Argon user's guide book

Refer to online Wiki for complete documentation

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Contents

Articles

Introduction to ARGON

ARGON Servo Drive

Argon	
	
Device type	Servo motor drive
Model number	ARGON-4K000
Supported motors	AC, DC, BLDC, Linear
Control modes	Position, Velocity, Torque
Status	Active production, started 2013
Electrical	
DC supply voltage	84 - 380 VDC
AC supply voltage	85 - 264 VAC
Output current range	0.1 - 15A
Setpoint signals	Pulse and direction, PWM, Analog, SimpleMotion V2
Feedback devices	Quadrature encoder
General	
Configuration tool	Granity
Agency approvals	CE
3D model	IGES & STEP

Argon is a digital servo drive designed for driving AC/BLDC and DC servo motors in various operating modes.

Features

State of the Art

- High dynamic range torque control
- Wide range motor support, from DC, BLDC, AC and Linear, from 50 W to 1500 W
- Sophisticated dead-time distortion elimination
- Flexible feedback device port supporting incremental, serial and analog encoders and resolvers [1]
- Dual CPU architecture with dedicated open source ARM CPU for user functionality
- High functional density and cost efficiency: all features included in the standard model

Control

- Input setpoint signals including pulse and direction, quadrature, analog and PWM
- Multidrop & multiaxis capable real-time SimpleMotion V2 field bus for setup & control
- Internal axis homing function with sensorless hard-stop operating mode

Protections & Ruggedness

- 3-way Safe torque off with motor braking
- Prevent machine damage via I^2t (motor temperature modeling), blocked motion and tracking error detection
- Industry leading ruggedness: over current, short circuit, over voltage, under voltage and over temperature protections, internally fused, data/communication error detection
- Internal AC inrush current limiter
- Warranty 24 months

[1]) At the moment only incremental encoder feedback is supported, more devices supported in upcoming firmware upgrades

Applications

- Industrial servo control
- CNC
- Precision robotics
- Spindles
- Semiconductor handling
- Food & white goods

Functionality and specifications

See main article Argon specifications.

Documentation & user guides

See the main article Argon setup guide.

Availability

Shipping worldwide at Granite Devices web shop.

Set-up overview & first connection

Argon user guide

Disclaimer: In no event the Product Information or parts hereof shall be regarded as guarantee of conditions or characteristics. The Product Information or any part thereof may also not be regarded as a warranty of any kind. No liability of any kind shall be assumed by Author with respect to Product Information or any use made by you thereof, nor shall Author indemnify you against or be liable for any third party claims with respect to such information or any use thereof.

This is the official and latest setup guide of Argon (servo drive). Read it through before installing or operating Argon.

NOTE: This guide attempts to be as complete and precise as humanly possible, however it can never be perfect. Writers of this guide are not responsible if possible damages or losses caused by mistakes or lacks of this guide.

IMPORTANT: Argon drive should be installed and operated only by qualified electricians. Dangerous voltages and mechanics are involved and possibility of severe injury or even death is possible in case of installation or usage errors.

CURRENT STATUS: This guide is partially work in progress, however complete on the main topics.

Reading the guide

Read trough the guide by **following the outline** and follow the **hyper links** to subtopics provided in the articles. Many useful and important key points are presented as:

Electrical hazard warning (safety)

Warning/Caution (safety)

Machine danger (safety)

Risk of equipment damage

Info

Tip

Articles containing safety & equipment damage related information of Argon

In addition to other documentation, make sure you have carefully read and understood all of the pages containing safety and equipment damage warnings before operating the device:

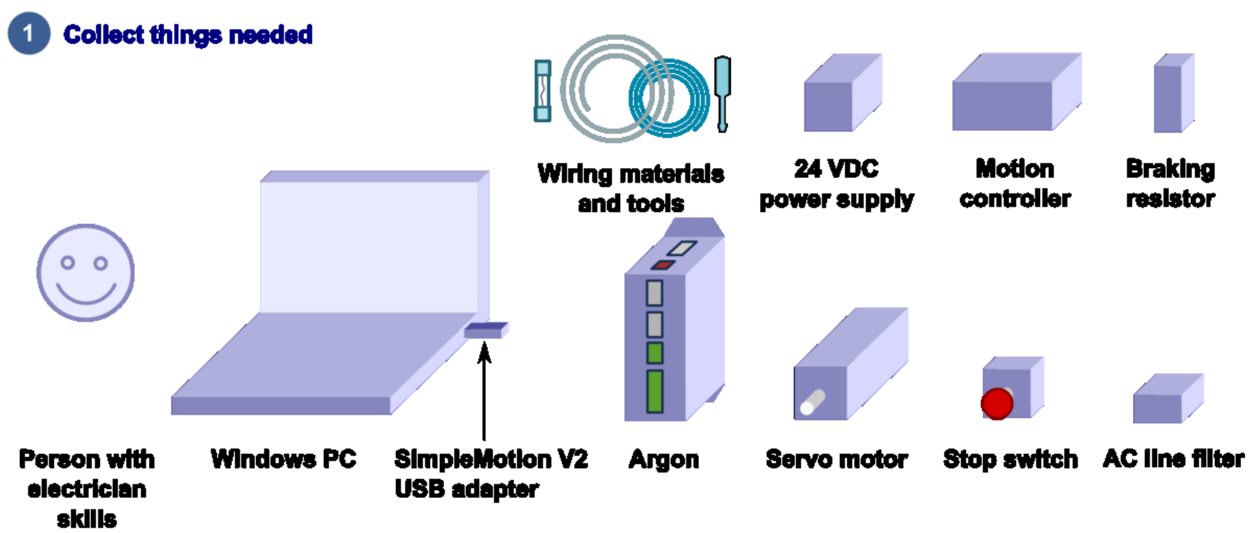
- Argon specifications
- Argon user guide
- Argon user guide/Braking resistor
- Argon user guide/Drive parameterization
- Argon user guide/Earthing
- Argon user guide/J1 connector wiring
- Argon user guide/J4 connector wiring
- Argon user guide/J5 connector electrical interfacing
- Argon user guide/Power supply safe discharging
- Argon user guide/Wiring
- Granity user guide/Connect
- Replacing Argon fuse
- SimpleMotion V2 port

Argon introduction

Argon is a servo motor drive designed by Granite Devices [1]. If you are not familiar with the features and specifications of the drive, see following articles:

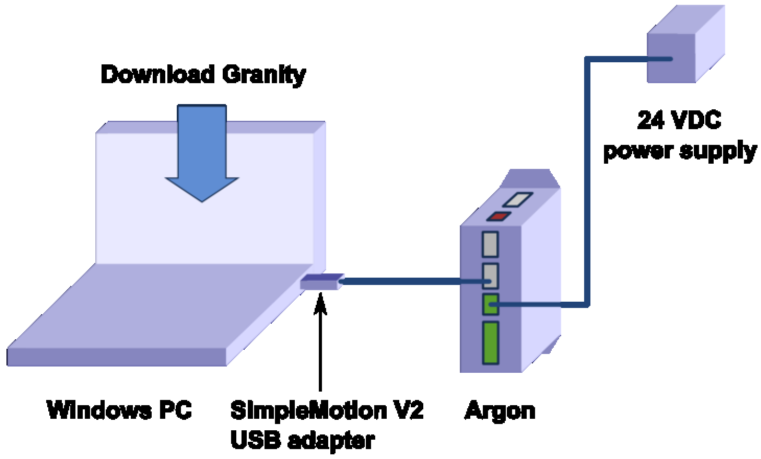
- Argon (servo drive) - overview & features
- Argon specifications - electrical, physical and operating condition specs

The setup process



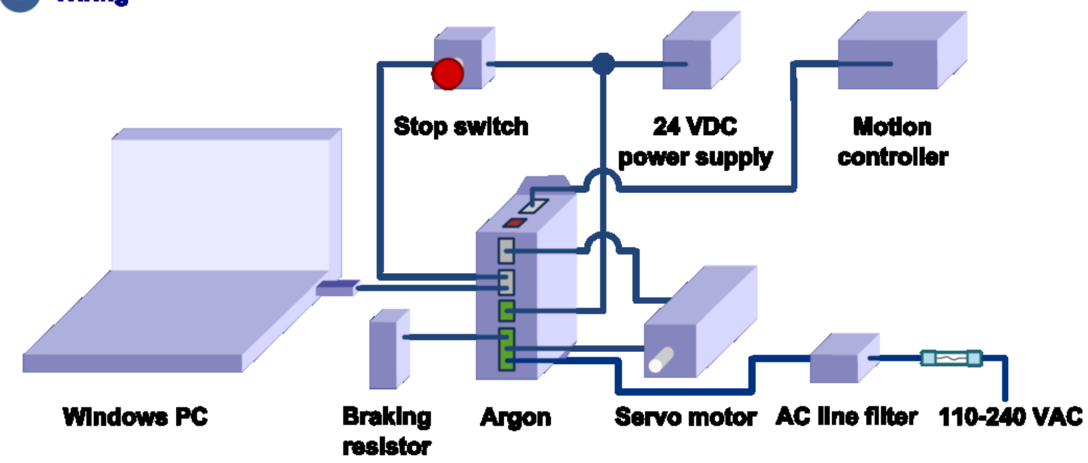
Read the page List of things needed for details.

2 Connect drive to Granity software



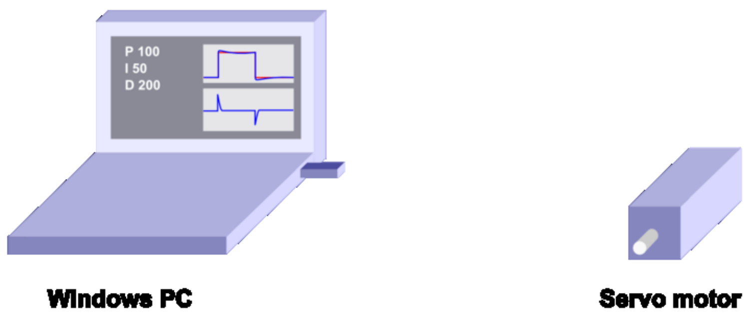
Connect drive to PC with SimpleMotion V2 USB adapter and Granity to test connection, upgrade firmware if necessary and to learn Granity. If you're already familiar with all this, you may skip this step. Read the article Making the first Granity connection

3 Wiring

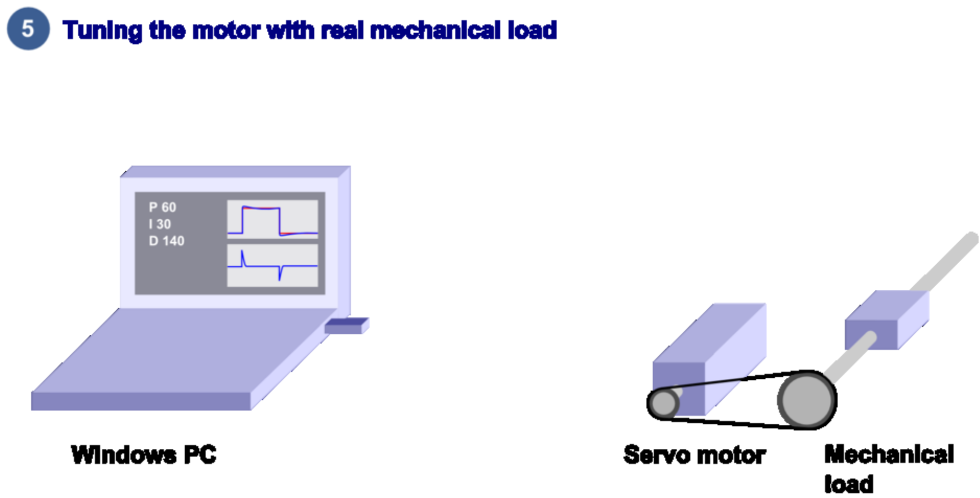


Carefully do the full wiring of the servo system. Consult an qualified electrician if necessary as dangerous voltages will be present. Befower powering up, triple check everything by using multimeter to find short circuits. Read the main article Wiring.

4 Tuning the motor without a mechanical load



Power-up the system and connet again with Granity. Now set-up the motor to work as intented. See the main article Drive parameterization. If you already have a working configuration to your motor model, you may just load the settings file to the drive.



After motor and drive are fully functional, connect motor to the mechanical load and find the optimum velocity or position control gains. Read the main article Servo motor tuning guide.

Troubleshooting

In case of troubles, refer to the articles in general troubleshooting category and Argon troubleshooting category.

References

[1] http://granitedevices.com

Argon user guide/List of things needed

The list of necessary things to build a working servo system with Argon

- Argon drive
- SimpleMotion V2 USB adapter
- 2 or more RJ45 Ethernet cables (see details & examples)
- Regulated 24 VDC power supply, output capability at least 0.5A per drive
- A Argon compatible servo motor
- Shielded power conductors for AC input, motor and braking resistor. Non-shielded will also work but increase EMI.
- Fuses with fuse holder
- Windows PC
- Motion controller. This may be also a software on a computer.

Optional but highly recommended items

- Emergency stop button (normally closed NC type) or equivalent
- Braking resistor
- Ferrite core EMI filters, samples included with Argon package
- AC Power line filter, see list of recommended types here

Needed for high current motors (>4A average)

- A cooling fan and/or additional heat sinks. See list of compatible heat sinks here.

Tools needed

- Screwdrivers
- Wire cutter

Skills needed

- Qualified electrician skills (license to make mains AC connections)
- Basic knowledge of servo systems

Setting device bus address

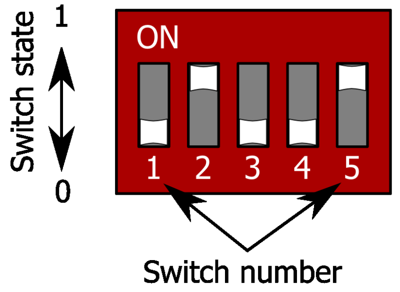
All SimpleMotion V2 compatible devices have a settable address that identifies the device on a multidrop communication bus. Each device sharing the same bus must have an unique address number to make error free communication possible. For example configuring bus address is required to establish a connection with Granity software.

Setting bus address

The method of how address is set depends on device hardware implementation. This chapter lists methods for Granite Devices products.

Argon

Argon (servo drive) has a 5 channel DIP switch that sets the address. The table below lists all possible settings of DIP switch settings. Switches 1-4 set the address and the switch number 5 sets termination on or off.

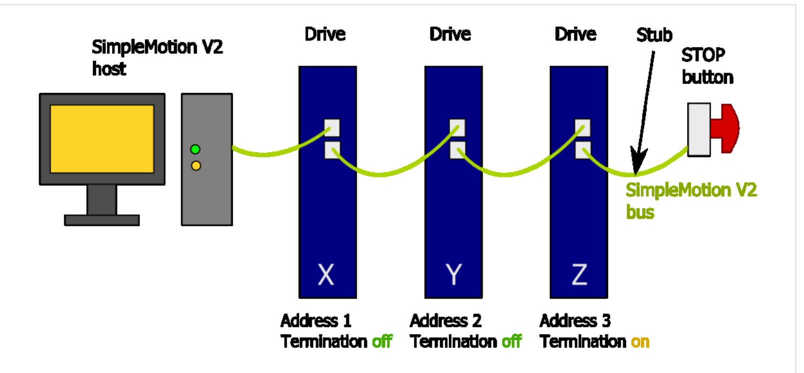


DIP switch of Argon. In this case the DIP has value 01001.

Address	Bus termination	DIP switch setting (switches from 1 to 5)
255 (firmware upgrade mode)	Off	00000
255 (firmware upgrade mode)	On	00001
1	Off	00010
1	On	00011
2	Off	00100
2	On	00101
3	Off	00110
3	On	00111
4	Off	01000
4	On	01001
5	Off	01010
5	On	01011
6	Off	01100
6	On	01101
7	Off	01110
7	On	01111
8	Off	10000

8	On	10001
9	Off	10010
9	On	10011
10	Off	10100
10	On	10101
11	Off	10110
11	On	10111
12	Off	11000
12	On	11001
13	Off	11010
13	On	11011
14	Off	11100
14	On	11101
15	Off	11110
15	On	11111

Bus termination



Proper configuration of devices on a bus

SimpleMotion V2 bus must be terminated for reliable communication. This means that last device of the bus must have termination DIP switch set to On position.

Bus may be also *alternatively* terminated with external 100 ohm resistor connected between RS485_A and RS485_B wires at the end of bus cable chain (see SimpleMotion V2 port). If DIP switch termination is used, then drive internal 100 ohm resistor is connected across the A and B wires.

Stub

If an E-stop button is connected with RJ45 cable after the last device, a bus **stub** is formed. Stub must not be longer than 30 cm or 1 foot to ensure reliable bus operation.

Methods to eliminate the stub on SimpleMotion V2 port cable E-stop cable if longer than 30cm E-stop cable is needed:

- Cut the RS485_A and RS485_B wires from the cable near connector, this ends the RS485 bus next to connector and minimizes stub
- Alternatively, connect termination resistor at end of RS485_A and RS485_B wires and set DIP switch termination off

Troubleshooting

Following errors may cause unreliable connection:

- If two or more devices have same address on a single bus
- If termination is missing or is present multiple times
- If bus stub is too long

Argon user guide/Making the first Granity connection

Follow the instructions to make the first Granity connection to Argon drive.

Preparations

1. Download and install the Granity software. Lates version is downloadable from the link: Granity software [1] for windows (approx 15 MB)
2. Connect PE of J4 connector to protective earth. After that wire 24 VDC power supply to Argon's J3 connector, however do not power up yet.
3. Set Argon DIP switches to give an bus address to the device.
4. Connect Argon J2.1 connector to SimpleMotion V2 USB adapter with a straight Ethernet cable and plug USB adapter to computer.
5. Power up the 24 VDC power. Some leds should start blinking at the drive (more about blinking sequences).
6. Launch Granity software and:
    1. Go to Connect tab
    2. Ensure that "SimpleMotion V2 Adapter" is selected from drowdown list called *Communication interface device*. (note 1)
    3. Click *Connect to drive*
    4. Once list of connected drives pop up, select the one you connected and click *Open*

Now if everything has gone well, you should see information like drive model and serial number on the Connect tab. Connection has been successfully tested and drive may be disconnected to proceed with next setup step.

Note 1) If multiple choices are named as "SimpleMotion V2 Adapter", then try each of them to find the correct one. Also if no adapters found, try launching Granity again as the list updates only at start-up.

References

[1] http://granitedevices.com/assets/files/granity_setup.exe

Wiring

Argon user guide/Wiring

Mechanical installation and cooling

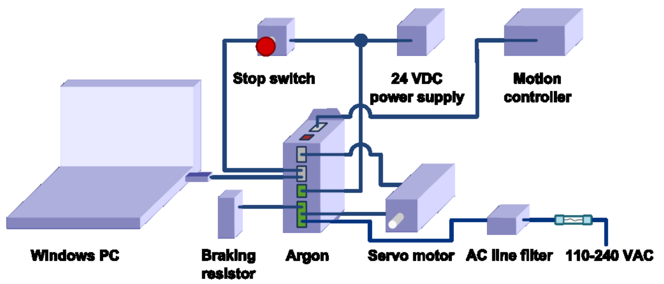
Argon drives should be installed vertically (J5 connector up) with at least 50 mm free air space between the device surfaces and possible cabinet walls to allow heat transfer along the heat sink side of the device.

Cooling may be further by mounting additional heat sinks to the bottom of the device and/or using a fan blowing air from bottom to up. If fan is used, it should have dust filter to prevent dust inside the drives.

Such additional cooling measures are typically necessary only when **average** motor current is higher than 4 Amperes peak value of sine. Most of position control servo systems run cool enough without additional cooling as the load is highly varying and the average output power is low. In any case, it is safe to experiment without cooling as drive's over temperature protection will shut down the drive in case of overheating.

A proper Argon installation orientation and spacing with optional heat sinks and an optional cooling fan. For high power application, replacing also the internal fuse may be necessary.

Wiring overview



The minimum wiring for a servo system (after configuration state)

1. Safety earthing to port J4 and preferably to the Argon case
2. 24 VDC wiring to port J3
3. Safe torque off and enable signals to port J2. See how.
4. Motion controller wiring:
   1. if pulse & direction, analog, PWM or quadrature setpoint signal used, wire signals to port J5
   2. if setpoint delivered over SimpleMotion V2 bus, then a cable from SimpleMotion V2 compatible communication interface device to J2
5. Axis limit switches wired to port J5
6. Feedback device wiring to port J1
7. Motor connection to port J4

8. AC input power to port J4. Use an external fuse with this input.

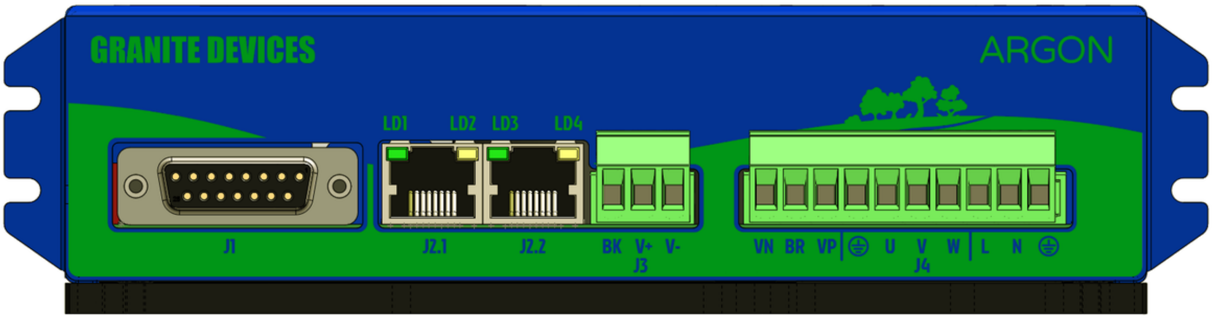
Optional wiring

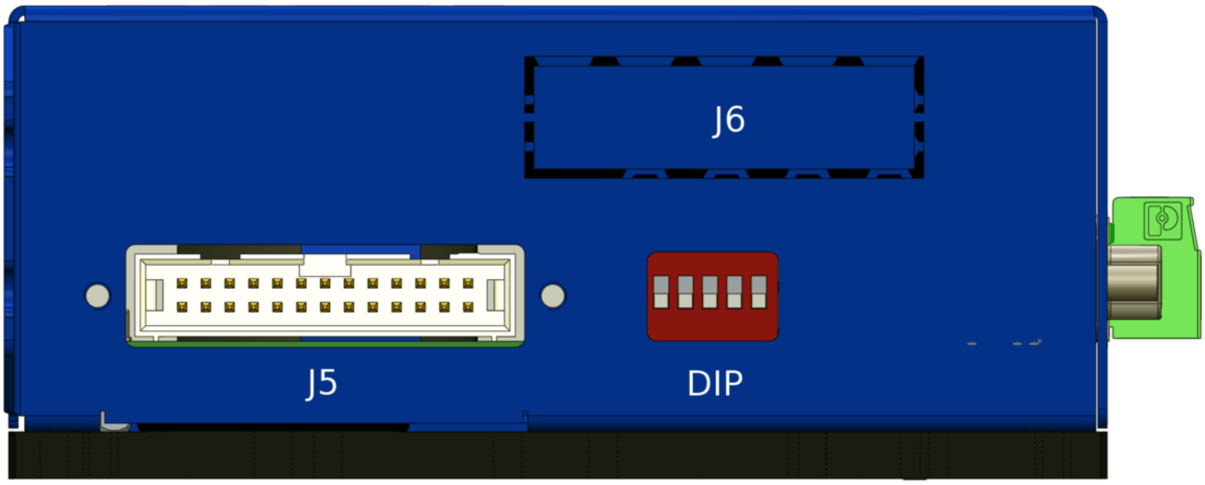
1. AC Power line filter on the wire entering J4
2. Wiring of optional braking resistor to port J4
3. Motor solenoid brake wiring to port J3

Additionally following are required for drive configuration with Granity

1. A cable from SimpleMotion V2 USB adapter to port J2

Ports and connectors





J1 feedback device port

J1 connector type is 15 pin female D-Sub and should be mated with 15 pin male D-Sub counterpart.

For pin-out and connection examples, see the main article J1 connector wiring.

J2.1 and J2.2 Simplemotion & E-stop ports

J2.1 and J2.2 are RJ45 type connectors and mates with standard Cat 5 & 6 Ethernet cables. Both of these ports are connected pin-to-pin parallel to allow chaining of Argon devices.

See the main article SimpleMotion V2 port.

J3 24V power and motor brake port

J3 is a 3 pole terminal block type connector used for supplying 24VDC to drive and optionally controlling motor solenoid brake.

See the main article J3 connector wiring.

J4 power & motor port

J4 is a 10 pole terminal block connector for several functions: earthing, AC power input, motor output, regenerative resistor output and HV DC link sharing.

See the main article J4 connector wiring.

J5 Inputs/Outputs

J5 Is a 26 pin IDC connector [1] located on the side of Argon. The connector serves as general purpose I/O with setpoint signal inputs featuring: limit & home switch inputs, status indicator outputs, analog, pulse and direction, quadrature or PWM types of setpoint inputs and secondary feedback device input.

See the main article Argon I/O connector electrical interfacing for pin-out and wiring guide.

J6 Expansion slot

This slot is reserved for Argon add-on card that may be installed inside the drive.

DIP Switches

DIP switches serves as address selector when connecting the drive to SimpleMotion V2 bus or Granity.

See the main article Setting device bus address.

Mating parts

See list of Argon mating connectors and accessories

Wiring recommendations

Read general wiring recommendations articles at:

- Wire routing recomendations [2]
- Cable shield connection [3]

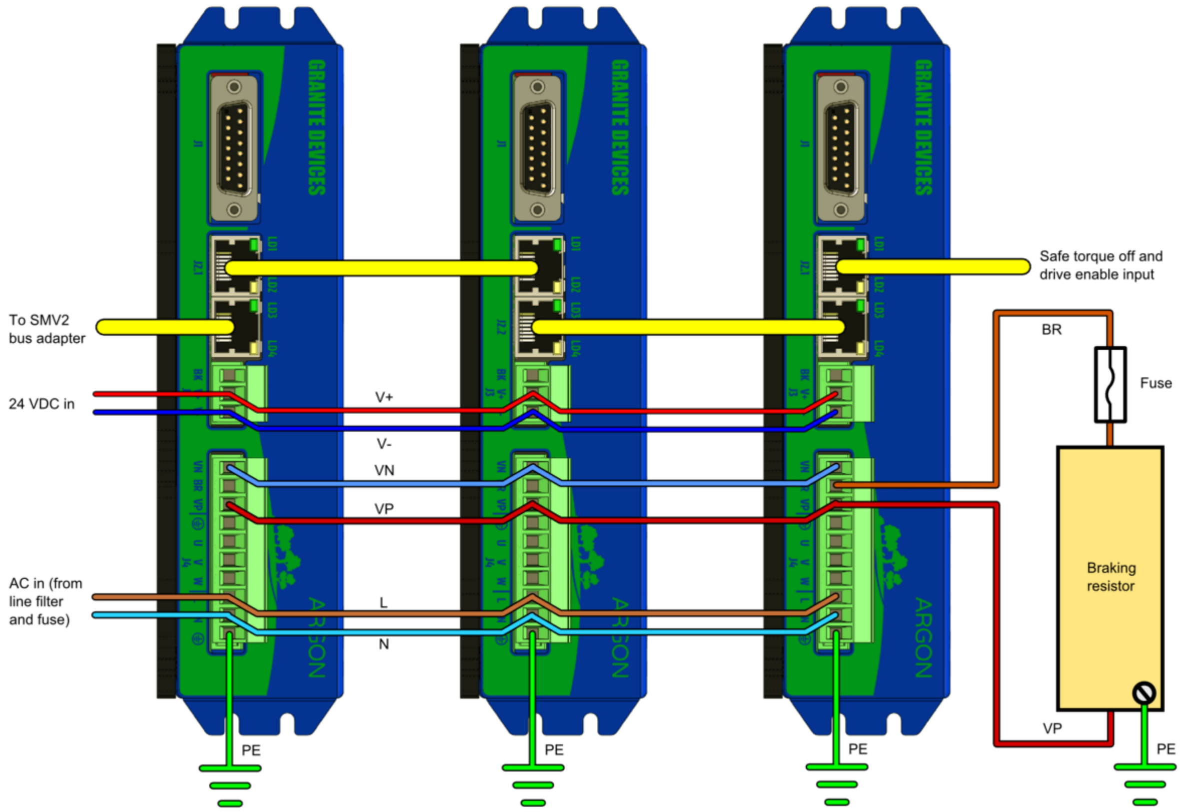
Basic wiring scheme

Before wiring, be sure to read through the main articles regarding J1-J5 ports.

