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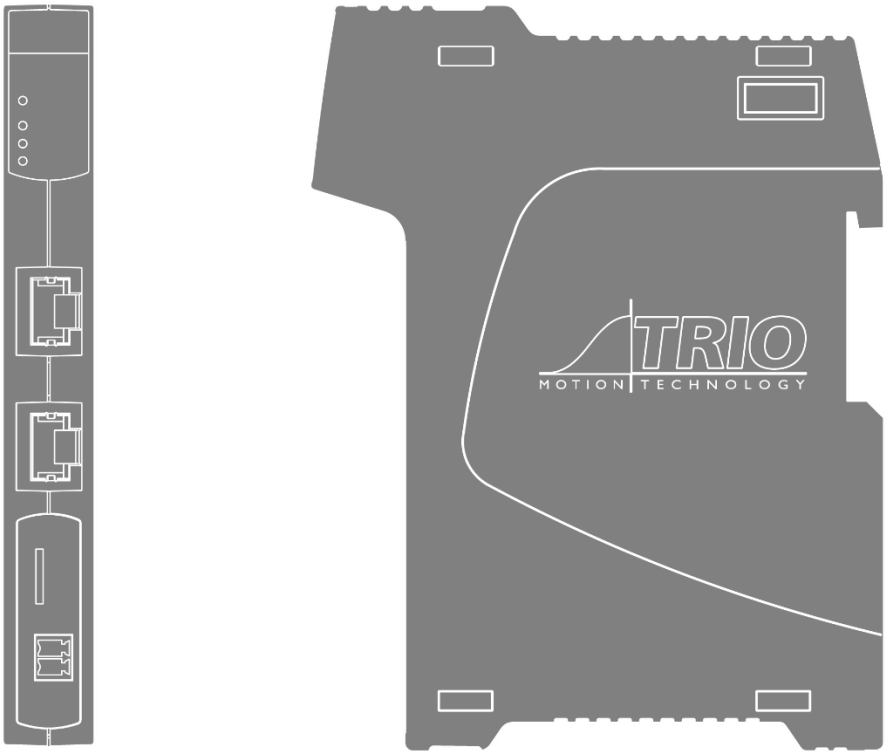

Flex-6 Nano

EtherCAT 64 AXIS MOTION COORDINATOR

USER MANUAL

About this Manual

Purpose

This manual provides the information required for the Selection, Wiring, Connection, Setup, Operation and Functions of the FLEX-6 NANO Motion Coordinator.

Please read and understand this manual to ensure correct usage of the product.

Terms

Terms that may be used in this manual are defined as follows.

Term	Meaning
Axis	A software control that operates a Servo or Stepper Motor.
Drive	A Servo or Stepper Drive, which is used for controlling the Motor.
Servo System	A Servo Control System that includes a Motor, a Drive, a host controller (Motion Coordinator) and peripheral devices.
WDOG ON	Setting the control word on EtherCAT to signal that the Drives may be Enabled.
WDOG OFF	Clear the control word to signal that the Drives must be Disabled.
Motion Perfect	The PC Tool for commissioning and programming the Trio product suite.
Pulse+Direction	An electronic output from the Motion Coordinator that produces one pulse per step of the motor position, with a second output to signal the direction of motion.
Motion-iX	The motion-centric programming language, an extension of BASIC.
EtherCAT	Ethernet based fieldbus for synchronised control of slave devices in real-time.

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Revision History

Date	Version	Revised Contents
29 Jun 2021	1.00	Initial release
31 Jan 2023	1.01	Updated specification table

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All goods supplied by Trio are subject to Trio's standard terms and conditions of sale.
This manual applies to systems based on the Motion Coordinator FLEX-6 NANO.

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Safety Warning



During the installation or use of a control system, users of Trio products must ensure there is no possibility of injury to any person, or damage to machinery.

Control systems, especially during installation, can malfunction or behave unexpectedly.

Users must ensure that in all cases of normal operation, controller malfunction, or unexpected behaviour, the safety of operators, programmers or any other person is totally ensured.

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User Manual FLEX-6 NANO

Overview



The Motion Coordinator FLEX-6 NANO is based on Trio's high-performance ARM Cortex-A7 double-precision technology and provides up to 64 axes of coordinated motion using the EtherCAT bus system to connect to Drives and I/O. The FLEX-6 NANO is housed in a rugged plastic case with integrated earth chassis and incorporates two screened RJ45 Ethernet ports, a 24V dc power connector and micro SD card slot. The upper RJ45 connector is for a standard Ethernet connection to the PC for programming and the lower connector is for the EtherCAT Fieldbus. Filtered power supplies (DC/DC converters) are included so that it can be powered from the 24V d.c. logic supply present in most industrial cabinets.

It is designed to be configured and programmed for the application using a PC running Trio's Motion Perfect application software, and then may be set to run "standalone" if an external computer is not required for the final system. Programs and data are stored directly to FLASH memory, thus eliminating the need for battery backed storage.

The Multi-tasking version of Motion-iX for the FLEX-6 NANO allows up to 22 Motion-iX programs to be run simultaneously on the controller using pre-emptive multi-tasking. In addition, the operating system software includes the IEC 61131-3 standard run-time environment that has access to the full library of motion functions.

Programming

The Multi-tasking ability of the FLEX-6 NANO allows parts of a complex application to be developed, tested and run independently, although the tasks can share data and motion control hardware. The 22 available processes can be used for Motion-iX or IEC 61131-3 programs, or a combination of both can be run at the same time, thus allowing the programmer to select the best features of each.

