MagneMotion QuickStick and QuickStick HT

Bulletin Number QuickStick 100, QuickStick 150, QuickStick HT

Allen-Bradley
by ROCKWELL AUTOMATION

Design Guide

Original Instructions

Important User Information

Read this document and the documents listed in the additional resources section about installation, configuration, and operation of this equipment before you install, configure, operate, or maintain this product. Users are required to familiarize themselves with installation and wiring instructions in addition to requirements of all applicable codes, laws, and standards.

Activities including installation, adjustments, putting into service, use, assembly, disassembly, and maintenance are required to be carried out by suitably trained personnel in accordance with applicable code of practice.

If this equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

In no event will Rockwell Automation, Inc. be responsible or liable for indirect or consequential damages resulting from the use or application of this equipment.

The examples and diagrams in this manual are included solely for illustrative purposes. Because of the many variables and requirements associated with any particular installation, Rockwell Automation, Inc. cannot assume responsibility or liability for actual use based on the examples and diagrams.

No patent liability is assumed by Rockwell Automation, Inc. with respect to use of information, circuits, equipment, or software described in this manual.

Rockwell Automation recognizes that some of the terms that are currently used in our industry and in this publication are not in alignment with the movement toward inclusive language in technology. We are proactively collaborating with industry peers to find alternatives to such terms and making changes to our products and content. Please excuse the use of such terms in our content while we implement these changes.

Additional Safety Information

Although every effort is made to keep this manual accurate and up-to-date, MagneMotion® and Rockwell Automation® assumes no responsibility for any errors, omissions, or inaccuracies. Information that is provided in this manual is subject to change without notice. Any sample code that is referenced in this manual or included with MagneMotion software is included for illustration only and is, therefore, unsupported.

ATTENTION: For additional safety notices and definitions, see the Notes, Safety Notices, and Symbols section and/or the Symbol Identification section.

Preface

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About This Publication

This manual explains how to design and configure the QuickStick® transport system. Use this manual in combination with the other manuals and documentation that supports the transport system to design, install, configure, and test a QuickStick (QS) transport system.

Summary of Changes

This publication contains the following new or updated information. This list includes substantive updates only and is not intended to reflect all changes.

Topic	Page
QuickStick repeatability analysis information from publication MMI-AT005 was added to this publication.	28
Information on Electrostatic Discharge (ESD) protection from publication MMI-AT023 was added to this publication.	63
QuickStick power cable sizing information MMI-AT020 was added to this publication.	69
Information on QuickStick power management from MMI-AT021 was added to this publication.	69
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QuickStick 100 and 150 magnetic field measurement information from MMI-AT034 was added to this publication.	103
QuickStick HT™ magnetic field measurement information from MMI-UM034 was added to this publication.	107

Prerequisites

The information that is provided in this manual assumes the following:

- Basic familiarity with general-purpose computers and with the Windows® operating system, web browsers, and terminal emulators.
- All personnel who configure, operate, or service the transport system are properly trained.

Read and understand the safety instructions in Notes, Safety Notices, and Symbols on page 7 and Safety Considerations on page 9 to familiarize yourself with important precautions for QS transport systems.

The examples in this manual are included solely for illustrative purposes. Because of the many variables and requirements that are associated with any linear synchronous motor (LSM) system installation, Rockwell Automation cannot assume responsibility or liability for actual use that is based on these examples.

Notes, Safety Notices, and Symbols

Notes, safety notices, and symbols that are used in this manual have specific meanings and formats. Examples of notes, the different types of safety notices and their general meanings are provided in this section. Adhere to all safety notices provided throughout this manual to achieve safe installation and use.

Notes

Notes are set apart from other text and provide additional or explanatory information. The text for notes is in standard type as shown in the following example.

Identifies information that is useful and can help to make a process easier to do or easier to understand.

Safety Notices

Safety Notices are set apart from other text. The color of the panel at the top of the notice and the text in the panel indicates the severity of the hazard. The symbol on the left of the notice identifies the type of hazard see Symbol Identification on page 10 for symbol descriptions. The text in the message panel identifies the hazard, methods to avoid the hazard, and the consequences of not avoiding the hazard.

Examples of the standard safety notices that are used in this manual are provided in this section. Each example includes a description of the hazard level indicated.

DANGER

Danger indicates a hazardous situation which, if not avoided, can result in death or serious injury.

WARNING

Warning indicates a hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION

Caution indicates a hazardous situation, which if not avoided, could result in minor or moderate injury.

IMPORTANT	Identifies information that is critical for successful application and understanding of the product.

Safety Considerations

These safety recommendations are basic guidelines. Any additional safety guidelines and applicable local and national safety codes for the facility must be followed.

Personnel Safety Guidelines

QS components and transport systems can provide several direct safety hazards to personnel if not properly installed or operated. General safety guidelines are provided in this section, specific cautions are provided as needed. For additional information, see Mechanical Hazards on page 12, Electrical Hazards on page 13, and Magnetic Hazards on page 14.

- Personnel operating or servicing the QS transport system must be properly trained.
- Be aware of the hazardous points of the QS transport system.
- High-strength neodymium iron boron magnet arrays are used on vehicles with the QuickStick motors.
  - To avoid severe injury, people with pacemakers and other medical electronic implants must not handle or approach the magnet arrays. These individuals must consult their physician to determine the susceptibility of their device to static magnetic fields and to determine a safe distance between themselves and the magnet array.
  - Handle only one vehicle/magnet array at a time. Do not place any body parts, such as fingers, between a magnet array and any QS motors, ferrous material, or another magnet array to avoid injury from strong magnetic attractive forces.
  - Vehicles and magnet arrays not on the QS transport system must be secured individually in isolated packaging.
- Moving mechanisms have no obstruction sensors and can cause personal injury.
- Whenever power is applied, the possibility of automatic motion of the vehicles or user-supplied equipment in the QS transport system exists. It is the responsibility of the user to provide appropriate safeguards.
- Make sure that propulsion power is disabled whenever maintenance is being performed on the vehicles, track system, or motors.
- Make sure that the QS motors and related components are properly decontaminated before performing any service. Follow the decontamination procedures at the facility.
- Follow all facility, local, and national procedures for the disposal of any hazardous materials or waste.

Equipment Safety Guidelines

The following safety considerations are provided to aid in the placement and use of the QS transport system.

- The QS components are not provided with an Emergency Off (EMO) circuit. The facility where the system is installed is responsible for an EMO circuit. For information on E-stops and interlocks, see Additional Functions on page 35.
- Do not place the power and communication cables for the QS transport system where they can cause a trip hazard.
- Do not place the QS transport system in a location where it can be exposed to physical damage.
- Make sure that all electrical connections to the QS components are made in accordance with the appropriate facility, local, and national regulations.
- Make sure that the QS components receive proper airflow for cooling.
- Do not remove safety labels or equipment identification labels.
- Turn off the power before inserting or removing the power cables.
- Use of the QS components for any purpose other than as a linear transport system is not recommended and can damage the QS components or the equipment they are connected to.

- Always operate the QS transport system with appropriate barriers in place to help prevent contact with moving objects by personnel.
- Do not install or operate the QS transport system if any of the components have been dropped, damaged, or are malfunctioning.
- Keep cables and connectors away from heated surfaces.
- Do not modify the connectors or ports.

Shipping Magnet Arrays

- Magnet arrays being shipped, for return or to another facility, must be shipped per U.S. Department of Transportation and The International Air Transport Association (IATA) Dangerous Goods Regulations.

Symbol Identification

Symbols are used in this manual and on the products to identify hazards, mandatory actions, and prohibited actions. The symbols that are used in this manual and their descriptions are provided in the following tables.

Table 1 - Hazard Alert Symbol Identification

Symbol	Description
	**General Hazard Alert** – Indicates that failure to follow recommended procedures can result in unsafe conditions, which could cause injury or equipment damage.
	**Lifting Hazard** – Indicates that the specified object is heavy or awkward to handle. Personnel must use lifting aids and proper techniques for lifting to avoid muscle strain or back injury.
	**Automatic Start Hazard** – Indicates the possibility of machinery automatically starting or moving, which could cause personal injury.
	**Hazardous Voltage** – Indicates that a severe shock hazard is present that could cause personal injury.
	**Magnetic Field Hazard** – Indicates that a strong magnetic field is present that could cause personal injury.
	**Pinch/Crush Hazard** – Indicates that there are exposed parts that move, which could cause personal injury from the squeezing or compression of fingers, hands, or other body parts between those parts.

Table 2 - Mandatory Action Symbol Identification

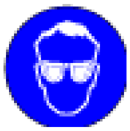
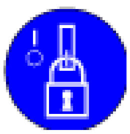
Symbol	Description
	**Eye Protection Required** – Indicates that appropriate eyewear must be worn to help prevent injury to eyes from flying shards.
	**Foot Protection Required** – Indicates that appropriate footwear must be worn to help prevent injury to feet from falling objects.
	**Lockout Required** – Indicates that all power must be disconnected using a method that helps prevent accidental reconnection.

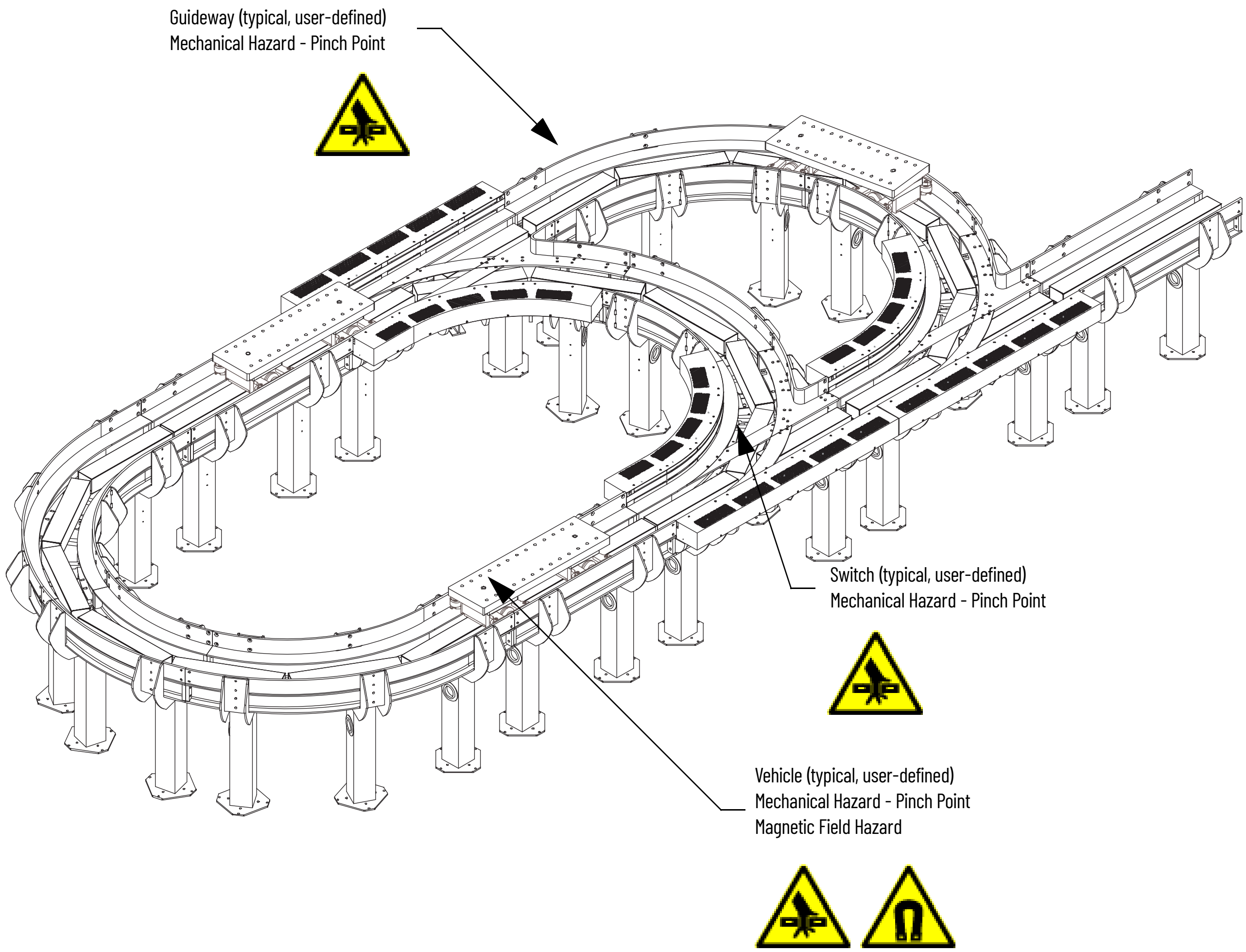
Table 3 - Prohibited Action Symbol Identification

Symbol	Description
	**Magnetic or Electronic Media Prohibited** – Indicates that magnetic media (memory disks/chips, credit cards, tapes, and so on) is not allowed in the specified area due to the possibility of damage to the media.
	**Metal Parts or Watches Prohibited** – Indicates that watches, instruments, electronics, metal tools, and metal objects are not allowed in the specified area due to the possibility of damage.
	**Pacemakers or Medical Implants Prohibited** – Indicates that persons with medical implants are not allowed in the specified area due to the possibility of personal injury.

Mechanical Hazards

The QS transport system is a complex electromechanical system. Only personnel with the proper training should install, operate, or service the QS transport system. Figure 1 shows examples of possible hazardous points on the QS transport system.

Figure 1 - Locations of Hazardous Points on the QS Transport System



All facilities to the QS transport system must be disconnected as outlined in the lockout/tagout procedure for the facility before servicing to help prevent injury from the automatic operation of the equipment. The proper precautions for operating and servicing remotely controlled electromechanical equipment must be observed. These precautions include wearing safety glasses, safety shoes, and any other precautions that are specified within the facility where the QS components are being used.

WARNING

Crush Hazard

Moving mechanisms have no obstruction sensors.

Do not operate the QS components without barriers in place or personal injury could result in the squeezing or compression of fingers, hands, or other body parts between moving mechanisms.

WARNING

Automatic Movement Hazard

Whenever power is applied, the possibility of automatic movement of the vehicles on the QS transport system exists, which could result in personal injury.

CAUTION

Loose Material Hazard

Payloads are susceptible to vector motion forces.

Always account for the effects of acceleration, deceleration, and directional changes upon the payload. Control forces to avoid projectile motion of the payload, limit move profiles and/or provide tooling to secure the payload to the vehicle.

CAUTION

Lift Hazard

The QS motors can weigh as much as 37.6 kg (83 lb). Failure to take the proper precautions before moving them could result in personal injury.

Use proper techniques for lifting and wear safety toe shoes when moving any QS components.

Electrical Hazards

The user-supplied power supplies, node controllers, network switches, and power modules are connected to the AC mains of the facility and can generate hazardous energy. The proper precautions for operating and servicing electrical equipment must be observed. These precautions include following facility lockout/tagout procedures, and any other specified action within the facility where the QS components are being used.

WARNING

Electrical Hazard

All electrical power to the QS transport system must be disconnected per the facility lockout/tagout procedure before servicing to help prevent the risk of electrical shock.

CAUTION

Electrical Hazard

To avoid electric shock, do not open any QS component. Motors, controllers, and other components do not contain any user-serviceable parts.

Do not turn on electrical power to the power supplies, motors, and node controllers until after connecting all other transport system components.

To avoid equipment damage:
- Make sure that the transport system is properly grounded.
- Make sure that all vehicles are grounded to the guideway through conductive wheels or static brushes.
- Do not connect or disconnect any components while the transport system has power.

Magnetic Hazards

The QS transport system uses high-strength neodymium iron boron (NdFeB) magnets in the magnet arrays that get attached to the vehicles. The proper precautions for using high strength magnets must be observed.


WARNING

Magnetic Field Hazard

The mover uses strong magnets.

There is a risk of health hazard for persons with heart pacemakers, metal implants, hearing aids, and other medical electronic implants while in proximity of magnetic and magnetic-field producing components. The magnetic field that is generated can disrupt the functionality of automatic implantable cardioverter defibrillators (AICD). People with cardiac pacemakers must stay away from the magnet arrays.


WARNING

Crush Hazard

Strong magnets in use.

To avoid severe injury:

- Handle only one vehicle or magnet array at a time.
- Do not place any body parts (for example, fingers) between a magnet array and any QS motors, ferrous material, or another magnet array to avoid injury from strong magnetic attractive forces.
- Vehicles and magnet arrays not being used must be secured individually in isolated packaging.



CAUTION

Magnetic Fields

Strong magnets in use.

To avoid damage to watches, electronic instruments, and magnetic media (for example, cell phones, memory disks/chips, credit cards, and tapes) keep these items away from the magnet arrays.

Handling Magnet Arrays

- The neodymium iron boron (NdFeB) magnets that are used in the QS 100 magnet arrays require special handling. General handling guidelines and cautions are provided in this section. It is the responsibility of the user to define and implement their own handling guidelines in accordance with the applicable facility, local, and national safety codes for the installation site.
- Pacemakers and other medical implants – Individuals with pacemakers and other medical electronic implants must not handle or approach the magnet arrays. These individuals must consult their physician to determine the susceptibility of their device to static magnetic fields and to determine a safe distance between themselves and the magnet array.
- Electronic Equipment Damage – Do not allow any magnet arrays near sensitive electronics, equipment with cathode ray tubes (CRTs) or other displays, or magnetic storage media (for example, disks, credit cards, cell phones).

- Pinch/Crush – The magnet arrays have a high attractive force to each other, the QS motors, and ferromagnetic materials like steel, iron, some stainless steels, and nickel. Pinching happens if the magnet arrays are allowed to come together against a body part – usually fingers. Do not try to stop moving objects or magnet arrays that have been attracted to each other.
- Impact – Do not strike the magnet arrays as the magnets within them can shatter and break. The magnets within the magnet arrays can spark on impact. Handle carefully in explosive atmospheres.
- Sharp Fragments – The magnet arrays are strong and unsecured magnet arrays can accelerate toward other magnets, magnet arrays, or ferromagnetic materials. The magnets in the arrays are brittle, and if allowed to collide, the magnets in the arrays can shatter and break, possibly sending particles flying at high speed.
- Debris Accumulation – Protect all magnet arrays in a transport system to help prevent the accumulation of debris. If debris is accumulated, it can get caught between the magnet array and the motor, which affects system performance and can damage the cover of the motor.
- Corrosion – The magnets in all magnet arrays are protected against corrosion. However, damage (for example, scratches, chips) to the magnet array or the magnets creates the potential for corrosion. NdFeB rare-earth magnets that have corroded have changed their physical properties. The Safety Data Sheets (SDS) for the component materials (iron, neodymium, boron, nickel, and copper) must be consulted before the use, handling, or transportation of corroded magnets.
- Machining – Do not drill, grind, machine, or sand the magnets or the magnet arrays. The magnets can shatter or break when drilled or machined. The magnet dust that machining creates is hazardous and can be harmful if inhaled or allowed to get into eyes. Drilling, grinding, and machining can produce metal powder, which is flammable and can ignite and burn at high-intensity, which creates toxic fumes. Additionally, machining can cause high heat to develop resulting in demagnetization.
- Use – The magnet arrays must never be used to lift any objects. The magnet arrays must only be used for propulsion with a QuickStick motor by attaching the array to a vehicle.
- Storage – Store magnet arrays in appropriate storage or shipping containers (shielded with steel or isolated). Never leave magnet arrays unattended outside the storage containers. If unshielded magnet arrays must be left unattended, the area must be marked with a Magnetic Hazard sign in accordance with the applicable facility, local, and national safety codes for the installation site.
- Handling – Appropriate handling is required. Handle only one magnet array at a time. If an array is attracted to another object, do NOT attempt to stop it. Wearing gloves and safety glasses when handling the magnet arrays is recommended. Inspect the area before handling the magnet arrays and make sure it is free of other magnet arrays or ferromagnetic materials.
- Temperature – If the temperature of the magnet arrays gets over approximately 80 °C (176 °F), the magnets begin to lose field strength irreversibly. A maximum operating temperature of 50 °C (122 °F) and maximum storage and shipping temperatures of 60 °C (140 °F) is recommended.
- Signage – Make sure that appropriate cautionary signage is in place in all locations where the magnet arrays are located. Signage must be in accordance with the applicable facility, local, and national safety codes for the installation site.

Separate Magnet Arrays

Magnet arrays can become stuck to each other or to any ferrous materials through improper handling. The end user is responsible to define and implement magnet array separation procedures. It can be impossible to separate large magnet arrays.

- If a magnet array is stuck to a surface, slide the magnet array to the edge, so it is in minimal contact with the surface. At the free end of the magnet array, lift the magnet array away and off the surface.

Additional Resources

These documents contain additional information concerning related products from Rockwell Automation. You can view or download publications at rok.auto/literature.

Resource	Description
MagneMotion System Configurator User Manual, publication MMI-UM046	This manual explains how to use the MagneMotion Configurator to create and modify the Node Controller Configuration File (Configuration File) for the MagneMotion® transport systems.
QuickStick Motors Technical Data, publication MMI-TD051	This manual includes technical specifications for the QuickStick 100 and QuickStick 150 motors.
MagneMotion Node Controller Interface User Manual, publication MMI-UM001	This manual explains how to use the supplied interfaces to configure and administer node controllers that are used with transport systems. This manual also provides basic troubleshooting information.
MagneMotion LSM Synchronization Option User Manual, publication MMI-UM005	This manual explains how to install, operate, and maintain the LSM Synchronization Option for use with transport systems.
MagneMotion NCHost TCP/IP Interface Utility User Manual, publication MMI-UM010	This manual explains how to use the NCHost TCP/IP Interface Utility to run a transport system for testing and debugging. This manual also explains how to develop Demo Scripts to automate vehicle motion for that testing.
MagneMotion Virtual Scope Utility User Manual, publication MMI-UM011	This manual explains how to install and use the MagneMotion Virtual Scope utility. This utility provides real-time feedback of the change in Linear Synchronous Motor (LSM) performance parameters.
MagneMotion Node Controller Hardware User Manual, publication MMI-UM013	This manual explains how to install and maintain the node controllers that are used with transport systems.
MagneMover LITE Ethernet Motor Configuration and Communication User Manual, publication MMI-UM031	This manual describes the network topologies for wiring MagneMover® LITE™ Ethernet motors and for combining both RS-422 and Ethernet motors in the same transport system.
MagneMotion Host Controller TCP/IP Communication Protocol User Manual, publication MMI-UM003	These manuals describe the communication protocols between the high-level controller and a host controller. These manuals also provide basic troubleshooting information.
MagneMotion Host Controller EtherNet/IP™ Communication Protocol User Manual, publication MMI-UM004	
Power Supply Reference Manual 1606-XLS960F-3, publication 1606-RM032	This manual provides the specifications for the 1606 power supplies.
MagneMover LITE User Manual, publication MMI-UM002	This manual explains how to install, operate, and maintain the MagneMover LITE transport system. This manual also provides information about basic troubleshooting.
QuickStick 100 User Manual, publication MMI-UM006	This manual explains how to install, operate, and maintain the QuickStick 100 transport system. This manual also provides information about basic troubleshooting.
QuickStick 150 User Manual, publication MMI-UM047	This manual explains how to install, operate, and maintain the QuickStick 150 motors and magnet arrays. This manual also provides information about basic troubleshooting.
QuickStick HT User Manual, publication MMI-UM007	This manual explains how to install, operate, and maintain the QuickStick High Thrust (QSHT) transport system. This manual also provides information about basic troubleshooting.
Kinetix 5700, 5500, 5300, 5100 Servo Drives Specifications, publication KNX-TD003	Provides catalog numbers and product specifications, including power, performance, environmental, certifications, dimension drawings, and accessories for Allen-Bradley® servo drives.
EtherNet/IP Network Devices User Manual, publication ENET-UM006	Describes how to configure and use EtherNet/IP™ devices to communicate on the EtherNet/IP network.
Ethernet Reference Manual, publication ENET-RM002	Describes basic Ethernet concepts, infrastructure components, and infrastructure features.
System Security Design Guidelines Reference Manual, publication SECURE-RM001	Provides guidance on how to conduct security assessments, implement Rockwell Automation products in a secure system, harden the control system, manage user access, and dispose of equipment.
UL Standards Listing for Industrial Control Products, publication CMPNTS-SR002	Assists original equipment manufacturers (OEMs) with construction of panels, to help ensure that they conform to the requirements of Underwriters Laboratories.
Safety Guidelines for the Application, Installation, and Maintenance of Solid-state Control, publication SGI-1.1	Designed to harmonize with NEMA Standards Publication No. ICS 1.1-1987 and provides general guidelines for the application, installation, and maintenance of solid-state control in the form of individual devices or packaged assemblies incorporating solid-state components.
Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1	Provides general guidelines for installing a Rockwell Automation industrial system.
Product Certifications website, rok.auto/certifications.	Provides declarations of conformity, certificates, and other certification details.
Product Compatibility and Download Center (PCDC) website, rok.auto/pcdc	Get help determining how products interact, check features and capabilities, and find associated firmware updates to download.

QuickStick Transport System Overview

This chapter provides an overview of the QuickStick® transport system features and provides information on required and customer-supplied components.

QuickStick Transport System Features

QuickStick is an intelligent transport system that provides fast, precise motion, and the positioning and tracking of medium loads in a transport system. The transport system is a configuration of linear synchronous motors (LSM) and related control electronics that move independently commanded material carriers (vehicles) in a controlled manner at various acceleration/deceleration and velocity profiles while carrying a wide range of payloads with high precision.

The QuickStick (QS) transport system consists of the following components:

- QS motors
- User-designed and -supplied vehicles with QS magnet arrays
- Node controllers
- User-supplied power supplies
- User-supplied host controller
- User-designed and supplied guideway and track system

QS motors provide repeatable positioning with no hard stops required, bidirectional travel, smooth motion, and continuous vehicle tracking and reporting.

- Motor, drive, controller, positioning, and guidance are built into the motor.
- Servo repeatability at any position (dependent on the size of the gap between the motor and the vehicle-mounted magnet array):
  - QS 100 ±0.5 mm (0.02 in.)
  - QS 150 ±0.05 mm (0.002 in.)
  - QSHT ± 1.0 mm (0.04 in)

  Repeatability can vary based on the PID settings that are used, and the track and vehicle design/structure, but the repeatability is not applicable over the gaps between motors.
- Vehicles are controlled individually allowing the host controller to prioritize the routing of individual vehicles over different paths.

Motion is provided by using user-designed vehicles with magnet arrays that are attached to the surface closest to the motor.

Observe these requirements for QS 100 and QS 150 user-defined vehicles:

- Up to five vehicles in queue or in motion per meter [150 mm (5.9 in.) vehicle length].

  The maximum number of vehicles per meter is determined using the shortest magnet array that is allowed on a straight guideway. Using a longer magnet array or a curved guideway decreases the number of vehicles that fit per meter.
- Motors can move payloads in excess of 100 kg (220 lb) (the vehicle and track system must be designed to support the load).
- Minimum magnet array length is 3 cycles (~150 mm).

- For the QS 100: Speeds up to 2.5 m/s (5.6 mph) and acceleration up to 24 m/s^2 (2.45 g), payload dependent.
- For the QS 150: Speeds up to 4.0 m/s (8.95 mph) and acceleration up to 24 m/s^2 (2.45 g), payload dependent.

Observe these requirements for QSHT user-defined vehicles:

- Up to two vehicles in queue or in motion per meter [238 mm (9.4 in.) vehicle length].

  The maximum number of vehicles per meter is determined using the shortest magnet array that is allowed on a straight guideway. Using a longer magnet array or a curved guideway decreases the number of vehicles that fit per meter.
- Motors can move payloads in excess of 4,500 kg (9,900 lb). The vehicle and track system must be designed to support the load.
- Minimum magnet array length is 238 mm (9.4 in.).
- Speeds up to 5.0 m/s (11.2 mph) and acceleration up to 60 m/s^2 (6.1 g).

Additional QS motor and system design features include:

- QS motors and magnet arrays are designed for use in cleanrooms and specific environments.
- Less wear and tear – no belts, chains, gears, or external sensors required – fewer moving parts means less maintenance.
- Standard industrial communication protocols, PC or programmable logic controller (PLC) controlled, and software configured move profiles (PID control loop) for fast and easy changeovers to new configurations.
- Standard motor and configuration elements provide plug-and-play capability and make it easy to implement layout changes.
- Configuration and simulation software tools simplify transport system design and optimization.

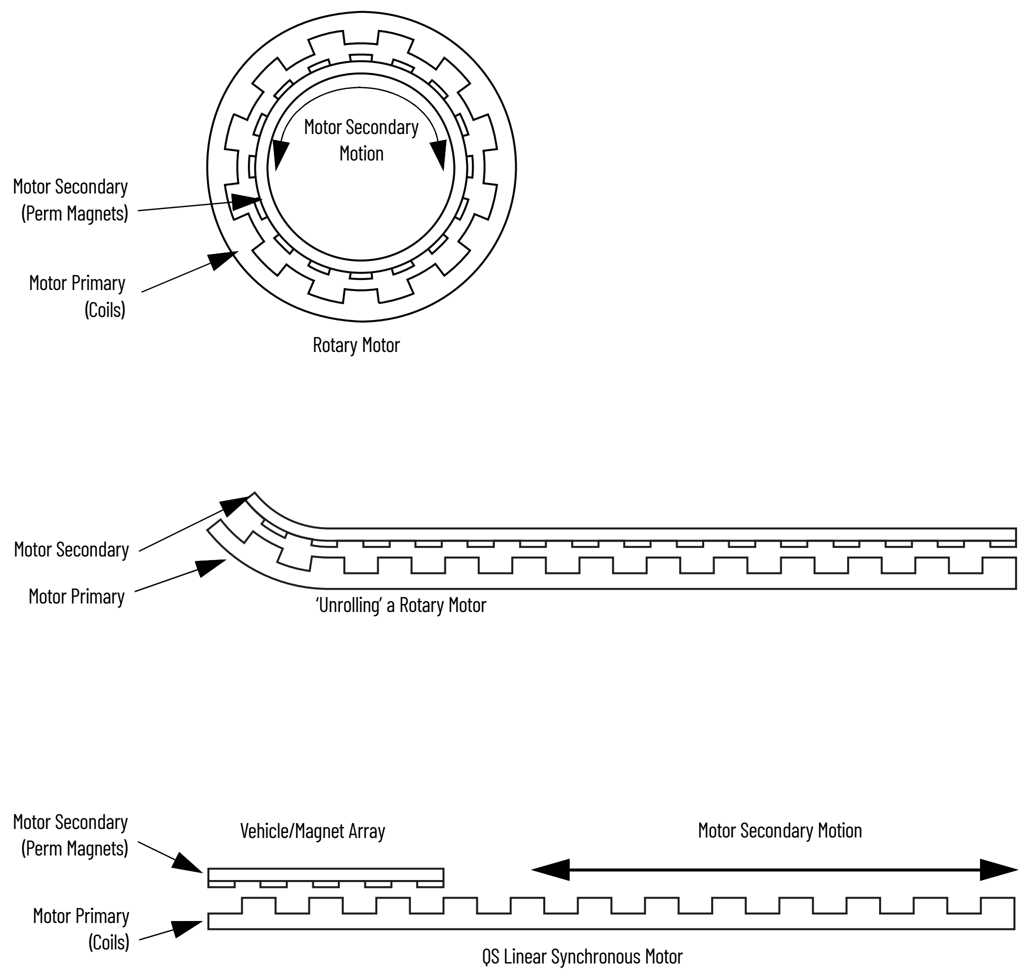
For additional features for the QSHT, see the QuickStick HT User Manual, publication MMI-UM007.

Theory of Operation

The QuickStick (QS) is a new approach to LSM technology, which provides a faster, cleaner, and more advanced alternative to conventional propulsion and conveyor methods. With a scalable, adaptable, and innovative design, the QS transport system can achieve various acceleration and velocity profiles while moving a wide range of payloads with high precision.

The QS motors are similar in operation to a brushless DC rotary motor, with its stator (motor primary) and rotor or armature (motor secondary) 'unrolled' to allow linear motion as shown in Figure 2. The motor primary is a series of coils that generate a magnetic field within the QS motor. The motor secondary is an array of magnets that is attached to the object to move, referred to as a vehicle. The motor primary generates a magnetic field to move the motor secondary (vehicle) in a controlled manner. The QS motors also use the magnets to track the position of the vehicle over the motor.

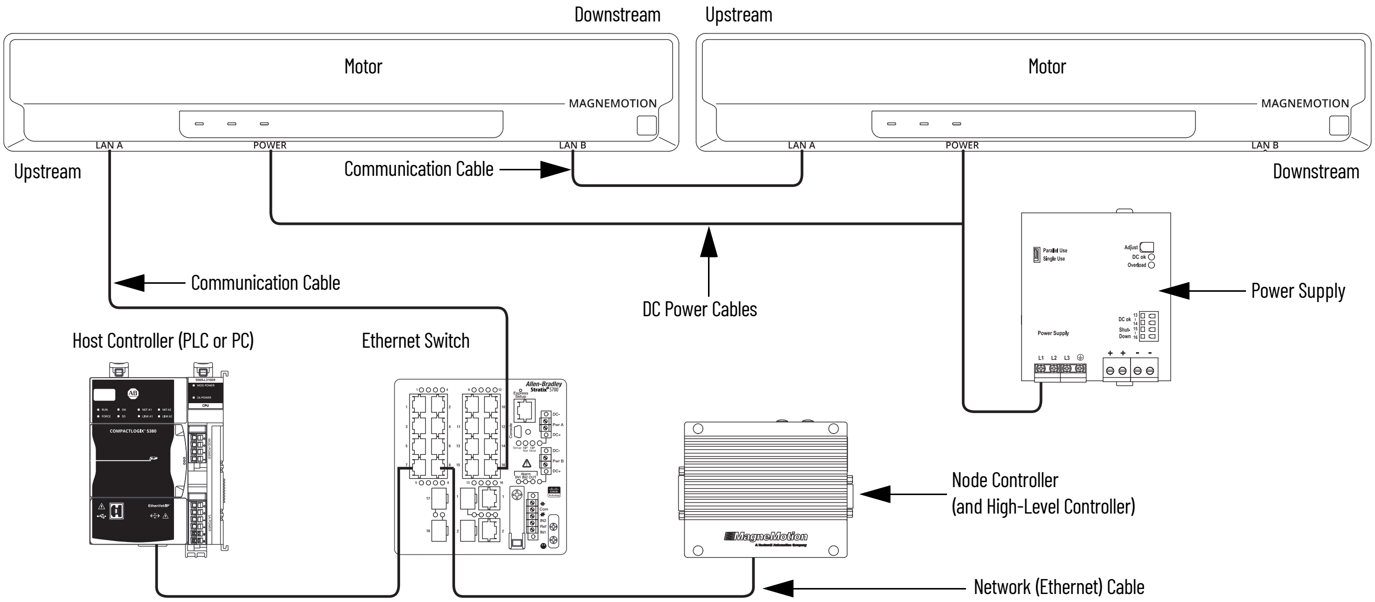
Figure 2 - Linear Synchronous Motor (LSM) Derived From Rotary Motor



Transport System Components Overview

This section identifies the system-level components of a QS transport system as shown in Figure 3 and described after the figure.

Figure 3 - QuickStick Transport System Example

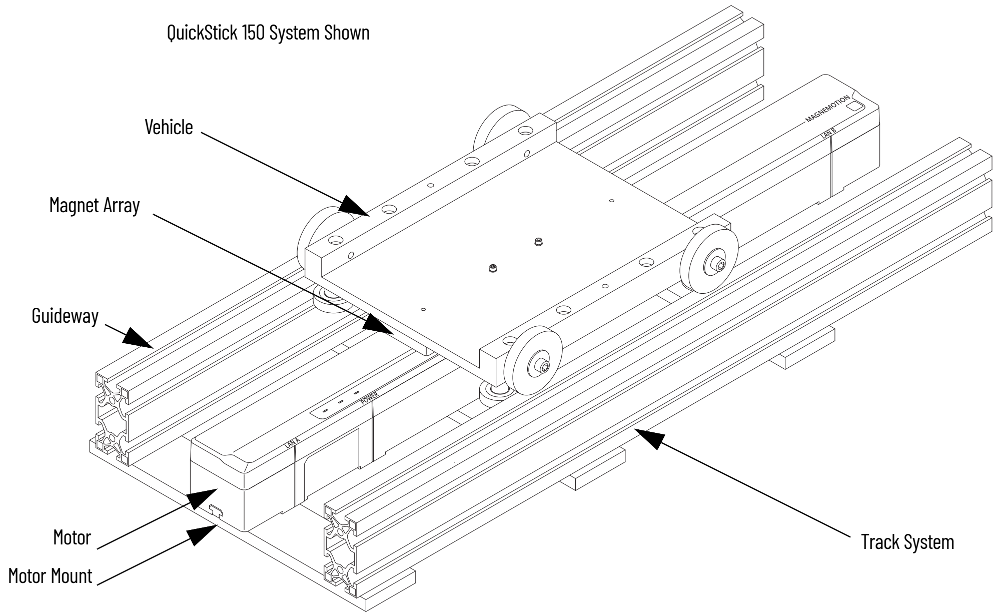


- **DC Power Cables** – Distributes DC power to the motors.
- **Communication Cables** – Provides communication between the components of the transport system.
- **High-level Controller** (HLC) – A software application that is enabled on one node controller. This application handles all communication with the user-supplied host controller and directs communication to the individual node controllers.
- **Host Controller** – Provides user control and monitoring of the QS transport system. User-supplied, it can be either PC-based or a programmable logic controller (PLC).
- **Motor** – The linear synchronous motor (LSM).
- **Network** – Ethernet network providing communication (TCP/IP or EtherNet/IP™) between the host controller and the HLC (TCP/IP is used between node controllers).
- **Node Controller** (NC) – Coordinates motor operations and communicates with the HLC. Provides an active network port, digital inputs, and digital outputs.
- **Power Supply** – Provides DC power to the motors.

Transport System Components

This section provides an overview of the individual QS transport system components.

Figure 4 - Detailed View of QuickStick Transport System Components

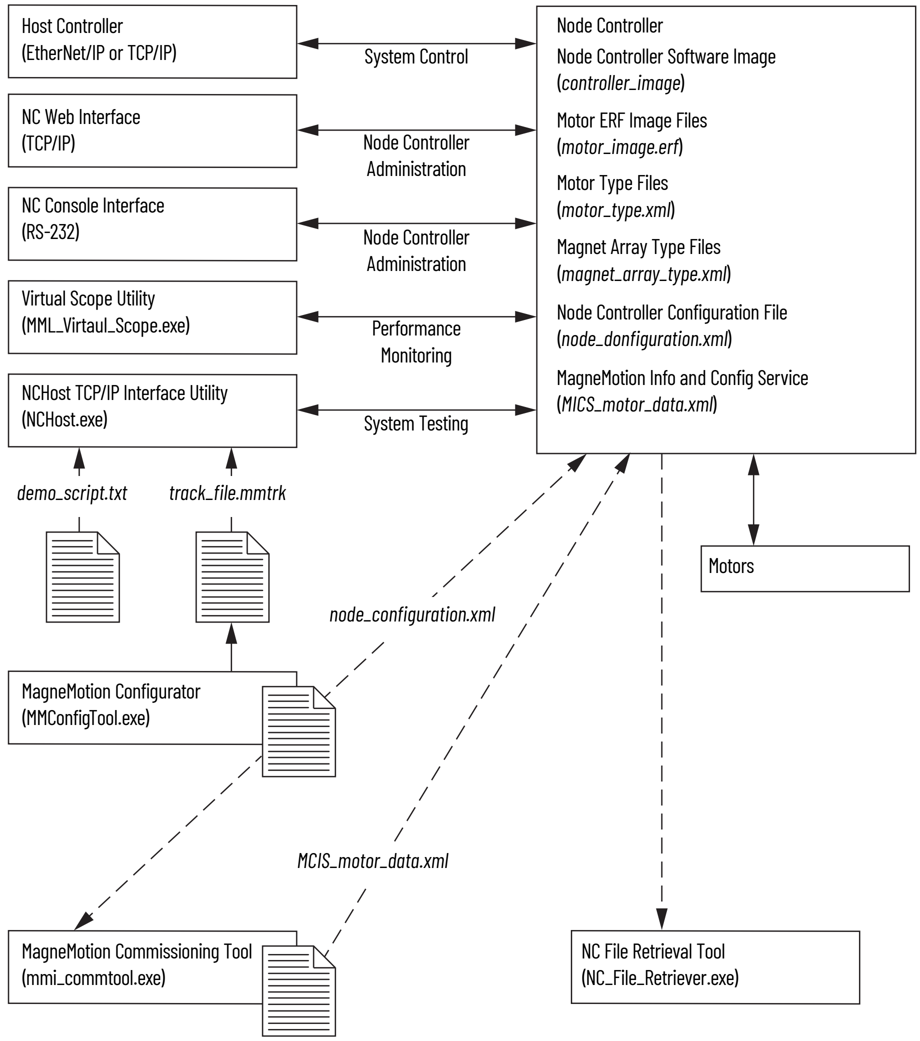


- **Track System** – The components that physically support and move vehicles. The track system includes the support structure, the guideway, one or more QS motors, and mounting hardware.
- **Guideway** – Used to make sure that the vehicles are maintained in the proper relationship to the motors.
  - **Straight and Curve** (straight shown) – Motors placed end-to-end to provide a continuous path of motion.
  - **Switch** – (not shown in Figure 4) Three motors that are configured to provide either a merge of two paths into one or a diverge from one path into two.
- **Motor** – The linear synchronous motor (LSM).
- **Motor Mount** – Used to mount the motor to the guideway.
- **Vehicle with Magnet Array** – Carries the payload through the QS transport system as directed. The magnet array is mounted to the vehicle and interacts with the motors, which moves the vehicle.

Transport System Software Overview

Several software applications are used to configure, test, and administer a QS transport system as shown in Figure 5 and described after the figure. See Additional Resources on page 16 for communication protocol and node controller user manuals for additional information on these applications.

Figure 5 - Simplified View of QuickStick Transport System Software Relationships



IMPORTANT	Modifications to the image or type files could cause improper operation of the transport system.

Determine What You Need

For each transport system, the magnet array, motor, drive, and controller have a specific set of required and optional accessories. See the QuickStick Motors Technical Data, publication MMI-TD051 and the QuickStick HT User Manual, publication MMI-UM007, for detailed QS motor specifications.

Motor Features

The QS motors can be mounted in any orientation: right side up, sideways, upside down, and vertically. The motors have a required direction, with an upstream end and a downstream end. The QS motors must always be installed with the upstream end of one motor following the downstream end of the previous motor. Forward vehicle motion on the QS motors is from upstream to downstream, however vehicles can move backwards (downstream to upstream) if necessary.

If the motor is mounted on an incline or vertically, the motor does not hold a vehicle in place during startup, restarts, or if power is lost.

Table 4 - QuickStick Motor Features [1]

Attribute	QuickStick 150	QuickStick 100	QuickStick HT
Motor Type	Linear Synchronous Motors (LSM)		
Logic Power	48V DC at 0.2 A		
Continuous Thrust per Cycle	4.07 N/A/cycle[2]		18.81 N/A/cycle[3]
Ride-through [4] Hold-up Time	2 ms	—	2 ms
Peak Thrust per Cycle	29.2 N/cycle[2]	19.8 N/cycle[2]	333.4 N/cycle[3]
Attractive Force per Cycle	58.8 N/cycle[2]		483.2 N/cycle[3]
Rated Speed (max velocity)	4 m/s (8.95 mph)	2.5 m/s (4.47 mph)	5 m/s (11.2 mph)
Compatible Node Controllers[5]	NC-LITE, NC-E, NC-S	NC-LITE, NC-S	NC-S, NC-E, NC LITE
Compatible Power Cables	MMI-QS-CPSS-00XX000, MMI-QS-CPSS-00AA*xxx*, MMI-QS-CPDS-14AF*xxx*, MMI-QS-CPDR-14AF*xxx*, MMI-QS-CPCS-00XX000, MMI-QS-CPAS-14AA*xxx*, MMI-QS-CPTS-10AA*xxx*, MMI-QS-CPRS-00XX000	700-1635-00, 700-1640-*xx*, 700-1686-*xx*	—
Compatible Magnet Arrays	MMI-QS-M*xxxx*-*x*		700-1616-*xx*, 700-1618-*xx*, 700-1642-*xx*
Magnetic Cycle Length	48 mm		120 mm
Paint Color	Black	Gray	Gray or Black
Acceleration, max	24 m/s^2 (2.45 g) payload dependent		60 m/s^2 (6.1 g) payload dependent
Number of Independent Inverters (See Table 6 on page 37)	1.0 m: 10 independent three phase inverters 0.5 m: 5 three phase inverters 0.3 m: 3 three phase inverters	1.0 m: 10 independent three-phase inverters 0.5 m: 5 three phase inverters	1.0 m: 2 independent three-phase inverters 0.5 m: 1 three-phase inverter 0.5 m (double wide): 1 three-phase inverter
Servo Repeatability[6]	± 0.05 mm at specified gap and friction	± 0.50 mm at specified gap and friction	± 0.50 mm (dependent on the size of the gap between the motor and the vehicle-mounted magnet array)
Maximum Payload	Determined by the magnet array length and support structure.		
Typical Applications	Material Handling		Material Handling, Automotive
Ingress Protection (IP) Rating	IP66 and IP67[7]	Designed for IP54 Designed for IP65 with mated gland connectors	Designed for IP67 or IP69
Compatible Power Supplies	1606-XLS		Kinetix 2198-P*xxx*[8]
Compatible Ethernet Switches	Stratix 2000, Stratix 2500, Stratix 5700	—	Stratix 2000, Stratix 2500, Stratix 5700
Communication Type	Ethernet	RS-422	Ethernet
Compatible Communication Cables	1585D-M4TBDM-*x* (Motor-to-motor) 1585D-M4TBJM-*x* (Motor to node controller) 1585J-M8TBJM-*x* (Node controller to switch)	700-0663-*xx*, 700-0757-*xx*, 700-1367-*xx*, 100-2090-*xx*	1585J-M8TBJM-*x* (Node controller to switch)
Mean Time Between Failures (MTBF)	See MagneMotion Application Note, QuickStick Mean Time Between Failures (MTBF), publication MMI-AT002.		

(1) Performance varies based on payload, acceleration, velocity, and vehicle density.
(2) 3 mm vehicle gap, typical.
(3) 11 mm vehicle gap, typical.
(4) It represents a short-term removal of power (0…2 ms maximum) the power supply remains in regulation (at specified load and input voltage) without registering a fault.
(5) For compatible Programmable Logic Controllers, see the Independent Cart Technology Libraries, available on the Product Compatibility and Download Center website, rok.auto/pcdc.
(6) Repeatability is dependent on the size of the gap between the motor and the vehicle-mounted magnet array and varies based on track and vehicle design/structure. Repeatability is not applicable over the gaps between motors.
(7) IP66/IP67 is only ingress protected when connectors are mated or when caps are present and tightened to 1.24 N•m (11 lb•in).
(8) Only when designing a QSHT 5700 transport system. Kinetix 5700 DC-bus power supply is a converter power supply with 200V and 400V-class (three-phase) AC input. Provides output current in a range of 10.5…69.2 A. Systems typically consist of one module, however, up to three modules in parallel is possible. Must be used with an AC line filter (catalog number 2198-DBR*xx*-F).

Electrical Specifications

Use these electrical specifications to help design you QS transport system.

- Control Power should be applied before bus voltage; however, no performance issues can be present if bus power is applied before control power.
- SELV/PELV rated supplies must provide 48V DC / 43V DC control input power voltage.
- Short circuit protection helps prevent a short due to an inverter shoot through. Output short circuit protection is not needed due to internal connections that are not accessible to the end customer. The product supports short circuit detection through the feature of the inverter gate drivers.

ATTENTION: You must verify that the control power supply and propulsion power supply wiring is correct. Risk of equipment damage exists.

Table 5 - Electrical Specifications

Attribute	QuickStick 150	QuickStick 100	QuickStick HT
Control Input Power[1]	48V DC ±10%	48V DC ±10%	24V DC ±10%
Input Propulsion Power[2]	48…72V DC ±10% (43…79V DC)	48V DC ±10%	276…747V DC
Stall Current	1.5 A	2.0 A	5.4 A
Maximum Regenerated Power	See Deceleration (Regeneration) on page 79		
Lowest Propulsion Power	43V DC		265V DC
Maximum Propulsion Bus Voltage	83V DC	59V DC	830V DC
Operating Voltage (not for direct connection to AC line)	48…72V DC	48V DC	300…800V DC
Nominal DC Bulk Capacitance per Inverter	> 100 μF		> 390 μF
Motor Control Power (max power)	1 m – 10 W 48V DC ±10%, 0.5 A max	1 m – 10 W 48V DC ±10%, 2 A typical, 5 A max	29 W 24V DC ±10%, 1.2 A typical, 5.8 A max
	0.5 m – 5 W 48V DC ±10%, 0.5 A max	0.5 m – 5 W 48V DC ±10%, 1 A typical, 2.5 A max	
	0.3 m – 5 W 48V DC ±10%, 0.5 A max	–	
Propulsion Inverter Output Current, Continuous (0-pk)	2.0 A		5.44 A
Propulsion Inverter Output Current, Peak (0-pk)	7.5 A	5.0 A	20 A
Vehicle – Propulsion Power[3]	Variable		
Stall Threshold Current	4 A		10 A
Active Stall Time-out Current	5 seconds (time when the drive has not moved the load more than one cycle)		

(1) The number of cycles per minute the control input power is allowed to apply and remove from the drives must not exceed 1 cycle every 10 seconds.
(2) The number of cycles per minute the propulsion bus input power is allowed to apply and remove from the drives must not exceed three cycles every 1 minute.
(3) The motor draws maximum power when the vehicle is moving at maximum acceleration and velocity. Contact Rockwell Automation Support for help with determining the correct power supply size based on the motor application and size of the magnet array.

