a new address if it is to be persistent.

8 SYSTEM USAGE

8.1 INSTRUCTIONS

The actuator should be operated within its ratings for load, duty cycle, and temperature. If power is lost or removed, the actuator shaft is free moving.

⚠ **WARNING**	**Be aware of loading on actuator at all times!** The actuator is capable of holding large forces in place. Sudden loss of power may cause injury due to a free moving actuator. The load may collapse with the free moving actuator. **Failure to follow these instructions may result in death or injury!**

8.2 POWER ON THE ACTUATOR:

1. Apply power to the actuator
   - Actuator will not respond until power is provided
   - An unpowered actuator will be free moving
2. Send “start motor” via packet through the communications port
3. Send set point data via packet through the communications port to command the actuator
   - Actuator will be free moving until set point is provided to the controller
   - Actuator will maintain current position and velocity after a set point is provided until “stop motor” command is sent
   - Refer to the Communications Protocol document (document # 2150080) for a complete listing of commands

8.3 NORMAL OPERATION:

- Control actuator by sending set point data via packet through the RS-232 port
- Refer to the Communications Protocol document (document # 2150080) for a complete listing of commands

8.4 POWER OFF THE ACTUATOR:

- Turn off power supply to the actuator
- Actuator will be free moving when power is removed from actuator and it does not have an internal failsafe brake

8.5 FREE MOVEMENT INFORMATION:

- Typical internal friction is 10% of the unit's maximum output force.
- Once internal friction is surpassed the unit will begin to move.
- If your model has an internal clutch brake system the unit will not free move unless it is commanded to release the brake.

8.6 CONVENTIONS AND ERROR MESSAGES

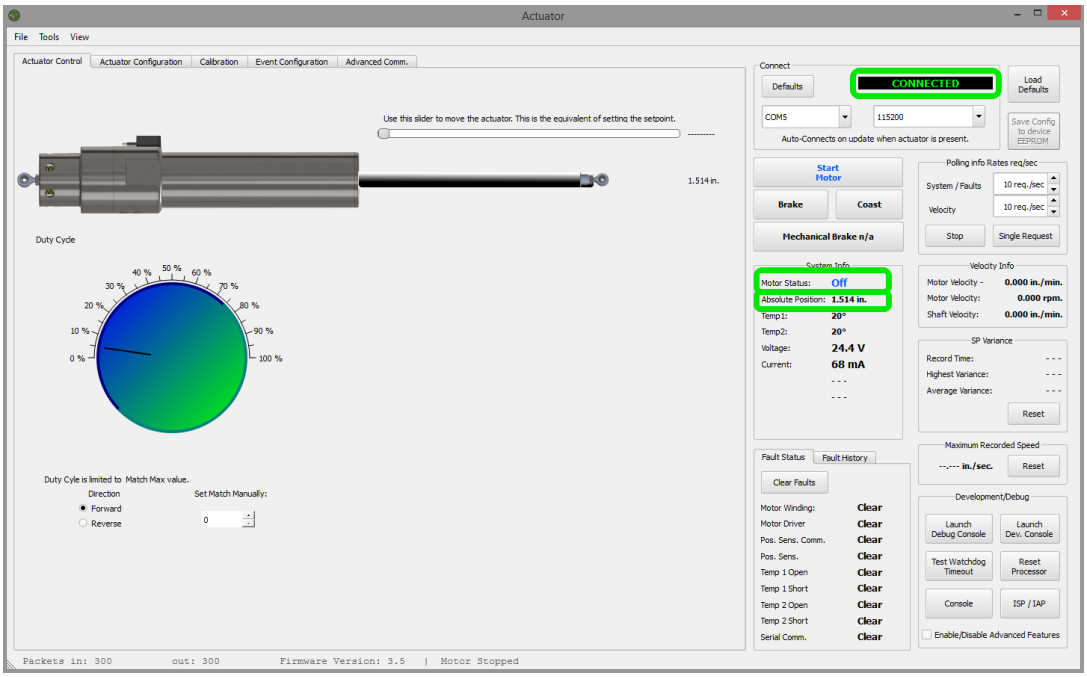
The actuator contains firmware which includes fault detection and error message generation. Typical failure modes, messages, and possible resolutions are provided in the table below.

Mechanical Faults:	
Leaking oil	Contact 2G Engineering
Mechanical Faults in Submerged Observations:	
Bubbles	Contact 2G Engineering
Droplets	Contact 2G Engineering
Controllers constantly running Built In Tests 'BIT' Observations:	
Motor Driver Fault	Under voltage Over temperature Logic Fault
Temperature Fault	Sensor1: High > 68ºC, Low < -33ºC Sensor2: High > 68ºC, Low < -33ºC
Position Sensor Communications Fault	Invalid data reported from onboard position sensor
Communication Fault	CRC failures caused by one or more of the following: • Cross talk with power • Excessive cable length • Intermittent connection • Corrosion at input terminals • Serial grounding issue • Mismatched baud