The Flex-6 Nano is fully compatible with Trio's Robot Programming System (RPS) and the user can decide to write programs using the powerful Motion iX functions or the RPS motion suit which is tailored to Scara and other industrial robot systems. Both RPS and Motion iX / IEC programs may be run on the same Motion Coordinator thus allowing the powerful Flex-6 Nano to control many auxilliary motors as well as the robot arm(s).

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I/O Capability

The FLEX-6 NANO has the ability to add up to 16 EtherCAT FLexslice input / output modules using the EBUS connector on the side. Modules are supported mechanically by a positive latch system that allows rapid assembly that results in a robust final assembly ready for clipping on the DIN rail. These may be used for system interaction or may be defined to be used by the controller for end of travel limits, soft registration, datuming and feedhold functions if required. The FLEX-6 NANO can have up to 1024 external Input and Output channels connected using a combination of the local EBUS and remote EtherCAT IO via the P366 bus coupler module.

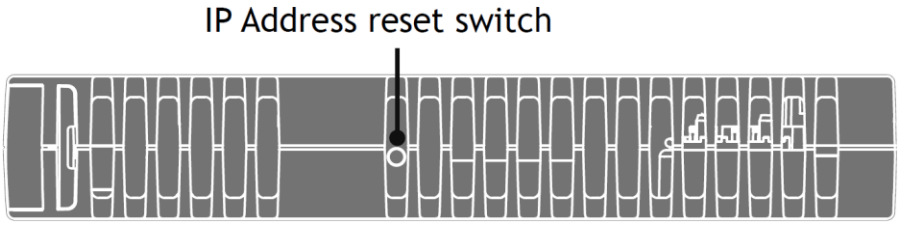
Communications

A 100 base-T Ethernet port is fitted as standard and this is the primary communications connection to the FLEX-6 NANO. Protocols supported include Telnet (Client and Server), Modbus TCP (Client and Server), Ethernet IP (Slave), Profinet (Slave) and the TrioPCMotion DLL/ActiveX channel.

IP Address reset

To reset the IP _ ADDRESS, IP _ GATEWAY and IP _ NETMASK to their default values press the IP reset button, located under the upper ventilation slots, and power cycle the controller while keeping the button pressed.

The factory default IP address is 192.168.0.250. This can be changed using the ETHERNET or IP_ADDRESS commands via Motion Perfect.



IP_ADDRESS and other settings may also be changed by adding the commands to a file called TRIOINIT.BAS on a micro-SD card and powering up the FLEX-6 NANO with the card inserted in the SD slot.

Removable storage

The FLEX-6 NANO has a micro-SD Card slot which allows a simple means of transferring programs, firmware and data without a PC connection. Offering the OEM easy machine replication and servicing.



The memory slot is compatible with a wide range of micro-SD cards up to 32 GBytes using the FAT32 compatible file system.

Axis positioning functions

The motion control generation software receives instructions to move an axis or axes from the Motion-iX or IEC 61131-3 language which is running concurrently on the same processor. The motion generation software provides control during operation to ensure smooth, coordinated movements with the velocity profiled as specified by the controlling program.

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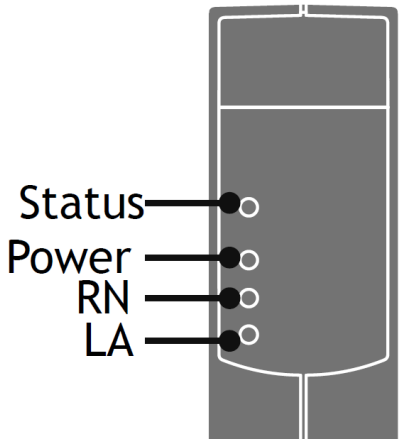
Linear interpolation may be performed on groups of axes, and circular, helical or spherical interpolation in any two/three orthogonal axes. Each axis may run independently, or they may be linked using interpolation, variable electronic gearboxes and kinematic transform.

Consecutive movements may be merged to produce continuous path motion and the user may program the motion using programmable units of measurement (e.g. mm, inches, revs etc.). The module may also be programmed to control only the axis speed. The positioner checks the status of end of travel limit switches which can be used to cancel moves in progress and alter program execution.

LED indicators



2 LEDs show the status of the power and the enable circuit. The enable circuit drives the watchdog relay and activates the pulse output signals.

Red LED ON shows that the WDOG is off and the axes are disabled. When the red LED is OFF, the axes are enabled and ready to move. A flashing red LED indicates that one or more axes are in error.

RN is the run status of the EtherCAT network and LA show the EtherCAT network activity.

RN LED	**EtherCAT State**
OFF	Initial
Uniform flash	Pre-Operational
Brief flash	Safe-Operational
ON	Operational

Connections to the FLEX-6 NANO

Ethernet port connection



RJ45 socket 10/100 base-T

The Ethernet port is the default connection between the Motion Coordinator and the host PC running the Motion Perfect development application.

In addition, the Ethernet port will provide connection using common Ethernet industrial protocols such as Modbus, CIP and Profinet.

EtherCAT port connection

RJ45 socket 100 base-T



The Flex-6 Nano acts as an EtherCAT master. EtherCAT drives and I/O devices are normally connected in a chain.

