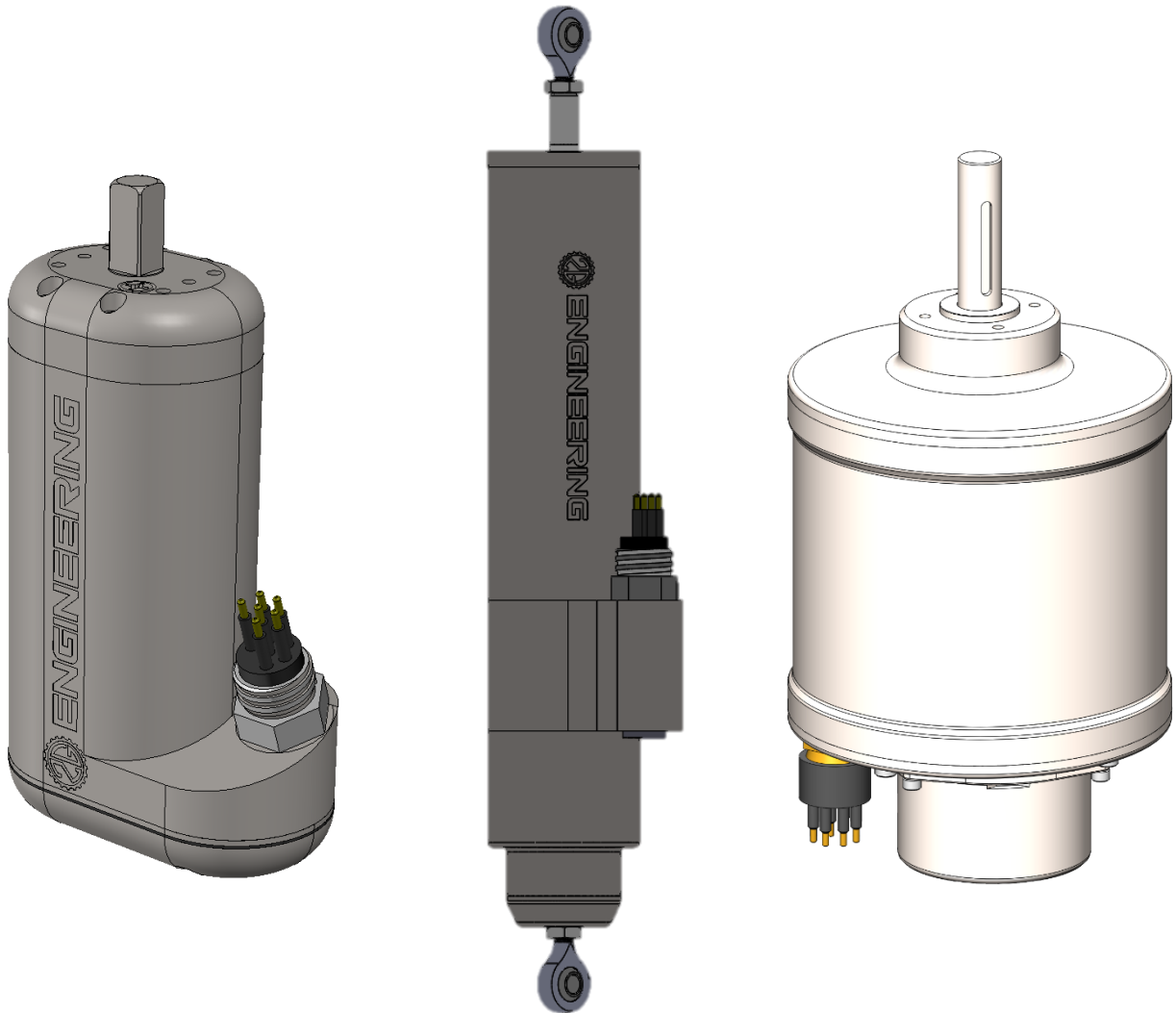


# ACTUATOR USER MANUAL

This manual provides operation and maintenance instructions for linear and rotary actuators designed by 2G Engineering



**DO NOT OPEN YOUR ACTUATOR**  
**OPENING THE ACTUATOR WILL VOID WARRANTY**  
**UNITS MUST BE VACUUM-SEALED FOR PROPER OPERATION**

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## 1. GETTING STARTED

### 1.1 Overview of This Publication

The Actuator User Manual describes the installation, wiring, configuration, and operation of actuator products available from 2G Engineering.

Please note that our products are often customized, and the specifications and operation of your actuator may differ from what is described in this document. Please consult the technical documents you received regarding your actuator and reach out to 2G for additional support if needed.



### 1.2 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.

### 1.3 Safety Considerations and Warnings

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:

	<b>WARNING</b>	"Warning" indicates the information following is essential to avoiding a safety hazard.
	<b>CAUTION</b>	"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 and use.

#### General Safety

Failure to follow safe installation guidelines can cause serious injury or death. 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 comply 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 to be 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 that 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 that might result in a hazardous situation, either directly through intended operation or through unintended 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. When necessary, further measure should be implemented to reduce the risk, e.g., a fail-safe 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.

### 1.4 Suggested Supplemental Materials

Documents that may assist you with your actuator include the following, most of which can also be found on the 2G website or by contacting 2G:

- [PID Controls Wikipedia](#)
- [The Basics of Tuning PID Loops](#)
- [2G Communications Protocol document #2150080](#)
- 2G Actuator CAN Message Document (actuators equipped with CAN bus)
- 2G Actuator Modbus Document (actuators equipped with Modbus)
- 2G Actuator EDS file & EIP Sheet (actuators equipped with Ethernet/IP)

### 1.5 Technical Support

Our technical team is available to work with you and will do our best to answer your questions. If you need to reach us, please call us at 1-608-825-4799. We are available weekdays from 9:00 am to 5:00 pm Central Time (USA). We also encourage you to visit our website at [www.2g-eng.com](http://www.2g-eng.com), where you will find technical and non-technical information about our products and our company.

## 2. SYSTEM DESCRIPTION

### 2.1 Key Features

- All 2G Engineering actuators are operational in air or submerged unless explicitly stated otherwise.
- Depending on the material option that is chosen, the unit 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 with integrated motor drive electronics.
- All units provide a closed loop servo motion system for precise position and velocity control.
  - The servo system provides both trapezoidal motion profiles and simple movement commands
  - The unit is fully operational, without the need for 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 and RS-485 communications are optional on all units.
- CAN bus and Ethernet are also optionally available on some units.
- Units can be equipped with analog proportional or digital (on/off) control upon request. Motion sequencing state machines can also be implemented per customer specifications.
- 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.

### 2.2 Operation Environment

The intended use of most 2G actuators is in submersed deep marine applications (salt water) unless explicitly stated otherwise. All actuators are generally designed to operate at pressures of up to 5000 psi at temperatures from -20°C to 65°C.

Please refer to your specific model's specifications sheet for unit specific parameters.

### 2.3 System Operations

Once properly installed, standard operation of the actuator is accomplished by issuing movement commands to the unit via data packets over the communications port. The default communications pack format is 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 of this manual. For information on communication through methods other than the standard 2G packet protocol, please refer to the supplemental documentation provided with your actuator.

2G Engineering provides the application, ACT3 (available for Windows, MacOS and Linux) that allows a user to easily control, configure, tune and manipulate the unit during bench testing.



## 2.4 Product Overview

All actuators from 2G Engineering are fully integrated; to operate, they only need power and a command signal. The units need no external oil filled hoses, compensators, motor drivers, servo controllers, or sensors. Power and communication are supplied via a single electrical connector on the unit, and are all that is required for basic operation in a pre-programmed setpoint mode.

In addition to the mechanical components (brushless DC motor, gears, housing, etc.), each actuator contains the motor drive circuits, position sensor, servo controller with configurable PID tuning, non-volatile memory for revolution counting and more, self-test and fault reporting, temperature sensors, and communications circuitry. We also have on-board pressure compensation.

2G's actuators can be controlled via a simple open/close signal, a proportional analog input signal, or a full serial data stream. The units output their status and position via analog outputs or serial data. Actuator movement commands can be as simple as sending an "On" command followed by a "Move to setpoint" command. More advanced control options that are supported include:

- Event-based actions: The actuator can seek up to 30 pre-programmed positions based on analog triggers or timers, or simply move to one setpoint after another;
- Move to setpoint at a fixed velocity, at a fixed acceleration rate (Trapezoidal move);
- Control actuator by either absolute or relative positioning commands;
- Custom Human Machine Interface (HMI) software is available from 2G Engineering for even further advanced control.

With each actuator, we also include:

- Basic firmware customization to better fit your application;
- Actuator Universal application, for controlling, testing, and configuring the unit;
- Communications Protocol, for ease of integrating control directly into your systems;
- Technical support from the engineering team;
- A standard 1-year warranty.

### 2.4.1 Linear Actuators

2G offers a range of linear actuators that are capable of output forces from hundreds to thousands of foot-pounds. They are well-suited to a variety of applications such as wings and rudders, latches, mast movement, and hydraulic cylinder replacement.

Please visit us online for [our full linear actuator line-up](#) and the most up-to-date model information and specifications.

### 2.4.2 Rotary Actuators

Our rotary actuators can be tailored to fit your application with both high-speed and high-torque configurations available and torque capabilities from 50 to several hundred foot-pounds. Our rotary actuators are well-suited for a variety of applications such as valve actuation, torque tools, and wenchers or tensioner systems.

Our [full rotary product line-up](#) and most up-to-date model information are available on our website.

### 2.4.3 Hydraulic Pressure Unit

These standalone electrical hydraulic pumps are a great way to add fluid power to your subsea system. The units feature piston and gear pumps that can generate up to 5,000 PSI above ambient pressure and flow rates over 3 GPM and are speed controlled. [Visit us online](#) to see all the technical specifications and



product information. Each HPU product will have a datasheet with a flow vs speed calibration constant or graph listed for typical operating conditions and pressures. To use a pump, a user would command “motor on” then command the speed that corresponds to the flow rate desired. Select models also include pressure control by limiting motor torque.




### 3. WIRING

#### 3.1 Power


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 two or more pairs of power pins, all must be connected.

 <b>CAUTION</b>	<b>MAXIMUM VOLTAGE INPUT</b> Do not exceed the maximum rated voltage of the device! Motor back EMF, power supply ripple, power line ringing and system overvoltage behavior must be considered when selecting a power source for the actuator. Contact 2G to discuss a systems power configuration and its suitability for actuator power supply. <b>Failure to follow these instructions may result in damage to system components!</b>
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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. If it does drop below the operating range the unit will be reset and the motor will turn off.

The power source for the actuators should have a current limiting device installed. A fuse or circuit breaker are typical and are generally installed at the power source to protect any wiring or devices located after them. **2G Actuators are not internally fused.**

 <b>CAUTION</b>	<b>HOT PLUGGING!</b> Do not connect or disconnect the actuator while the power supply is energized. This creates an arc across the connector contacts which degrades them and can produce an overvoltage spike due to current inrush compounded with line impedance. Just because it worked once does not mean will always be safe. <b>Failure to follow these instructions may result in damage to system components!</b>
--	--

There is significant onboard capacitance internal to the units. Care must be taken with the power switching system to avoid line ringing and its associated over voltage spikes. Long wires between the power source and actuator will exacerbate this. 2G Engineering recommends use of a current-limited DC power supply, a solid-state switch, and/or a pre-charge circuit to supply and control power to the actuator. If you are unsure whether this will be a problem in your application, please contact 2G and we will provide feedback on this. Typically, wiring less than 10 ft would not require any startup protection; if over 100ft, startup protection should be seriously considered.

2G actuators come equipped with a wide range of connector brands, configurations, current requirements and voltage requirements. Please review unit specific documentation for further info.

### 3.2 Communication

Serial data communication is typically used to control the actuator. The communications port is used to transfer data packets which contain commands such as motor power control or position setpoint. The specific format and available commands are 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. Some units may have custom software features generated. Actuator firmware build numbers are unique for each software released by 2G and can be used for a reference.