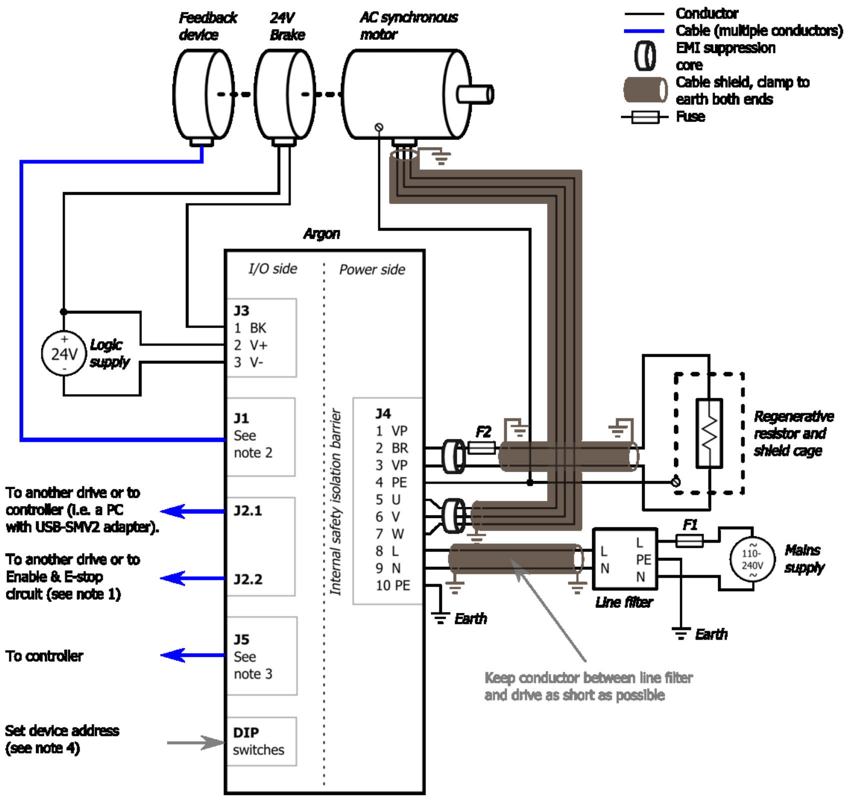
Connecting multiple drives

Note this drawing does not include wiring to motor (J4), motor brake (J3), feedback device (J1), controller (J5) and AC power input circuity.

Using HV DC bus sharing via VP and VN terminals or supplying external DC voltage to them, renders the safe torque off **STO1** input unusable because STO1 is based on by cutting the AC supply. In order to preserve STO1 functionality with DC bus sharing, the STO1 signal must be fed simultaneously to all DC bus sharing drives. If an external DC supply is used (no AC input to L & N), then STO1 will not operate.
STO1 will also be inoperable if DC voltage is supplied to L & N inputs instead of AC. With DC supply, STO1 ibput must be always powered as the internal relay may damage if STO1 used with DC supply.



Wiring of single drive



References

[1] http://en.wikipedia.org/wiki/Insulation-displacement_connector
[2] http://www.electrical-installation.org/enwiki/Wiring_recommendations
[3] http://www.electrical-installation.org/enwiki/EMC_implementation_-_Implementation_of_shielded_cables

Argon user guide/Earthing

Connecting a protective earth to Argon drive is the most crucial single connection to be made. Argon has two earthing methods:

- **Earthing through the J4 PE terminal** (always required)
- **Earthing the device case** (highly recommended and may be required by regulations in some countries)

Supplying power to the drive **without proper earthing** will allow leakage current to raise voltage potential of the device case to hazardous levels. Also ELV circuits (the other ports than J4) may become hazardous without earthing.

Earthing through the J4 PE terminal

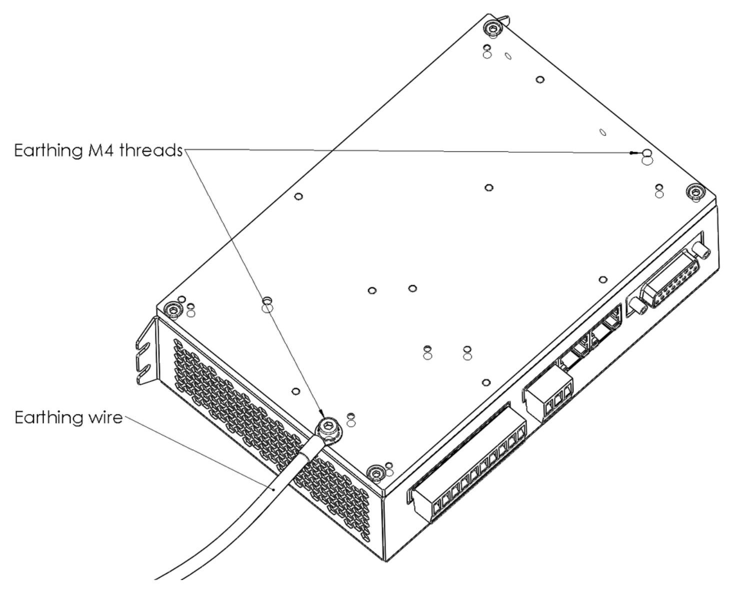
This is a mandatory connection. Follow the Argon wiring instructions.

Earthing the device case

Attaching protective earth wire to the case can provide much lower impedance PE connection compared to the J4 terminal making it highly recommended addition to grounding through J4. Using both of the methods provides redundancy in the case of one method fails.

Parts needed:

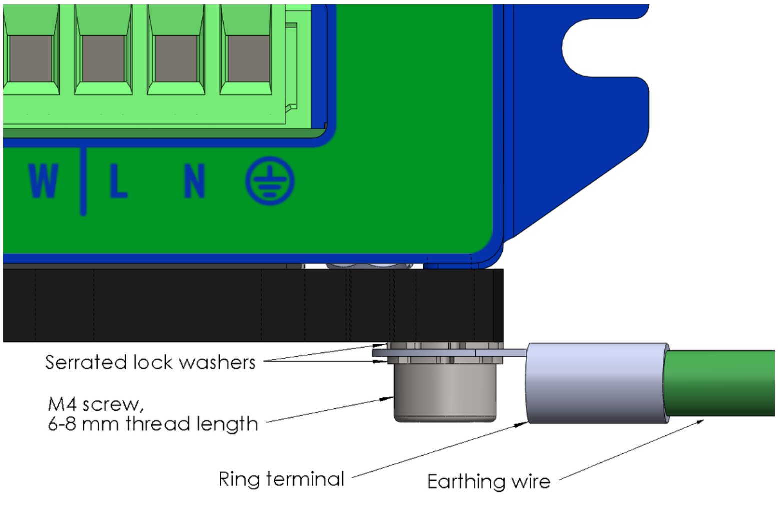
- 1pcs wire ring terminal with 4-5.5 mm hole with at least 20 Ampere capable earthing conductor
- 2pcs M4 serrated/toothed lock washers
- 1pcs M4 screw, 6-8 mm thread length



Earthing points of the case

Verifying connection

After wiring, verify electrical connection by using a resistance meter between the case PE wire and J4 PE terminal while J4 PE wire is not connected.



Proper earthing wire installation with toothed locking washers ensure an electrical contact through surface coatings.

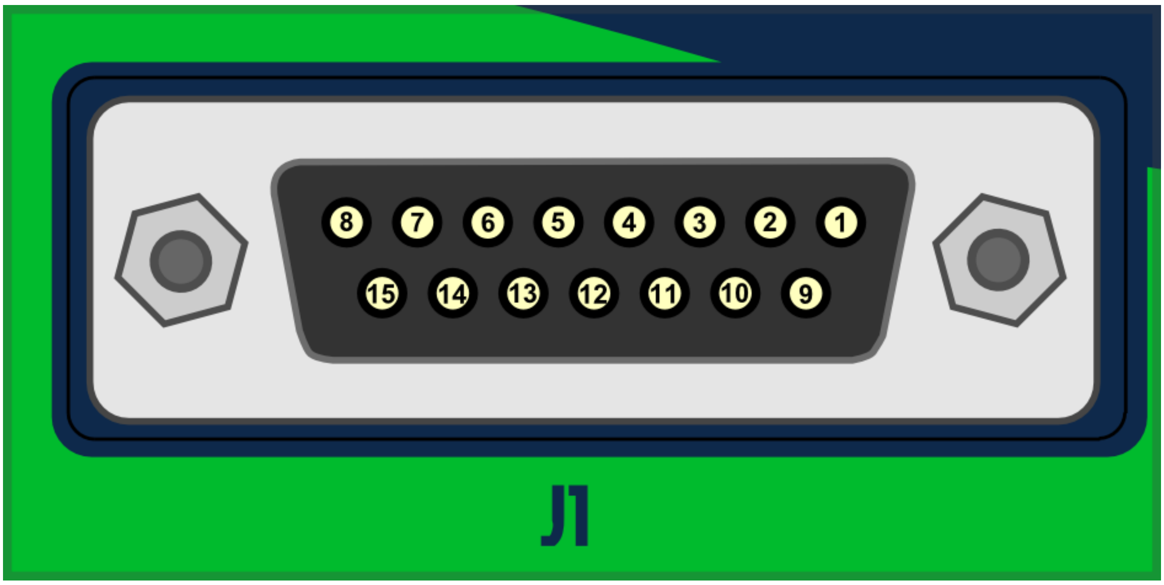
Argon user guide/J1 connector wiring

This page lists most common wiring schemes to Argon feedback device ports. See also the main article Argon user guide/Wiring.

The naming conventions of feedback device wires and signals vary between different manufacturers. The most important things to ensure are:
- proper ground and supply wiring
- sensor voltage levels are compatible

Pin-out

J1 connector type is 15 pin female D-Sub and should be mated with 15 pin male D-Sub counterpart. Many of the J1 pins have dual functions. The operating mode of pin is determined by feedback device mode selected from Granity.



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Pin #	Pin name	Electrical function	Alternate electrical function	Uses
Shell	PE	Earth/case		Feedback cable shield
1	HALL_W	Hall sensor input, phase W	Possible to use as general digital input in custom firmware	Hall sensor input
2	HALL_V	Hall sensor input, phase W		
3	HALL_U	Hall sensor input, phase W		
4	CHE+	Differential input E+	Differential output E+	Serial encoder I/O
5	CHB-	Differential input B-	Analog input B+	Quadrature encoder/SinCos/serial encoder/resolver input
6	CHB+	Differential input B+	Analog input B-	
7	CHA-	Differential input A-	Analog input A-	Quadrature encoder/SinCos/serial encoder/resolver input
8	CHA+	Differential input A+	Analog input A+	
9	5V_OUT	Encoder supply 5V output		Encoder supply
10	GND	Encoder supply ground		
11	CHE-	Differential input E-	Differential output E-	Serial encoder I/O
12	CHD-	Differential input D-	Differential output D-	Serial encoder I/O, resolver coil drive
13	CHD+	Differential input D+	Differential output D+	
14	CHC-	Differential input C-		Encoder index channel/serial encoder input
15	CHC+	Differential input C+		

J1 wiring guide

Incremental encoder

Differential

Differential outputs (RS422 electrical standard) of encoder provides a good EMI immunity and supports long cables with high speed signals. Typical differential encoder has 6-8 wires:

- Ground
- Supply
- Channel A+
- Channel A-
- Channel B+
- Channel B-
- Index+ channel (optional)
- Index- channel (optional)

The negative outputs have the inverted (or mirror image) signal of the positive outputs.

J1 pin #	Pin name	Pin function	Encoder wire
Shell	PE	Earth/case	Cable shield
5	CHB-	Differential input B-	Channel B-
6	CHB+	Differential input B+	Channel B+
7	CHA-	Differential input A-	Channel A-
8	CHA+	Differential input A+	Channel A+
9	5V_OUT	Encoder supply 5V output	Encoder supply
10	GND	Encoder supply ground	Encoder ground
14	CHC-	Differential input C-	Index- channel
15	CHC+	Differential input C+	Index+ channel

Pins not listed in the table are left open or used for other functions such as Hall sensor.

Single ended

Single ended output type is usually one of the following:

- Open collector outputs
- TTL outputs
- CMOS outputs

Typical single ended encoder has 4-5 wires:

- Ground
- Supply
- Channel A
- Channel B
- Index channel (optional)

J1 pin #	Pin name	Pin function	Encoder wire
Shell	PE	Earth/case	Cable shield
6	CHB+	Differential input B+	Channel B
8	CHA+	Differential input A+	Channel A
9	5V_OUT	Encoder supply 5V output	Encoder supply
10	GND	Encoder supply ground	Encoder ground
15	CHC+	Differential input C+	Index channel

Pins not listed in the table are left open or used for other functions such as Hall sensor.

Hall sensor

Some AC/BLDC/Linear motors are equipped with a Hall sensor which allows faster drive initialization after power-on as phase search can be skipped. Hall sensor is also necessary in the case where motor is not able to move freely in both directions when powered on (i.e. if axis rests at the end of mechanical travel or is vertical axis).

Many Hall sensors have differential outputs (non-inverted and inverted channels, just like differential encoder), however Argon has only single ended Hall sensor inputs which supports both output types (single ended and differential).

It is possible to connect a Hall sensor together with other feedback devices to the same port. In such case supply pins may be shared between multiple FBD's.

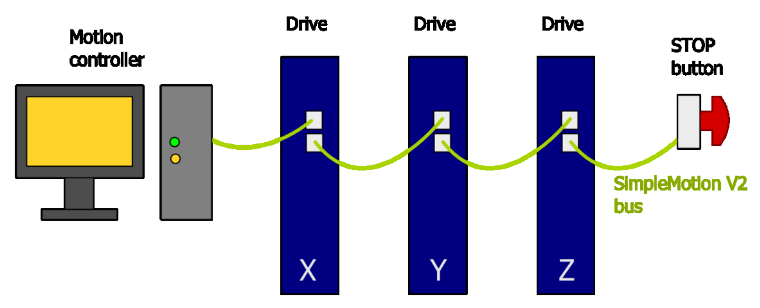
J1 pin #	Pin name	Electrical function	Hall sensor wiring
Shell	PE	Earth/case	Feedback cable shield
1	HALL_W	Hall sensor input, phase W	Hall sensor W (if differential, then W+ channel)
2	HALL_V	Hall sensor input, phase V	Hall sensor V (if differential, then V+ channel)
3	HALL_U	Hall sensor input, phase U	Hall sensor U (if differential, then U+ channel)
9	5V_OUT	Encoder supply 5V output	Hall sensor supply
10	GND	Encoder supply ground	Hall sensor ground

Pins not listed in the table are left open or used for other functions such as Hall sensor.

SimpleMotion V2 port

SimpleMotion V2 communication link and Argon drives use RJ45 [1] connectors and cables as physical connection standard.

RJ45 is well known from Ethernet connectors and same cables may be used with SimpleMotion wiring.



SM V2 multidrop bus with E-stop functionality

Electrical properties

SimpleMotion V2 uses RS485 electrical serial communication standard for all data transfer. Some main benefits of using RS485 are:

- Multidrop buses possible (up to 32 devices in single serial link)
- High reliability due to differential signaling
- High data rates and long cable lengths possible
- Easy to interface even from smallest microcontrollers with UART

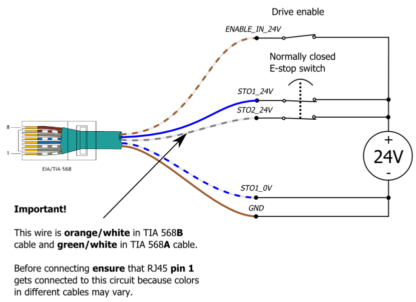
- Low wire count, only 2 signal wires + ground needed
- Bidirectional data transfer (receive & transmit) in one wire pair

RJ45 cable compatible with Ethernet and SimpleMotion V2

As default SimpleMotion V2 uses 460800 BPS bitrate and can deliver over 10 000 motion commands per second.

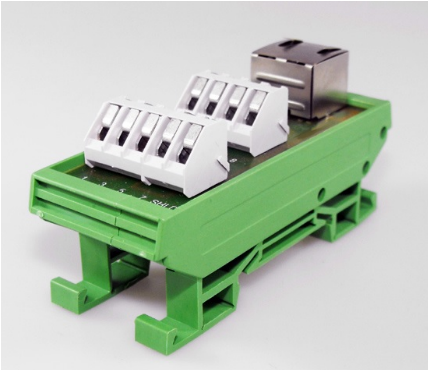
Use as E-stop & Enable input

In Argon drive, the same connector acts also as emergencecy stop or Safe torque off input. User may connect a e-stop button directly at the end of device chain to gain reliable stopping mechanism for all linked devices.



E-stop and enable signal wiring to RJ45 cable

A quick'n'dirty way to make enable drive & disable safe torque off connection. May be used for testing before final wiring.



A RJ45 break-out terminal may be useful for wiring of the STO and Enable signals.

Connector pinout

Pin #	Signal name	Description	Electrical wiring
1	STO2_24V	STO input 2	Supply 24VDC in this pin referenced to GND to disable STO2. [1]
2	Reserved	Reserved for future use	Do not connect
3	RS485_A	RS485 signal A	RJ45 cable routes this between devices and SimpleMotion V2 USB adapter
4	STO1_24V	STO input 1 24V in	Supply 24VDC between STO1_24V and STO1_0V to disable STO1. STO1 inputs are floating and isolated from GND. [1, 2]
5	STO1_0V	STO input 1 0V in	
6	RS485_B	RS485 signal B	RJ45 cable routes this between devices and SimpleMotion V2 USB adapter
7	ENABLE_IN_24V	Drive enable control signal	Supply 24VDC in this pin referenced to GND to set drive in enabled state.
8	GND	Ground reference for: RS485, STO2 and ENABLE_IN	RJ45 cable routes this between devices and SimpleMotion V2 USB adapter. For enable & STO connect this to external 24V power supply ground.

1) STO1 and STO2 are controlling two independent Safe torque off methods. Both must be supplied 24V simultaneously to enable torque to the motor.

2) STO1 has limited functionality on Argon if HV DC bus is shared between drives or external DC voltage is supplied. For more info, see Argon user guide/J4 connector wiring.

Even when RJ45 connector and cables are being used in Ethernet and SimpleMotion, these protocols are not electrically compatible. Never connect SimpleMotion device to Ethernet device.

Don't use crossover [2] cables in SimpleMotion V2 system

References

[1] http://en.wikipedia.org/wiki/Modular_connector#8P8C
[2] http://en.wikipedia.org/wiki/Ethernet_crossover_cable

Argon user guide/J3 connector wiring

Argon's J3 is a 3 pole terminal block type connector used for supplying 24VDC to drive and optionally controlling motor solenoid brake.

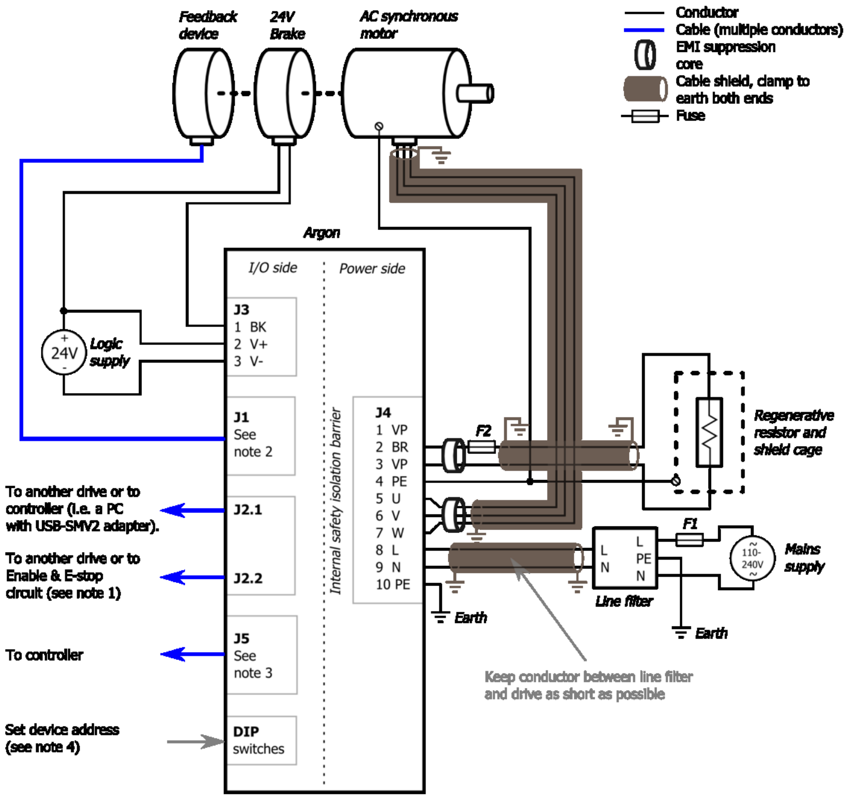
Pin-out

Pin #	Pin name	Description	Connection
1	BK	Motor brake output	If motor has a 24V solenoid brake, connect brake between BK and V+
2	V+	24V supply positive input	Connect to 24V PSU +
3	V-	24V supply ground, on J1, J2.x and J5 connectors tied to GND	Connect to 24V PSU -

24VDC typical current consumption is between 0.1 - 0.7ADC depending on how much current is drawn by feedback device and an optional motor brake.

Wiring guide

Brake output is optional and may be left unconnected if brake is not present in the axis.



Argon user guide/J4 connector wiring

J4 is a 10 pole terminal block connector for several functions: earthing, AC power input, motor output, regenerative resistor output and HV DC link sharing. See also the main article about Argon wiring.

Dangerous & non-isolated mains potential voltages are present in the connector J4! Keep away from this connector and its wiring when drive has been powered recently. Carefully read the page Power supply safe discharging before operating.

Pin-out

Pin #	Pin name	Descrpition	AC/BLDC motor connection	Brush DC motor connection
1	VN	HV DC link negative rail	Do not connect, unless linking multiple drives with VN & VP to share their internal power supplies and braking resistor.	
2	BR	Braking resistor output	Optional braking resistor terminals. See Argon braking resistor	
3	VP	HV DC link positive rail		
4	PE ▯	Protective earth	Connect to motor PE conductor and motor cable shield	
5	U	Motor phase output	Motor U phase [1]	Motor armature+
6	V	Motor phase output	Motor V phase [1]	Motor armature-
7	W	Motor phase output	Motor W phase [1]	No connection
8	L	AC mains supply Line	Connect to AC supply line	
9	N	AC mains supply Neutral	Connect to AC supply neutral	
10	PE ▯	Protective earth	Connect to supply protective earth. This connection is always mandatory when any voltage larger than 30 VAC or 42 VDC is supplied to the device!. See Argon user guide/Earthing.	

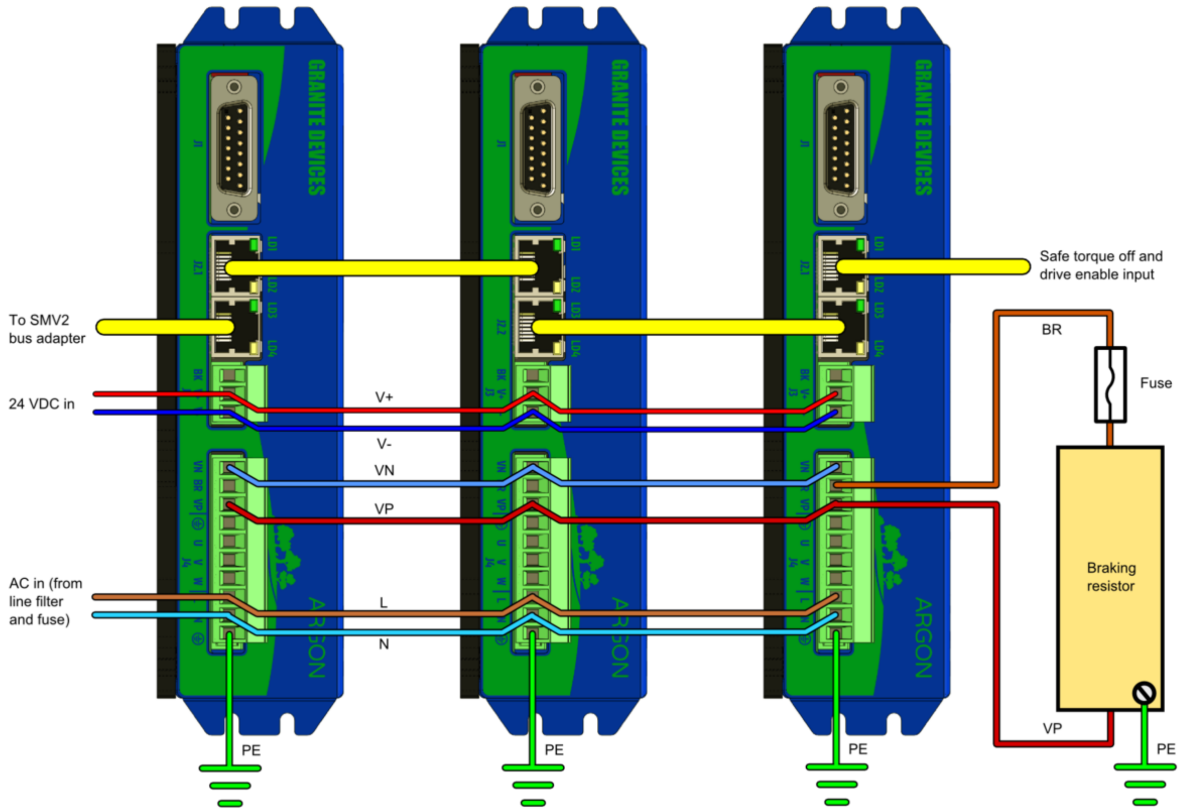
[1] In some motors U,V,W phases are called R,S,T instead.

J4 wiring guide

Wiring multiple drives with power supply & braking resistor sharing

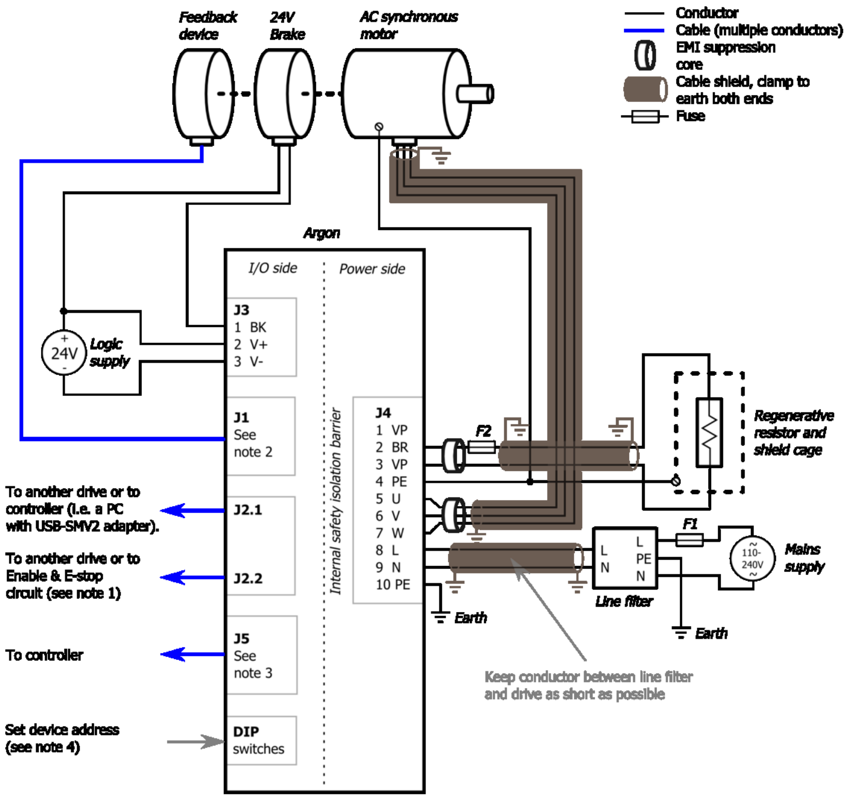
Note this drawing does not include wiring to motor (J4), motor brake (J3), feedback device (J1), controller (J5) and AC power input circuity.

Using HV DC bus sharing via VP and VN terminals or supplying external DC voltage to them, renders the safe torque off STO1 input unusable because STO1 is based on by cutting the AC supply. In order to preserve STO1 functionality with DC bus sharing, the STO1 signal must be fed simultaneously to all DC bus sharing drives. If an external DC supply is used (no AC input to L & N), then STO1 will not operate.
STO1 will also be inoperable if DC voltage is supplied to L & N inputs instead of AC. With DC supply, STO1 ibput must be always powered as the internal relay may damage if STO1 used with DC supply.


To SMV2
bus adapter
24 VDC in
AC in (from
line filter
and fuse)
V+
V-
VN
VP
L
N
PE
PE
PE
Safe torque off and
drive enable input
BR
Fuse
Braking
resistor
VP
PE
GRANITE DEVICES
ARGON

Detailed single drive wiring schematics

Basic wiring scheme of Argon (servo drive). Use of shielded cables is optional but highly recommended for EMI compliance and optimal reliability. For recommended accessories, EMI filters etc, see Mating connectors and accessories.



Argon user guide/J5 connector electrical interfacing

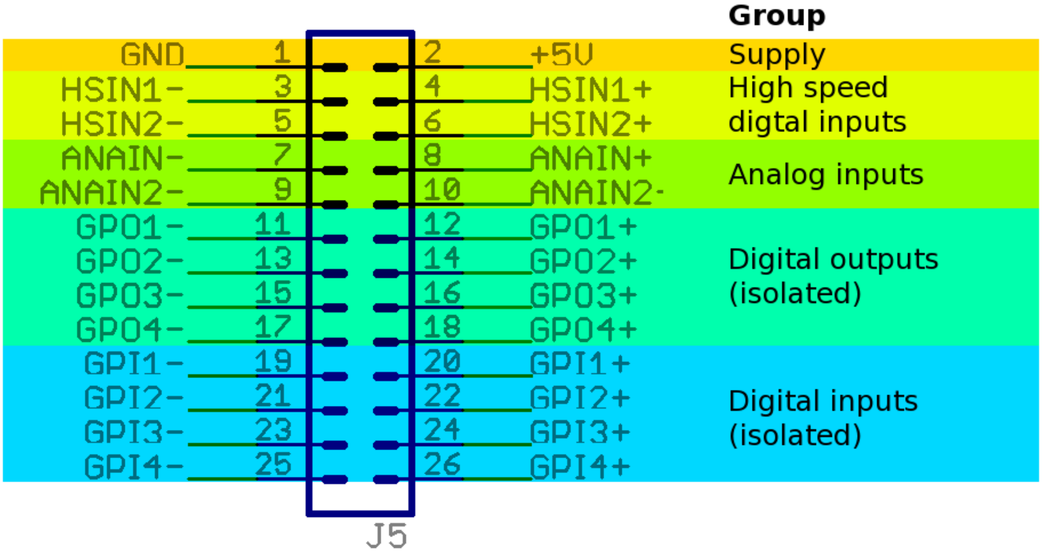
This article explains the internal circuity behind J5 connector of Argon servo drive.