Ethernet standard pin assignment:

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Pin	Signal	Description
1	TD+	Transmission data +
2	TD-	Transmission data -
3	RD+	Receive data +
6	RD-	Receive data -

Straight through (patch) or cross-over cables can be used between EtherCAT devices.

Minimum cable specification: CAT 5e shielded SF/UTP cable is recommended.

Registration

FLEX-6 NANO requires servo and stepper drives connected by EtherCAT to support the CiA402 Touch Probe system. With the touch probe objects included in the cyclic data PDO, the Motion Coordinator programs can use the REGIST command to access the registration inputs and functions in the remote drives. Precise position capture can then be done to enable operation of many machine types which include printing, cutting and scanning machines.

Expanding the system

The Flexslice system makes available a selection of digital and analogue I/O terminals as well as motion modules with analogue servo and pulse + direction outputs designed for precise positioning of stepper and servo motors via suitable drive technology. The digital I/O modules have high-speed functionality and can sample on each EtherCAT cycle. In addition, analogue modules and axis modules may be fitted to make a superbly tailored system that can be placed remotely from the master if needed.



All Flexslice modules support automatic addressing with the master able to automatically detect and configure the modules on startup. The Flex-6 Nano supports up to 16 input/output modules which have a positive mechanical lock and bus connector, making a reliable “back-bone” style connection (EBUS). The complete assembly can be DIN rail mounted.

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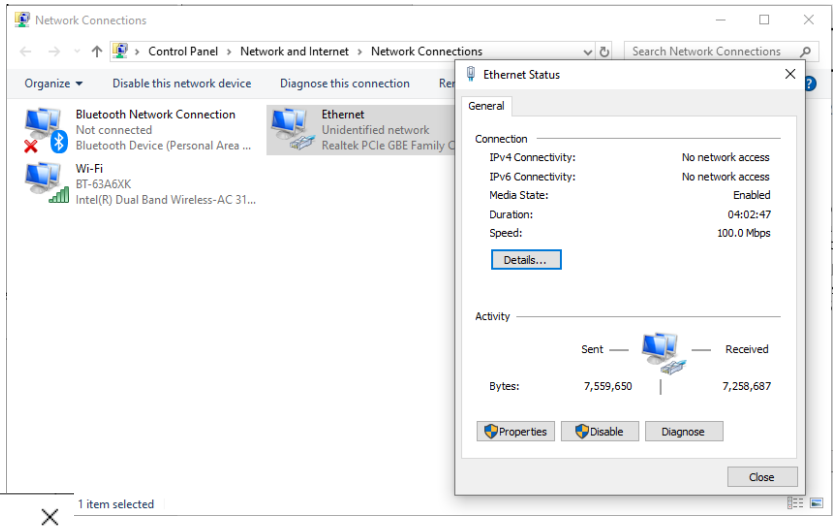
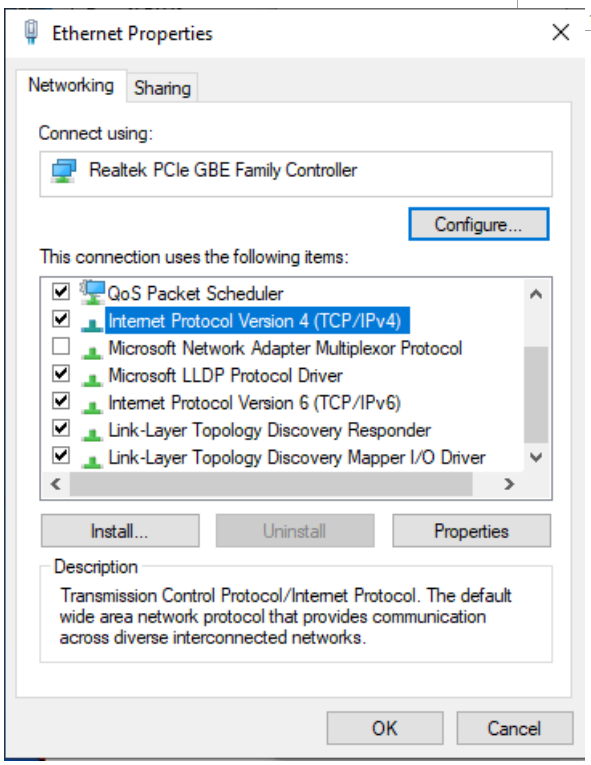
Support Software

Motion Perfect version 5 or later is required for configuration, programming and system debug. A PC running Microsoft Windows (Windows 10 or later recommended) is required. Download Motion Perfect from www.triomotion.com and install on the PC.

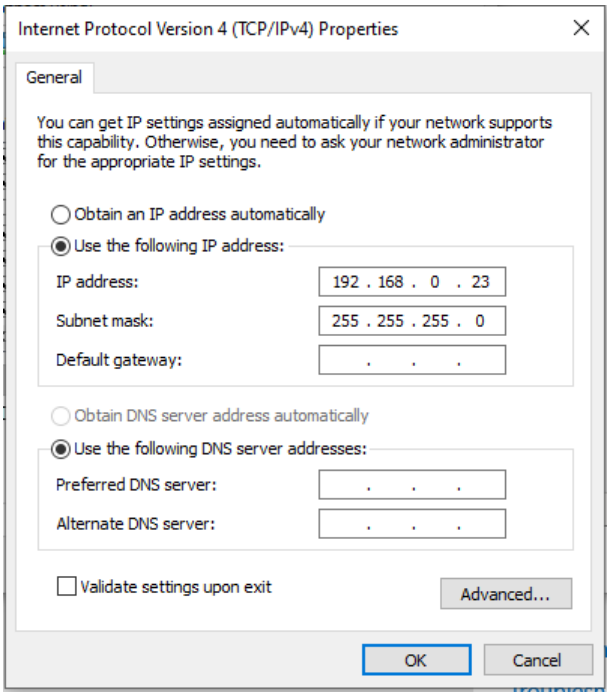
Connection is via the Ethernet port. Ensure that the PC has a valid Ethernet Address. For single point-to-point connection, a fixed IP address must be set in the PC. Go to Settings, Network and Internet then open Change Adapter Settings. Open the Ethernet port.