QuickStick HT Optional Equipment

For a details on these QuickStick HT (QSHT) compatible accessory kits, see the Kinetix 5700 Servo Drive User Manual, publication 2198-UM002:

- Connector Kits
- AC Line Filters
- Passive/Active Shunts
- System Mounting Tool Kit
- Line Reactors
- DC Bus Connector Kit
- Feedback Connector Kit
- Motor Cables

Notes:

Design Guidelines

This chapter provides guidelines for designing a QuickStick® transport system.

Transport System Layout

To plan for a Quick Stick (QS) transport system installation, define the following layout features:

- Type and location of all motors (all motors provide bidirectional motion) and switching mechanisms.
- Number of vehicles on the transport system.
- Locations of all interfaces to other equipment in the facility.
- Paths and the direction of forward (downstream) motion.
- Type and number of nodes.
- Type and number of node controllers.
- Identify the node controller that is assigned as the high-level controller (HLC).
- Additional connections such as motor power, communication, and network.
- Additional functions such as E-stop, interlock, and light stack.

The transport system layout is used to locate the motors and other transport system components in the facility. For a list of transport system limits, see the MagneMotion® Node Controller Hardware User Manual, publication MMI-UM013.

The transport system layout is also used as a reference when connecting the components of the transport system and defining the elements of the node controller configuration file. For additional information on the Node Controller Configuration file, see the MagneMotion Node Controller Interface User Manual, publication MMI-UM001, and the MagneMotion System Configurator User Manual, publication MMI-UM046.

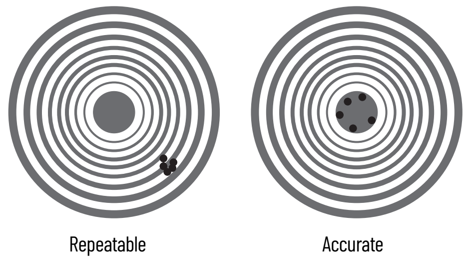
To use the installed transport system, create an application that runs on the host controller. This host application provides all monitoring and control of the transport system.

Transport System Repeatability and Accuracy

Repeatability and accuracy are typically considered as important attributes of any precision electro-motive system. Certain system variables can affect the repeatability and accuracy of a QuickStick or QuickStick HT™ transport system. The purpose of this section is to provide information on how to design a track to optimize the repeatability of the QS transport system. Throughout this chapter repeatability and accuracy are defined as:

- Repeatability – the tolerance within which the system repeats a position
- Accuracy – the tolerance from the ordered position the system achieves

Figure 6 - Repeatability and Accuracy



Consider both repeatability and accuracy as characteristics that are internal to the system. Therefore, all distances are taken relative to the location commanded in the software application or to a point on the track. This can only be used in reference to an external reference point if the ordered location has already been determined experimentally and the system is fixed relative to the reference point. Repeatability is considered bi-directionally, with vehicles arriving from both directions being considered.

Repeatability and accuracy are key factors in many applications, especially those involving interactions with other machines. In many applications, the repeatability is more important than accuracy since the accuracy of a high repeatability system can be improved by applying fixed adjustments to the motion command. For this reason, it is useful to be able to determine how closely the vehicle can repeat a move to a position. Therefore, the remainder of this chapter focuses on repeatability. There are two factors in determining the repeatability of movements on a system; the motor capabilities and the track hardware configuration.

QuickStick Motor Capabilities

The capabilities of the QS motor are the same on any track. QS motors employ Hall Effect Sensor (HES) technology for position feedback. In an ideal system, one with no track to vehicle interaction, the HES resolution is the positional repeatability for any single magnet array or vehicle to that position.

Track Hardware Configuration

The hardware characteristics of the track are what determine the actual repeatability. Hardware selection can affect both positional repeatability and velocity variation for movements within a system.

Consider the effects of:

- Friction
- Guidance system selection
- Vehicle construction tolerances
- Track construction discrepancies
- Track rigidity
- Payload
- Motor spacing

Track Construction

Bumps in the rails, misaligned rails, loose bolts, and many other construction anomalies can affect the repeatability. An inconsistent track produces inconsistent results.

Track Rigidity

The rigidity of the track becomes a factor when examining vibrations. Vehicles moving on a track can create vibrations. The magnitude of these vibrations can depend on vehicle weight, the interface with the track, and the dynamics of the maneuvers being performed. The vibrations can cause the entire track to shift, which results in movement of a vehicle relative to the environment, even if the vehicle remains stationary relative to the track. If the track is sufficiently rigid or dampened, these vibrations can be reduced.

Payload

The payload can affect the repeatability of the system in a number of ways. For example, a heavy payload reduces the linear dynamic range of the servo drive system, resulting in slower and less predictable responses that may lead to reduced motion repeatability.

Payload also increases the effects of friction, as the coefficient of friction is multiplied by the weight of the vehicle. Therefore, a larger payload is more sensitive to variations in friction.

Increasing the payload also reduces the control system sensitivities to force disturbance. With everything else being equal, an increased payload results in smoother motion and better position repeatability, provided the system has the thrust that is needed to control the larger payload. In practice, achieving optimal repeatability performance requires trade-offs among payload, rail characteristics, and servo turning.

Motor Spacing

Reduced repeatability at the spaces between QS motors is expected due to disruption in drive patterns. For this reason, it is preferable to have all repeatability critical operations occurring with full magnet array coverage over a motor, rather than over a space.

Static and Dynamic Friction

The difference between static and dynamic friction can induce variations in positioning. Dynamic friction determines the amount of force that is needed to keep the vehicle moving at a constant speed. Static friction determines the force necessary to start moving a vehicle from rest. In certain systems, the static friction can be larger than the dynamic friction. This means that when starting or stopping, the two actions that determine repeatability, there is already a friction variation inherent in the system.

In a closed-loop system such as QuickStick or QuickStick HT with PID controller, friction affects accuracy and repeatability through the introduction of non-linearity into the servo system. In general, higher degrees of system non-linearity require higher servo bandwidth from the PID controller. The PID controller is employed in the QS control system if the same level of motion accuracy and repeatability performance is required. Variations in friction within the system makes it more difficult to tune for optimal repeatability.

As the friction in the system approaches the thrust limit of the motor, the consistency of the friction plays a larger role. As the thrust produced by the motor is needed to both overcome friction and accelerate the vehicle, increasing the amount of thrust that is required to overcome friction decreases the amount available for the quick acceleration that is needed to exactly position the vehicle. Therefore variations in friction near the high limit of the motor can result in insufficient thrust being available for fine vehicle positioning.

The following actions can compensate for friction and increase repeatability:

- Tune the PID controller for the friction that is present. A properly tuned system results in improved repeatability.

- Minimize static and dynamic friction. This increases thrust available for dynamic adjustment and reduce the thrust requirements to break the hold of static friction, which makes tuning easier. In the case of a theoretically perfect guidance system with no friction, the control loop would result in positional repeatability equal to the resolution of the motor.
- Minimize the difference between static and dynamic friction. This helps ensure that the friction remains constant even when approaching a stop. Using pre-loaded bearings can aid in this and keep the friction curves smoother.
- If not possible, keep the dynamic friction consistent. This helps ensure that the PID controller can be more accurately tuned, as it must account for less variation in thrust requirements.

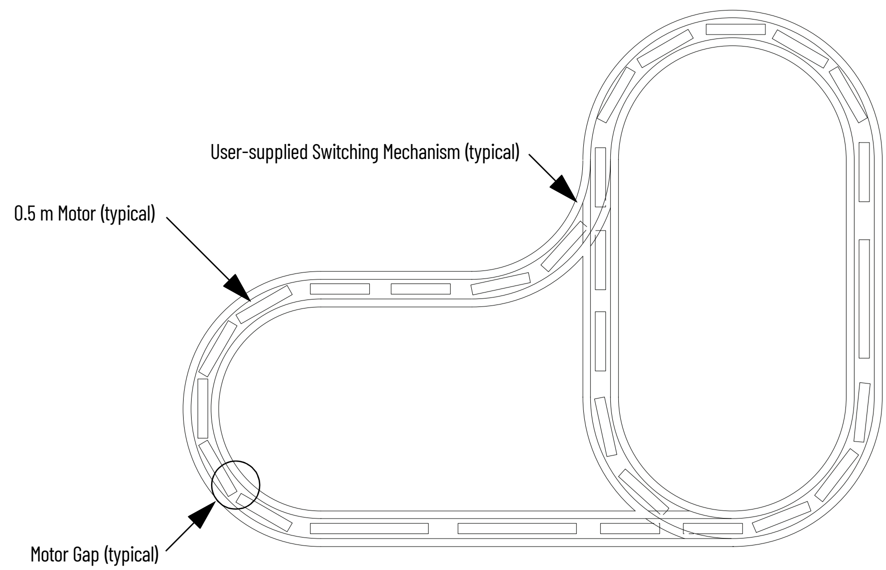
Transport System Components

The QS transport system components are a set of basic building-blocks that provide an easy to assemble and implement transport system (for example, motors, switches, and vehicles). The modular nature of the components makes it easy to implement layout or control changes. An example of how the basic building-blocks are used is provided.

Transport System Layout

The transport system layout is a plan view layout of the transport system. The plan identifies each motor and switching mechanism (if necessary) in the transport system (see Figure 7 for an example). The drawing also includes how the motors and switching mechanisms are physically located, the space between each motor, and any interfaces to other facility equipment.

Figure 7 - Sample Transport System Layout Showing Motors



Motors

Motors are used to move the vehicles on the transport system. When using multiple motors, they must be installed such that the downstream end of one motor is followed by the upstream end of the next motor in the same path. For more information on paths, see Paths on page 32.

Switches

Switches connect multiple paths and direct the vehicles from one path on the transport system to another path. The switch mechanism is user-defined and -supplied.

Vehicles

Vehicles are user-designed independent platforms with integral magnet arrays that are used on QS transport systems. Each vehicle is independently controlled and provides a platform for securing and carrying the payload in transit. Forward vehicle motion is from upstream to downstream, however vehicles can move backwards (downstream to upstream) if necessary. The transport system assigns a unique vehicle ID at startup, which is retained until the transport system is restarted, the vehicle is moved through a Terminus or Gateway node, or the vehicle is deleted. Additionally, the transport system makes sure that vehicles do not collide with each other by implementing anti-collision algorithms. It is not necessary to show the vehicles on the transport system layout.

It can be useful to show facility features on the drawing.

Magnet Arrays

The standard magnet array for the motors has an arrangement of alternating North-oriented and South-oriented neodymium iron boron (NdFeB) permanent magnets placed perpendicular to the direction of motion. Orientation of the magnets is referenced to the surface facing the motor. magnet arrays are intended for use as the motor secondary as part of the vehicle and must not be used for any other purpose. For additional information, see Magnet Arrays on page 41, and the QuickStick Motors Technical Data, publication MMI-TD051.

Static Brushes

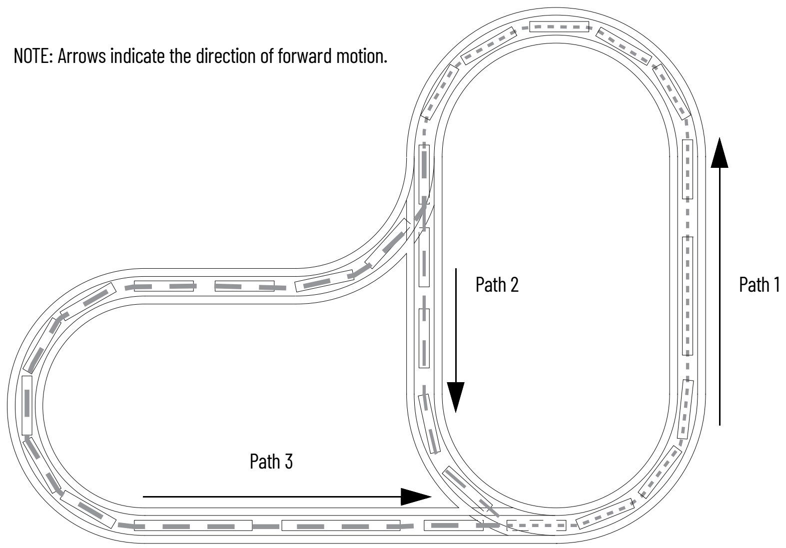
A static brush is a conductive brush that is mounted to the vehicle that is preferably in constant contact with the grounded track. Rockwell Automation recommends this method for preventing static discharges into the motor. See Chapter 3 on page 63 for detailed electrostatic discharge (ESD) information.

SHOCK HAZARD: Vehicles must be grounded to the guideway through conductive materials such as wheels, skids, or static brushes. Make sure that the equipment or track system where the QS motors are mounted and the motor mounting surfaces are properly grounded to safety (earth) ground.

Paths

Once all motors have been identified on the transport system layout, the individual paths must be defined (see Figure 8 for an example). Path definition includes identifying all motors on the path and the direction of forward (downstream) motion.

Figure 8 - Sample Transport System Layout Showing Paths



Paths define the routes for vehicle motion. All paths include one or more motors arranged end to end. All paths must begin at a node and can end at a second node, depending on the use of the path. Paths are unique and do not overlap. Each path is provided a unique identifier in the Node Controller Configuration File. Each motor is identified as belonging to a specific path and provided a unique identifier in the Node Controller Configuration File.

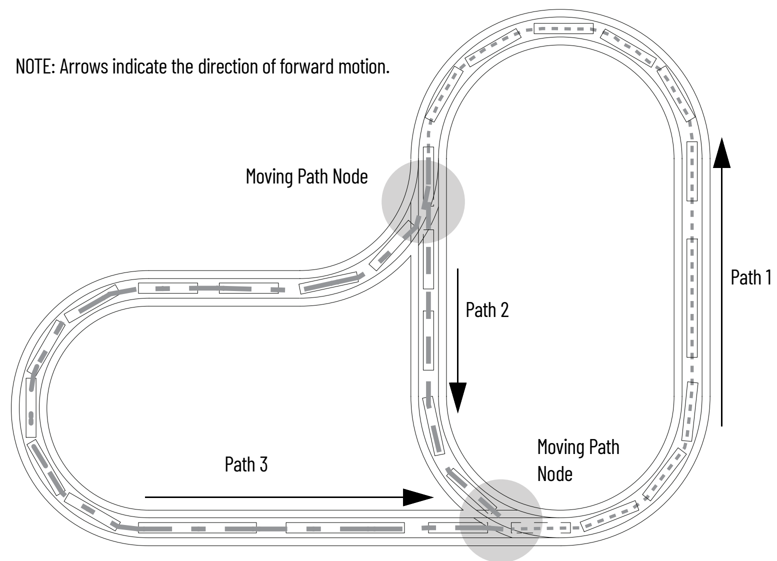
The node controller that is connected to the upstream end of the path controls the path. Paths must have a connection to a node controller at their downstream end if a vehicle moves off the downstream end of the path, either onto another path or onto another type of transport system. For a detailed description of paths, see the applicable user manual for your motor in Additional Resources on page 16.

Each path in the transport system starts at a node and the motor at that node is connected to a node controller. The node controller connection is either direct when using RS-422 communication or through the transport system network when using Ethernet communication.

Nodes

Once all paths have been identified on the transport system layout, the nodes that connect those paths must be defined (see Figure 9 for an example). Node definition includes identifying the type of node used.

Figure 9 - Sample Transport System Layout Showing Nodes



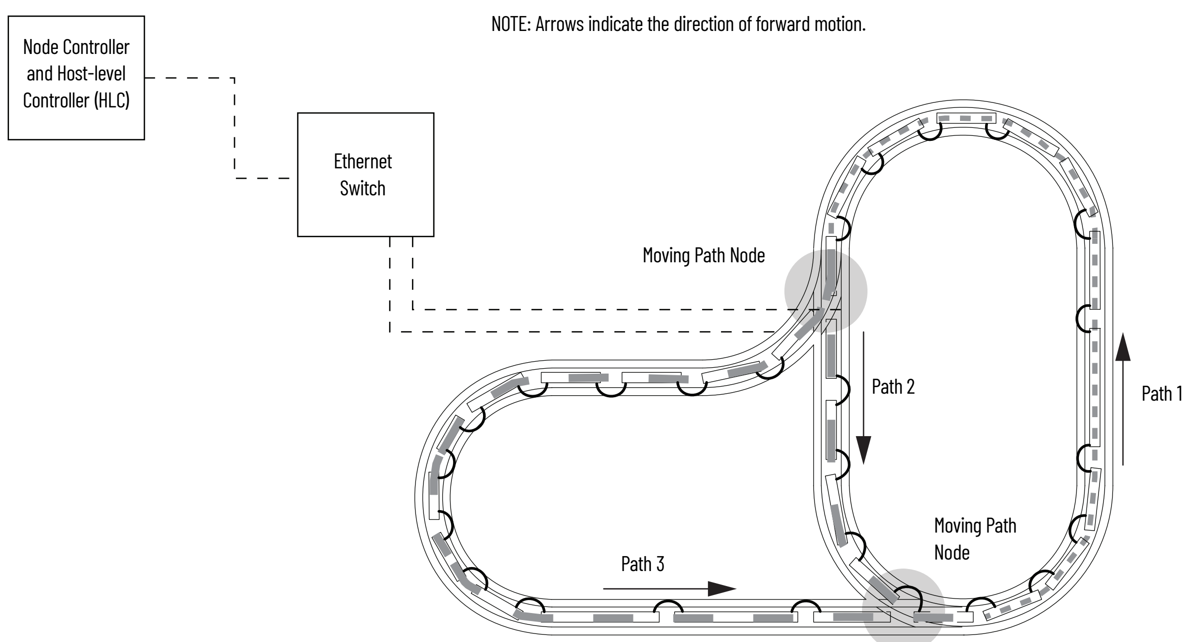
Nodes define the beginning of all paths and the connections between paths. See the MagneMotion System Configurator User Manual, publication MMI-UM046 for a detailed description of nodes and all node types.

The connections to the motors at the ends of all paths that meet in a node must be made to the same node controller.

Node Controllers

Once all paths and nodes have been identified on the QS transport system layout, the node controllers and their connections to the motors at the nodes must be defined. This definition typically includes identifying the type of node controllers being used (the example in Figure 10 shows a node controller that uses Ethernet communication).

Figure 10 - Example Transport System Layout Showing Node Controllers



Node controllers coordinate all motor operations and communicate with the high-level controller (HLC). In all transport systems, one node controller is designated as the HLC. The HLC manages the communication between the node controllers in the transport system and the host controller.

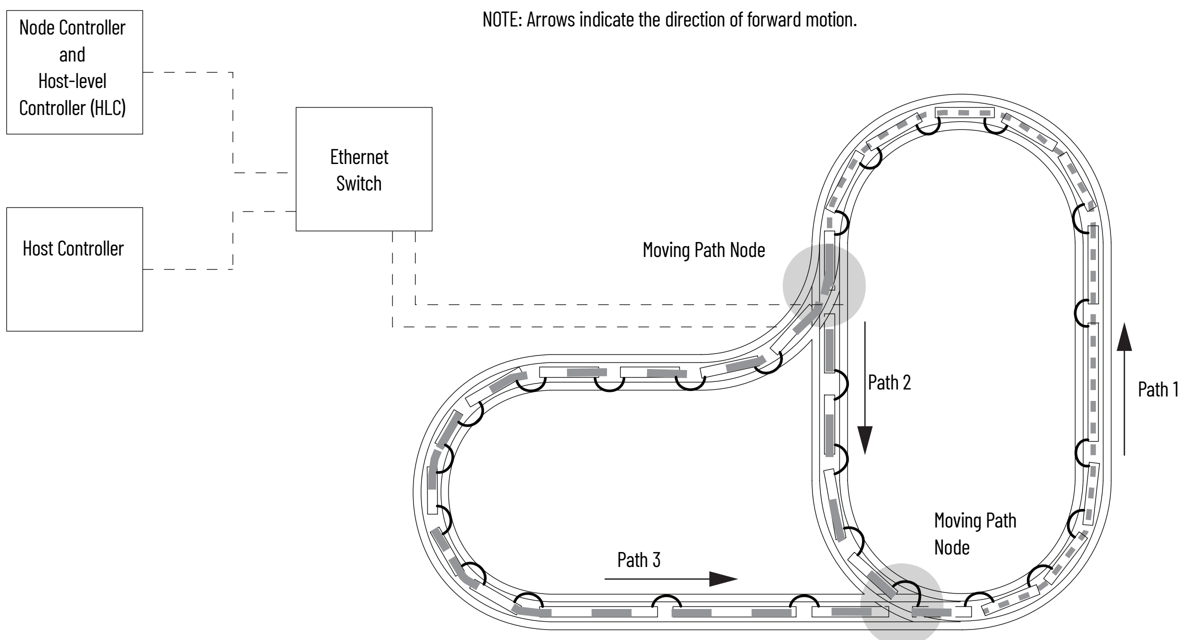
For more information on node controllers, see MagneMotion Node Controller Hardware User Manual, publication MMI-UM013 and MagneMotion Node Controller Interface User Manual, publication MMI-UM001.

All motor connections at a node must be made to the same node controller.

Additional Components

The remaining components and connections must be defined on the QS transport system layout. The components include power supplies for the motors and network switches for communication with the node controllers and host controller (see Figure 11 for an example).

Figure 11 - Example QS Transport System Layout Showing Additional Connections



If node controllers with digital I/O are being used, E-stop buttons, and interlocks can be configured and their locations identified. For more information, see Additional Functions on page 35.

- **Power Wiring** – Identifies the power connections between motors that are connected to the same power supply.
- **Power Supplies** – DC power supplies are required for powering the QS motors. See the Table 4 on page 23 for details. For motor control power requirements, see Table 5 on page 24.
- **Ethernet Switches** – Ethernet switches provide signal routing from the host controller to the node controllers and between node controllers. All node controllers must be on the same local area network subnet.
- **Host Controller** – User-supplied controller that runs the application for monitoring and control of the transport system.

Additional Functions

The QS transport system can use digital I/O, provided through a node controller, for monitoring and control of local E-stop buttons and interlocks. For details on installation and configuration, see these publications:

- MagneMotion Node Controller Hardware User Manual, publication MMI-UM013
- MagneMotion System Configurator User Manual, publication MMI-UM046

Transport System Design

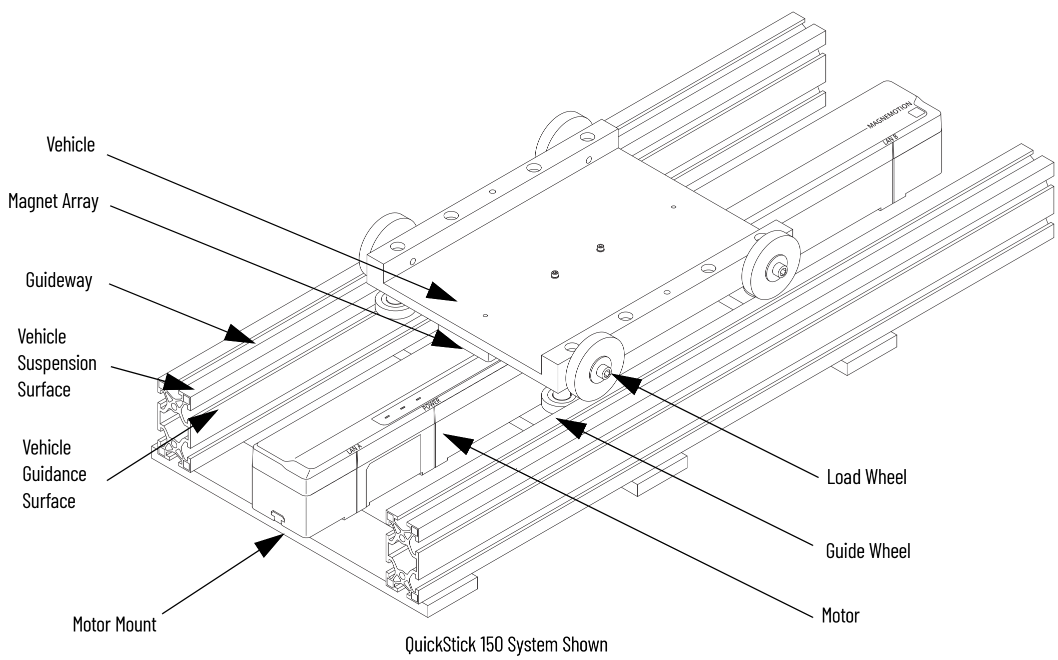
This section describes some of the basic considerations for designing a track system for a QS transport system. The track system includes the guideway, the guideway supports, the QS motors, the vehicles with magnet arrays, and the mechanism for mounting the motors to the guideway (see Transport System Layout on page 27 for layout guidelines).

One advantage of the QS transport system is that it is possible to have vehicles move at different rates of speed in the same direction, or in opposite directions without a collision.

The track and vehicle construction play a substantial role in the achievable system repeatability. The same motors can have different motion quality on different tracks and from vehicle-to-vehicle. The best way to determine the system movement characteristics is to build a prototype section of track to test the vehicle. This can help determine the effects the bearing type, track material, motor spacing, and vehicle construction have on repeatability.

The control software makes sure that the minimum distance between vehicles when not moving is maintained. For additional information about motor topology, see the applicable user manual for your motor in Additional Resources on page 16.

Figure 12 - QuickStick System, Single Array Vehicle



Transport System Design Guidelines

Use standard engineering practices to reduce torque, vibration, and other stresses on the guideway and other parts of the system. Factors specific to QS transport systems to consider include:

- Vehicles are not held in place if power is removed.

- The magnetic attractive force between the magnet array and the QS motors is constant (assuming the vehicle gap is maintained) regardless of the power that is applied to the motors. See Appendix A on page 141 for additional information about determining attractive force.
- The vehicle gap (distance between magnet array and motor) must be maintained throughout the system. See Figure 21 on page 47.
- Keep the Downstream Gap (distance between motors) as small as possible to make sure that there is enough thrust to move the vehicle over the gap. See Figure 14 on page 39.
- Do not locate process stations where the center of the magnet array is within the Downstream Gap between motors, as settling time and repeatability can be negatively affected.
- Make sure that the track system configuration accounts for power and communication connections and all cables.
- Make sure that the track system configuration accounts for points for grounding the track to earth ground in the facility and for grounding of all motors.
- When choosing the materials for the vehicle and guideway, consider the stresses applied to the vehicle and guideway during use.
- When choosing the materials for the vehicle and guideway, consider those materials that provide low friction and low wear.
- When choosing the materials for the vehicle and guideway, consider static electricity dissipation between the vehicles and the guideway. For details on mitigating Electrostatic Discharge (ESD), see Chapter 3 on page 63.
- The vehicle (magnet array) must remain centered over the motors throughout the system.
- When choosing the materials for the wheels, consider the life expectancy of the wheel material and the noise level as they move on the guideway. Noise can be created when moving across the joints in a straight/curved guideway or into a switch.
- Off-centered and/or large payloads can affect system performance.

Motors

The QS motors can be mounted in any orientation: right side up, sideways, upside down, and vertically. QS motors have a required direction, with an upstream end and a downstream end, see the QuickStick Motors Technical Data, publication MMI-TD051 or the QuickStick HT User Manual, publication MMI-UM007, for mechanical information related to your motor.

If the motor is mounted on an incline or vertically, the motor does not hold a vehicle in place during startup, restarts, or if power is lost.

Before designing a QS transport system, review the following information:

- Application for the QS system
- Desired throughput
- Maximum payload
- Total transport length
- Transport topography
- Move time
- Vehicle length

Once these characteristics are known, identify additional requirements:

- Accommodations for track length and topology.
- Determine the optimal thrust force, vehicle gap, and magnet array size. See Table 6.
- The QS transport system allows only one vehicle at a time on a motor block. Each block is a discrete motor primary section of multiple coils within the motor that is energized over its full length. See Table 6.

Table 6 - QuickStick Independent Motor Inverters (Motor Blocks)

<table>
<tr><th>Motor Type</th><th>Stator Length [m]</th><th>Block Length [mm]</th><th>No. Blocks</th><th>Internal Gap [(1)] [mm]</th></tr>
<tr><td>QS 150 and QS 100</td><td>1.0</td><td rowspan="3">96</td><td>10</td><td rowspan="3">9</td></tr>
<tr><td>QS 150 and QS 100</td><td>0.5</td><td>5</td></tr>
<tr><td>QS 150</td><td>0.3</td><td>3</td></tr>
<tr><td>QSHT</td><td>1.0</td><td rowspan="3">480</td><td>2</td><td>3</td></tr>
<tr><td>QSHT</td><td>0.5</td><td rowspan="2">1</td><td rowspan="2">4</td></tr>
<tr><td>QSHT</td><td>0.5, double-wide</td></tr>
</table>

(1) Internal gap is used to calculate downstream motor gap. Downstream motor gap is shown in Figure 14 on page 39. The internal gap is present on both motors involved in a gap (meaning the upstream internal gap and the downstream internal gap).

- The magnetic attractive force present per magnet cycle and the required thrust must be accounted for with the QS motors. For QS 150 and QS 100 motors, see Table 7. For QSHT motors, see Table 8. Complete tables for thrust and attractive force are available in Appendix A on page 141.

Table 7 - QS 150 and QS 100 Thrust and Attractive Force, Standard Covered Magnet Array

Attribute	Force (Typical)
Thrust per cycle[(1)]	4.07 N/A/cycle
Attractive force per cycle	58.8 N/cycle

(1) 3 mm vehicle gap.

Table 8 - QSHT Thrust and Attractive Force, Standard Covered Magnet Array

Attribute	Force (Typical)
Thrust per cycle[(1)]	18.81 N/A/cycle
Attractive force per cycle	483.2 N/cycle

(1) 11 mm vehicle gap.

Available Thrust

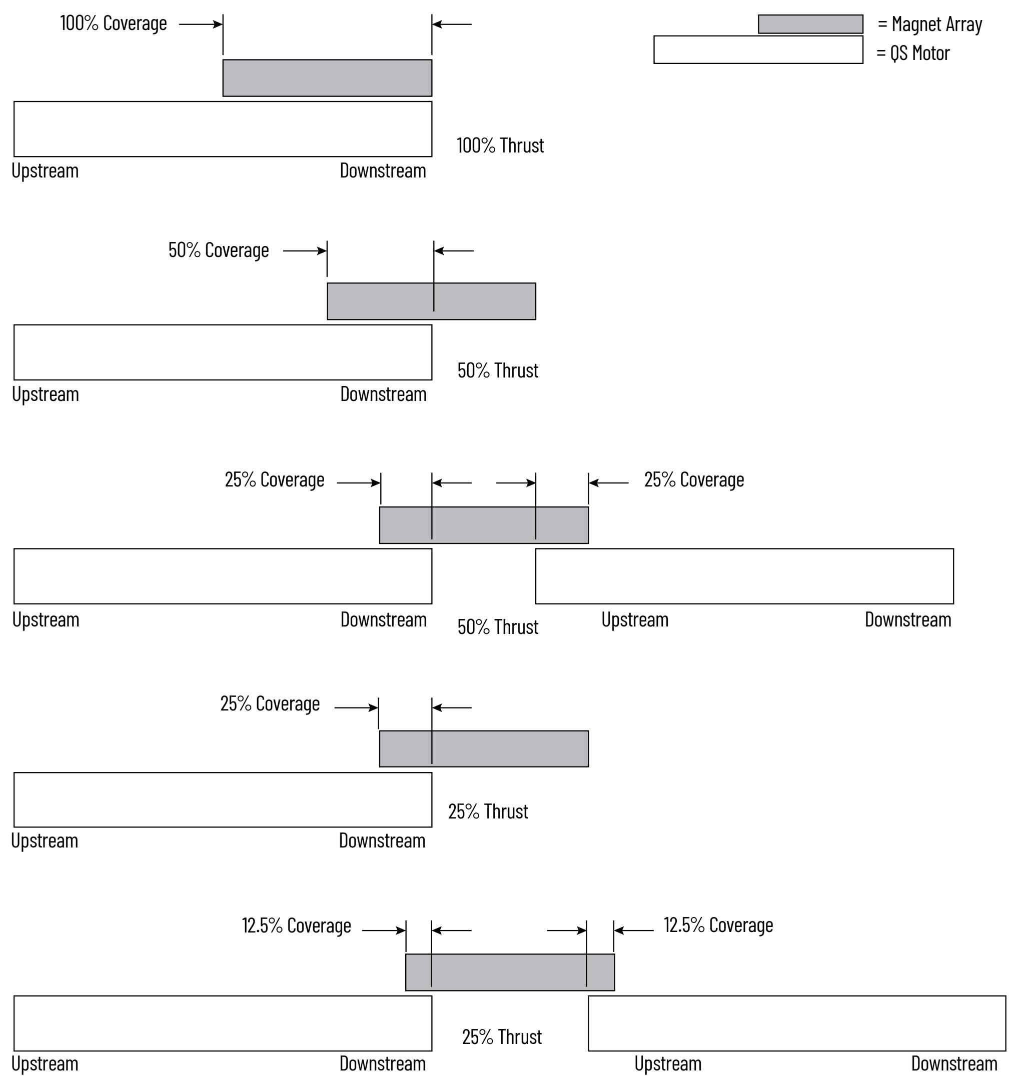
Several variables determine the thrust available from the QS motors to move a vehicle:

- Magnet array length (in cycles).
- Vehicle gap (distance between the magnet array that is attached to the vehicle and the motor).
- Friction or drag between the vehicle and the guideway.
- Motor gap (physical distance between motors) and downstream gap (actual distance between motor blocks in adjacent motors), see Figure 14 on page 39.

For details on calculations for available thrust, see Appendix A on page 141.

At the nominal vehicle gap (the space between the magnet array and the top of the motor) the QS motors provide a calculated thrust per magnet array cycle at a set stator current, see Table 7 on page 37 and Table 8 on page 37. The magnet arrays are available in various lengths to provide the appropriate thrust for the application. Two arrays can be used in a dual-array vehicle, see Dual-array Vehicle on page 48), which effectively doubles the length of the magnet array. By increasing the length of the magnet arrays, the number of motors in the system can be decreased. However, you must account for the loss of thrust in the gaps between the motors. Figure 13 provides examples of the amount of thrust based on the size of the motor gap.

Figure 13 - Available Thrust Examples



Required Thrust

Several variables determine the thrust required to move a vehicle:

- Required acceleration
- Mass to be moved
- Friction or drag between the vehicle and the guideway

Motor Gap

For QS motors installed in a transport system, there is always a space (motor gap) between motors.

- For QS 100 and QS 150 motors, the minimum space is 2 mm (for thermal expansion), with typical spacing placing 1.0 m QS 100 and QS 150 motors on a 1.0 m pitch. See Figure 14.
- For QSHT motors the minimum space is 2 mm (for thermal expansion), with typical spacing placing 1.0 m QSHT motors on a 1.0 m pitch. See Figure 15.

Figure 14 - QS 100 and QS 150 Motor Gaps

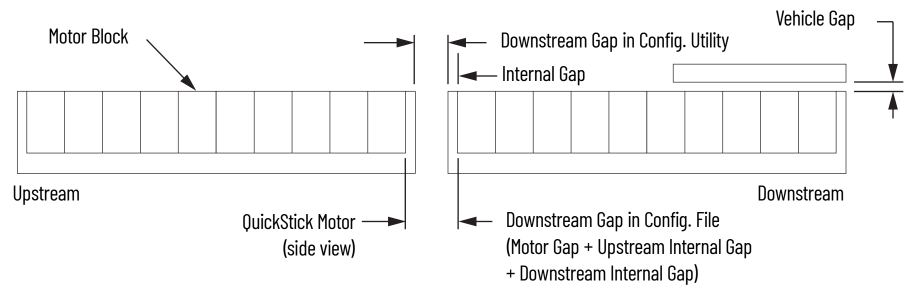
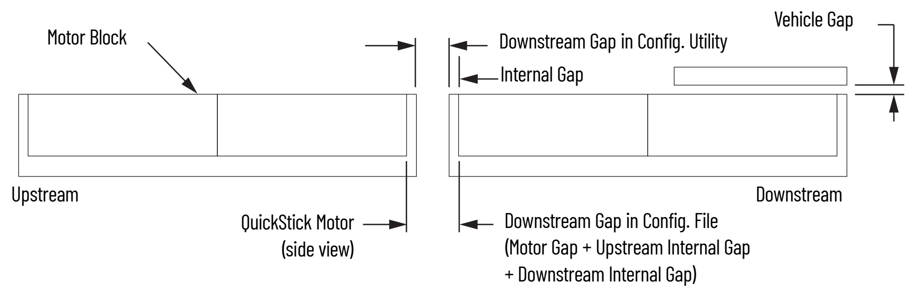


Figure 15 - QSHT Motor Gap



Downstream Gap

An additional measurement between QS motors is the distance from the last block of the stator in one motor to the first block of the stator in the next motor downstream. This space is referred to as the Downstream Gap (shown in Figure 14) and includes the distance inside the motor from the end of the stator to the end of the motor housing. The Downstream Gap varies based on the length of the motor being used.

For QS 100 and QS 150, the maximum downstream gap between motors is the length of a magnet array minus 2-cycles, minus 18 mm. This means that a magnet array will not exist between the gap between motors. When a dual-array vehicle is used, the max downstream gap remains the same as if a single magnet array were used.

For QSHT, the maximum gap between motors is the length of the magnet array minus (0.75 x cycle length x 2) minus (2 x internal gap). When a dual-array vehicle is used, the maximum downstream gap remains the same as if a single magnet array is used. See the QuickStick HT User Manual, publication MMI-UM007 for additional information on downstream gaps.

- For the QS 100 and QS 150 magnet arrays, the cycle length is always 48 mm.
- For the QSHT magnet arrays, the cycle length is always 120 mm.
- For the QS 100 and QS 150, the maximum allowable gap is the length of the magnet array minus 120 mm
- For the QSHT, the maximum allowable gap is the length of the magnet array minus 194.6 mm

The Downstream Gap affects the force available for vehicle motion between motors. There is a certain amount of thrust available per magnet array cycle, providing that the magnet array cycle is located above the motor (magnet array coverage). There must be enough thrust to move the vehicle past the gap between motors. Do not locate process stations within the gap between motors as settling time and repeatability are negatively affected.

The QS motors do not compensate for the amount of thrust that is lost when the magnet array is over the Downstream Gap. This means that if the array only has half coverage as shown in Figure 13 on page 38, the effective PID values, and peak thrust are halved, and the system does not perform as it would with full coverage.

It is important to note that the Downstream Gap measurement is added to the last motor block of all motors in the transport system. This gap value is important when considering the motor blocks that a vehicle owns. The gap value is also used for determining when vehicles are considered to be at the end of a path or cleared of a node boundary (such as a Terminus node). See the applicable user manual for your motor in Additional Resources on page 16.

Motor Cogging

Any cogging between the QS motor and the QS magnet array is typically not an issue unless there is a direct human interaction with the vehicle while it is being moved, in which case it might be felt. Any cogging does not affect the positioning accuracy of the motor. For information on Motor Operation and Motor Cogging, see the applicable user manual for your motor in Additional Resources on page 16.

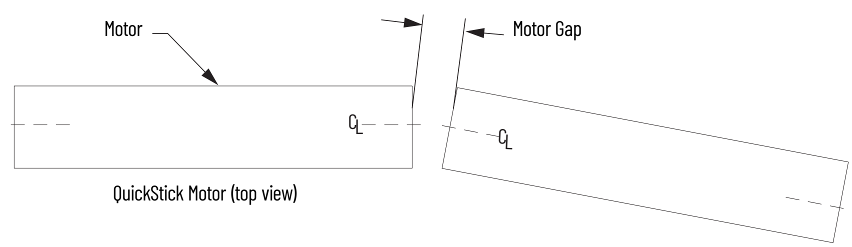
The following methods can minimize cogging:

- Placing motors at the optimal pitch on the transport system (see Downstream Gap on page 39).
- Maximizing the vehicle gap between the motor and the magnet array.
- Providing external damping between the vehicle and the payload.

QuickStick 100 and QuickStick 150 Motors on a Curve

For motors on a curve, the distance from the center of the motor housing on one motor to the center of the housing on the next (downstream) motor is the motor gap (See Figure 16). By default, this defines the downstream gap (motor gap + 18 mm).

Figure 16 - Motors on Curves



Since the motors and the magnet arrays are not curved, the alignment of the magnet array over the motors is not optimal in a curve and the alignment of the magnet array changes as the vehicle moves through the curve (see Figure 20 on page 47). To minimize some of this misalignment the magnet arrays that are used for curve geometry are wider than usual to provide more magnetic array coverage. A dual-array vehicle (see Dual-array Vehicle on page 48) can be used, which allows the magnet arrays to stay better aligned to the motors.

Additionally, when a motor is on a curve, the 'On Curve' option for that motor in the Node Controller Configuration File may need to be selected. The On Curve option is used based on the configuration of the motors in the curve to enable the use of a correction table (supplied by Rockwell Automation) to locate the vehicle correctly relative to the position sensors in the motors. This is more commonly required for tight radius curves or single array vehicles (see the MagneMotion System Configurator User Manual, publication MMI-UM046).

See Appendix B on page 149 for more information on curve design and the use of a curve correction table.

IMPORTANT If On Curve is selected for a motor and Rockwell Automation has not supplied a unique version of software with the correction table, the vehicles may not move properly and the system may not perform as expected.

Motor Drives, Controllers, and Inverters

For the QS 100 and QS 150, each motor has one motor controller located inside the motor. The motor controller is responsible for controlling the thrust that is applied to each vehicle by the motor and reading the sensors in the motor to determine the vehicle position. The motor controllers communicate with each other and a node controller via an Ethernet network. The QS 100 and QS 150 do not use motor drives or inverters.

For the QSHT, the motor drive is located externally to the motor. Each QSHT motor has one motor drive, either a QSMC or QSHT 5700 Inverter. When there are two consecutive 0.5 m motors, they can share a drive. The motor drive is responsible for controlling the thrust that is applied to each vehicle by the motor and reading the sensors in the motor to determine the vehicle position.

Each QSMC motor controller can control one 1.0 m QSHT motor or one 0.5 m double-wide QSHT motor. Each QSMC-2 motor controller can control two consecutive 0.5 m QSHT motors on the same path. The QSMC motor controllers communicate with each other and a node controller via an RS-422 serial network.

Each QSHT 5700 inverter can control one 1.0 m motor, or one or two consecutive 0.5 m motors on the same path, or one 0.5 m double-wide motor. The QSHT 5700 inverters communicate with each other and a node controller via an Ethernet network.

Magnet Arrays

The amount of linear thrust that a QS motor provides is primarily a function of QS magnet array length.

Magnet Array Length and Attractive Force

There is a strong magnetic attractive force present between the QS magnet array and the motor. This force is an important consideration in designing the support structure for the transport system and in determining the force that is required to move a vehicle. The magnetic attractive force is always present, even if there is no power to the motor. The amount of magnetic attractive force present is also dependent on the length of the magnet array.

See the QuickStick Motors Technical Data, publication MMI-TD051, and the QuickStick HT User Manual, publication MMI-UM007, for additional information on magnet array length and attractive force.

Choose a magnet array length that is no longer than the vehicle length. Based on the application, multiple magnet arrays can be used for each vehicle end-to-end.

Magnet array length is measured in three ways:

- Number of cycles
- Physical length in millimeters
- Number of poles

Number of Cycles

The amount of thrust force and attractive force is reported as force per magnet array cycle. The more cycles in the magnet array, the greater the thrust and attractive forces. A magnet array cycle is:

- The distance from the edge of a half North-oriented magnet to the center line of a full North-oriented magnet as shown in Figure 17 on page 43.
- The distance from the center line of one full North-oriented magnet to the centerline of the next full North-oriented magnet as shown in Figure 17 on page 43.

Table 9 - Maximum Motor Gap for Smallest Magnet Array

QS Motor Type	Smallest Magnet Array Cycles	Dimensions [mm (in.)]	Max. Motor Gap [mm]
QS 100	3	144 (5.67)	24.0
QS 150	3		
QSHT	2	238 (9.4)	45.4

IMPORTANT When determining the number of cycles that are required for the magnet array, be sure to account for the downstream gap.

Number of Poles

The number of poles in a magnet array is simply the number of North-oriented and South-oriented poles in the magnet array. The number of poles is always an odd number (see Figure 17 on page 43) as it includes the half magnets at each end of the array. The number of poles can also be calculated from the number of cycles (*cycles* * 2 + 1).

Magnet Array Width

Magnet arrays are available in several different widths. The application determines the width that is used.

Regular width magnet arrays are used in applications where the array does not need to be wider than the motor. These applications are typically when motors are arranged in a straight line.

Wide arrays are used in applications where the array must be wider than the motor. This array width is typically used when motors are arranged in a curve to provide coverage when there is a misalignment between the motor and the magnet array. This loss of coverage due to misalignment leads to a loss of thrust.

Magnet Array Forces

As mentioned previously, there is a certain amount of thrust and attractive force available per magnet array cycle; however, the number of cycles is not the only variable that affects available thrust. Other variables are the vehicle gap and the downstream gap. These other variables and their effect on available thrust are discussed later in this chapter.

Magnet Array Use

The magnet arrays are intended for use as the motor secondary as part of the vehicle only and must not be used for any other purpose.

Protect all magnet arrays on the transport system from debris accumulation. If debris is accumulated, it can get caught between the magnet array and the motor. Any accumulated debris affects the performance and can damage the cover of the motor or the magnet array.

Proper precautions must be taken when magnet arrays with stainless-steel covers are used in wash down applications or in environments where water or fluids are contacting the array. The mounting must secure the array with a suitable form of gasketing to help prevent water ingress into the array through either its back surface or the seam where the cover meets the back iron of the array. The top surface and sides of the cover are water-resistant.

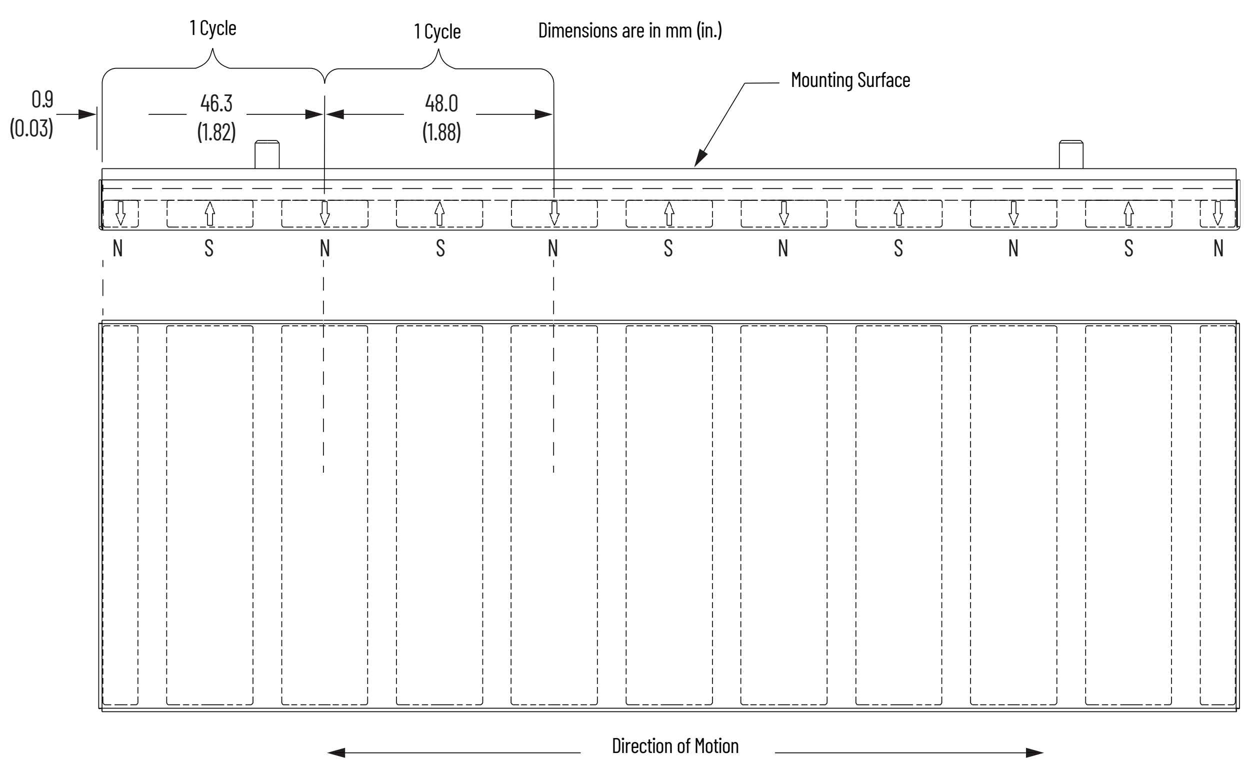
For additional information on magnet array installation and cleaning, see the applicable user manual for your motor in Additional Resources on page 16.

Standard Magnet Arrays

The standard magnet array for the motors is an arrangement of alternating North-oriented and South-oriented neodymium iron boron (NdFeB) permanent magnets placed perpendicular to the direction of motion. The magnet arrays come in several lengths and widths, with full magnets of alternating polarity in the middle of the array and a North oriented half magnet at each end of the array. Orientation of the magnets is referenced to the surface facing the motor as shown in Figure 17.

For information on QSHT high flux magnet arrays, see QuickStick HT User Manual, MMI-UM007. The remaining examples in the section are specific to QS 100 and QS 150 standard magnets.