Exceeding ratings may affect drive operation and cause instability or even damage the drive.

J5 connector pin-out and electrical ratings

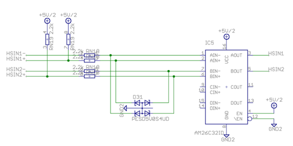
- Overview: Argon wiring
- I/O electrical ratings: Argon specifications

Pin groups

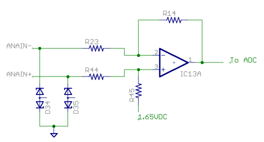


Internal schematics of pin groups

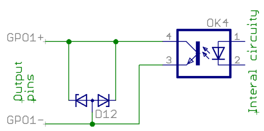
These images show the circuity behind the J5 connector inside the Argon drive (simplified schematics). Left side end represents J5 pins and right side continues to drive internal circuity.



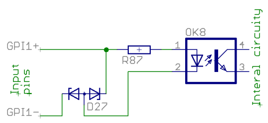
High speed digital input circuity inside the drive. Total 1 of these circuits.



Analog input circuity inside the drive. Total 2 of these circuits.



Digital output circuity inside the drive. Total 4 of these circuits.



Digital input circuity inside the drive. D27 protects optocoupler from reverse polarity and ESD. Total 4 of these circuits.

Pin-out

Pin #	Pin name	Electrical	Isolated	Function[1]
1	GND	Supply	No[2]	Ground
2	+5V_OUT	Supply		5V output
3	HSIN1-	High speed digital input		Pulse train, Quadrature A channel or PWM input setpoint
4	HSIN1+	High speed digital input		
5	HSIN2-	High speed digital input		Pulse train direction, Quadrature B channel
6	HSIN2+	High speed digital input		
7	ANAIN1-	Analog input		Analog input setpoint
8	ANAIN1+	Analog input		
9	ANAIN2-	Analog input		Direction reversal signal for analog input setpoint signal.
10	ANAIN2+	Analog input		
11	GPO1-	Digital output	Yes[2]	Servo ready status. True when drive is initialized and ready to accept user commands/setpoint.
12	GPO1+	Digital output		
13	GPO2-	Digital output		Position/velocity control mode tracking error warning status. True when tracking error has reached more than user configured 1/8 of fault limit value or when drive is not enabled. May be used by controller to throttle the setpoint thus avoid triggering an tracking error fault. May require FW upgrade.
14	GPO2+	Digital output		
15	GPO3-	Digital output		Fault stop status. True when drive is stopped due to fault.
16	GPO3+	Digital output		
17	GPO4-	Digital output		Braking status. Set true when drive attempts to brake motor.
18	GPO4+	Digital output		
19	GPI1-	Digital input		Home switch input.
20	GPI1+	Digital input		
21	GPI2-	Digital input		Positive feed enable input. Used for axis limit switches.
22	GPI2+	Digital input		
23	GPI3-	Digital input		Negative feed enable input. Used for axis limit switches.
24	GPI3+	Digital input		
25	GPI4-	Digital input		Clear drive faults input. Transition from false to true attempts to reset active faults of drive. If drive is simultaneously in enabled state, motor will start moving immediately.
26	GPI4+	Digital input		

[1]) This is the default function with stock firmware. Function may be different in future or custom firmware versions.

[2]) Non-isolated lines are referenced to GND pin / J3 V- terminal. Isolated lines have functional isolation between GND and other isolated +-/- pairs.

Wiring guide

Supply

Supply pins output a regulated 5V voltage to external circuits. GND pin is tied to J3 connector V- terminal.

Electrical properties

- Output voltage 4.9-5.2 V
- Maximum load 500 mA
- Maximum injected current -10 mA

Never connect multiple supply outputs parallel. Supply output may be connected only current consuming circuity to prevent current injection to the supply port.

High speed digital input group

HSIN is differential digital input capable of receiving digital signals up to 4 MHz.

Electrical properties

- Maximum voltage to HSINx+/- pins referenced to GND: -0.5 to 6V. Nominal 3.3 or 5.0V.
- Maximum injected current +/- 10 mA
- When negative input (HSINx-) is left floating, it floats around 2.5V
- Input state reads logic 1 when voltage on positive pin is greater than voltage on negative pin, otherwise it's logic 0

Wiring when driving using differential source

- Positive outputs of source to HSINx+
- Negative outputs of source to HSINx-
- GND must be connected to source ground

Wiring when driving using single ended source (TTL, CMOS or open collector)

- Outputs of source to HSINx+
- Leave HSINx- floating
- GND must be connected to source ground

Analog input group

Analog input accepts ±10V from and may be used as setpoint signal. Electrical properties

- Input impedance ~10 kΩ
- Maximum ANAINx+/- pin voltage vs GND ±25V
- Maximum injected current ±10 mA
- Sampling resolution 12 bits

Wiring to differential signal source

- Connect positive output to ANAINx+
- Connect negative (inverted) output to ANAINx-
- Connect source ground to GND

Wiring to single ended signal source

- Connect output to ANAINx+
- Connect source ground to ANAINx-
- Connect source ground to GND

Wiring to 0-10V analog output with digital direction output:

- Follow the earlier guidelines but connect controller's direction signal to ANAIN2+ and the ground reference of digital output to ANAIN2-. Setpoint gets inverted inside the drive if ANAIN2 voltage is between 3-24VDC and non-inverted between 0-3VDC. May require FW upgrade.

Digital output group

Digital output is an optoisolated transistor output to drive various types of inputs of target devices (logic gates, relays, lights etc) Electrical properties

- Load voltage range 3-24V
- Maximum allowed load 50 mA
- Logic 1 state equals conducting state of optocoupler transistor (current flows from GPO+ to GPO- pins), logic 0 stops current flow between GPO+ to GPO- pins.
- + to - pin voltage drop at 50 mA less than 2 VDC

Wiring to logic gate input (CMOS or TTL)

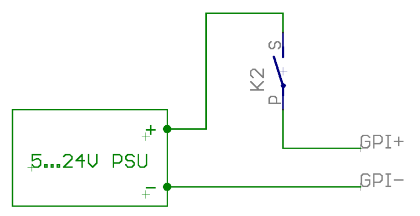
- Connect GPO+ pin to target VCC (typ 5V)
- Connect GPO- pin to target input pin (so input pin is pulled to 5V when output state is logic 1)

Multiple GPO's may be wired parallel to combine multiple status signals into one wire. In such connection the combined output becomes logic 1 (conductive) if any of the paralleled outputs becomes logic 1.

Digital input group

Digital inputs are optoisolated (floating potential) inputs for general purpose control signals. Electrical properties

- Signal voltage range 3-24V
- Logic 0 when difference between +/- inputs less than 1.5V, logic 1 when voltage is between 2.9-25V
- Current needed to drive logic 1 is 0.8-9 mA depending on input voltage
- Maximum voltage difference between GPIx+/- inputs 27 VDC
- Maximum voltage difference between GPIx+/- inputs vs GND 120 VDC



Connection from electromechanical switch or relay to isolated digital input. PSU may be external power supply or 5V supply from J5 connector.

Connection to electromechanical switch or relay

- See schematics image in right side

Connection to CMOS source

- Connect source output to GPIx+ input
- Connect source ground to GPIx- input

Connection to open collector or TTL source

- Connect source output to GPIx- input
- Connect source VCC (typ 5V) to GPOx+ input

Digital input and output isolation is only functional and does not provide safety insulation. Connect only to ELV circuits [1].

Examples

Wiring axis limit and home switches to J5

To operate the motor, limit switches must be connected to the GPI1 and GPI2. Feeding logic 1 to one of these ports enables axis motion feed in certain direction.

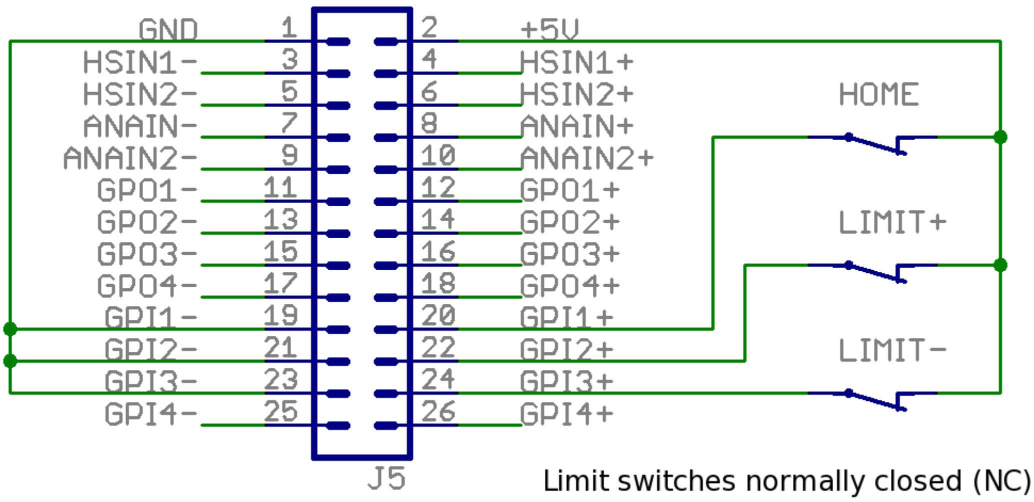
The behavior of feed enable signals can be configured via Granity machine tab. Logic 1 to these pins is required for drive operation:

- GPI1 - enable positive direction feed.
- GPI2 - enable negative direction feed.

Home switch (optional):

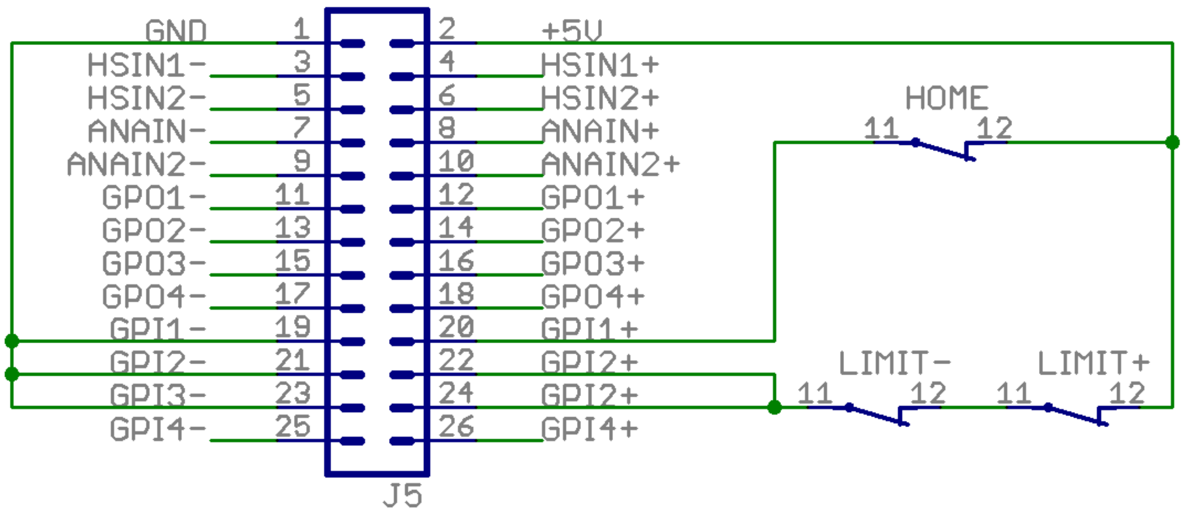
- GPI3 - home switch input. Polarity can be configured via Granity.

In the image below A way to connect switches to J5 port. Inputs are supplied by the J5 connector 5V output. Alternatively the switches may be also supplied from an external 5-24VDC supply.



Limit switches normally closed (NC)

The example below illustrates an alternative way of connecting limit switches that are connected in series. However this way requires that axis is being manually pulled away from end of travel if either switch is open as drive doesn't know which way is the safe running direction.



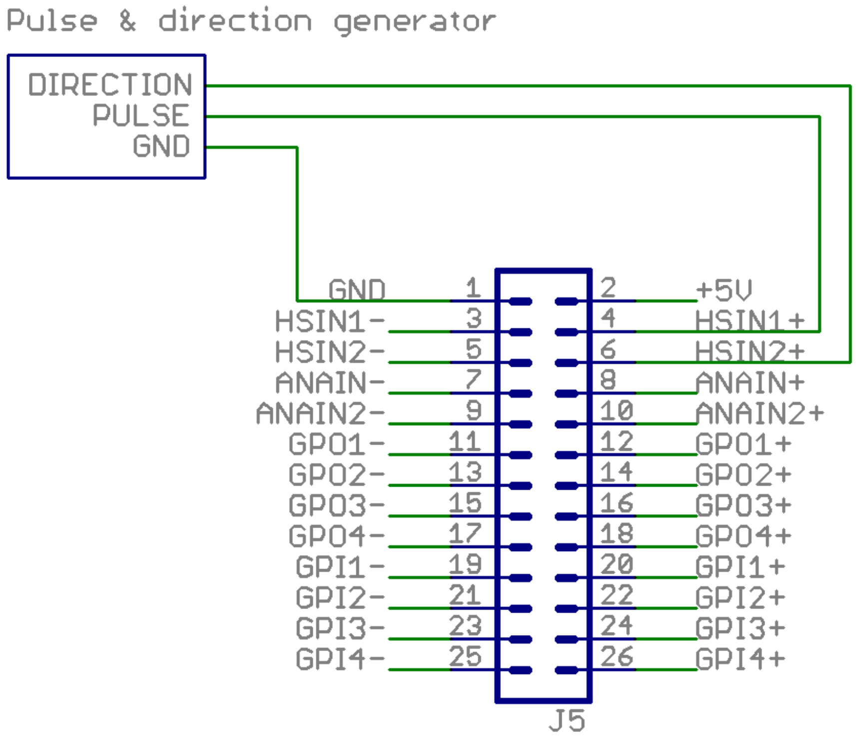
Alternative limit switch wiring considerations

It is possible to connect limit switches several way, or omit them completely. The table below summarizes the different methods:

Method #	Connections / configurations	End of travel causes a fault stop state	End of travel causes active braking of motor	Can move motor electrically out end of travel	Remarks
A	Connect limit switches independently to GPI2 and GPI3 inputs	Yes (but depends on parameterization)	Yes (but depends on parameterization)	Yes	This is the most typical method used
B	Connect limit switches in series to GPI2 and GPI3 inputs parallel	Yes (but depends on parameterization)	Yes (but depends on parameterization)	No	Drive has info only that limit switch is open but no info about which way is safe to move
C	No limit switches, instead use homing function (position control mode only) and set soft travel limits by parameterization	No	Yes	Yes	Sensorless & wireless solution
D	Connect limit switches Safe torque off input	Yes	No, motor may free wheel	No	A very secure way to remove torque from motor. If such feature is desired, it's recommended to install second pair of limit switches or use soft travel limits that stop motion *before* the STO switches, so STO switches would serve only as backup.
E	Connect limit switch to enable drive input	No	Yes	Yes	

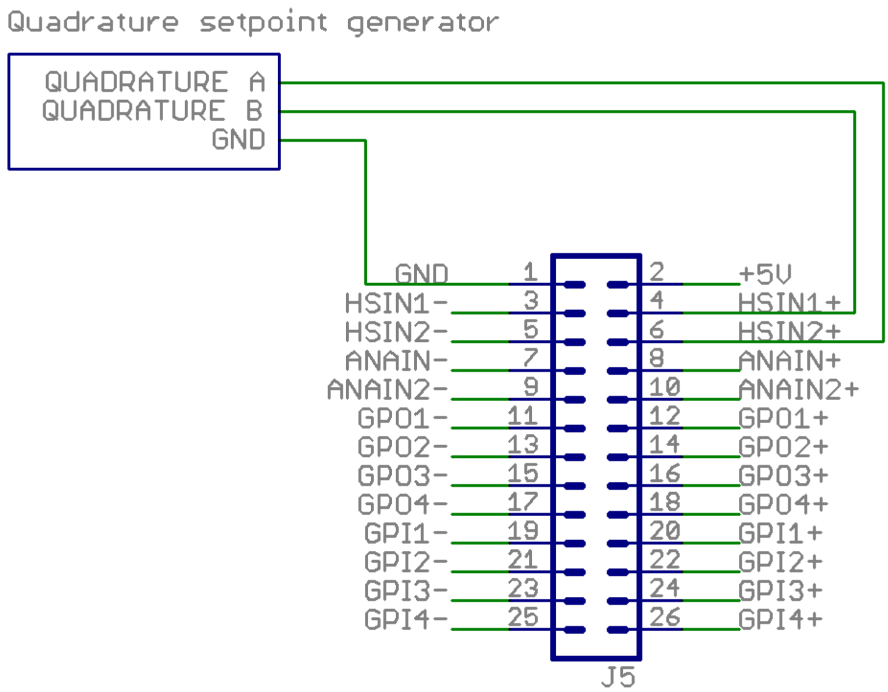
Pulse and direction setpoint

This example shows how to wire a typical single ended pulse and direction controller.



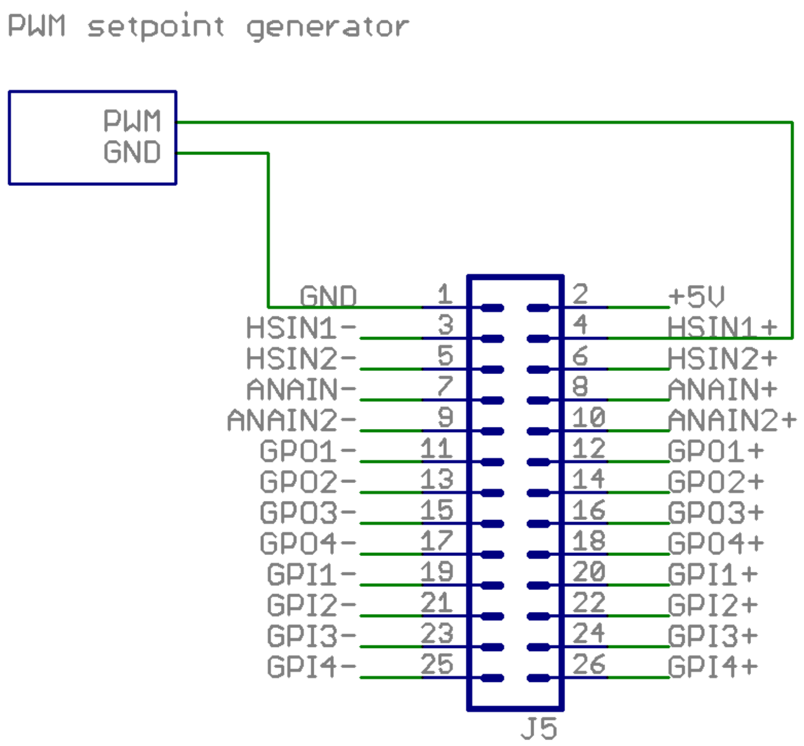
Quadrature signal setpoint

This example shows how to wire a typical single ended quadrature controller.



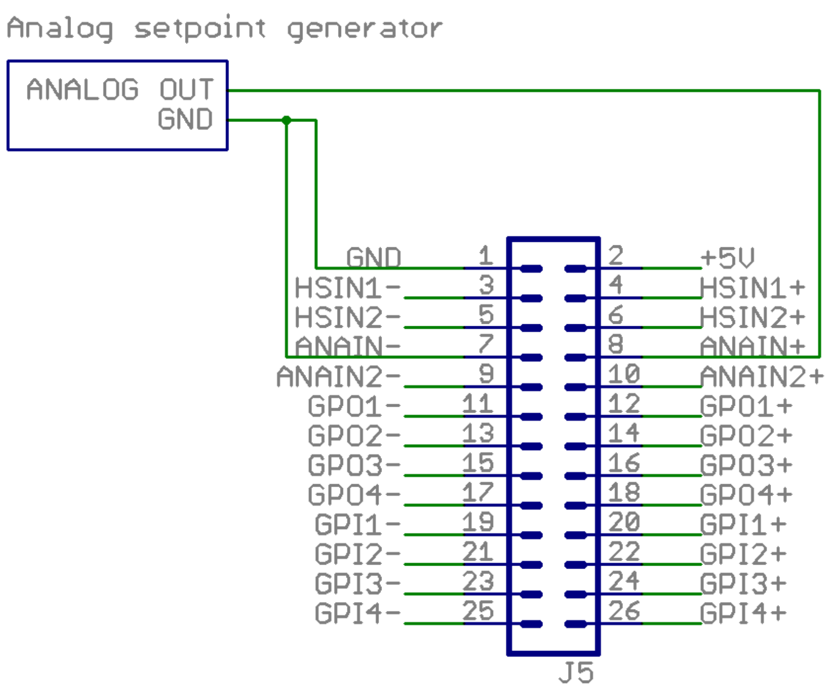
PWM signal setpoing

This example shows how to wire a typical single ended PWM controller.



Analog signal setpoint

This example shows how to wire a typical single ended Analog setpoint controller. Maximum analog signal voltage is +/-10V.



0-10V analog input with digital direction signal

Follow the earlier guidelines but connect controller's direction signal to ANAIN2+ and the ground reference of digital output to ANAIN2-. Setpoint gets inverted inside the drive if ANAIN2 voltage is between 3-24VDC and non-inverted between 0-3VDC. May require FW upgrade.

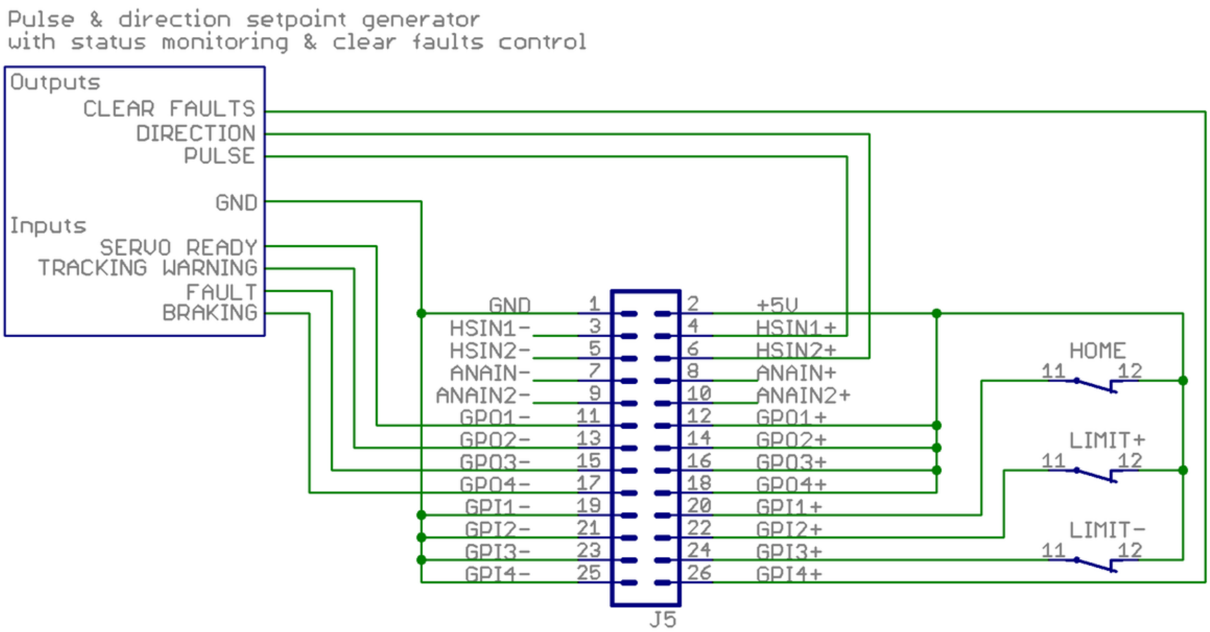
Complete example with pulse & direction

The examples above can be combined to achieve the user goals. The example below has complete set of I/O features used.

- Pulse & direction set point
- Clear faults output (off-on-off pulse generated by controller user if FAULT input goes on)
- Monitoring of drive state: servo ready, tracking error warning, drive fault, motor braking status
- Axis limit switches & home switch

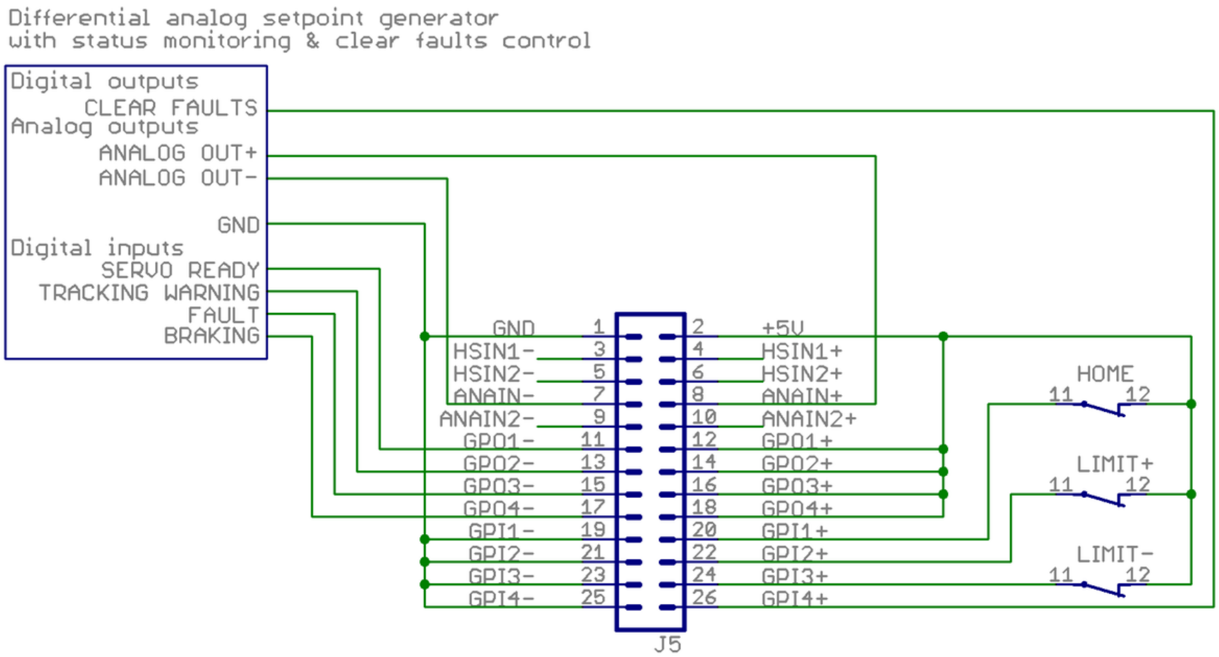
Notes:

- The controller in the example has 5 volt single ended inputs & outputs
- Controller inputs have pull-down resistor or other means to ensure *off* or 0 state when input is floating
- It's not required to to monitor & control the I/O lines at controller



Complete example with differential analog setpoint

Same as above expect this time the setpoint signal is a differential analog voltage output (max +/-10V).



References

[1] http://en.wikipedia.org/wiki/Extra-low_voltage

Argon user guide/Braking resistor

Regenerative resistors are usually a required part with servo drives to absorb returned energy from decelerating or braking servo axis.

Servo drive with motor can act two ways: energy supply and energy generator. The generator behavior occurs during decelerations and this causes current flow from motor to drive power supply capacitors. If that generated energy is not absorbed anywhere, the voltage of capacitors will rise above overvoltage threshold and trigger an software clearable overvoltage fault.

Argon supports connecting braking resistor directly to drive J4 connector.

250 Watt 82 ohm regenerative resistor suitable for Argon drive

Suitable resistor type

Characteristics of Argon regenerative resistor output:

Property	Value	Units
Maximum current	6	A
Series fuse	8	A
Minimum resistance @ 230 VAC supply	70	Ω
Minimum resistance @ 115 VAC supply	35	Ω
Resistor power dissipation	0-2400[1]	W

[1]) Power dissipation depends on how much system's kinetic energy is directed to the resistor

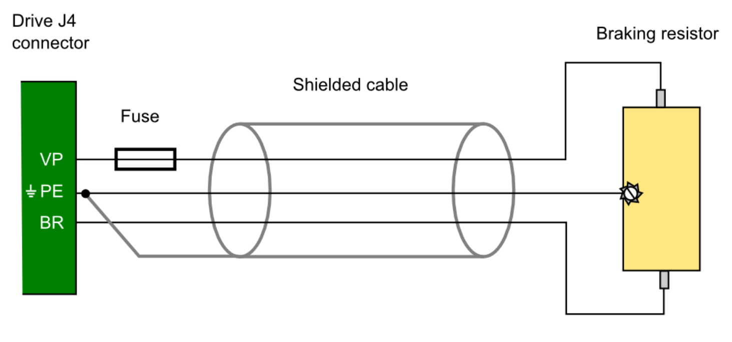
Recommended resistor specifications:

- Resistance 80-100 ohms @ 220-240 VAC
- Resistance 40-50 ohms @ 110-120 VAC
- Power rating 150-300 Watts, this may greatly vary depending on how much energy the braking resistor must absorb
- Wire wound construction (no film resistors unless high peak energy capable)
- Preferrable in metal housing for grounding/noise shielding

The 250W resistor in the image can absorb enough peak energy to stop 100 kg mechanical linear axis moving up to 3 m/s.