Click the Properties button and then select Internet Protocol Version 4 (TCP/IPv4).



Click Properties and select Use the following IP address. Set an IP address in the same subnet as the FLEX-6 NANO. Usually this will be 192.168.0.xxx.



Click OK and close the Ethernet setup dialogues.

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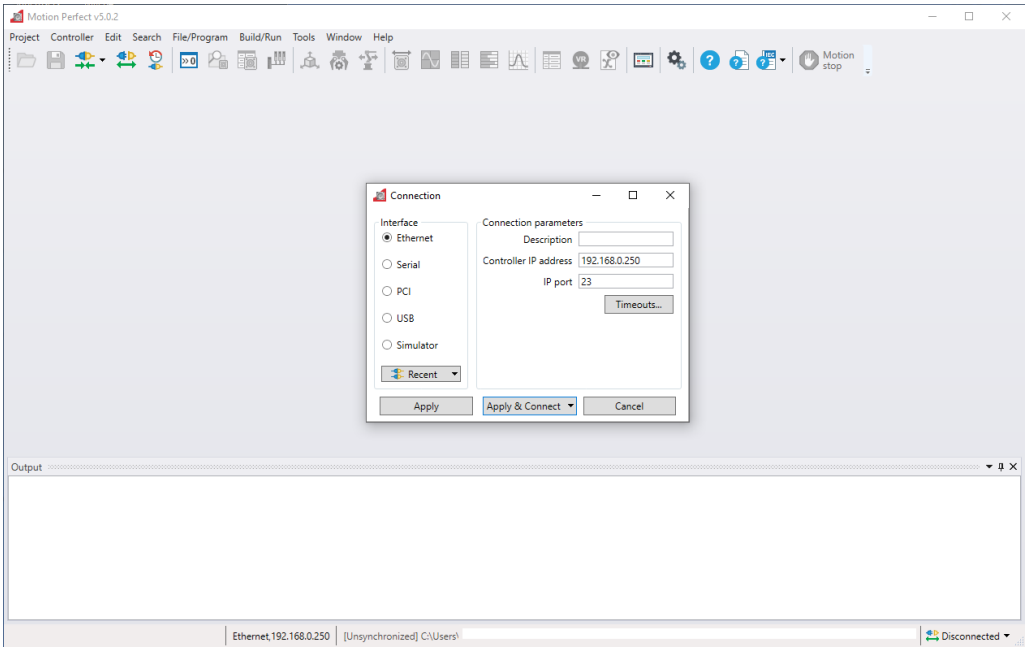
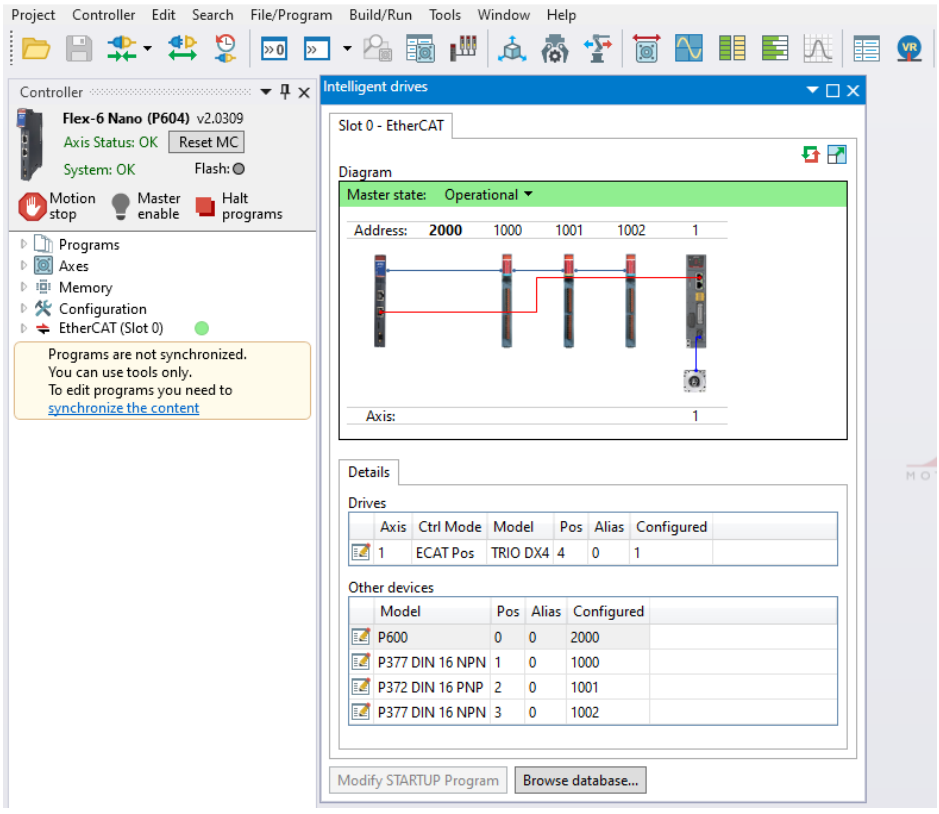
Motion Perfect version 5

Launch Motion Perfect and select the IP address of the FLEX-6 NANO. By default this will be 192.168.0.250. Click the Apply and Connect button.