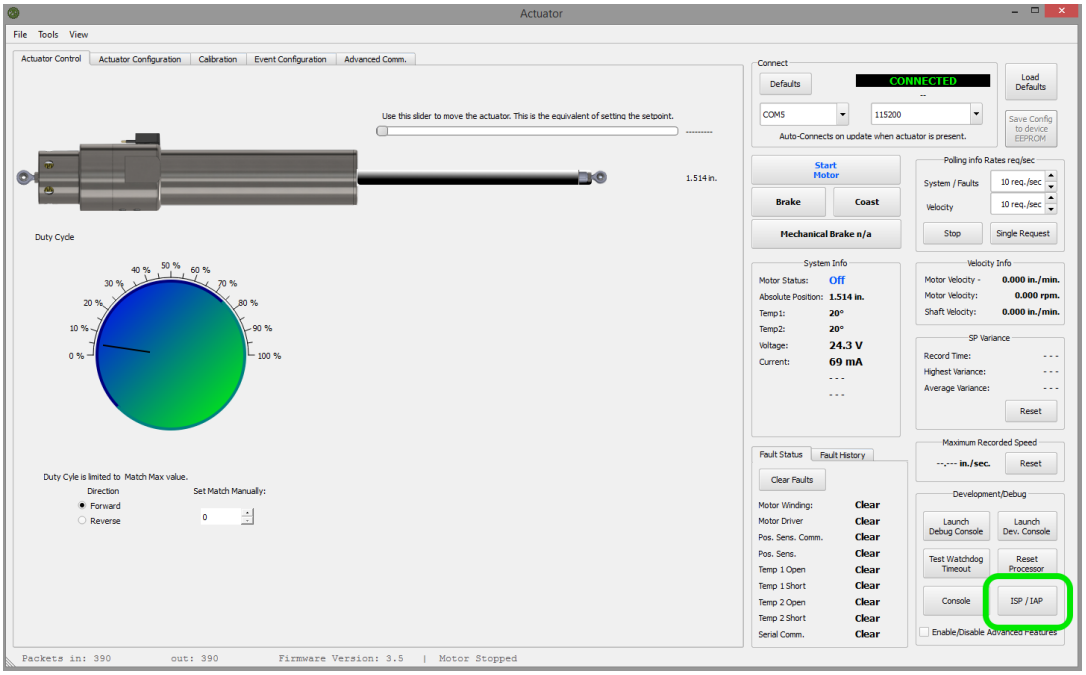
Controller faults are covered in the Communications Protocol document (Document # 2150080).

8.7 UPDATING ACTUATOR FIRMWARE

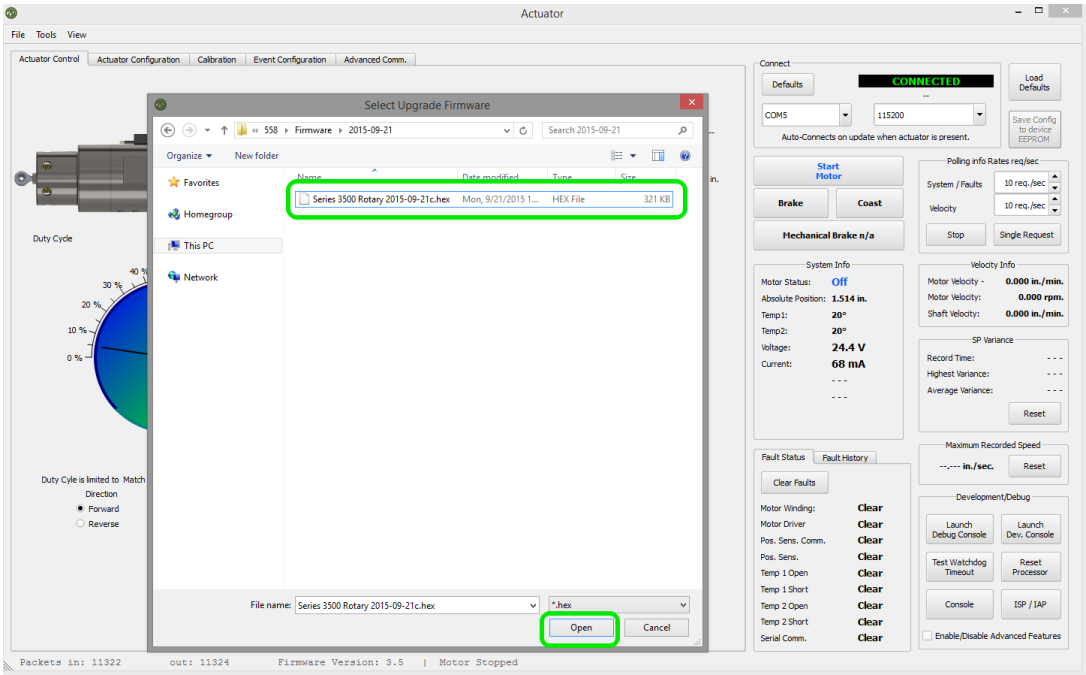
1. Launch the actuator control software. Verify that the actuator is connected, the motor is stopped, and there is no mechanical load on the actuator. (Motor Status should read “Off”). Record the absolute position of the actuator.