Figure 17 - QS 100 and QS 150 Standard Magnet Array, 5 Cycles, 11 Poles

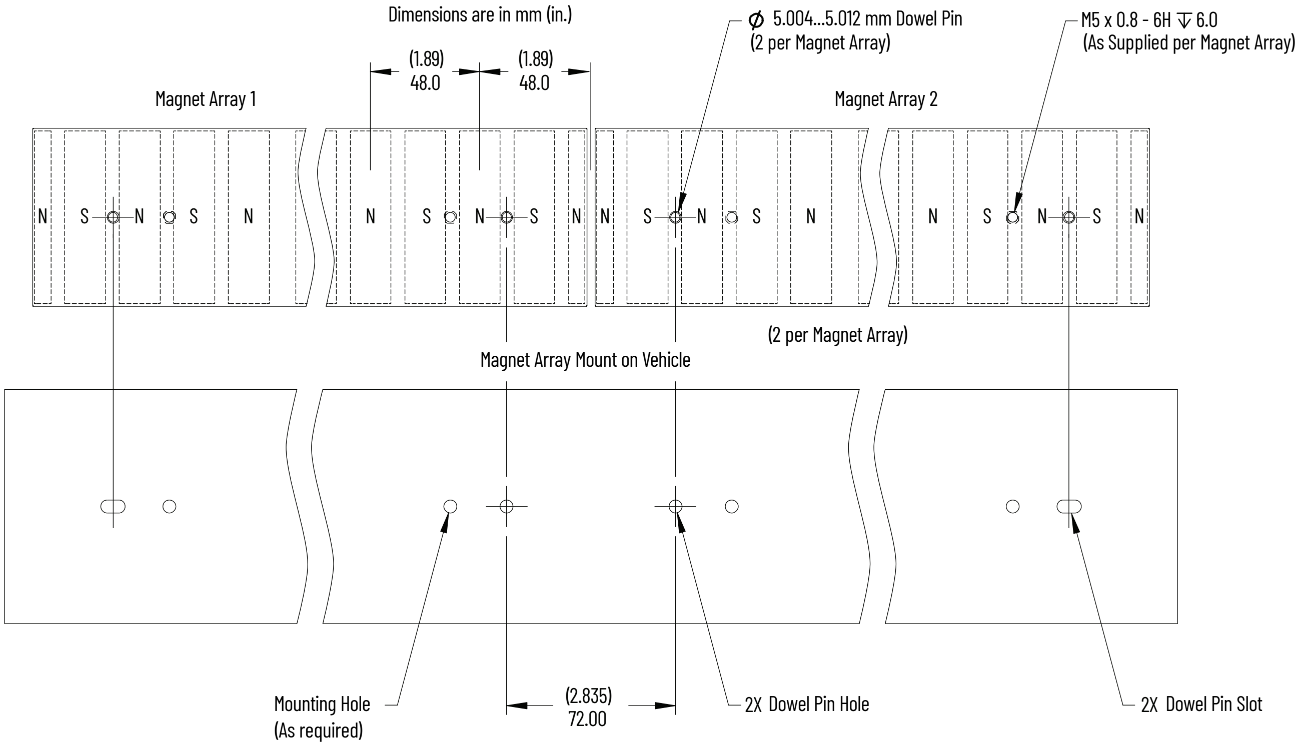


IMPORTANT	Even though the magnet arrays are covered with a stainless steel cover the magnets can still be damaged and are subject to corrosion if damaged.

Two covered arrays can be placed end-to-end with a minimal gap between the arrays to create longer arrays (for example, two 3-cycle arrays can be used to create a 6-cycle array). When mounting arrays this way, the arrays must be mounted to make sure that all cycles in the combined array measure 48 mm (1.89 in.) (as shown in Figure 18).

The dowel pin holes for the magnet array pins must be 72.00 mm (2.835 in.) apart from each other (as shown in Figure 18) to make sure the cycle length remains constant. This sets the correct physical gap between the magnet arrays and is true for any mix of magnet array lengths.

Figure 18 - Mounting Two Covered Magnet Arrays End-To-End



OS 100 and OS 150 Physical Length

The physical length of the standard covered magnet arrays can be measured using a non-ferrous measuring tool. The physical length can also be calculated, if the number of cycles is known.

The equation to calculate the physical length of a standard covered magnet array is:

$$MagnetArrayLength = ((Cycles - 2) \times 48) + 92.6\ mm + 1.9\ mm$$

Where:

MagnetArrayLength is the length of the array, in millimeters.

Cycles is the number of whole cycles in the array.

92.6 mm is the additional length of the half cycles at each end of the array.

1.9 mm is the additional length of the cover protecting the array.

QSHT Physical Length

The physical length of the high flux magnet arrays can be measured using a non-ferrous measuring tool. The physical length can also be calculated, if the number of cycles is known. The equation to calculate the physical length of a high flux magnet array is:

MagnetArrayLength = (Cycles x 120) - 2 mm

Where:

- *MagnetArrayLength* is the length of the array, in millimeters
- *Cycles* is the number of whole cycles in the array
- 2 mm is subtracted from the overall length to allow stacking of magnet arrays end-to-end

Vehicles

Vehicles carry payloads through the QS transport system as directed. A high-strength QS magnet array, described in Magnet Arrays on page 41, is mounted to the surface of the vehicle closest to the QS motors. The magnet array interacts with the motors, which moves the vehicle.

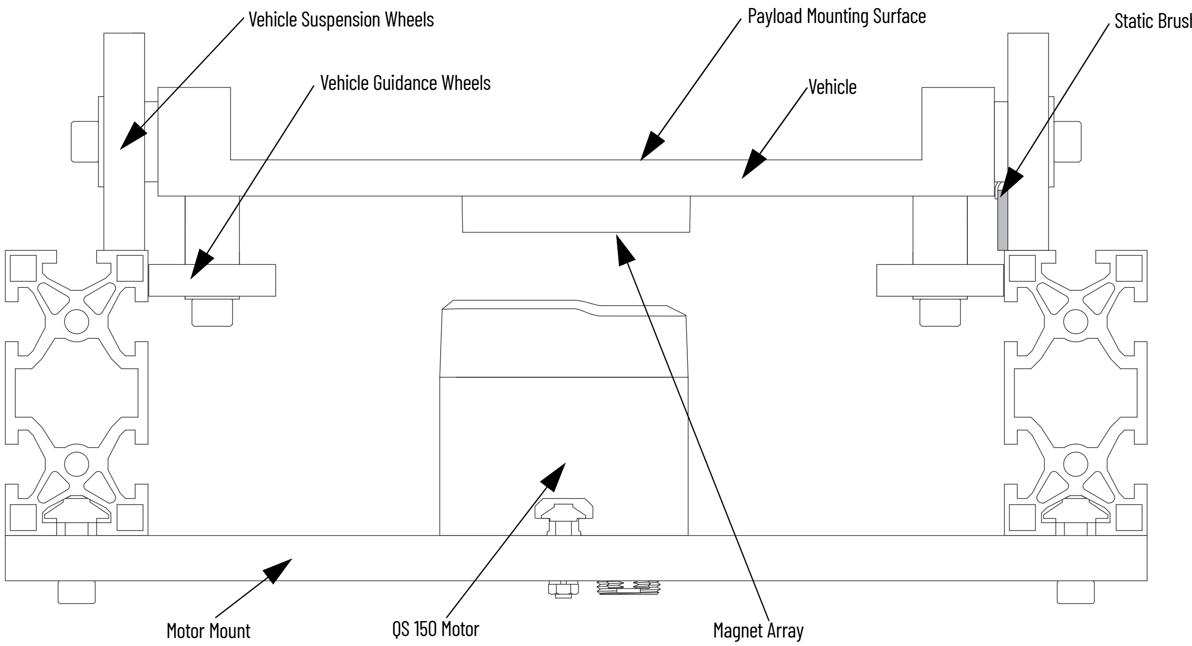
The vehicle is passive with no electronics on the vehicle and no power or signal connections required. A vehicle can be of almost any size and shape, depending on the requirements of the application. Vehicles must be designed to hold the mass of the payload, to hold the magnet array, and to withstand the attractive force present between the magnet array and the top of the motor. There are several design elements that must be met:

- The vehicle design must provide guides to make sure that the magnet array position is maintained over the center of the motor, as shown in Figure 19 on page 46.
- The vehicle supports the magnet array and its placement in the guideway must make sure that the vehicle gap is maintained throughout the system, as shown in Figure 21 on page 47.
- The vehicle platform must be at least as long, and preferably longer than the magnet array.

SHOCK HAZARD: Vehicles must be grounded to the guideway through conductive materials such as wheels, skids, or static brushes. Make sure that all vehicles are grounded to the guideway. For details on mitigating Electrostatic Discharge (ESD), see Chapter 3 on page 63.

- Vehicles must be grounded to the guideway through conductive materials such as wheels, skids, or static brushes.
- The vehicle must have low friction with the guideway.
- All vehicles on connected guideways must be the same size and use the same size and type of magnet array.

Figure 19 - Typical Vehicle on Guideway



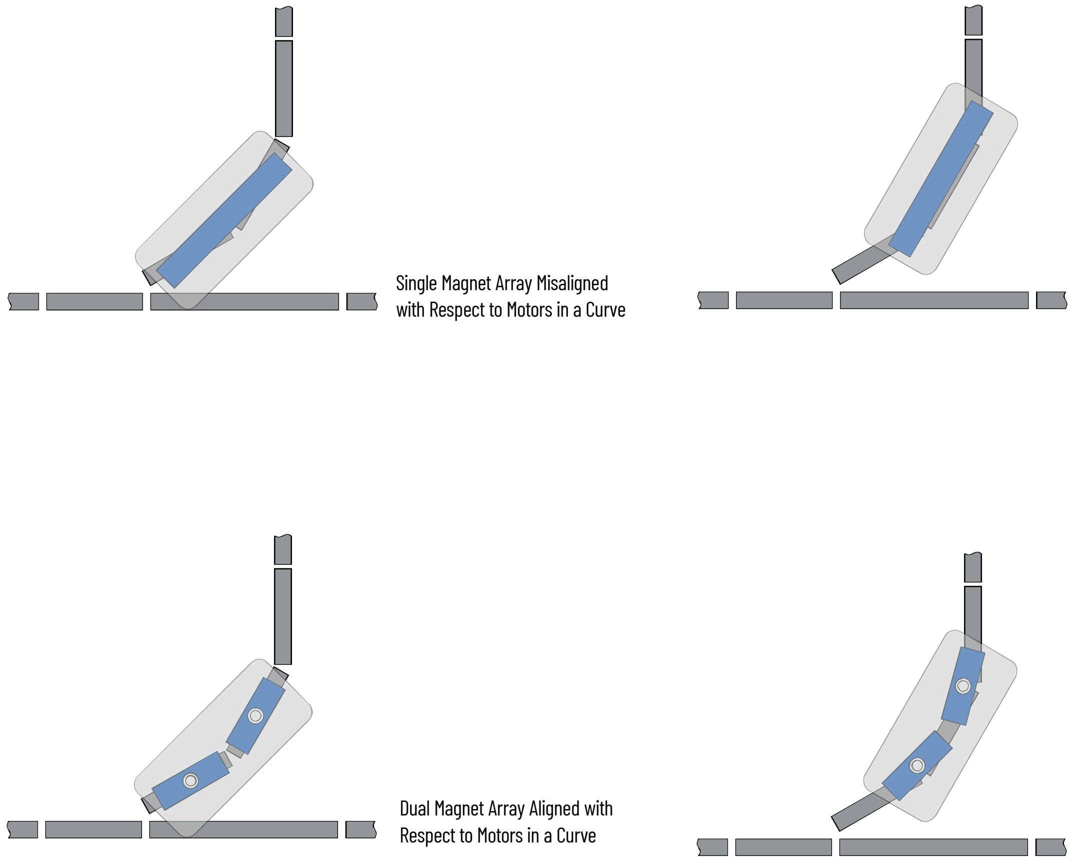
Various materials can be used to construct the vehicles in a transport system. Any material that is used must be able to carry the payload without deflecting while supporting the magnet array in the correct relationship to the motors. In general, use a lighter weight vehicle to maximize the acceleration capability of the system for moving the payload.

Wheels or rollers are used to support the vehicles on the guideway while allowing the vehicles to move freely upstream and downstream (see Guideways on page 52 for more information). They also maintain a consistent space between the magnet array that is attached to the vehicle and the motors (vehicle gap). Wheel and roller materials affect the frictional resistance, which affects the amount of thrust that is required to move a vehicle. The selected material must be hard enough to provide a low rolling resistance but, depending on the environment the system is used in, soft enough to minimize excess noise when traversing the joints between guideway sections.

In a system with multiple vehicles, differences between vehicles can affect repeatability (see Transport System Repeatability and Accuracy on page 28 for details on repeatability). While the system may be calibrated using one vehicle, that one vehicle used for tuning or calibration may locate its payload differently than every other vehicle on the track. This is because design tolerances between the magnet array and the payload can affect the position of the payload relative to external tooling. These differences between vehicles can be noted and compensated for, either in hardware using a vehicle with an adjustable payload position or in software using a look-up table and slight variations in position orders based on which vehicle is being ordered.

Vehicles can have one or two magnet arrays that are attached to the surface closest to the motors based on the use of the vehicle and the design of the guideway. Typically, when vehicles travel guideways with curves they have two independent magnet arrays to help maintain maximum alignment of the arrays with the motors while traveling through the curve as shown in Figure 20 on page 47.

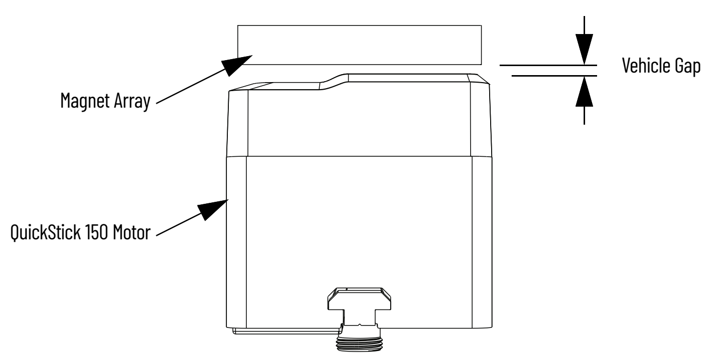
Figure 20 - Magnet Array to Motor Alignment



Vehicle Gap

The vehicle gap, which is shown in Figure 21, is the distance that is maintained between the magnet array and the motor. This gap must be maintained throughout the QS transport system to make sure that the vehicle operates consistently. The larger the gap the longer the QS magnet array must be to achieve the same thrust. See Appendix A on page 141 for vehicle thrust calculations. The smaller the gap the greater the risk of contact between the magnet array and the top of the motor, which could cause damage to the motor or magnet array.

Figure 21 - Vehicle Gap



The vehicle gap must be such that any deviation in the flatness of the vehicle suspension surface does not allow the magnet array on the vehicle to touch down on either the suspension surfaces or the motors. Variation in the vehicle gap results in variable vehicle performance.

However, the greater the tolerance on the flatness of the guideway the larger the vehicle gap must be to make sure that the magnet array never touches the top of a motor. Also, with a larger gap, the magnet array must be larger to provide the same thrust as would be achieved from a smaller vehicle gap.

The vehicle gap must be such that any deviation in the flatness of the vehicle suspension surface does not allow the magnet array on the vehicle to touch down on either the suspension surfaces or the motors.

The recommendations for the vehicle gap when using magnet arrays that are shown are for reference only. Using a smaller minimum vehicle gap or a larger maximum vehicle gap is possible. However, exceeding the vehicle gap recommendations typically requires special design considerations and can make it difficult for the position sensors in the motor to locate the vehicles precisely. Contact Rockwell Automation customer support for additional information.

QuickStick 100 and QuickStick 150

- Minimum vehicle gap is 1 mm
- Nominal vehicle gap is 3 mm for typical industrial applications
- Maximum vehicle gap is 9 mm

QuickStick HT

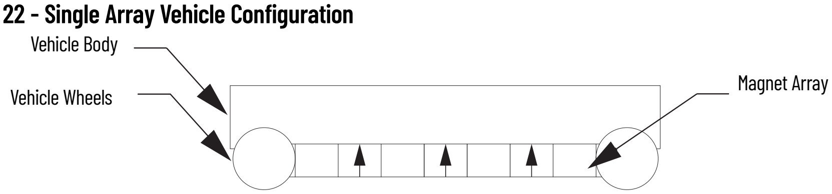
- Minimum vehicle gap is 4 mm
- Nominal vehicle gap is 11 mm for typical industrial applications
- Maximum vehicle gap is 22 mm

Single Array Vehicle

Vehicles with single QS magnet arrays are typically used in QS transport systems where all motion is in a straight line. However, they can be used where the guideway includes curves by using a wider magnet array to minimize thrust loss through the curve due to misalignment of the QS motor to the magnet array.

Attributes of systems that use single array vehicles include:
- The magnet array is typically the same width as the motor.
- The guideway does not have any curves or it only uses large radius curves and the magnet array is shorter or wider than the motor.

Figure 22 - Single Array Vehicle Configuration



Dual-array Vehicle

Vehicles with two QS magnet arrays are typically used in QS transport systems where the guideway includes curves or large distances between QS motors. For systems where the track runs in a straight line these arrays can be mounted directly to the vehicle. For systems where the track has curves these arrays can be mounted on independent bogies.

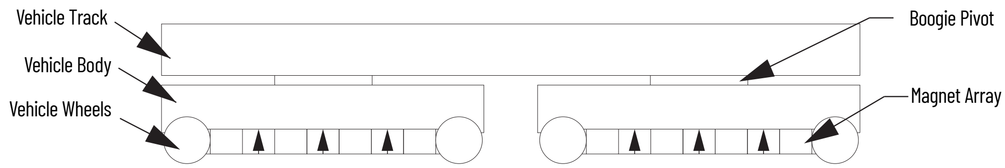
On a curve, there can be misalignment between the motor and the magnet array on the vehicle, which could lead to a loss of force. The dual-array vehicle for use on curves has two independent bogies that are connected to the vehicle by pivots, where each bogie has its own magnet array. By allowing the bogies to rotate independently of each other under the vehicle, each magnet array can stay as closely aligned to the motors as possible (as shown in Figure 20 on page 47), which minimizes the thrust loss that occurs while moving through a curve.

Both magnet arrays in a dual-array vehicle must be the same length and the magnet arrays must be mounted so that the gap between the arrays is a multiple of a cycle.

Attributes of systems that use dual-array vehicles include:

- The magnet array is typically wider than the motors.
- The guideway uses small radius curves.

Figure 23 - Dual-array Vehicle Configuration



Vehicle Design

When designing vehicles for use with the QS motors, the following vehicle design guidelines and considerations must be accounted for:

- Make the vehicles longer than the magnet array to help protect the array from impacts. A minimum of 5 mm extra length at the front and back of the vehicle is recommended.
- The vehicle design and the magnet array size determine the quantity and locations of suspension and guidance wheels or other suspension and guidance features.
- The use of a low friction barrier, such as UHMW material, is recommended to help prevent damage to either the magnet array or the motor if there is contact between the magnet array and the motor.
- Maximum vehicle length:
  - For QS 100 and QS 150, up to five vehicles per meter [150 mm (5.9 in.) maximum vehicle length] in motion or in queue. Transport systems with short vehicles with 150 mm magnet arrays can encounter startup issues if the vehicles are too close to one another.
  - For QSHT, up to two vehicles per meter [238 mm (9.4 in.) minimum length] in motion or in queue.
- The payload, vehicle mass, and required acceleration must be within the limits of the magnet array.
- Vehicles that carry payloads sensitive to magnetic fields must provide shielding or separate the payload from the magnet array by 50…100 mm.
- When using curved guideways, make sure that the vehicle design is able to negotiate the curves.

Vehicle Materials

Some examples of commonly used vehicle materials and considerations:

Steel

- Good strength properties.
- High density yields heavier vehicles.
- Caution is required when using carbon steel (a ferromagnetic material).
- 300-series stainless steel is suitable.

Aluminum

- Good combination of comparatively high strength and low mass.
- Less caution is required because of no magnetic attractive force.
- The area under the vehicle magnet array must be clear of aluminum, as the aluminum can create eddy currents, which create a breaking force.

Wheel Materials

Some examples of commonly used wheel materials and key considerations:

Steel

- Durable, typically used in systems that move heavy payloads or for difficult environmental conditions.
- Low rolling resistance.
- When used on a metal guideway are typically noisier than plastics.

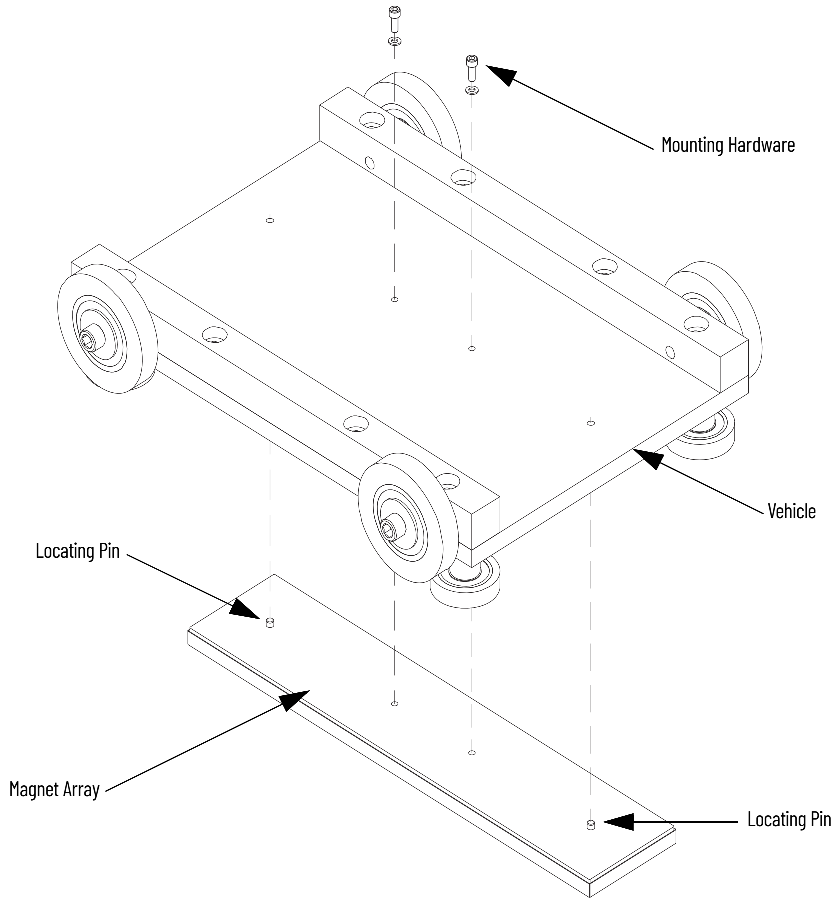
Plastic, Teflon, or Urethane

- Plastics with a high durometer number (hardness) are a good choice of wheel material for many applications, particularly for systems with moderate to low payload weights.
- Plastic or urethane wheels can develop a small flat area if the vehicle remains stationary for a long time period due to the vehicle mass and the magnet attractive force. In most cases, these flat spots disappear after the vehicle is put in motion again.
- Higher rolling resistance than steel, but usually operate more quietly than steel wheels when used on a metal guideway.
- Typically requires the vehicle be grounded to the guideway with static brushes. For details on mitigating Electrostatic Discharge (ESD), see Chapter 3 on page 63.

Mounting Magnet Arrays to Vehicles

QS magnet arrays are provided with locating features to provide consistent mounting to the vehicles and threaded holes for attachment. Magnet arrays must be attached using stainless-steel hardware that fully engages the threads in all magnet array mounting holes as shown in Figure 24.

Figure 24 - Magnet Array Mounting Example



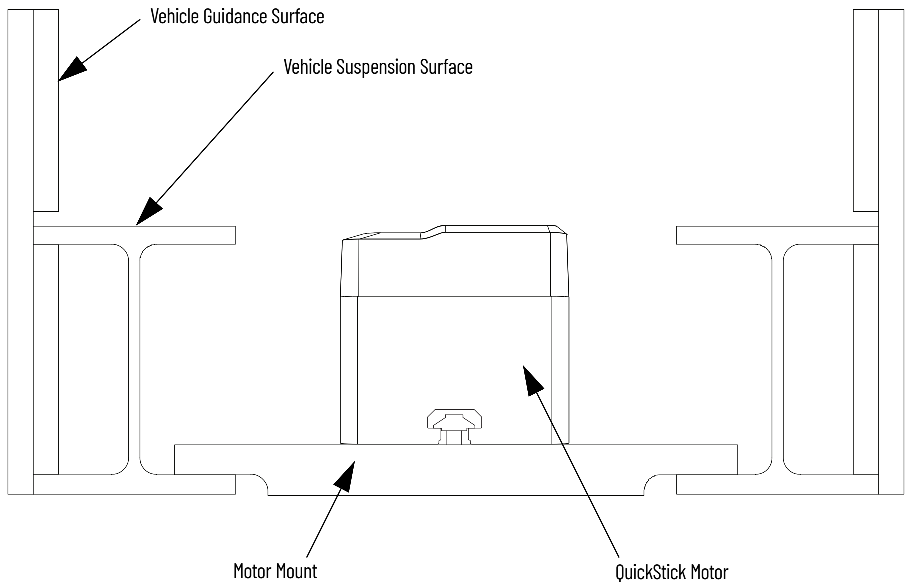
Guideways

As with any conveyance technology, vehicle motion imparts dynamic loads on the guideway system. The guideway must be adequately secured to a rigid, permanent structure, which helps reduce vibrations and other stresses on the system.

Guideway Design

This section provides information on guideway design.

Figure 25 - Alternate Guideway Detail



Basic guideway design guidelines and considerations:

- The payload mass, vehicle mass, and QS motor mass must be within the weight limits of the guideway.
- The guideway can have any orientation in relation to the motors and vehicles as long as the QS magnet array on the vehicle is held in position next to the top of the motor.
- The guideway must hold the motors in position to make sure that the spacing from motor to motor does not change (see Figure 14 on page 39).
- The guideway must hold the motors and support the vehicles to make sure that the vehicle gap (see Figure 21 on page 47) is maintained throughout the system.
- The guideway must provide sufficient space around the motor mounting surface for all connectors and for the bend radius of all cables.
- Keep the suspension surfaces on which the vehicles move as flat as possible to minimize the variation in the vehicle gap throughout the transport system. Maintaining a tight tolerance allows the vehicle gap to be as small as possible, which maximizes vehicle thrust.
- When using curved guideways, make sure that the guideway material supports curving.
- Keep the joints between sections of the guideway as smooth as possible to minimize noise and wear on the wheels.
- The guideway must provide features to allow the vehicle to maintain its position on the guideway (see Figure 19 on page 46 and Figure 25).
- The guideway must provide proper grounding to provide static dissipation. For details on mitigating Electrostatic Discharge (ESD), see Chapter 3 on page 63.

Guideway and Support Materials

As with any installation, the operational environment must be considered when choosing compatible support structure materials. Some examples of commonly used guideway structure materials and key considerations follow:

Steel

- Good strength properties.
- Strong and provides a stable platform for vehicle movement.
- Can be heavier than is necessary.
- Caution is required when using carbon steel (a ferromagnetic material).
- Can be more expensive than other alternatives.

Aluminum

- Good combination of comparatively high strength and low mass.
- Less caution is required because of no magnetic attractive force.
- The area under the vehicle magnet array must be clear of aluminum as the aluminum can create eddy currents, which create a breaking force.
- Available in various weights, thicknesses, and prices.

Motor Mounts

The QS motors provide adjustable mounting features on the bottom, which provides for a simple mounting scheme. The following guidelines are provided for designing the motor mounts to interface with the QS motor mounting features.

- Design the mounts to allow the motors to have a small amount of movement relative to each other for adjustment of the motor-to-motor gap during installation.
- Design the mounts to support consistent spacing between the motors, which simplifies the creation of the Node Controller Configuration File and provides consistent thrust.
- Design the mounts to make sure that the tops of all motors are coplanar to each other to meet the standard thrust requirements. The tolerance requirement for motor top coplanarity is dictated by the tolerance stack that is associated with the overall system guideway and structure design.
- Design the mounts to make sure that the motor is securely fastened and cannot move.
- Make sure that all motor mount locations are used and all bolts for the mounts are fully secured.

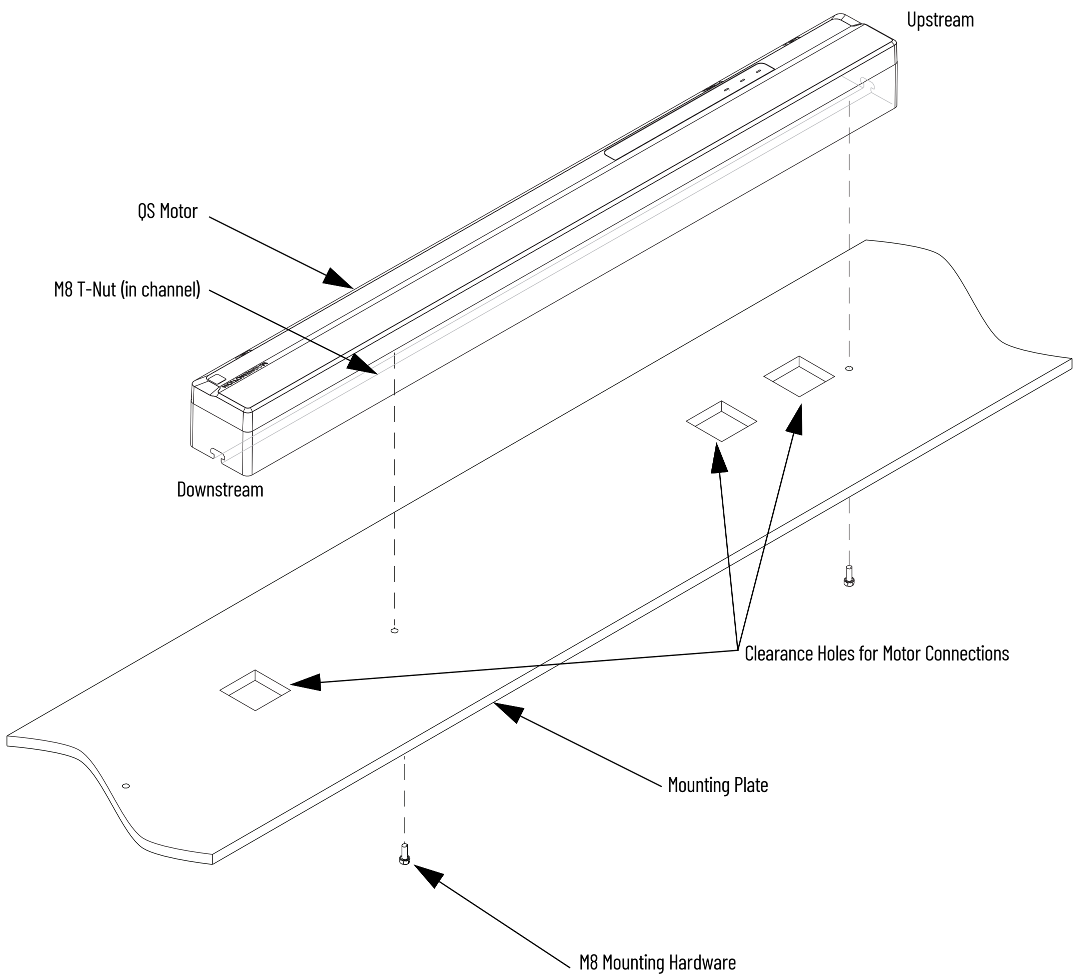
Motor Mounting Methods

All examples that are shown in this section are for the QS 150 motor. For QS 100 motor mounting information, see the QuickStick 100 User Manual, MMI-UM006. For QSHT motor mounting information, see the QuickStick HT User Manual, MMI-UM007.

The following QS motor mounting guidelines are provided when designing a guideway.

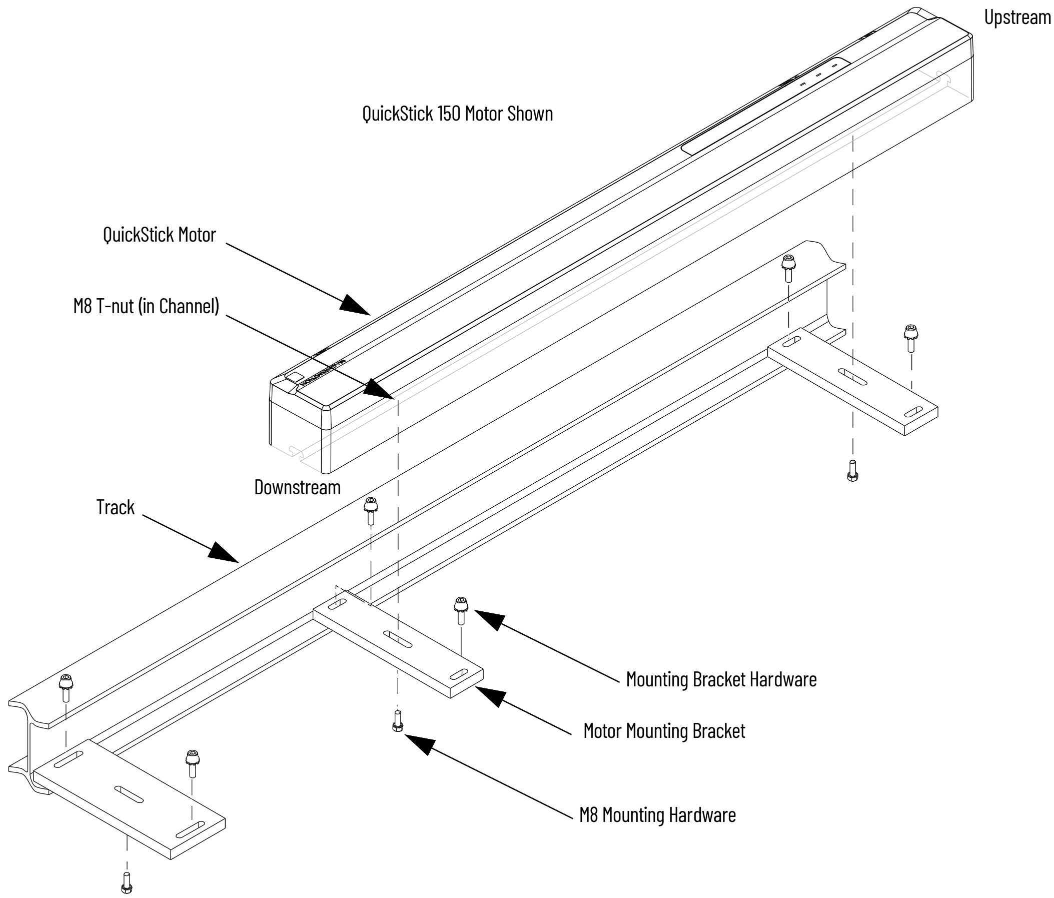
- When attaching directly to the track or mounting plate as shown in Figure 26, make sure that clearance holes for all motor connections are provided. This mounting method does not provide for any adjustment of the motor position once the motor is installed unless adjustment features are provided in the mounting plate.

Figure 26 - Motor Mounting to Flat Surface



- When attaching mounting brackets to the motors and securing the brackets to the track as shown in Figure 27, make sure that the brackets are located to allow access to all motor connections. This mounting method provides easy adjustment of the motor position once the motor is installed.

Figure 27 - Motor Mounting Using Brackets



When using either of the mounting methods shown, consider these requirements:

- Design your mounting interface to allow flexibility to adjust the motor position on the mounting brackets. The motor mounts should allow the motors a small amount of movement relative to each other.

  The upstream end of the motor is the end where the power connector is located.

- Make sure that there is consistent spacing between the motors.
- Make sure that the top surfaces of all motors are coplanar to each other.
- Treating each motor to motor interface as a separate operation, tighten the motor mounts.

See the QuickStick Motors Technical Data, publication MMI-TD051, for additional information on motor dimensions and mounting clearances.

Guideway System Selection and Examples

There are various guidance systems that can be used to support a vehicle relative to the motors. These include many permutations of wheels on rails, a flat platform on rollers, a surface sliding on another surface, maglev, air tables, or many other options. The selection of a guidance system affects the friction present in a system. For example, a guidance system utilizing wheels and rails has a lower coefficient of friction than a surface sliding on another surface. This leaves more thrust available for precise vehicle control as noted in the previous section. The guidance system also affects the consistency of the friction applied.

Figure 28 provides an example of a guideway and vehicle where the guideway is constructed of extruded aluminum with linear bearing guide rails. The vehicle has linear bearing slides that ride on the rails, and holds the vehicle and QS magnet array in the correct relationship to the QS motors.

ATTENTION: Vehicles are not held in place if power is removed.

Figure 28 - Guideway Example #1

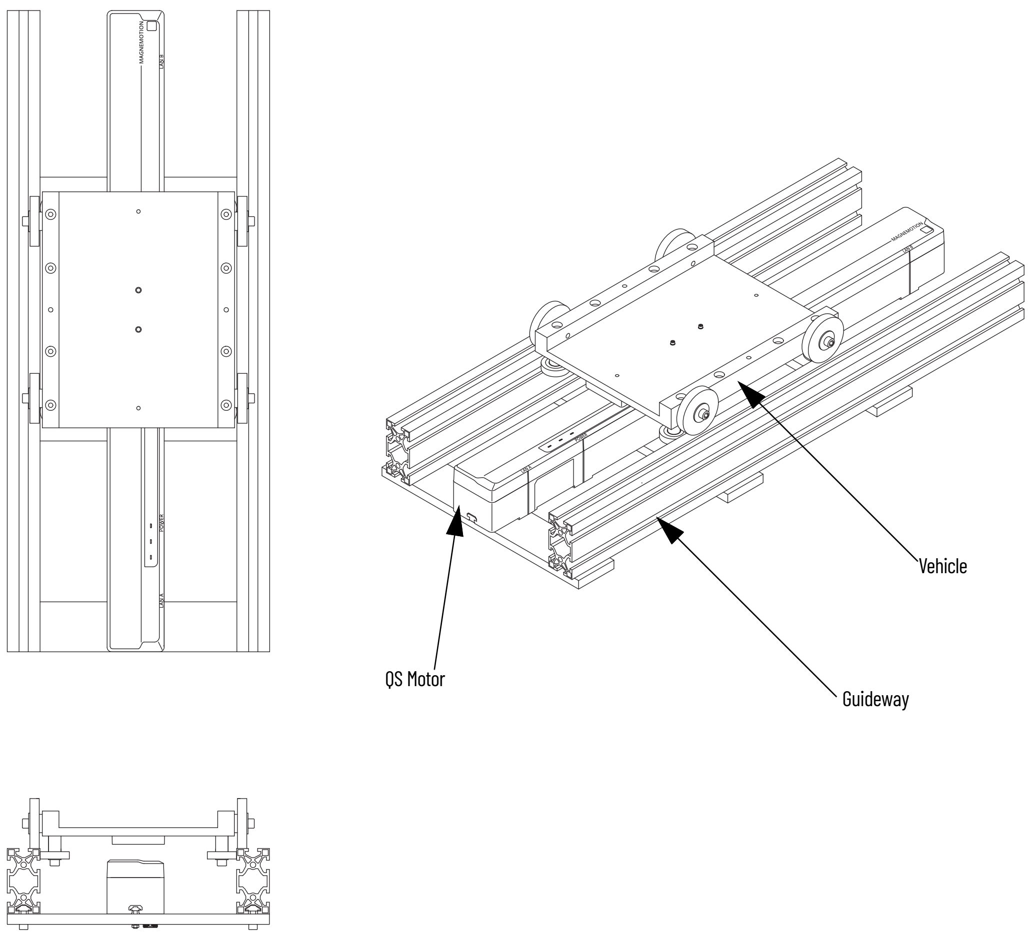


Figure 29 provides an example of a guideway and vehicle where the guideway is constructed of stiff steel sides and a sheet metal base. The vehicle has flanged wheels that ride on the top of the side plates, which holds the vehicle and magnet array in the correct relationship to the motors.

ATTENTION: Vehicles are not held in place if power is removed.

Figure 29 - Guideway Example #2

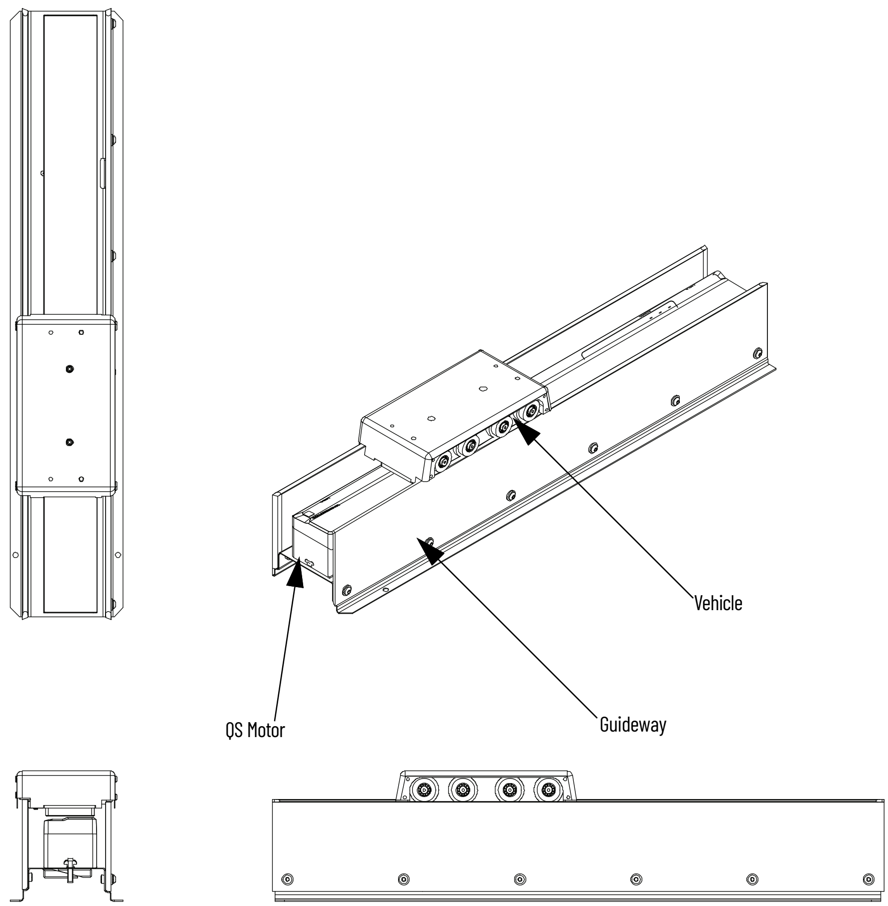
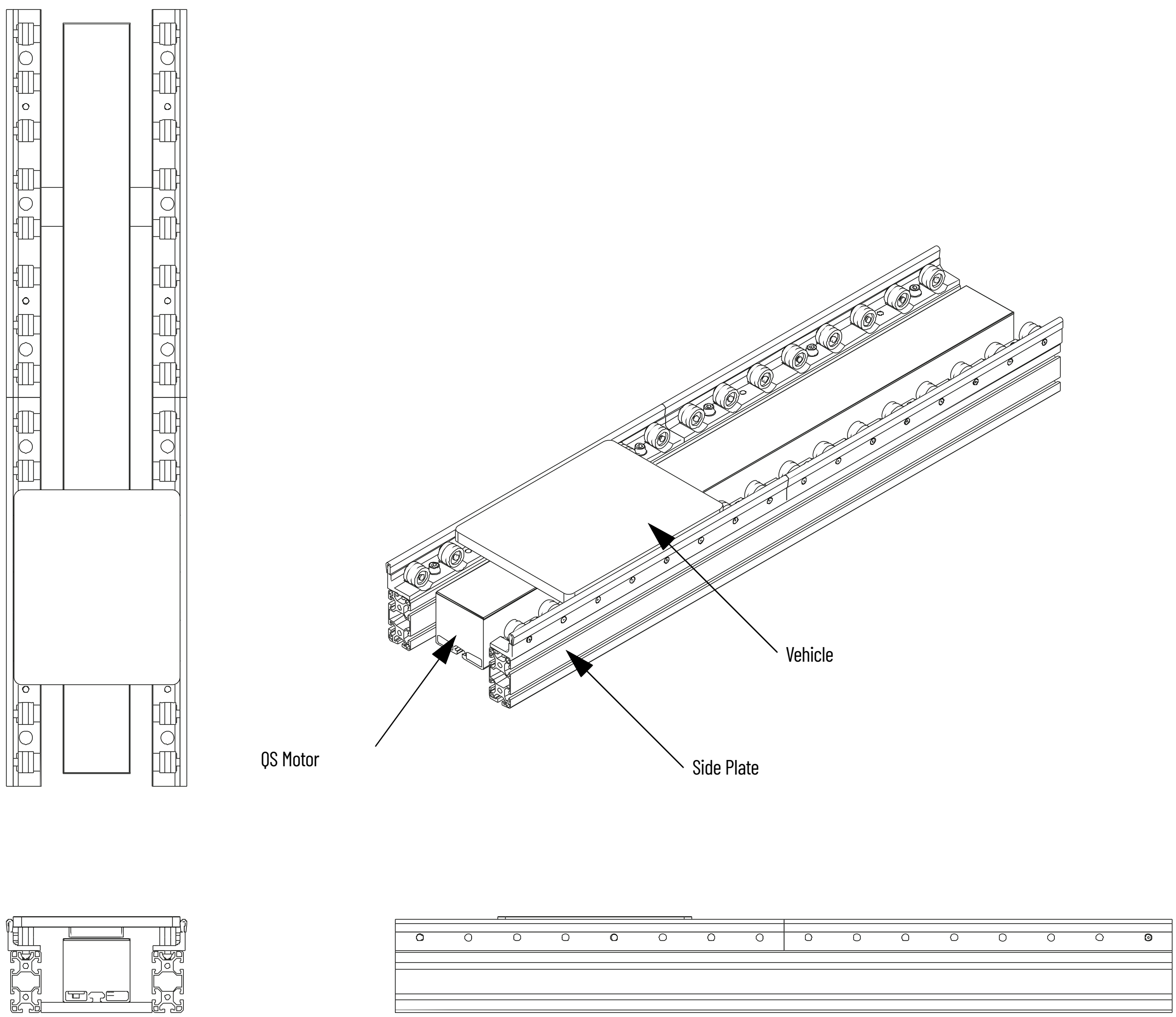


Figure 30 provides an example of a guideway and vehicle where the guideway is constructed of extruded aluminum with rollers that are mounted along the top of the guideway. The vehicle sits on the rollers and between the side plates, which hold the vehicle and QS magnet array in the correct relationship to the QS motors. This type of system continuously experiences a more consistent friction. In the system using rollers, the vehicle intermittently impacts stopped rollers and is moving on different numbers of rollers at different times, resulting in changing friction and degrading repeatability.

ATTENTION: Vehicles are not held in place if power is removed.

Figure 30 - Guideway Example #3



The guidance system can also create settling points, which are areas where a vehicle prefers to stop. For example, settling points can be a gap between rails, a joint in a surface, or an area with higher than average friction. If one of these areas is near a station, a vehicle might tend to settle into it, degrading repeatability.

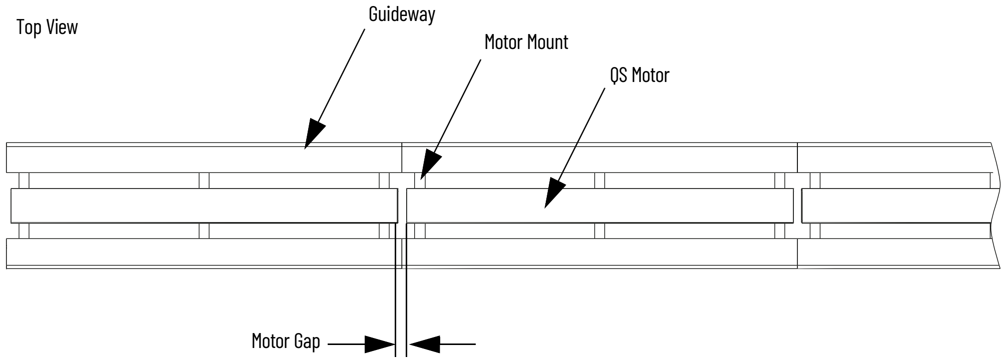
Transport System Configuration

All examples that are provided are for horizontal track layouts unless otherwise specified. The guideway is shown in cross-section in Figure 25 on page 52.

Straight Track Configuration

Figure 31 illustrates the location of the primary components that are used in a straight track configuration.

Figure 31 - Straight Track Configuration



Review these design considerations for a straight track configuration:

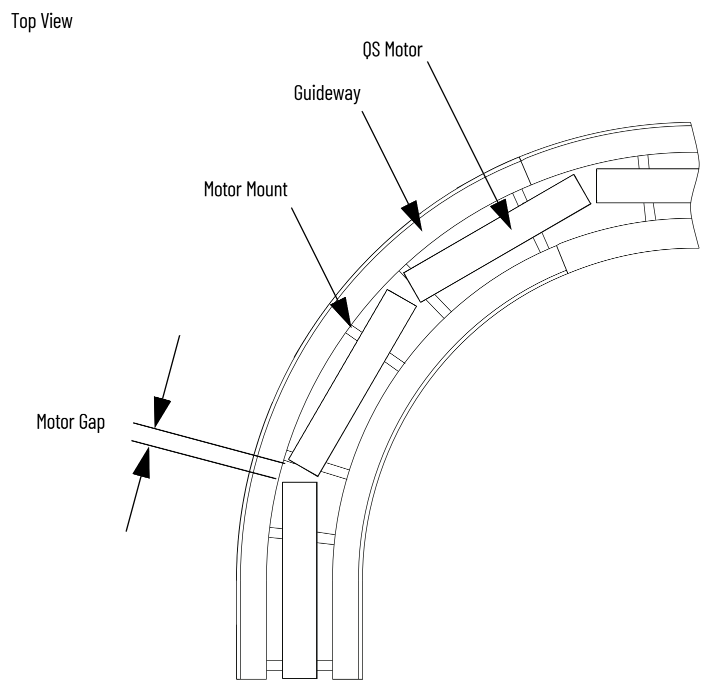
- Node types at the beginning of a path: Simple, Relay, Terminus, Gateway.
- Node types at the end of a path: Relay, Terminus, Gateway.
- Keep the motor gaps consistent over the length of the path and over the entire system if possible to make creation of the node controller configuration file simpler.