Example of suitable resistor for most 220-240 VAC installations: Tyco HSC 250 82R (data sheet pdf).

Installation



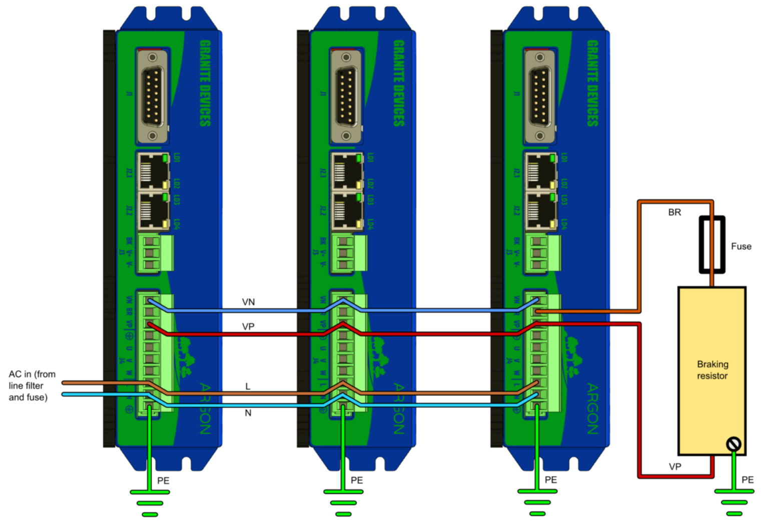
Wiring of braking resistor to Argon drive

The image aside shows proper wiring of braking resistor. Proper installation has:

- Shielded cable with 3 conductors with wire gauge at least 0.75 mm² / 18 AWG
- Cable shield AND earth conductor connected to drive PE terminal
- Earth conductor connected to resistor casing. Place toothed locking washers between wire terminal and resistor to break the insulating coating of resistor case.
- Two other conductors connected to resistor terminals through 8A fast blow fuse
- Resistor should be also mounted on heat sink
- Additionally it is a recommended to shield the resistor terminals from accidental touching

Resistor sharing

It is possible to share HV DC link between Argon drives to reduce number of braking resistors needed. Sharing DC bus also forms a higher power HV DC supply between the drives allowing higher power drawn from a single drive if other drives are running on lighter load.



Wiring of shared braking resistor between multiple Argon drives

The terminals of the resistors are connected to dangerous voltages. Never touch them before drive power has been safely discharged.

Parameterization

Argon user guide/Drive parameterization

This article will describe how to set-up Argon parameters with Granity to make motor operational and ready for servo tuning.

Preparations and connection

As the goal is to parameterize and make motor operational, we should have:

1. The drive and motor fully wired. However it's not required to have controller (to J5 port) or braking resistor connected at this point.
2. Be familiar with the operation and parameters of Granity. Make sure you have read Granity user guide.
3. Granity connection working. See Making the first Granity connection

Walk-through of initial parameterization

In this chapter we walk-trough all Granity tabs and modify the parameter needed. This guide assumes that the drive is in factory defaults state (not configured before). Restore drive to factory state can be done by uploading a firmware file to the drive.

Connect tab

No other actions than connect to drive needed on this tab. Once connection successful, proceed to the next tab.

Goals tab

The factory defaults (torque control as control mode and serial only as setpoint) as well as the other defaults are the correct ones for beginning.

Machine tab

In this tab we configure the motor and its feedback device.

Axis mechanics

Axis type, units and scale parameters AXT and AXS affect only on the unit conversion of Granity parameters (such as acceleration/velocity limit unit conversions) and has no effect on drive operation.

Choose your axis type and scale, or leave them as defaults.

Motor

Find motor parameters from the motor data sheet/manufacturer specifications.

1. Choose motor type from the drowndown list MT. If motor is linear type, see configuring linear servo motor.
2. Set motor pole count MPC (non-brush DC motors only). If unsure, see Determining motor pole count.
3. Set maximum rated speed MMS of the motor, or alternatively the maximum allowed motor speed in the target application
4. Set motor continuous MMC and peak MMC current values. If non-brush DC motor type has been selected, then these are measured as the peak value of sine.

5. Set coil resistance MR and inductance ML, these values are measured Phase-to-phase. If unavailable, perform Tuning torque controller manually after initial parameters are set.
6. Set thermal time constant MTC. Motor thermal time constant value in seconds, used for thermal modeling of motor to avoid motor overheating with peak current MMC. If not available, use formula 200*motor_weight (kg) as approximate, so a 2 kg motor would get a 400 second time constant. There is no guarantee of accuracy of this method.

As torque is directly proportional to motor current, it is advisable to set current limits lower at the beginning of testing. I.e. 50% of motor's rated current will produce 50% of motor's rated torque.

Feedback device

1. Choose feedback device type from the dropdown FBD
2. Set feedback device resolution. If FBD is quadrature encoder, then manufacturers typically give resolution as pulses per revolution (PPR) or lines per revolution (LPR) which are the same thing and shall be entered directly into FBR field. Some manufactures also call PPR as CPR.
3. Configure the polarity of feedback device counting direction by FBI parameter. Motor and feedback device must have same electrical positive rotation direction to make a stable servo system. If your system shows no stability (instant following error after a motor "jump"), try changing this setting.
4. Leave the Hall sensors Off FBH during initial setup. Enable later if necessary (see when).

Tuning

Tuning tab contains feedback gain values for velocity and position control modes as well as torque bandwidth limit setting. Configuring these parameters are documented in Servo motor tuning guide. However, before proceeding into tuning, go through all other settings listed in this article.

Fault limits

Fault limits define the conditions in which drive is willing to operate. If condition is out of the set values, drive will enter into a fault state and stop motor control until errors are cleared.

Drive fault limits

These settings specify drive electrical condition such as supply voltage and over current tolerance.

1. Leave FOC value as default if no overcurrent faults occur. See Tuning torque controller if overcurrent faults occur.
2. Set FOV following way depending on your AC mains voltage:
    1. 220-240 VAC mains, set this 340-360 VDC
    2. 110-120 VAC mains, set this to 170-200 VDC
3. Set FUV following way depending on your AC mains voltage:
    1. 220-240 VAC mains, set this 200 VDC
    2. 110-120 VAC mains, set this to 100 VDC
4. It is important to goal deviation faults (i.e. FFT, FPT, FVT, FEV) as low as possible. Set them so that faults don't occur during normal operation but any anomaly or unexpected behavior will trigger them.

If goal deviation faults are unnecessary high, drive may pose a danger in case of unexpected behavior. For example if motor starts running away full speed without command, then proper velocity fault threshold values may save from damage.

Goal deviation faults

These faults adjust motor monitoring during operation. Drive will enter into fault state if motor condition deviates more than allowed from the desired condition. See Granity unit conversion before adjusting.

1. Goal fault filter time FFT sets the time how fast FPT, FVT, FEV and FMO faults react. Setting higher time value allows drive to continue operation over short deviations thus avoid false triggering. Set this from 0.0 to 0.2 seconds in the beginning.
2. Set Position tracking error threshold FPT according how much mechanical axis is allowed to deviate from the setpoint position in position control mode.
3. Set Velocity tracking error threshold FVT according how much motor or axis speed may may deviate from the velocity setpoint. This affects also in position mode as velocity controller is the intermediate step between torque and position controllers.
4. Set Over speed fault FEV according to the maximum speed allowed for the motor or axis. Helps to stop motor if system goes totally out of control and speeds up spuriously.
5. Leave Motion fault threshold FMO as 0 (0 = disabled) for the beginning. Using nonzero value enables motion fault.
6. Choose Limit switch function LFS according to your preference. If other than *Do nothing* option requires that limit switches are installed and connected to J5 port. Note: at the moment *Servo stop* option is active in the drive firmware and will do nothing until FW upgrade enables it.

Testing tab

These settings does not affect drive operation, so nothing to be changed here at this point. These controls will be used for servo tuning purposes and fault analysis.

Servo motor tuning

Tuning a servo motor is a compulsory task to make motor behave as desired and perform well during operation. Follow the Servo motor tuning guide.

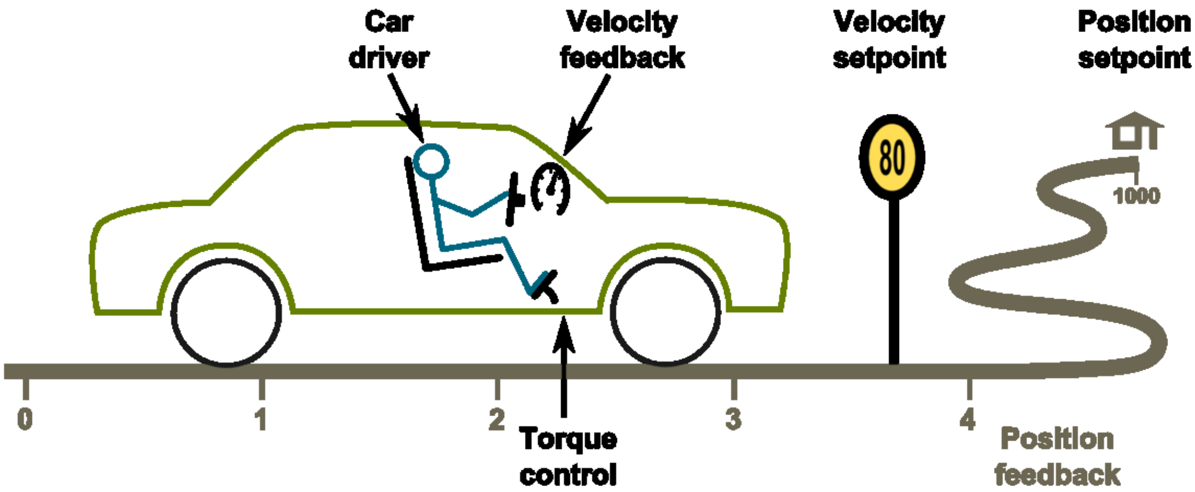
Servo tuning basics

Driving a servo motor is much like driving a car. Driving a car has many similarities including the key concepts of torque, velocity and position control. Most of this happens in the driver's head the same way than a servo drive does with a motor.

Driving (a.k.a servoing) a car

Driving a car to a destination is much like driving a servo motor to it's destination position. The analogies in between are:

Car	Servo axis
Pedal (motor gasoline feed)	Torque setpoint (motor current feed)
Speed limit	Velocity setpoint
Target location	Position setpoint
Speed meter	Velocity feedback
Trip meter	Position feedback
Car driver	Servo drive



The ultimate goal of driver is to get to the target. To achieve this, he follows the road (trajectory) at certain velocity and decelerates once target is being reached. Without knowing, the driver acts as servo controller where he:

- Controls car's velocity based on the speed meter value and speed limit
- Controls car's position based on trip meter's reading or by observing location trough the windshield
- All actions the driver makes, is based on comparing the setpoints and the actual state

Servo controller basics

Controller gains and a PI controller

Controller gain means **sensitivity to change output** due to *tracking error* (the difference between setpoint and feedback).

The simplest form of feedback based controller is a **proportional** gain controller (P controller) where output follows the formula *output = Pgain*(setpoint-feedback)*. The problem of proportional gain controller is that it may never reach the setpoint because output starts approaching zero when the following error is reaching zero.

Because of this, it's better to add in **integrating** component to the controller (forming PI controller). Integrator accumulates the tracking error to a integrator variable. Integrator variable is like a bucket of water, when you add water, the water level rises and when you take out water, the level lowers. In controller the equation becomes: *output = Pgain*(setpoint-feedback) + Igain*IntegralOf(setpoint-feedback)*.

The characteristics of feedback gain variables:

- P-gain - reacts instantly to the tracking error but can't eliminate tracking error completely
- I-gain - reacts slowly over time, adjusts output until tracking error is zero

When driving a car, human brain closely resembles the operation of a PI controller. For in-depth info about PI controllers and its variants, see the Wikipedia article PID controller [1].

Tuning the gains

Controller tuning means finding of the optimum gain values for the given system.

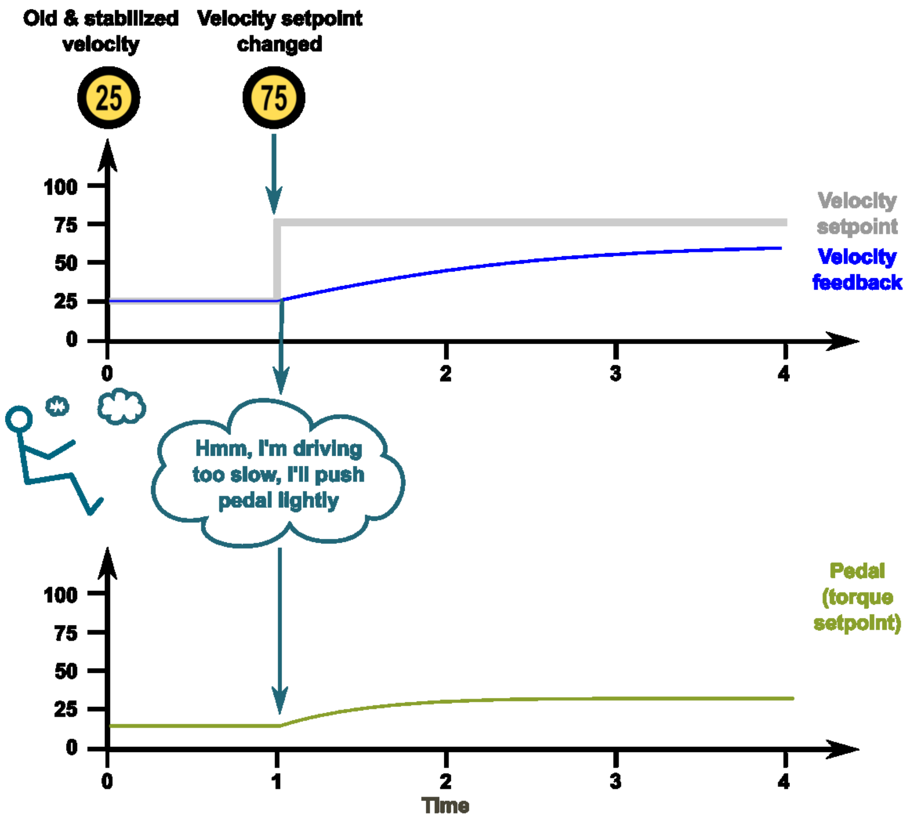
The proper gain values always depend on many aspects, especially the target system dynamic properties (such as motor properties, axis transmission ratios, inertias and masses). Change of properties introduces the requirement of tuning the gain values as gain values that work fine in one system may not behave satisfactory on a different system.

In servo drive case, this means that each motor type and mechanical axis need to be tuned separately. However, if axis and motors are identical, then the same gains should work equally.

Gain tuning (car) example

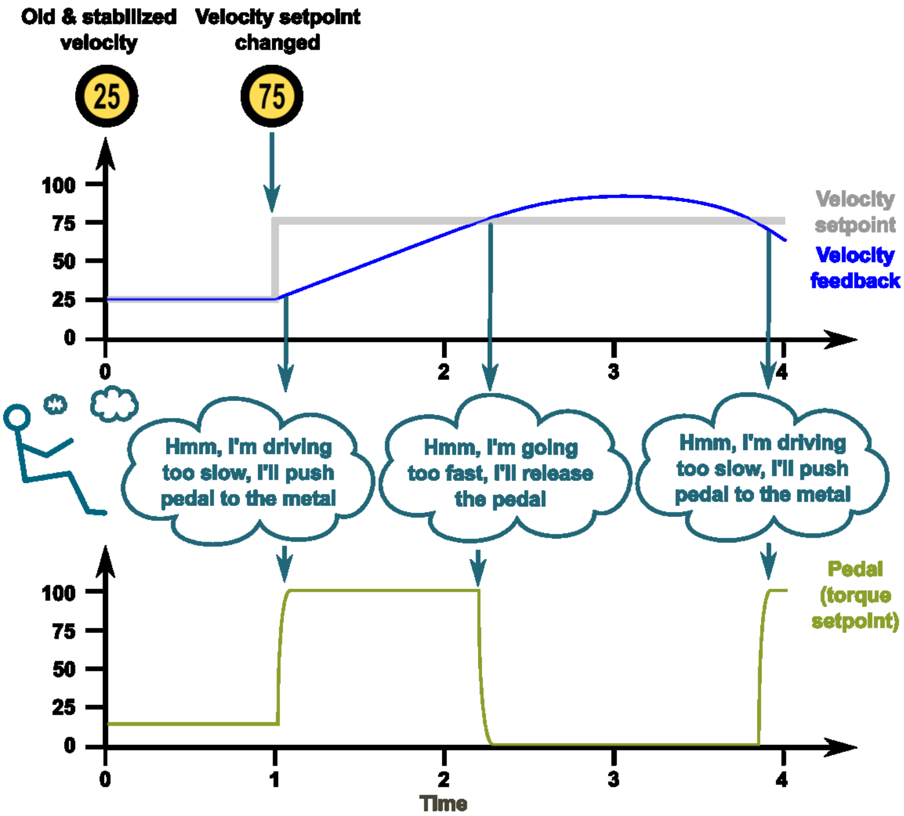
The following series of images illustrate an imaginary car driving scenario where the driver acts as velocity controller of the car. The magnitude of PI gain values equal the driver's aggressivity of controlling the pedal to reach the desired speed.

Low gains - sluggish response



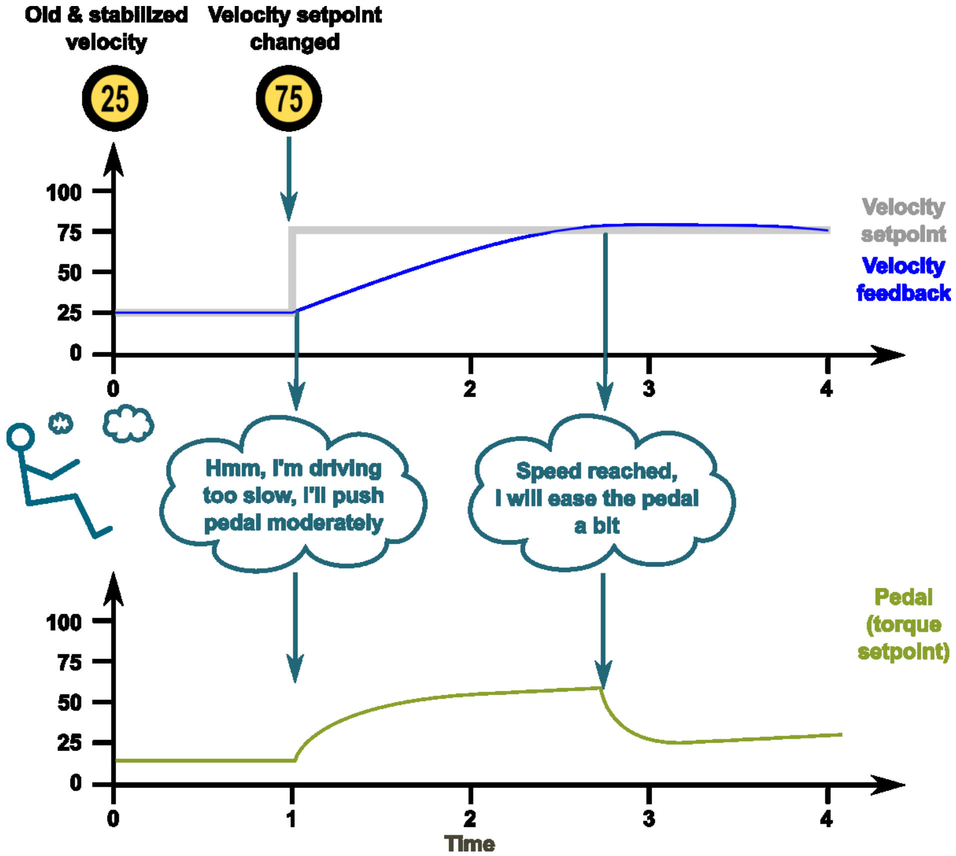
If the gains are set too low, the system response tends to be sluggish and sometimes leave a static tracking error (not reaching setpoint in any time). In this imaginary case we could think PI gains to be P=20 I=10.

Too high gains - oscillation & instability



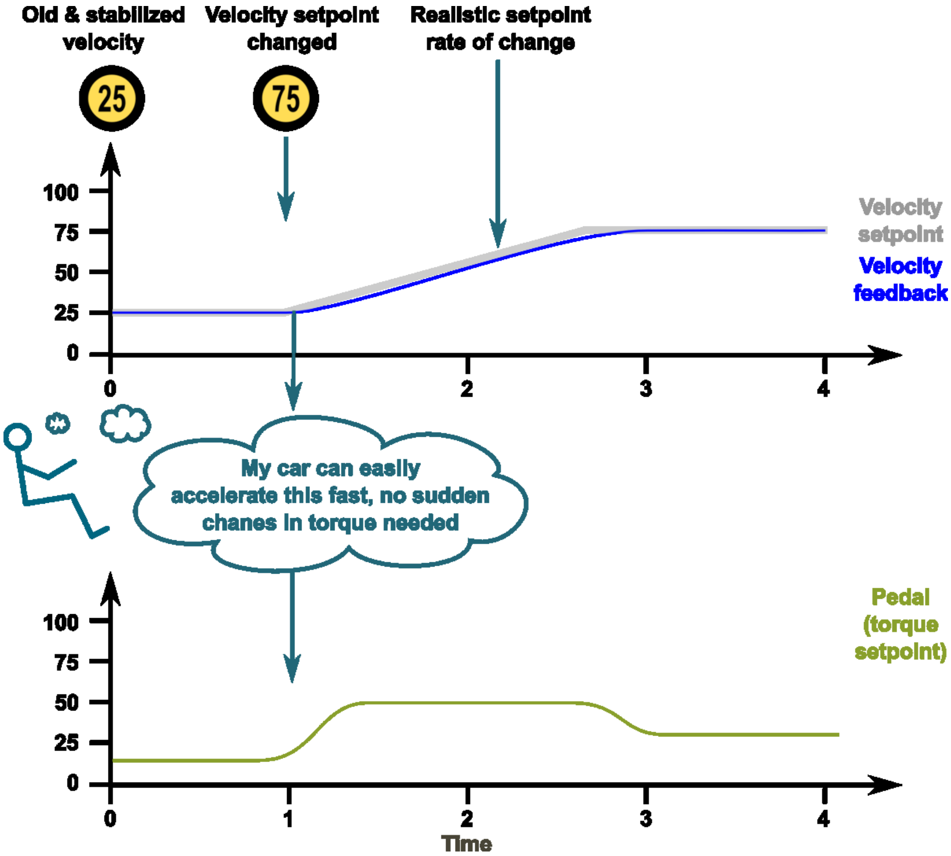
If the gains are set too high, the system becomes overshooting, oscillating and less stable. Here the comparable PI gains could be P=200 I=100

Optimum gains - only little overshoot



When the gains are tuned correctly, the response shows rapid response with low overshoot and no ringing or oscillations. The comparable gains here P=50 I=25.

Optimum gains with realistic setpoint - optimum response



The response can be improved further by introducing a limit to the slew rate of setpoint signal. The controller behaves optimally when the system is able to follow the setpoint continuously with little tracking error. In this case the gains could be same as before, P=50 I=25.

References

[1] http://en.wikipedia.org/wiki/PID_controller

Tuning torque controller

Torque controller tuning means finding the correct gain values for a torque controller inside the servo drive to achieve a proper response from a torque setpoint change.

Direct inductance & resistance setting method

In Granity, there is no dedicated torque control PI gains as the software supports entering motor coil inductance and resistance where the suitable PI gains are calculated from.

If your motor comes with coil specifications containing phase-to-phase inductance and resistance values, then the only necessary step is to enter the given values into motor resistance MR and inductance ML parameter fields. In case of troubles with this method, proceed with manual tuning method.

Manual tuning method

Manual tuning of torque controller is some times done in order to optimize the torque controller response or to find the correct motor resistance MR and inductance ML parameters if unknown. Manual tuning also usually yields better torque response than the direct method which may help tuning of velocity or position tuning.

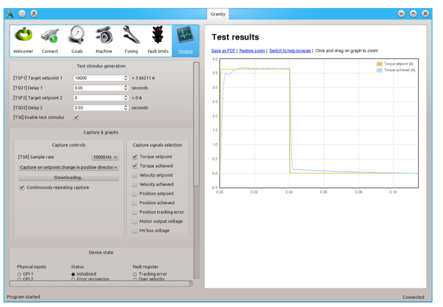
If satisfactory performance was achieved by direct inductance & resistance setting method, you may skip the manual tuning method.

In order to change torque tuning, one needs to change motor resistance MR and inductance ML parameters until the torque response looks satisfactory.

Preparations

Steps to do to begin torque tuning:

- Ensure that motor is parameterized correctly and working
- Fix the motor shaft so that it cannot rotate under full peak torque of the motor
- Make following parameter changes to Granity and click apply afterwards:
  - Set drive in torque control mode CM
  - Set torque bandwidth limit TBW to maximum
  - Choose *Serial only* setpoint input CM
  - Untick Setpoint smoothing CIS
  - Set Goals tab DIV and MUL to 50
  - Make other necessary adjustments to have drive powered and enabled
- Set-up the test stimulus and capture settings from Testing tab:
  - Set target setpoint 1 TSP1 to 5000-15000
  - Set delay 1 TSD1 to 0.05 seconds
  - Set target setpoint 2 TSP2 to 0
  - Set delay1 STD2 to 0.5 s
  - Choose sample rate TSR of 10000 Hz or more
  - Choose *Capture setpoint change ind positive direction* from the dropdown
  - *Tick Continuously repeating capture*
  - Tick *Torque setpoint* and *Torque achieved* from signals



Correct torque tuning settings on the Testing tab.

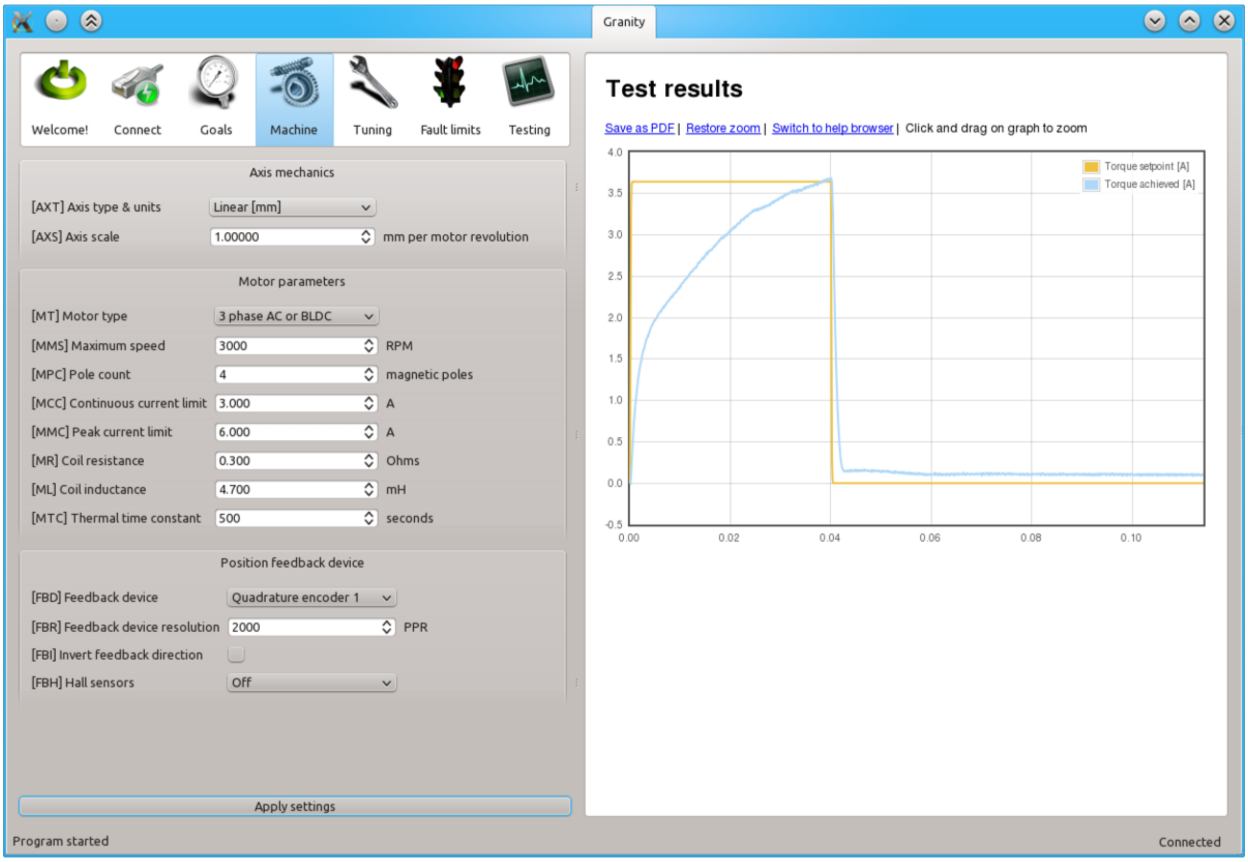
- Tick *Start capture* to begin continous capture.
- Tick Enable test stimulus TSE to begin a pulsed torque generation

Once the steps above are done, motor should be generating short torque pulses to a fixed shaft and torque response graphs should appear on the right side of Granity about once in 3-5 seconds.