#### 3.2.1 RS-232

The most common serial data physical layer, which easily interfaces using a modern PC, and is typically available on all 2G actuators, is RS-232. The default baud rate and port settings are 115200, 8N1. The baud rate may be changed by the customer using data packets or, more conveniently, the Actuator Universal software. Supported baud rates are 80 - 230400 bps. Higher baud rates may be supported on some units. The RS-232 communication standard typically only supports a single actuator per communications port.

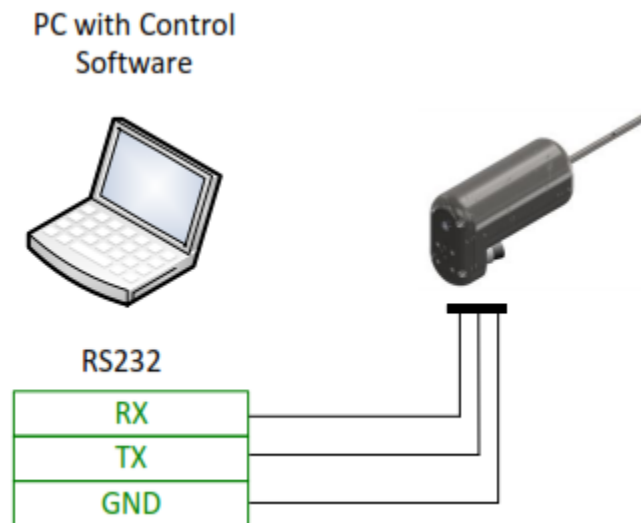


Figure 1: RS-232 Wiring Configuration Example

### 3.2.2 RS-485

RS-485 communication is commonly used when multiple actuators are installed in a single system. When using RS-485 communication, multiple actuators can be connected to the same communication port. RS-485 networks will typically be wired in a linear topology as shown below. The network will require a termination resistor (typically 120Ω) at each end. 2G actuators include a built-in termination resistor that can be enabled or disabled using the Actuator Universal software. Some actuators include dual RS-485 connectors, which provide fully redundant power and data paths for high reliability applications. When more than one actuator is used on the same bus, the addressed packet mode must be used. In this mode, each actuator will have a unique address number (1-255) that identifies it on the bus. This identifier can be assigned using the Actuator Universal software.

Supported RS-485 baud rates are 80-1000000. All serial ports (RS-232 and RS-485) on the actuator share the same baud rate setting.

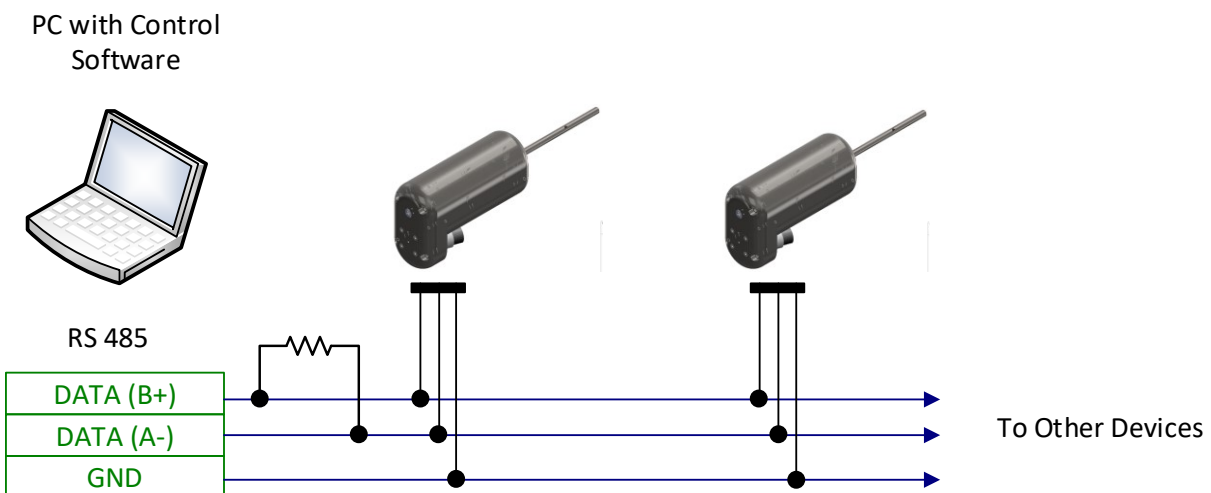


Figure 2: RS-485 Wiring Configuration Example

### 3.2.3 Modbus

2G Engineering's actuators can be ordered with a Modbus communication option. The serial Modbus interface will run over the RS-232 and RS-485 connections and utilize the standard Modbus RTU protocol variant. Modbus over TCP/IP is also supported, which will use the Modbus TCP protocol. In either case, 2G Engineering's JAMBUI (available for Windows, MacOS and Linux) application can be used to communicate with the actuator.

See the 2G actuator Modbus document for more information on available Modbus registers and functions.

### 3.2.4 CAN Bus

2G actuators can optionally be equipped with a CAN 2.0 compatible interface. The CAN bus can be configured to use either 11-bit or 29-bit identifiers. The base identifier and other CAN configuration parameters can be set using serial packets. See the [Communications Protocol document \(document #2150080\)](#) for more information on CAN configuration, and the supplemental CAN documentation for more information on CAN messages sent and received by the actuator.

CAN bus will typically be wired in a linear bus configuration with termination on both ends, similar to RS-485. All CAN-equipped 2G actuators include a built-in termination resistor that can be enabled using the Actuator Universal software.

Standard CAN baud rates up to 1Mbit/sec are supported with the exception of 800kbit/sec.

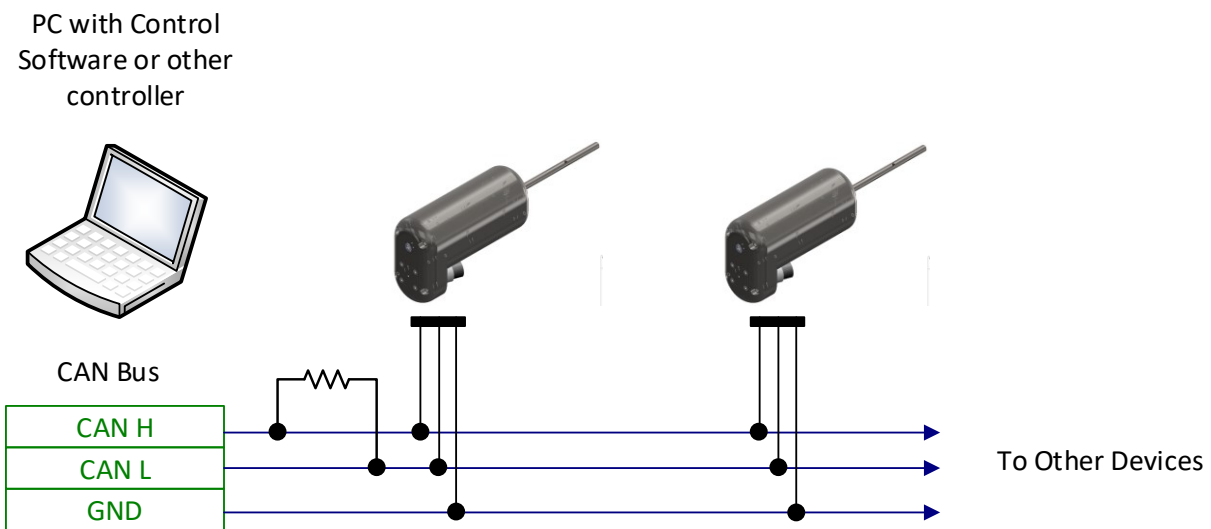


Figure 3: CAN Bus Wiring Example

### 3.2.5 Ethernet

2G actuators can optionally be equipped with an Ethernet communication interface. This interface provides IPv4 connectivity and allows for actuator configuration and control over the Ethernet/IP or Modbus TCP protocols, depending on the options selected by the customer. The Ethernet interface defaults to DHCP mode and will automatically acquire an IP address when it is connected to a network. It can be configured to use a static IP address using the Ethernet/IP TCP/IP object, Modbus TCP registers, or the serial interface, depending on actuator options. Ethernet-equipped actuators support the Simple Service Discovery Protocol (SSDP) to allow discovery of their address on a network. The actuator will respond to SSDP M-Search messages with the following ST values:

- uuid:2G-ENG-COM-2G\_ACTUATOR
- uuid:2G-ENG-COM-ALL
- UPNP:ROOTDEVICE
- UPNP:ALL
- SSDP:ALL
- UUID:ALL

SSDP support is also integrated into 2G's JAMBUI software to allow easy connections to 2G products.

### 3.2.6 Analog Control

If the unit is equipped with the analog control option, the RS-232 serial port is available for general configuration, but once the unit is configured as desired, an external analog control voltage may be used to manipulate the unit. Depending on customer requirements, the analog input may map to actuator speed or actuator position. The analog input may also be operated in digital mode, where a low voltage moves to one endpoint, and a high voltage maps to another endpoint. More complex control mappings are also available upon request. Please contact 2G Engineering for additional information about the usage of this option. Units with the analog control option are typically equipped with a feedback signal, unless a customer specifies otherwise, which outputs a voltage proportional to their absolute angle, linear position, or velocity. Units equipped with analog control can also be operated from a digital control interface such as RS-232. To switch an analog control-equipped unit to digital control mode, send it a motor on, motor off, coast, or brake command. The actuator will then be in digital control mode, and analog control will be disabled until it is power cycled or issued a reset command.

## 4. INITIAL SET-UP & TESTING

### 4.1 Unpacking Your Actuator

After receiving your actuator, please check for the following:


- Make sure the package includes all of the contents:
  - Linear or rotary actuator
  - Documentation (Printed and/or electronic)
  - Cabling & other accessories (optional)
  - Other optional items as ordered
- Inspect the unit to ensure that it was not damaged during shipping
- Make sure that the part numbers indicated on the actuator corresponds with the part numbers on your order.
- Be sure to retain the original packaging materials in the unlikely event that the actuator needs to be returned to 2G Engineering for service.

### 4.2 Mechanical Considerations

Please consult the model datasheet for mechanical mounting configuration. 2G will often customize a model to add features such as face mounting or trunnion mounting on linear actuators, or specific output shaft configurations or features on a customer-by-customer basis.

When mounting rotary actuators, every effort should be made to minimize misalignment. Typically, 2G rotary units have precisely located dowel pins down holes on their face to aid in alignment. Any misalignment will decrease the life of the components within the actuator and may make it more difficult for the actuator to perform as intended.

Linear actuators are designed to be used as a 2-force member; in other words, no bending moment should be applied to the output shaft.

 <b>CAUTION</b>	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.
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### 4.3 Quick testing and Set-Up

2G provides software for system configuration, testing and tuning called Actuator Universal. This software is maintained by 2G Engineering and is distributed free of charge. There is no requirement to use it in a customer system; it is provided as a straightforward starting point for system set up and usage. All of the commands described below do not have to be performed through Actuator Universal. They can be completed using 2G's communication protocol packets.

It is recommended that initial testing and set up of the actuator be performed on a test bench. Wiring should be kept away from the actuator's output shaft, actuator mounting points, and any other moving parts in the system.

The actuator does not require calibration before use. It comes fully assembled and calibrated by 2G Engineering.

Actuator Universal may be download [on our website](#). It provides features for configuration, testing, issuing movement commands, charting and logging of system response, etc.

 <b>CAUTION</b>	Always make sure power is off before attempting to work on or near the actuator and its electrical controls.
 <b>WARNING</b>	The actuator is factory lubricated for life. No disassembly is ever required for routine maintenance. The actuator contains no user-serviceable components and cannot be properly serviced by anyone outside of 2G Engineering  <b>Attempts at opening or tampering with components internal to the device may damage system components and will void all warranties on the device.</b>

#### 4.4 Configuration of Unit Address

When the unit is used with addressed packet commands (typical over RS-485), the address of each unit must first be set in order to distinguish among multiple units while running on the same communications bus. ACT3, can help with this. Unit addresses can also be set 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 issued to make the address persistent across power cycles.