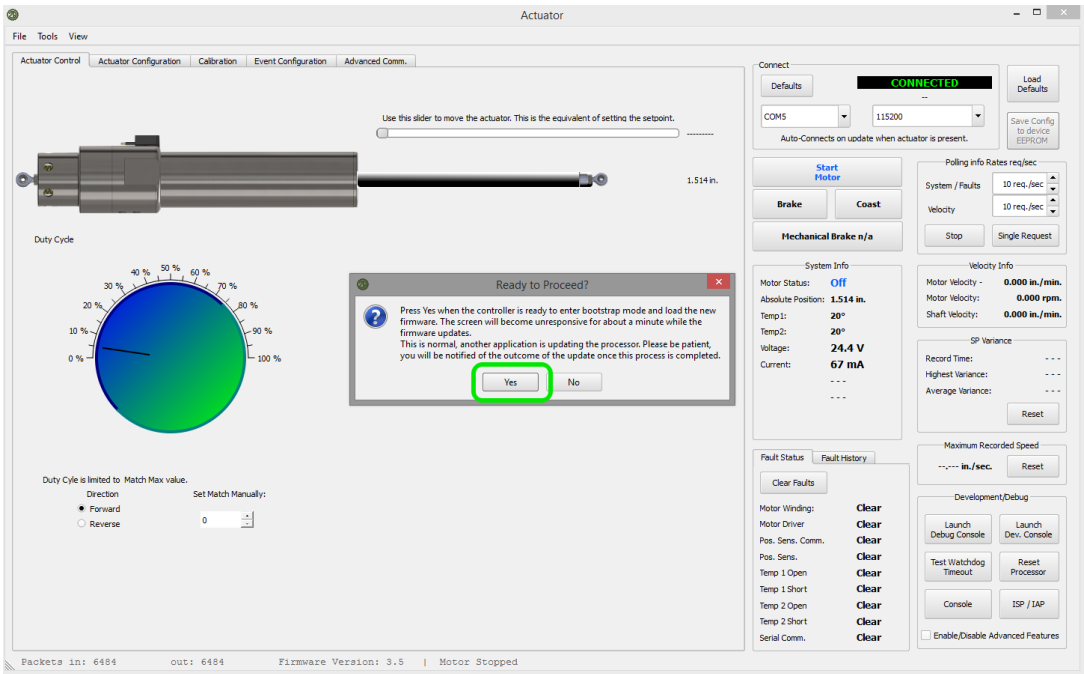
2. In the lower right-hand corner of the actuator window, click on the “ISP/IAP” button.



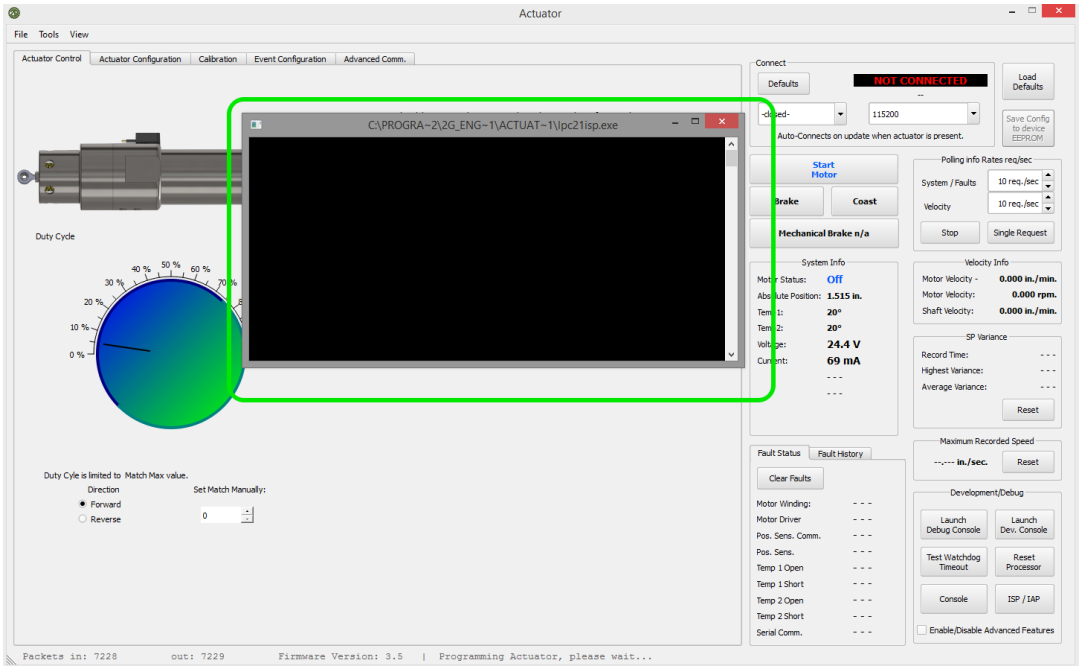
3. Navigate to the firmware hex file, select it, and click “Open”.