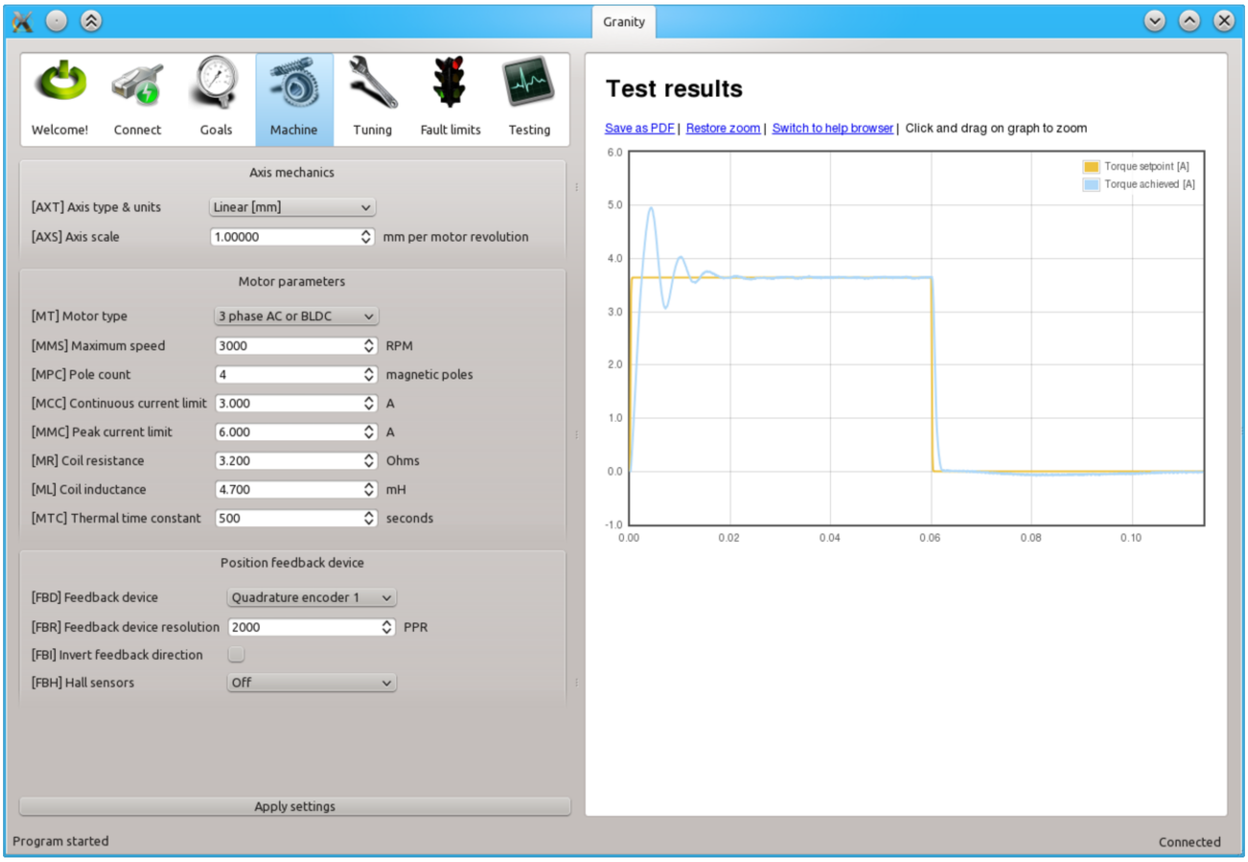
Adjusting MR and ML to for optimum torque control

The task here is to adjust the MR and ML parameters to achieve near optimum step response for the torque controller. Observe the images below for guidance.

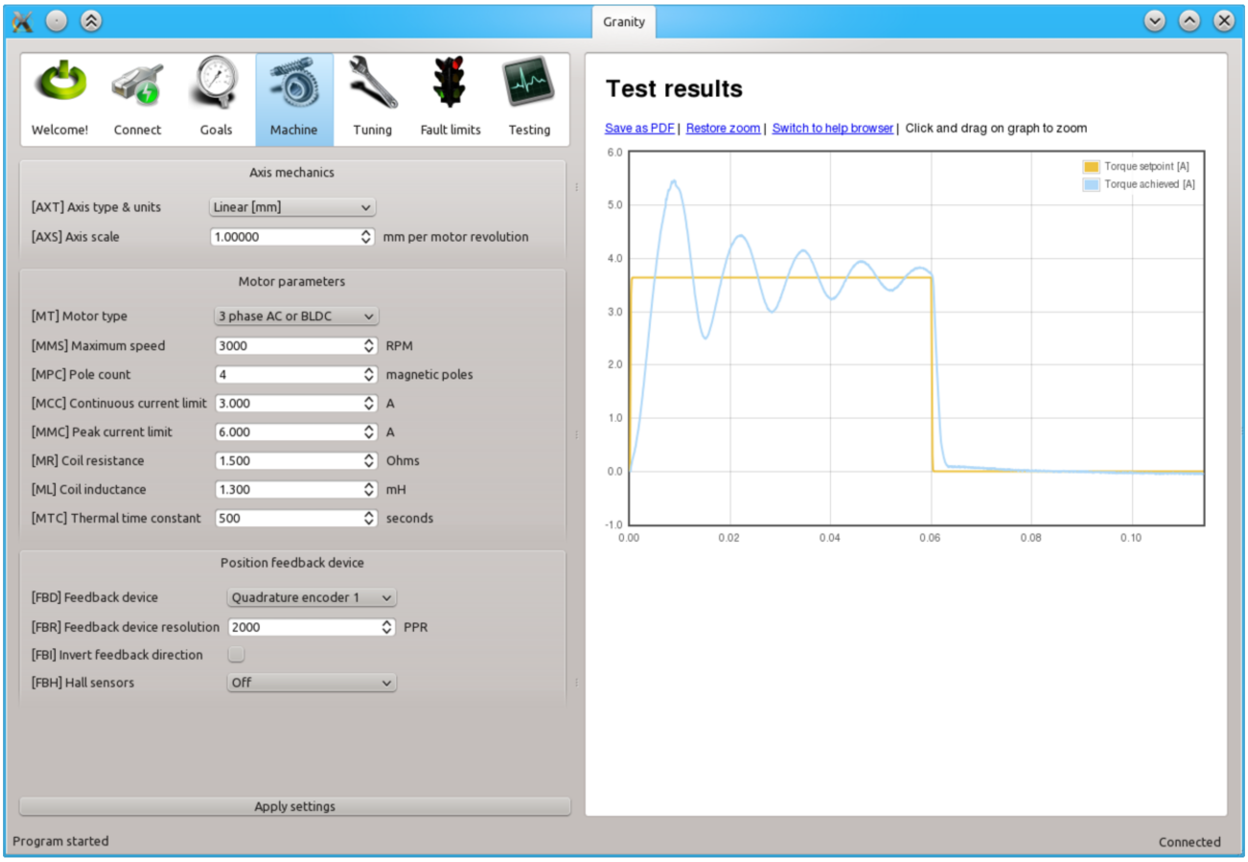
If the drive faults during this testing due to overcurrent, try reducing TSP1 value or increase fault current tolerance FOC parameter. Or try radically different MR and ML values.



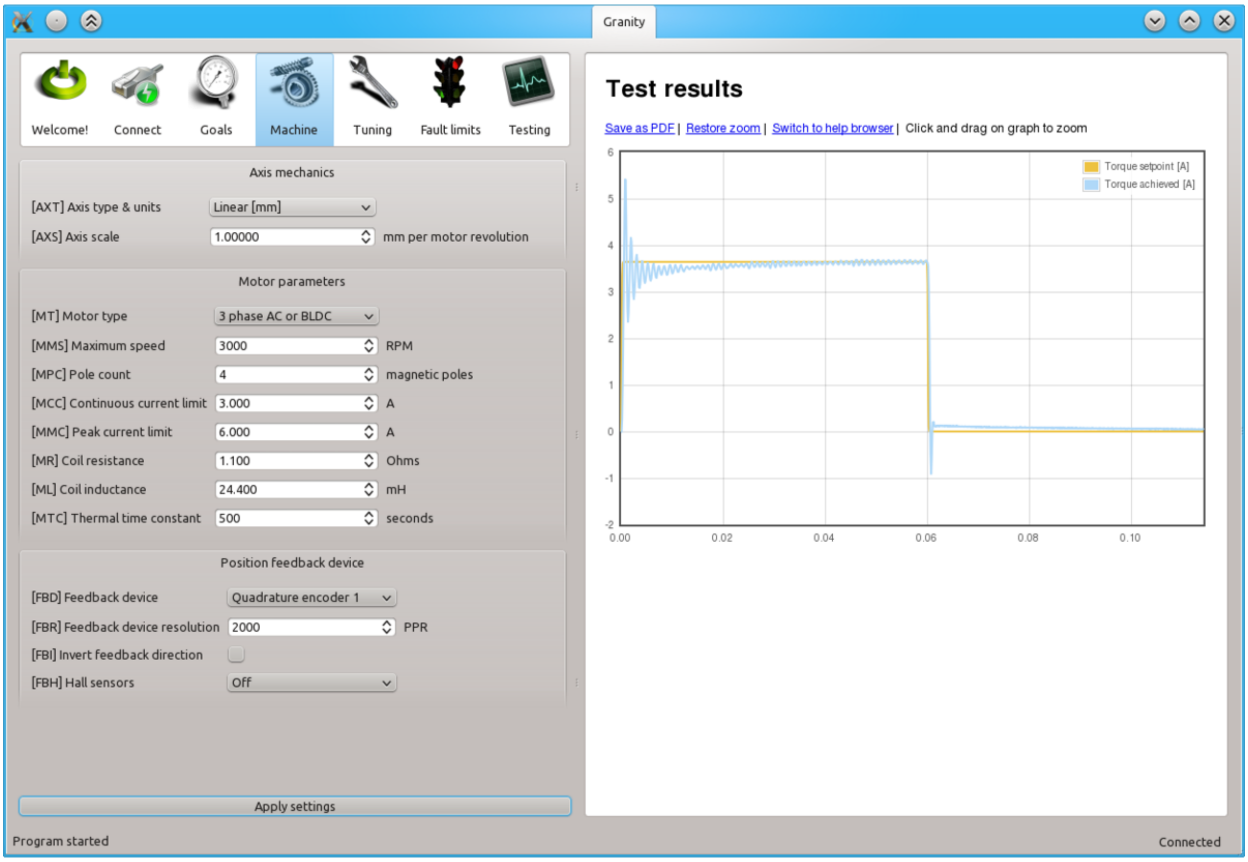
In this case the resistance MR value has been set too low causing slowly rising achieved torque curve. Such slow response would reduce servo responsiveness.



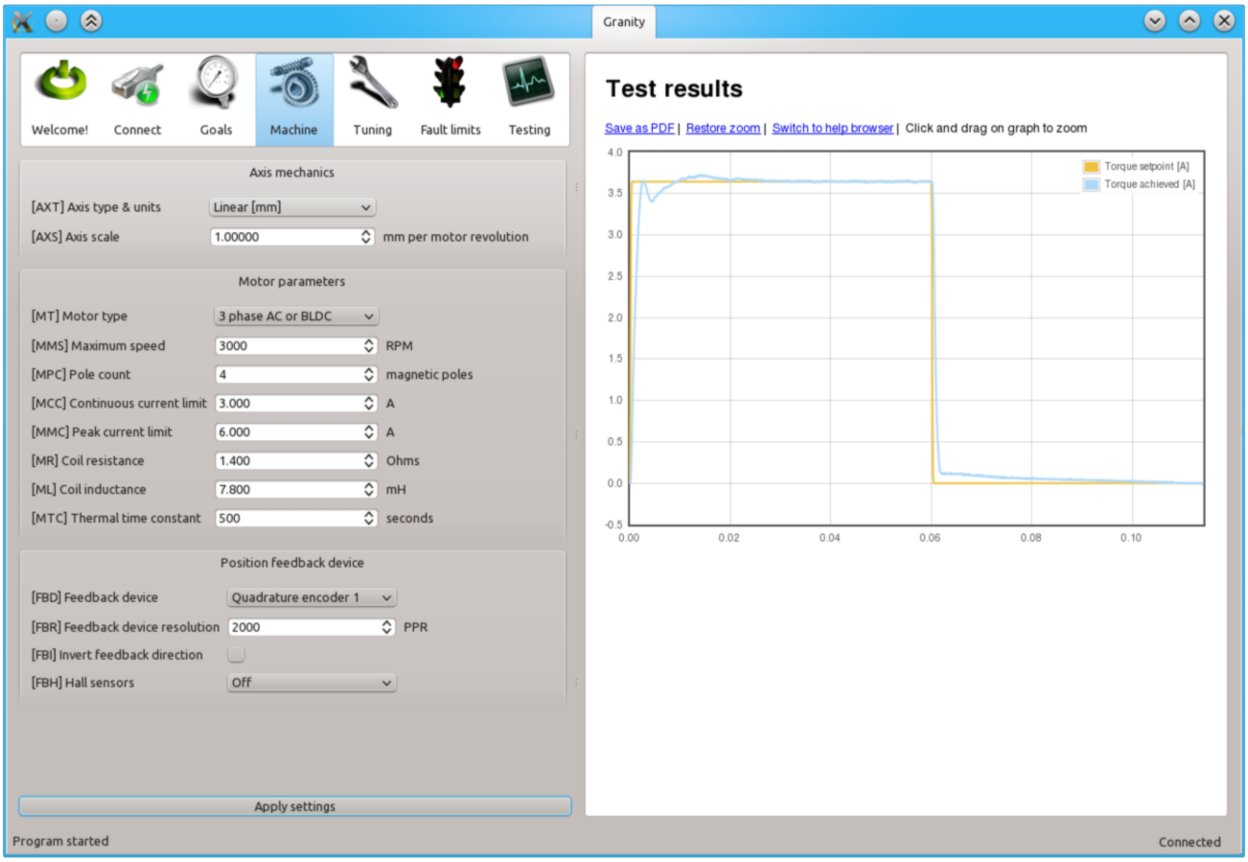
In the opposite case (too high MR value) the response shows wavy oscillations and ovesrhoot.



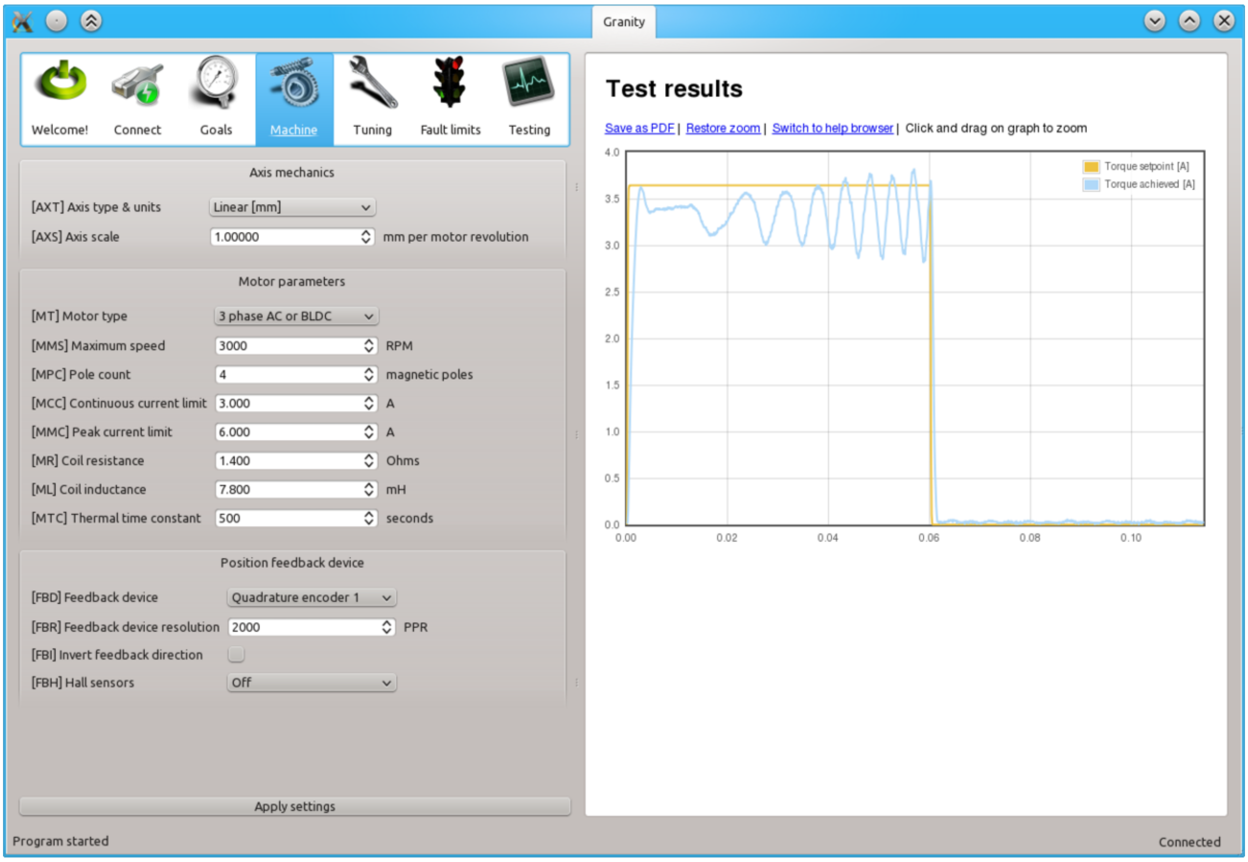
Same kind of phenomenon will be seen if motor inductance ML value is too low. Finding oscillation free tuning is finding the correct balance between the MR and ML as both affect each other.



Too high inductance ML will cause sharp overshooting and high frequency oscillations. Motor may produce audible noise if oscillations are continuous (occurs with way too high ML).



The above image shows near optimum torque response with fast rising edge combined to minimal overshoot.



The above image shows what may happen if motor shaft is not fixed properly (allowed to rotate). This is with the same optimum settings like the previous image.

Steps to do after manual tuning finished

- Stop test stimulus by unticking TSE
- Stop scope catpure by unticking *Continuously repeating capture*
- Undo all temporary changes made to settings (such as TBW, CM, DIV, MUL) but leave the optimized MR and ML values active
- Save settings to drive memory by clicking *Save settings on drive non-volatile memory* button

Tuning velocity controller

Velocity controller tuning means finding the correct drive settings and feedback gain values to achieve a proper Servo stiffness and response to a velocity setpoint change.

This tuning guide is for you if the final application uses the motor in velocity control mode such as spindle or as position mode with external closed loop position controller such as LinuxCNC.

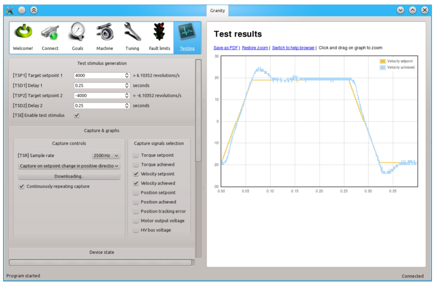
Velocity control tuning method

If motor has been tuned without the real load (i.e. motor shaft not attached), tuning parameters should be re-adjusted with the real load as the dynamic properties of the load has a significant effect on them. Large change of load properties may even cause servo instability.

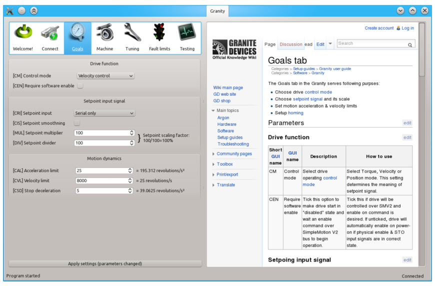
Preparations

Steps to do to begin position tuning:

- Ensure that motor is parameterized correctly and working and torque control tuning has been properly done.
- Attach motor to the target load and ensure it can rotate in both directions **infinitely**
- Make following parameter changes to Granity and click apply afterwards:
  - Set drive in velocity control mode CM
  - Choose *Serial only* setpoint input CM
  - Make other necessary adjustments to have drive powered and enabled
  - Untick Setpoint smoothing CIS
  - Set Goals tab DIV and MUL to 50
  - Set acceleration CAL & velocity CVL limits reasonably to the levels that motor is expected to handle
- Set-up the test stimulus and capture settings from Testing tab (an example, may be varied):
  - Set target setpoint 1 TSP1 between 1000 and 16383 (16383 equals the max speed that is configured via CVL)
  - Set delay 1 TSD1 to 0.25 seconds
  - Set target setpoint 2 TSP2 to same, but *negative*, value of TSP1
  - Set delay1 STD2 to 0.25 s
  - Choose sample rate TSR of 500 to 2500 Hz
  - Choose *Capture setpoint change in positive direction* from the dropdown
  - *Tick Continuously repeating capture*
  - Tick *Velocity setpoint* and *Velocity achieved* from signals
  - Tick *Start capture* to begin continous capture.
  - Tick Enable test stimulus TSE to begin a continuous position back and forth spinning motion generation



An example of Testing tab settings for velocity controller tuning. Different settings should be experimented during the process to observe the stability and behavior of the settings.



Initial settings on Goals tab before beginning the example in this tuning guide.

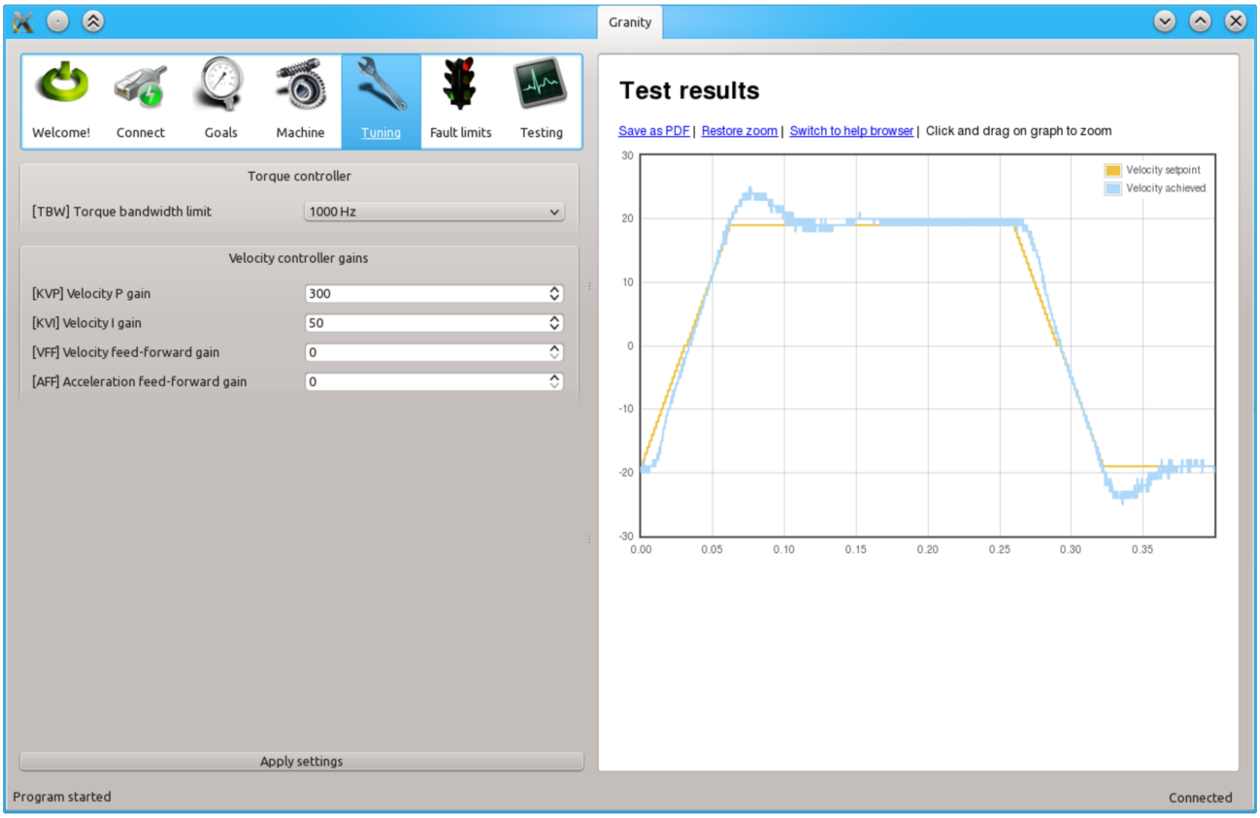
Once the steps above are done, motor should be generating direction reversing spinning and velocity response graphs should appear on the right side of Granity about once in 3-5 seconds.

Finding velocity control gain values

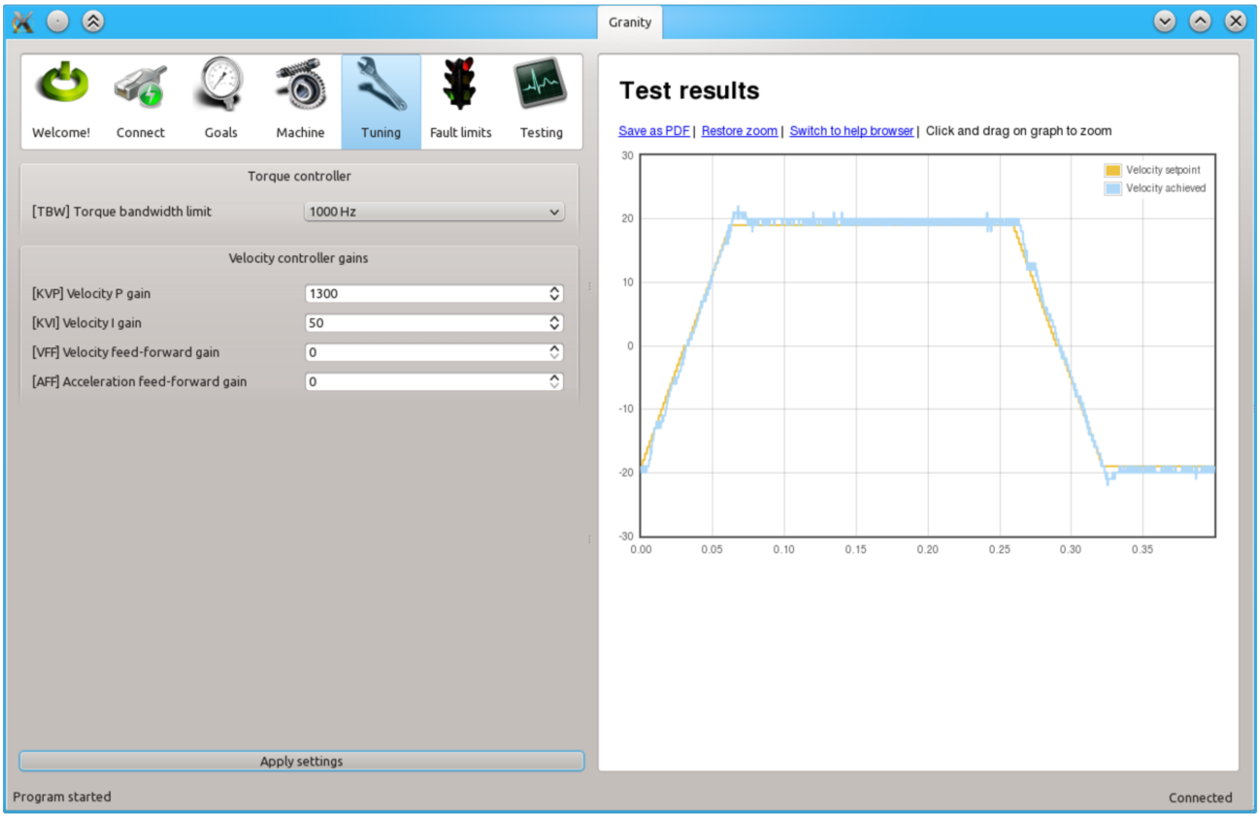
If the drive faults during this testing due to overcurrent, see Tuning torque controller for solutions. If drive faults due to following error or motion fault, increase the goal deviation fault limits at Fault limits tab.

Tuning protocol

Tuning is begun with low or medium target speeds (TSP1 & 2 values below 5000).