Different size gaps between motors must be identified in the node controller configuration file, see the MagneMotion System Configurator User Manual, publication MMI-UM046.

Curve Track Configuration

Figure 32 illustrates the location of the primary components that are used in a curve track configuration.

Figure 32 - Curve Track Configuration



Review these design considerations for a curve track configuration:

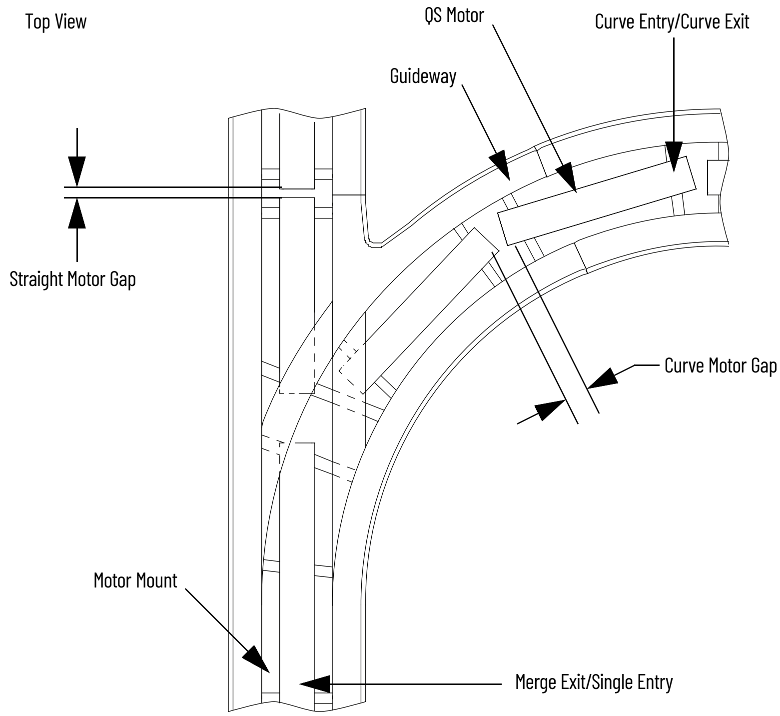
- Node types at the beginning of a path: Simple, Relay, Terminus, Gateway.
- Node types at the end of a path: Relay, Terminus, Gateway.
- Minimum radius is determined by motor length, and magnet array/vehicle length.
- May require a vehicle with dual magnet arrays (see Figure 20 on page 47).
- Motors may need to be configured as being On Curve in the node controller configuration file. See QuickStick 100 and QuickStick 150 Motors on a Curve on page 40 for more information.
- Keep the motor gaps consistent over the length of the curve in the guideway.

Different size gaps between motors must be identified in the node controller configuration file (see the MagneMotion System Configurator User Manual, publication MMI-UM046).

Switch Configuration

Figure 33 illustrates the location of the primary components that are used in a switch track configuration.

Figure 33 - Switch Configuration



Review these design considerations for a switch track configuration:

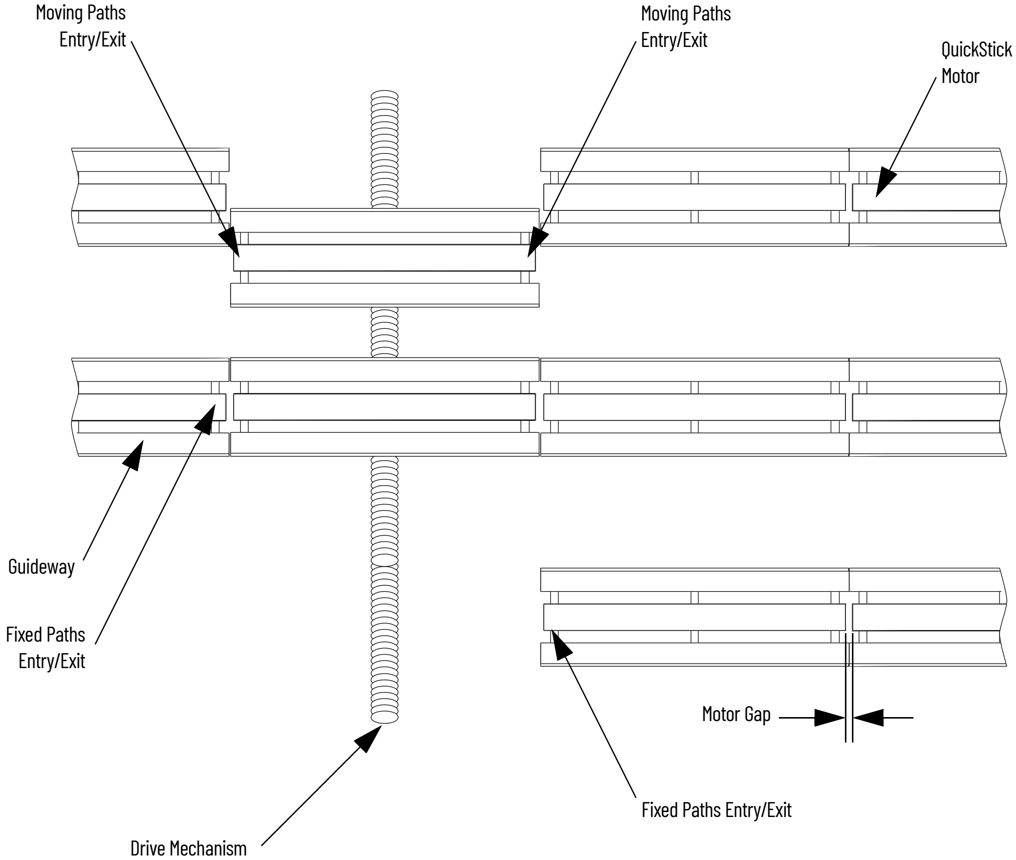
- Node types at switch: Moving path.
- Provides a merge of two paths into one (straight entry, curve entry, merged exit).
- Provides a diverge from one path into two (single entry, curve exit, straight exit).
- Requires a switching mechanism (electromagnetic or mechanical).
- Minimum radius is determined by motor length, and magnet array/vehicle length.
- May require a vehicle with dual magnet arrays (see Figure 20 on page 47).
- Motors in the curve section may need to be configured as being On Curve in the node controller configuration file.
- Motor gaps can vary from section to section of the guideway (entry, exit, curve), but keep the motor gaps consistent in each section of the guideway.

Different size gaps between motors must be identified in the node controller configuration file, see the MagneMotion System Configurator User Manual, publication MMI-UM046.

Moving Path Configuration

Figure 34 illustrates the location of the primary components that are used in a moving path configuration.

Figure 34 - Moving Path Configuration



Review these design considerations for a moving path track configuration:

- Node type: moving path.
- Provides multiple entries and exits (maximum of 12). The example that is shown in Figure 34 uses two moving path nodes, one for entry onto the moving paths and one for exit from the moving paths.
- Requires a Host-controlled drive mechanism to position the moving paths.
- QS motors can be used as the drive mechanism to provide movement of the moving paths.
- The moving path can consist of multiple motors.
- Motor gaps can vary from section to section of the guideway (entry, exit), but keep the motor gaps consistent in each section of the guideways.

Different size gaps between motors must be identified in the Node Controller Configuration File, see the MagneMotion System Configurator User Manual, publication MMI-UM046.

Electrostatic Discharge Protection on QuickStick Systems

This section presents both the Electrostatic Discharge (ESD) rating of the QuickStick® transport system and methods to help prevent discharge in the motors that exceed this rating.

ATTENTION: The guideway must be earth grounded and provide a path to ground for ESD discharge from the vehicle. Conductive wheels or static brushes must also be used to dissipate static charge. These elements are customer-installed and are not included with the motor.

As in any system with electrically isolated moving components, there is the possibility that the vehicle on a QuickStick (QS) system builds up a static charge while moving. Alternately, a charge can be placed on the vehicle while the system is interacting with other machinery. If not dissipated, the potential difference between the vehicle and ground can eventually build to the point where electricity will arc from the vehicle into the nearest grounded object. In many cases, the arc is to the grounded case of the QS motor.

If a motor receives an electrostatic discharge, there is a chance that the discharge can trigger abnormal operating conditions such as resetting one or more of the internal processors. Vehicles cannot continue forward when they reach the region of the track that the processor controls. The motor must be reset to reload the configuration into the processors to allow them to be used again.

Regular electrostatic discharges into the motor for a prolonged time can reduce the life of the motor and interrupt system operation.

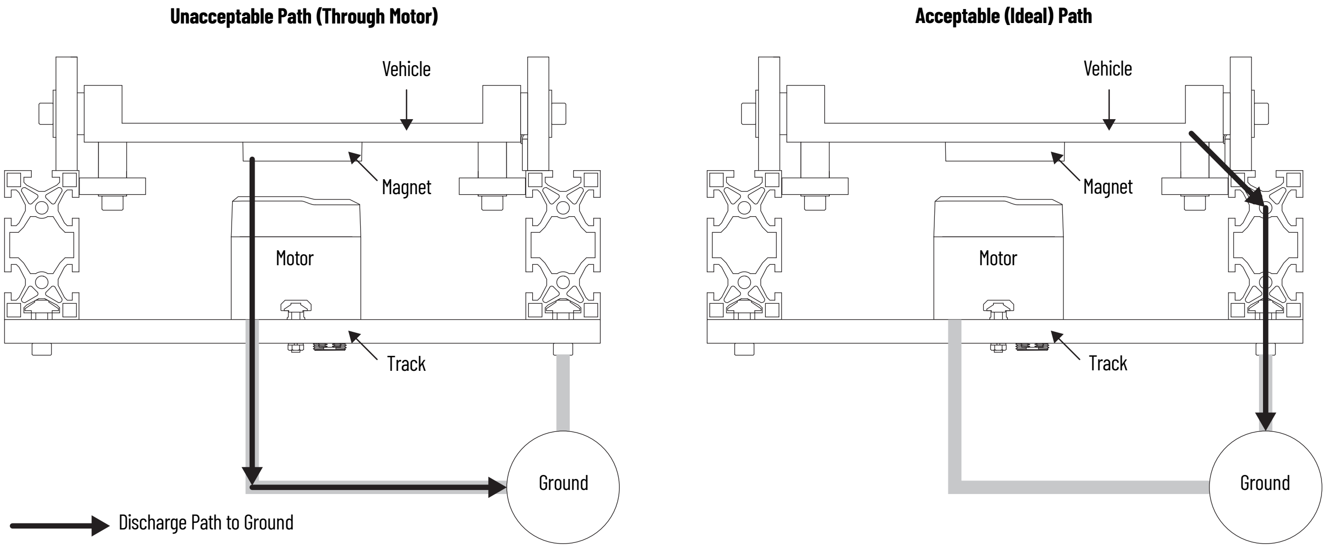
Component ESD Rating

The QS is CE-compliant and the pertinent ESD levels can be found in EN61000-6-2:2005 Immunity for industrial environments. The heavy industrial limits were used when testing. This testing verifies that the unit tested was not reset by an 8 kV non-contact discharge (arcing though the air) or by a 4 kV contact discharge.

Component Protection

Electricity takes the path of least resistance from the point where the charge has built up to ground. To protect a component from ESD, the component must not be the shortest route to ground. In Figure 35, the image on the left depicts a system where the path of least resistance is through the QS motor, which is unacceptable. The image on the right depicts the ideal situation where the vehicle is grounded by using a path that excludes the motor.

Figure 35 - Possible Discharge Paths from the Vehicle



Discharge the Vehicle

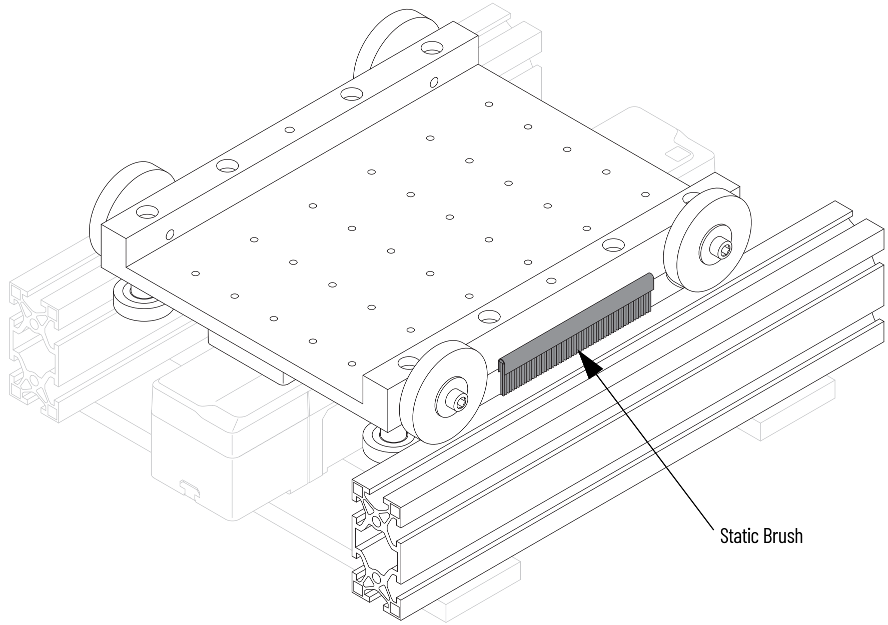
For an electrical discharge to cross the air gap between the vehicle and the motor, the potential difference between the vehicle and ground must be high enough to overcome the resistance of the air between the vehicle and the motor. To help prevent the vehicle from discharging into the motor, provide an alternate discharge path that triggers at a lower potential difference. Ideally, a vehicle would be constantly grounded, which would help prevent any charge from building as it would immediately go to ground.

IMPORTANT	Never provide a discharge path from a vehicle through or around the motor. Only discharge vehicles through the track.

Discharge Through Static Brushes - Preferred

Static brushes are the recommended method to help prevent electrostatic discharges into the motor. A static brush is a conductive material that is mounted to the vehicle, preferably in constant contact with the grounded track. The brush can either act as a permanent connection to ground or as a discharge point with a low resistance. This method keeps static from building appreciably and helps prevent any arcing to the motors or track. All parts of the vehicle that can retain a charge must be electrically connected to the brush to help prevent isolated components from building up a charge. Figure 36 displays an example of a vehicle and guiderail system using a static brush. Some coatings, such as anodic oxide film, on surfaces in contact with the static brush are insulating and can break the discharge path.

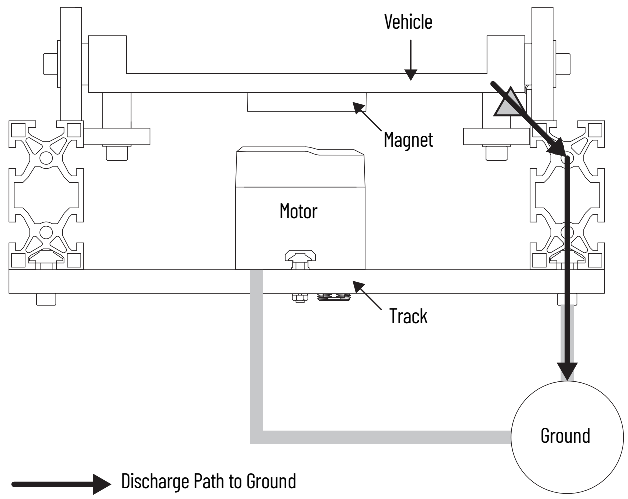
Figure 36 - An Example Use of a Static Brush



Discharge Through a Favorable Discharge Point - Acceptable Alternate

An alternative to using static brushes would be to establish a favorable discharge point where arcing is allowed to occur as shown in Figure 37. To provide a favorable discharge point, modify the vehicle such that there is a point on the vehicle closer to the track than to any motor with more favorable electrical conductivity on both the vehicle and track at that gap. Sharp points are preferred discharge points. The goal of this method is to create a point where the electricity will arc at a lower potential level than is required to arc to the motors. This method allows a much larger charge to build than using a static brush, but does not require the additional rubbing contact between the brush and track.

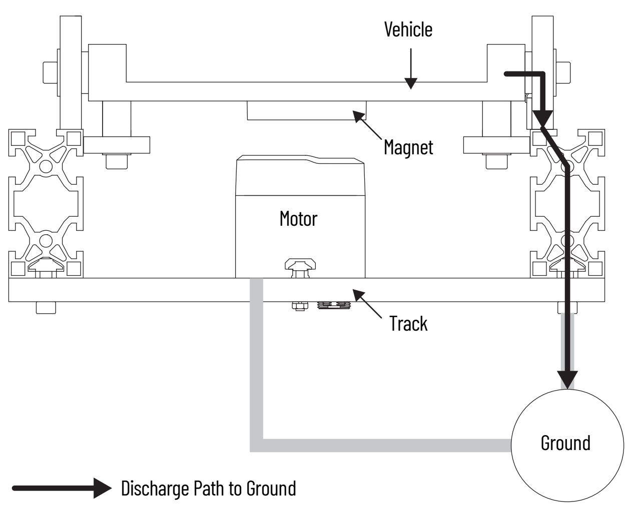
Figure 37 - Discharge Through a Favorable Point



Discharge Through Conductive Wheels and Bearings - Acceptable Alternate

The vehicle can also be grounded using the existing contact points between the wheels and track as shown in Figure 38. If conductive wheels and bearings are used, then the vehicle is grounded through the wheels and unable to build up charge. All components capable of holding a charge must be electrically tied to the wheels for this method to be effective. A bearing that is made of conductive materials does not conduct energy between its inner and outer race if there is no electrical path between them. Most bearings have packing grease, which can lead to an intermittent conductive path from the vehicle to the guideway. Ideally, the bearing that is selected has conductive lubrication.

Figure 38 - Discharge Through a Wheel



Summary

By providing the electrical energy a route to ground other than through the motor, sudden system stoppages due to a static discharge can be prevented. Any one of the methods that are described in this chapter should be sufficient to help prevent the discharge of static through the motor. Multiple methods can be used to create redundancy.

Notes:

QuickStick Motors Power Management and Cable Sizing

This chapter introduces how to select power supply cables and power cabling architecture for a QuickStick® system. It details how voltage conditions at the QuickStick (QS) motor are managed and communicated. This document provides a limited selection of background knowledge that is required for this analysis. Following the instructions in the document is not a replacement for the analysis of your system's power wiring by a qualified electrical engineer.

Information that is contained in this chapter pertains to the QuickStick 100 and QuickStick 150 motors only. For QuickStick HT™ power sizing, see Chapter 5 on page 93.

Introduction

When designing a power transmission system, it is important to consider that the voltage that is present at the supply may not be the same as the voltage that is present at the QS motor-end of the power wiring. A voltage drop or regeneration of power can cause the voltage at the QS motor to be higher or lower than what the supply provides.

Like any other electrical component, the QS motors have a defined operating voltage range.

- The QS 100 platform is designed to operate at a nominal 48V DC ±10% tolerance. It has a maximum coil current draw of 5 A.
- The QS 150 platform is designed to operate at a nominal 48…72V DC ±10% tolerance. It has a maximum coil current draw of 7.5 A.

Rockwell Automation recommends allowing for a minimum tolerance of 0.5V from these values when you design power supply wiring. However, voltage drops in the power distribution system when delivering power to one or more stators, and voltage increases during regeneration events lead to fluctuations in the voltages seen at the QS stator terminals. Operating below or above this range can result in the motor turning off or being damaged. While the motor has protections in place to help prevent this damage, design the power supply system so that the voltage limits are not exceeded during normal operating conditions.

Determine Vehicle Power Draw

During the quoting process for a QS system, a sizing estimate sheet is provided. The sizing sheet generates a movement profile and a corresponding peak propulsion power draw per vehicle.

Figure 39 - Power Estimate from a Sample Sizing Sheet

Thrust and Acceleration Estimate

Total Mass to be Moved: 34.900 kg

	Minimum Engagement	Maximum Engagement
Magnet Array Engagement	1856.0 mm	1896.0 mm
Hold Down Force	2274.8 N	2323.8 N
Total Weight and Hold Down Force	2617.2 N	2666.2 N
Force Required to Overcome Friction	52.3 N	53.3 N
Thrust Produced by Motor	616.9 N	630.2 N
Thrust Available for Acceleration	564.5 N	576.8 N
Acceleration Limit	9.80 m/s/s	9.80 m/s/s

Movement Estimate

Maximum Acceleration:	9.80 m/s/s
Peak Velocity:	2.50 m/s
Ramp Time:	0.26 sec
Ramp Distance:	0.32 m
Cruise Time:	0.14 sec
Cruise Distance:	0.36 m

Power Estimate

Peak Power Required per Vehicle:	1372 W
System Constant Logic Power:	385 W
System Peak Propulsion Power:	26065 W

Logic Power

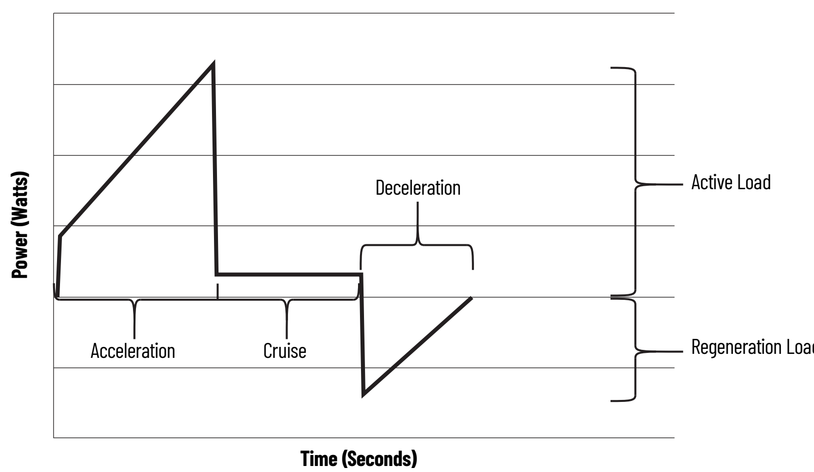
Logic power is used to operate the control circuits of a motor and draws a constant 10 W. Logic power can be provided separately or through the propulsion power connector pins. If logic power is provided separately, the power source must remain above 45V. If logic power is provided through the propulsion power feed, add 10 W to the peak vehicle power draw when calculating power per motor.

Logic power is considered as a separate power source in the examples in this section.

Propulsion Power

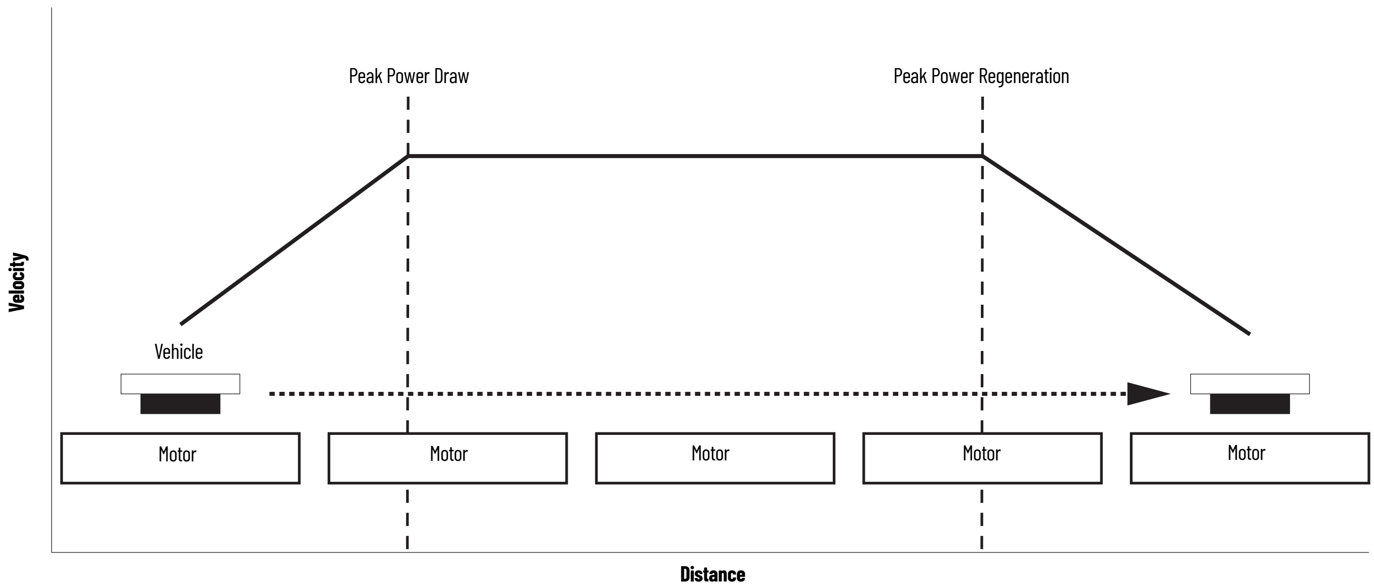
Propulsion power refers to the power used to accelerate and decelerate a vehicle. This is the main function that consumes power and varies based on the activity of the motor.

Figure 40 - Example of Power Consumption for a Single Movement from the Sizing Sheet



The vehicle motion consumes power when it accelerates and regenerates power when it decelerates. The locations in the system where peak power and regeneration are reached depends on the move profile being used.

Figure 41 - Location of Power Peaks During Motion



Calculate Propulsion Power Draw

Power is drawn from the power supply through the QS motors to convert electrical energy into mechanical energy to accelerate the vehicle along the track. The vehicle power draw is found using the power to accelerate the vehicle plus the heat loss in the motor stator times the power supply safety factor.

Vehicle Propulsion Power =

*(Heat Loss in Motor Stator + Power to Accelerate the Vehicle) * [(Power Supply Safety Factor / 100) +1]*

Heat Loss in Motor Stator =

$(0.75 * I^2 * R * \text{Maximum Occupied Block Equation})$

Where R = 1.9 ohms

Maximum Occupied Block Equation =

Round Up [Minimum Magnet Engagement Length (mm) / Magnet Motor Block (mm)] + 1

Power to Accelerate the Vehicle = $F * V$

Where $F = ma + \mu (mg + F_a)$

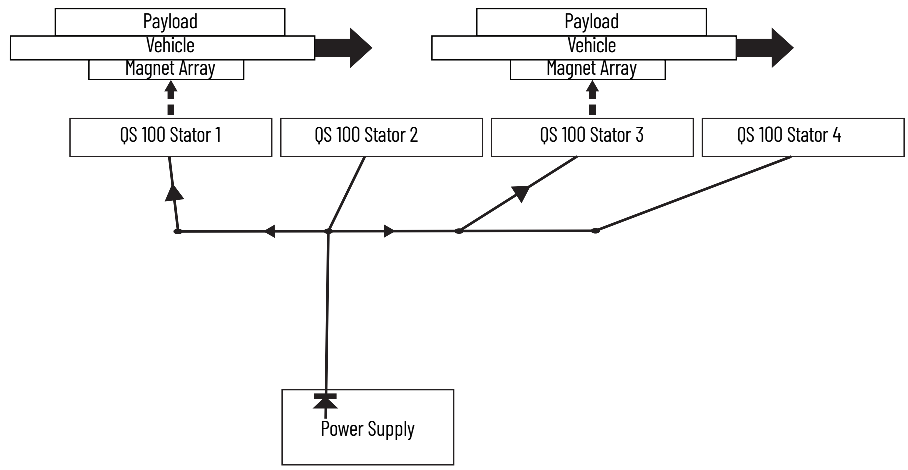
To calculate the power to accelerate the vehicle, it is required to multiply the force applied times the velocity. To calculate the force that is exerted on the vehicle, it is necessary to consider the mass of the vehicle, the friction of the track, and the angle of inclination of the motor (if any).

Transfer of Propulsion Power within a System

The power system that drives the QS motors is designed to provide power to individual motors while the vehicle is accelerating and to transfer power between motors when the vehicle is decelerating.

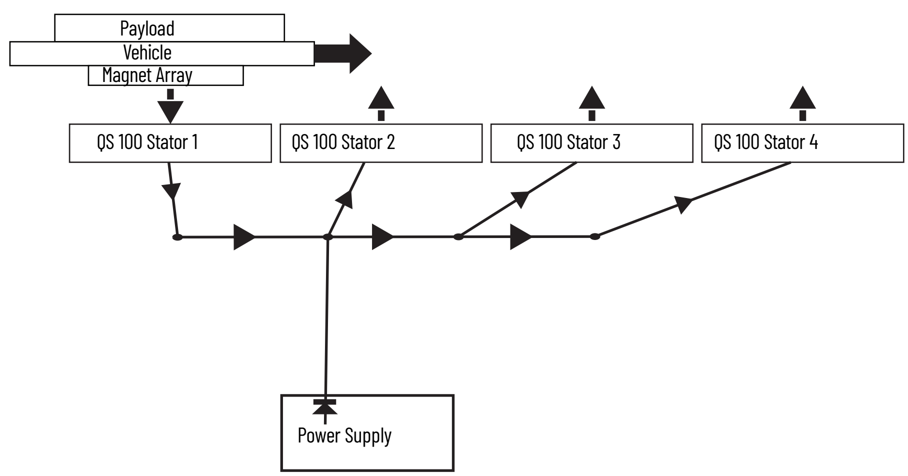
While accelerating, power is drawn from the power supply and into the motors that are accelerating the vehicles. This power is converted into mechanical energy to move the vehicle.

Figure 42 - Power Transfer, Acceleration Case



While decelerating, the mechanical energy of the vehicle is converted into electrical power. This power is then passed to the other motors in the system to be dissipated or used. In these examples, the power supply cannot dissipate power.

Figure 43 - Power Transfer, Deceleration Case



Acceleration (Power Draw)

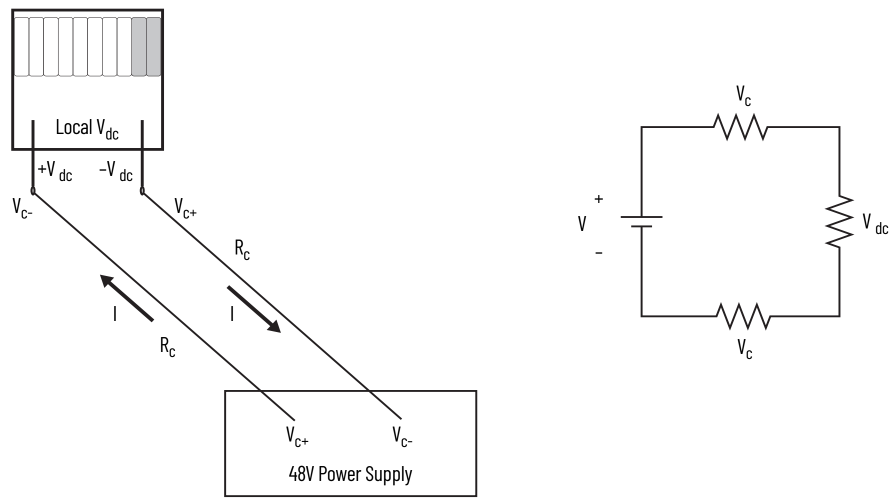
While the vehicle accelerates, the motor draws power from the power supply system. In the worst case, a motor can draw up to the value for peak power per vehicle that is shown in Figure 39 on page 70 while the vehicle is finishing its acceleration.

The current to each motor in a system at a given time depends on system behavior and vehicle size. When sizing cables, always use the worst-case power draw, current, and vehicle movements.

Example - Single Motor

The first case that we consider is a motor that is connected directly to the power supply.

Figure 44 - Example of a Power System for Single Motor



In Figure 44:

- Local V_{dc} is the voltage at QS
- V_{ps} is the voltage output by the Power Supply
- I is the current in the cable
- R_c is the resistance of the cable (one way)

Half of the total cable resistance is on one conductor and the other half of the total resistance is on the return conductor. By Kirchhoff's Voltage Law, all voltages in the loop must sum to zero. V_C refers to the voltage drop within a cable.

$$V_{ps} - V_C - Local\ V_{dc} - V_c = 0$$

$$V_{ps} - Local\ V_{dc} = 2V_c$$

By Ohm's Law, the voltage across a component is equal to the resistance of that component multiplied by the current through that component.

$$V_{ps} - Local\ V_{dc} = 2IR_c$$

The term V_{ps} - Local V_{dc} is referred to as voltage drop, this is the deviation from the nominal power supply voltage that is experienced at the load end of the power system. Based on Kirchhoff's Current Law, the currents through each element of the system are the same. Use the Power Law, and divide the peak power draw from the motor by the local voltage at the motor to determine what this current is.

The QS 100 and QS 150 motors each operate at different nominal voltages. For these examples, use the peak power draw identified in Figure 39 on page 70 of 1372 W, which is specific to the QS 100 motor. Rockwell Automation recommends sizing cables so that the voltage drop is not within 0.5V of the low voltage limit, a Local V_{dc} of 43V is used for this example.

$$I = (P / V) = (1372\ W / 43V) = 31.9\ A$$

$$48V - Local\ V_{dc} = 2IR_C$$

$$48V - 43V = (2 * 31.9\ A)\ R_C$$

$$RC = [(48V - 43V) / (2 * 31.9\ A)] = 0.078\ \Omega$$

So in this case, a cable resistance of less than 0.078 Ω would be required. If the minimum allowable local voltage of 42.5V is used, the calculations are as follows.

As shown, the cable resistance must be selected based on the desired voltage at the QS motor. This calculated cable resistance can then be used to select the appropriate size cable for the system.

$$I = (P / V) = (1372\ W / 42.5V) = 32.28\ A$$

$$48V - Local\ V_{dc} = 2IR_C$$

$$48V - 42.5V = (2 * 32.28\ A)\ R_C$$

$$R_C = [(48V - 42.5V) / (2 * 32.28\ A)] = 0.085\ \Omega$$

Example - QS 100 Series Bus

The preferred architecture for a QS power bus is several junction boxes (shaded boxes in Figure 45) connected in series to form one, low resistance, power bus. Each junction box supplies power to multiple motors. Both logic and propulsion power connections are also shown, but only propulsion power is used for the calculations.

Figure 45 - Example Power System for QS 100 Series Bus Architecture

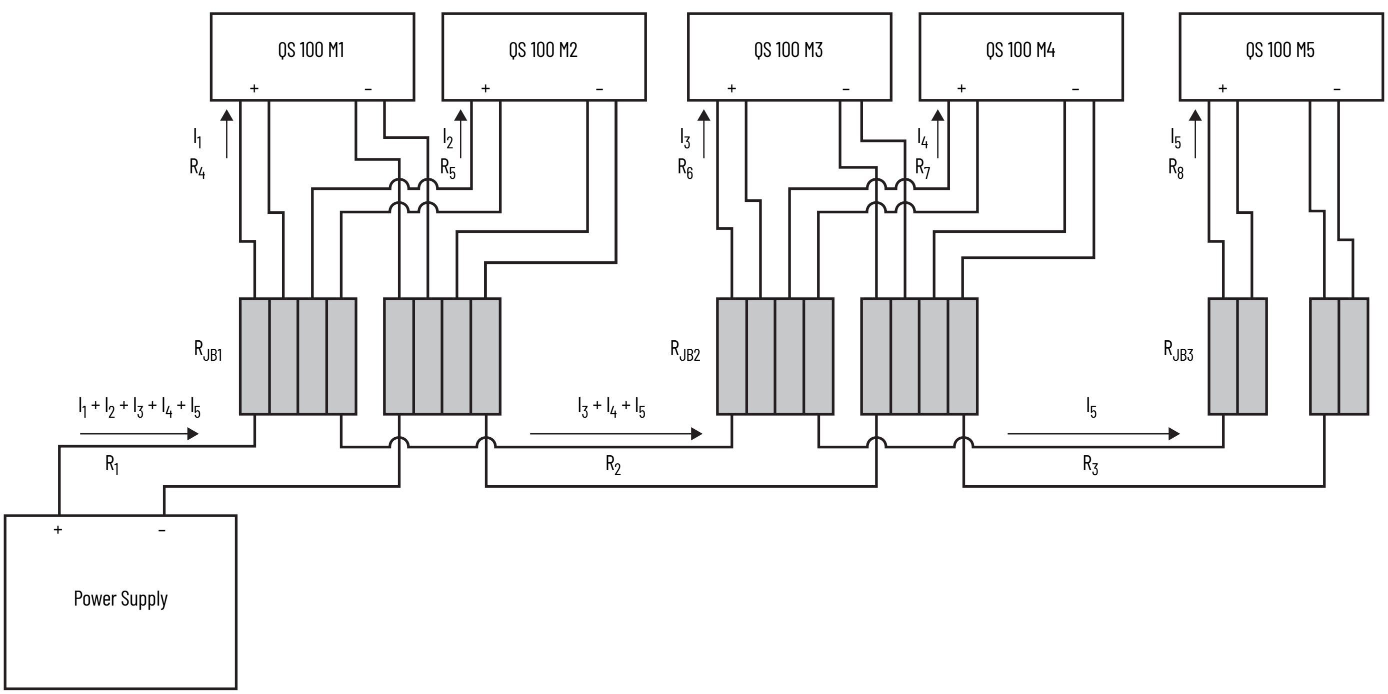
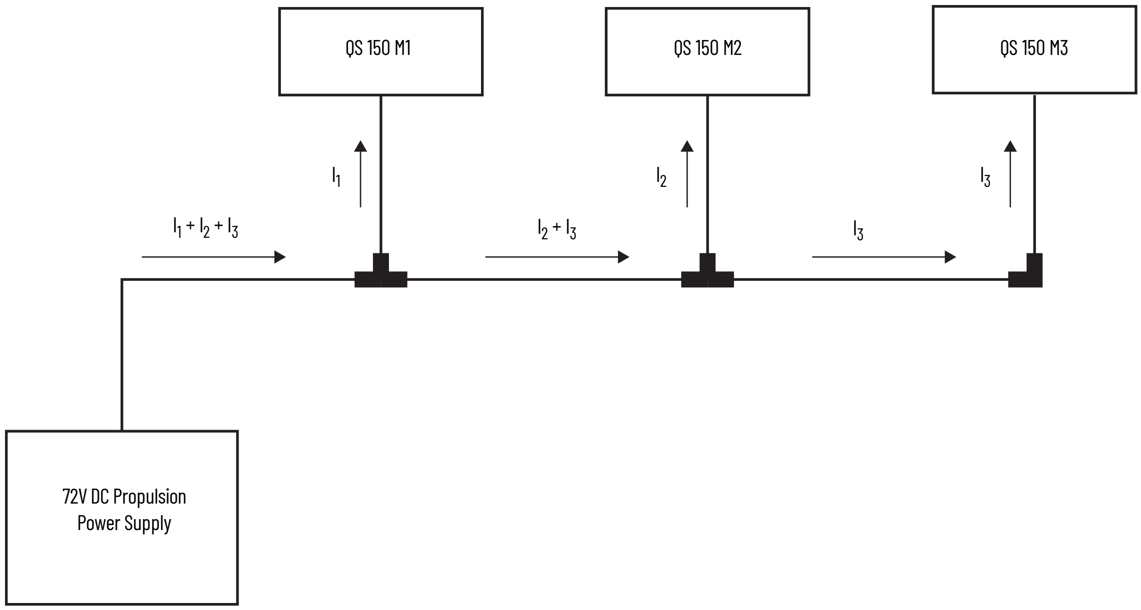


Figure 46 - Example Power System for QS 150 Series Bus Architecture



Kirchhoff's Current Law must be applied to determine which current must be used when evaluating the voltage drop across a particular component. In this case, the application of Kirchhoff's Current Law shows that the current in the single main bus line decreases the further from the bus the motor is located. The current to each motor depends on system behavior and vehicle size. Always use the worst-case power draw and current when sizing cables.

The equation for modeling the cable resistance and voltage at motor 1 (V1) would be as follows:

$$V_{ps} - V_1 = [2\,(I_1 + I_2 + I_3 + I_4 + I_5)\,(R_1 + R_{JB1})] + (2I_1R_4)$$

The equation for modeling the cable resistance and voltage at motor 5 (V5) would be as follows:

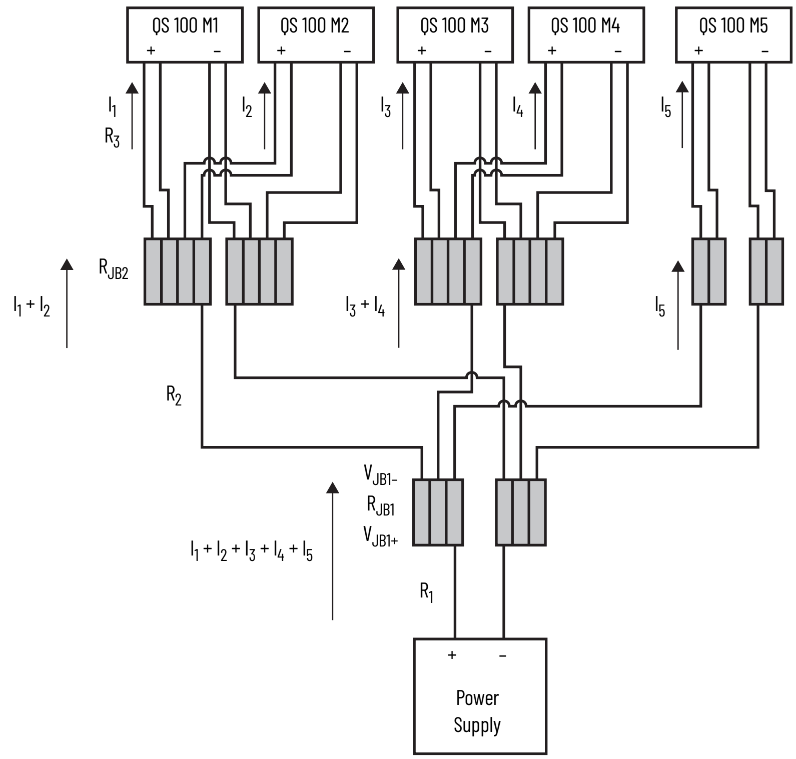
$$V_{ps} - V_5 = [2\,(I_1 + I_2 + I_3 + I_4 + I_5)\,(R_1 + R_{JB1})] + [2\,(I_3 + I_4 + I_5)\,(R_2 + R_{JB2})] + [2(I_5)\,(R_3 + R_{JB3} + R_8)]$$

Example - QS 100 Central Bus

One type of power architecture that has been used for certain systems is the central bus architecture. Several QS motors are attached to a local junction box that supplies propulsion power (junction box terminals that are shown in green in Figure 47 on page 76). Each junction box is then routed back to a central power cabinet, where they are connected to a central bus line connected to the power supply.

QS 150 does not typically use a central bus system.

Figure 47 - Example Power System for QS 100 Central Bus Architecture



Here, Kirchhoff's Current Law shows that the currents become smaller as the single bus splits into multiple cables. In this example, the equation by Ohm's Law for voltage across the first junction box (JB1) would be:

$$V_{JB1} = (I_1 + I_2 + I_3 + I_4 + I_5)\, R_{JB1}$$

The equation for modeling the cable resistance and voltage at motor 1 (V1) would be as follows:

$$48V - V_1 = [2\,(I_1 + I_2 + I_3 + I_4 + I_5)\,(R_1 + R_{JB1})] + [2\,(I_1 + I_2)\,(R_2 + R_{JB2})] + (2I_1R_3)$$

Undersized cables can lead to various problems, such as undervoltage/overvoltage faults, and warnings.

- The QS 100 operates at a nominal voltage of +48V DC.
- The QS 150 can operate in different nominal voltages including +48V DC and +72V DC.

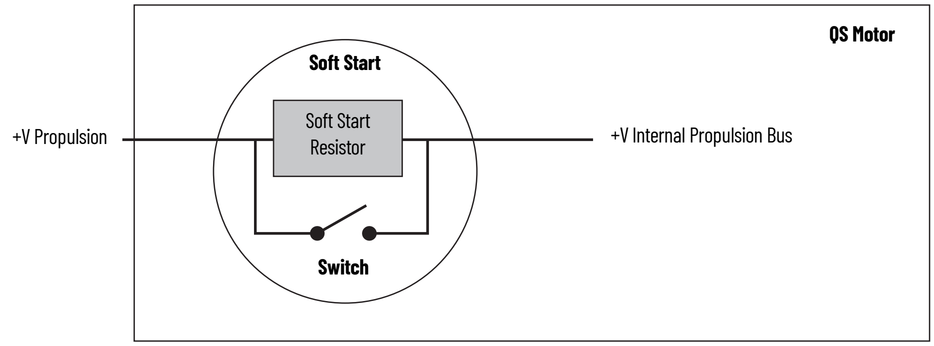
Table 10 - Undervoltage Faults and Limits by System

Undervoltage Fault/Warning Limits by System	QS 100	QS 150
Soft Start not complete Fault Limit (SS_{FL})	41V	41V
Soft Start not complete Fault Clear (SS_{FC})	43V	43V
Undervoltage Fault Limit (V_{FL})	41V	41V
Undervoltage Fault Clear (V_{FC})	43V	43V
Undervoltage Warning Limit (V_{WL})	42.5V	42.5V
Undervoltage Warning Clear (V_{WC})	43V	43V

Soft Start not Complete Fault

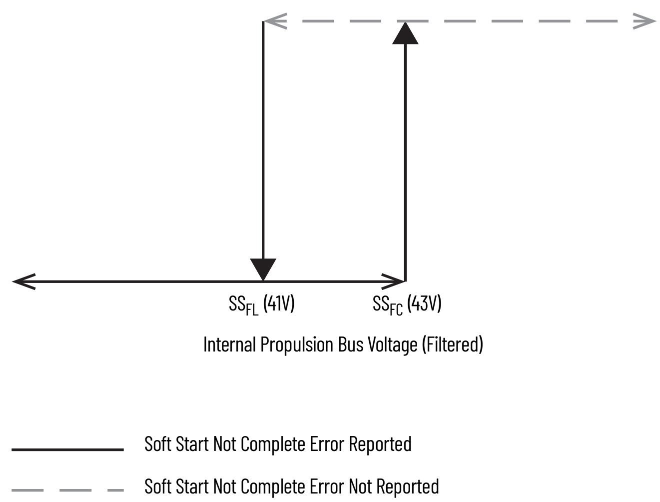
The QS inverters are enabled when the filtered internal propulsion bus (after the soft start circuitry, see Figure 48) rises above the SS_{FC} (43V). Until this voltage is reached, the QS motor status through the HLC reports a soft start not complete and the system supports vehicle motion and operates as intended (soft start switch closed). If the internal bus voltage drops below SS_{FL} (41V) during operation, the soft start switch open disables and any vehicle in motion over the stator is no longer under active control and the motion becomes undefined.

Figure 48 - High-level Detail of Soft Start Circuit



Normal operation resumes (soft start switch closed) once the internal propulsion bus voltage returns to SS_{FC} (43V) or greater. When normal operation resumes, the motor status for the soft start error message automatically self-clears. This messaging behavior is illustrated in Figure 49 on page 77. Not shown is the additional constraint that the voltage across the soft start resistor that is shown in Figure 48 must be < 2V to allow the switch to close to help prevent a soft start not complete error message to appear. A soft start fault can be due to an internal failure, but is more likely to be because of the voltage that is applied to the propulsion bus being too low.

Figure 49 - Soft Start not Complete Messaging Behavior



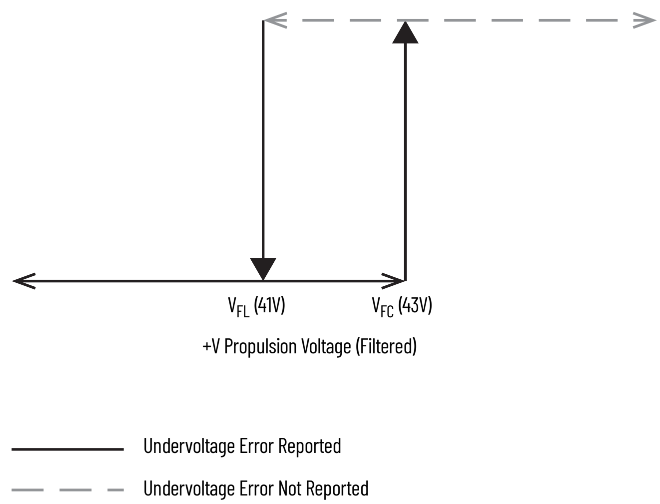
Undervoltage Fault

An undervoltage fault is declared and is reported to the host when the measured propulsion filtered voltage drops below V_{FL} (+41V). The QS motor status through the HLC reports this undervoltage fault. This fault self-clears when the filtered propulsion input voltages rise back to >V_{FC} (>43V). The behavior of this fault messaging is illustrated in Figure 50. For additional information, see:

- MagneMotion Host Controller TCP/IP Communication Protocol User Manual, publication MMI-UM003
- MagneMotion Host Controller EtherNet/IP Communication Protocol User Manual, publication MMI-UM004

This fault is usually a result of power not being connected or due to excessive propulsion/return cable resistance from the power source to the motor. A fault on one block, excluding block one, can indicate an internal failure.

Figure 50 - Undervoltage Messaging Behavior



Undervoltage Warning Limit

When the propulsion bus drops below V_{WL} (42.5V), the HLC logs an undervoltage warning when the log level for faults is set to the warning level. This warning is not pushed to the host. The fault self-clears when the voltage rises back up to V_{WC} (+43V). No voltage filtering is associated with this warning since the intent is to capture maximum voltage excursions. Upon initial system power-up, this fault is present and persist until the propulsion bus reaches V_{WC} (+43V). For additional information, see:

- MagneMotion Host Controller TCP/IP Communication Protocol User Manual, publication MMI-UM003
- MagneMotion Host Controller EtherNet/IP Communication Protocol User Manual, publication MMI-UM004

The intent of this feature is to verify proper cabling and power distribution for new systems and to do a periodic assessment of the system to make sure that no degradation has occurred. A properly designed system should never exhibit this alarm following system power-up.

Deceleration (Regeneration)

In addition to providing the power used to accelerate a vehicle, the wiring must also be designed to manage regenerated power from a vehicle as it stops. In general, if a system is designed to support the power supply during acceleration, it also supports the deceleration case.