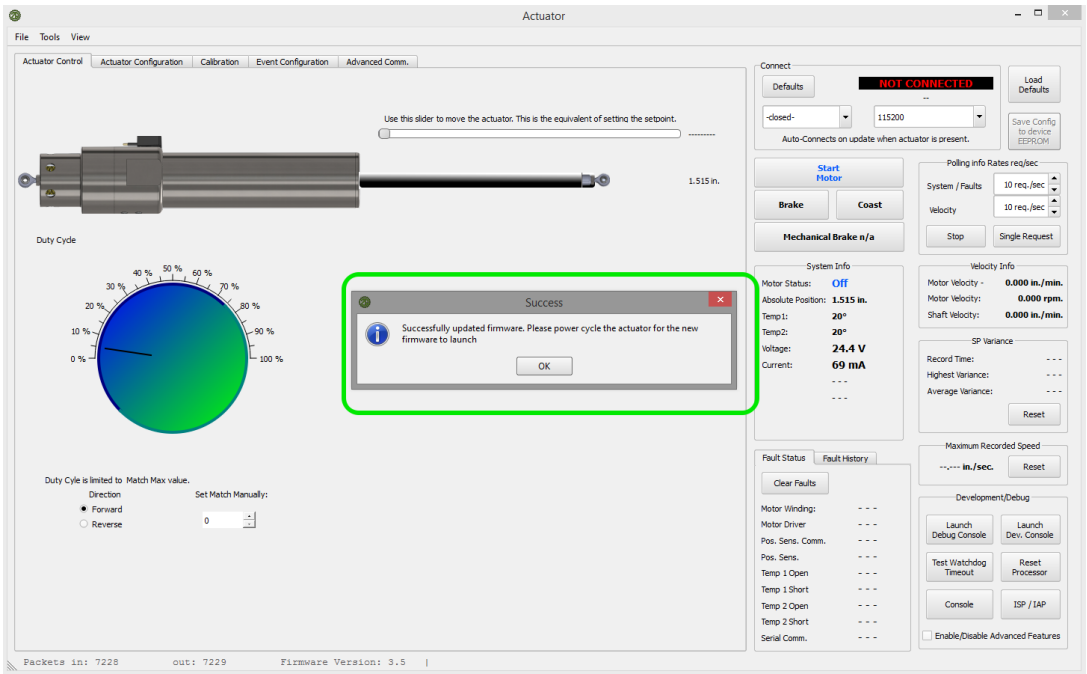
4. At the “Ready to Proceed?” prompt, click the “Yes” button.



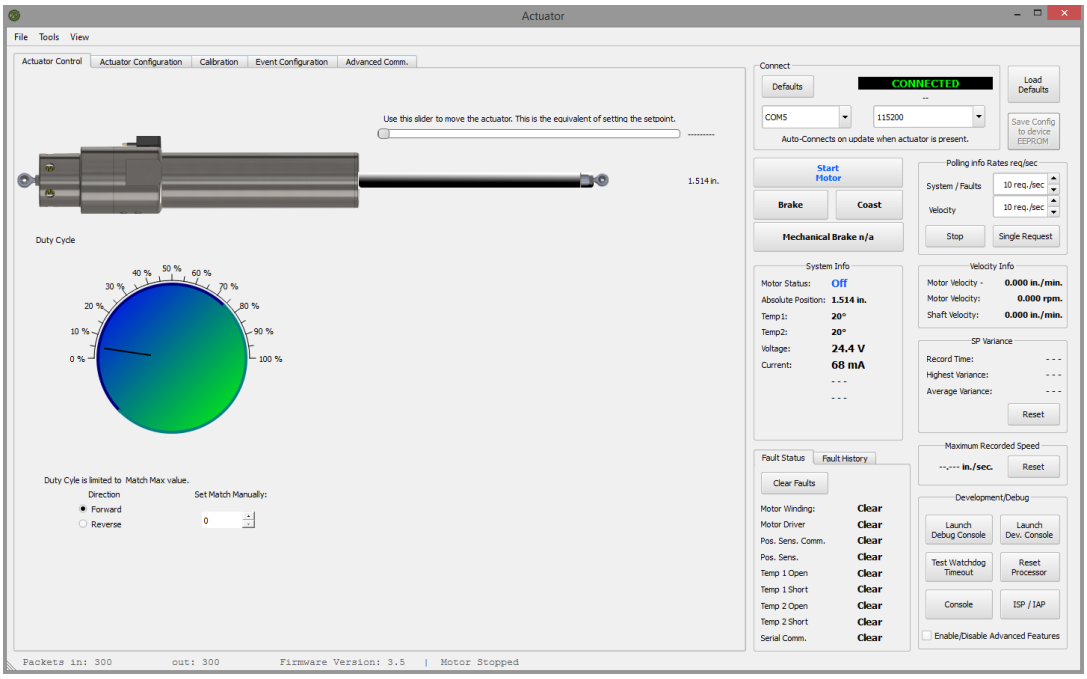
5. After several seconds, a black command prompt window will appear. This is normal and indicates that the firmware update is in progress.