From the 2G Actuator Communications 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 ACT3 application developed by 2G Engineering, communication can be established with a single unit at a time by enabling the “TX: Send Address in outgoing packets” option. This can be found under the “Communication” tab under the “To actuator” sub heading.

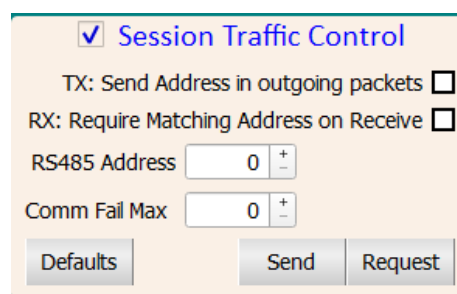
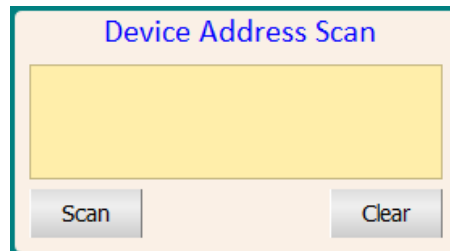


Figure 4: Session Traffic Control Modal in ACT3



ACT3 allows the user to send commands to receive the address of a single unit on the bus or set the address of the unit. Make sure to issue a save to EEPROM command after setting a new address if it is intended to be persistent.

It may be useful to find other actuators that are connected to a communications bus, the Device Address Scan feature can help. This can be found under the “Communication” tab under the “To actuator” sub heading:



**Figure 5: Device Address Scan Modal in ACT3**

Click the “Scan” button, and the addresses of any detected devices will be listed in the text box.



## 5. USING YOUR ACTUATOR

### 5.1 Feature Set

All units can report back their operational status, position, and movement via motion control commands. 2G Engineering provides an application called ACT3 which offers customers the ability to communicate with, and prototype position command control loops. Actuators will come pre-loaded with control loop gains that correspond with sane defaults defined during Factory Acceptance Testing. The image below depicts the “Servo Tuning” page depicted in ACT3.

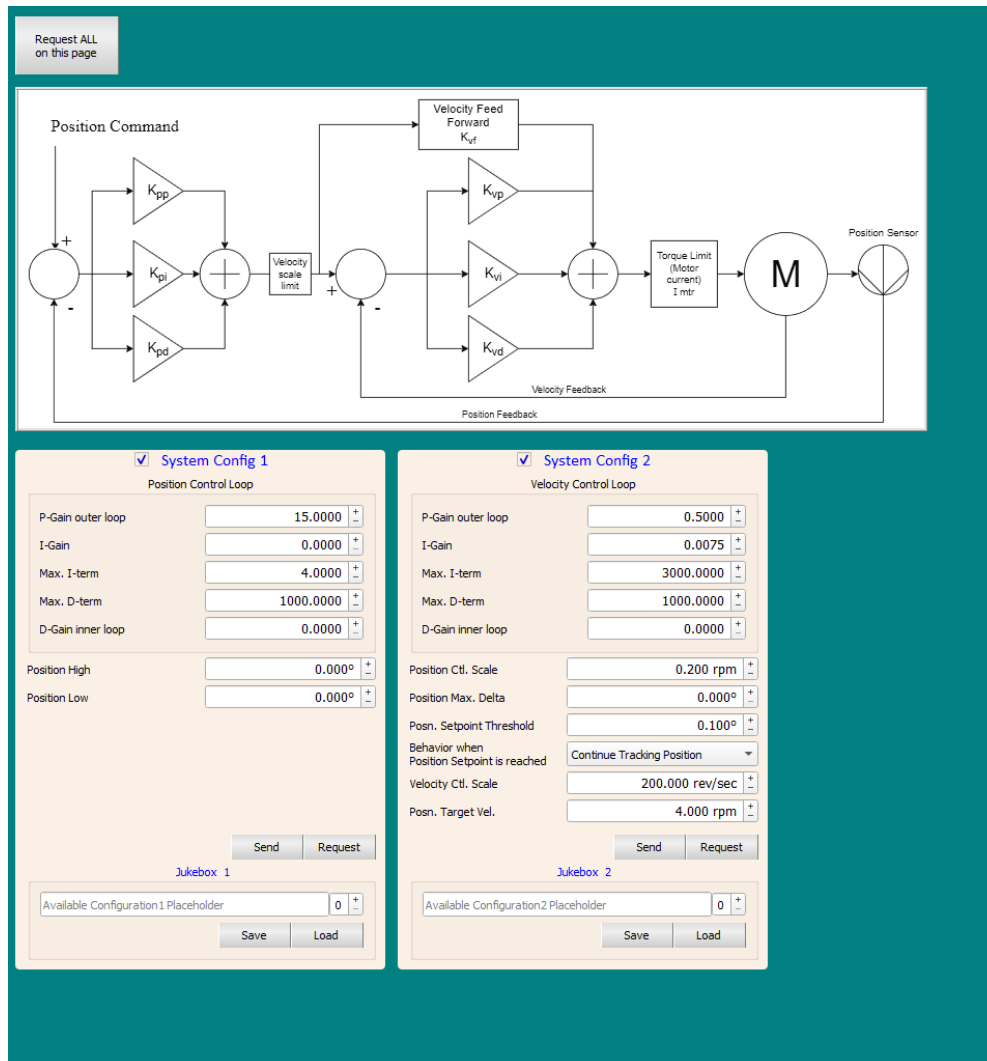


Figure 6: Example Servo Tuning Screenshot from ACT3

Units run with a cascaded position-driven velocity loop that has one set of PID gains to determine how aggressively units respond to a position error. Position error drives the velocity target, and the second set of gains controls the system response to a velocity error. The units also have commands for gain scheduling, feed forward control, and motion profiling that may be used to help meet a customer’s needs. 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.

### 5.1.1 Fault Reporting

The actuator has a number of internal diagnostics and sensors that can detect faults with various actuator subsystems. These diagnostics are run continuously in the background whether or not the user requests them using the Fault packet. By default, the actuator will continue operating as long as possible in the event that a fault is detected. The only event that guarantees a fault shutoff is a position sensor error. (On units with analog control, temperature faults will also force a shutdown.) The fault behavior settings allow the user to specify an action for the actuator to take when a fault is detected so that the actuator can automatically stop or apply the brake when a fault is detected to prevent potential damage.

### 5.1.2 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 for motor power or torque. It bypasses many of the internal checks 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 it is not intended to be used for a production system.
  - If this feature is to be used for force or torque control in an application, it is the customer’s responsibility to close any external loops on position and ramp down the unit’s output force as necessary to protect any external systems from over-travel.
- The 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.
  - When a position command completes (determined based on a specified distance to the setpoint), 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)
- The 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.

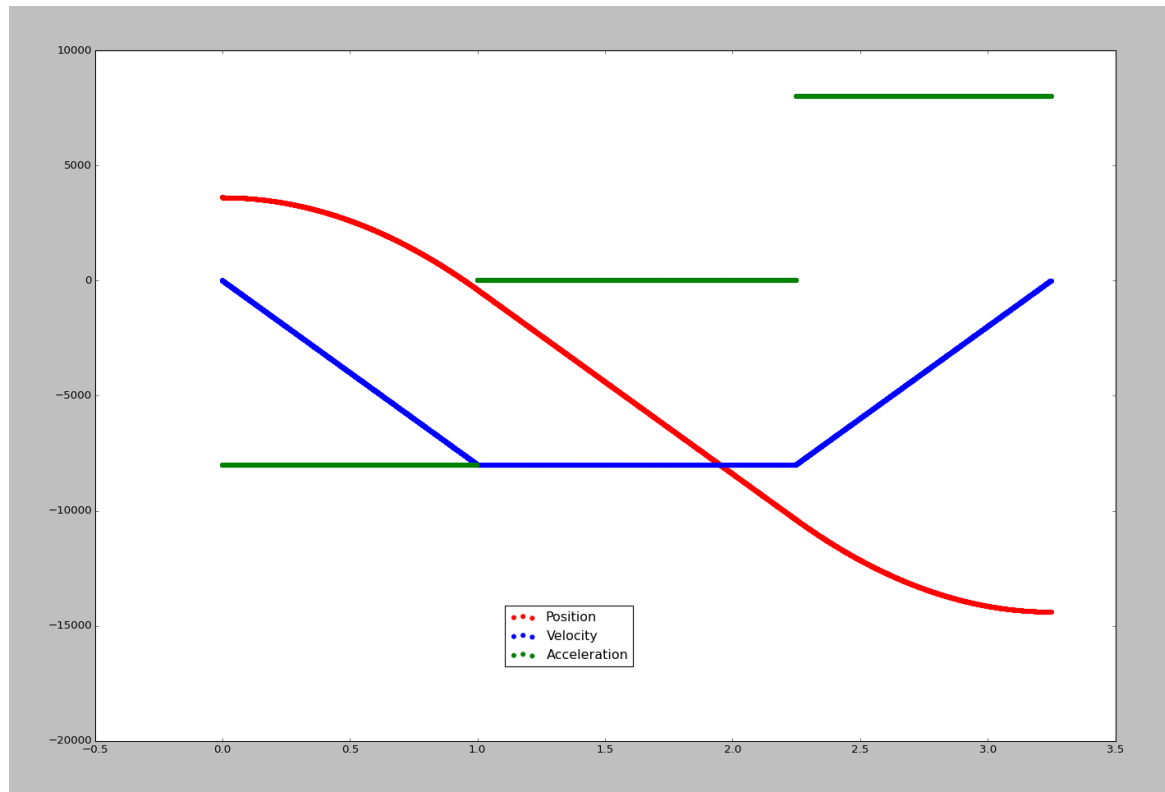


Figure 7: Example of a Complex Motion Profile

- 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.

### 5.1.3 Other Available Settings

#### 5.1.3.1 Current Limits

Two current limits are provided for system protection:

- Board current limit:
  - Board current is a measurement of the actual current going into the actuator. This is the value that you would measure if you placed an ammeter in line with the actuator’s power supply wire.
  - When this limit is reached, the unit will “throttle back” its output.

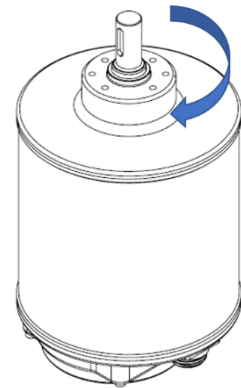
- Motor current limit:
  - Motor current measures the actual current in the motor windings inside the actuator. It is not a value that can be measured external to the unit and is not strongly related to the actual input current to the actuator.
  - The motor current limit value is directly related to the system's output torque or force. It can be set higher or lower than the board current limit.
  - The motor current limit functions as a rudimentary torque/force control limit. This control provides approximately +/- 30% control of torque output independent of system voltage.

### 5.1.3.2 PID Controls

There are also configurable PID control values. For a primer on PID controls, see Appendix B.

### 5.1.3.3 Forward & Backward Movement

For rotary actuators, clockwise movement while looking into the output shaft is described as forward movement. See the picture to the right for further clarification.




**Figure 8: Rotary Actuator Movement Reference**



## 5.2 System Usage

### 5.2.1 Instructions

The actuator should be operated within its ratings for load, duty cycle, and temperature. If power is lost or removed, the actuator's shaft or push rod may become free-moving.

 <b>WARNING</b>	<p><b>Be aware of loading on actuator at all times!</b></p> <p>The actuator is capable of holding large forces in place. Sudden loss of power may cause injury due to a free-moving load.</p> <p><b>Failure to follow these instructions or take appropriate safety precautions may result in injury or death!</b></p>
--	--

### 5.2.2 Power On the Actuator

- Apply power to the actuator.
  - Actuator will not respond until power is provided.
  - An unpowered actuator may be free-moving.
- Send the command “start motor” via packet through the communications port.
  - Unit will be in coasting mode until a start motor command is issued or a brake command is issued.
- Depending on a unit's configuration, there may be a mechanical brake installed. If so, the unit will not be free-moving. 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.