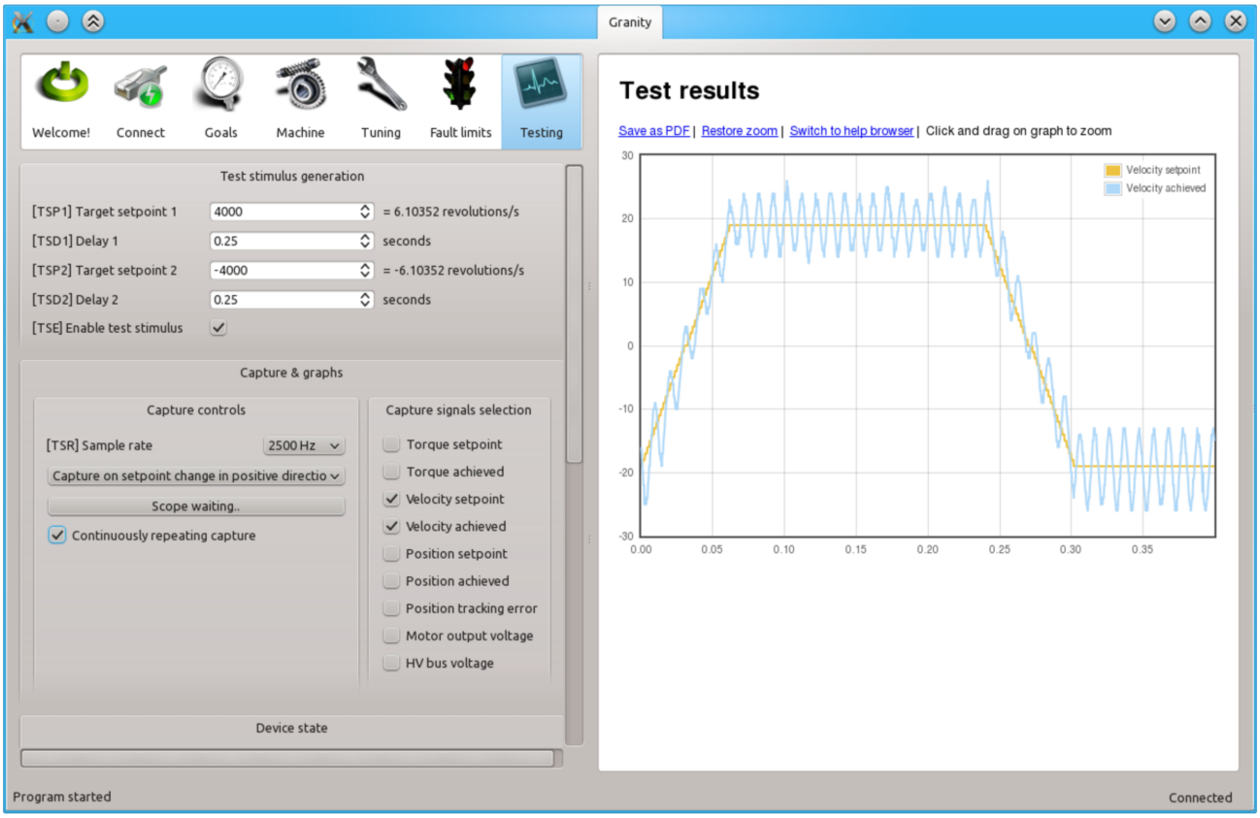


Initial velocity response with the default settings. As seen from the achieved velocity graph, it follows the setpoint velocity lazily and exhibits overshooting. In such state motor servo stiffness is low can be easily decelerated by adding load to the shaft.



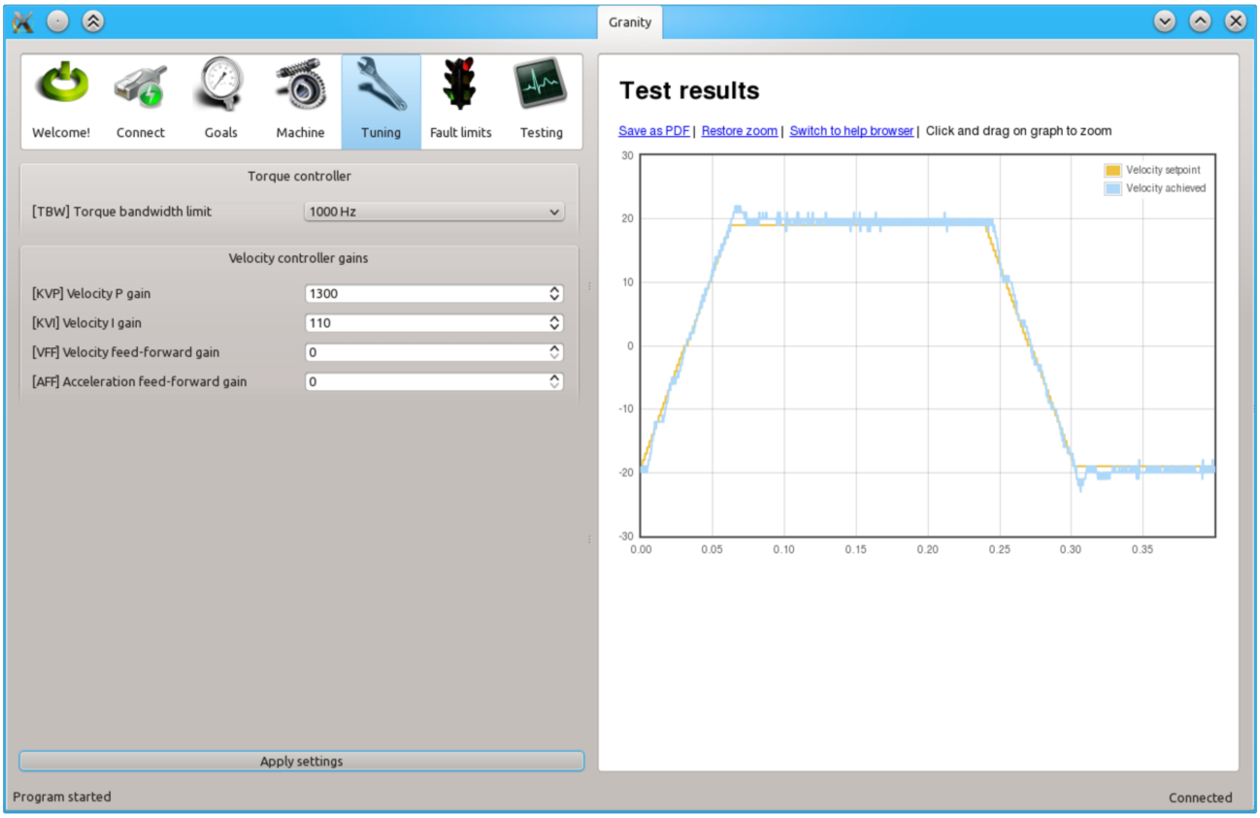
Begin tuning by increasing KVP gain. This makes motor follow velocty setpoint much better.

To try different gains, go to Tuning tab, change value and click the Apply settings button.

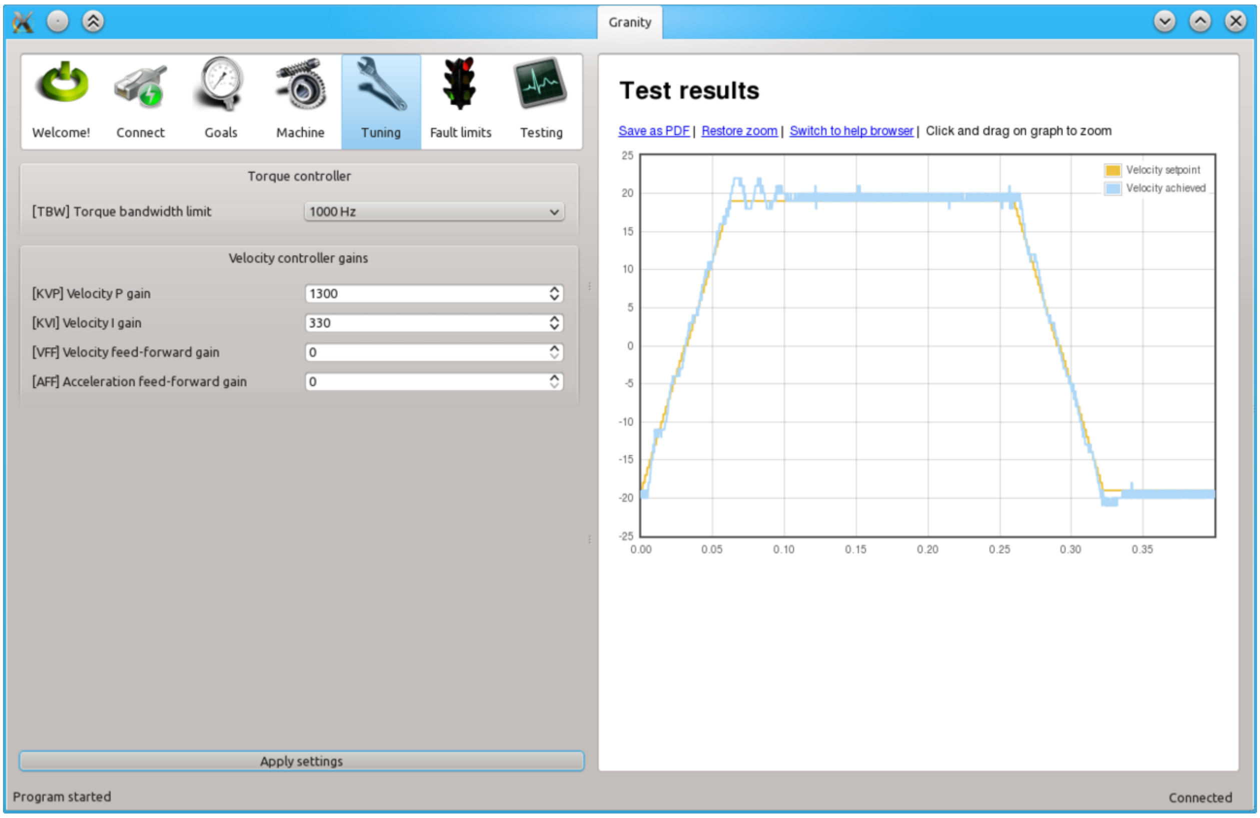


When KVP has been increased too much, the system becomes unstable and may start oscillating. In such case, you may hit Esc button to disable drive, reduce the gain and enable drive again.

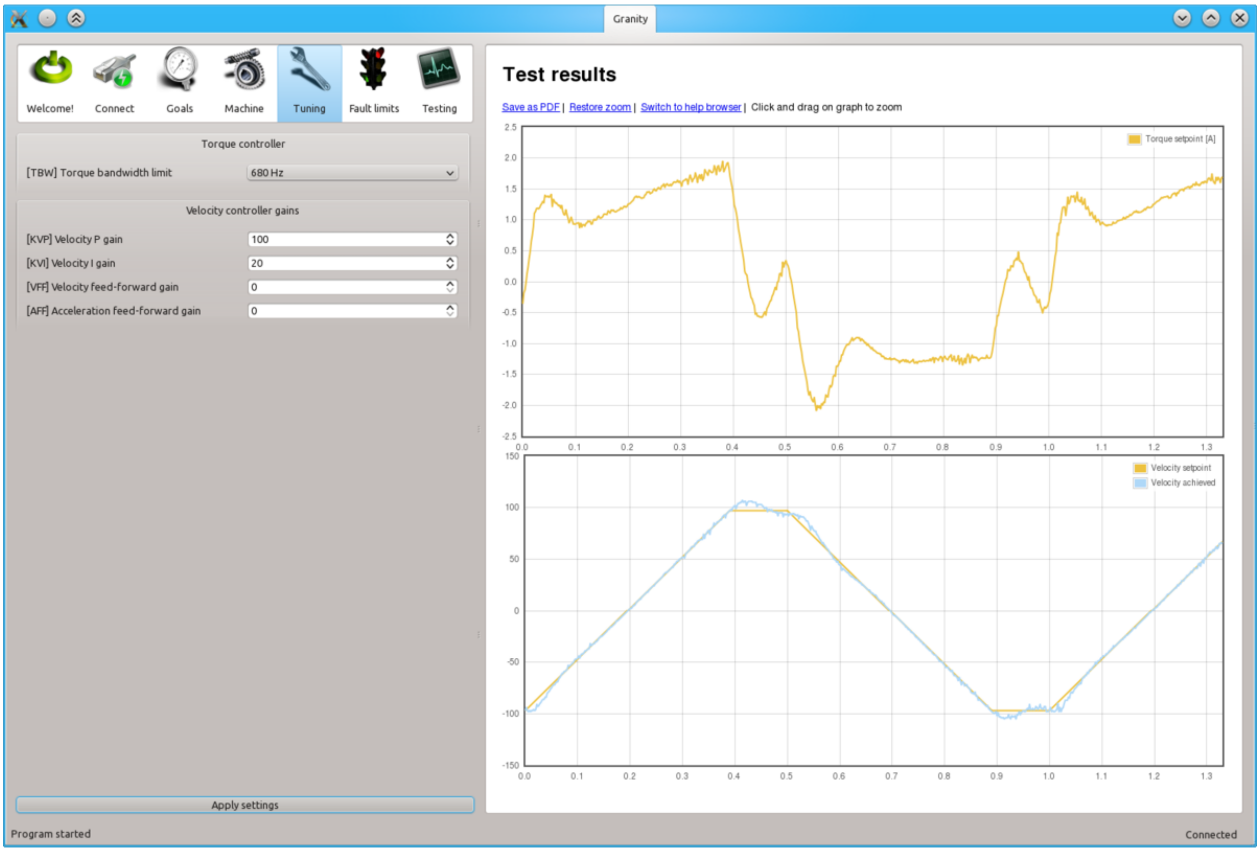
Tip: torque bandwidth has significant effect on the behavior of KVP value and the point where it goes unstable. One may experiment different TBW settings to find the optimum.



Once a maximum perfectly stable KVP value has been found, start increasing KVI gain by a similar fashion. The higher KVI value is, the better servo stiffness.



If KVP is increased too much, the result is overshooting and even sustained oscillation. The cure is similar to the too high KVP gain as described earlier.

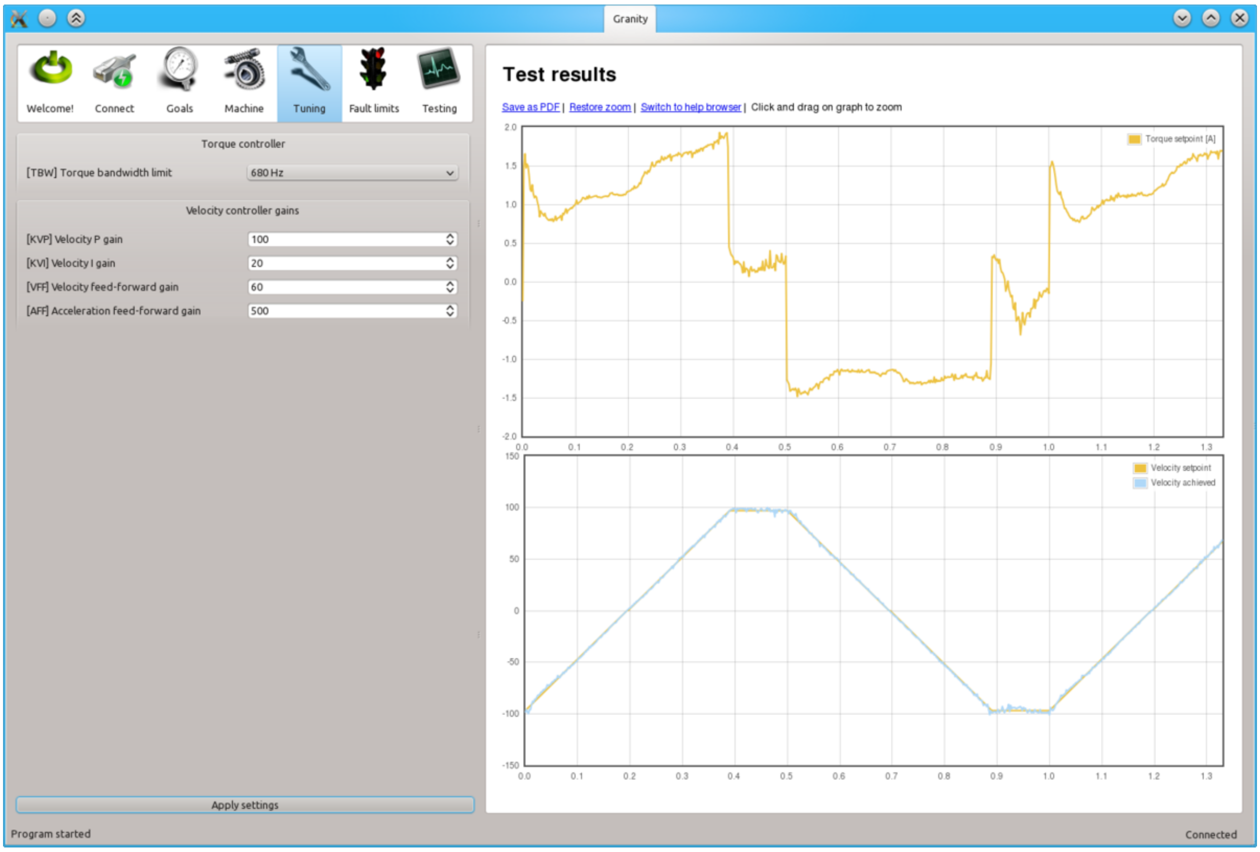


Once stable and stiff gains has been found, increase setpoint values (TSP1 & 2) to test the settings with higher speeds. If necessary adjust the gains experimentally to find the optimum tuning that works satisfactory on all needed speeds.

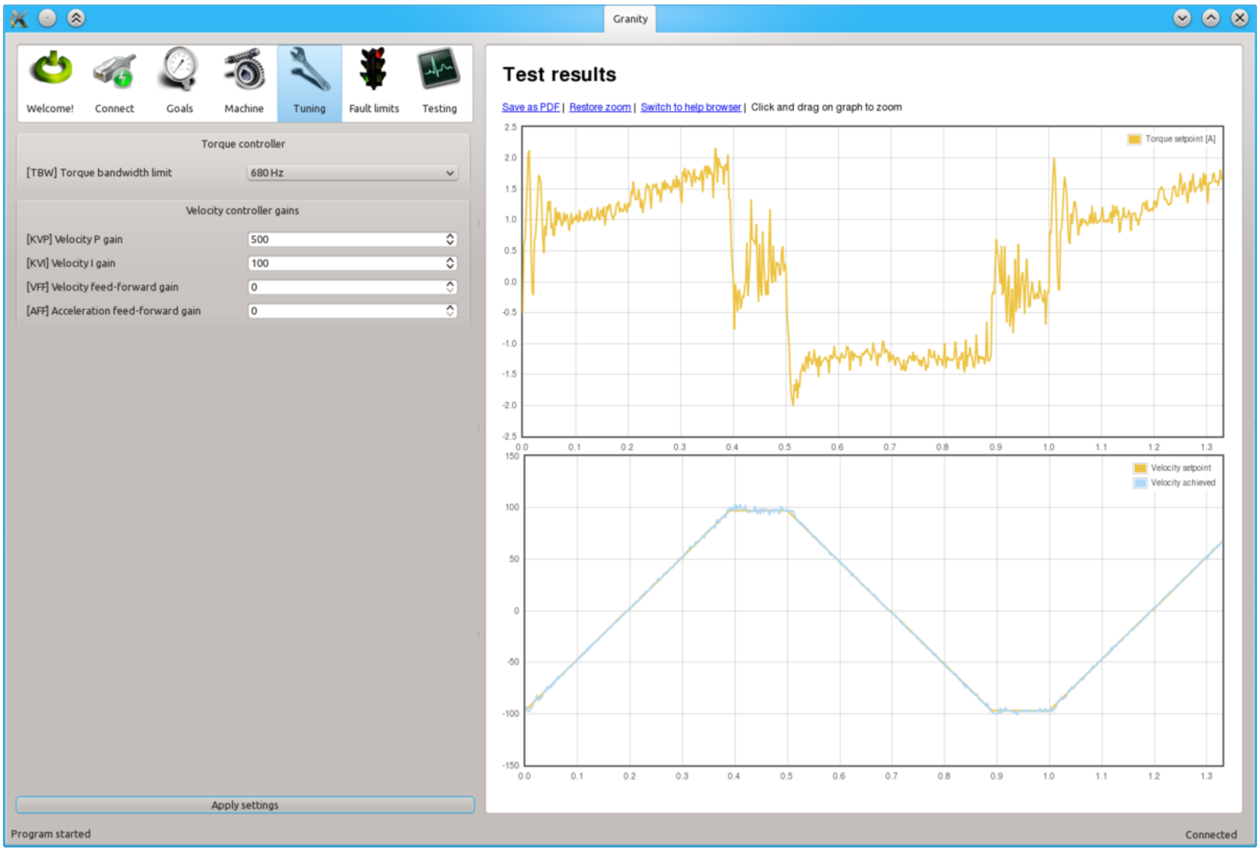
Advanced tuning: Feed-forwards

Feed-forward parameters may be used to boost motor responsiveness to setpoint change. Feed-forward gains VFF and AFF essentially compensate system friction and mass limiting the dynamic performance.

The recommended way to tune FF gains, is to start increasing velocity feed-forward VFF until the optimum level has been found. After that, increase acceleration feed-forward AFF until the optimum point has been reached.



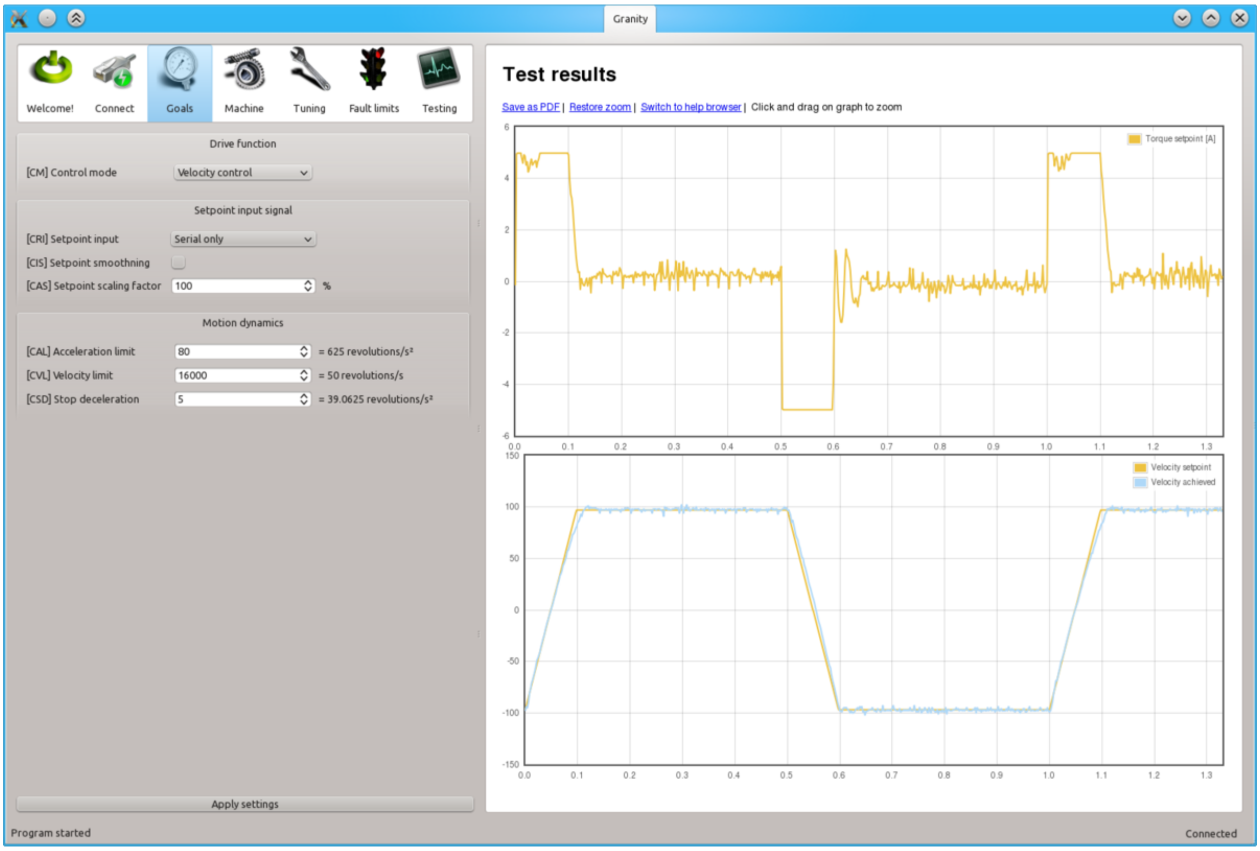
In the image above a sharp response has been achieved even with low feedback gains as feed-forward gains help motor to accelerate as demanded.



The image above shows similar response without feed-forwards but using high feedback gain values (optimally tuned according to the previous chapter).

Problem cases

In this test we run motor with higher speeds (TSPn > 10000) and illustrate few typical problem cases.

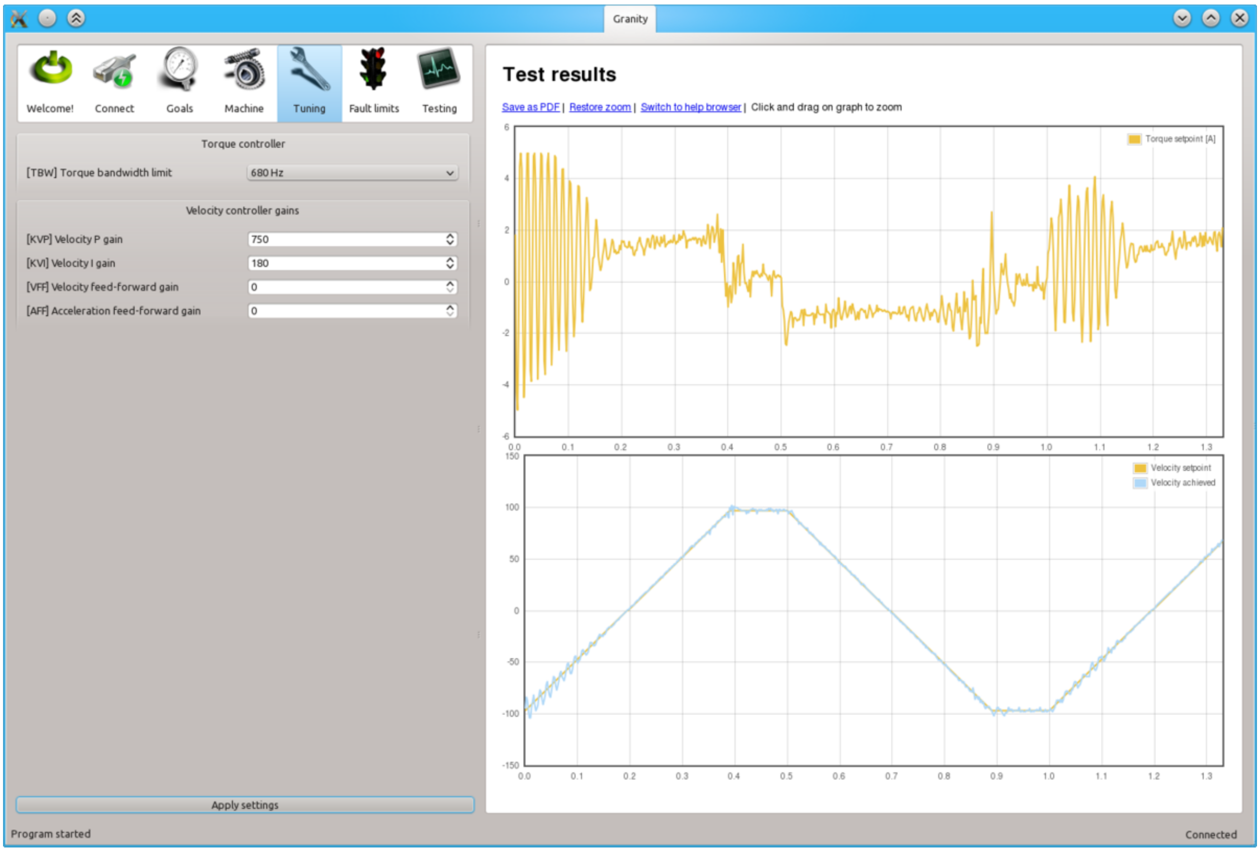


The image above shows acceleration limited by insufficient torque produced by the motor. In this example the acceleration limit is set too high to be accelerated with the given motor torque limits (or current limits).

To verify if the problem happens due to torque limit, tick also Torque achieved and Torque setpoint signals from the Testing tab settings. In such way also motor currents will be displayed simultaneously with the position response curves. If the torque curve is limited to the set peak current limit MMC, then the problem is insufficient torque. In the image above we can see that the torque curves are saturated/clipping at 5A and -5A levels which matches the configured MMC value of 5A in this demonstration.

To help this, try:

- Increasing current limits MMC and MCC if possible
- Reducing acceleration CAL and/or velocity CVL limits



The above example shows instability and oscillation with high speeds even when the system was stable at lower speeds with the same parameters. In such case tune the system again at the most infavourable conditions and speeds to achieve stability over all required operating conditions.

Steps to do after tuning finished

- Stop test stimulus by unticking TSE
- Stop scope catpure by unticking *Continuously repeating capture*
- Undo all temporary changes made to settings
- Save settings to drive memory by clicking *Save settings on drive non-volatile memory* button
- Set preferred setpoint source CRI, also consider the use of CIS
- If setpoint signal scaling is needed, adjust MUL and DIV values

If drive will be controlled by an external motion controller with acceleration & velocity limits, such as CNC controller programs like Mach3 or LinuxCNC, then its recommended to increase acceleration limit CAL to the maximum value of 32767 and disable setpoint smoothing CIS to prevent drive's internal acceleration limiter modifying the setpoint signal. Using these settings effectively disables the internal acceleration limit and let's external controller to control accelerations.

Tuning position controller

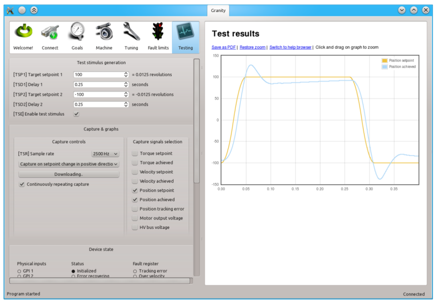
Position controller tuning means finding the correct drive settings and feedback gain values to achieve a proper Servo stiffness and response to a position setpoint change.

Position control tuning method

This article describes a practical approach for finding proper drive parameters to achieve a stable and stiff position control.

If motor has been tuned without the real load (i.e. motor shaft not attached), tuning parameters should be re-adjusted with the real load as the dynamic properties of the load has a significant effect on them. Large change of load properties may even cause servo instability.

Preparations



An example of Testing tab settings for position controller tuning. Different settings should be experimented during the process to observe the stability and behavior of the settings.