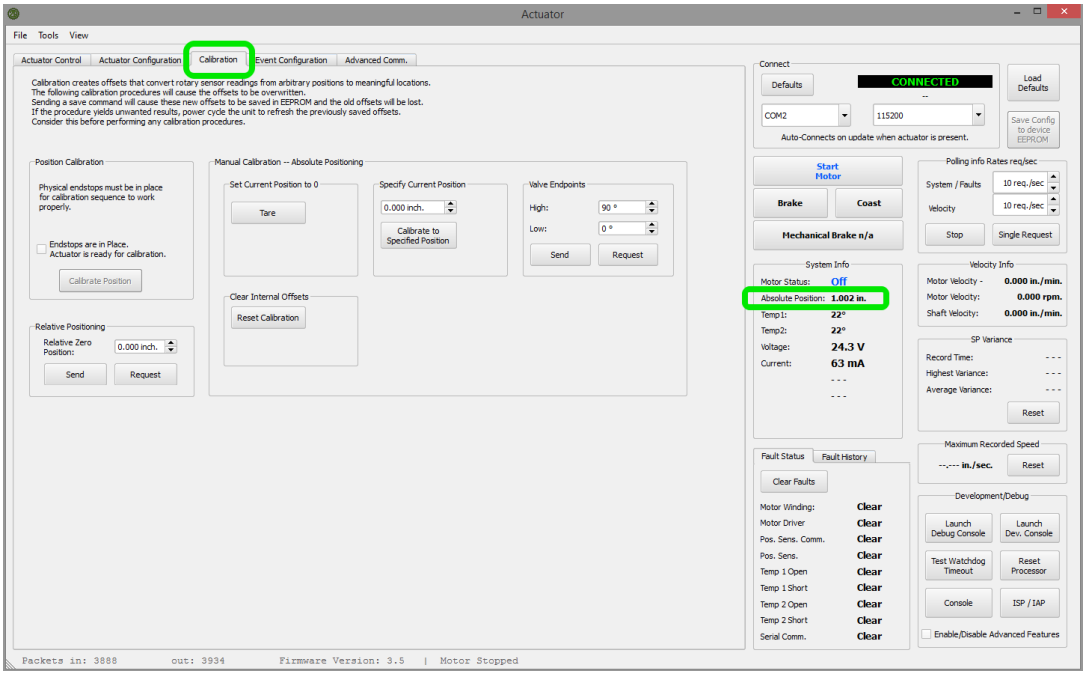
6. After 30-90 seconds, the command prompt window will disappear and a status dialog will appear indicating that the firmware update has either succeeded or failed. If the update fails, power cycle the unit and try again from step 2.



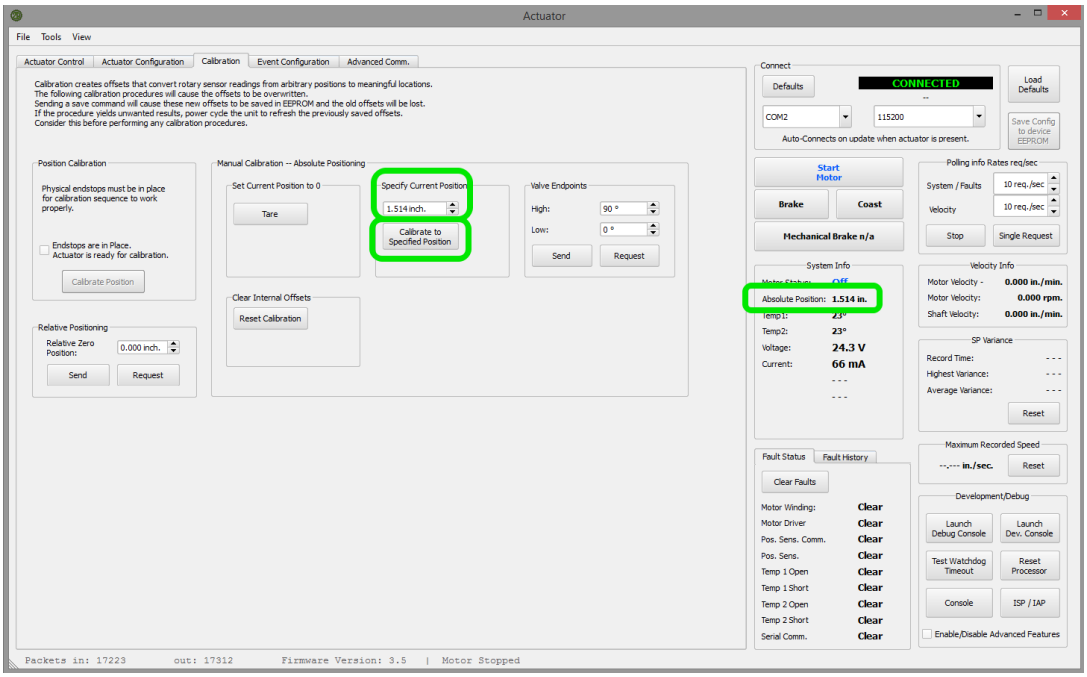
7. Power cycle the actuator and the software should reconnect to it.