### 5.2.3 Normal Operation

- Actuator is controlled by sending position or velocity set point commands.
- Typically, when the setpoint is reached, the default mode is to continue holding position against any external forces.
- Other modes include
  - Coasting (stop tracking setpoint) Useful for units with acme screws.
  - Braking (can be electronic or mechanical).
- Refer to the [Communications Protocol document \(document #2150080\)](#) for a complete listing of commands.



**5.2.4 Power Off the Actuator**

- Turn off power supply to the actuator.
- Actuator will be free-moving when power is removed from the actuator unless it is configured with an internal failsafe brake.

**5.2.5 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.

**5.2.6 External End Stops**

- Linear actuators have internal end stops that typically have greater than a 4:1 safety factor before damage is done to the unit. Customer applications have unknown masses and therefore unknown force that may be needed to hold the load. Do not rely on units' internal end stops to limit the travel of a system. Please consult 2G for review if you wish to use the internal end stops of a unit for this purpose.
- Rotary units have no internal end stop unless specially requested by a customer. This means that rotary units are free to spin 360+ degrees.

**5.2.7 Conventions and Error Messages**

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

<b>Mechanical Faults:</b>		
Leaking oil	Contact 2G Engineering	
<b>Controllers constantly running Built In Tests 'BIT' Observations:</b>		<b>Possible Resolutions</b>
Motor Driver Fault	Under voltage Over temperature Logic Fault	Ensure power supply has sufficient current capacity for actuator.  Ensure there is a reliable connection between the power supply and the actuator.  Reduce the length of the cables between the power supply and the actuator.  Verify that the power supply is providing a stable output voltage.  Move the actuator away from large sources of electrical noise.



Temperature Fault	Sensor1: High > 68°C, Low < -33°C  Sensor2: High > 68°C, Low < -33°C	Turn the actuator motor off and allow it to cool.  Move the actuator to a warmer or cooler environment.
Position Sensor Communications Fault	Invalid data reported from onboard position sensor	Cycle power to the actuator.  Move the actuator away from large sources of electrical noise or magnetic fields.
Communication Fault	CRC failures can be caused by one or more of the following: <ul style="list-style-type: none"> <li>• Cross talk with power</li> <li>• Excessive cable length</li> <li>• Intermittent connection</li> <li>• Corrosion at input terminals</li> <li>• Serial grounding issue</li> <li>• Mismatched baud</li> </ul>	Verify that there is a reliable connection to the actuator's data lines.  Verify that the correct baud rate is being used.  Increase the interval between packets sent to the actuator.  Run power and communications cables separately where possible.  Reduce the length of communications cables.  On differential protocols such as RS-485, ensure that data lines are a twisted pair.  On actuators with an isolated communications ground, ensure that power ground and communications are attached to the correct points in your system. With an isolated communications ground, ground loops can develop quite easily. Depending on your system configuration, it may be necessary to tie the two grounds together at an appropriate point.
EEPROM Read	Actuator configuration corrupt and has been reset to defaults (this is normal after updating firmware)	Restore any custom configuration settings from backup.  Allow at least 5 seconds after issuing a "Save to EEPROM" command before removing power to the actuator.

Controller faults are covered in the [Communications Protocol document \(document #2150080\)](#).



### 5.2.8 Reset to Default Communication Parameters

Units operating with firmware version 8.6 (build 10567, implemented October 2021) and newer have a feature to reset the actuator to a known set of communication bus parameters.

The reset sequence is as follows:

1. Power on for 5 seconds, power off
2. Power on for 10 seconds, power off
3. Power on for 15 seconds, power off
4. Power on for 30 seconds, power off

The next time the actuator is powered on, it will start up in recovery mode. Each time interval has a +/- 1.5 second tolerance on it. If the sequence is not followed exactly, it will reset and you will need to start over from the beginning.

Recovery mode configures the actuator's communication settings as follows:

- Serial
  - Modbus mode RTU
  - Address 1
  - Baud rate 115200, 8N1
  - Termination enabled
- CAN
  - Baud rate 125000
  - TX base address 0x2F1
  - RX base address 0x28D
  - Extended IDs disabled
  - All transmit messages enabled
  - Transmit interval 250ms
  - Termination enabled
- Ethernet
  - DHCP disabled, periodic SSDP NOTIFY broadcast enabled
  - IP address 192.168.100.200
  - Default gateway 192.168.0.1
  - Subnet mask 255.255.0.0



### 5.2.9 Updating Actuator Firmware

1. Launch the ACT3 application 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 following values:
  - Absolute position of the actuator and Total Revolution Count.
  - (If applicable) Under the Servo Tuning tab, record any other actuator configuration settings (PID-gains, current limits, motion profile, stall detection, gain scheduling, etc.) The terms from both System Config 1 and System Config 2 will be necessary.

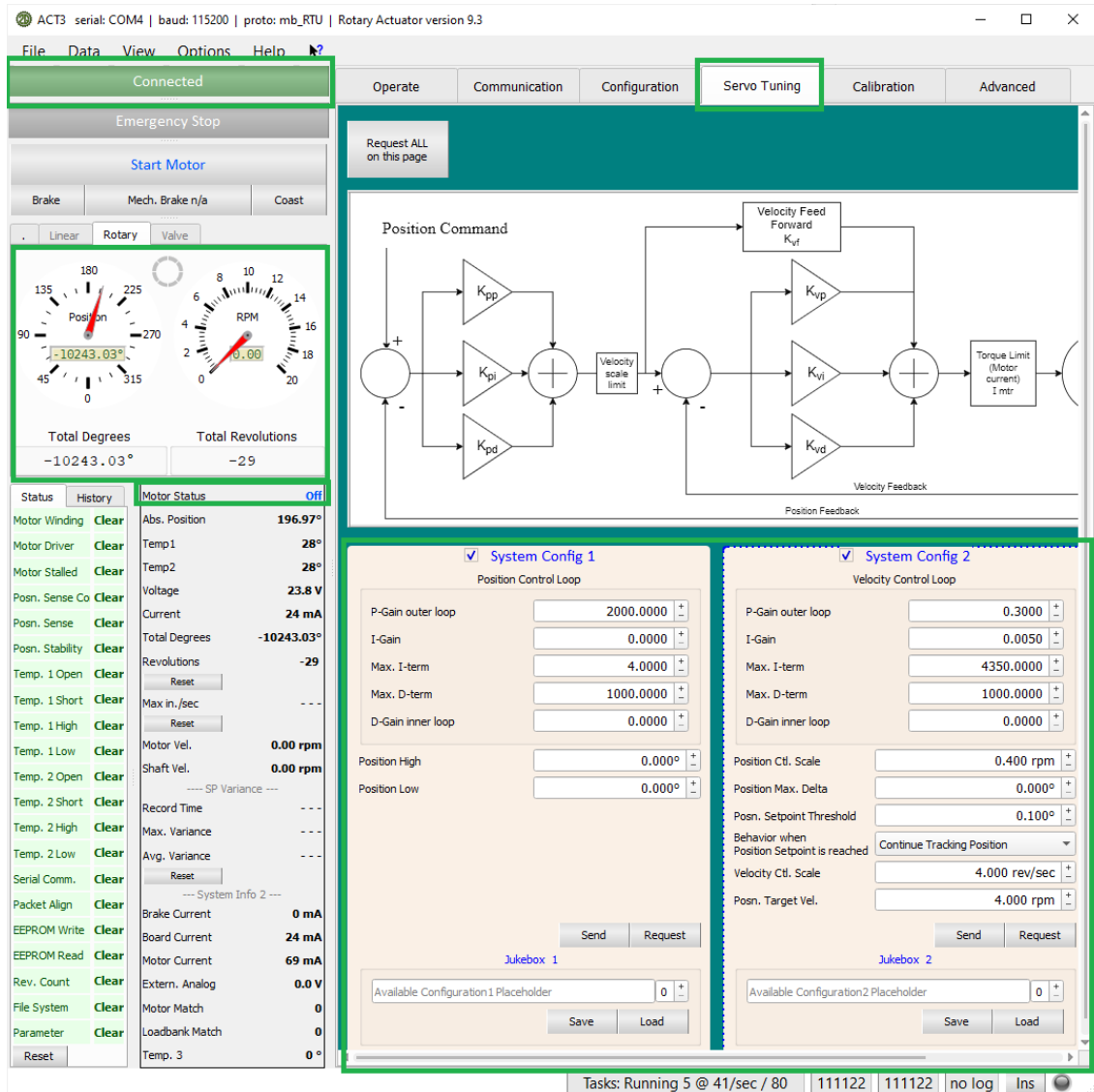
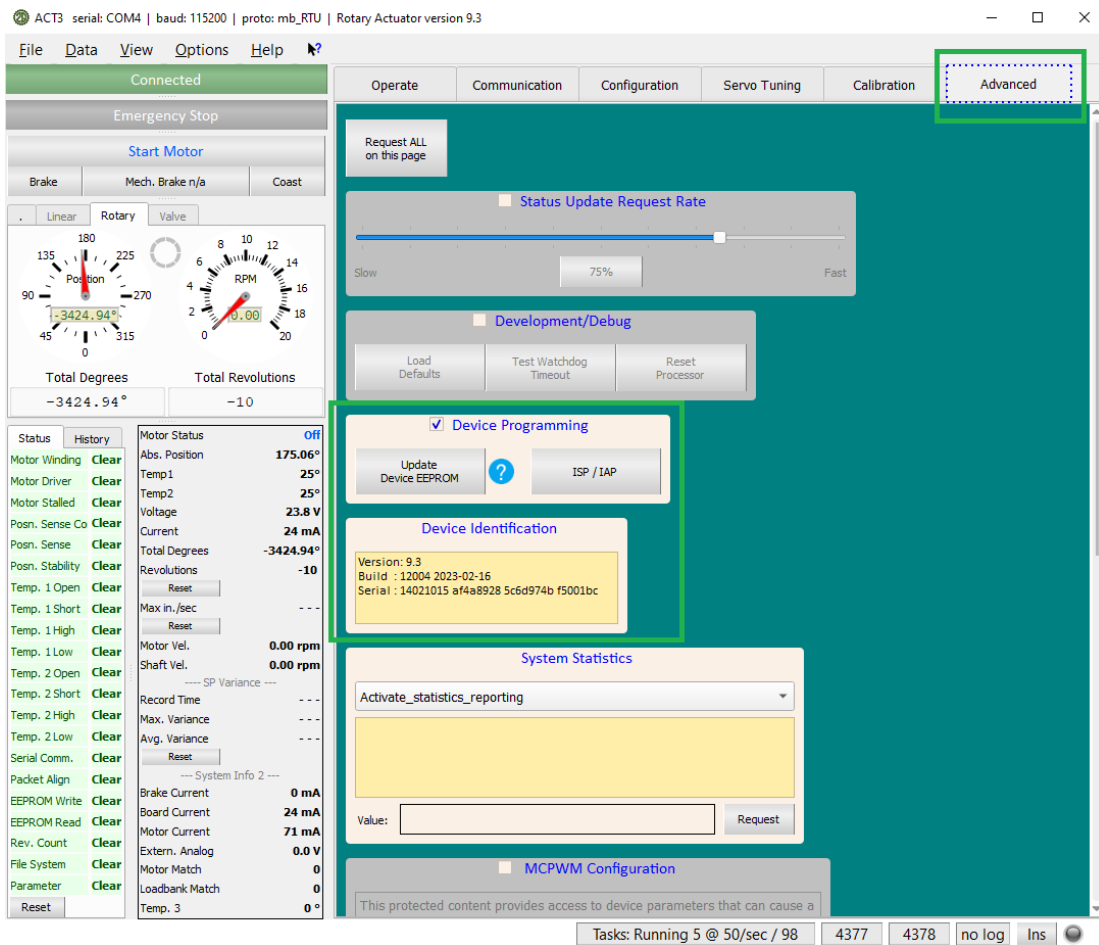


Figure 9: Servo Tuning Page

2. Select the “Communication” tab at the top of the window.
3. Note the current firmware version and build in the “Device Identification” section
4. Ensure that Device Programming is enabled and click the “ISP/IAP” button.