- The QS 100 operates at a nominal voltage of 48V DC.
- The QS 150 can operate at different nominal voltages, including 48V DC and 72V DC.

IMPORTANT	If a power supply has a maximum rated output voltage of less than 83V DC is used, an appropriately sized diode must be used to help prevent regenerative power from reaching the power supply.

Power Regenerated by a Vehicle

When a vehicle slows to a stop, the mechanical energy of the vehicle is converted to electrical energy on the power bus. This energy must be dissipated to avoid having the bus voltage rise beyond the acceptable limit of the overvoltage maximum limit (OV_{ML}) of your system.

Power is provided to the stator coils to slow down the vehicle actively, so the net effective regeneration power is lower than the power required to accelerate the vehicle. The reduction is based on several factors, but a conservative first estimate is that the net effective regeneration power is about 75% of the acceleration power. For the example power draw used in Example - Single Motor on page 73:

Energy Regenerated = $(F * V) - (0.75 * I^2 * R * \text{Maximum Occupied Blocks})$

Where $F = ma - \mu(mg + F_a)$

Where F_a = attractive force

As the vehicle slows down under constant deceleration, the regeneration power drops linearly with speed. For additional details to calculate the generation Power Draw calculations, check the Calculate Propulsion Power Draw on page 71, where the *Power Dissipated = The Power To Accelerate The Vehicle - Heat Loss In The Stator*.

Overvoltage Maximum Limit

Based on the specific system wiring and vehicle activity, it is possible for the regenerated power that results from vehicle decelerations to cause the propulsion bus voltage to rise to excessive levels. The motor has implemented protective features to guard against operating conditions that could damage it. This condition is due to the regeneration effects associated with active braking or deceleration of a vehicle (loaded or unloaded) over the stator, to eliminate regenerated power, shut down the QS inverters. See Table 11 for overvoltage values.

Table 11 - Overvoltage Faults and Limits by System

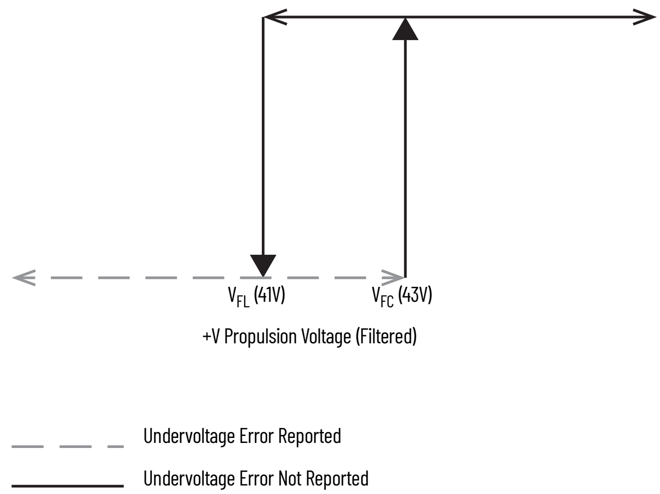
Overvoltage Fault/Warning Limits by System	QS 100	QS 150
Overvoltage Maximum Limit (OV_{ML})	58.0V	83.0V
Overvoltage Fault Limit (OV_{FL})	58.0V	83.0V
Overvoltage Fault Clear (OV_{FC})	57.0V	82.0V
Overvoltage Warning Limit (OV_{WL})	57.0V	82.0V
Overvoltage Warning Clear (OV_{WC})	56.5V	81.5V
Coil Dissipation Threshold (CD_T)	51.5V	80.0V

When the propulsion bus reaches the overvoltage threshold (OV_{ML}), the inverters are shut down to eliminate any regeneration effects within this stator, this assumes that the stator contributes to regeneration. Vehicle arrays over this stator are no longer under active control and therefore do not decelerate as intended. An overvoltage fault reports to the host when this condition is detected. To avoid issuing an overvoltage fault to the host due to spurious noise, the propulsion voltage that is used to trigger this event is filtered. For additional information, see:

- MagneMotion Host Controller TCP/IP Communication Protocol User Manual, publication MMI-UM003
- MagneMotion Host Controller EtherNet/IP Communication Protocol User Manual, publication MMI-UM004

This error message and the associated fault persist until the filtered voltage at the propulsion bus drops below the overvoltage fault clear (OV_{FC}). At this time, the system attempts to resume active control of the vehicle. This inverter status behavior is shown in Figure 51.

Figure 51 - Inverter Status and OV Fault Behavior for QS 100



Overvoltage Warning Limit

When the motor controller detects instantaneous voltages in excess of the overvoltage warning limit (OV_{WL}) on its propulsion bus, an overvoltage warning is issued to the HLC when the log level for faults is set to the warning level. This warning fault is not pushed to the host and self-clears once the propulsion bus voltage drops below the overvoltage warning clear (OV_{WC}) threshold. See the values in Table 11 on page 79 for additional information. For additional information, see:

- MagneMotion Host Controller TCP/IP Communication Protocol User Manual, publication MMI-UM003
- MagneMotion Host Controller EtherNet/IP Communication Protocol User Manual, publication MMI-UM004

The intent of this feature is to verify proper cabling and power distribution for new systems and to support periodic assessments of the system to make sure that no degradation has occurred. Any warnings observed as part of system commissioning must be addressed and resolved using one or several of the resolution methods that are described in overvoltage faults.

Power Dissipation within MagneMotion Systems

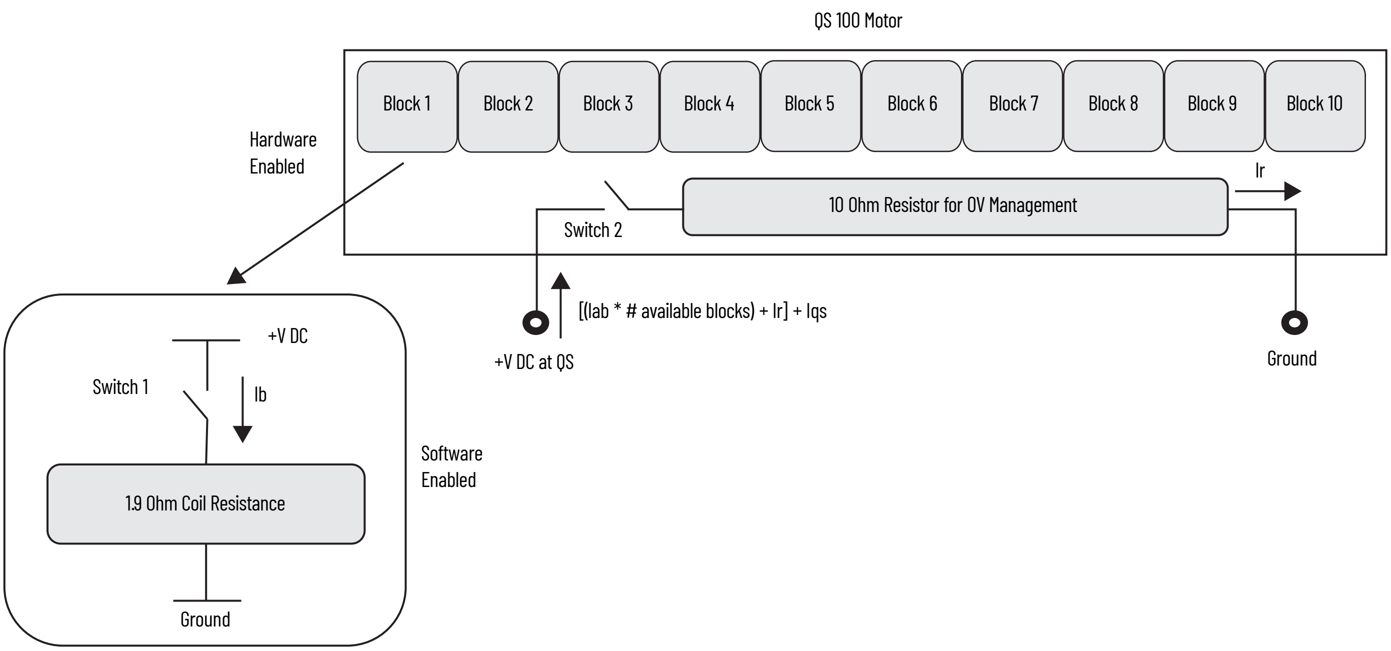
The QS motors work to dissipate the extra power that is generated as the vehicle slows and helps to prevent the bus voltage from rising. This is done using two different types of overvoltage protection features in the motor.

The overvoltage protection activates in two stages:

1. Software enabled to supplement any external power management schemes that are applied to a QS system, a means of internally consuming regenerated power within a QS stator is incorporated as a product feature. If a block is available to dissipate power, when VDC is greater than the coil dissipation threshold (CD_T), switch 1 closes.
2. Hardware enabled (QS 100 only): When VDC is greater than the OV max limit, switch 2 closes and begins dissipating power through the 10 Ω resistor. Switch 1 opens to protect the blocks and inverters and an overvoltage fault is declared. Inverter shutdown eliminates regeneration and also leads to uncontrolled vehicle motion. See the values in Table 11 on page 79 for overvoltage limits by system.

   Switch 2 should not close during normal operation. It is for the protection from an unusual event, and not something that should be used regularly during normal operation. Under normal use conditions, this resistor should never be activated or be relied upon to absorb regeneration power. This resistor is meant to handle anomalous high-voltage transients that might otherwise lead to catastrophic voltage-induced stator failure. Continuous use of the open/close operation on switch 2 can lead to damage on the motors and cause premature failure.

Figure 52 - QS 100 Overvoltage Protection Features



To supplement any external power management schemes that are applied to a QS system, a means of internally consuming regenerated power within a QS stator is incorporated as a product feature. It is crucial to keep in mind that the power consumed by the block varies according to the QS System.

- The QS 100 has a maximum coil current consumption of 5.0 A.
- The QS 150 has a maximum coil current consumption of 7.5 A.

Coil/Block Level Power Management (Software Enabled)

When the filtered internal propulsion bus reaches the overvoltage coil dissipation threshold (CD_T), current begins to ramp in coils/blocks that are available. This effectively allows the QS stator to absorb/dissipate the power from other QS stators that are connected on a commonly shared power supply that is created during regeneration. Table 12 on page 82 provides the maximum power that is dissipated per QS motor.

IMPORTANT Insufficient power dissipation capabilities on a power bus with QS 150 and QS 100 motors could cause the QS 100 motors to experience an overvoltage condition.

Table 12 - Coil Dissipation Parameters

Coil Dissipation Parameters by System	QS 100	QS 150
Coil Dissipation Threshold (CD_T)	51.5V	80.5V
Coil Maximum Dissipation Threshold (CD_T+2V)	53.5V	82.5V
Peak Current Consumption	5.0 A	5.0 A
Coil Resistance	1.9 Ω	1.9 Ω
Maximum Power Dissipated per Block	47.5 W	47.5 W
Maximum Power Dissipated per 0.3 m motor	—	142.5 W
Maximum Power Dissipated per 0.5 m motor	237.5 W	237.5 W
Maximum Power Dissipated per 1.0 m motor	475.0 W	475.0 W

The current in these available blocks ramps linearly to the maximum amperage over a 2V range starting from CD_T to CD_T+2V, and is maintained at the maximum. The coil current remains constant at max (5 A) for voltages above CD_T+2V and drops to zero for voltages above the OV_{ML} since all inverters are turned off as previously mentioned. See Figure 53 and Figure 54.

Figure 53 - Coil/Individual Block Current vs. 48V Internal Propulsion Bus Voltage (1 ms Filter Applied) in QS 100

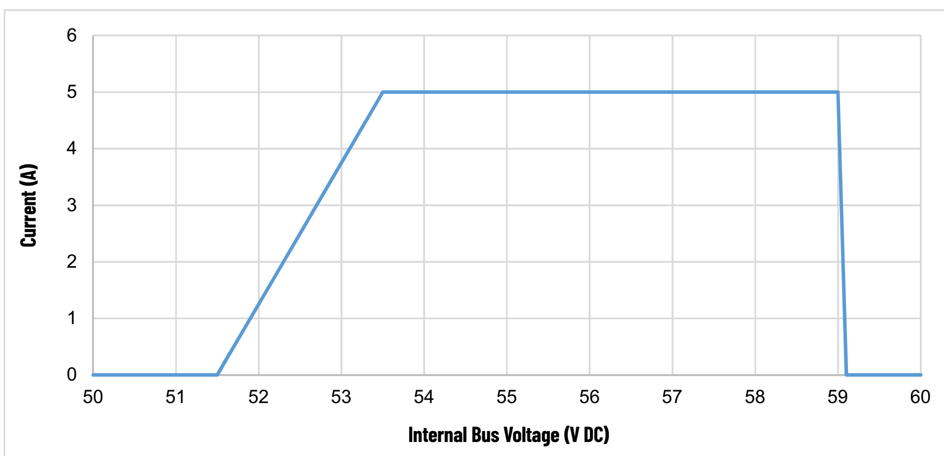
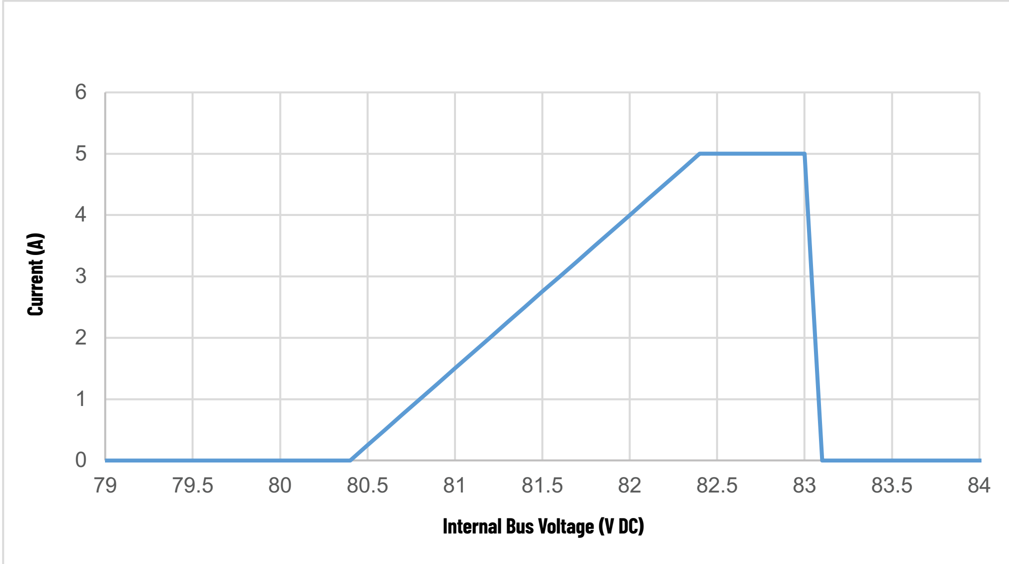


Figure 54 - Coil/Individual Block Current vs. 48V Internal Propulsion Bus Voltage (1 ms Filter Applied) in QS 150



For a nominal coil/block resistance of 1.9 Ω, the dissipated power is different depending on the system and its configuration.

- For QS 100, 47.5 W per block are dissipated when the 5 A current level is reached and remains at this level up to the OV_{ML} (59V). The dissipated power versus 48V DC internal propulsion bus voltage is shown in Figure 55.
- For QS 150, 47.5 W per block are dissipated when the 5 A current level is reached and remains at this level up to the OV_{ML} (83V). The dissipated power versus 48V DC internal propulsion bus voltage is shown in Figure 56.

For example, in the QS 100 when the +48V internal propulsion bus is between 51.5V and 53.5V, the power that is dissipated per block is:

*11.875 * (+48V internal propulsion bus - 51.5) 2 Watts*

The QS 1.0 m stator has ten blocks and the QS 0.5 m stator has five blocks. The QS 0.3 m stator, available for the QS 150 only, has three blocks. See Table 12 on page 82 for the maximum power dissipated per QS motor.

Figure 55 - Power Dissipation per Block vs. 48V Internal Propulsion Bus Voltage in QS 100

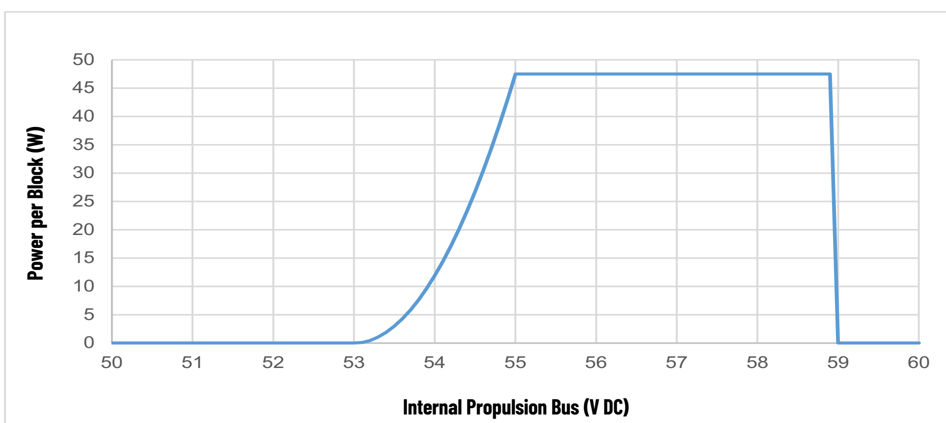
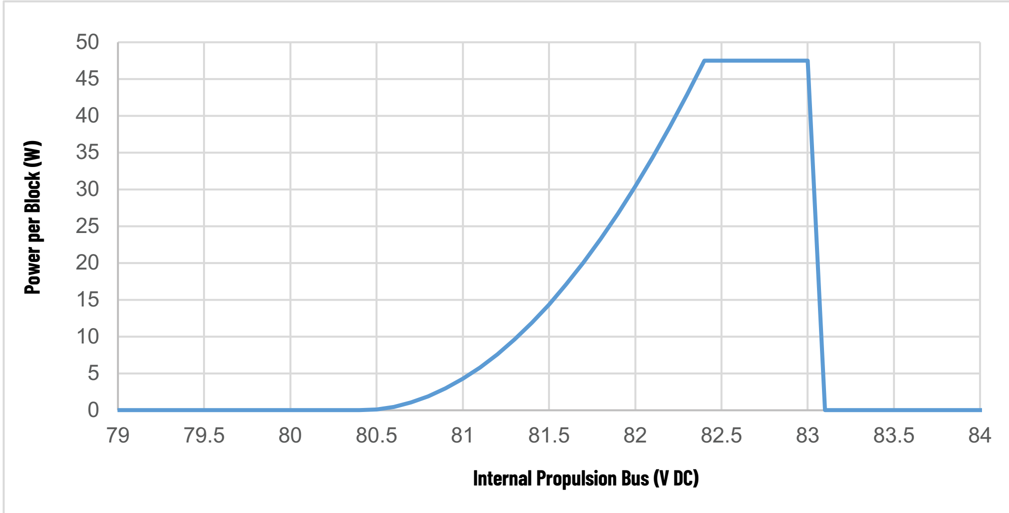


Figure 56 - Power Dissipation per Block vs. 48V Internal Propulsion Bus Voltage in QS 150

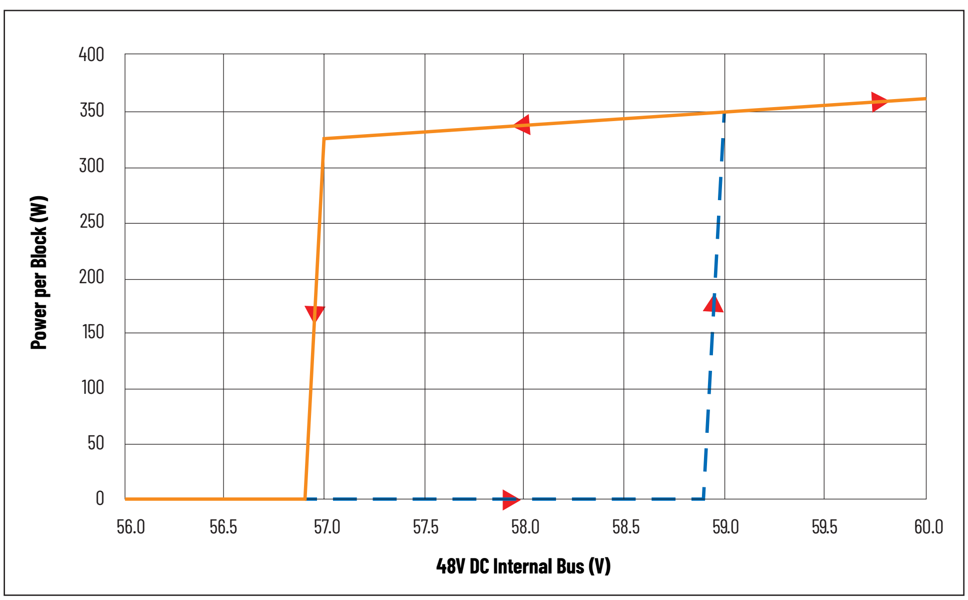


Hardware Power Management for QS 100

This section only applies to QS 100. The QS 150 excludes the 10 Ω internal voltage clamp resistor.

When the internal propulsion voltage rises above the OV_{ML} (59V), a 10 Ω internal voltage clamp resistor within the QS motor is switched across +V propulsion and -V return as shown in Figure 39 on page 70. This internal load remains active for voltages higher than this voltage and is removed when the voltage goes below OV_{FC} (57V). The power dissipated by this load, which is shown in Figure 57, is additive to any power dissipated by the coils/blocks.

Figure 57 - 10 Ohm Internal Voltage Clamp Resistor Power Dissipation vs. 48V Internal Propulsion Bus Voltage in QS 100



The power dissipation through this 10 Ω internal voltage clamp resistor can be expressed as:

(+V propulsion)^2 */ 10 Watts*

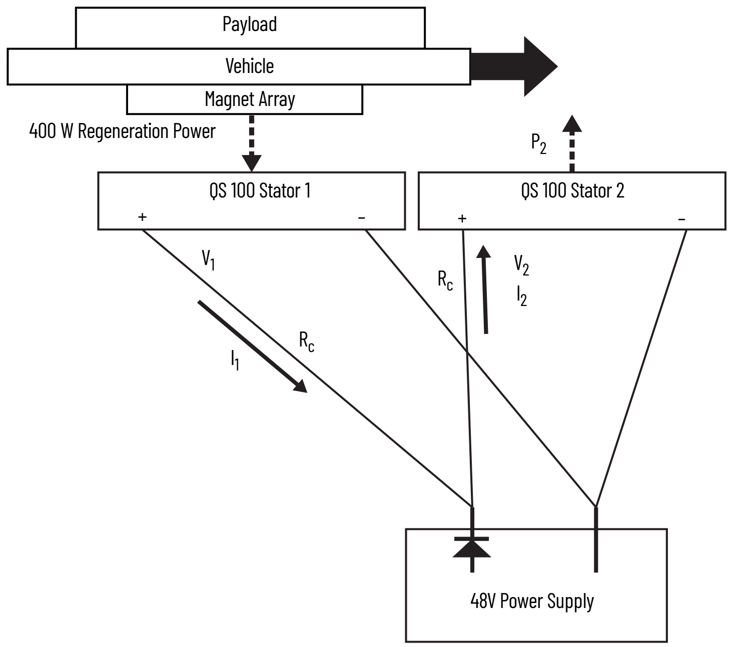
For example in the QS 100, at 59V this translates to 347 W and at 57V it would be 324 W.

Example - Two Motors

The example that is shown in Figure 58 uses QS 100 motors. The first example to be considered is one motor that is dissipating power and one motor input power. To simplify the analysis, the following assumptions were made for this example:

- All cable resistances are identical.
- The magnet array and its adjacent blocks occupy exactly (1) 1 m motor (10 motor blocks per motor).
- The vehicle is just beginning to decelerate at that location.
- The power supply has a diode and is not capable of absorbing power.

Figure 58 - Single Vehicle Decelerating with Two Motors



V_1 can be set to 57V, the maximum allowable voltage for the system during normal operation. Based on this, the Power Law can be used to find the current i_1.

$$i_1 = (P_1 / V_1) = (400\ W / 57V) = 7.02\ A$$

By Kirchhoff's Current Law, the sum of the currents entering and leaving the junction near the power supply must be zero.

$$i_1 - i_2 = 0$$

$$i_1 = i_2$$

Motor 2 has no magnet array over it, so all 10 blocks are available to dissipate power. Assuming that power loss in the cables is negligible, this means that the power that is dissipated per block is

$$(400\ W / 10\ blocks) = 40\ W/block$$

Using Figure 55 on page 83, this puts V_2 at 53.3V. Using Ohm's Law, the maximum allowable resistance in the cables can be found.

$$V_1 - V_2 = i1R_c + i2R_c = 2i1R_c$$

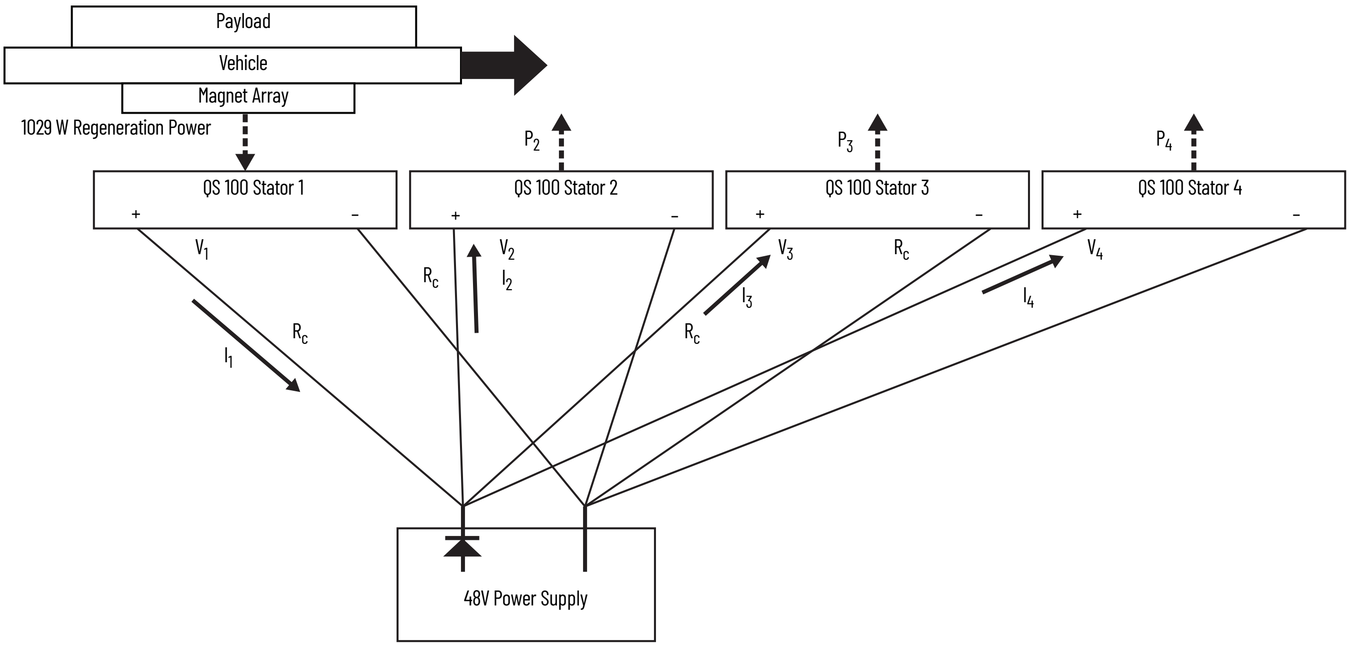
$$57V - 53.3V = 2\,(7.02\ A)\,R_c$$

$$R_c = [(57V - 53.3V) / (2*7.02\ A)] = 0.26\ \Omega$$

Example - Central Bus with One Vehicle

The example that is shown in Figure 59 uses QS 100 motors. The following considers one vehicle that is decelerating on a path. Use the same assumptions as in the previous example and the example sizing for regenerative power.

Figure 59 - Single Vehicle Decelerating with Four Motors



V_1 can be set to 57V, the maximum allowable voltage for the system during normal operation. Based on this, the Power Law can be used to find the current i_1.

$$i_1 = (P_1 / V_1) = (1029\ W / 57V) = 18.05\ A$$

By Kirchhoff's Current Law, the sum of the currents entering and leaving the junction near the power supply must be zero.

$$i_1 - i_2 - i_3 - i_4 = 0$$

$$i_1 = i_2 + i_3 + i_4$$

Additionally, the voltage at each motor is related by the voltage at the connection point near the power supply. The voltage drop from the motor to the supply must bring the motor voltage to the same level as the power supply.

$$V_{PS} = V_1 - i_1R_c = V_2 + i_2R_c = V_3 + i_3R_c = V_4 + i_4R_c$$

The system must also dissipate all power into the system.

$$P_1 = i_1^2R_c + P_2 + i_2^2R_c + P_3 + i_3^2R_c + P_4 + i_4^2R_c$$

If there were any partially covered motors or differing cable resistances in this example, a model would be required to balance the current, voltage, and power dissipation in each block. In this simple example, because there are no partially covered motors and all cable resistances are the same, power dissipation in each motor can be assumed to be identical.

$$P_2 = P_3 = P_4$$

Since all cable resistances are the same, this also makes the current and voltage at each motor identical.

$$V_2 = V_3 = V_4$$

$$i_1 = 3i_2$$

On this basis, the power that is required to be dissipated can be divided by the number of available blocks. This assumes that the power loss in the cables (the i^2R_c term) is negligible. In this case there are three empty motors, so there are 30 available blocks.

(1029 W / 30 blocks) = 34.3 W/blocks

From Figure 55 on page 83, the voltage at motors 2 …4 is 53.2V. If the value produced by this calculation cannot be found in Figure 55 on page 83, not enough blocks are available to dissipate the regenerated power.

Examining the voltage drop between V_1 and V_2, the cable resistance can be determined.

$$V_1 - V_2 = i_1R_c + i_2R_c = [(4/3) * i_1R_c]$$

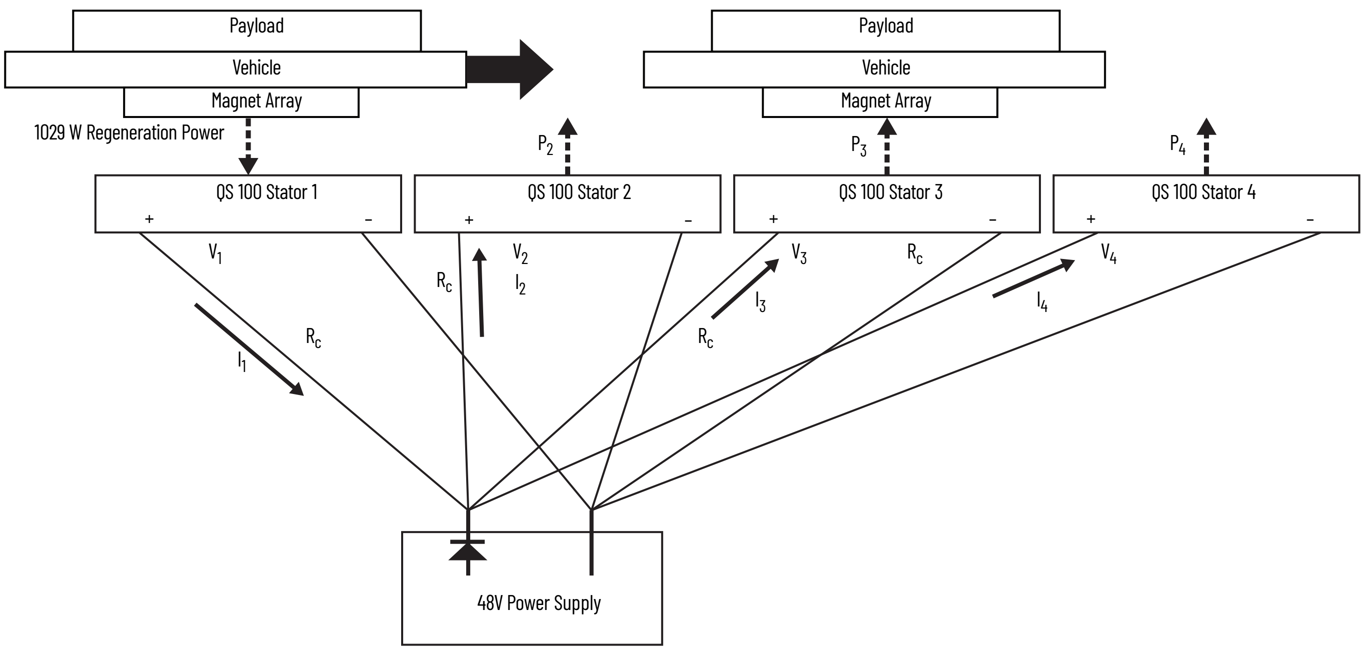
$$57V - 53.2V = [(4/3) * (18.05\ A)R_c]$$

$$R_c = [(57V - 53.2V) / ((4/3) * 18.05\ A)] = 0.158\ \Omega$$

Example - Central Bus with Two Vehicles

The example in Figure 60 uses QS 100 motors. Consider the previous example, but with a second vehicle stopped on the path.

Figure 60 - Single Vehicle Decelerating with Four Motors and Parked Vehicle



In this case, the same assumptions and equations apply, however there are 20 blocks to dissipate power because motor 3 is occupied and unavailable.

$$P_3 = 0$$

$$i_3 = 0i_1 = 2i_2$$

$$V_3 = V_{PS}$$

(1029 W / 20 blocks) = 51.45 W / block

Figure 55 on page 83 shows a maximum power dissipation per block of 47.5 W. There are not enough free blocks in this system to dissipate the power being regenerated. To help prevent overvoltage faults more motors must be added to the power bus, the velocity or acceleration (and thus regenerated power) must be decreased, or a voltage clamp must be installed.

Power Cabinet Structure

This section provides examples of how the power system can be structured within a cabinet. When designing your cabinet structure, consider the following:

- Proper circuit protection must be customer provided per local regulations.
- All power supply DC return wires must be referenced to ground (PE).
- The logic and power supplies and node controller ground (GND) wires must be referenced to the same ground (PE) point.

Figure 61 and Figure 62 provide power system wiring examples.

Figure 61 - QuickStick Power System with a Single Logic Power Supply Example

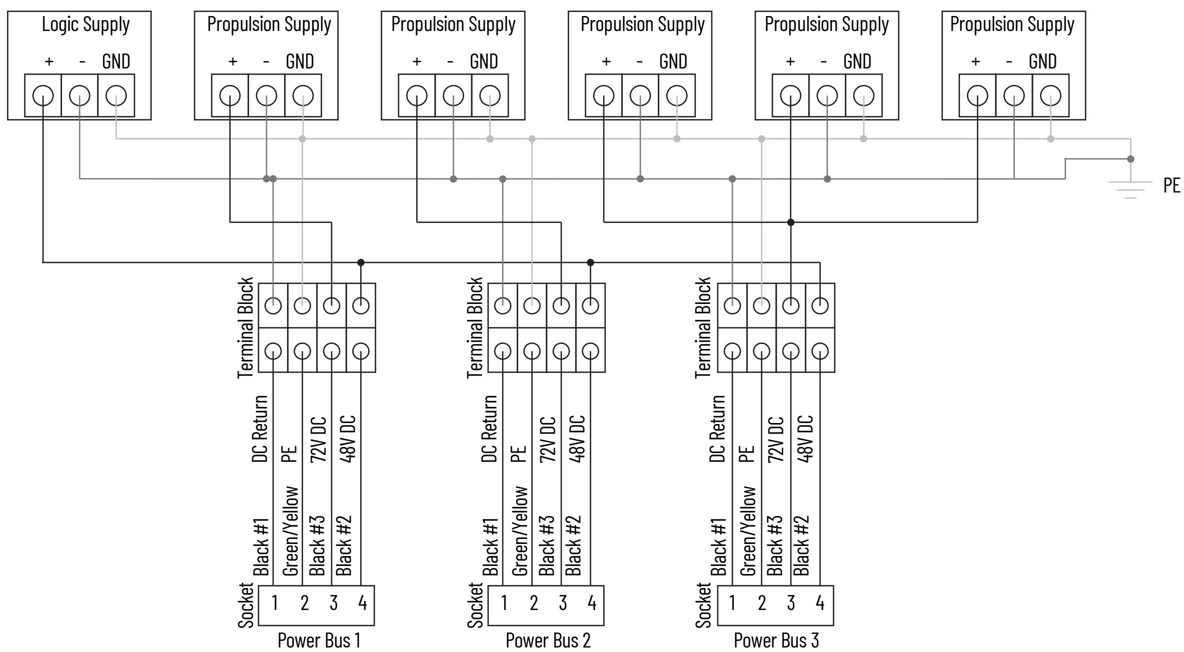


Figure 62 - QuickStick Power System with Two Logic Power Supplies Example

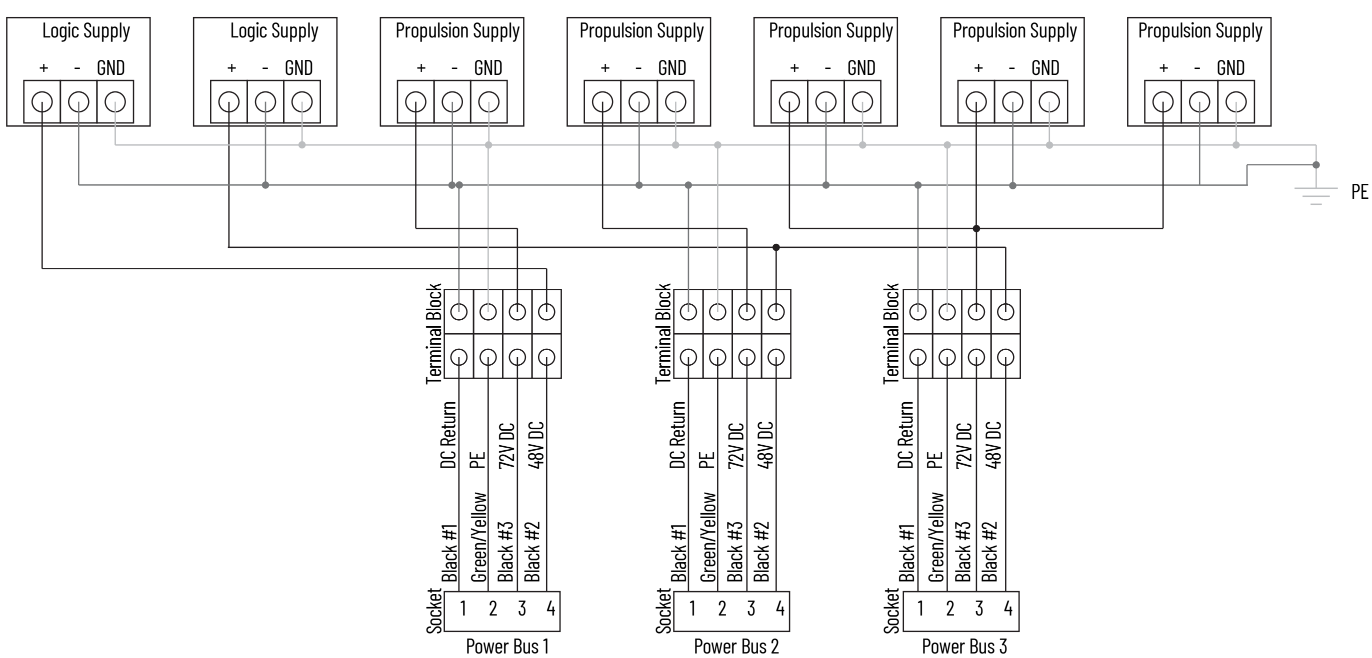
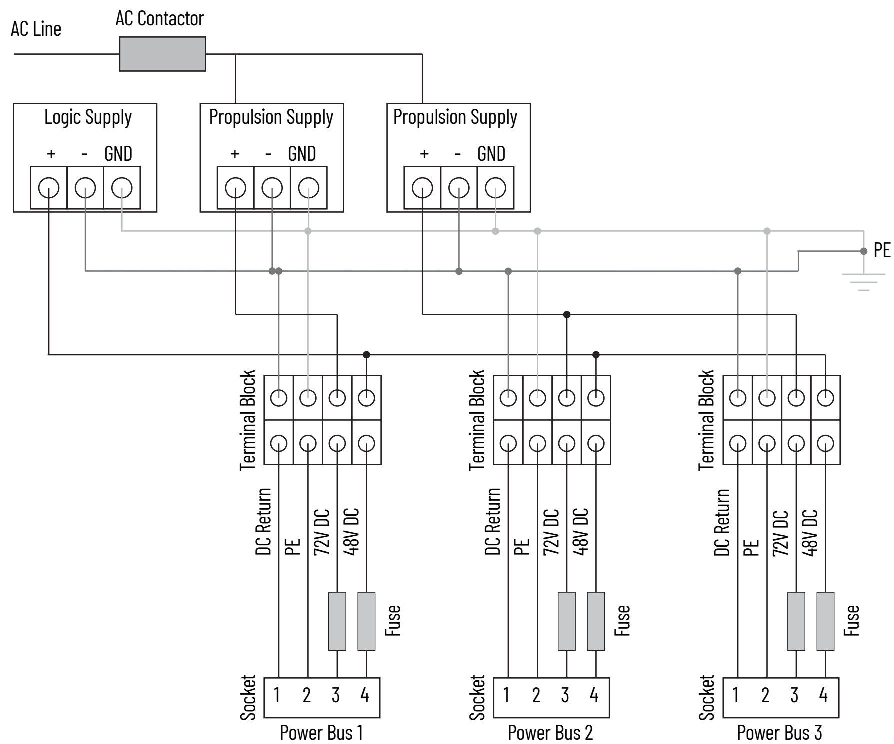


Figure 63 provides an example implementation of cabinet wiring structure with protection devices.

Figure 63 - Cabinet Implementation Example



Note that circuit protection requirements will be based on downstream wire gage, local regulation, and end user requirements.

Methods to Reduce Voltage Increase Through Hardware Changes

There are several possible solutions available to help prevent an overvoltage fault. Figure 64 and Figure 65 on page 91 provide examples of these solutions.

Implement these methods to help prevent an overvoltage fault:

- Reduce cable resistance between stators that share a common propulsion supply if voltage drops in these cables lead to excessive voltages on stators undergoing regeneration. This reduces the voltage difference between the motor regenerating power and the motors dissipating power and allow the voltage at the regenerating motor to be lower.
- Reduce maximum speed and/or maximum accelerations to reduce the amount of regenerated power that flows back into the system.
- Increase the space between vehicles on stators that share a common propulsion supply to increase the number of blocks available to absorb power during regeneration.
- Connect more QS stators to a common propulsion supply to increase the number of blocks available to absorb regenerated power.
- If the resolution paths have been explored and the problem persists, the only solution is to add an active voltage clamp across the +V propulsion supply local to the power supply or to the QS stators that are exhibiting this issue. A voltage clamp is a circuit that begins dissipating power if the voltage on the bus goes above a certain level. The clamping voltage should be above the coil dissipation threshold (51.5V for QS 100 and 80.5V for QS 150) but kept as low as possible.

Figure 64 - QuickStick 100 Central Bus with Reduced Cable Resistance Between Motors

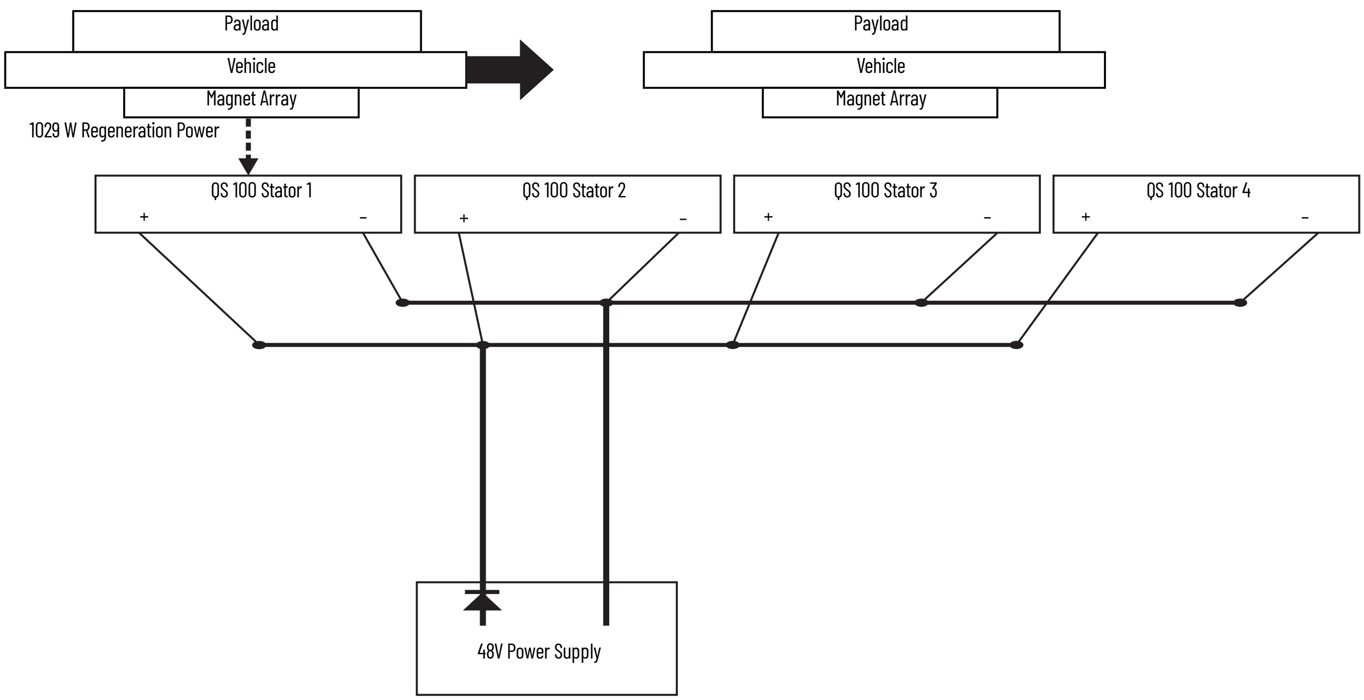
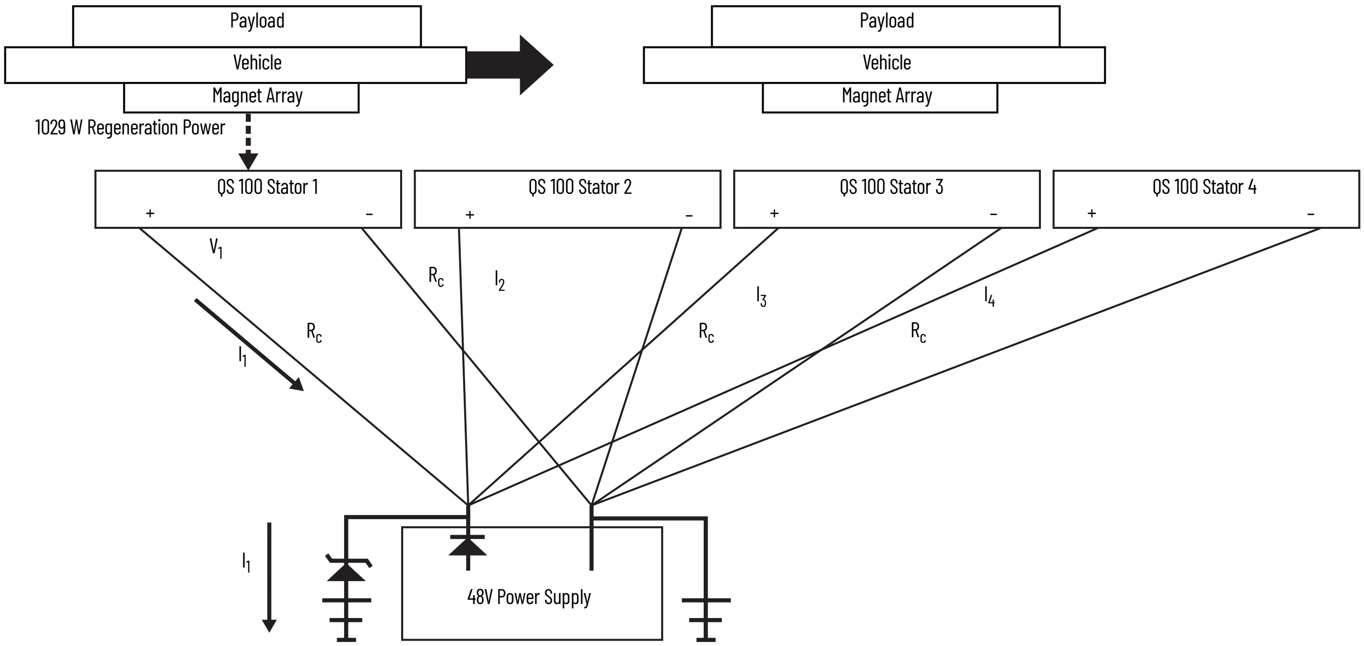


Figure 65 - QuickStick 100 Four Motor System with a Clamp at the Power Supply



If the clamp is set at less than the coil dissipation threshold CD_T (51.5V for QS 100), no power is sent to other motors to be dissipated.

$$0 = i_2 = i_3 = i_4$$

The voltage at the regenerating motor equals the clamp voltage plus the voltage drop in the cable leading to the clamp. This can be represented as a combination of the Power Law and Ohm's Law.

QS 100:

$$V_1 = (P_1 / i_1) = 50V + i_1R_c$$

QS 150:

$$V_1 = (P_1 / i_1) = 80V + i_1R_c$$

This method has no effect on the undervoltage case directly but can allow the power supply to be set to a higher voltage to compensate for voltage drop in longer cables without risking exceeding the high-voltage limit of the motor.

If a clamp voltage below the CD_T is selected as shown here, confirm that the circuit is rated for the total regenerated power. This is because, below the CD_T, the other motors do not dissipate power.