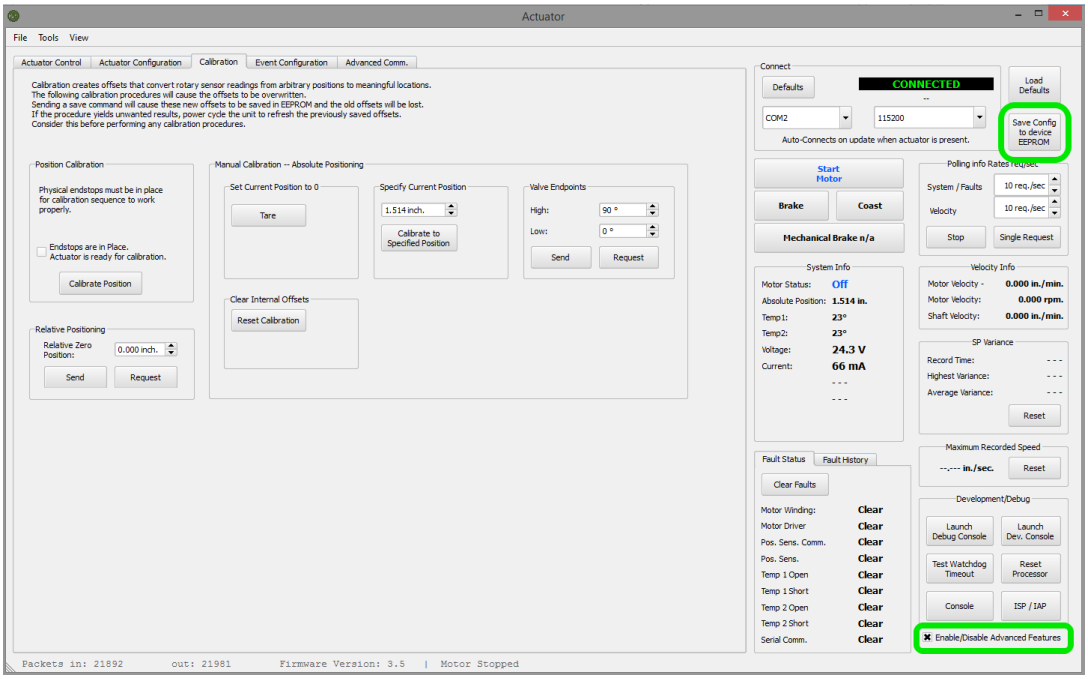
8. Under certain conditions, the actuator calibration may be overwritten by the firmware update process. Verify that the absolute position reading is not significantly different from the recorded value. If it is, switch to the calibration tab.



9. Enter the absolute position you previously recorded into the “Specify Current Position” field. Click the “Calibrate to Specified Position” button. Verify that the reported absolute position has updated to the specified position.



10. Ensure the “Enable/Disable Advanced Features” checkbox is selected. Click the “Save Config to device EEPROM” button. Allow at least 5 seconds for the save operation to complete. Power cycle the actuator and verify that the reported position is still correct. If it is not correct, repeat steps 9 and 10. This concludes the firmware update process.



9 MAINTENANCE AND SERVICE

9.1 GENERAL SERVICE STATEMENT

This actuator is not user serviceable. There are no spare parts or consumables associated with this actuator. The actuator is lubricated at the factory and under normal operating conditions is lubricated for life. If the actuator fails to operate, or is compromised in any manner, the actuator should be returned to 2G Engineering for service during the warranty period. The actuator may be returned after the warranty period, but this will incur a servicing fee.

For extended shelf life of the actuator, do not store in direct sunlight.

CAUTION	**Regular inspections are suggested to maximize service life of the actuator.** Regular inspections can help to reduce replacement costs, equipment down time, and unexpected failure of the unit. Failure to perform inspections may result in degraded performance and/or greatly reduced actuator service life expectancy. **Failure to follow these instructions may result in irreparable damage to actuator system components!**

9.2 SERVICE

The actuator should be returned to 2G Engineering for maintenance.

Contact 2G engineering for service information specific to your model.

During 2G Engineering servicing, the following wear parts will be inspected and replaced if necessary:

- Any mechanical fasteners or moving parts such as an output shaft or pushrod
- Any replaceable mounting points such as rod ends
- The electrical bulkhead connector
- Gears
- Bearings
- Bushings

During a regular service the following parts will be replaced:

- All o-rings (bulkhead connector o-ring, diaphragm retainer, shaft seal, top cap, main body)
- All seals
- Compensator diaphragms
- Wipers

Service intervals are dependent on application. Consult with 2G Engineering on desired use cases to set up a maintenance schedule for your application.

9.3 SUGGESTED CUSTOMER INSPECTIONS

Inspect once every 1-6 months depending on frequency of use:

- Ensure actuator shaft is free from corrosion, nicks, scarring, and debris
- Ensure actuator shaft is free from abnormal discoloration
- Inspect for bio fouling around the shaft to top cap seal
- Inspect for bio fouling around the compensator components
- Ensure system powers up without errors reported through the protocol
- Ensure measured voltage matches voltage reported through protocol
- Ensure electrical contacts are free from corrosion
- Ensure mounting holes and bolts are free from corrosion

10 CONTACT INFORMAION

2G Engineering LLC
2752 Capitol Dr. Suite 103
Sun Prairie WI, 53590
www.2g-eng.com
608-825-4799

11 ACTUATOR SPECIFICATIONS

2000 SERIES ROTARY REFERENCE TABLE:

(PLEASE SEE DATASHEET SPECIFIC TO YOUR MODEL)