The screenshot shows the software interface for a rotary actuator. The top menu bar includes File, Data, View, Options, and Help. The main window has several tabs: Operate, Communication, Configuration, Servo Tuning, Calibration, and Advanced (highlighted with a green box). The Advanced tab contains several sections:

- Status Update Request Rate:** A slider set to 75%.
- Development/Debug:** Buttons for Load Defaults, Test Watchdog Timeout, and Reset Processor.
- Device Programming:** A section with a checked checkbox and buttons for Update Device EEPROM and ISP / IAP (highlighted with a green box).
- Device Identification:** A section displaying device information: Version: 9.3, Build: 12004 2023-02-16, and Serial: 14021015 af4a8928 5c6d974b f5001bc (highlighted with a green box).
- System Statistics:** A section with a dropdown menu set to 'Activate\_statistics\_reporting' and a 'Request' button.
- MCPWM Configuration:** A section with a warning message: "This protected content provides access to device parameters that can cause a".

On the left side, there is a status panel with a "Reset" button and a list of system parameters:

Parameter	Status	Value
Motor Status	Off	
Abs. Position		175.06°
Temp1		25°
Temp2		25°
Voltage		23.8 V
Current		24 mA
Total Degrees		-3424.94°
Revolutions		-10
Motor Vel.		0.00 rpm
Shaft Vel.		0.00 rpm
SP Variance		---
Record Time		---
Max. Variance		---
Avg. Variance		---
Brake Current		0 mA
Board Current		24 mA
Motor Current		71 mA
Extern. Analog		0.0 V
Motor Match		0
Loadbank Match		0
Temp. 3		0°

At the bottom, the task bar shows: Tasks: Running 5 @ 50/sec / 98, 4377, 4378, no log, Ins.

Figure 10: Device Programming Page

5. Navigate to the firmware hex file, select it, and click “Open”.
  - a. NOTE: For reliability, 2G Engineering recommends that this .hex is saved on the local disk of the workstation performing the firmware update. Although it is possible to initiate a firmware upload using a .hex file a network file share, it is not advised.

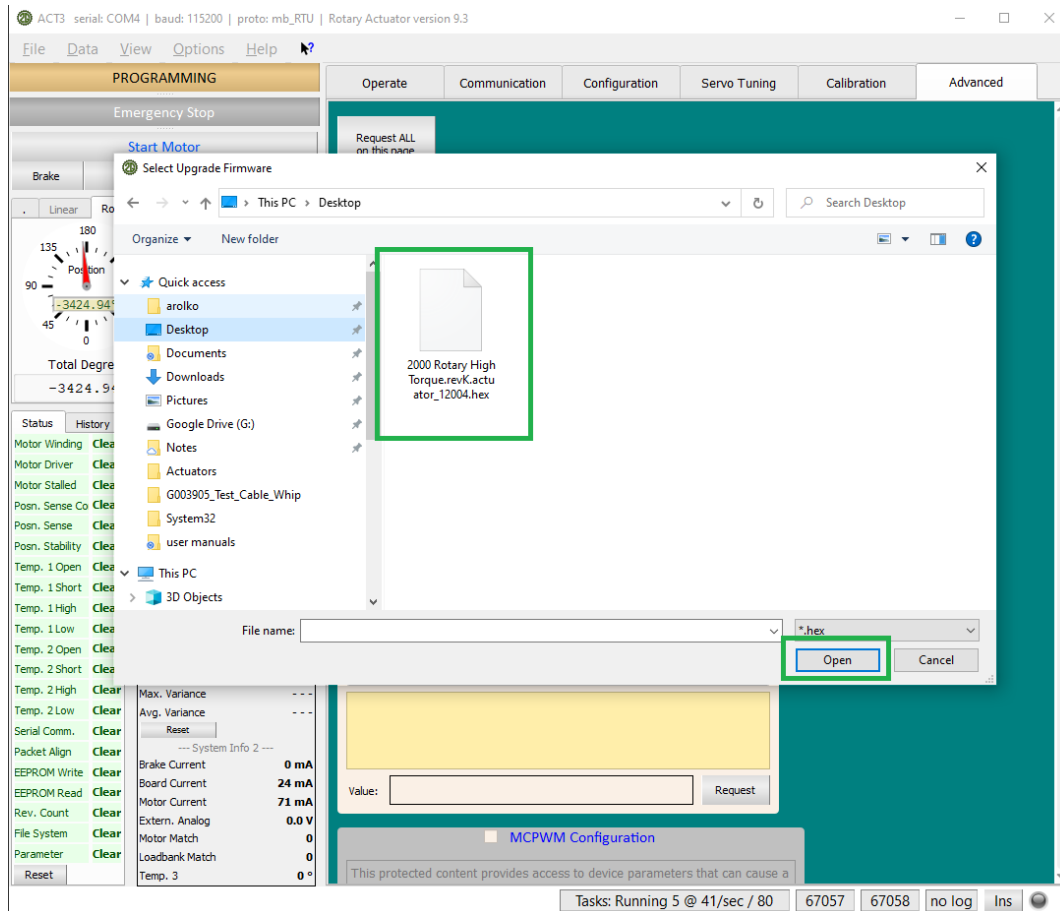


Figure 11: Hex File Selection Using Windows Explorer

6. At the “ACT3 Ready to Proceed?” prompt, click the “Yes” button when ready.
7. The status indicator will display “Programming”, and a progress bar will appear in the center of the window. Progress will also be displayed along the bottom of the window while the unit is being programmed. After the unit has been programmed, the firmware will be verified.

NOTE: The process should take 30-90 seconds.

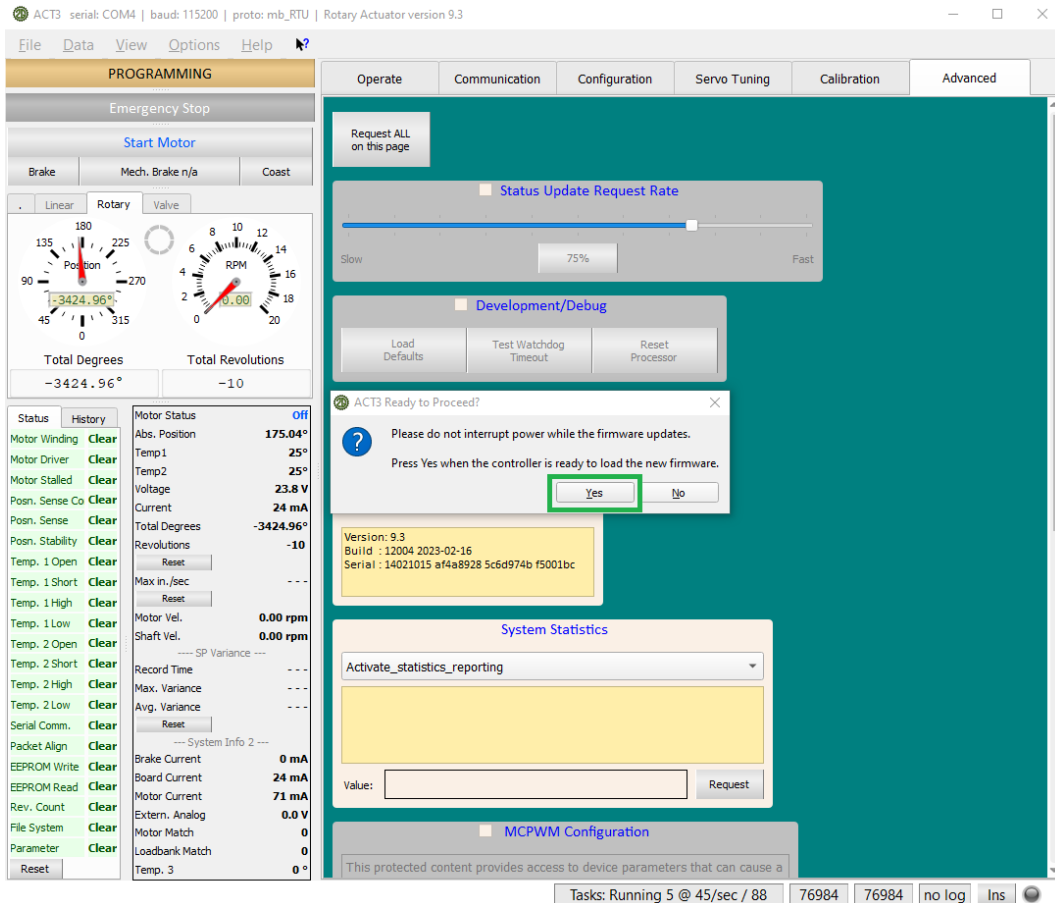


Figure 12: Firmware Flash Confirmation

8. The software will automatically reconnect to the actuator after programming has completed. If programming fails, a dialog box will appear. If this happens, power cycle the unit and try again. If programming succeeds, the field in the upper right should show “Connected”:

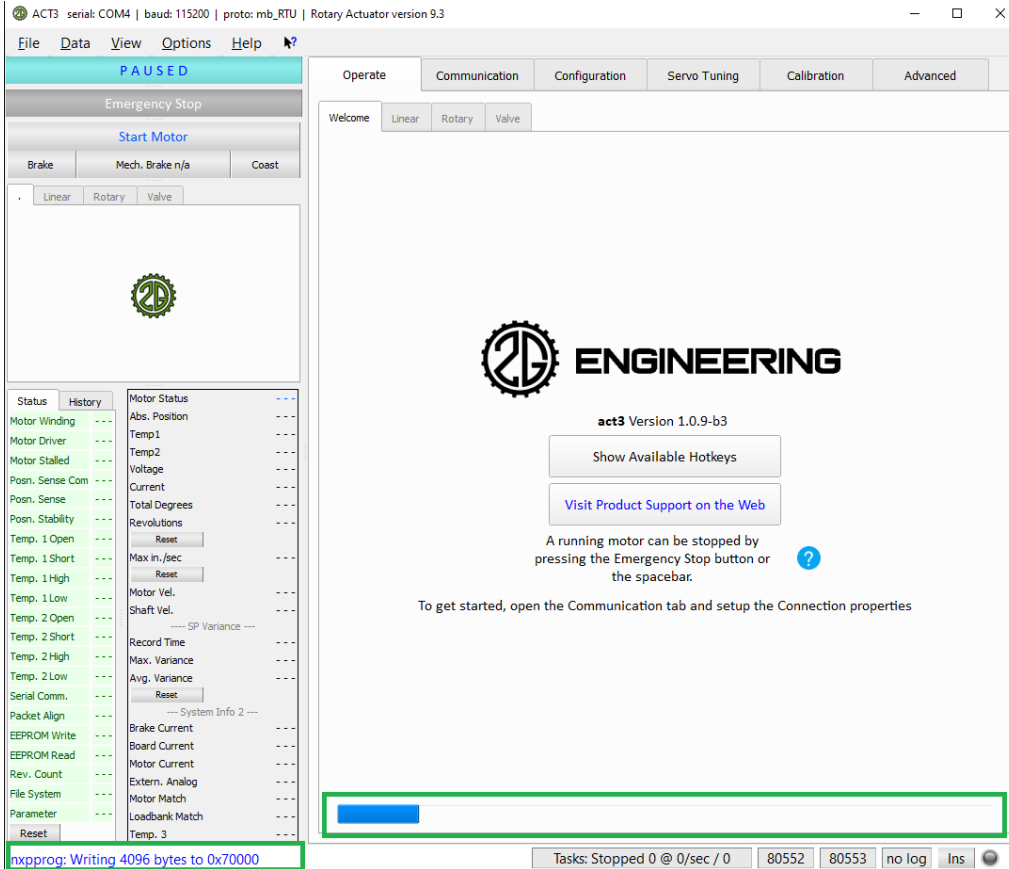
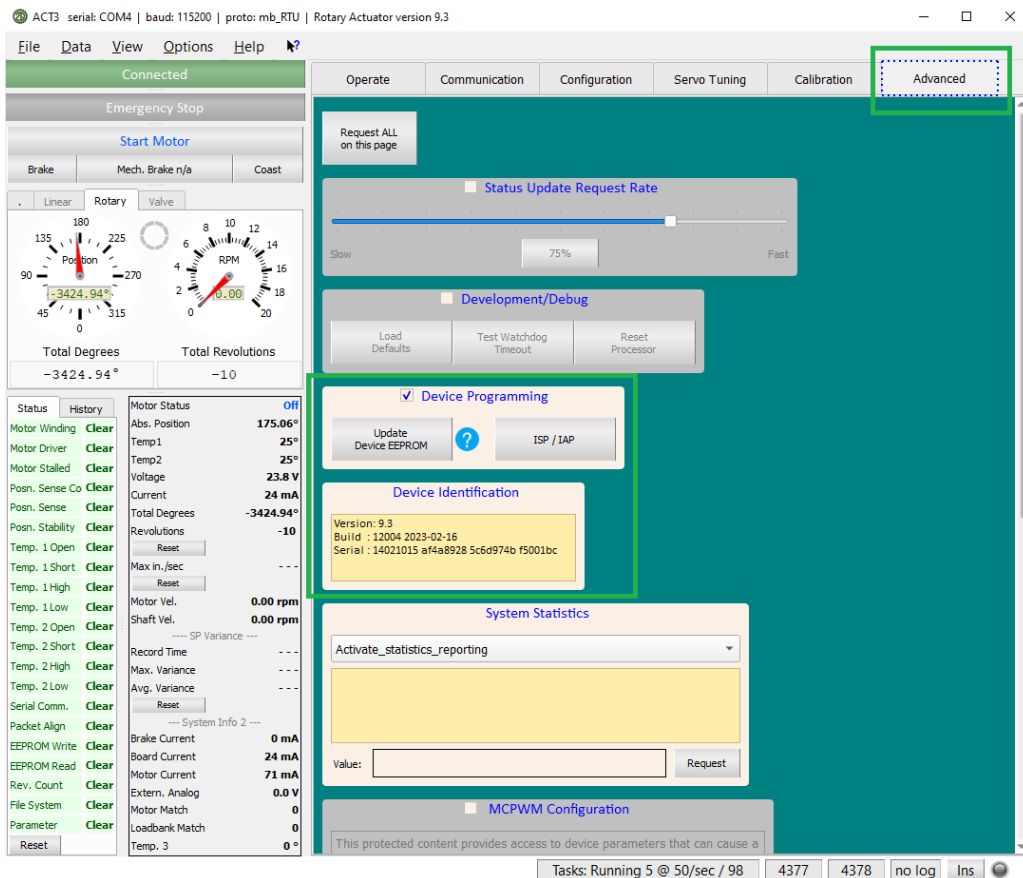