If the IP Address of the FLEX-6 NANO is not known, then reset it by holding the IP Reset button, located under the ventilation slots on the top face, while powering up the FLEX-6 NANO. This will reset the IP_ADDRESS to 192.168.0.250.



Motion Perfect in Synchronised connection mode.

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Software functions

The Flex-6 Nano contains a stand-alone operating system which includes a rich set of built-in motion functions accessible from both the interpreted Motion iX text language and the IEC-61131-3 standard PLC language. A short summary of the main functions is shown in the table below.

Function name (Keyword)	Description	Notes
MOVE	Incremental move. One axis or multiple axes move at the programmed speed and acceleration.	SPEED sets vector speed.
MOVEABS	Absolute position move. Move one axis or multiple axes to position(s) referenced with respect to the zero (home) position.	
MOVECIRC	Moves 2 orthogonal axes in such a way as to produce a circular arc at the tool point.	
MHELICAL	Moves 2 orthogonal axes in such a way as to produce a circular arc at the tool point with a simultaneous linear move on a third axis.	
MSPHERICAL	Moves 3 orthogonal axes along a spherical path.	
MOVEABSSEQ	Allows a sequence of movements to be run from a pre-loaded table of position values. The moves can be automatically merged together using fillets. (circular arcs)	
MOVESP	Same as MOVE with addition of speed profile control for cutting and machining operations.	CORNER CONTROL enabled
MOVEABSSP	Same as MOVEABS with addition of speed profile control for cutting and machining operations.	
MOVECIRCSP	Same as MOVECIRC with addition of speed profile control for cutting and machining operations.	
MHELICALSP	Same as MHELICAL with addition of speed profile control for cutting and machining operations.	
MSPHERICALSP	Same as MSPHERICAL with addition of speed profile control for cutting and machining operations.	
CONNECT	Link 2 axes together so that one axis follows the other with a defined gear ratio.	
MOVELINK	Link 2 axes together temporarily with a defined ramp up and ramp down on the following axis.	Linear or S-curve acceleration profile
FLEXLINK	Link an axis to a driving axis with varying ratio over a base distance and programmable excitation distance.	
CAMBOX	User defined constantly changing ratio between the axis and its driving axis. (Cam shape supplied by user program)	
MOVEPICK	Pre-defined pick and place profile. User defined overlap and withdraw distances.	

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Firmware recovery

In the unlikely event that the Motion Coordinator firmware becomes corrupted and the processor will not start the Ethernet port and allow communication, the Flex-6 Nano, has a firmware recovery mode. The recovery is automatic and forces the processor to run a protected boot area of the memory that is dedicated to restoring the full operating system from a SD card.

The following equipment is needed to complete the Firmware Recovery:

- Micro SD card formatted to FAT32. Max size 32GB.
- Firmware file for the Flex-6 Nano, downloaded from the Trio Website.

Rename the firmware file to r_600.out and copy it to the root folder on the micro-SD card.

With the power off, insert the micro-SD card into the slot and then turn on the power. The red LED will flash during the firmware loading process. When the Red LED becomes steady it will be possible to re-connect to the Motion Coordinator via Ethernet. If the IP address is not known, then power off, hold the IP reset button and power on again to set the default IP address 192.168.0.250, subnet mask 255.255.255.0 and default gateway 192.168.0.225.