Summary

In larger systems, the sizing of the power cabling can have a significant effect on system performance. Incorrectly sized cables can lead to:

- Soft start not complete faults resulting in the motor losing propulsion power
- Overvoltage faults results in the motor shutting down
- Damage to the motors
- Soft start resistor failure due to a repeated under voltage
- Protection resistor failure due to a repeated over voltage
- Reduced motor life due to an increased component stress
- Possible uncontrolled vehicle motion due to a loss of propulsion or control power leading to collisions

The electrical design of the power system for the QS motors is the responsibility of the system integrator. Rockwell Automation strongly recommends that all power systems be reviewed by an electrical engineer before installation. The examples in this document are simplifications of an actual electrical system and apply only to the specific circumstances described.

ATTENTION: A qualified electrical engineer should always be consulted when working with high-voltage systems.

QuickStick High Thrust (HT) 5700 Inverter Power Sizing Selection

This chapter provides information on the power system sizing selection for a QuickStick® HT™ 5700 Inverter Servo Drive system using a Kinetix® 2198-P*xxx* DC-bus power supply.

ATTENTION: A qualified electrical engineer should always be consulted when working with high-voltage systems.

Information in this chapter pertains to the QuickStick HT. For QuickStick 100 and QuickStick 150 power management and cable sizing, see Chapter 4 on page 69

The QuickStick HT (QSHT) 5700 utilizes the Kinetix 5700 bus bar system for power transmission. As a result, the sizing process primarily focuses on the selection of a power supply, the arrangement of the drive modules in relation to the power supply, and the selection of a power shunt if needed. The design of the power bus, input protection, and mechanical structure should follow the standard process for the Kinetix 5700 drive system.

See the following documents for details on the components that compose the QSHT 5700 power bus system:

- QuickStick HT User Manual, publication MMI-UM007
- Kinetix 5700, 5500, 5300, 5100 Servo Drives Specifications, publication KNX-TD003
- Kinetix 5700 Servo Drives User Manual, publication 2198-UM002

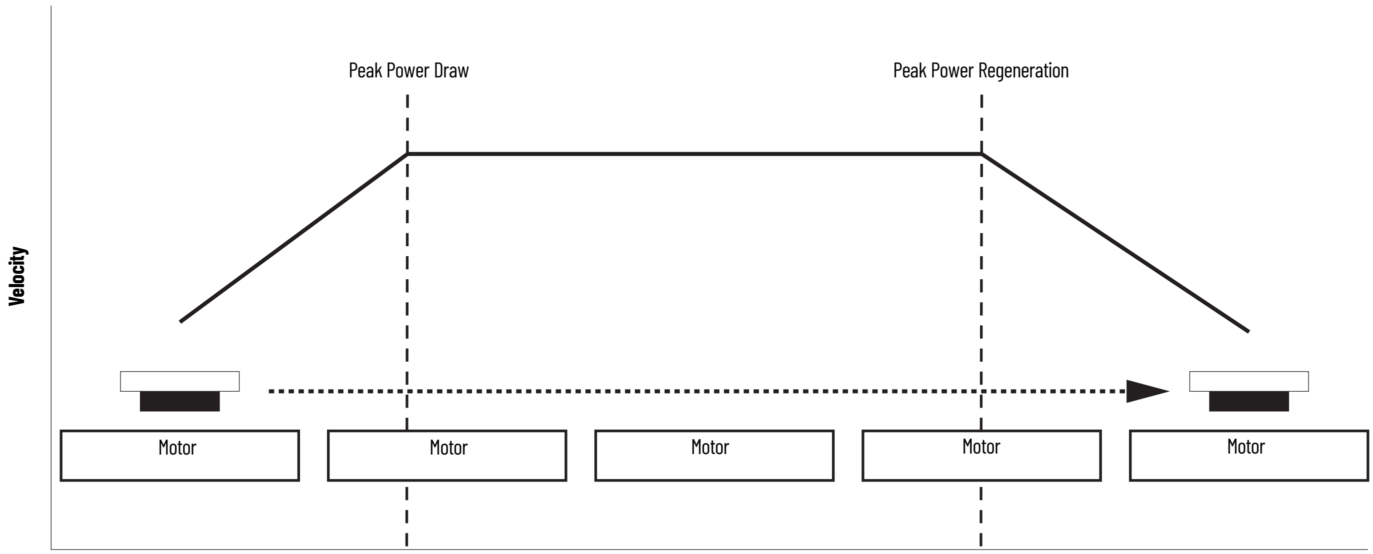
Performance Estimate Sheet

During the quoting process for a QSHT 5700 system, a performance estimate sheet is provided. The sizing sheet generates a movement profile and a corresponding peak propulsion power draw per vehicle using input parameters. The input parameters consist of the vehicle parameters, magnet array selection, motor quantities, track parameters, move parameters, and power parameters. An example of a performance estimate is used in an application example in this section for a demonstration of a QSHT 5700 system setup.

Propulsion Power

Propulsion power is the power that is used to accelerate and decelerate a vehicle. This is the main function that consumes power and varies based on the activity of the motor. The vehicle motion consumes power when it accelerates and regenerates power when it decelerates. The locations on the system where peak power and regeneration power are reached depend on the move profile being used. Figure 66 provides an example of the power peak locations in a QS system.

Figure 66 - Location of Power Peaks During Motion



While the vehicle is accelerating, the motor is drawing power from the motor power supply system, including any excess power being generated from regeneration in other motors connected to the same power supply system. In general, if a system is designed to support supplying full power during acceleration, it also supports the excess power minus heat loss that regeneration creates during deceleration or braking.

Calculations

For equations to calculate thrust and attractive force, see the appendix section of the QuickStick HT User Manual, publication MMI-UM007.

Table 13 - Data for Transport System Calculations

Category	Value
Stator Peak Current:	20.0 A
Stator Continuous Current	5.44 A
Stator Resistance	4.5 Ω
Drive Capacitance	309 µF
Magnet Motor Block Length	480 mm

Power Consumption During Acceleration and Travel

Power that is consumed from the 2198-P*xxx* power supply and QSHT 5700 drives to power the system, converts electrical energy into mechanical energy to accelerate the vehicle along the track. The vehicle power draw is found using the power to accelerate the vehicle plus the heat loss in the motor stator multiplied by the power supply safety factor.

Vehicle Propulsion Power = *(Heat Loss in Motor Stator + Power to Accelerate the Vehicle) * [(Power Supply Safety Factor / 100) +1]*

The power to accelerate the vehicle requires a force (F) multiplied by the vehicle's velocity (V). To get this force, you must use the total vehicle mass (m) multiplied by the maximum engagement acceleration the vehicle can run at its total mass (a) plus the worst-case friction from the vehicle. This calculation results in the vehicle's normal force. The vehicle's normal force is the vehicle's total mass, times the acceleration of gravity (g), plus the attractive force between the motor and the magnet, times the coefficient of friction (μ) used for the vehicle.

Where R = 4.5 Ohms

Power to Accelerate the Vehicle = $F * V$

Where $F = ma + \mu (mg + F_a)$

To find the heat loss in the stator, take 75% of the power in the stator multiplied by the maximum occupied blocks. The power in the stator can be calculated by taking the square value of the stator peak current and multiplying it by the stator resistance.

Heat loss in Motor Stator = $(0.75 * I^2 * R * \text{Maximum Occupied Blocks})$

To find the value of the maximum occupied blocks, use the minimum engagement value of the magnet array (length of the magnet array that is over a motor) divided by the block length of the motor stator plus one.

Maximum Occupied Blocks =
Round Up [Minimum Magnet Engagement Length (mm) / Magnet Motor Block (mm)] + 1

Lastly, multiply the power to accelerate the vehicle plus the heat loss to the motor stator by the power supply safety factor. Since we are finding the total power consumption for all of these components, add one to the power supply safety factor percentage when you multiply the safety factor component, and this adds the safety factor component into the power consumption equation to give the propulsion power draw per vehicle value at any given time.

Regenerative Power

As the vehicle brakes or decelerates to a stop, the mechanical energy of the vehicle is converted back to electrical energy, which is then applied to the internal propulsion bus of the motor. This energy must then be dissipated to avoid the bus voltage rising beyond the maximum recommended system-operating voltage of 832V DC for the 480V nominal AC input to the 2198-P*xxx* power supply and 820V DC for the QSHT 5700 drives.

In a QSHT system, when the internal propulsion bus is above 805V DC, available blocks begin to ramp the current in their stator coils to allow the motor to dissipate regenerated power. This regenerated power can be from within the motor or from neighboring motors sharing the DC bus. An available block is any block that does not have part of a vehicle over the block. Since the available block is not needed for vehicle movement, the block can be used to dissipate power.

To find how much power is being dissipated, determine how much energy is lost to heat when the mechanical energy is converted to electrical energy.

To calculate the energy that is regenerated to the system, take the Power to Decelerate the Vehicle and subtract it from the Heat loss in the Motor Stator using the equation that is shown here.

Friction is subtracted from the energy that is required to decelerate the vehicle because it is helping us to slow down.

Energy Regenerated = $(F * V) - (0.75 * I^2 * R * \text{Maximum Occupied Blocks})$

Where $F = ma - \mu\,(mg + F_a)$

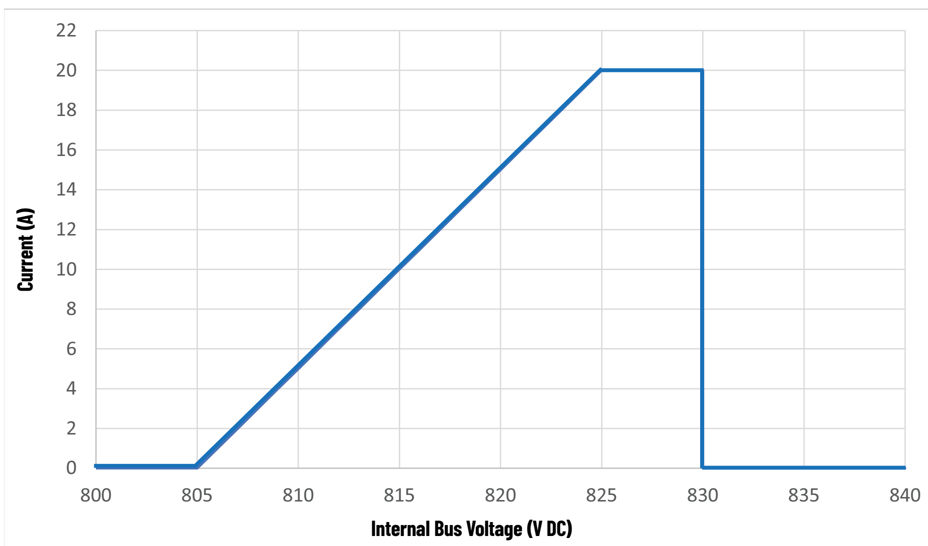
Where F_a = attractive force

This regenerative power must be dissipated to the available blocks if any in the track system exists. If there are no available blocks for dissipation, then an additional power shunt or brake resistor must be added to the power supply system to dissipate this regenerative power. For additional passive shunt modules and resistors, see the Passive Shunt Modules and Resistors section in the Kinetix 5700, 5500, 5300, 5100 Servo Drives Specifications, publication KNX-TD003. If the system has multiple vehicles on the same power bus and the additional vehicles are accelerating, these additional vehicles would then be able to use the decelerating vehicle's regenerative power that must be dissipated. The system's wiring must be designed to support full power during acceleration and the excess power that regeneration creates during deceleration.

Available Blocks to Dissipate Power

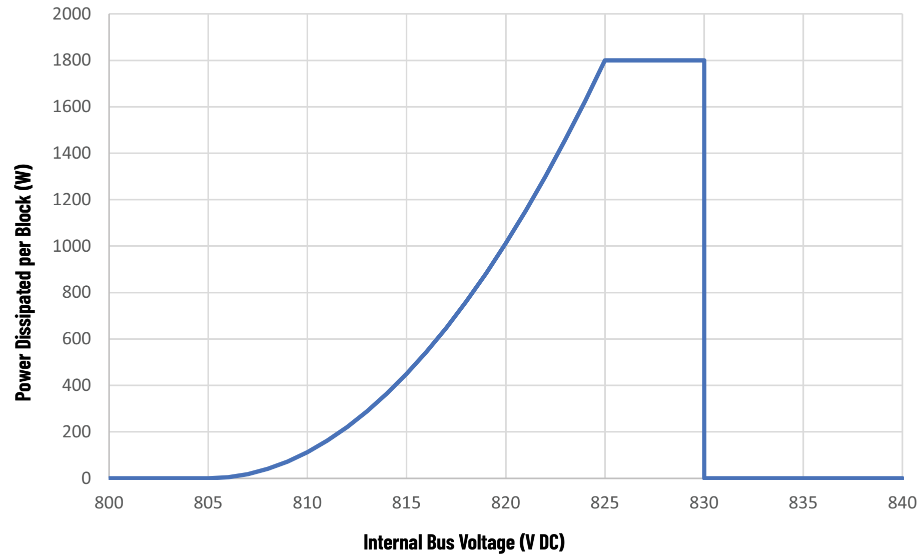
To identify blocks that are unavailable to regenerate power, the software determines which blocks are or are about to be occupied by a vehicle. When the internal propulsion bus reaches 805V DC, available blocks begin to drive current in their stator coils to allow the motor to dissipate regenerated power. Over a 20V range, the current ramps up linearly to 20 A and remain constant at 20 A from 825V…830V before dropping to 0 A, as shown in Figure 67.

Figure 67 - Individual Block Current vs. Internal Propulsion Bus Voltage



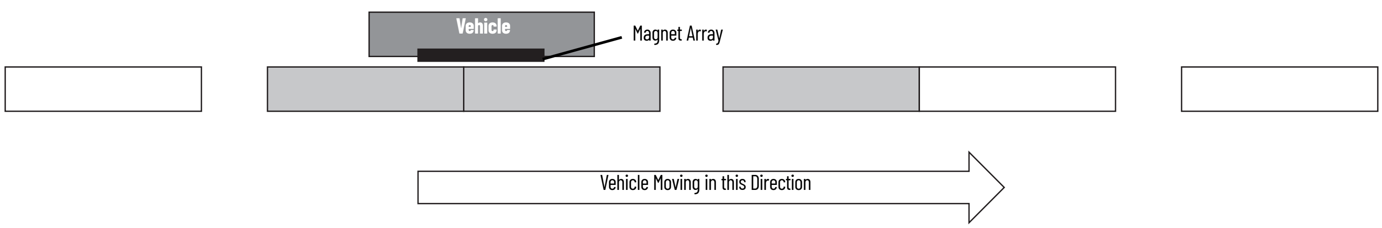
With a stator resistance of 4.5 Ω, the dissipated power per block is 1800 W when the 20 A current level is reached and remains at this level up to 830V DC.

Figure 68 - Power Dissipation per Block vs. Internal Propulsion Bus Voltage



Only blocks that are occupied by a magnet array or next to a block that is occupied by a magnet array are considered unavailable to absorb power. Available blocks for the QSHT motors can absorb up to 1000 W per block to be used to dissipate the regenerative power. Considering a worst-case scenario, the vehicle that is shown below would take up three blocks.

Figure 69 - Blocks Unavailable to Dissipate Power



Component Configuration

This section provides information on the configuration that is required for the primary system components.

Select a Power Supply

A power supply is required to provide propulsion power for your transport system. The System Peak Propulsion Power contained in the performance estimate sheet is the amount of power the power supply must provide for the system to work properly. Be sure that the selected power supply can meet both the peak and continuous output power based on the number of accelerating vehicles over the drives that are associated with the supply at any given time. To select a Kinetix 2198-P*xxx* DC-bus power supply, see the Technical Specifications - Kinetix 5700 Drive Modules section in the Kinetix 5700, 5500, 5300, 5100 Servo Drives Specifications, publication KNX-TD003.

System Drives per Bus Capacitance

After a power supply has been selected, the total system capacitance must be considered because the total system capacitance draws on the power supply and must stay below the maximum supported DC-bus capacitance of the power supply. Consult the Kinetix 5700 Servo Drives User Manual, publication 2198-UM002, for power supply capacitance to determine how many QSHT 5700 drive modules the selected 2198-P*xxx* power supply can support. Take the total supported max capacitance of the 2198-P*xxx* power supply, subtract it from the internal capacitance of the power supply, and then divide it by the Drive Capacitance value that is included in the Data for Transport

System Calculations (Table 13 on page 94) to find the remaining amount of drives the power supply can support.

Maximum Drives per Power Supply =
(Power Supply Capacitance Limit - Power Supply Capacitance) / Drive Capacitance

If the power supply provides power to a combination of QSHT 5700 drive modules and a standard Kinetix axis, be sure that the total capacitance does not exceed the capacitance of the power supply.

System Logic Control Power

To control the vehicle on each motor with a QSHT 5700 inverter drive module, control power is needed for each motor that is used in the power system sizing estimate. The QSHT 5700 drive modules require 24V DC input power. Mount the 24V DC control power as close to the QSHT 5700 drive system as possible to minimize input voltage drop over the system. The system may require multiple 24V DC power supplies due to drive count or cabinet configuration. A QSHT 5700 inverter drive module can control either one 1.0 m motor, two consecutive 0.5 m motors, or one 0.5 m double-wide motor.

Consult the Kinetix 5700 Servo Drives User Manual, publication 2198-UM002, for Control Power Current Specifications to reference the 24V current per modules and 24V inrush current for the 2198-P*xxx* power supply. The QSHT 5700 drive modules follow the same current per module and inrush current as the 2198-D032-ERS*x* field. Each 24V power supply must not exceed 40 A.

Maximum Drives per Power Supply =
(Lesser of Power Supply Capacity or 40 A - Number of Drives and/or Power Supplies in Power Supply Inrush Current) / Motor Inrush Current

System Ethernet Network

An Ethernet network allows communication to pass from one QSHT 5700 drive to another to send the vehicle around the track. Consult the Order of Modules section in the QuickStick HT User Manual, publication MMI-UM007, to see how many drives can be supported with the 2198-P*xxx* DC-bus power supply for each Ethernet switch in a line or from one QSHT 5700 drive to another QSHT 5700 drive.

When used, the 2198-P*xxx* DC power supply should be the first connected device on the Ethernet network.

Passive Shunt Resistor

The Kinetix 5700 external module passive shunt resistor can be connected to the 2198-P*xxx* DC-bus power supply to provide additional shunt capacity for applications where the DC-bus power supply's internal shunt capacity is exceeded during power regeneration when braking. If there are not sufficient blocks available to dissipate the regenerative power, then a shunt resistor must be properly allocated for the regenerative power to not damage the power supply. For additional Passive shunt modules and resistors see the Kinetix 5700, 5500, 5300, 5100 Servo Drives Specifications, publication KNX-TD003, section Passive Shunt Modules and Resistors or the Kinetix 5700 Servo Drives User Manual, publication 2198-UM002, section Passive Shunt Considerations.

Application Example

The application example constructs a QSHT 5700 power system using the QSHT 5700 Inverter Servo drives and the Kinetix 2198-P*xxx* DC-bus power supply. Figure 70 on page 99 provides an example performance estimate.

Figure 70 - Performance Estimate Example

QuickStick High Thrust Performance Estimate Sheet

Estimates of travel time, and total time of moves are estimates only and need to be determined in customer tests. Settling times are influenced by machine structure, repeatability requirements, and other factors.

Inputs

Vehicle Parameters		**Track Parameters**	
Length:	1.000 m	Coefficient of Friction:	0.025
Width:	0.250 m	Orientation:	Upright
Vehicle Mass:	200.000 kg	Motor Spacing:	33.0 mm
Payload Mass:	1000.000 kg	Array to Motor Gap:	12
		Smallest Motor:	0.5m
		Motor Current:	10.90 A
Array Selection		**Move Parameters**	
Magnet Array Type:	Standard	Accleration Limit:	60.00
Magnet Array Length:	960 mm	Velocity Limit:	5.00
Magnet Arrays per Vehicle:	1	Move Distance:	10.0 m
		Dwell Time:	1.0 sec
Motor Quantities		**Power Parameters**	
Number of 1.0m standard motors:	10	Number of Vehicles:	1
Number of 0.5m standard motors:	5	Accelerating Vehicles (Count):	1
Number of double wide 0.5m motors:	0	Accelerating Vehicles (Percent):	100%
		Safety Factor:	10%

Outputs

Note: All calculations assume a maximum of a 25% duty cycle on a single coil.

Thrust and Acceleration Estimate

Total Mass to be Moved: 1218.000 kg

	Minimum Engagement	Maximum Engagement
Magnet Array Engagement	876.0 mm	918.0 mm
Hold Down Force	3122.3 N	3272.0 N
Total Weight and Hold Down Force	15070.9 N	15220.6 N
Force Required to Overcome Friction	376.8 N	380.5 N
Thrust Produced by Motor	1331.3 N	1395.1 N
Thrust Available for Acceleration	954.5 N	1014.6 N
Acceleration Limit	0.78 m/s/s	0.83 m/s/s

Movement Estimate		**Power Estimate**	
Maximum Acceleration:	0.78 m/s/s	$\boxed{\text{Peak Power Required per Vehicle: 5442 W}}$	
Peak Velocity:	2.80 m/s	System Constant Logic Power:	248 W
Ramp Time:	3.57 sec	System Peak Propulsion Power:	5442 W
Ramp Distance:	5.00 m		
Cruise Time:	0.00 sec		
Cruise Distance:	0.00 m		
Minimum Move Time:	7.14 sec		

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For this example, the system peak propulsion power from the performance estimate is 5442 W. This system wattage value is within the continuous and peak output power to bus ranges for the Kinetix 5700 2198-P031 DC-bus power supply. See the Kinetix 5700, 5500, 5300, 5100 Servo Drives Specifications, publication KNX-TD003. If you have multiple vehicles or power buses in your system, you must consider how many vehicles would be on a particular power bus when selecting a power supply rather than using the system peak propulsion power.

After the power supply has been selected, the total system capacitance must be considered because the total system capacitance draws on the power supply. The total system capacitance must stay below the maximum supported DC-bus system capacitance of 8000 μF for the 2198-P031 power supply. This power supply uses an internal capacitance of 585 μF, which leaves an allowable capacitance of 7415 μF to use for all QSHT 5700 drives for this power system. Each QSHT 5700 drive has an internal capacitance of 390 μF. When dividing the remaining power supply capacitance of 7415 μF by the drive capacitance of 390 μF, the total amount of QSHT 5700 drives this system could handle is 19.

The number of motors that are used in the track layout determines how many QSHT 5700 drives are needed for the system. The performance estimate uses 12.5 m of track or a total of 15 motors. Since none of the 0.5 m motors are next to one another, this system uses one motor per QSHT 5700 drive for a total of 15 drives.

Each QSHT 5700 drive module requires 24V DC input power for its logic control power. Each 24V control power supply cannot exceed 40 A. The 2198-P031 power supply uses 4 A of inrush current and each QSHT 5700 drive uses 1.8 A of inrush current per drive. One 480 W power supply can provide control power for nine QSHT 5700 drives with one 2198-P031 power supply in a left-to-right chain. This system requires two 24V DC control power supplies to provide control power to all 15 QSHT 5700 drives, one to power the 2198-P031 DC-bus power supply and eight of the QSHT 5700 drives, and the other to power the other seven remaining QSHT 5700 drives.

To make sure that the vehicle can travel from motor-to-motor, those motors must be able to communicate with each other and to the node controller. The QSHT 5700 drives are connected using an Ethernet network. A maximum number of 16 QSHT 5700 drives plus one power supply can be connected in a linear chain. In this example, all drives and the power supply can be daisy chained together and consume only one Ethernet port on one switch.

Now that the system has been configured for power and communication, the total power consumption to accelerate the vehicle must be considered to see how much power is then dissipated during the deceleration process of the vehicle that returns to the system for regenerative power. The Vehicle Peak Propulsion System Power Calculation shows the performance estimate for the Vehicle Propulsion Power using the equations from Power Consumption During Acceleration and Travel on page 95 that are also shown below.

EXAMPLE: Vehicle Peak Propulsion System Power Calculation for Applications

Power to Accelerate the Vehicle =

*(1218.0 kg * 0.78 m/s²) + 0.025 [1218.0 kg * (9.81 m/s²) + 3272.0 N] * (2.80 m/s) = 3725.55 W*

Heat Loss in the Motor Stator =

*(0.75 * 10.9² A * 4.5 Ohms) * Roundup [(876 mm / 480 mm) +1] = 1202.95 W*

Vehicle Peak Propulsion Power =
*(3725.55 W + 1202.95 W) * [(10 / 100) + 1] = 5421.35 (or approximately 5442 W)*

Using the energy regenerated equation, this system would regenerate a total of 391.68 W.

EXAMPLE: Energy Regenerative Calculation for Application Example

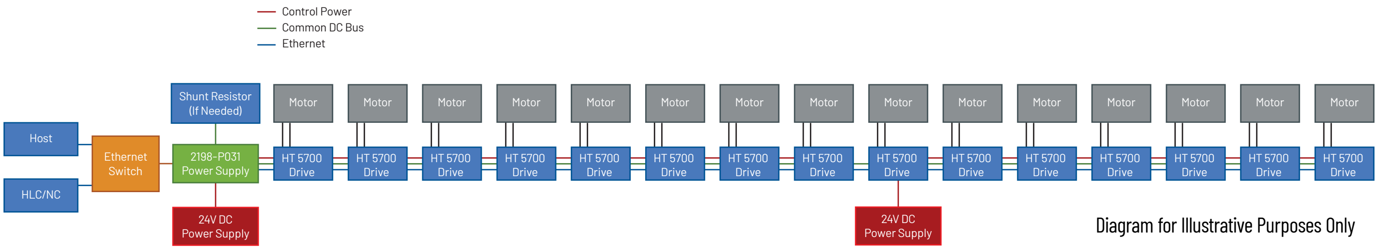
Energy Regenerative = *(569.53 N * 2.80 m/s) – 1203 W = 391.68 W*

Where F = *(1218.0 kg * 0.78 m/s2) – 0.025 [1218.0 kg * (9.81 m/s2) + 3272.0 N] = 569.53 N*

The 15 motors that are used in this system contain a total of 25 blocks, which provide 21 available blocks that could be used to dissipate the regenerative power. Each available block can receive up to 1000 watts of power to dissipate. Therefore, only 1 available block is required for the regenerative power and no additional power shunt or brake resistor is needed for this system.

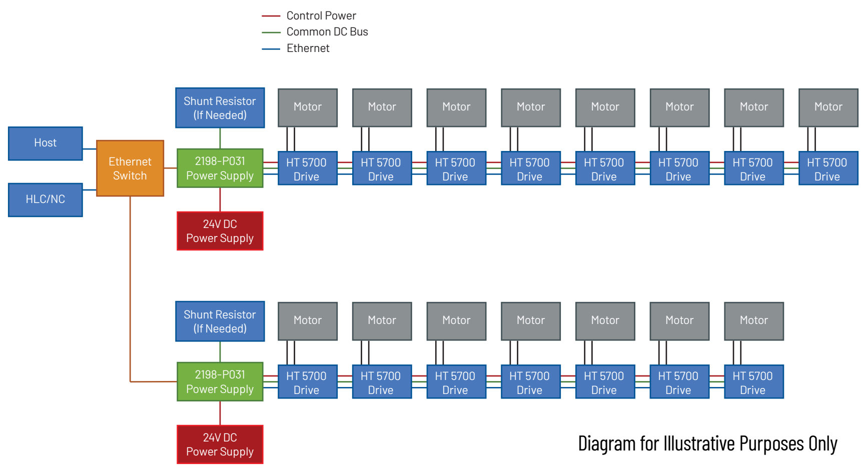
Figure 71 provides an example of a daisy chained, 15 motor system using one DC-bus power supply.

Figure 71 - Power System Configuration with One DC-bus Power Supply Example



An additional way that you can configure the system is to add a second 2198-P031 DC-bus power supply, which reduces the cabinet width and allows one set of the drives to be installed above the other, as shown in Figure 72. This configuration requires that two Ethernet ports are used on the Ethernet switch.

Figure 72 - Power System Configuration with Two DC-bus Power Supplies Example



Summary

In larger systems, QSHT 5700 system power sizing can have a significant effect on the system's performance. Incorrect power sizing can lead to:

- Under Voltage Fault below 265V, which causes a Soft Start Not Complete. The result of the fault is a loss of motor propulsion power and motor suspension.
- Over Voltage Fault above 830V, which results in the shutdown of all QSHT 5700 inverters. An Over Voltage Fault can result from regenerative power not having enough available blocks to dissipate energy.
- Damage to motors.
- Reduced motor life due to increased component stress.
- Possible uncontrolled vehicle motion due to a loss of propulsion or control power leading to collisions.
- Inverters can experience a Hardware Overcurrent Fault and cause the inverters to reset.

See the QuickStick HT User Manual, publication MMI-UM007, section QSHT 5700 Power-Related Power Related Fault Resolution for several possible solutions available to mitigate these types of faults.

ATTENTION: The electrical design of the power system for the QSHT motors is the responsibility of the system integrator. Rockwell Automation recommends that a qualified electrical engineer reviews all power systems before installation. The application example in this document is a simplification of an electrical system and applies only to the specific circumstances described.

QuickStick Motors Magnetic Field Measurements

This section provides information on the magnetic field levels surrounding a QuickStick® magnet array. The QuickStick (QS) magnet arrays consist of alternating polarity magnets on a steel back plate that cancels the field to near zero on the top of the array. For additional technical information about the compatible magnet arrays, see QuickStick Motors Technical Data, publication MMI-TD051.

Information in this chapter pertains to the QuickStick 100 and QuickStick 150 only. For QuickStick HT magnetic field measurements, see Chapter 7 on page 107.

Figure 73 shows a diagram of the field surrounding the magnet array. Some materials being transported with a QS system are sensitive to magnetic fields, therefore it is important to characterize these magnetic fields and to reduce the magnetic fields for those applications if necessary.

Figure 73 - Strength of the Magnetic Field Magnitude for QuickStick Magnet Array

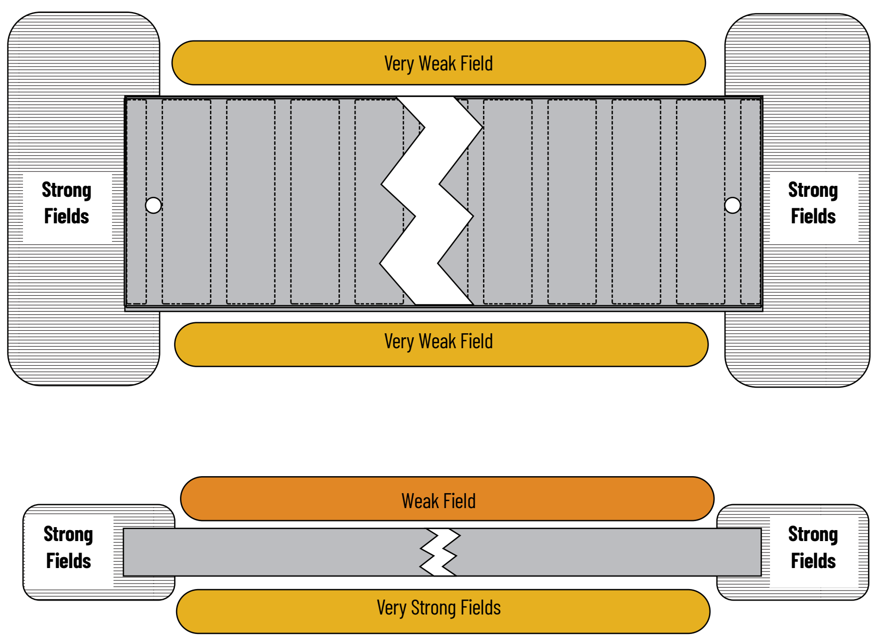


Diagram for illustrative purposes only.

Magnetic Field Measurement Methods

Magnetic field measurements were taken with a Vector/Magnitude Gauss meter. After the probe is zeroed at the ambient magnetic field, the probe is then used to measure the magnitude of the field at a given point.

The magnetic field is described in terms of its magnitude.

$$|B| = \sqrt{(B^2_x + B^2_y + B^2_z)}$$

Figure 74 shows the axis direction and origin location with respect to the magnet array for our measurements. Figure 75 shows the basic dimensions for a magnet array, where N denotes one cycle of a magnet array. A cycle is described as a half North-oriented magnet, a full South-oriented magnet, and a half North-oriented magnet. The number of these cycles placed end-to-end describes the magnet array that is selected. There is a 3 mm potting material at each end of the magnet array.

Figure 74 - Axis Direction and Location of Origin with Respect to the Magnet Array

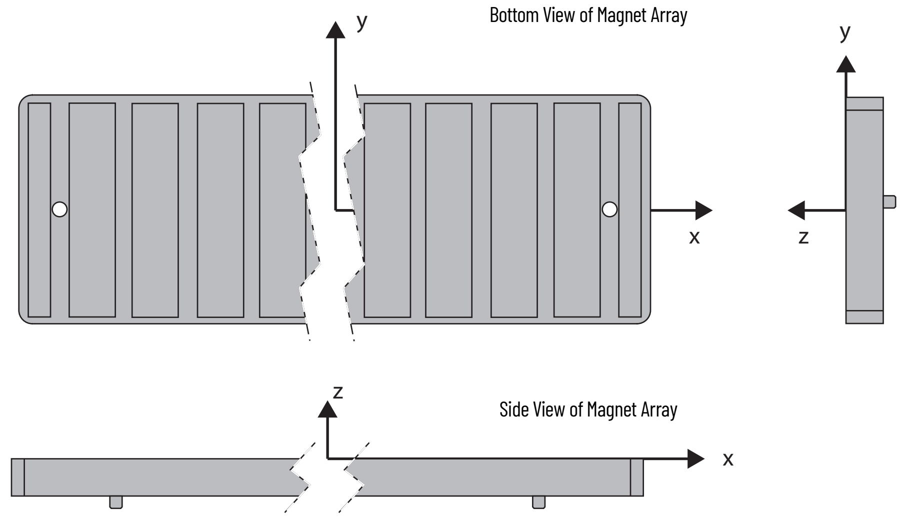
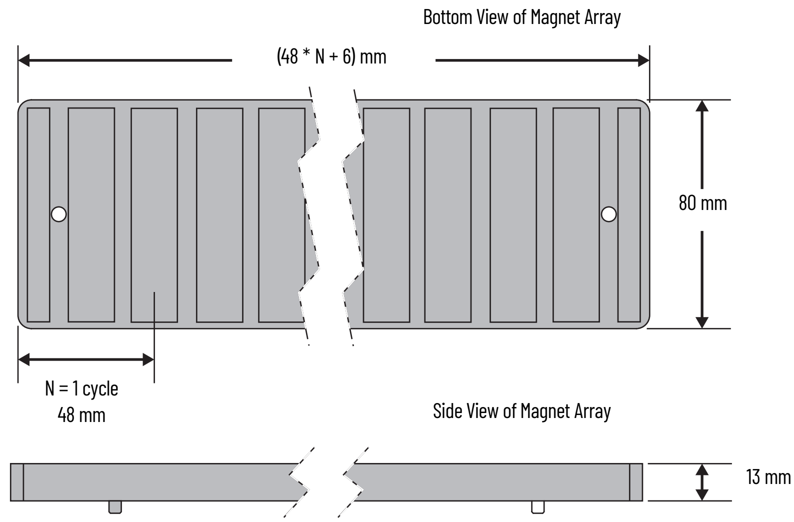


Figure 75 - Overall Magnet Array Dimensions



It is important to note that due to the design of the magnet array, the X-axis, and Y-axis measurements are symmetric, but the z-axis is not. Magnetic field magnitude measurements are taken at the following heights:

- Z = 0 mm (front face of magnet array)
- Z = -13 mm (back face of magnet array)
- 50 mm interval above and below the face of the magnet array

For the following conditions while the puck is not on a motor:

- Measurements taken along direction of travel (along X-axis) and Y = 0

Due to the nature of a multi-cycle magnet array, where the magnetic field alternates between cycles, measurements were taken for peak magnetic field magnitudes at a distance above the array. This measurement is the worst case magnetic field for a QS magnet array.

10,000 G = 1 Tesla

Magnetic Field Measurement Results

Earth's magnetic field is between 0.3...0.6 G. At the test location, the ambient magnetic field is 0.5 G. Figure 76 and Figure 77 show how the strength of the magnetic field drops to approximately the ambient field as the measurement probe is moved further from the surface of the magnet array.

The measurements for Figure 76 are taken from the bottom surface near the edge and center of the magnet array at different distances. The measurements for Figure 77 are taken from the top surface near the edge and center of the magnet array at different heights.

Figure 76 shows the magnetic field below the magnet array, where the field is the strongest. As the magnetic field magnitude drops to close to 1 G, it is considered to reach ambient fields. As some materials being transported by a puck might be sensitive to magnetic fields, Figure 77 shows the field strength above the magnet array.

Figure 76 - Magnetic Field Strength to Distance from Magnet Array, Bottom

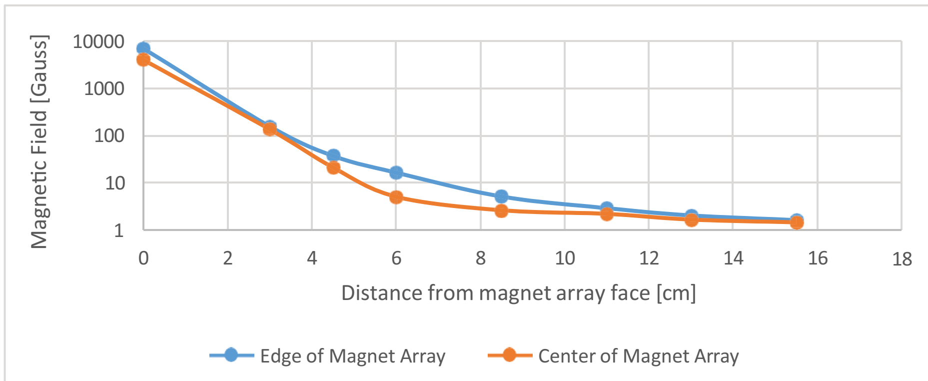
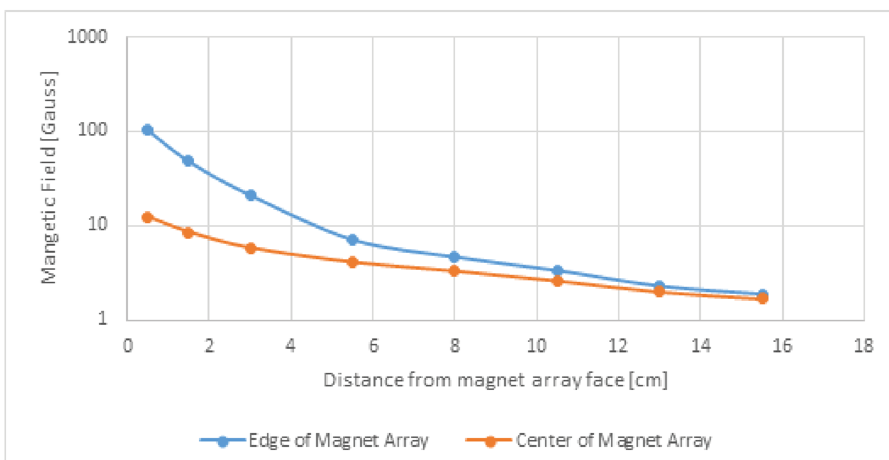


Figure 77 - Magnetic Field Strength to Distance from Magnet Array, Top



Magnetic Field Shielding

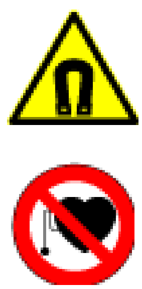
The puck's magnetic field can be shielded by the addition of ferromagnetic metal. Metals such as iron, nickel, or cobalt can work as a shield.

Permeability is the ability to redirect magnetic flux, in effect providing a short circuit path to steer the flux away from the area you are trying to shield. Higher permeability materials are better than lower permeability materials. Also consider the saturation point (the point at which the material loses the ability to steer additional magnetic flux) and the thickness of the material. Thinner materials saturate at a lower flux density than thicker ones. Once the material saturates, the shielding effect diminishes. If saturation is an issue, multiple layers of material can be used.

Steel is commonly used because it is inexpensive and widely available. It saturates around 22 kG, and has a permeability from 1000 to 3000 times (the permeability of free space). Steel is a good shielding material for applications involving large, powerful neodymium magnets due to the higher saturation point of steel. In these cases, steel provides good attenuation and a much higher saturation threshold.

Magnet Array Safety and Handling

See Handling Magnet Arrays on page 14 for important magnet array safety and handling information.



WARNING

Magnetic Field Hazard

The mover uses strong magnets.

There is a risk of health hazard for persons with heart pacemakers, metal implants, hearing aids, and other medical electronic implants while in proximity of magnetic and magnetic-field producing components. The magnetic field that is generated can disrupt the functionality of automatic implantable cardioverter defibrillators (AICD). People with cardiac pacemakers must stay away from the magnet arrays.

CAUTION

Magnetic Fields

Strong magnets in use.

To avoid damage to watches, electronic instruments, and magnetic media (for example, cell phones, memory disks/chips, credit cards, and tapes) keep these items away from the magnet arrays.

Magnetic Field Summary

The magnetic field is largest below the face of the magnet array, where it interacts with the motor for propulsion. Due to the orientation of the magnet array, the longitudinal direction fields are stronger than the lateral direction. Table 14 shows a summary of the distance that is required to reduce magnetic fields to approximately 1G in the different scenarios.

Table 14 - Distance to Reduce Magnetic Field to 1G

Orientation	Distance [cm]
Above array (x = 31, z = 0)	15
Below array (x = 0, z = 0)	15

Additional shield material, such as a steel sheet, reduces the distance at which the magnetic field dissipates to ambient levels. Factors that affect shield performance are the shape, size, and thickness of the shield and distance from the shield to the array.

QuickStick High Thrust Motors Magnetic Field Measurements

This section provides information on the magnetic field levels surrounding a QuickStick® HT™ magnet array. The QuickStick HT (QSHT) magnet array consists of alternating polarity magnets that are mounted to a Zinc-plated, steel back-plate that reduces the field to near zero on the top of the array. For additional technical information about the compatible magnet arrays for the QSHT motors, see the QSHT High Flux High Temp Magnet Arrays, publication MMI-TD038, and QuickStick HT High Flux Magnet Arrays, publication MMI-TD025.

Information in this chapter pertains to the QuickStick HT (QSHT) only. For QuickStick 100 and QuickStick 150 magnetic field measurements, see Chapter 6 on page 103.

Figure 78 shows a diagram of the field surrounding the magnet array. Some materials being transported with a QSHT system are sensitive to magnetic fields. Therefore, it is important to characterize these magnetic fields and to reduce the magnetic fields for those applications if necessary.

Figure 78 - Strength of the Magnetic Field Magnitude for the QuickStick HT Magnet Array

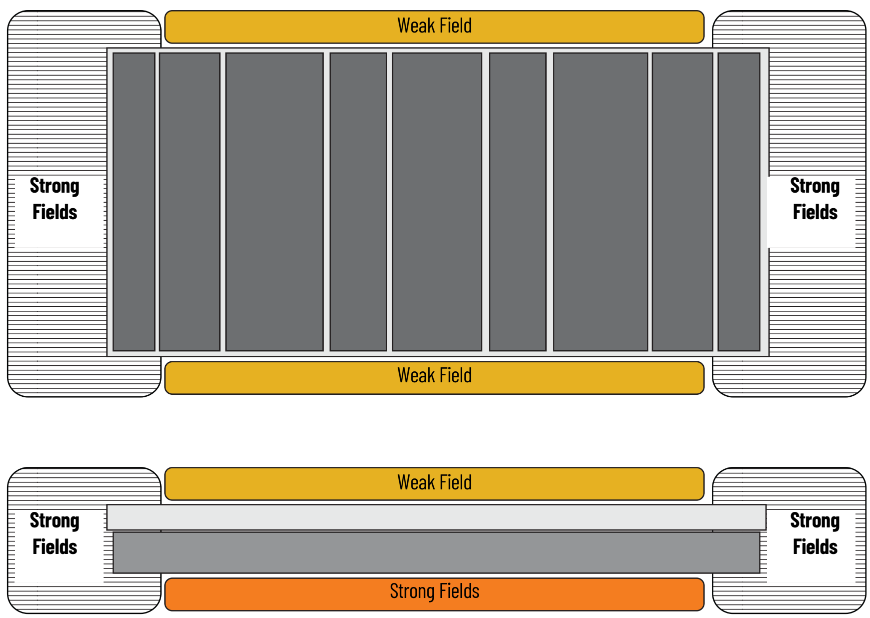


Diagram for illustrative purposes only.

Magnetic Field Measurement Methods

Magnetic field measurements were taken with a Vector/Magnitude Gauss meter. After the probe is zeroed at the ambient magnetic field, the probe is then used to measure the magnitude of the field at a given point.

The magnetic field is described in terms of its magnitude:

$$|B| = \sqrt{(B^2_x + B^2_y + B^2_z)}$$

Figure 79 shows the axis direction and origin location with respect to the magnet array for the measurements using a Gauss meter. Figure 80 shows the basic dimensions for a 2 cycle, 5 poles high flux magnet array from the Rockwell Automation Product Catalog. A cycle is described as a half North-oriented magnet, a full South-oriented magnet, and a half North-oriented magnet. The number of these cycles placed end-to-end describes the magnet array that is selected. The array is manufactured with the end cycles being 1 mm shorter than a standard cycle. The shorter end cycles allow two arrays to be placed end-to-end, with a minimal gap between the arrays to create longer arrays. When using end-to-end magnet arrays, the length of the array is 2 mm subtracted from the overall cycle length to allow for stacking of the magnet arrays end-to-end.

Figure 79 - Axis Direction and Location of Origin with Respect to the Magnet Array

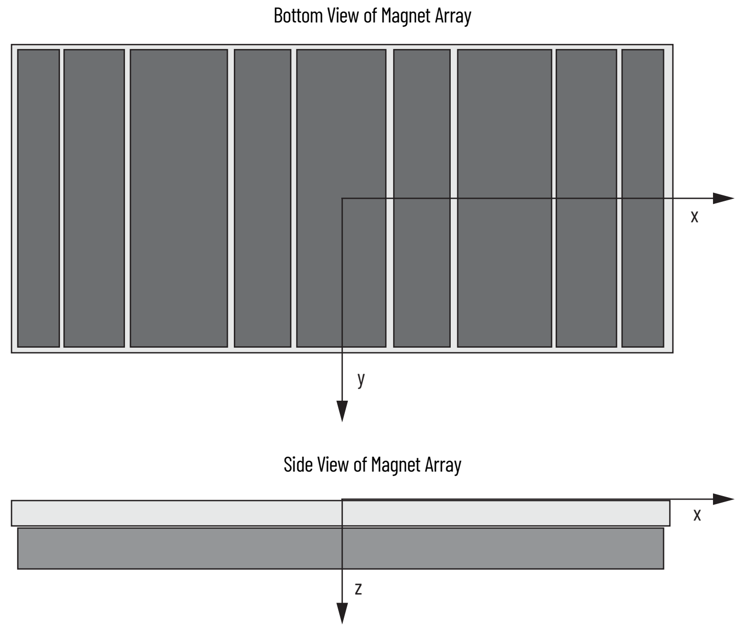
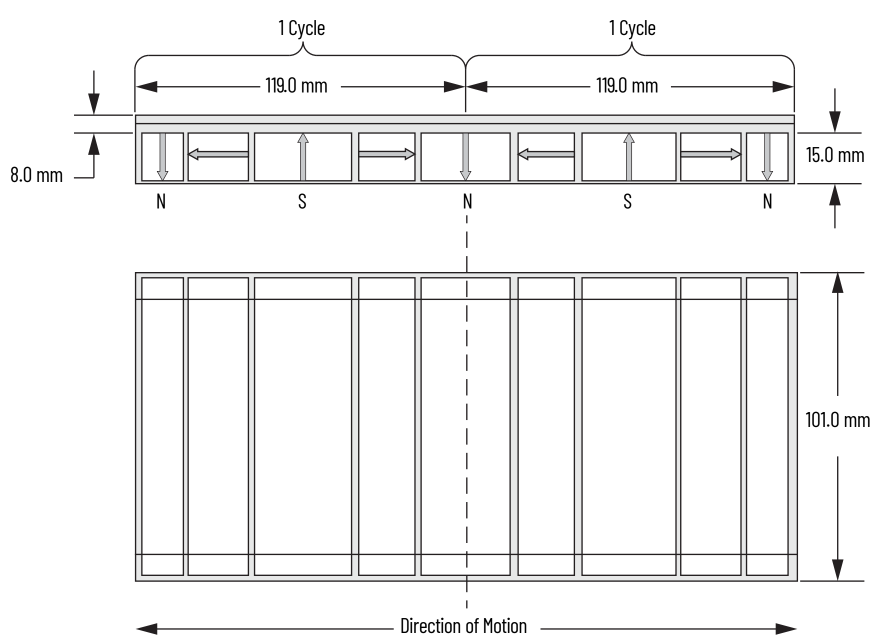


Figure 80 - QSHT High Flux Magnet Array Dimensions, 2 Cycles, 5 Poles



It is important to note that due to the design of the magnet array, the X-axis, and Y-axis measurements are symmetric, but the Z-axis is not. Magnetic field magnitude measurements are taken at the following heights:

Z = 0 mm (Mounting face of the magnet)

Z = 23 mm (Active face of the magnet)

20 mm interval above and below the faces of the magnet

For the following conditions while the magnet array is not on a motor:

1. Measurements taken on the Z-axis and X-axis to reach 1 G, 10 G, 100 G, and 1000 G, from the magnet array
2. Measurements taken on the X-axis and Y-axis to reach 1 G, 10 G, 100 G, and 1000 G, from the magnet array
3. Measurements taken along direction of travel (X-axis) with no Z-axis offset using the center and edge positions of the magnet array
4. Measurements taken along direction of travel (X-axis) with a 20 mm Z-axis offset using the center and edge positions of the magnet array
5. Measurements taken along direction of travel (Y-axis) with no Z-axis offset using the center and edge positions of the magnet array

10,000 G = 1 Tesla

Due to the nature of a multi-cycle magnet array, where the magnetic field alternates between cycles, measurements that are taken for peak magnetic field magnitudes are at a distance below the array on the active face. This measurement is the worst-case magnetic field for a QSHT magnet array.