Figure 13: Firmware Flashing Underway

9. Switch to the “Advanced Communication” tab and verify that the displayed build number matches that of the new software.



ACT3 serial: COM4 | baud: 115200 | proto: mb\_RTU | Rotary Actuator version 9.3

File Data View Options Help

Connected

Operate Communication Configuration Servo Tuning Calibration **Advanced**

Emergency Stop

Start Motor

Brake Mech. Brake n/a Coast

Linear Rotary Valve

Position: -3424.94° RPM: 0.00

Total Degrees: -3424.94° Total Revolutions: -10

Status History

Motor Status	off
Motor Winding	Clear
Motor Driver	Clear
Motor Stalled	Clear
Posn. Sense Co	Clear
Posn. Sense	Clear
Posn. Stability	Clear
Temp. 1 Open	Clear
Temp. 1 Short	Clear
Temp. 1 High	Clear
Temp. 1 Low	Clear
Temp. 2 Open	Clear
Temp. 2 Short	Clear
Temp. 2 High	Clear
Temp. 2 Low	Clear
Serial Comm.	Clear
Packet Align	Clear
EEPROM Write	Clear
EEPROM Read	Clear
Rev. Count	Clear
File System	Clear
Parameter	Clear

Motor Status: off

Abs. Position: 175.06°

Temp1: 25°

Temp2: 25°

Voltage: 23.8 V

Current: 24 mA

Total Degrees: -3424.94°

Revolutions: -10

Reset

Max in./sec: ---

Reset

Motor Vel.: 0.00 rpm

Shaft Vel.: 0.00 rpm

--- SP Variance ---

Record Time: ---

Max. Variance: ---

Avg. Variance: ---

Reset

--- System Info 2 ---

Brake Current: 0 mA

Board Current: 24 mA

Motor Current: 71 mA

Extern. Analog: 0.0 V

Motor Match: 0

Loadbank Match: 0

Temp. 3: 0°

Request ALL on this page

Status Update Request Rate: 75%

Development/Debug

Load Defaults Test Watchdog Timeout Reset Processor

Device Programming

Update Device EEPROM ? ISP / IAP

Device Identification

Version: 9.3  
Build: 12004 2023-02-16  
Serial: 14021015 aF4a8928 5c6d974b f5001bc

System Statistics

Activate\_statistics\_reporting

Value: Request

MCPWM Configuration

This protected content provides access to device parameters that can cause a

Tasks: Running 5 @ 50/sec / 98 4377 4378 no log Ins

Figure 14: Firmware Flashing Confirmation

### 5.2.10 Actuator Calibration (If Required)

Under certain conditions, the actuator configuration (including calibration) may be overwritten by the firmware update process. If this happens, the software will indicate an “EEPROM Read” fault. This is normal and can safely be cleared using the “Reset” button. It is possible to restore position calibration by manually defining the pre-recorded values and updating the EEPROM.

1. Verify that the absolute position reading is not significantly different from the recorded value. If it is, switch to the calibration tab
2. When on the Calibration page, read the notice information carefully and click “Acknowledge” if you accept the terms and unlock the relevant interface elements

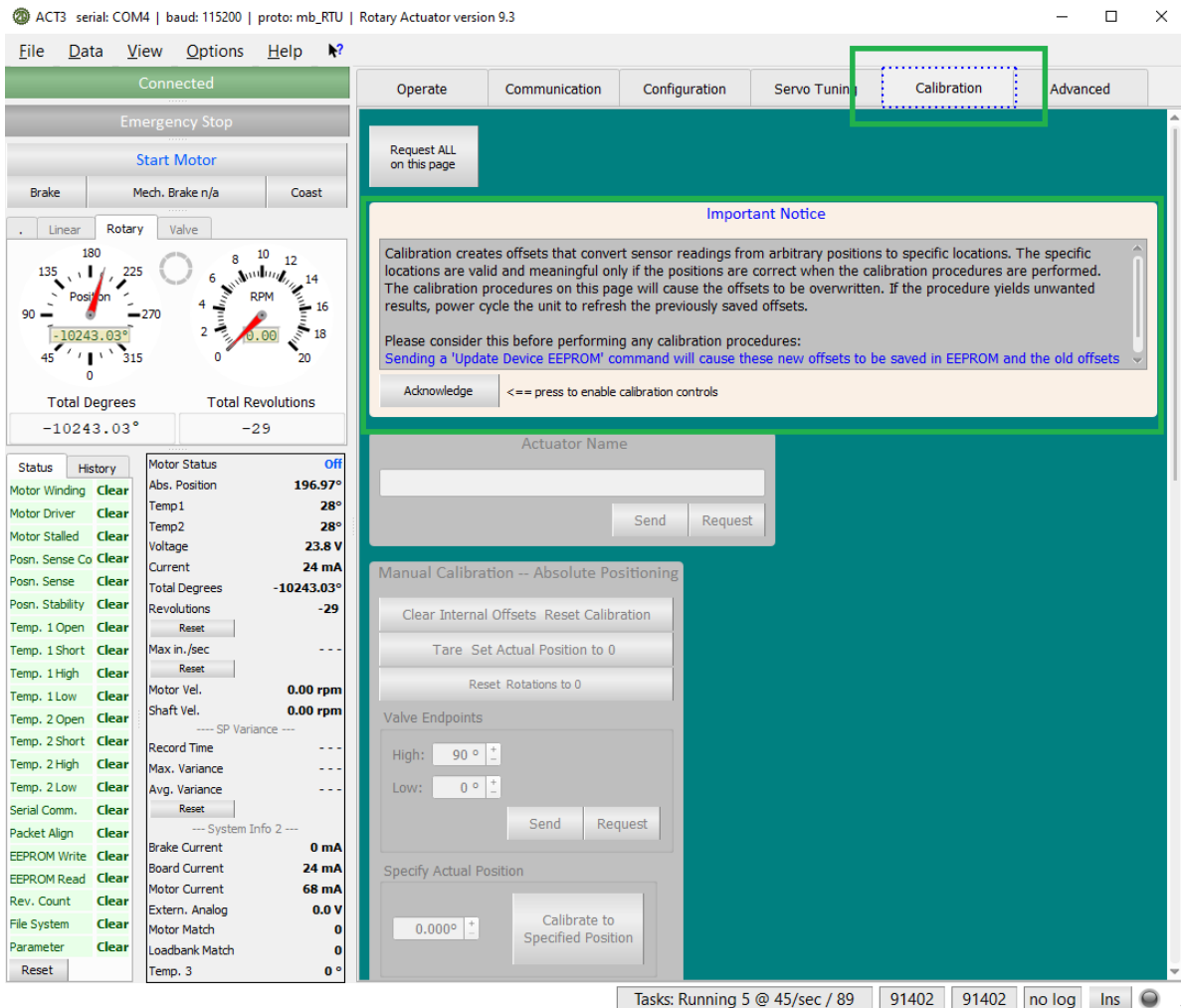


Figure 15: Device Calibration Page

- Enter the previously recorded absolute position into the “Specify Current Position” field. Click the “Calibrate to Specified Position” button. Verify that the reported absolute position has been updated to the specified position. Return to the “Actuator Configuration 1” and “Actuator Configuration 2” tabs and restore any other previously recorded settings.

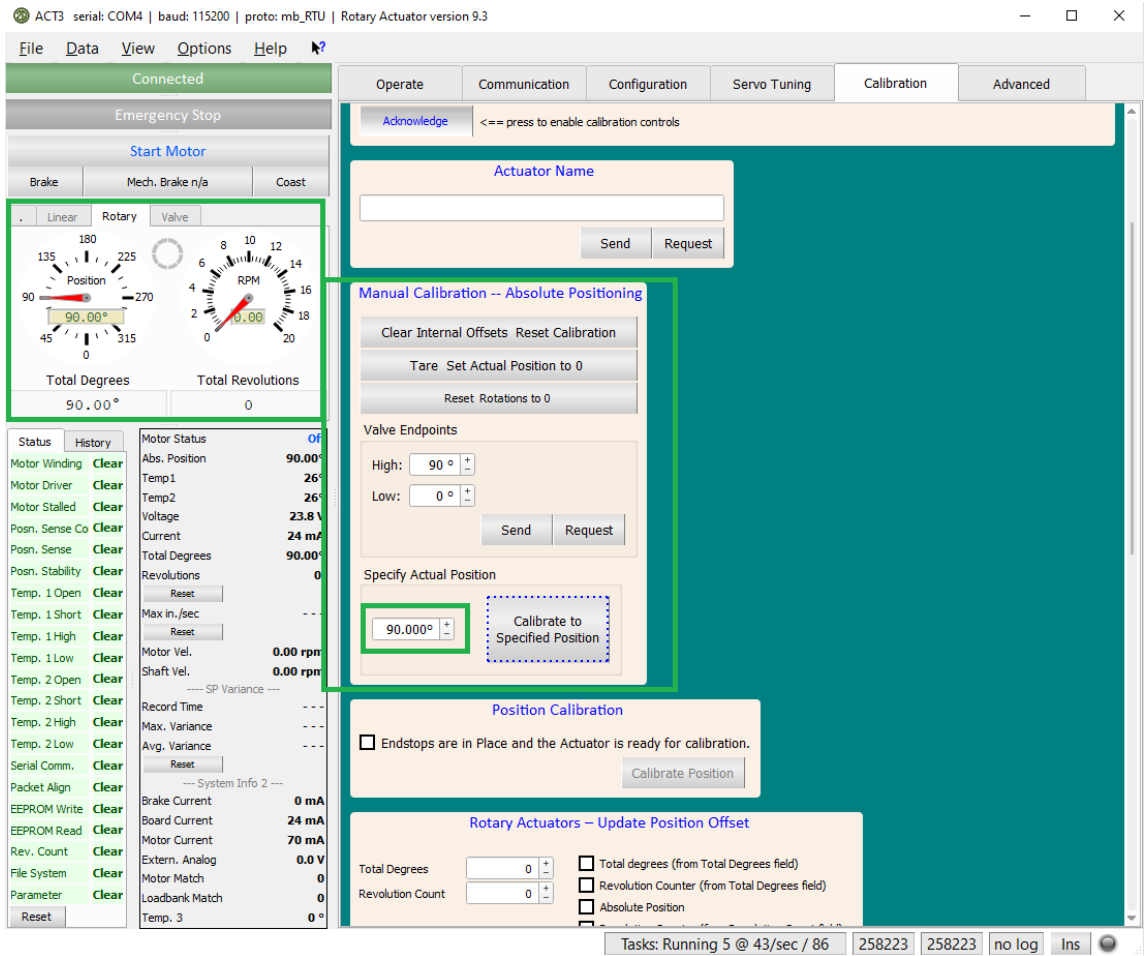


Figure 16: Manual Position Definition



4. In order to have the newly define calibration settings persist across power cycles, the EEPROM must be updated. Switch to the “Communication” tab.
5. Ensure the “Device Programming” checkbox is selected and then click the “Update Device EEPROM” button.
6. Allow at least 5-10 seconds for the save operation to complete.
  - a. NOTE: No visual indication is provided that the EEPROM Update process is underway
7. After the EEPROM has been updated, power cycle the actuator and validate that the reported position is correct. If there is still a deviation between the reported and expected values, repeat the calibration and EEPROM update steps above.