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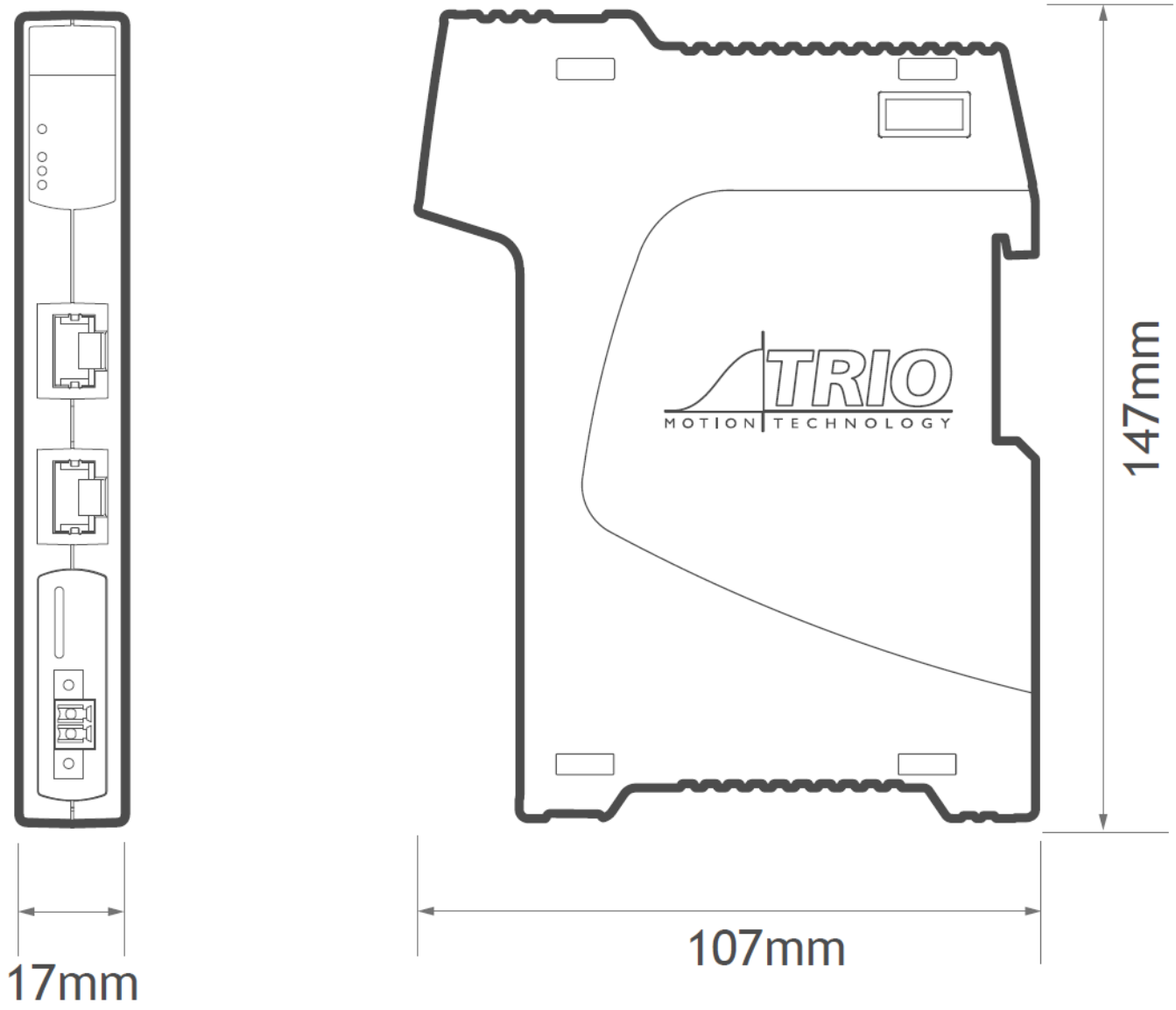
Dimensions



Mounting

The FLEX-6 NANO has a standard DIN rail mount with over-centre clip operated by a lever on the lower face. It must be installed on an unpainted metal plate with DIN rail which is connected to earth.

Ventilation: When the FLEX-6 NANO is mounted in an enclosed cabinet, there must be an adequate volume of circulating air to maintain the environmental temperature within the operating temperature range. If clearance is allowed for cable connections, there is no further limit on spacing next to other components that do not emit heat.

Place below heat sources such as drives and power supplies.

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Specifications

Specification table	
Size	147 mm x 107 mm x 17 mm (HxWxD)
Weight	160g
Operating Temp.	0 - 45 degrees C
EMC (CE)	EMISSIONS – EN IEC 61000-6-4 : 2019 IMMUNITY – EN IEC 61000-6-2 : 2019
EMC (UKCA)	EMISSIONS – BS EN IEC 61000-6-4 : 2019 IMMUNITY – BS EN IEC 61000-6-2 : 2019
Control Inputs Via I/O expansion	Forward Limit Reverse Limit Datum Input Feedhold Input
Communication Ports	Ethernet : 10/100 Base-T multiple port connection. EtherCAT : 100 Base-T cyclic at SERVO_PERIOD rate. EBUS : Local EtherCAT bus for Flexslice Module expansion.
Position Resolution	64 bit internal position registers
Speed Resolution	32 bits. Speed may be changed at any time Moves may be merged
Servo Cycle	125µs minimum 1ms default 4ms max
Programming	Multi-tasking Motion iX system IEC 61131-3 programming system. Maximum 22 user processes.
Interpolation modes	Linear, circular, helical, spherical, CAM Profiles, speed control, software gearbox and linked motion. Special profiles for Pick and Place, Dispensing and CNC.
Processor	ARM Cortex-A7 dual core, 1GHz max clock frequency.

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Memory	128 Mbyte DDR3 Ram 128 Mbyte Fast serial flash memory 12 Mbyte user program memory Automatic flash EPROM program and data storage
VR	16384 global VR data in FLASH memory (automatic-store)
TABLE	512000 x 64 bit TABLE memory
Real Time Clock	Super-capacitor support for 10 days of power off
SD Card	Standard micro-SD Card FAT 32, up to 32 GB Stores programs and data Can be used for firmware update, user program installation and system recovery
Power Input	24V d.c. +/- 20%. Class 2 transformer or power source 18..29V d.c. at 350mA + IO supply
Amplifier Enable Output	Software enable via EtherCAT
Product Code	P600 : Flex-6 Nano 4 EtherCAT Motion Coordinator (2 axes) P601 – P605 : Flex-6 Nano with axis codes for 4 – 64 axes

Electromagnetic Compatibility

Trio Motion Technology products are certified to comply with the requirements of Annex I to the Directive 2014/30/EU on Electromagnetic disturbance and Electromagnetic immunity. To achieve this compliance, certain requirements or best engineering practices must be implemented by the corresponding system designer.