Specification	2000RHS	2000RHT
Type	Rotary High Speed	Rotary High Torque
Actuator Length	5.58” + shaft length	5.58” + shaft length
Max Output Force	10 ft.-lbs.	50 ft.-lbs.
Max Rotational Speed (no load)	60 RPM @ 24 V	9 RPM @ 24 V
Rotation Degrees	360º+	360º+
Nominal Operating Voltage	12 - 32 VDC	12 – 32 VDC
Current Limit	5 A	5 A
Communications Port	RS-232 & RS-485	RS-232 & RS-485
Communications Protocol	2G Packet Protocol	2G Packet Protocol
Standard Electrical Interface Connector (options available)	MCBH 6 Micro Wet Pluggable male	MCBH 6 Micro Wet Pluggable male
Thermal Cutoff	68ºC	68ºC
Operating Depth	> 10,000 ft.	> 10,000 ft.
Operating Temperature Range	-20ºC to 65ºC	-20ºC to 65ºC
Storage Temperature Range	-30ºC to 85ºC	-30ºC to 85ºC
Estimated Weight in Air	< 5 lbs.	< 5 lbs.
Position System Type	Hall Effect	Hall Effect
Position System Resolution	< 0.1°	< 0.1°
External Case Material	316 Stainless Steel, 6061 Aluminum, or Titanium	316 Stainless Steel, 6061 Aluminum, or Titanium
Compensator Material	Nitrile Rubber	Nitrile Rubber
Max Radial Shaft Load	25 lbs.	25 lbs.
Max Thrust Shaft Load	10 lbs.	10 lbs.

2000 SERIES LINEAR REFERENCE TABLE:

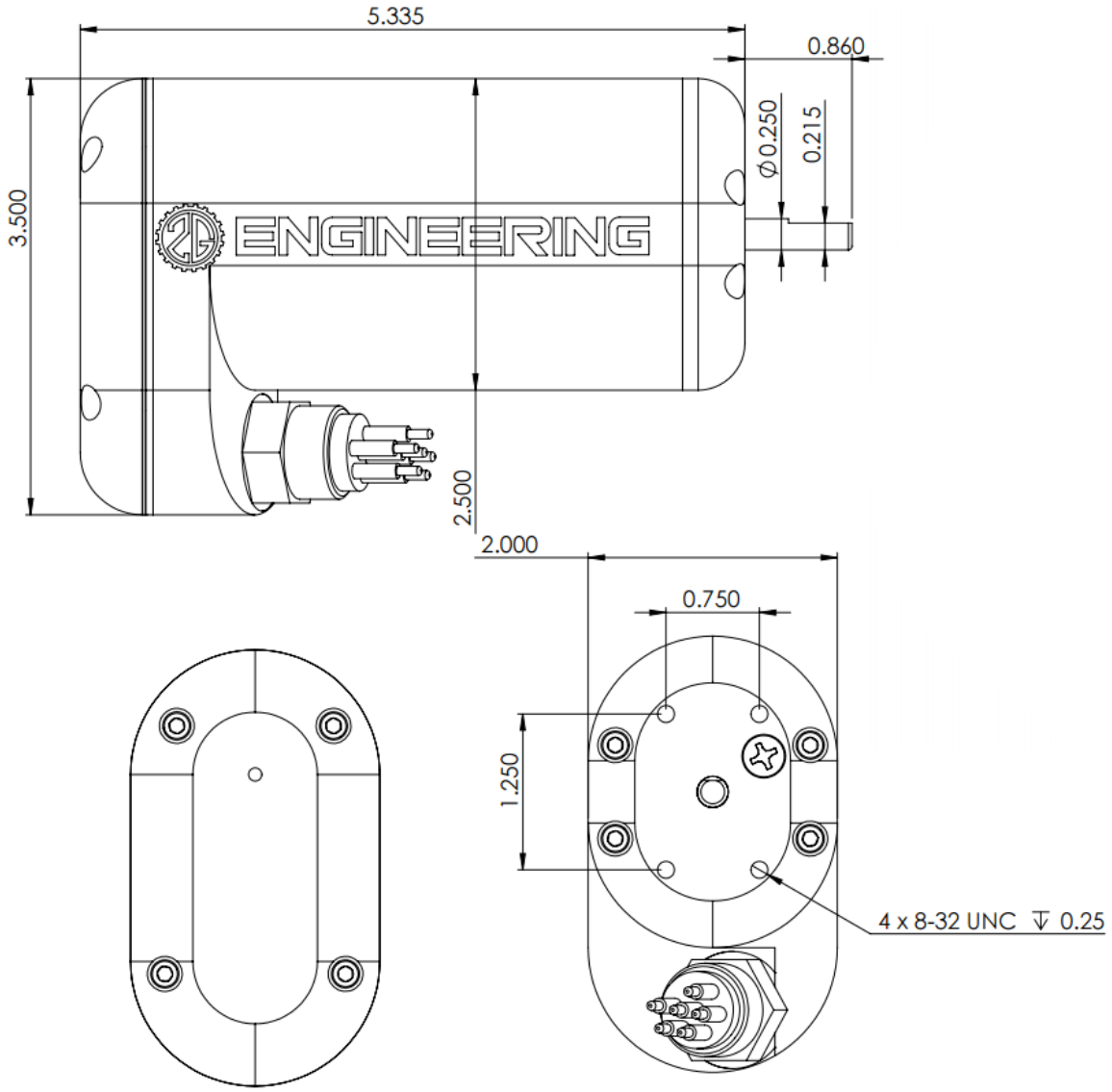
(PLEASE SEE DATASHEET SPECIFIC TO YOUR MODEL)