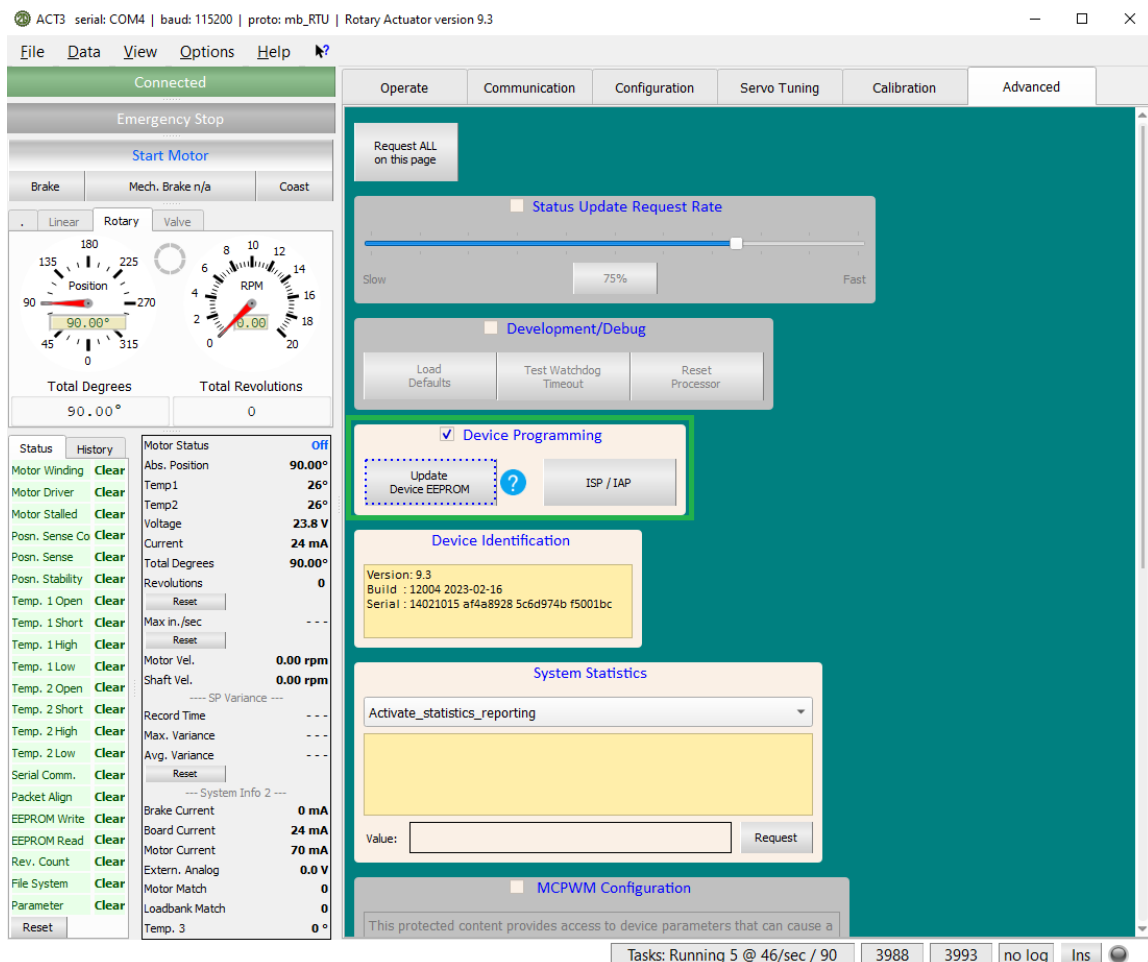


Figure 17: EEPROM Update

## 6. ACTUATOR TUNING

### 6.1 Monitoring Tools

ACT3 supports graph display and data logging features will help the user to verify the proper operation of the servo control system. The chart functionality can be accessed by pressing the “F9” key or navigating to “View” then “Chart” from the application menu. The application has the ability to log and export all of the data from the actuator. Using the “Setup” sub-menu on the Strip Chart windows, the user can modify the parameters that are displayed on the fly.

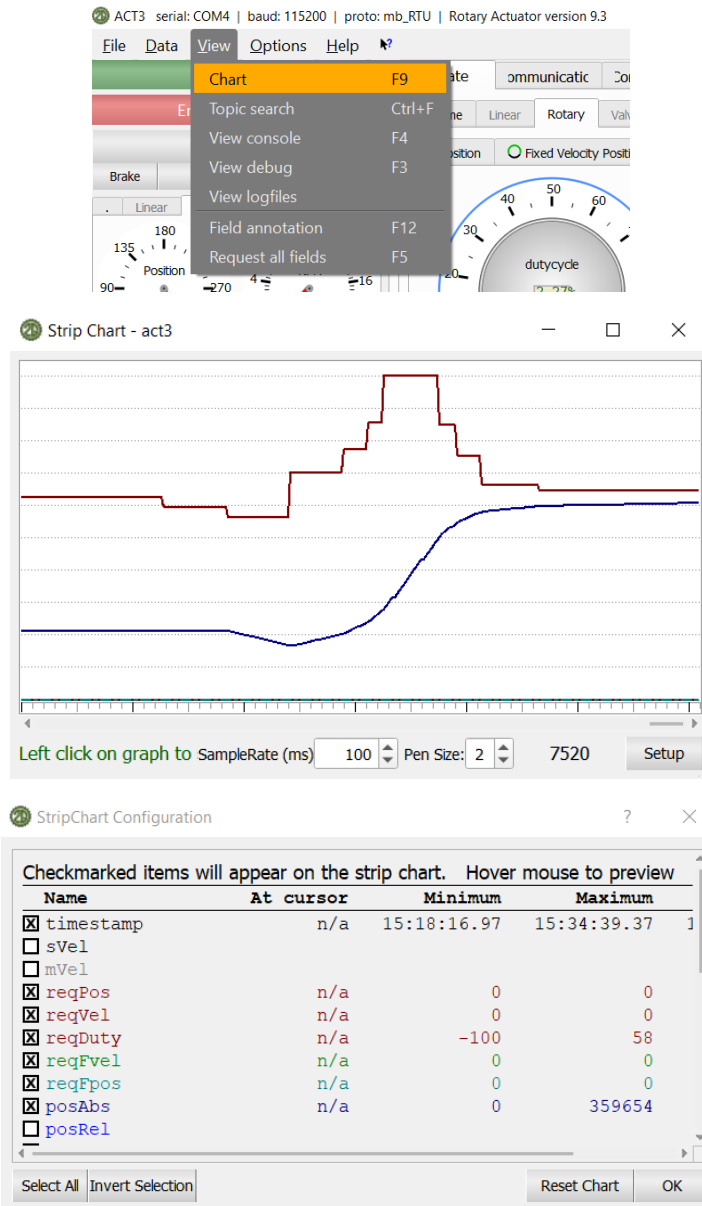


Figure 18: Measurement Charting and Configuration Options

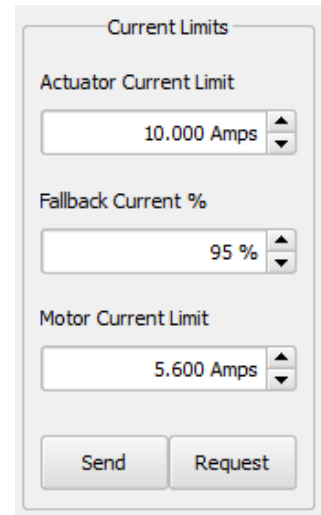
## 6.2 Important Tuning Parameters

### 6.2.1 Actuator Current Limit

NOTE: That the factory default settings can be restored by sending pressing the “Request ALL on this page” button.

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.



Current Limits	
Actuator Current Limit	10.000 Amps
Fallback Current %	95 %
Motor Current Limit	5.600 Amps
Send Request	

### 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.

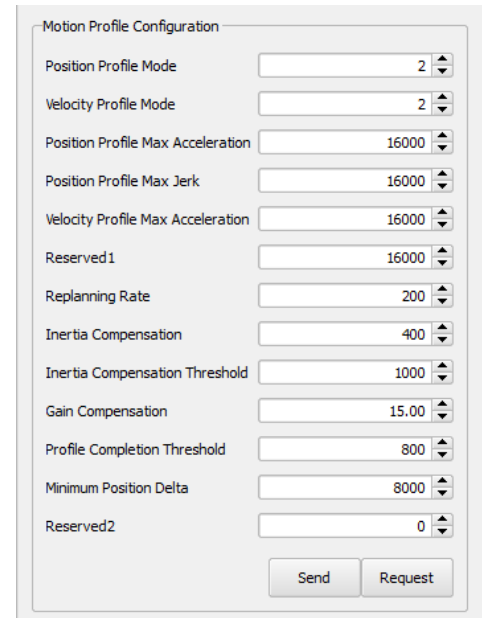
This parameter is independent of actuator operating voltage or speed; the output force will be the same. At higher rates of speed, to maintain a given force, the parameter may have to be increased because the windage losses of the system may also increase.