Steps to do to begin position tuning:

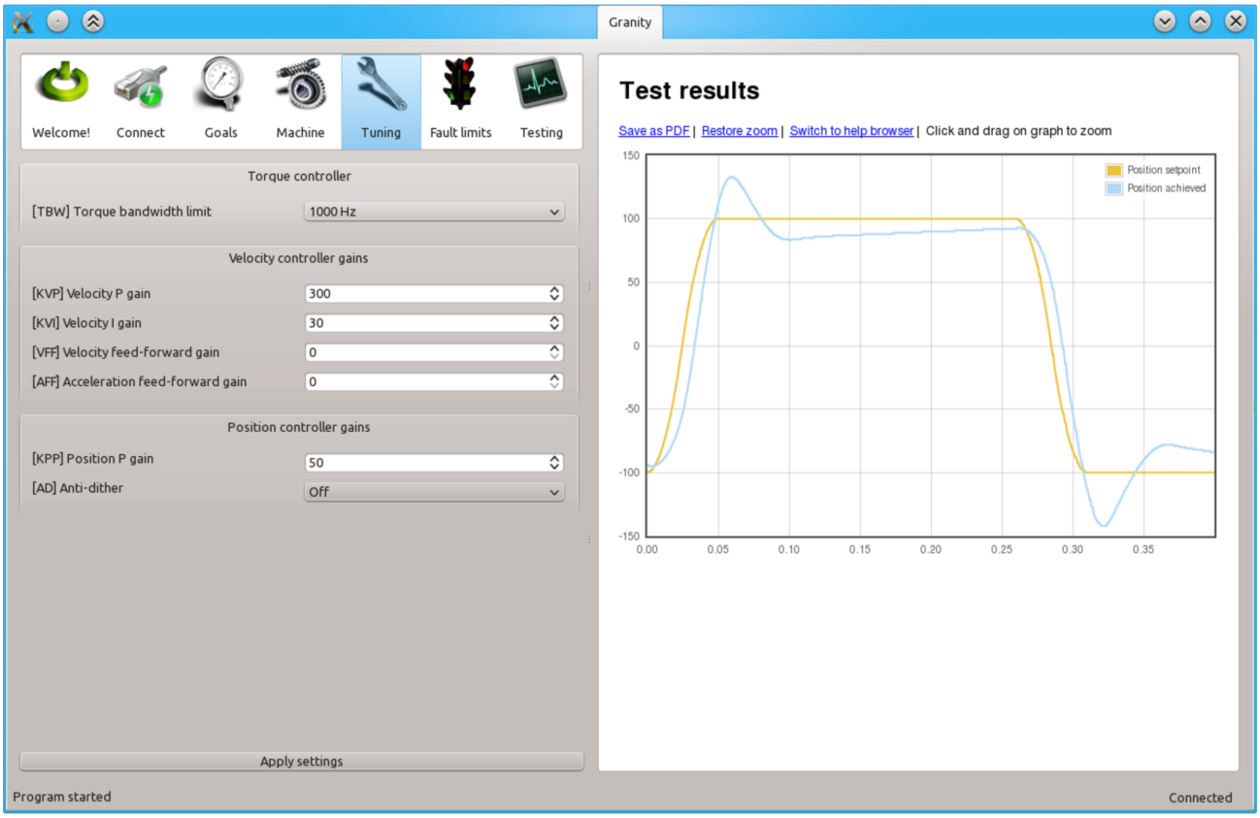
- Ensure that motor is parameterized correctly and working and torque control tuning has been properly done.
- Attach motor to the target machine in a position where it can rotate in both directions
- Make following parameter changes to Granity and click apply afterwards:
  - Set drive in position control mode CM
  - Choose *Serial only* setpoint input CM
  - Make other necessary adjustments to have drive powered and enabled
  - Untick Setpoint smoothing CIS
  - Set Goals tab DIV and MUL to 50
  - Set acceleration CAL & velocity CVL limits reasonably to the levels that motor is expected to handle
- Set-up the test stimulus and capture settings from Testing tab (an example, may be varied):
  - Set target setpoint 1 TSP1 to 100
  - Set delay 1 TSD1 to 0.25 seconds
  - Set target setpoint 2 TSP2 to -100
  - Set delay1 STD2 to 0.25 s
  - Choose sample rate TSR of 500 to 2500 Hz
  - Choose *Capture setpoint change in positive direction* from the dropdown
  - *Tick Continuously repeating capture*
  - Tick *Position setpoint* and *Position achieved* from signals
  - Tick *Start capture* to begin continous capture.
  - Tick Enable test stimulus TSE to begin a continuous position back and forth motion generation

Once the steps above are done, motor should be generating short distance back and forth motion motion and position response graphs should appear on the right side of Granity about once in 3-5 seconds.

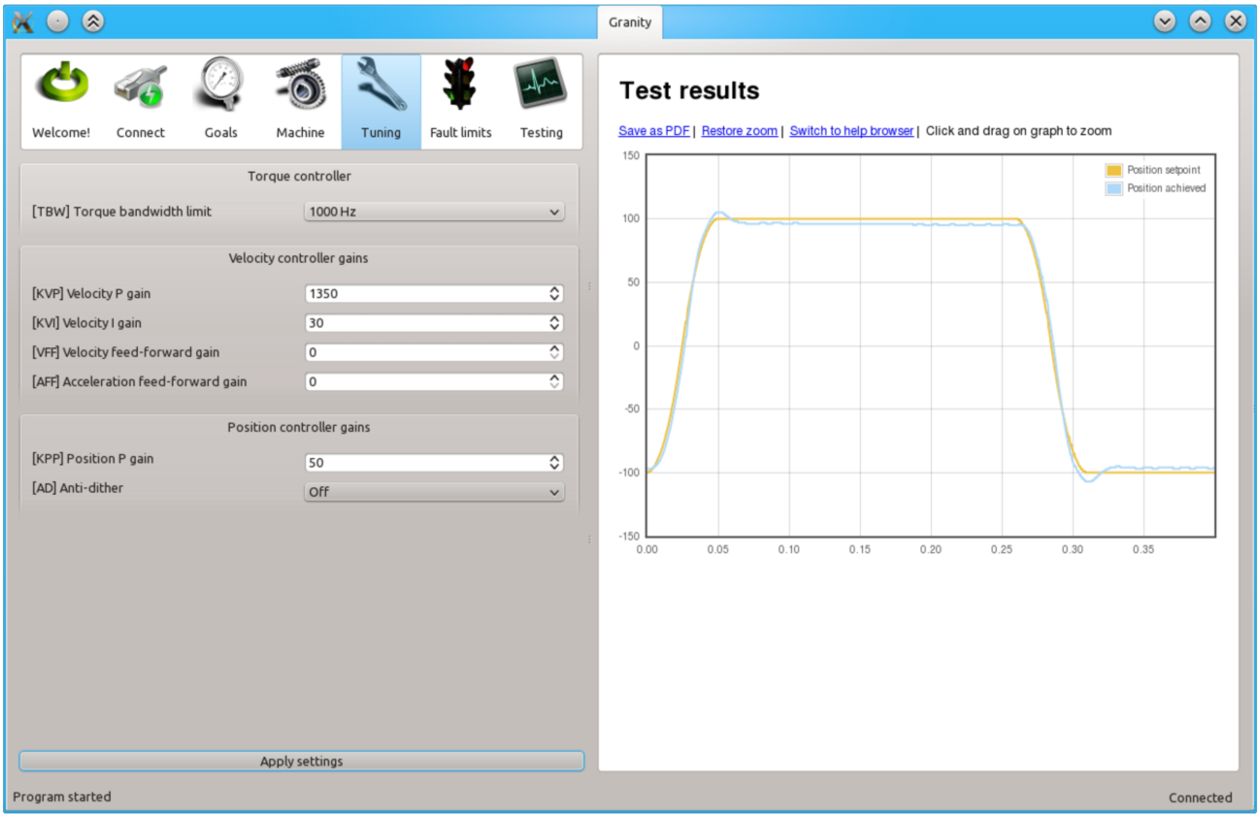
Finding velocity & position control gain values

The task here is to adjust the MR and ML parameters to achieve near optimum step response for the torque controller. Observe the images below for guidance.

If the drive faults during this testing due to overcurrent, see Tuning torque controller for solutions. If drive faults due to following error or motion fault, increase the goal deviation fault limits at Fault limits tab.

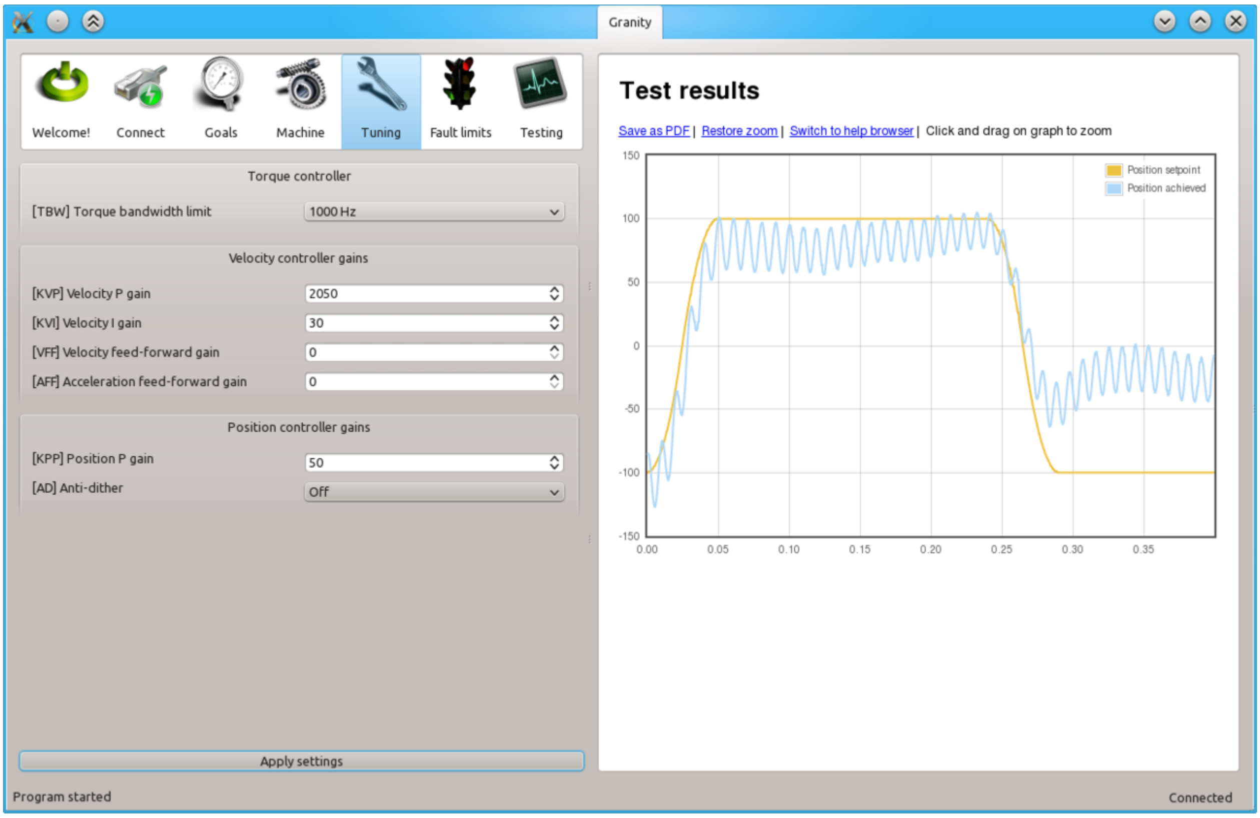


The image above represents the initial position step response with low feedback gains. As seen, motor reaction is sluggish, lagging and has overshooting.



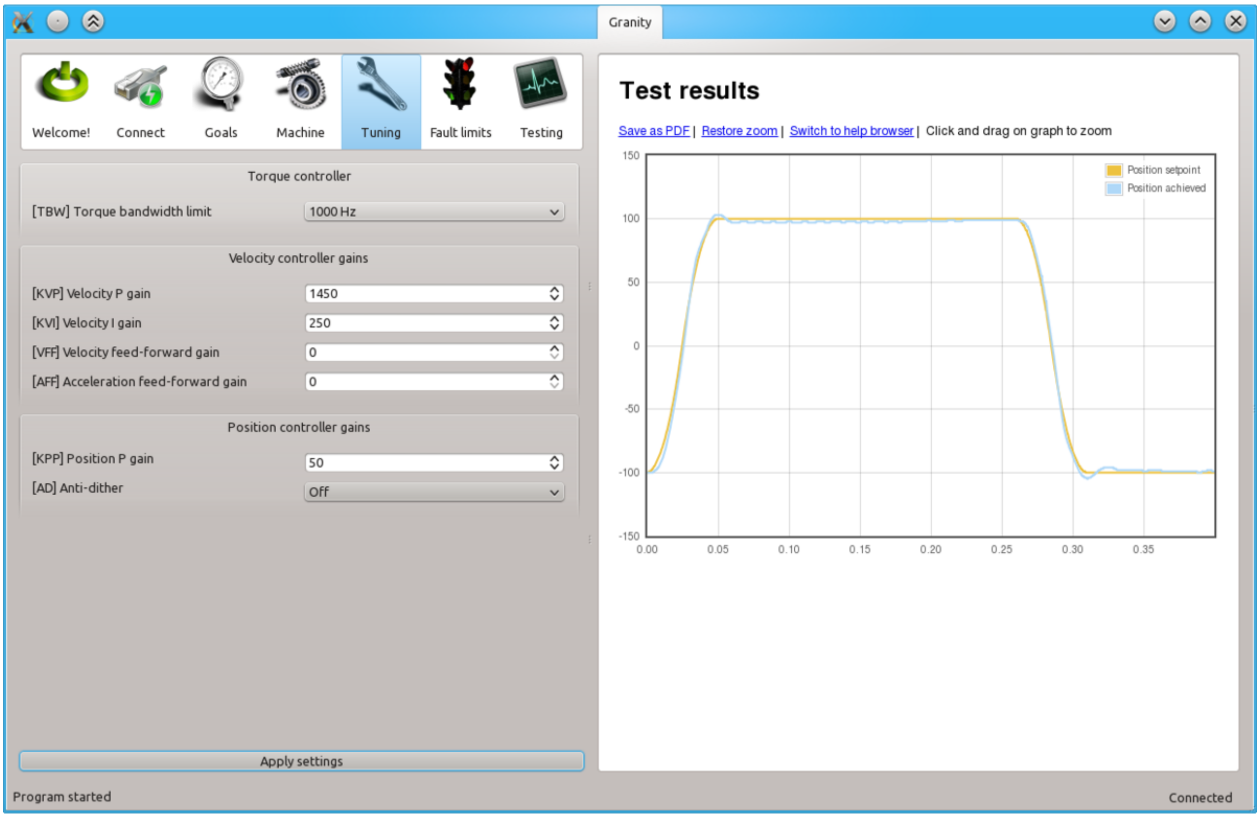
The next step is to increase KVP gain as much as possible. The graph may start looking acceptable but it motor still has low stiffness thus it will get lag once mechanical load increases.

To try different gains, go to Tuning tab, change value and click the Apply settings button.

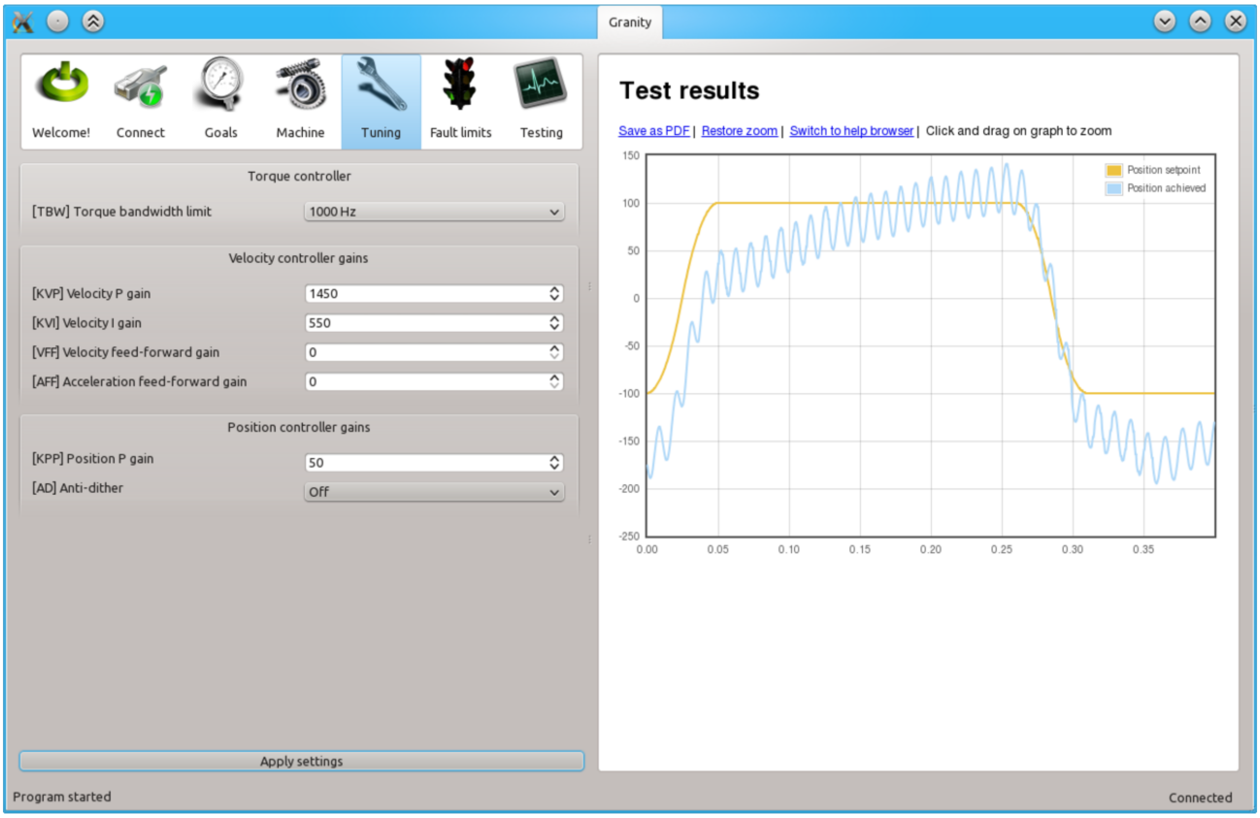


When KVP has been increased too much, the system becomes unstable and may start oscillating. In such case, you may hit Esc button to disable drive, reduce the gain and enable drive again.

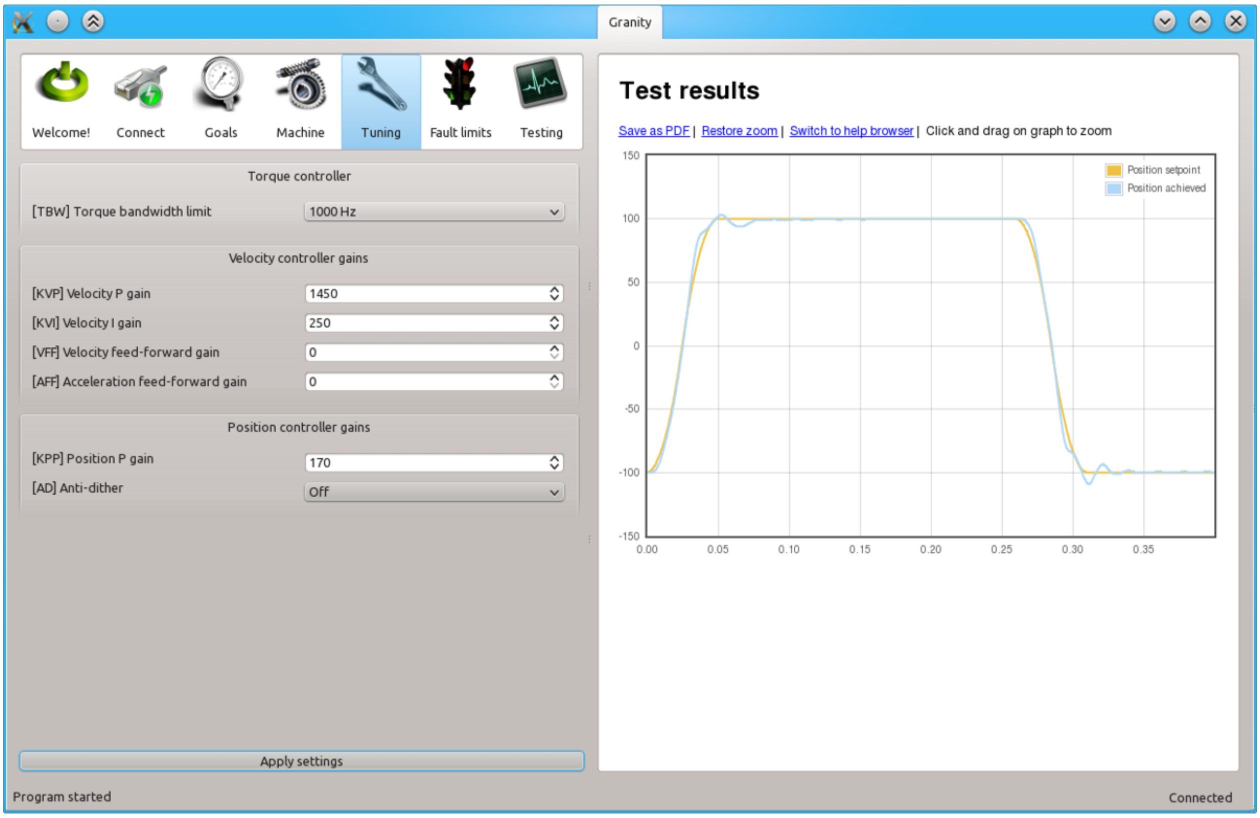
Tip: torque bandwidth has significant effect on the behavior of KVP value and the point where it goes unstable. One may experiment different TBW settings to find the optimum.



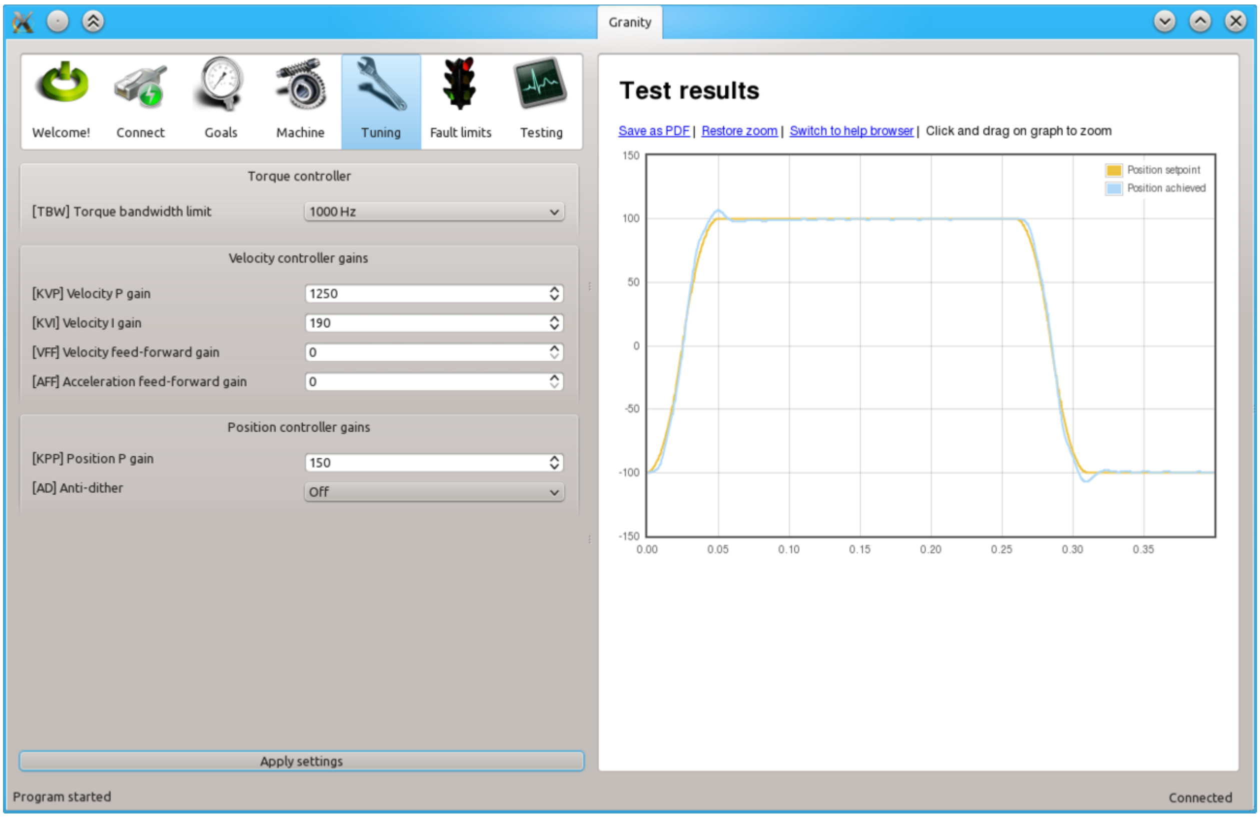
Once a maximum perfectly stable KVP value has been found, start increasing KVI gain by a similar fashion. The higher KVI value is, the better servo stiffness.



If KVP is increased too much, the result is instability and oscillation. The cure is similar to the too high KVP gain as described earlier.



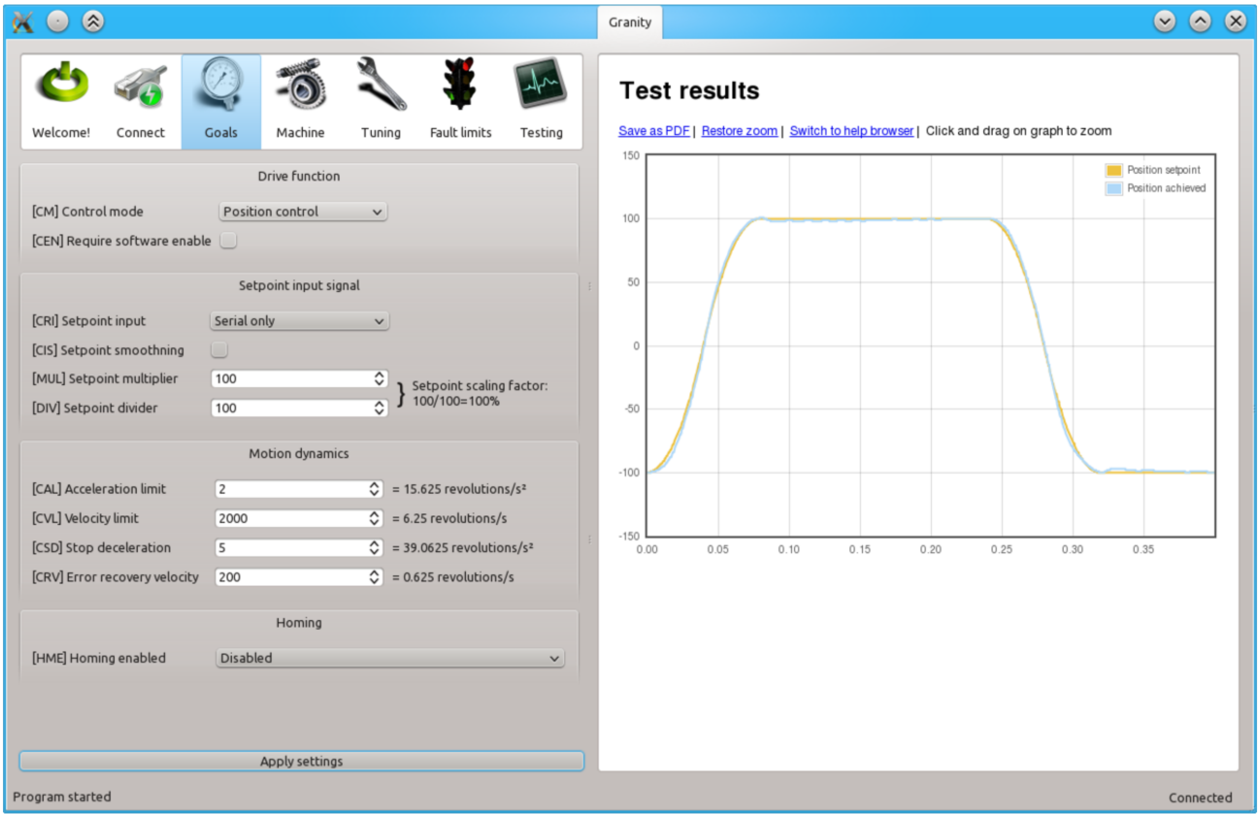
Once both KVP and KVI has been optimized, the next step is to increase KPP gain the same way. Increasing KPP gives better servo stiffness but may also increase overshooting. Overshoot less than 10 feedback device counts is generally considered good.