Specification	2000L
Type	Linear
Stroke Length	2” or 4”
Actuator Length (center to center between mounting points with shaft retracted)	8.12” (2” stroke) 10.73” (4” stroke)
Max Output Force	100+ lbs.
Max Linear Speed	2+ in./second
Nominal Operating Voltage	12 - 36 VDC
Current Limit	5 A
Communications Port	RS-232 & RS-485
Communications Protocol	2G Packet Protocol
Standard Electrical Interface Connector (options available)	MCBH 6 Micro Wet Pluggable male
Thermal Cutoff	68ºC
Operating Depth	> 10,000 ft.
Operating Temperature Range	-20ºC to 65ºC
Storage Temperature Range	-30ºC to 85ºC
Estimated Weight in Air	< 5 lbs.
Position System Type	Hall Effect
Position System Resolution	< 0.1°
External Case Material	316 Stainless Steel, 6061 Aluminum, or Titanium
Compensator Material	Nitrile Rubber
Max Radial Shaft Load	0 lbs.

12 MECHANICAL SPECIFICATION

Example only. See model specific datasheet for more info.

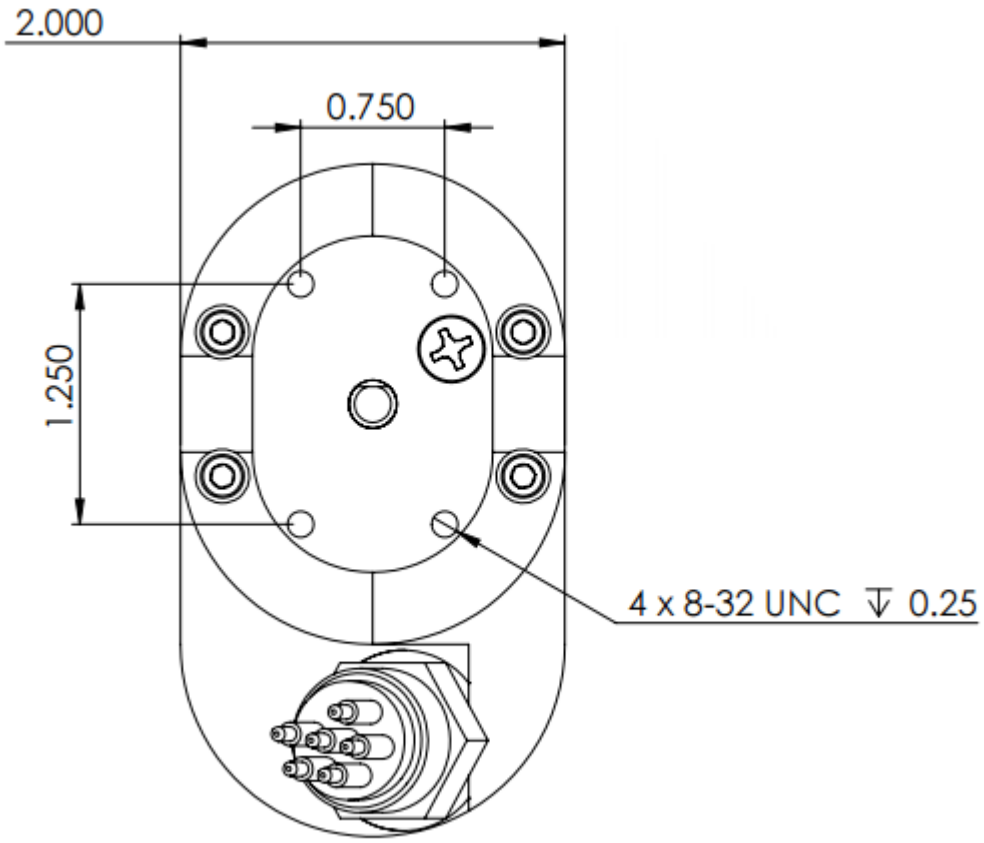
12.1 PHYSICAL DRAWING:



NOTE: The drawing provided here is an example only. Actuator length, shaft length, shaft diameter, and shaft design are variable depending on model.

12.2 MECHANICAL INSTALLATION:

Mechanical Mounting Configuration: The standard configuration available is rear mounting holes as shown with a front 0.250 inch diameter output shaft.



Mounting and Operating Considerations:

Every effort should be made to minimize misalignment. Any misalignment will decrease the life of the components within the actuator and may create problems within the application.

CAUTION	Excessive side load on the output shaft of the actuator will dramatically reduce the life of the actuator and should be avoided completely. Side load can be caused from misalignment or loading that is not in line with the actuator output shaft.