Figure 19: Current Limit Definition

### 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:



Motion Profile Configuration

- Position Profile Mode: 2
- Velocity Profile Mode: 2
- Position Profile Max Acceleration: 16000
- Position Profile Max Jerk: 16000
- Velocity Profile Max Acceleration: 16000
- Reserved1: 16000
- Replanning Rate: 200
- Inertia Compensation: 400
- Inertia Compensation Threshold: 1000
- Gain Compensation: 15.00
- Profile Completion Threshold: 800
- Minimum Position Delta: 8000
- Reserved2: 0

Buttons: Send, Request

Figure 20: Motion Profile Configuration

Position Profile Mode	Controls whether 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 whether 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 $\geq 10$ .
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:

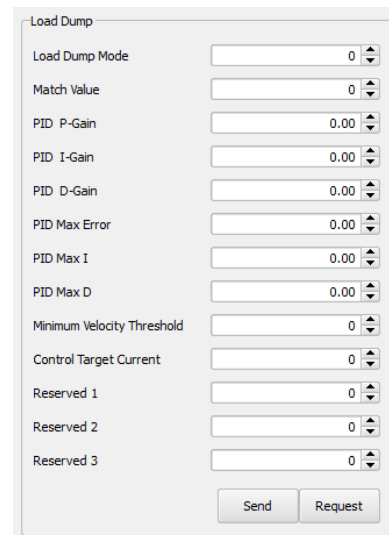


Figure 21: Load Dump Configuration

Load Dump Mode	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.  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.  Operation in manual mode is recommended for testing purposes only, and extended operation at high power may damage the internal load bank.
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	<p>Sets the amount of current (in mA) that the load dump system will attempt to draw in automatic mode.</p> <p>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.</p> <p>A typical value for a 3500 series rotary actuator might be around 1500 mA.</p>
Reserved 1 (Load Dump Load Direction)	<p>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.</p> <p>Set to 1 to only enable the load dump when moving in the forward direction.</p> <p>Set to 2 to only enable the load dump when moving in the reverse direction.</p> <p>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.</p>

### 6.2.5 Stall Detection

If the actuator is installed in a system that 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:

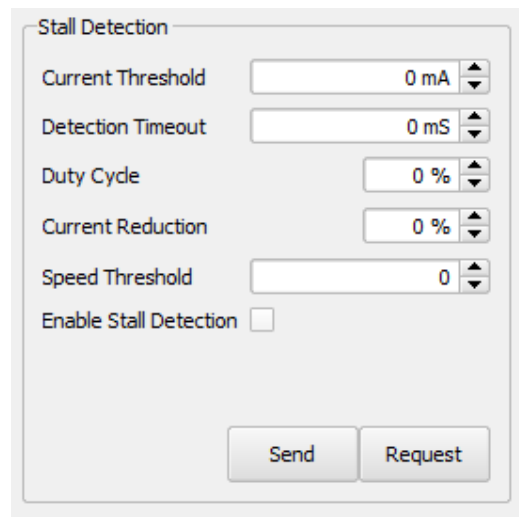


Figure 22: Stall Detection Configuration

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.





### 6.2.6 Gain Scheduling

For some applications (e.g., those requiring an extremely fast response and small settling time), constant PID-gain values will not be sufficient. A high gain value will provide the required dynamic response but will result in instability under steady-state conditions. Reducing the gain will result in stable steady-state operation at the expense of control loop responsiveness. For these applications, gain scheduling may be used to provide both responsiveness and stability. Gain scheduling allows you to set a threshold and scaling factor which will reduce the gain value when the actuator is near the position and/or velocity setpoint. With the appropriate initial gain values, this provides a combination of fast response to setpoint changes and stability under steady-state conditions. Gain scheduling can be configured using the following options:

Enable Gain Scheduling	When selected, the other gain scheduling options will take effect. When not selected, all other gain scheduling options are ignored
Enable Position-Dependent Position Gain Scheduling	When selected, the system will use the specified position threshold and scaling values to update the PID position P-gain in response to the distance between the current actuator position and the current position setpoint. When the distance is less than the threshold, the P-gain value will be multiplied internally by the scaling factor.
Enable Position-Dependent Velocity Gain Scheduling	When selected, the system will use the specified position threshold and scaling values to update the PID velocity P-gain in response to the distance between the current actuator position and the current position setpoint. When the distance is less than the threshold, the P-gain value will be multiplied internally by the scaling factor.
Enable Velocity-Dependent Position Gain Scheduling	When selected, the system will use the specified velocity threshold and scaling values to update the PID position P-gain in response to the difference between the current actuator velocity and the current velocity setpoint. When the difference is less than the threshold, the P-gain value will be multiplied internally by the scaling factor.
Enable Velocity-Dependent Velocity Gain Scheduling	When selected, the system will use the specified velocity threshold and scaling values to update the PID velocity P-gain in response to the difference between the current actuator velocity and the current velocity setpoint. When the difference is less than the threshold, the P-gain value will be multiplied internally by the scaling factor.
Position-Dependent Position Gain Scaling Factor	This value is multiplied by the position P-gain when position-dependent position gain scheduling is enabled and the position threshold condition is met.
Position-Dependent Velocity Gain Scaling Factor	This value is multiplied by the velocity P-gain when position-dependent velocity gain scheduling is enabled and the position threshold condition is met



Velocity-Dependent Position Gain Scaling Factor	This value is multiplied by the position P-gain when velocity-dependent position gain scheduling is enabled and the velocity threshold condition is met.
Velocity-Dependent Velocity Gain Scaling Factor	This value is multiplied by the velocity P-gain when velocity-dependent velocity gain scheduling is enabled and the velocity threshold condition is met.
Position-Dependent Position Scheduling Threshold	When the difference between the actuator's actual position and the actuator's position setpoint is less than this value, the position P-gain scaling factor will be applied. For rotary actuators, this is in milli-degrees. For linear actuators, this is in milli-inches.
Position-Dependent Velocity Scheduling Threshold	When the difference between the actuator's actual position and the actuator's position setpoint is less than this value, the velocity P-gain scaling factor will be applied. For rotary actuators, this is in milli-degrees. For linear actuators, this is in milli-inches.
Velocity-Dependent Position Scheduling Threshold	When the difference between the actuator's actual velocity and the actuator's velocity setpoint is less than this value, the position P-gain scaling factor will be applied. For rotary actuators, this is in milli-RPM. For linear actuators, this is in milli-inches per minute.
Velocity-Dependent Velocity Scheduling Threshold	When the difference between the actuator's actual velocity and the actuator's velocity setpoint is less than this value, the velocity P-gain scaling factor will be applied. For rotary actuators, this is in milli-RPM. For linear actuators, this is in milli-inches per minute.

**6.2.7 Feed-Forward Control**


Feed-forward control can be enabled if a faster response time is desired in the customer application. Feed-forward works by conferring a no-load velocity versus drive command offset value. As an example, when a position error generates a new target velocity, the feed-forward system already knows the motor drive command to generate that velocity; it does not need to wind up the velocity PID control loop to achieve that velocity. This works well for increasing the system response time to a velocity error but should ideally be used in conjunction with a motion profiler to limit system acceleration rates. Feed-forward may be on by default. Please see our [Communications Protocol document \(document #2150080\)](#) for how to configure and use it.

## 7. MAINTENANCE & SERVICE

### 7.1 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.

 <b>CAUTION</b>	<p><b>Regular inspections are suggested to maximize service life of the actuator.</b></p> <p>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.</p> <p><b>Failure to follow these instructions may result in irreparable damage to actuator system components!</b></p>
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### 7.2 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
- Any O-rings
- Any sealing components
- Compensator diaphragms
- Fasteners and internal hardware
- Lubrication

### 7.3 Preventative Maintenance Schedules

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



#### **7.4 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 biofouling around the shaft to top cap seal
- Inspect for biofouling 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

## 8. APPENDICES

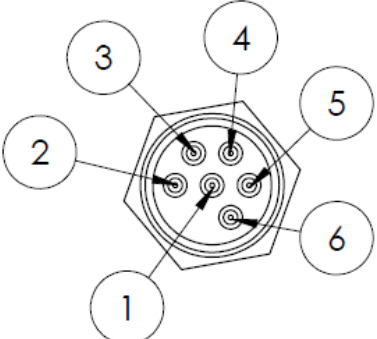
### 8.1 APPENDIX A: PINOUTS

Depending on the model, there can be multiple pinout configurations. Please refer to your unit's datasheet.

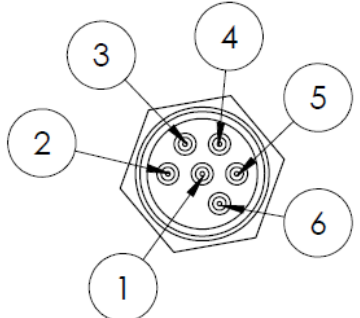
The typical wiring options are listed below:

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

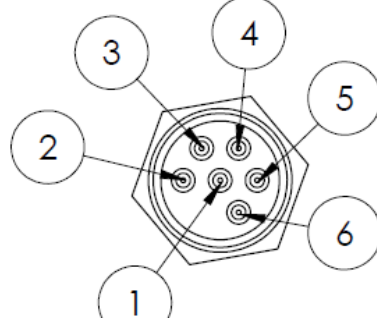
1. Dual "RS-485" and "RS-232" (Most Common)

 <p>Male Plug Face View</p>	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:

 <p>Male Plug Face View</p>	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:

 <p>Male Plug Face View</p>	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

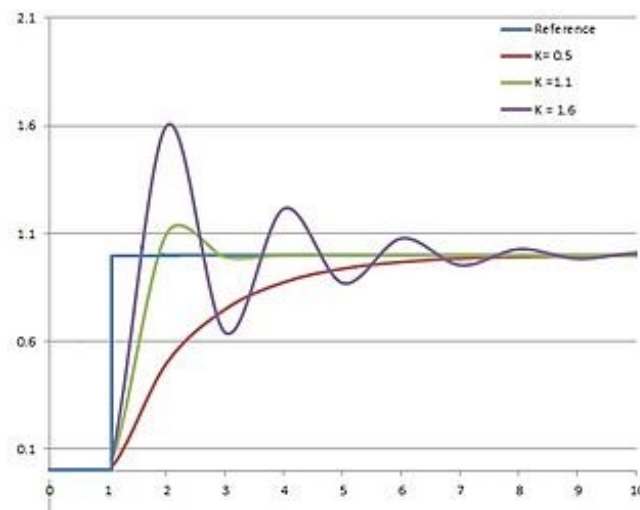
## 8.2 APPENDIX B: PID CONTROL PRIMER

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 for this online.

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 an “Update device EEPROM” command. The “Update device EEPROM” saves the values so that they 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.

### 8.2.1 Proportional Term

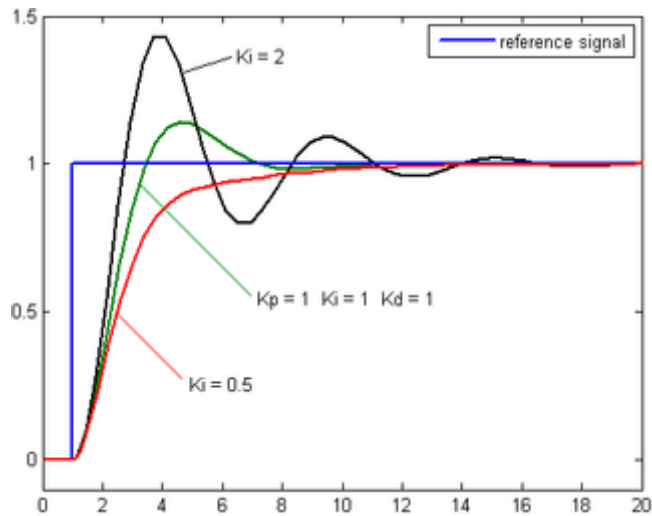


Above is a plot of the set point desired vs actual over time for three values of P-gain. When adjusting the P-gain, one would typically set both the I-gain and the D-gain to 0.

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.

### 8.2.2 Integral Term



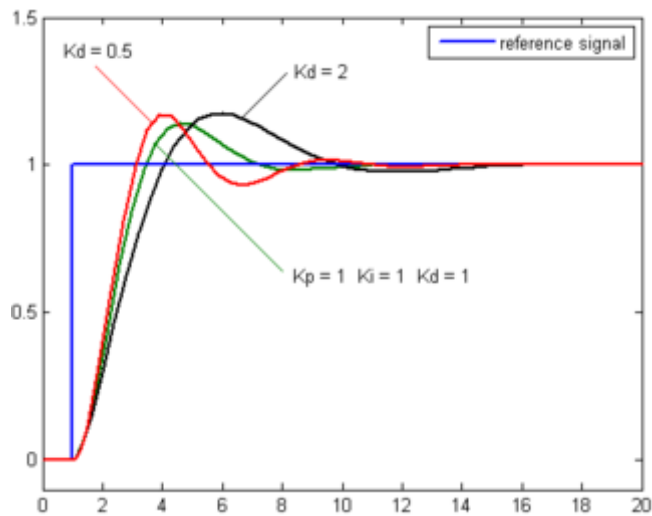
Above is a plot of the set point desired vs actual over time for three values of I-gain. When adjusting the I-gain one would typically leave the P-gain constant and have the D-gain set to 0.

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.



### 8.2.3 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.