Intended conditions of use

Trio Motion Technology products are designed for operation in Industrial environments with high noise levels that may induce currents or electrical potentials that are damaging to microelectronics. Our products are nevertheless designed and tested to withstand the level of electromagnetic disturbance common to these environments, on the provision that the appropriate EMC guidelines have been employed by a qualified competent system integrator.

The Trio Motion Technology product range is designed to be integrated, by the customer, as a control system for industrial machines and auxiliary equipment.

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EMC Considerations

Electromagnetic Interference problems can usually be avoided by careful wiring and following a few basic rules.

- Mount noise generators such as contactors, solenoid coils and relays as far away as possible from the Motion Coordinator.
- Where possible use solid-state contactors and relays.
- Fit suppressors across coils and contacts.
- Place high voltage cables in separate trunking to low voltage and signal cables.
- Ensure all the modules have a secure earth connection.
- Where screened cables are used, terminate the screen with a 360 degree termination rather than a “pig-tail”. Connect both ends of the screen to earth. The screening should be continuous, even where the cable passes through a cabinet wall or connector.

These are just general guidelines and for more specific advice, see the installation requirements later in this chapter.

The consideration of EMC implications is more important than ever since the introduction of the EC EMC directive which makes it a legal requirement for the supplier of a product to the end customer to ensure that it does not cause interference with other equipment and that it is not itself susceptible to interference from other equipment.

Product specific requirements

Trio Motion’s extensive product and application knowledge combined with product testing reflect that the best immunity is achieved by placing some constraint on the system into which the product is being integrated. The information is presented in this section for the commissioning engineer.

Feature	Requirements	Notes
0V wire (current return)	1. Always connect ALL 0V current return wires 2. Do not use the screen for 0V current return 3. It is highly recommended to avoid connecting 0V across internal isolation barriers. If a single 24V supply is used for the main power and IO power then these two isolated 0V will have to be connected but this should only be done if the 24V supply is free from switching noise 4. Do not join together 0V from high power and / or noisy sources with the 0V from signal ports (incl. CAN bus DC input) 5. Do not use any controller 0V connection as a current return for peripheral devices	FLEX-6 NANO stepper 0V, encoder 0V and Auxiliary connector 0V are all common together. 24V supply 0V is isolated. 24V IO supply is isolated.
All 24V DC ports	1. It is highly recommended to use surge filters on all DC supply and 0V return. If more than one device is connected to the same PSU then this is	

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	a requirement. See Surge Protection below.	
Cable routing	1. Maintain 150mm separation of parallel Class I and Class II cable (IEC 61000-5-2:1997) 2. Unless otherwise specified, all cables must be <30m in length	
Proximity to source of disturbance	1. Place controllers and expansion modules as far from mains cables, mains filters, contactors, circuit breakers, drives, transducers or other high power sources of EM disturbance as physically possible within the enclosure design.	
Enclosure / Safety Cabinet design	1. Trio's products should always be installed within a locked cabinet with access limited to authorised personnel only.	
Differential Stepper / Encoder Signals	1. Screened, twisted pair cable. 2. Connect screen to metal chassis at both ends (See Cable Shields) 3. 0V reference connected at both ends.	
CAN bus	1. Screened, twisted pair cable with characteristic impedance of 120 Ohm. (±10 Ohm) 2. Connect screen to Chassis at every node.	Connect screen to Aux connector shell at FLEX-6 NANO. 0V on Aux connector, pins 4, 8 and 12 are common 0V.
Digital I/O	1. It is highly recommended to use a separate PSU and 0V return. (The I/O is internally isolated from the main 24V supply input.)	
ADC / DAC	1. Use DAC 0V reference pin not common 0V	0V on Aux connector.
RS232 / RS422 / RS485 Serial ports	1. Screened cable. 2. Connect screen to Chassis at both ends. 3. 0V reference connected at both ends.	Connect screen to Aux connector shell. 0V on Aux connector, pins 4, 8 and 12 are common 0V.
Ethernet	1. TIA Cat5e, minimum. 2. Shielded cable. 3. Cable ≤30m in length.	Overall Foil Braided Shield with Unshielded Twisted Pairs. Compliant with Industrial SF/UTP.
EMC Earth Connection	1. Mount on bare metal backplane. 2. Use a minimum 10mm wide, braided conductor to connect backplane / chassis to PE. 3. Do not use circular cross-section wire.	When the FLEX-6 NANO is screwed directly to the panel, the metal chassis provides the required EMC earth connection.

Recommended Installation

The following diagrams and information detail the typically required Surge Protection, EMC Earth and Cable Shields however more comprehensive information can be found in the corresponding Product Technical Manual (available at www.triomotion.com)