Magnetic Field Measurement Results

Earth's magnetic field is between 0.3…0.6 G. At the test location, the ambient magnetic field is 1.0 G. Figure 81 shows how the magnetic field falls off to the ambient field as the measurement probe is moved further from the magnet array.

Figure 81 shows the experimental measurements of the distance at the center location of the magnet as the probe traveled on the XZ-plane from the QSHT magnet array to reach earth ground (PE) of 1 G (blue, outer-most line). The graph also shows the distance that the probe traveled to reach 10 G (green line), 100 G (orange line), and 1000 G (red, inner-most line). Earth ground (PE) is reached when the probe is 500 mm away from the magnet array center location on both faces of the magnet array along the X-axis. Earth ground (PE) is reached at 350 mm away from the mounting face (z = 0) of the magnet array and 400 mm away from the active face of the magnet array (z = 23) along the Z-axis. The mounting surface of the magnet array has a fixed Zinc-plated steel plate joined to the magnet array, which shows a lower magnetic field strength closer to the magnet than regarding the active face of the magnet array. Figure 81 shows the worst case-scenario of measurements that are taken on the XZ-plane where measurements were taken at the center location of the magnet produced a stronger gauss value than measurements take on the edge location of the magnet.

Figure 81 - Distance Probed Moved on XZ-plane to Reach 1 G, 10 G, 100 G, & 1000 G from the Magnet Array

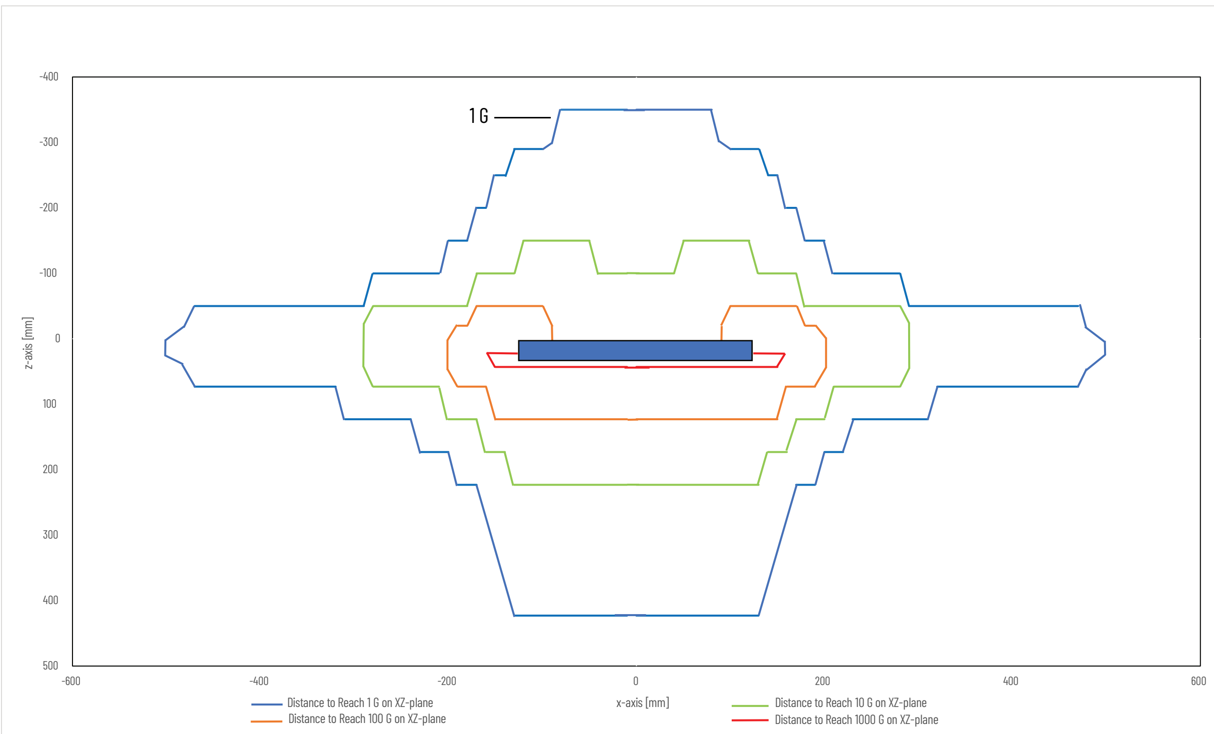


Figure 82 shows the experimental measurements of the distance that the probe traveled on the XY-plane from the QSHT magnet array to reach earth ground (PE) of 1 G (blue, outer-most line). The graph also shows the distance that the probe traveled to reach 10 G (green line), 100 G (orange line), and 1000 G (red, inner-most line). Earth ground (PE) is reached when the probe is 500 mm away from the magnet array center location along the X-axis and 340 mm away from the magnet array center location along the
Y-axis. Figure 82 shows the worst case-scenario of measurements that are taken on the XY-plane where measurements were taken at the center location of the magnet produced a stronger gauss value than measurements take on the edge location of the magnet.

Figure 82 - Distance Probed Moved on XY-plane to Reach 1 G, 10 G, 100 G, and 1000 G from the Magnet Array

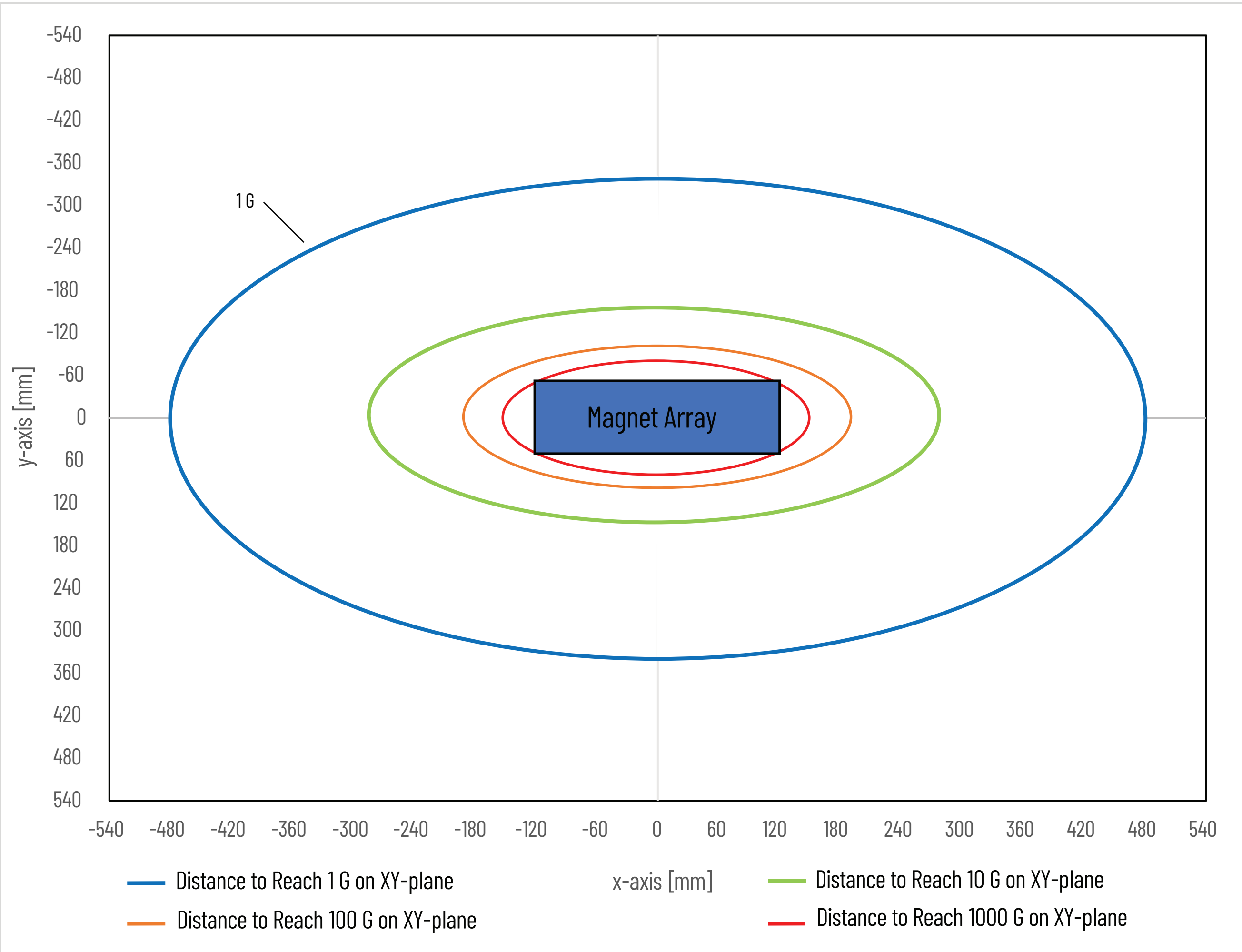


Figure 83 shows the magnetic field magnitude at the edge and center positions of the magnet array along the direction of travel (X-axis) with no Z-axis offset to the mounting and active face of the magnet array.

Figure 83 - Magnetic Field Magnitude Along X-axis with No Z-axis Offset

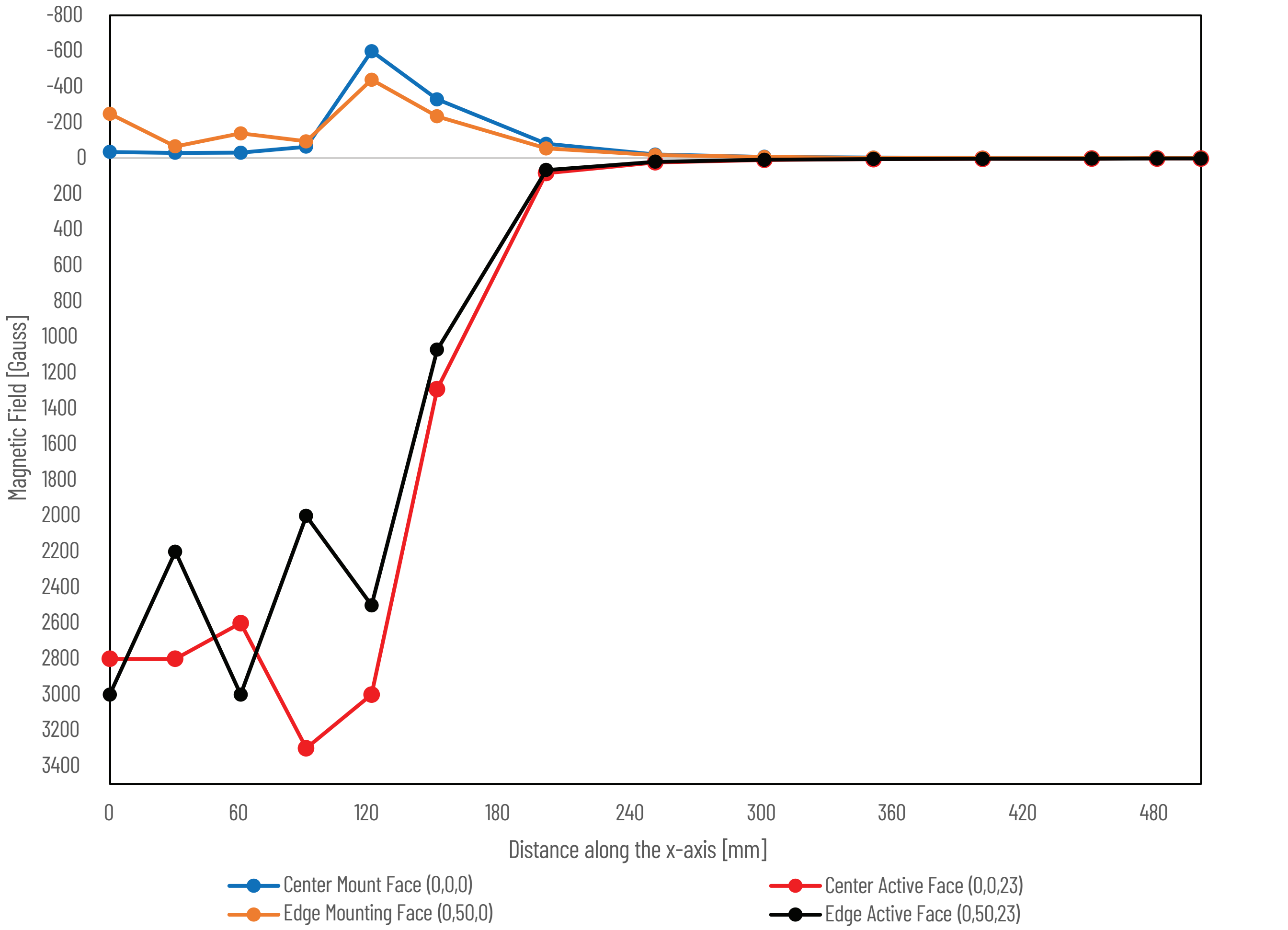


Figure 84 shows the magnetic field magnitude at the edge and center positions of the magnet array along the direction of travel (X-axis) with a 20 mm Z-axis offset to the mounting and active face of the magnet array.

Figure 84 - Magnetic Field Magnitude Along X-axis with 20 mm Z-axis Offset

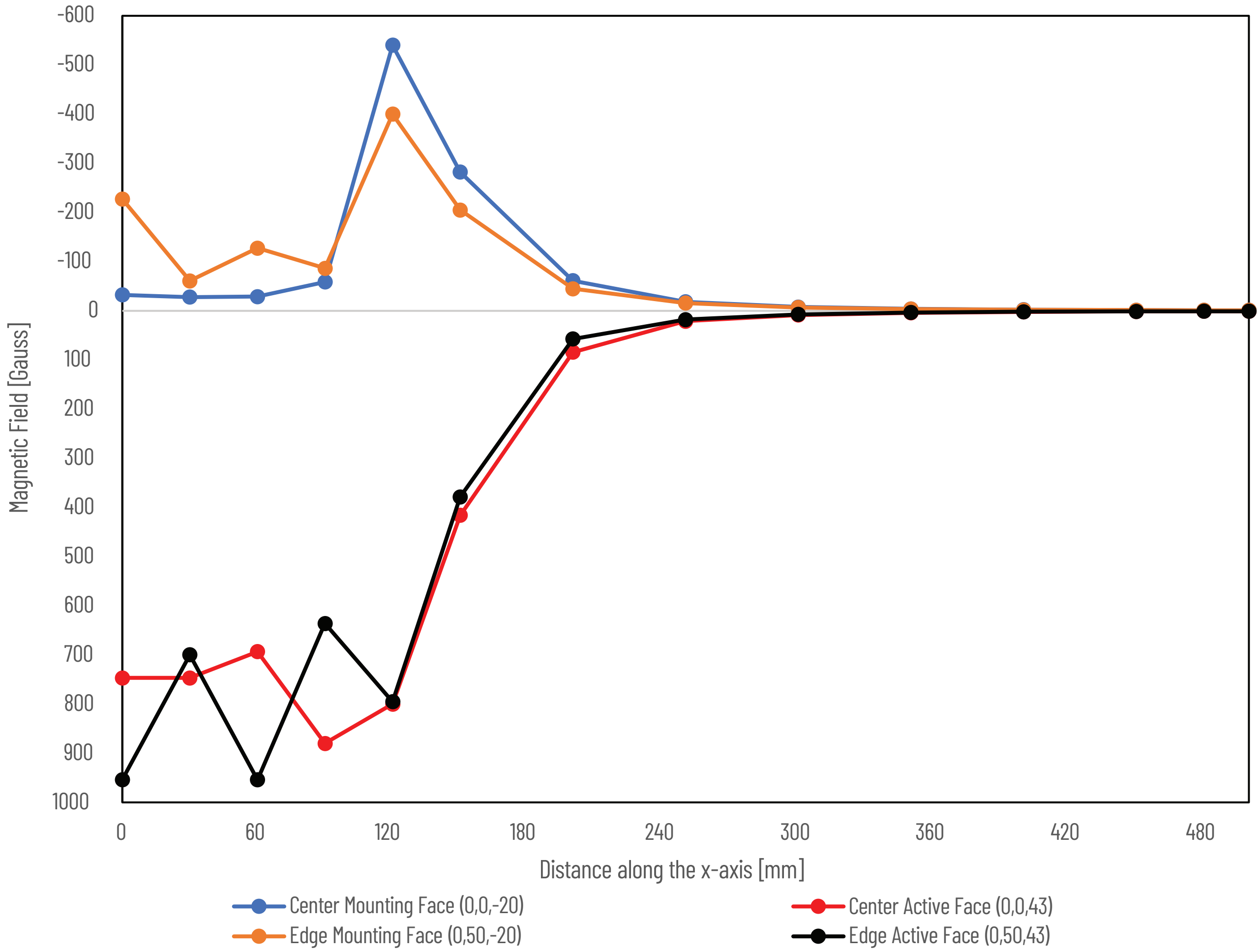
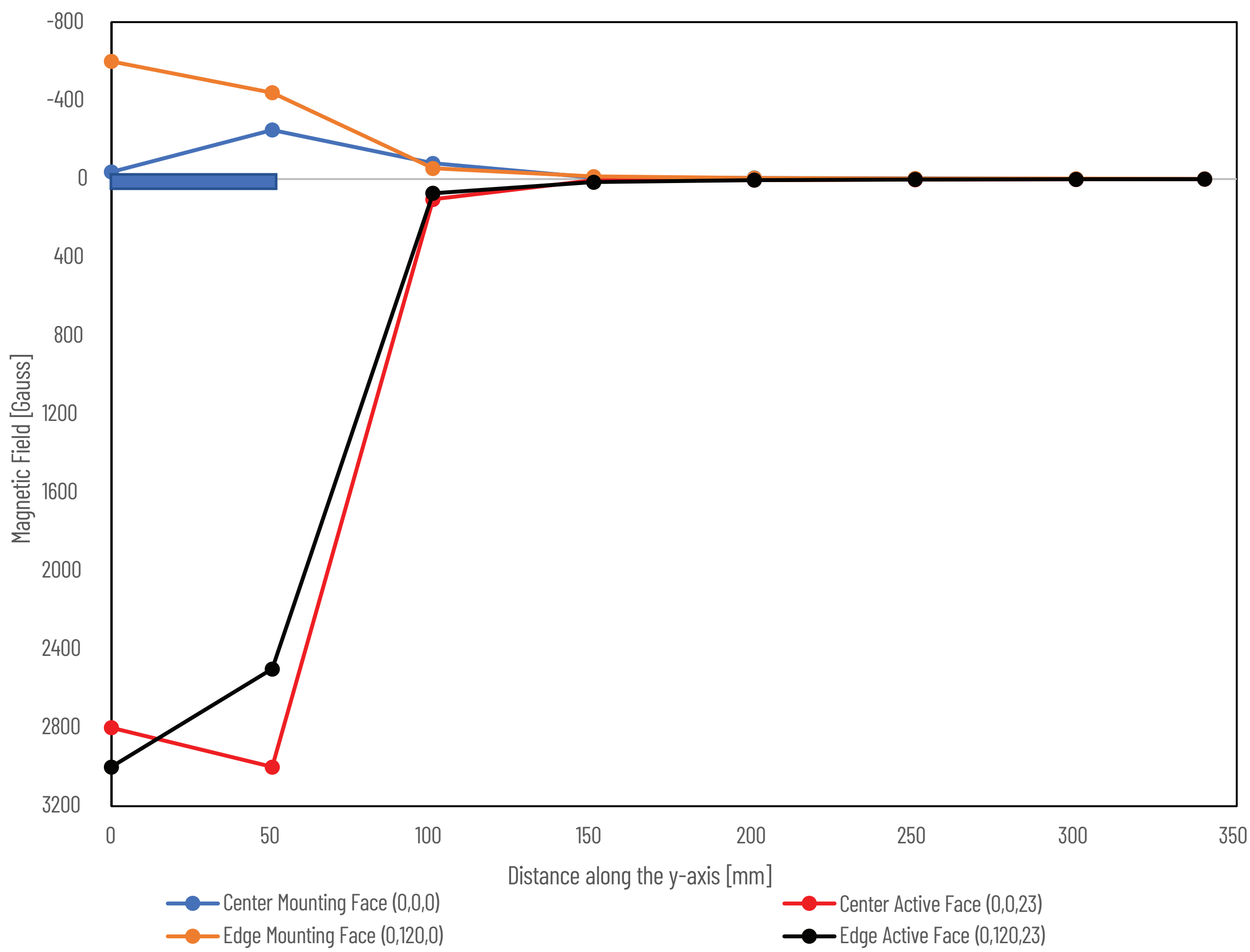


Figure 85 shows the magnetic field magnitude at the edge and center positions of the magnet array along the direction of travel (Y-axis) with no Z-axis offset to the mounting and active face of the magnet array.

Figure 85 - Magnetic Field Magnitude Along Y-axis with No Z-axis Offset



Magnetic Field Shielding

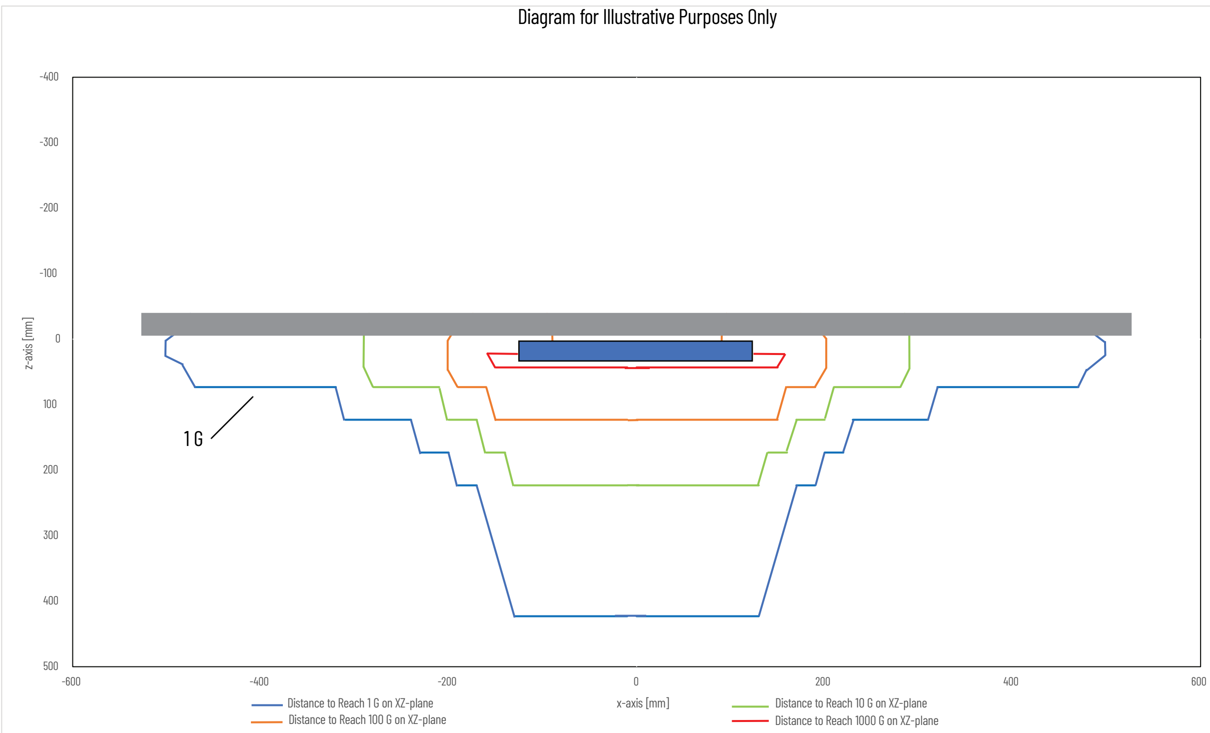
The magnet array's magnetic field can be shielded by the addition of ferromagnetic metal. Metals such as iron, nickel, or cobalt can work as a shield.

Permeability is the ability to redirect magnetic flux, in effect providing a short circuit path to steer the flux away from the area one is trying to shield. Higher permeability materials are better than lower permeability materials. Also consider the saturation point (the point at which the material loses the ability to steer additional magnetic flux) and the thickness of the material. Thinner materials saturate at a lower flux density than thicker ones. Once the material saturates, the shielding effect diminishes. If saturation is an issue, multiple layers of material can be used.

Steel is commonly used because it is inexpensive and widely available. It saturates around 22 kg and has a permeability from 1000 to 3000 times 0μ (the permeability of free space). Steel is a good shielding material for applications involving large, powerful neodymium magnets due to the higher saturation point of steel. In these cases, steel provides good attenuation and a much higher saturation threshold.

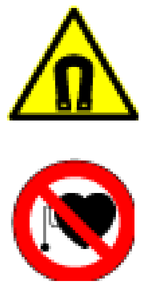
Figure 86 provides an example of the effect on the magnetic field when using a shielding material above the mounting face of a magnet array.

Figure 86 - Example of using a shielding material above the mounting face of a magnet array



Magnet Array Safety and Handling

See Handling Magnet Arrays on page 14 for important magnet array safety and handling information.



WARNING

Magnetic Field Hazard

The mover uses strong magnets.

There is a risk of health hazard for persons with heart pacemakers, metal implants, hearing aids, and other medical electronic implants while in proximity of magnetic and magnetic-field producing components. The magnetic field that is generated can disrupt the functionality of automatic implantable cardioverter defibrillators (AICD). People with cardiac pacemakers must stay away from the magnet arrays.

CAUTION

Magnetic Fields

Strong magnets in use.

To avoid damage to watches, electronic instruments, and magnetic media (for example, cell phones, memory disks/chips, credit cards, and tapes) keep these items away from the magnet arrays.

Magnetic Field Summary

The magnetic field is largest below the active face of the QSHT magnet array, where it interacts with the motor for propulsion. Due to the orientation of the magnet array, the active face direction fields are stronger than the mounting face directional fields of the magnet array and require more distance to reach 1G in the Z-axis.

Adding shielding material, such as a steel sheet above the mounting face, reduces the distance at which the magnetic field dissipates to ambient levels. Factors that affect shielding performance are the shape, size, and thickness of the shield and distance from the shield to the array.

QuickStick Motors Transport System Installation

This chapter provides an overview of the installation requirements for the QuickStick® components that are used in a transport system.

IMPORTANT	Before you complete any installation instructions, review Appendix C - QuickStick 150 Site Requirements on page 159.

For all transport system installation information for the QSHT, see QuickStick HT™ User Manual, publication MMI-UM007.

Included in this chapter are:

- QuickStick (QS) transport system component inspection guidelines.
- QS component installation including: hardware and system installation, facilities connections, and software installation and configuration.
- Transport system testing using demo scripts.

For QS motor installation, see the user manual for your respective motor in Additional Resources on page 16.

SHOCK HAZARD: Do not attempt the procedures in this document unless you are qualified to do so and are familiar with solid-state control equipment and the safety procedures in the Standard for Electrical Safety in the Workplace, publication NFPA 70E.

QuickStick System Installation and Commissioning

Use the process detailed in Figure 87 on page 118 to guide your system and QS motor installation, network configuration, and communication settings for your QuickStick and QuickStick HT transport systems.

Figure 87 - Workflow for QuickStick System Installation and Commissioning

Review manuals.

Familiarize yourself with the system components.

See Additional Resources on page 16

Go to rok.auto/pcdc

1. Click Downloads by Product.
2. Search for "QuickStick".
3. Select the desired QuickStick product and version.
4. In the selection box, click (Downloads).

Design and install the transport system.

See this manual (MMI-RM001).

Also see the applicable User Manual for your QuickStick motor:
- MMI-UM006 (QS 100)
- MMI-UM047 (QS 150)
- MMI-UM007 (QSHT)

Install the motor and components.

See the applicable User Manual for your QuickStick motor:
- MMI-UM006 (QS 100)
- MMI-UM047 (QS 150)
- MMI-UM007 (QSHT)

See also, these topics in this manual:
- Transport System Installation Overview on page 121
- Facilities Connections on page 135
- Software Overview on page 136

Install the node controllers.

See MMI-UM013

Install the MagneMotion System Configurator on a PC for user access.

See MMI-UM046
Review these topics:
- Introduction
- Use the MagneMotion System Configurator
- UI Reference

Create the Node Controller Configuration File.

See MMI-UM046
Review these topics:
- Use the MagneMotion Configurator
- Transport System Layout
- Transport System Configuration

See also: MMI-UM001

Set the IP address for each node controller and upload the configuration, image, and type files.

See MMI-UM001
Review these topics:
- Node Controller Administration - Console
- Web Interface Reference

For motors with Ethernet, create and upload the MICS file.(1)
See Appendix D on page 163.

See also: MMI-UM001
Review this topic:
- Node Controller Administration - Console

Restart Services

Program motors with ERF image files.

See the applicable User Manual for your QuickStick motor:
- MMI-UM006 (QS 100)
- MMI-UM047 (QS 150)
- MMI-UM007 (QSHT)

Test and debug.(2)

See MMI-UM010
Review these topics:
- Using the NCHost TCP/IP Interface Utility
- Demo Scripts

See also:
- MMI-UM006 (QS 100)
- MMI-UM047 (QS 150)
- MMI-UM007 (QSHT)

Configure the host controller.(3)

TCP/IP or EtherNet/IP:
- See MMI-UM003 (TCP/IP)
- See MMI-UM004 (EtherNet/IP)

Review these topics:
- Transport System Control
- Application Notes

(1) This configuration does not apply to QS 100 motors.
(2) Use the MagneMotion Virtual Scope Utility to confirm PID tuning for all motors, if necessary. See the MagneMotion Virtual Scope Utility User Manual, publication MMI-UM011.
(3) Configure LSM Synchronization for QS 100 motors, if necessary. See the MagneMotion LSM Synchronization Option User Manual, publication MMI-UM005.

Required Tools and Materials

These tools are required to install, troubleshoot, and maintain a QuickStick transport system.

- Metric hex wrench set
- Torque wrench (0.9…26.0 N•m [8…230 lb•in] range) with metric and Torx bits
- Soft jaw pliers
- Screwdriver, small flat blade
- Screwdriver, Phillips®
- 12 in. machinist square
- Laser level, rotary
- Digital multimeter
- Thread locker (adhesive or lock washers)

Component Inspection

The QS transport system components are shipped in separate packages. Open each package carefully following the steps that are provided in Shipping and Returns on page 120; inspect and verify the contents against the shipping documents. Report any damage immediately to the shipper.

One set of shipping documents is attached to the outside of the main shipping crate for easy access.

The number and contents of the shipping packages depends on the items purchased. See the shipping documents for the exact contents.

WARNING

Strong Magnets

ATTENTION: To avoid severe injury, people with pacemakers and other medical electronic implants must stay away from the magnet arrays.
To avoid severe injury from strong magnetic attractive forces:

- Handle only one vehicle or magnet array at a time.
- Do not place any body parts, such as fingers, between a magnet array and any QS motors, ferrous material, or another magnet array.
- Magnet arrays or vehicles not being used must be secured individually in isolated packaging.

WARNING: To avoid damage to watches, instruments, electronics, and magnetic media, keep metal tools, metal objects, magnetic media (for example, memory disks/chips, credit cards, and tapes) and electronics away from the magnet arrays.


WARNING

Magnetic Field Hazard

The mover uses strong magnets.

There is a risk of health hazard for persons with heart pacemakers, metal implants, hearing aids, and other medical electronic implants while in proximity of magnetic and magnetic-field producing components. The magnetic field that is generated can disrupt the functionality of automatic implantable cardioverter defibrillators (AICD). People with cardiac pacemakers must stay away from the magnet arrays.


CAUTION

Heavy Lift Hazard

The QS motors can weigh as much as 37.6 kg (83 lb). Failure to take the proper precautions before moving them could result in personal injury.

Use proper techniques for lifting and safety toe shoes when moving or installing any QS components.

Shipping and Returns

Save all shipping packaging for possible future use. If any of the components are shipped or returned, the original shipping packaging must be used.

1. Upon receiving the packages, visually verify that the packaging is not damaged. Inform the freight carrier of any inspection discrepancy.
2. Open each shipping package and verify the contents against the shipping documents.
3. Carefully inspect the components and all additional items for signs of shipping damage.
4. Move all items to their destination, see Transport System Installation Overview.

If a QS component must be shipped, either for return to Rockwell Automation or to another location, it must be packaged properly to make sure that it arrives undamaged. The following procedure provides the correct method for handling and packaging QS components for shipment.

CAUTION

Electrical Hazard

Before beginning this procedure, the QS transport system must be shut down. The shut-down procedure is used in the normal shutdown of the QS transport system. This procedure removes the power source and all other facilities to the components and provides guidelines for lockout/tagout. This procedure is NOT the same as an EMO circuit or other safety interlock.

For shut-down procedures, see the applicable user manual for your motor in Additional Resources on page 16.

CAUTION

Heavy Lift Hazard

The QS motors can weigh as much as 37.6 kg [83 lb]. Failure to take the proper precautions before moving them could result in personal injury.

Use proper techniques for lifting and safety toe shoes when moving any QS components.

Transport System Installation Overview

The QS transport system must be properly located within the facility so that other equipment can interface to it as required. The location must also make sure that there is adequate space for service access and for proper operation. Make sure that installation of the QS components provides access to items required for service after installation, such as connection panels. Once properly located, the QS transport system must be leveled and secured to the floor or other rigid mounting points to help prevent any movement.

Hardware Installation

Make sure that the track supports and guideways are properly prepared to receive the motors, cables, and vehicles with magnet arrays. The custom supports and guideways can require additional adjustments for proper operation of the motors and vehicles with magnet arrays.

All component preparation and installation must adhere to and follow all safety warnings and instructions, including but not limited to the safety considerations described in the Preface of this document.

Installation Overview

This sequence provides an overview of the QS transport system installation.

IMPORTANT	Make sure that the equipment or track system where the QS motors are mounted and the motor mounting surfaces are properly grounded to safety (earth) ground.

1. Assemble a section of the track, including the guideway, motor mounts, and stand, see Assemble the Guideway on page 122 and Vehicle Integration on page 134.
2. Prepare and level the equipment where the motors are going to be mounted, see Level the Transport System on page 122.
3. Secure the track to the floor or other equipment as required, see Secure the Transport System on page 122.
4. Install the power supplies, node controllers, network switches, and cables, see Electrical Specifications on page 24.
5. Make all communication, network, and power connections, see Facilities Connections on page 135.
6. Assemble the next section of the system following step 1 through step 5 and connect it to the previously installed section verifying that both sections are in the same plane and level to each other.
7. Continue assembling and installing sections of the track until the system is complete.
8. Create the necessary communication and software files. See Software Overview on page 136.

For information on these topics, see the applicable user manual for your motor in Additional Resources on page 16:

- System power up and operating features checks, safety features, and connections.
- Motor, magnet array, vehicle, and cable installation.
- Connections to motors, other than power and communication cables.

System Installation

Assemble the Guideway

The guideway with the motor mounts must be located and attached to stands or other equipment as required. Each guideway section must be connected to the guideway sections on either side of it to form the complete system layout. The layout can be broken into sections for ease of assembly. When breaking the layout into sections, make sure that each section is as self-contained as possible.

Before completing a closed guideway, add the vehicles by sliding them onto a section of guideway that has been installed, see Vehicle Integration on page 134.

Level the Transport System

Once the track assembly is complete, make sure that it is properly located and that all sections of the track are level.

1. Establish a datum for the system (interface to existing equipment).
2. Use a laser level to identify the datum throughout the installation area.
3. Make sure that all sections of the track are level and correctly referenced to the datum and adjust the track as necessary.

Secure the Transport System

Secure the QS transport system to the floor to help prevent system movement. Tie-downs for facilities that require earthquake protection are the responsibility of the user. Secure the transport system to the floor and to any other equipment as required.

IMPORTANT	Make sure that the transport system is properly grounded to safety ground (earth).

Prepare Motor Connections and Electronic Configuration

When connecting motors and electronics for the QS 100 motor, see the QuickStick 100 User Manual, publication MMI-UM006.

The electronics for the QS transport system can be attached to the transport system stands or positioned elsewhere in the facility in an appropriate location.

IMPORTANT	Make sure that all mounting surfaces and mounting hardware provide a conductive path to the transport system ground connection.

The QS transport system motors can use different network style connection schemes depending on the application. See Motor Communications: Straight Paths on page 127 and Ethernet Motor Communication Recommendations on page 128. The following procedure provides steps for connecting the motors as shown in the simplified wiring diagrams in Figure 91 ... Figure 95. Power and communication cables must be shielded from damage and easily accessible for service.

The following procedure provides the information that is required to make all motor connections as shown in Figure 120 on page 160. For detailed motor electrical connections and power connection pinouts, see the QuickStick 150 User Manual, publication MMI-UM047.

ATTENTION: Never connect or disconnect the power lines while power is applied to the QS transport system as damage to internal components can result.

IMPORTANT	The NC-E and QS motors do not support Power over Ethernet (PoE). Never connect these components to a powered Ethernet network as damage to internal components can result.

Prepare Electronics on the Transport System

Some track systems are designed to accept mounting of the electronic components of the transport system, such as node controllers, network switches, and power supplies. For these systems, mount these components, as required. For track systems that are not designed for mounting the electronic components, mount the components in racks or other control cabinets.

Stratix Managed Switch Configuration

The Allen-Bradley® Stratix® Ethernet switch is recommended for use with the MagneMotion® Ethernet motors. For full setup and operating information see the Stratix Managed Switches User Manual, 1783-UM007. This section covers the specific settings that are required for proper operation with the QS motors. For information on how to configure your managed switch for a QS motor, see the MagneMover® LITE™ Ethernet Motor Configuration and Communication User Manual, publication MMI-UM031.

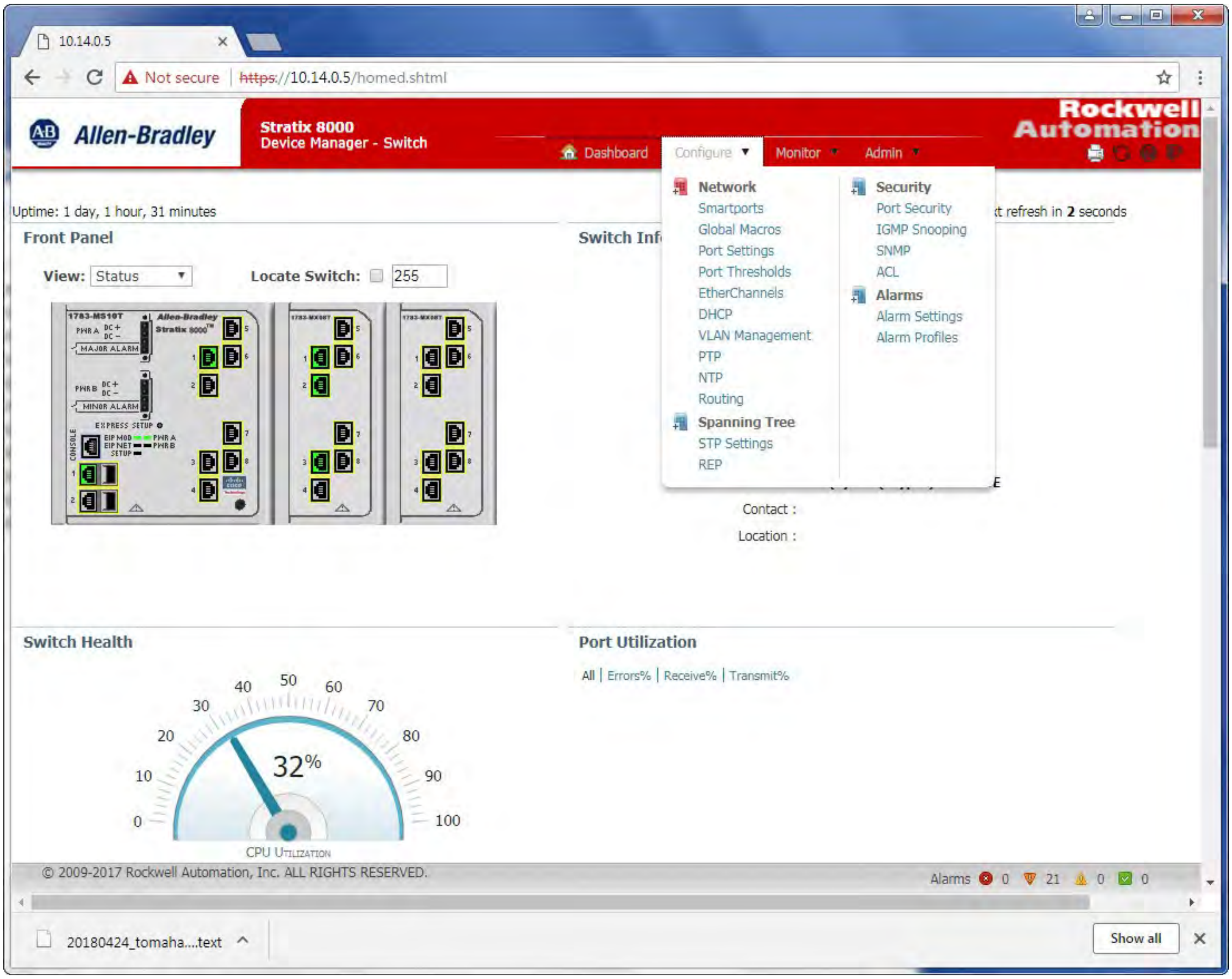
Express Setup

Use Express Setup to assign the switch an IP address and run the global macro to set initial configuration parameters.

Configure Network Settings

Once the initial configuration is complete, access to the switch is made through the network by its IP address as shown in Figure 88.

Figure 88 - Stratix Switch Main Menu

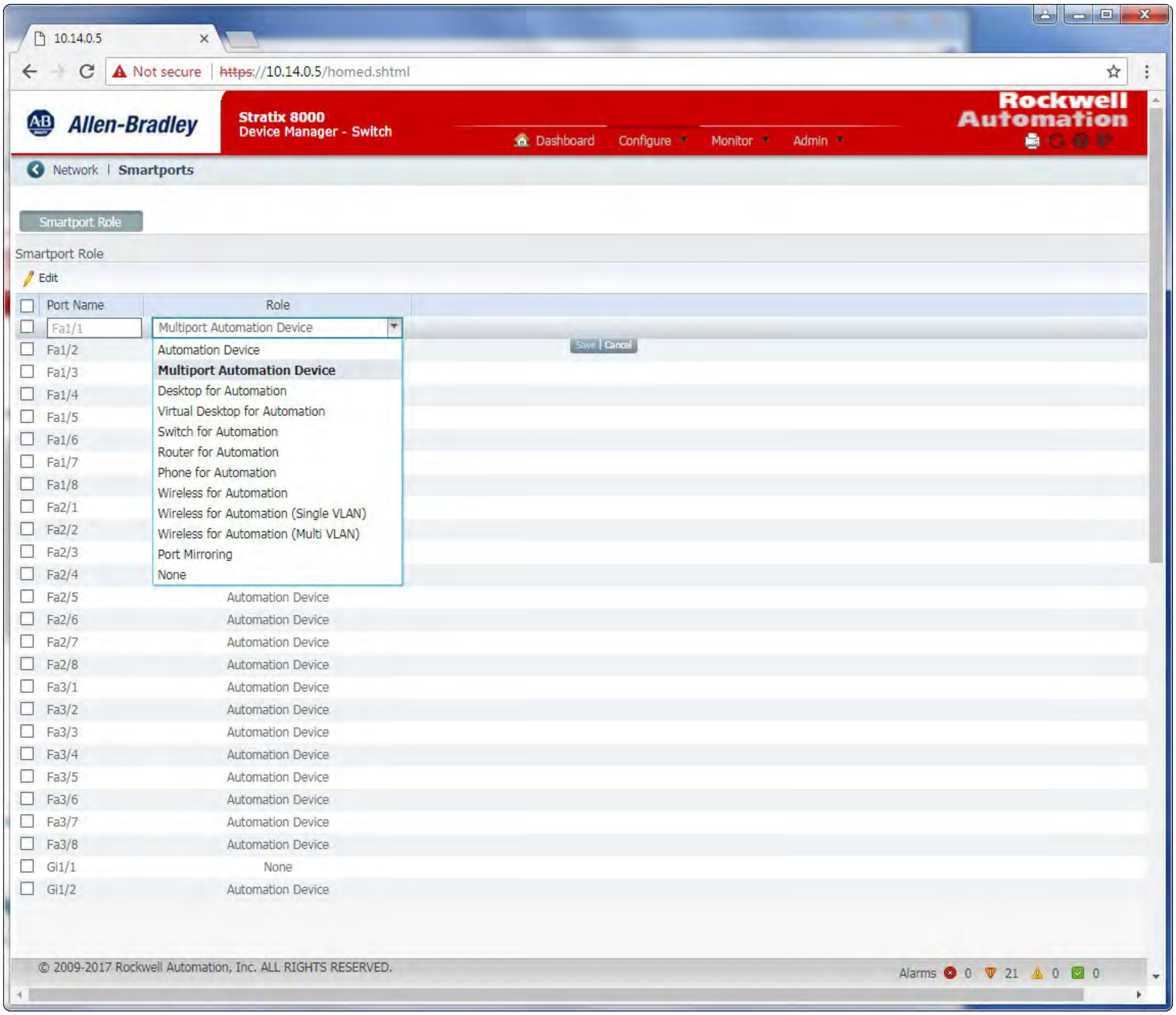


Network | Smartports

Smartports are recommended configurations for switch ports. These configurations, referred to as port roles, optimize the switch connections and provide security, transmission quality, and reliability for traffic from the switch ports. Port roles also help prevent port mis-configurations.

Select the Configure tab on the Device Manager for the switch as shown in Figure 88. From the Network menu, select Smartports to display the Smartport Role configuration as shown in Figure 89 on page 125. For each port where a motor is connected, select Multiport Automation Device.

Figure 89 - Stratix Switch Smartport Setting

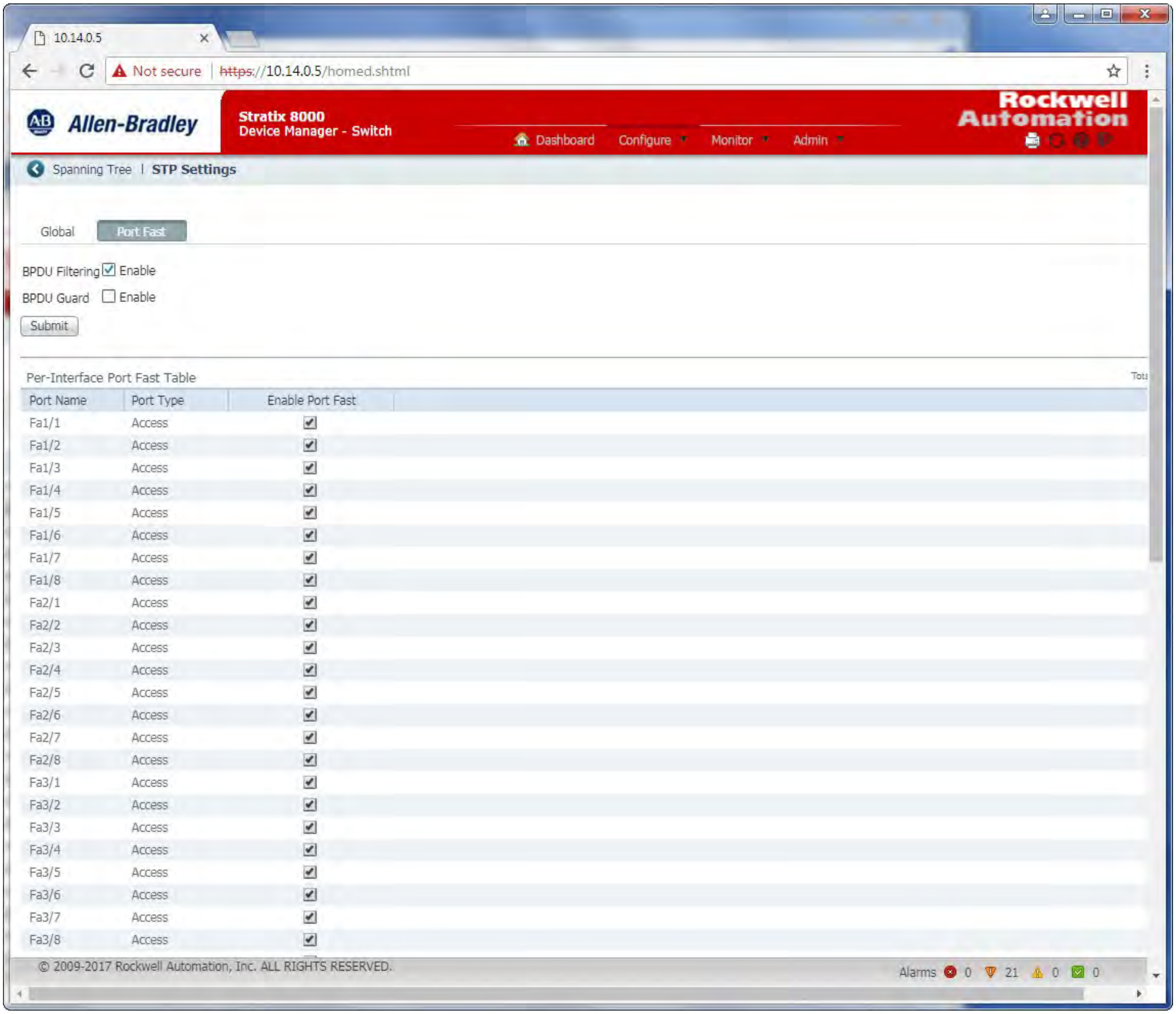


Spanning Tree | STP Settings

STP, the IEEE 802.1D bridge protocol, is a Layer 2 link management protocol that provides path redundancy and helps prevent loops in the network.