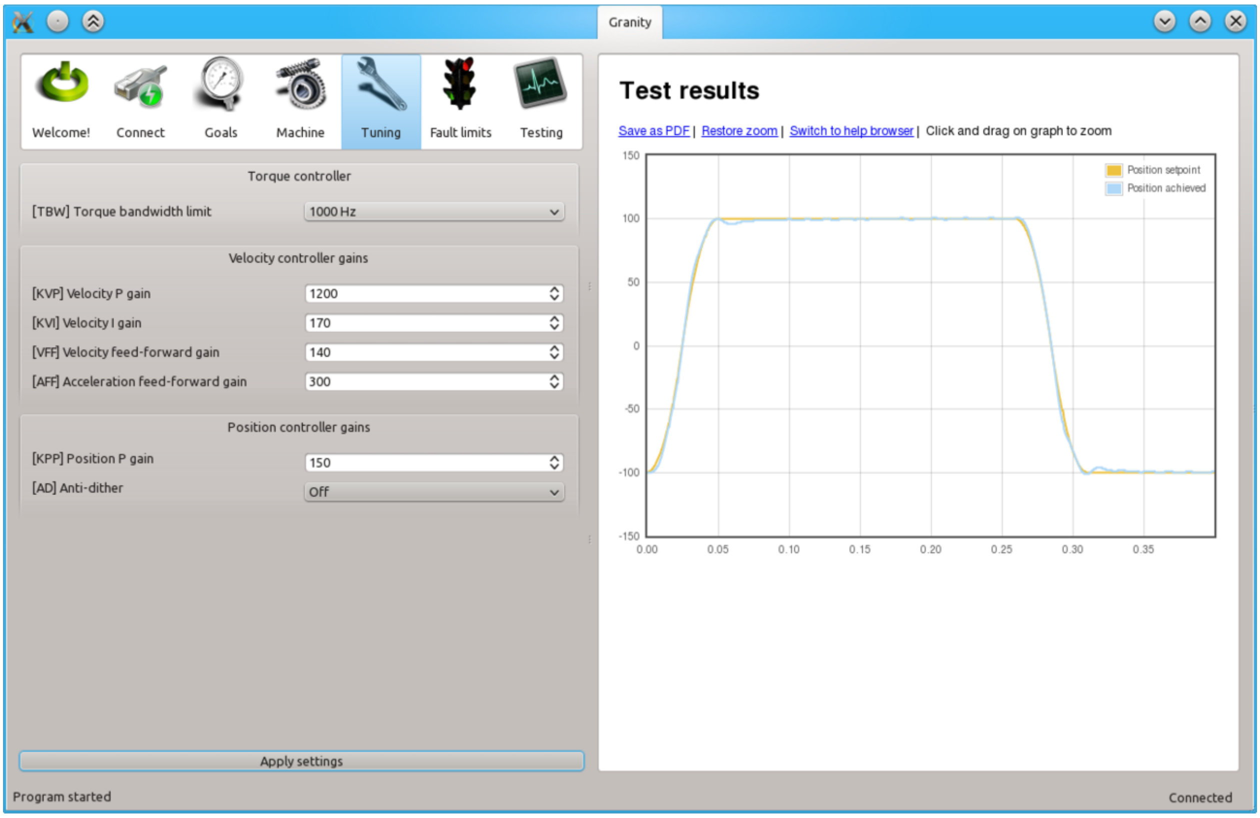
Finally after playing little bit with all of KVP, KVI and KPP gains experimentally, we find a less overshooting response without losing much stiffness.

Curing tracking error and overshoot

If servo overshoots too much, or can't follow the trajectory precisely, several cures may be tried.

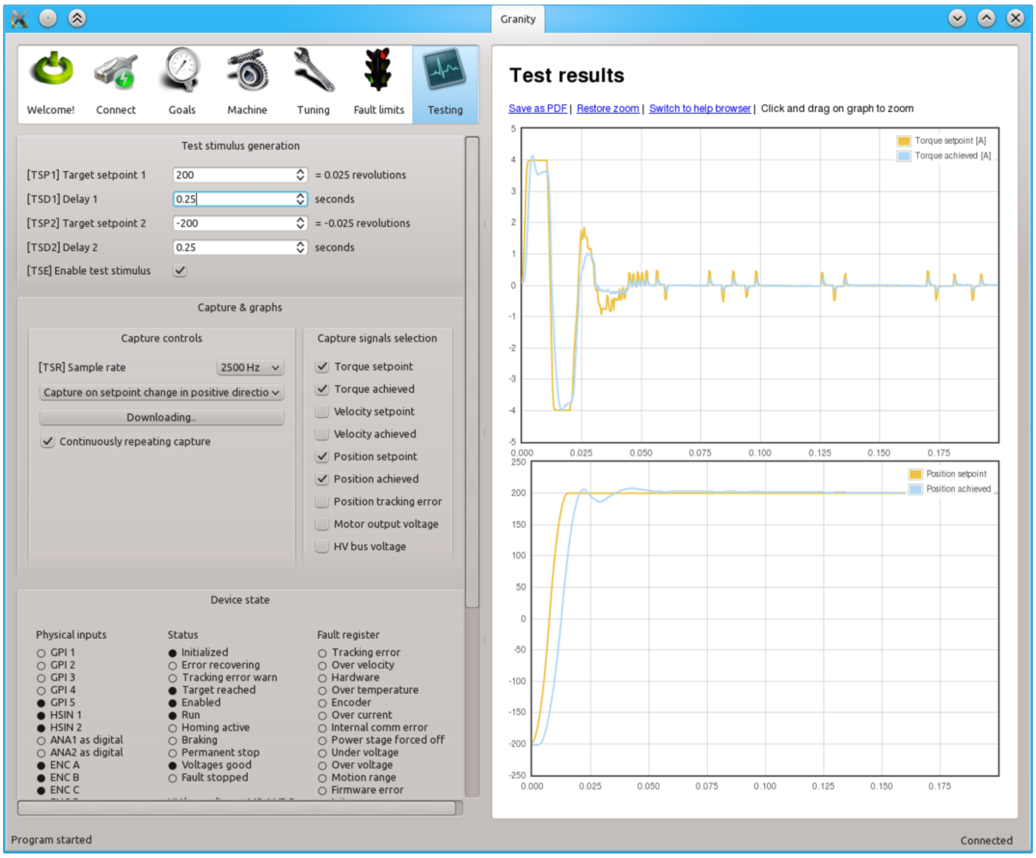


Reducing acceleration CAL and/or velocity CVL limits makes the trajectory easier to follow and reduces tracking error and overshooting.



The same may be also achieved by utilizing Feed-forward gains VFF and AFF which essentially compensate system friction and mass limiting the dynamic performance.

The recommended way to tune FF gains, is to start increasing velocity feed-forward VFF until the optimum level has been found. After that, increase acceleration feed-forward AFF until the optimum point has been reached.



If following the tuning procedure does not result in satisfactory tracking performance, the problem may be asking too much from the motor. In the example above the acceleration limit is set too high to be accelerated with the given motor torque limits (or current limits).

To verify if the problem happens due to torque limit, tick also Torque achieved and Torque setpoint signals from the Testing tab settings. In such way also motor currents will be displayed simultaneously with the position response curves. If the torque curve is limited to the set peak current limit MMC, then the problem is insufficient torque. In the image above we can see that the torque curves are saturated at 4A and -4A levels which matches the configured MMC value of 4A in this demonstration.

To help this, try:

- Increasing current limits MMC and MCC if possible
- Reducing acceleration CAL and/or velocity CVL limits

Steps to do after tuning finished

- Stop test stimulus by unticking TSE
- Stop scope catpure by unticking *Continuously repeating capture*
- Undo all temporary changes made to settings
- Save settings to drive memory by clicking *Save settings on drive non-volatile memory* button
- Set preferred setpoint source CRI, also consider the use of CIS
- If setpoint signal scaling is needed, adjust MUL and DIV values

If drive will be controlled by an external motion controller with acceleration & velocity limits, such as CNC controller programs like Mach3 or LinuxCNC, then its recommended to increase acceleration limit CAL to the maximum value of 32767 and disable setpoint smoothing CIS to prevent drive's internal acceleration limiter modifying the setpoint signal. Using these settings effectively disables the internal acceleration limit and let's external controller to control accelerations.

LED indicators

Argon user guide/LED indicators

Argon has four front panel led indicators which have dedicated indicating tasks:

- LD1 SimpleMotion transmit led. Blinks when drive transmits data to bus.
- LD2 SimpleMotion receive led. Blinks when drive receives data from bus.
- LD3 Fault indicator
- LD4 Motor control state indicator

How to read indications

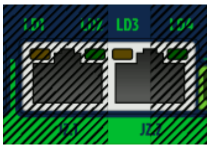
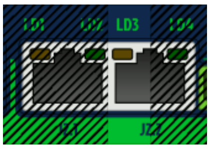
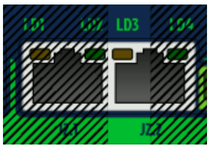
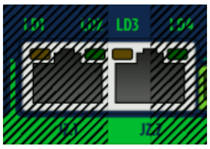
- LD1 and LD2, blink very briefly during data transmission. Due to short light pulses, these lights appear dimmer than other leds.
- LD3 and LD4 have programmed blinking sequences. Sequences consists series of short (S) and long (L) light pulses. For example LLS means the led will blink two long flashs and then one short flash. After sequence there will be a pause before the sequence repeats.
- LD3 and LD4 are independent and can show fault and motor state simultaneously. To easier reading sequence, cover one led with a thumb to be able to concentrate to one led.
- LD3 and shows the first fault occurred if multiple fault states are active simultaneously.

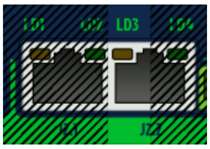
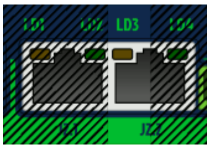
List of all LD3 and LD4 sequences

To see animated images, view this Wiki page in a web browser with animations enabled.

Faults originated from I/O side of drive

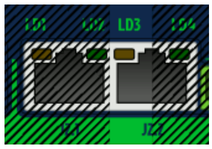
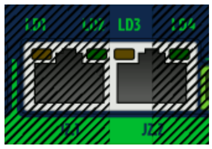
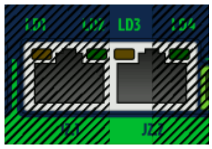
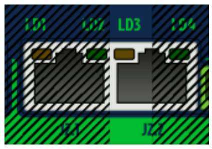
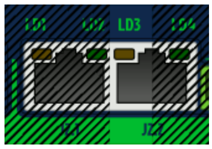
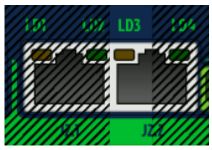
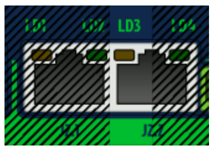
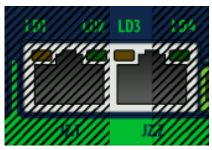
Only LD3 is being controlled by these faults.

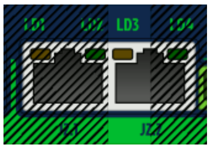
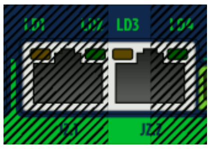
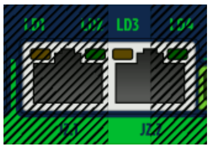
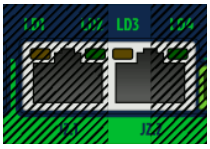
Fault reason	LED sequence	LED sequence as text
Hardware		SLLS
Program or memory		SLSL
Internal comm error (unable to establish comm)		SLSS
Internal comm error (in middle of operation)		SSLL

SimpleMotion communication		LSSS
Other/unknown		LLSL

Faults originated from GraniteCore side of drive

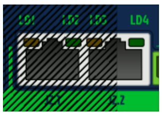
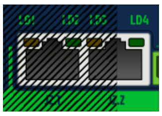
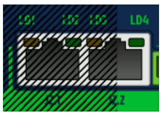
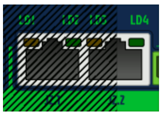
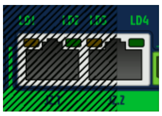
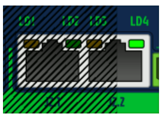
Only LD3 is being controlled by these faults.

Fault reason	LED sequence	LED sequence as text
Hardware		LLSS
Progral or memory		LSLL
Internal comm error (CRC)		LSL
Initialization		LSS
Over current		SLL
Over temperature		LSLS
Over voltage		SLS
Following error		LS

Under voltage		SL
Motion blocked or motor runaway		SSL
Setpoint range exceeded		LSSL
Other/unknown, possibly configuration error such as motor mode MT not selected		SSSL

Motor control states

Only LD4 is being controlled by these faults.

Status	LED sequence	LED sequence as text	Motor output powered
Permanent stop (need device reset)		LLS	No
Fault stop (observe LD3 for reason)		Off	Depends on fault
Follow error recovery motion		LS	Yes
Initializing		SL	Yes
Homing		LSS	Yes
Run		On	yes

Argon specifications & accessories

Argon specifications

This page lists official functional, electrical and physical specifications of the ARGON Servo Drive.

Main functionality

Function	Description

Servo motor drive	Closed loop control of various types of servo motors by sinusoidal field oriented control with dead-time distortion correction and high dynamic range torque control.
	• Support over 97% of all the servo motors below 2 kW in the market
	• Synchronous AC & BLDC motors
	  • Sinusoidal and trapezoidal commutated
	  • SPM (Surface Permanent Magnet) and IPM (Internal Permanent Magnet) types
	• Brush DC motors
	• Linear motors
	  • Iron core
	  • Ironless (with external inductive filter)

Control modes	• Torque control • Velocity/speed control • Position control
Closed loop	Cascaded control loops (PIV): • Torque / current control, update frequency 17.5 kHz • Velocity control, update frequency 2.5 kHz • Position control, update frequency 2.5 kHz Dual-loop feedback support planned as firmware upgrade
Feed-forwards	Feed-forwards working in velocity & position control modes: • Acceleration (inertia canceling) feed-forward • Velocity (friction canceling) feed-forward
Homing	Integrated homing function for position control mode: • Sensorless hard-stop homing • Home switch search • Index pulse search • Soft position limits (eliminate limit switches)
Setpoint signal	See setpoint signal / reference inputs list
Feedback devices	See feedback devices list

Safety	• Safe torque off with 3-way redundancy
	• Stopping motor on errors
	  • Tracking error (velocity & position)
	  • Over speed error
	  • Limit switch
	• DC motor runaway prevention on feedback loss
	• Communication error detection

Protections	• Over current • Short circuit (phase-to-phase) • I^2t motor thermal protection • Over & under voltage • Over temperature
Commissioning	• Granity setup software • Online user guide
Approvals	CE (LVD & EMC)

Mechanical

Property	Value	Units
Dimensions (with wall mounting tabs)[1]	51×197×127 (W×H×D)	mm
Dimensions (excluding wall mounting tabs)[1]	51×177×127 (W×H×D)	mm
Weight	0.88	kg
Case materials	Steel (cover), aluminum (heat sink)	
Drawings	2D (PDF), 3D (IGES & STEP)	

[1]) Wall mounting tabs are fixed part of enclosure

Environment

Property	Value	Units
Operating temperature	10-70	°C
Storage temperature	-30-90	°C
Humidity	0-95 non-condensing	%
Power dissipation	2-100[1]	W

[1]) Power dissipation is output current and input voltage related.

Power supply

Supply[2]	Input voltage	Input current typ	Input current max
Logic power	24 VDC +/- 10%	0.1 - 0.4 A	0.5 A
Motor power[3]	85 - 264 VAC 50/60 Hz	0 - 15 A[1]	26 A[1]
	84 - 380 VDC	0 - 15 A[1]	26 A[1]

[1]) Estimating true current or power consumption based on this table may be difficult as current demand typically varies greatly and and almost completely depends on motor load conditions.

[2]) Both logic and motor supplies are required.

[3]) Features internal inrush current limiter

Motor output

Property	Value	Units	Remarks
Supported motors	AC, BLDC, DC, Linear		Permanent magnet motors only
Continuous output current	0-10	A (peak value of sine)	User settable limit
Peak output current	0-15	A (peak value of sine)	Duration 1 sec, then returned to continuous limit. User settable current limit.
Maximum effective motor phase output voltage	Max 88% of input AC supply voltage AC or 124% DC.		I.e. for 230 VAC drive supply, max motor output is 202 VAC (AC/BLDC/Linear) or 285 VDC (brush DC).
Switching frequency	17.5	kHz	
Maximum modulation depth	88	%	Maximum effective output is 88% of HV DC bus voltage.
Torque control bandwidth (typ.)	1-3.3	kHz	Motor coil dependent
Torque control cycle time	57.1	µs	
Position & velocity control cycle time	400	µs	
Power conversion efficiency	90-95	%	Under typical conditions
Motor inductance range @ 230 VAC	1.4-25	mH	
Motor inductance range @ 115 VAC	0.7-25	mH	
Motor power range	0.05 - 1.5	kW	
AC commutation frequency	0-400	Hz	

Regenerative resistor

Property	Value	Units
Maximum current	6	A
Series fuse	8	A
Minimum resistance @ 230 VAC supply	70	Ω
Minimum resistance @ 115 VAC supply	35	Ω
Resistor power dissipation	0-2400[1]	W

[1]) Power dissipation depends on how much system's kinetic energy is directed to the resistor

Feedback devices

Status of feedback device support

Feedback device type	Status	Electrical interface
Quadrature incremental encoder	Standard feature	Differential 3-5.5V (RS422), Single ended 3-5.5V (CMOS,TTL,open collector)
Hall sensors	Standard feature	Single ended 3-5.5V (CMOS,TTL,open collector). Differential signals accepted.
Analog SinCos encoder	Under development[1]	1 V p-p, 12 bits sampling
Resolver/synchro	Under development[1]	10 kHz excitation
Serial SSI encoder	Planned[1]	RS422/RS485
Serial BiSS encoder	Planned[1]	RS422/RS485
Tachogenerator	Planned[1]	

[1]) Supported already by hardware, usage possible after firmware upgrade

Quadrature encoder electrical properties

Property	Value	Units	Remarks
Encoder count rate	0-4	MHz	After 4x decoding, digitally filtered
Supply voltage	4.8-5.2	V	Supplied from drive
Supply current	0-500	mA	Supplied from drive

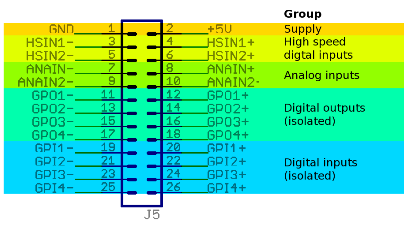
Setpoint signal / reference inputs

Setpoint signal type	Status	Electrical interface
Analog	Standard feature	Up to +/-10V or any lower range
Pulse and direction	Standard feature	Up to 4 MHz step rate, 5V signaling
Quadrature	Standard feature	Up to 4 MHz count rate, 5V signaling
PWM	Standard feature	3-30 kHz PWM carrier frequency
Serial communication	Standard feature	SimpleMotion V2 RS485 based real-time serial bus with open source SDK
Stand-alone operation or custom setpoint signal	User implementable	May be implemented in the Argon open source firmware
EtherCAT	Planned	Realized with add-on board

Inputs / outputs

List of I/O's

- Isolated digital inputs (4 channels) - used for limit & home switches and clear faults signal [1]
- Isolated digital outputs (4 channels) - used for status indication [1]
- Differential analog inputs (2 channels) - used as Analog setpoint [1]
- Differential digital inputs (2 channels) - used for pulse/direction or second encoder [1]
- Digital inputs (3 channels) - used for safe torque off and drive enable
- Digital output (1 channel) - used for motor solenoid brake



J5 I/O connector pin groups. In addition to J5, J2 has digital I/O's for enable and STO

[1]) Functions may be altered by modifying the Argon open source firmware

Electrical characteristics

For detailed specifications, see I/O electrical interfacing and pinout & wiring.

Property	Typical value	Maximum rating	Units
Protections (all I/O lines)	overvoltage, ESD, short circuit, reverse polarity		
Isolated digital input (GPIx) logic 1 voltage	4.5-24	25.5	V
Isolated digital input (GPIx) logic 0 voltage	0-1.3		V
Isolated digital output (GPOx) voltage	0-24	25.5	V
Isolated digital output (GPOx) current drive capability [1,2]	5-20	40	mA
High speed digital input (HSINx) voltage range	2.7-5.5	6.0	V
Analog input input (ANAINx) voltage range	±10	±25 vs GND	V
Analog input input (ANAINx) resolution	12		bits
Enable input input logic 1 voltage	20-24	25.5	V
STO input input logic 1 voltage	20-24	25.5	V
Motor brake voltage	12-24	25.5	V
Motor brake load current	0-0.5	0.7	A

[1]) Actual output drive capability may vary from unit to unit. Minimum guaranteed capability is 5 mA.

[2]) Do not exceed GPO safe operating area (SOA). Loading GPOx pin is within SOA when following equation is true: Voltage_drop_over_GPOx_pin_pair*Load_current < 0.1W. Example: if voltage over GPOx pins is 5V and current 0.01A, then 5V*0.01A=0.05W which is less than 0.1W so the operation is safe. The recommended practice is to drive only high impedance circuits with GPO to avoid overloading.

Communication

Property	Value	Units
Communication protocol	SimpleMotion V2	
Default bitrate	460800	BPS
Maximum number of Argon devices chained in a single bus	15	pcs
Command throughput	Up to 10000	Commands/s

Safety

Feature	Properties	Remarks
Safe torque off	• 3-way redundancy with 2 physical STO inputs 1. Cut AC input by safety relay @ STO1 input 2. Cut power stage gate voltage @ STO2 input 3. Disable power stage by software @ STO2 input	STO1 safe up to 6 A AC RMS input current. Not operational if AC input > 6 A RMS AC or if DC voltage is being supplied to drive through L & N terminals or VP & VN terminals.
Control error detection	• Tracking error (velocity & position) • Over speed error • Limit switch • DC motor runaway prevention on feedback loss • Communication error	
Electrical safety	• Galvanic isolation between I/O side and power side • Internal fuse on AC input • MOV based transient overvoltage protection • Earth leakage current typ. < 0.5 mA • ESD, short circuit, reverse polarity protection on all pins • Surge protection on AC & DC power inputs	Galvanic isolation on J1, J2, J3 and J5 connectors against J4 with live AC mains voltages
Overload safety	• Over current • Short circuit (phase-to-phase) • I^2t motor thermal protection • Over & under voltage • Drive over temperature	

Warnings

Exceeding ratings may affect drive operation and cause instability or even damage the drive or other equipment. Damaged equipment may pose danger to users.

Argon user guide/Mating connectors and accessories

This page lists available mating connectors, accessories and spare parts for Argon (servo drive). Most parts or equivalents are available from large number of distributors. Feel free to extend this list.

Connectors

J1 connector

Description	Manufacturer	Part number	Distributors and order codes
PLUG, D, SOLDER, 15WAY	MULTICOMP	5501-15PA-02-F1	• Farnell [1] 1084673 DE [2], US [3],UK [4],ES [5],FR [6],FI [7],SE [8],IT [9]

Accessories

Description	Manufacturer	Part number	Distributors and order codes
D-SUB BACKSHELL, 15WAY	MH CONNECTORS	DPPK15-GREY-K	• Farnell [1] 470028 DE [10], US [11],UK [12],ES [13],FR [14],FI [15],SE [16],IT [17]

J2 connector

Cable assemblies

Cable used for J2 should be shielded (S/FTP or FTP, *not UTP*) type and preferrably with standed wires.

Description	Manufacturer	Part number	Distributors and order codes
Premium patch cable 0.5m	VIDEK	3962-0.5	Farnell [1] 1525999 DE [18], US [19],UK [20],ES [21],FR [22],FI [23],SE [24],IT [25]
Premium patch cable 1m	VIDEK	3962-1	
Premium patch cable 2m	VIDEK	3962-2	Farnell [1] 1525753 DE [26], US [27],UK [28],ES [29],FR [30],FI [31],SE [32],IT [33]
Premium patch cable 5m	VIDEK	3962-5	Farnell [1] 1525755 DE [34], US [35],UK [36],ES [37],FR [38],FI [39],SE [40],IT [41]
Premium patch cable 10m	VIDEK	3962-10	
Shielded patch cable 0.5m	VIDEK	2992-0.5	Farnell [1] 1517504 DE [42], US [43],UK [44],ES [45],FR [46],FI [47],SE [48],IT [49]
Shielded patch cable 1m	VIDEK	2992-1	
Shielded Patch cable 2m	VIDEK	2992-2	Farnell [1] 1517506 DE [50], US [51],UK [52],ES [53],FR [54],FI [55],SE [56],IT [57]

Shielded patch cable 5m	VIDEK	2992-5	Farnell [1] 1517509 DE [58], US [59],UK [60],ES [61],FR [62],FI [63],SE [64],IT [65]
Shielded patch cable 10m	VIDEK	2992-10	
Shielded patch cable 0.5m	Assman	A-MCSP-80005/B-R	Digikey A-MCSP-80005/B-R [66]
Shielded patch cable 1m	Assman	A-MCSP-80005/Y-R	Digikey A-MCSP-80010/Y-R [67]
Shielded patch cable 2m	Assman	A-MCSP-80020/Y-R	Digikey A-MCSP-80020/Y-R [68]
Shielded patch cable 3m	Assman	A-MCSP-80050/Y-R	Digikey A-MCSP-80030/Y-R [69]
Shielded patch cable 5m	Assman	A-MCSP-80050/Y-R	Digikey A-MCSP-80050/Y-R [70]
Shielded patch cable 10m	Assman	A-MCSP-80050/Y-R	Digikey A-MCSP-80100/Y-R [71]

Accessories

Description	Manufacturer	Part number	Distributors and order codes
RJ45 break-out board with DIN rail fixutre (convert RJ45 to screw terminals). Helpful for wiring STO and Enable wires.	Camden boss	CIM/RJ45	Farnell [1] 2211819 DE [72], US [73],UK [74],ES [75],FR [76],FI [77],SE [78],IT [79]

J3 connector

This part is included with Argon package.

Description	Manufacturer	Part number	Distributors and order codes
3 pole 0.2" pitch terminal	On Shore Technology Inc	OSTTJ035153	• Digikey ED2909-ND [80]

J4 connector

This part is included with Argon package.

Description	Manufacturer	Part number	Distributors and order codes
10 pole 0.2" pitch terminal	On Shore Technology Inc	OSTTJ105153	• Digikey ED2904-ND [81] • FCI equivalent, Digikey 609-4220-ND [82]

J5 connector

Mating connector type is 0.1" pitch 26 pin IDC ribbon cable socket, see example (pdf).

Example of DIN rail attachable IDC terminal block/breakout board.

Description	Manufacturer	Part number	Distributors and order codes
SOCKET, IDC, 2.54MM, 26WAY	AMPHENOL	T812126A100CEU	• Farnell [1] 2215239 DE [83], US [84],UK [85],ES [86],FR [87],FI [88],SE [89],IT [90]
SOCKET, IDC, WITH S/RELIEF, 26WAY	MULTICOMP	MC6FD026-30P1	• Farnell [1] 1099240 DE [91], US [92],UK [93],ES [94],FR [95],FI [96],SE [97],IT [98]

Accessories

Description	Manufacturer	Part number	Distributors and order codes
IDC terminal block, 26WAY	Camden boss	CIM/202426W-IDCS	• Farnell [1] 2211821 DE [99], US [100],UK [101],ES [102],FR [103],FI [104],SE [105],IT [106]

Heat sinks & cooling & high power application

Description	Manufacturer	Part number	Distributors and order codes
Half brick heatsink. Up to 4 pcs of standard half brick heat sinks can be fitted to a drive to improve cooling and increase maximum power output. Install with thermal grease. Note: M3 mounting screws must not reach through the 5 mm thick heat sink of the drive!	CUI Inc	VHS-95	• Digikey 102-1489-ND [107]
Fuse, anti-surge, 6.3A. A replacement for original fuse in the drive. See replacing Argon fuse.	SCHURTER	0001.2512	Farnell [1] 1360860 DE [108], US [109],UK [110],ES [111],FR [112],FI [113],SE [114],IT [115]
Fuse, anti-surge, 10A. A higher power alternative fuse. See replacing Argon fuse.	SCHURTER	0001.2514	Farnell [1] 1360862 DE [116], US [117],UK [118],ES [119],FR [120],FI [121],SE [122],IT [123]

Fuse, anti-surge, 16A. A higher power alternative fuse. See replacing Argon fuse.	SCHURTER	0034.3129	Farnell [1] 1360824 DE [124], US [125],UK [126],ES [127],FR [128],FI [129],SE [130],IT [131]

Electromagnetic interference filtering

Multiple drives may be connected behind one power line filter as long as total current consumption doesn't exceed filter rating

Description	Manufacturer	Part number	Distributors and order codes
EMI suppression core for low frequency band	Laird	LFB159079-000	Digikey 240-2281-ND [132]
EMI suppression core for medium frequency band	Laird	28B0616-000	Digikey 240-2306-ND [133]
Power line filter for up to 12A AC input current, FN2090 series - low cost	Schaffner	FN2090-12-06	Digikey 817-1332-ND [134]
Power line filter for up to 16A AC input current, FN241x series - high performance	Schaffner	FN2412-16-44	Digikey 817-1358-ND [135]
Power line filter for up to 12A AC input current, FN350 series - optimal for single phase motor drives	Schaffner	FN350-12-29	Digikey 817-1130-ND [136]
Power line filter for up to 20A AC input current, FN350 series - optimal for single phase motor drives	Schaffner	FN350-20-29	Digikey 817-1131-ND [137]

Braking resistors

One resistor in a multiaxis system may be sufficient if drives are wired to share the HV DC bus between them

Description	Manufacturer	Part number	Distributors and order codes
82 ohm 250W braking resistor for 220-240VAC installation	Tyco	Tyco HSC 250 82R	Farnell [1] 1619350 DE [138], US [139],UK [140],ES [141],FR [142],FI [143],SE [144],IT [145]
47 ohm 250W braking resistor for 220-240VAC installation	Tyco	Tyco HSC 250 47RJ	Farnell [1] 1619349 DE [146], US [147],UK [148],ES [149],FR [150],FI [151],SE [152],IT [153]

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