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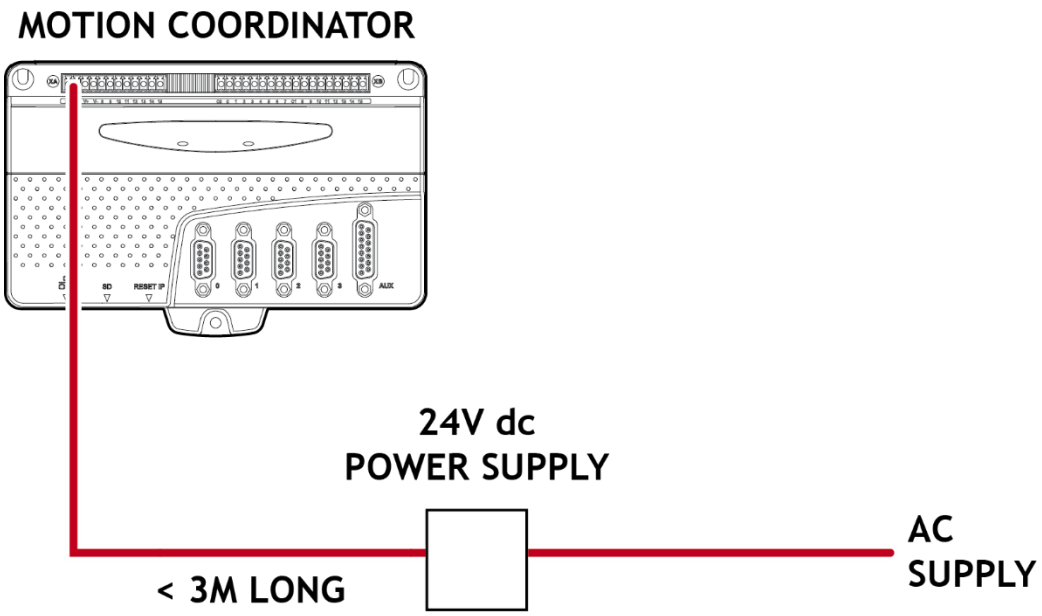
Surge Protection

Single power supply

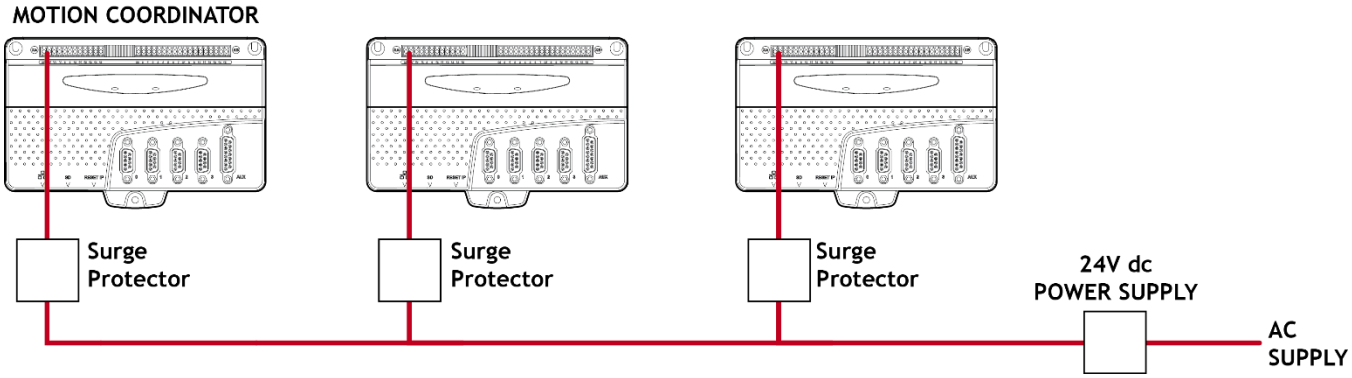
Where the device is supplied with 24V dc from one dedicated 24V power source and the connecting cable is less than 3 metres, there is no need for a separate surge protection device.



Motion Coordinator with dedicated power source

Distributed power supply

If the device is connected to a distributed power supply or the cable length between the power source and the device is longer than 3 metres, then a surge protection device must be fitted to comply with the CE EMC directive.



Distributed power supply with surge protection

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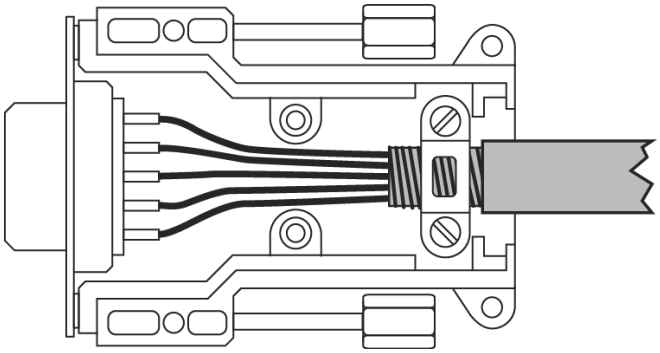
Surge protection device

Protection device - Minimum specification	
Operating Voltage	24V dc
Suppression Begins: Stage Two Stage Three	 30V 35V
Max. Clamp Volts for transients on the line: Stage Two Stage Three	 65V 77V
Surge Current (8/20mSec Pulse) + to - + to Earth - to Earth	 9000A 4000A 4000A
Surge Energy (2mSec Pulse) + to - + to Earth - to Earth	 94 Joules 44 Joules 44 Joules
Response Time	<5 nsec
Resistance to Earth: Max Over-Voltage Operating Voltage	 0.01 Ω > 1 MΩ

Cable Shields



Both ends of the encoder cable's screen must be connected using a 360 degree contact and not a pig-tail connection.

The 0V must be connected separately from the screen. Make sure that encoder cables are specified with one extra wire to carry the 0V.

All serial cables must be terminated in the 15-pin auxiliary connector. For best EMC performance, clamp the screen of the serial cable where it enters the connector cover.

Do not make a "pig-tail" connection from the screen to the plug cover. The 0V must be connected separately from the screen.

Make sure that serial cables are specified with one extra wire to carry the 0V.

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This applies to RS422/RS485 serial connections as well as RS232.

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