Select the Configure tab on the Device Manager for the switch as shown in Figure 88 on page 124. From the Spanning Tree menu, select STP Settings to display the STP configuration as shown in Figure 90 on page 126. Select the PortFast tab and make sure each port where a motor is connected is configured as shown in Figure 90 on page 126 (Enable Port Fast is selected).

Figure 90 - Stratix Switch PortFast Setting



Mount Node Controllers

Locate the node controllers close to the nodes that they are responsible for to minimize the length of all wiring. The node controllers can be oriented in any direction that is required, make sure the service and exclusion zones that are identified in the MagneMotion Node Controller Hardware User Manual, publication MMI-UM013 are maintained.

Motor Communications: Straight Paths

Figure 91 on page 127...Figure 95 on page 128 show simplified connection diagrams of the different methods for connecting a simple string of motors by using an Ethernet network. The specific connection method that is used depends on the application for the motors.

Figure 91 - Ethernet Motor Wiring – One Path, One Ethernet Chain

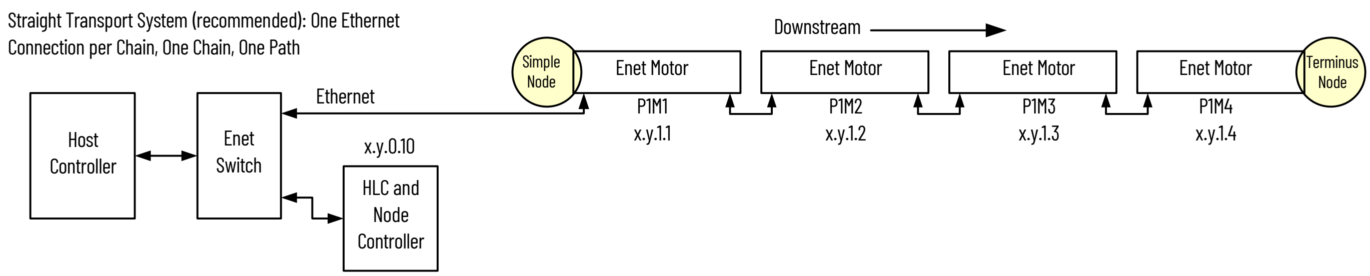


Figure 92 - Ethernet Motor Wiring – One Path, Two Ethernet Chains

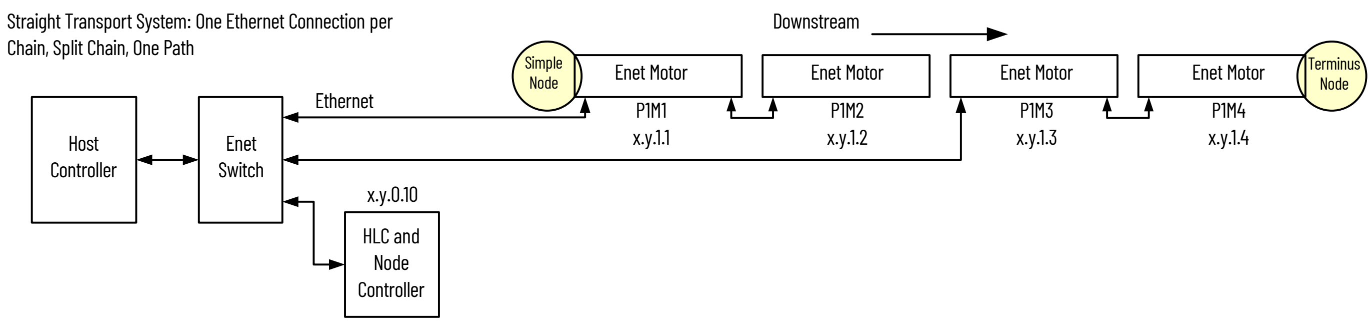


Figure 93 - Ethernet Motor Wiring – One Path, Ethernet Star

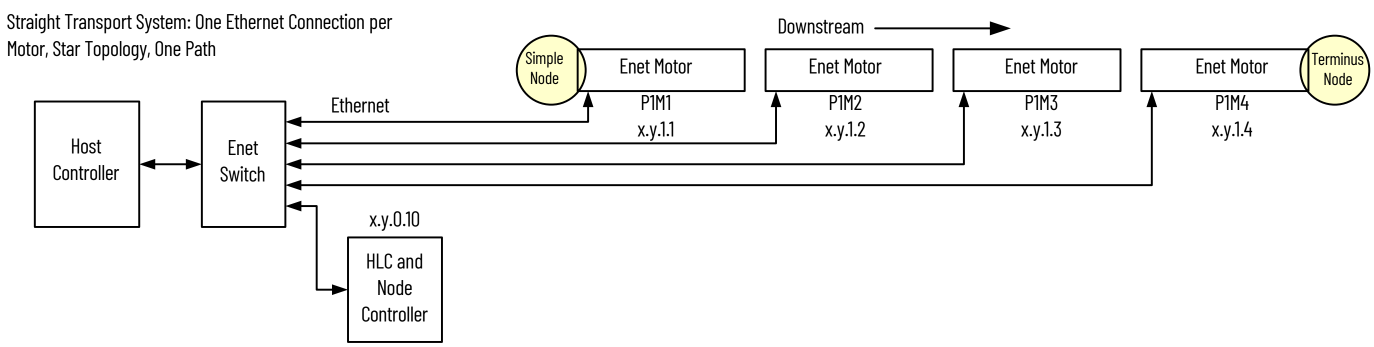


Figure 94 - Ethernet Motor Wiring – One Path, Ethernet Star, Multiple Ethernet Switches

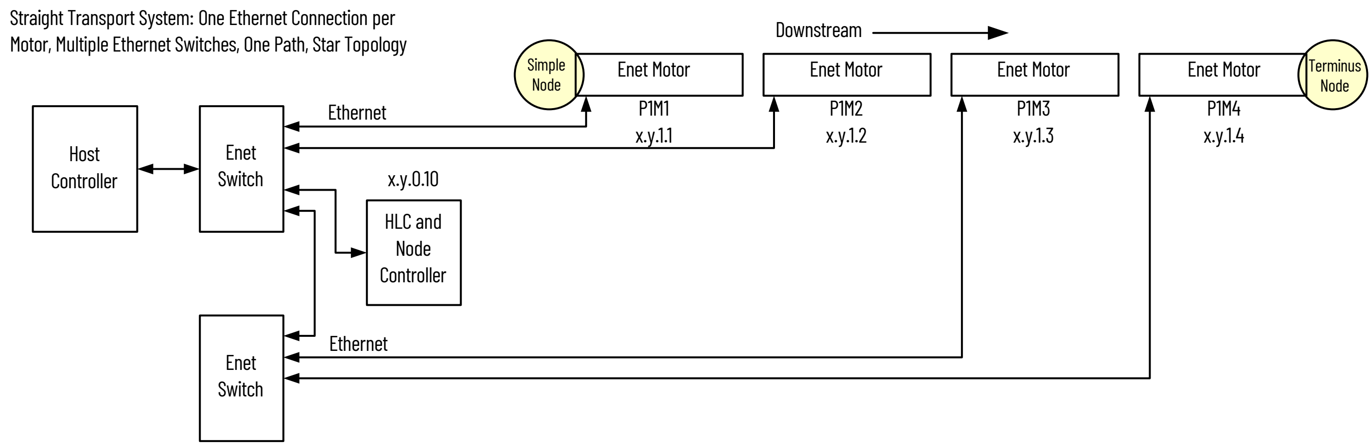
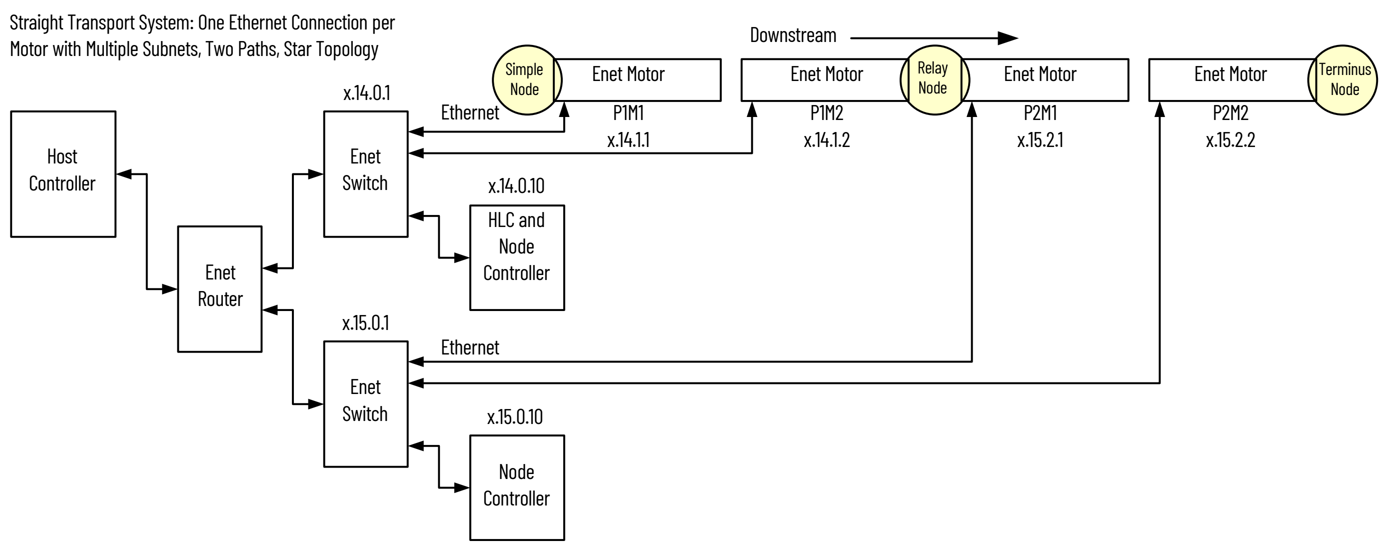


Figure 95 - Ethernet Motor Wiring – Two Paths, Ethernet Star, Multiple Node Controllers



Prepare Motor Communication Cables

See Figure 97 on page 131 for the communication connection locations on the QS 150 motors and the MagneMotion Node Controller Hardware User Manual, publication MMI-UM013 for the communication connection locations on the node controllers. See Figure 91 on page 127 ... Figure 95 for detailed examples of the wiring diagrams.

All motors must be able to communicate with each other via Ethernet. Ethernet motors can be daisy chained up to 25 motors in a line. See the MagneMotion System Configurator User Manual, publication MMI-UM046 for more information about nodes and paths.

Ethernet Motor Communication Recommendations

- The Ethernet track topology for the motors that use Ethernet for communication is defined in a MagneMotion Information and Configuration Service (MICS) file, see Appendix D on page 163 for MICS file configuration details.
- Recommended Ethernet addressing scheme, see Figure 91 on page 127):

  Network.Path.Motor

  - Network addresses are used for network configuration.
  - Path 0 addresses are used for Subnet configuration:

    x.y.0.m

Where:

m – Node controllers/Network devices

- Path p addresses are used for motors on that path:

  x.y.p.m

Where:

p – path
m – motor

- Switches are two logical track paths, only one IP address is assigned.
- Maximum number of motors per Ethernet chain = 25.
- The two Ethernet ports on the motors are not DLR enabled.
- Factory network design must minimize extra traffic on the physical network that the transport system is using.
  - Only use linear (chain) or star Ethernet connection topologies.
  - When using a linear topology, if any device becomes disconnected, all devices downstream of that device lose communication.
  - Closed-loop (ring) Ethernet connections must be avoided (industry standard Ethernet practice) to help prevent network saturation.
  - Only pass transport system communication through the Ethernet chains in the transport system.
  - Large amounts of traffic can degrade the performance of the transport system.
- Standard IP UDP communication, low latency.
- 100BASE-TX Fast Ethernet (IEEE 802.3u) compliant.
- Minimum of Cat 5 cabling is required.
- Ethernet communication topology is independent of transport system configuration (Ethernet chaining does not have to follow the physical path layout).
- The use of Allen-Bradley® Stratix® Managed Ethernet Switches is recommended to deliver the required network performance.
- Ethernet chains can consist of multiple paths (as defined in the transport system layout drawing).
- Chains do not need to start at the beginning of a path.
- If all motors in a path are not part of the same Ethernet chain, all chains the path is a member of must connect to the same network as the node controller.

Ethernet and Motor Power Connection Examples

The QS 150 motors, which use Ethernet for motor to motor communication and for motor to node controller communication can use different network topologies depending on the application. When using Ethernet, all motors in a specific path must be on the same network as the node controller. Additionally, all motors and their location in the transport system must be defined in the MICS file, see Appendix D on page 163.

For installation instructions for your motor, see the applicable user manual for your motor in Additional Resources on page 16.

SHOCK HAZARD: Do not attempt the procedures in this document unless you are qualified to do so and are familiar with solid-state control equipment and the safety procedures in the Standard for Electrical Safety in the Workplace, publication NFPA 70E.

When performing any of the following procedures, adhere to and follow all safety warnings, local and area regulations and guidelines, and installation instructions.

Figure 96 - Node Controller Connections to QS 100 Motors

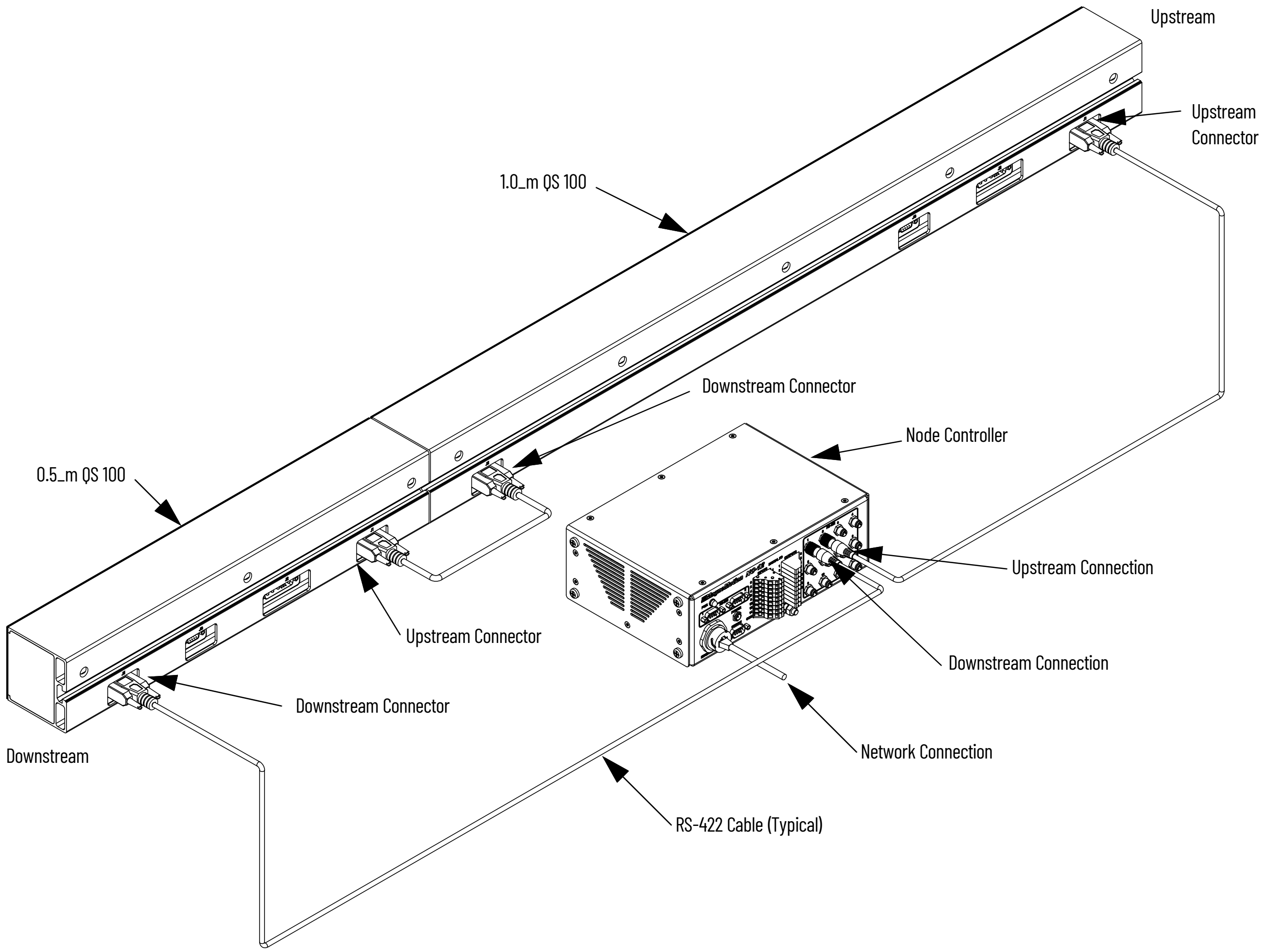


Figure 97 - Ethernet Communication Connections to QS 150 Motors

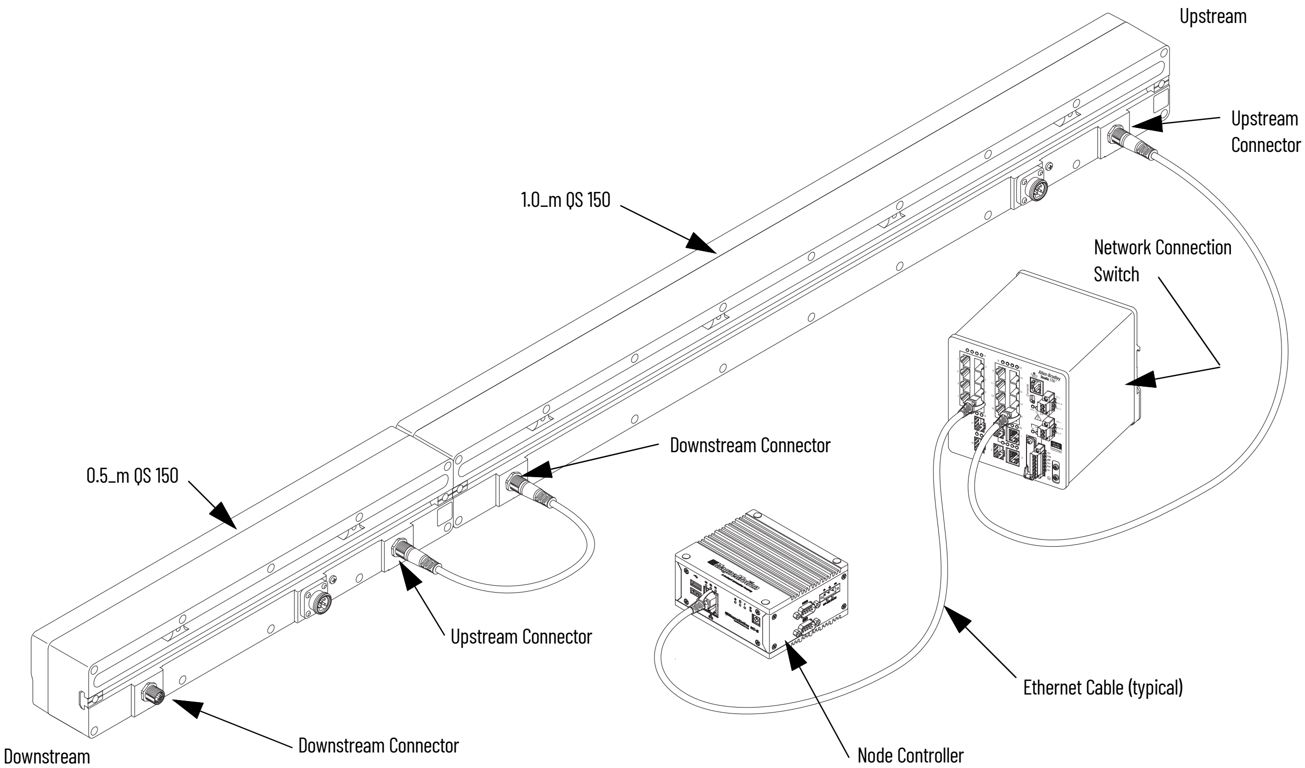


Figure 98 - QuickStick 100 Motor Power Connections

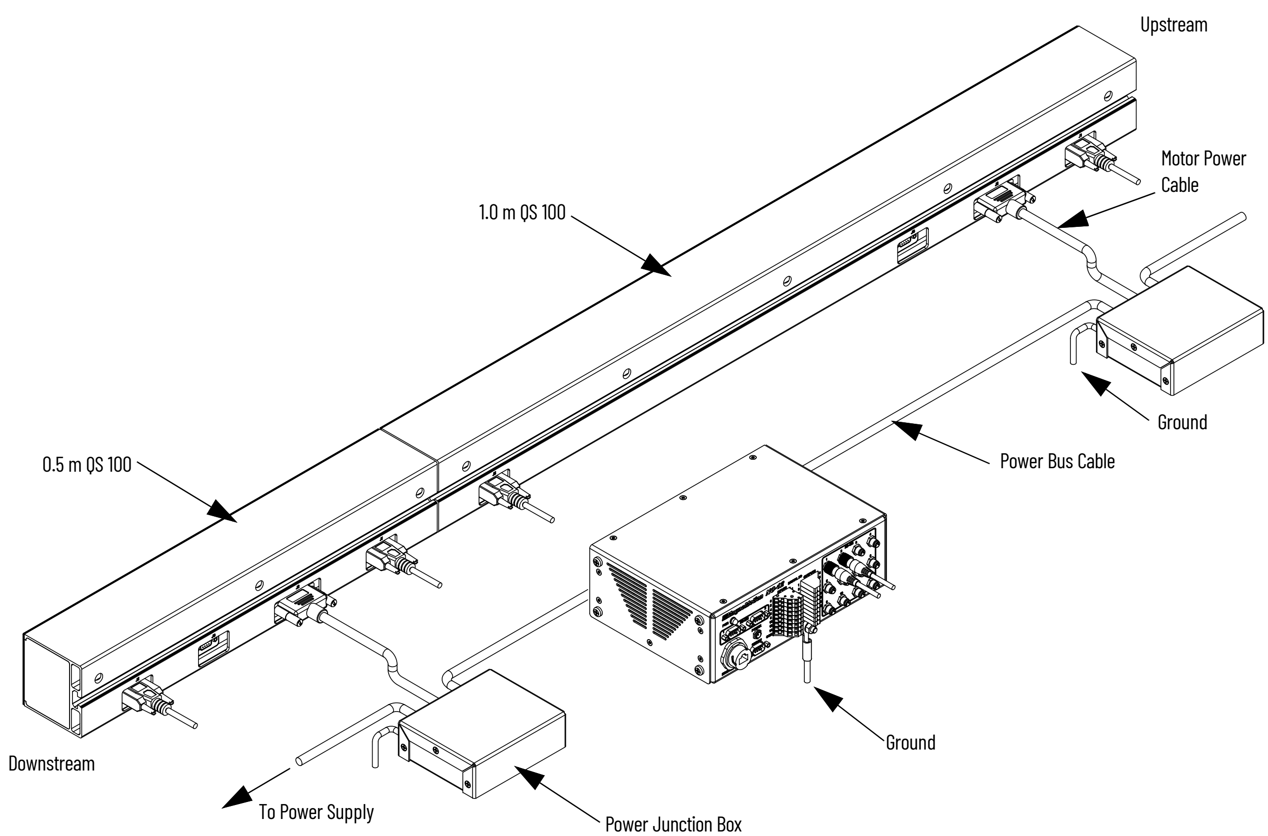


Figure 99 - QuickStick 150 Motor Power Connections - Two Motors

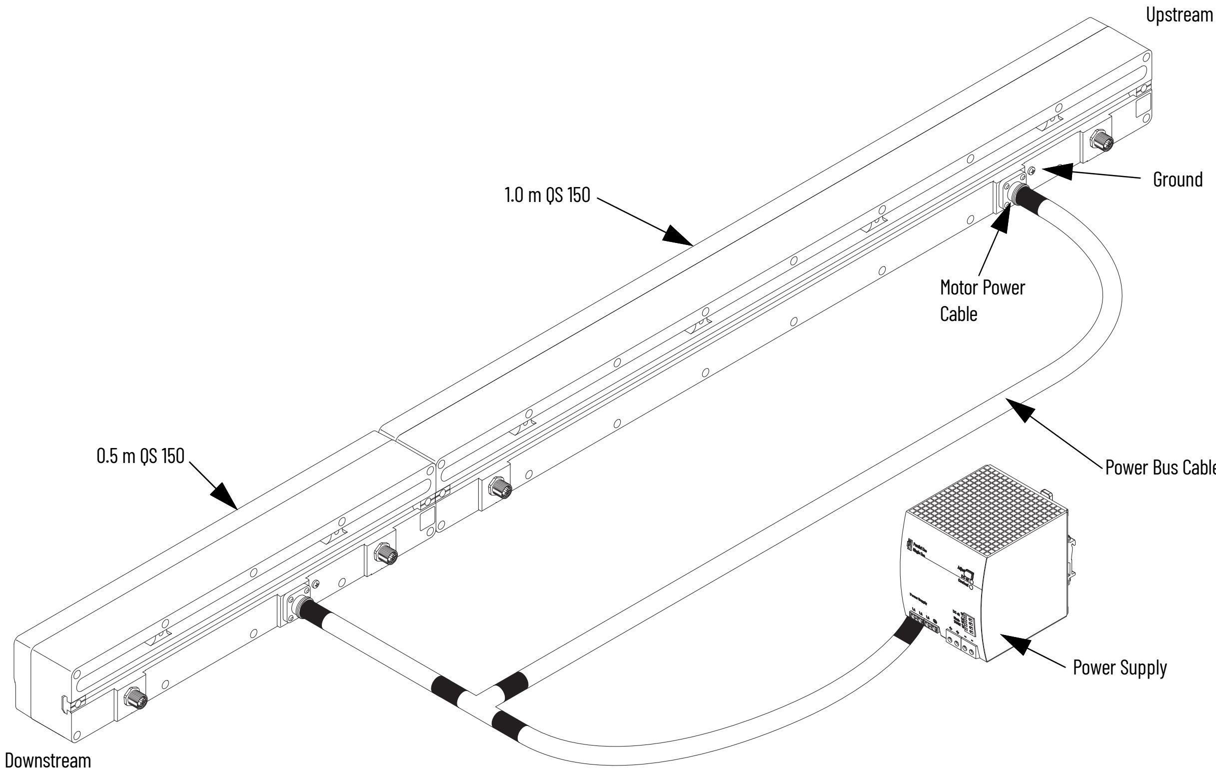
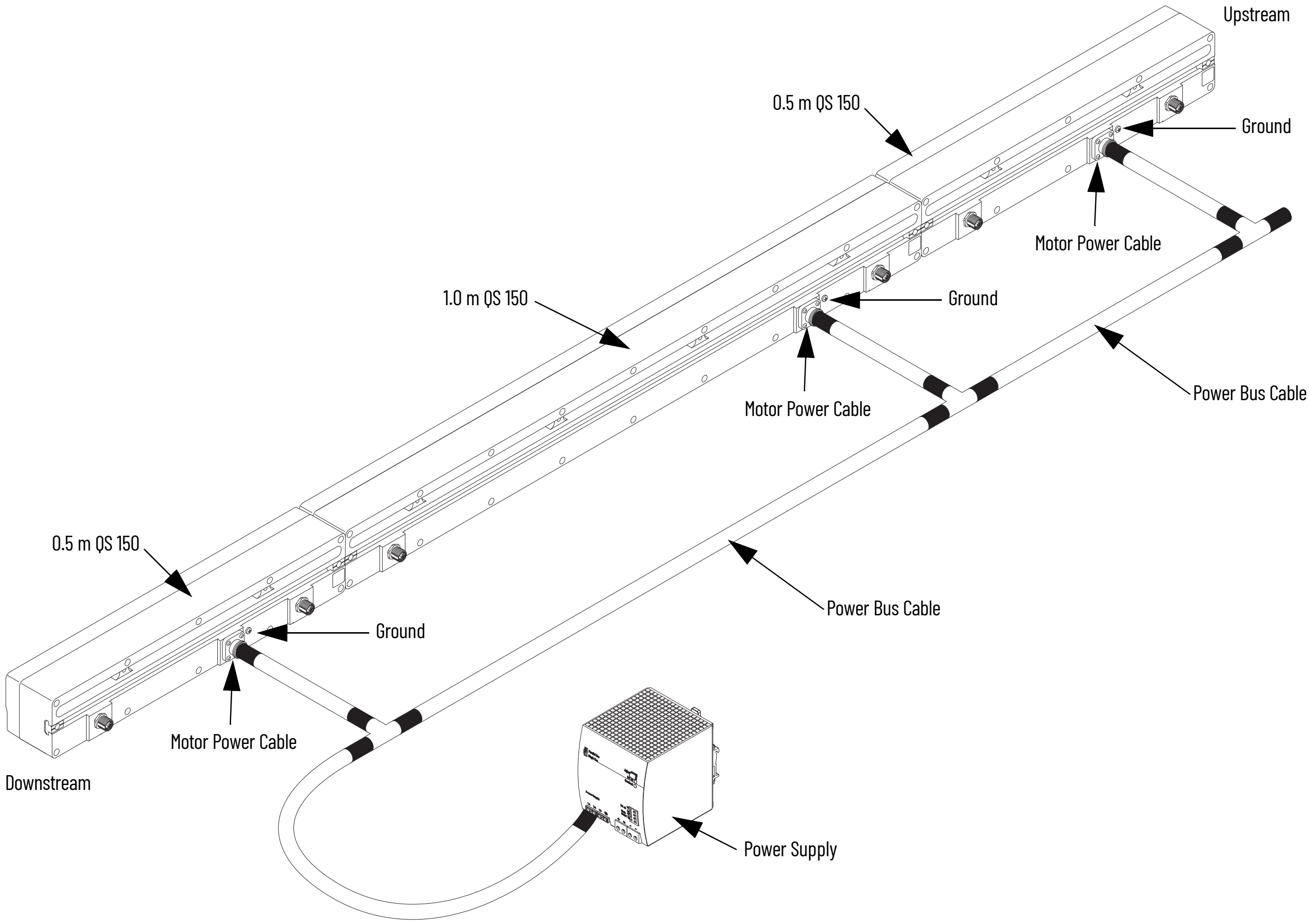


Figure 100 - QuickStick 150 Motor Power Connections - Three Motors



IMPORTANT	If a user-supplied power supply is used, it must be NRTL/ATL approved.

The AC power connections are made later, see Facilities Connections on page 135. See Electrical Specifications on page 24 to make sure that all power wiring is properly sized. See Table 10 on page 76 and Table 11 on page 79 when connecting the power cables to the motors to make sure that each chain of motors does not exceed the rated output of the power supply.

Vehicle Integration

For additional information on vehicle integration, see Additional Resources on page 16 for the user manual applicable to your QS motor.

WARNING

Strong Magnets

WARNING: To avoid severe injury, people with pacemakers and other medical electronic implants must stay away from the magnet arrays.
To avoid severe injury from strong magnetic attractive forces:

- Handle only one magnet array at a time.
- Do not place any body parts, such as fingers, between a magnet array and any QS motors, ferrous material, or another magnet array.
- Magnet arrays not being used must be secured individually in isolated packaging.

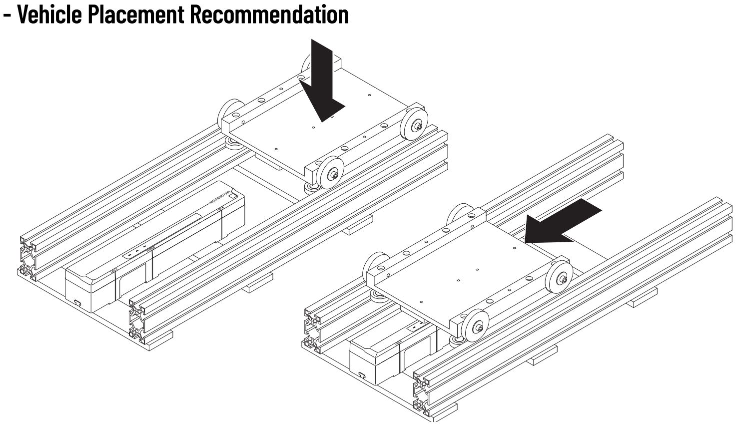
To avoid damage to watches, electronic instruments, and magnetic media (for example, cell phones, memory disks/chips, credit cards, and tapes), keep these items far away from the magnet arrays.

Vehicles can be added or removed as needed once the QS transport system is installed.

The design of the guideway and of the vehicle determines the ease of adding vehicles. That is, an open guideway allows vehicles to be placed onto it, while a closed guideway requires either an opening for placement of vehicles or placement of the vehicles before closing the guideway.

It is recommended that vehicles are pushed in from the end of the motor, not placed down on top of the motor to reduce the risk of a crush hazard. See Figure 101.

Figure 101 - Vehicle Placement Recommendation



Facilities Connections

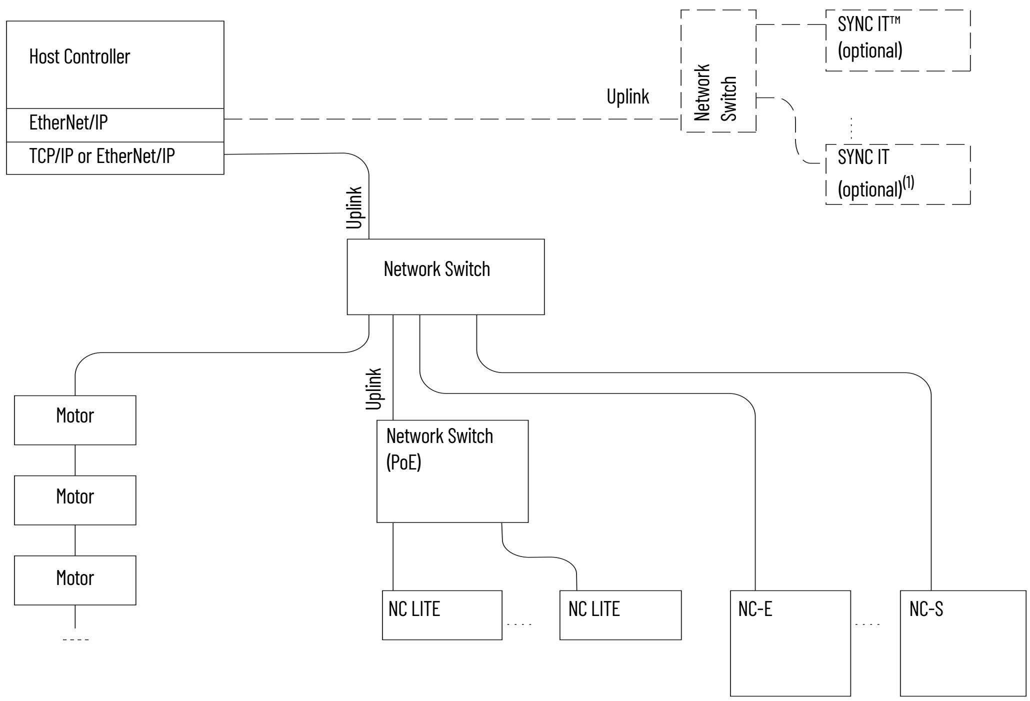
The standard configuration of the QS transport system requires user-supplied electrical power and communication connections. See Electrical Connections on page 136 for descriptions and specifications of all required facilities.

Network Connections

The QS transport system uses communication over an Ethernet network with a host controller for transport system control. The same Ethernet network is used for communication between node controllers. Use a dedicated, separate subnet for the transport system network to eliminate any unrelated network traffic.

The following procedure provides the information that is required to make all network communication and Power over Ethernet connections to the node controllers as shown in Figure 102. See Figure 91 on page 127…Figure 95 on page 128 for motor and network connections.

Figure 102 - Network Communication Connections



(1) SYNC IT is applicable to QS 100 and QS 150 Motors only.

1. Connect a Cat 5 network cable for transport system network communication from the host controller to the Uplink connector on the network switch as shown in Figure 102.

   When using multiple network switches to connect all node controllers, use one switch as a motor controller and connect all other switches to it as shown in Figure 102.

2. Connect a CAT 5 cable for network communication from the switch to each node controller, the MagneMotion Node Controller Interface User Manual, publication MMI-UM001 for the connection locations.
3. Connect an AC power cable from the power distribution on the main power disconnect for the facility to the power connector on the power supplies.

ATTENTION: Do not yet apply power or equipment failure occurs.

Electrical Connections

Electrical power is connected to the QS transport system for operation of the motors and other subsystems. An AC electrical connection is provided on those components that require facility power. See the Table 5 on page 24 for electrical requirements. Make sure that all electrical connections are for the appropriate voltage and power rating.

ATTENTION: Never connect or disconnect the power lines while power is applied to the QuickStick 150 transport system as damage to internal components can result.

1. Connect the power cable to each node controller.
2. Connect the AC power cable from either the optional remote power supply or a user-supplied power supply to the power distribution from the main power disconnect for the facility.
3. Connect the DC power cable to the power connector on each node controller.

Software Overview

Node controllers that are supplied with the QS transport system ship with just a basic node controller software image installed. This image is only used for testing during manufacturing and must not be used to run the transport system. Since different systems run different versions of the software, this basic software must be replaced with the software being used for the transport system. All node controller-related files (node controller image, motor images and type files, and magnet array type files) must be uploaded to the node controller and activated before using the transport system. See the MagneMotion Node Controller Interface User Manual, publication MMI-UM001 for details.

System Testing

Test the QS transport system to verify the proper operation of all nodes, paths, and vehicles. Testing can be accomplished using the NCHost TCP/IP Interface Utility to move vehicles without the host controller to verify proper operation before integrating a transport system into a production environment.

For system testing, troubleshooting, preventative maintenance, and check-out and power up information, see the user manual for your respective motor in Additional Resources on page 16.

Transport System Simulation

This chapter provides information on how to prepare a simulation of the QuickStick® transport system. A simulation can be beneficial to help test and observe system behavior without physically moving vehicles on the transport system.

Transport System Simulation Overview

The QuickStick (QS) transport system can be simulated to verify proper configuration of all nodes and paths and proper motion of commanded vehicles within the transport system. To run a simulation, the system must be fully defined in a Node Controller Configuration File, see the MagneMotion® System Configurator User Manual, publication MMI-UM046, and that file must be loaded onto the node controller being used for simulation, see the MagneMotion Node Controller Interface User Manual, publication MMI-UM001.

Simulated vehicles can be moved during the simulation to verify basic functionality. The motion profile of all simulated vehicles is an ideal profile. This profile assumes that there is no friction between the vehicle and the guideway and that the vehicle is not overloaded for the PID set being specified. The vehicle accelerates and decelerates at the rates that are specified in the command, with a maximum of the values specified in the Node Controller Configuration File.

Simulating the transport system requires one node controller, a fully defined Node Controller Configuration File, and a host controller (either the controller for the transport system or the NCHost TCP/IP Interface Utility).

Configuring a Simulation

1. Configure a node controller to run in Simulation Mode.
   a. Run the node controller web interface, see the MagneMotion Node Controller Interface User Manual, publication MMI-UM001.
   b. Select IP Settings on the main menu.
   c. In the Configured Functions section, make sure that “This box is a High-Level Controller Simulator” is selected.
   d. In the Configured Functions section, make sure that “This box is a Node Controller” is cleared.
   e. In the Configured Functions section, make sure that “This box is the High-Level Controller” is cleared.
   f. Select Apply Changes.
   g. The selected changes are applied.
   h. Select Reboot Controller on the main menu.
   i. The Reboot Controller page is displayed.
   j. Select Reboot Controller.

      The reboot status is temporarily displayed, then the General Status page is displayed once the node controller has rebooted.
2. Download the Node Controller Configuration File from the node controller. If a Node Controller Configuration File does not exist, see the MagneMotion System Configurator User Manual, publication MMI-UM046 to create one.
   a. From the node controller web interface, select Configuration Files on the Main Menu.

b. Under Node Controller Configuration File, select Download.

c. Specify a location for the file download, change the file name as appropriate, and select Save.

The file is named and saved as specified.

3. Edit the Node Controller Configuration File to add simulated vehicles.

The Simulated Vehicle is a simulated version of the vehicle that is defined in the Vehicle section of the Motor Defaults.

a. Open the copy of the Node Controller Configuration File in the Configurator, see the MagneMotion System Configurator User Manual, publication MMI-UM046.

b. Select Show Simulated Vehicles from the Options menu.

c. For each path where simulated vehicles start, define the simulated vehicles and enter the starting location for each vehicle.

- In the Configuration Tree, open the Paths list.
- Select the path where the simulated vehicle is initially located.
- Right-click on Simulated Vehicles and select Add to End to add a simulated vehicle.
- Select the simulated vehicle just added and specify its starting location on the path.
- Repeat step c for each vehicle to be added.

d. Save the updated Node Controller Configuration File.

4. Update the node controller with the latest file versions.

a. Upload the updated Node Controller Configuration File to the node controller, see the MagneMotion Node Controller Interface User Manual, publication MMI-UM001.

b. Make sure that the latest version of the motor type files is installed and upload new files if necessary, see the MagneMotion Node Controller Interface User Manual, publication MMI-UM001.

c. Select Reboot Controller on the Main Menu.

d. Select Restart Services.

The restart status is temporarily displayed, then the General Status page is displayed once the node controller has restarted.

Running a Simulation

Not all features of the transport system can be simulated. The differences between physical operation and simulated operation are described in Table 15.

Table 15 - Simulated Operation Differences

Feature	Physical Operation	Simulated Operation
Motors	All motors must be defined, connected to the node controllers, and operational.	All motors must be defined. • Motors do not need to be connected to the node controllers. • Motor Parameters are not simulated except for vehicle length.
Node Controllers	All node controllers in the transport system must be operational. Digital I/O operates as defined.	One node controller must be operational and configured as a Simulator. Digital I/O output operations write the contents of the Output Data field (with Mask applied) to the Input Data field.
Nodes	All nodes must be defined.	All nodes must be defined. • Gateway Nodes are not simulated. • Overtravel Nodes are not simulated.
Paths	All paths must be defined.	All paths must be defined.

Table 15 - Simulated Operation Differences (Continued)

Feature	Physical Operation	Simulated Operation
Stations	All stations must be defined.	All stations must be defined.
Vehicles	The vehicle properties must be defined in the Node Controller Configuration File. All vehicles being used must be installed in the transport system.	The vehicle properties must be defined in the Node Controller Configuration File. All vehicles being simulated must be defined in the Node Controller Configuration File.
Operation	Configurable functions perform as defined.	• Keepout Areas are not simulated. • Speed limits on a per motor basis are not simulated. • Move times do not reflect differences in payload or PID settings. • Hindered signals are not simulated. • E-stops are not simulated. • Interlocks are not simulated. • Wide vehicles are not simulated.

1. Connect to the node controller to run the simulation.
   - Use the NCHost TCP/IP Interface Utility to run the system manually, see the MagneMotion NCHost TCP/IP Interface Utility User Manual, publication MMI-UM010.
   - Use the application that is developed for the host controller to run the system as planned for production.
2. Issue a Reset command for all paths.

   All motors on the paths in the transport system are simulated.
3. Issue a Startup command to all paths.

   Motion on all paths is enabled, all simulated vehicles on the paths are identified and located as specified in the Node Controller Configuration File, and the paths become operational.

Resetting a path where simulated vehicles are located deletes those vehicles from the path.

Issuing a Startup command to a path where simulated vehicles are defined after any path has been reset adds new simulated vehicles to that path. Vehicles are added at either the location that is specified in the Node Controller Configuration File or in the next available space downstream.

4. Move vehicles as required.
   - Use the NCHost TCP/IP Interface Utility to move vehicles individually or create a Demo Script for repetitive testing, see the MagneMotion NCHost TCP/IP Interface Utility User Manual, publication MMI-UM010.
   - Use the host controller application to run the system as planned for production.

     All QS transport system elements are simulated as previously described.

Stopping a Simulation

1. Issue a Suspend Motion command for all paths.

   All vehicles come to a controlled stop.
2. Once all motion has stopped, issue a Reset command for all paths.

   All vehicle records are cleared.

Return the System to Normal Operation

1. Configure the node controller to run in Normal Mode.

   It is not necessary to remove the simulated vehicles from the Node Controller Configuration File as they are ignored during normal operation.

   a. Run the node controller web interface.
   b. Select IP Settings on the Main Menu.

      The IP Settings page is displayed.
   c. In the Configured Functions section, make sure that "This box is a High-Level Controller Simulator" is cleared.
   d. In the Configured Functions section, make sure that "This box is a Node Controller" is selected as appropriate.
   e. In the Configured Functions section, make sure that "This box is the High-Level Controller" is selected as appropriate.
   f. Select Apply Changes.

      The selected changes are applied.
   g. Select Reboot Controller on the Main Menu.

      The Reboot Controller page is displayed.
   h. Select Reboot Controller.

      The reboot status is temporarily displayed, then the General Status page is displayed once the node controller has rebooted.
2. From the host interface, issue a Reset command for all paths.

   All motors on the paths in the transport system are reset.
3. Issue a Startup command to all paths.

   Motion on all paths is enabled, all vehicles on the paths are identified and located, and the paths become operational.
4. Move vehicles as required.
   - Use the NCHost TCP/IP Interface Utility to move vehicles individually or create a Demo Script for repetitive testing, see the MagneMotion NCHost TCP/IP Interface Utility User Manual, publication MMI-UM010.
   - Use the host controller application to run the system as required.

     All QS transport system elements move as directed.

Force Calculations for System Design

This chapter provides information that is used to calculate your system through force, vehicle gap, or magnet array size for your transport system.

Data for Transport System Design Calculations

The tables and curves (charts) in this appendix provide data to help determine the optimal QuickStick® 150 thrust force, vehicle gap, or magnet array size for a QuickStick 150 transport system design. The theoretical attractive force, which is based on vehicle gap and magnet length is also provided. These values reflect simplified, optimal conditions to provide basic guidance for determining the optimal value. Consult Rockwell Automation for precise values.

See Determine Thrust Force on page 141 for more information about using thrust and attractive forces calculations.

For magnet array information, see Magnet Arrays on page 41.

For additional information on magnet array type and size information, see these publications:

- For QS 100 and QS 150 motors, see the QuickStick Motors Technical Data, publication MMI-TD051,
- For QSHT motors, see the QSHT High Flux High Temp Magnet Arrays, publication MMI-TD038, and QuickStick HT High Flux Magnet Arrays, publication MMI-TD025.

To use the following force charts, choose two parameters to determine the third. All calculations are based on motors running at a 25% duty cycle (thrust must be limited at 100% duty cycle to help prevent overheating of the motor).

- **Determine Thrust Force** – Choose a magnet array length (number of cycles) from the X-axis and then choose the curve for the vehicle gap that is being maintained throughout the transport system. Read the corresponding amount of force (thrust) from the Y-axis or the table. See Determine Thrust Force on page 141 for more information about calculating the thrust force.
- **Determine Vehicle Gap** – From the figures, choose the force (thrust) to maintain from the Y-axis, and then choose a magnet array length from the X-axis. Determine which vehicle gap curves come closest to the intersection point. As the vehicle gap increases, the magnetic attractive force decreases.
- **Determine Magnet Array Length** – Choose the force (thrust) to maintain from the Y-axis and then choose the curve for the vehicle gap that is being maintained throughout the transport system. Read the corresponding magnet array length (cycles) from the X-axis.

Determine Thrust Force

The thrust obtainable from a QS motor is dependent on several operational parameters, including the length of the magnet array engaged by the stators, the magnitude of the stator drive current, and the gap between the magnet array and stators. Further, the allowable magnitude of the stator drive current is limited by thermal considerations. Therefore, ambient temperature or the duty cycle of the drive current can impact the obtainable thrust.

Laboratory measurements of the thrust that is obtained with a QS motor at various operational parameter values were used to derive a model that describes the thrust that is produced. The thrust that is produced roughly varies with each of the operating parameters as follows.

- The thrust that is produced varies roughly in proportion to the length of magnet array engaged by stators. For example, an 8 cycle long magnet array yields twice the thrust of a 4 cycle array, assuming that both arrays are fully engaged by stators, with the same drive current and gap values, see Figure 103.
- The thrust that is produced varies roughly in proportion to the stator drive current. For example, a drive current of 5 A yields approximately twice the thrust that is obtained with a drive current of 2.5 A, assuming the same magnet array engagement and gap.
- The thrust that is produced decreases roughly in an exponential fashion as the gap between the motor and the magnet array is increased, see Figure 104 on page 143.

QuickStick 100 and QuickStick 150 Typical Static Thrust Calculation

The model equation that describes the thrust that a QuickStick 100 and QuickStick 150 motor produces with a standard magnet array is:

$$Thrust\ (\mathrm{N}) = (((-0.043 * I_{stator}^{2}) + (6.579 * I_{stator})) * \mathrm{EXP}^{(-0.158 * PhysGap)}) * NumCycles$$

To convert Newton (N) thrust force to Pound (lb) thrust force, divide the result of this equation by 4.4482.

Where:

NumCycles – The length of the array that is engaged by the stators, in cycles (a cycle for the QS 100 is 48 mm and the QS 150 is 96 mm).

$\mathbf{I_{stator}}$ – The stator current, in Amps.

PhysGap – The distance from the top of the stator to the bottom of the magnet array, in mm (from 1…9 mm).

The thrust equations were developed with a small tolerance in the physical gap to compensate for minor differences in magnet array spacing.

Thrust – The thrust force that is produced.

Figure 103 - QuickStick 100 and QuickStick 150 Thrust Force vs. Magnet Array Cycles, Standard Magnet Array Example

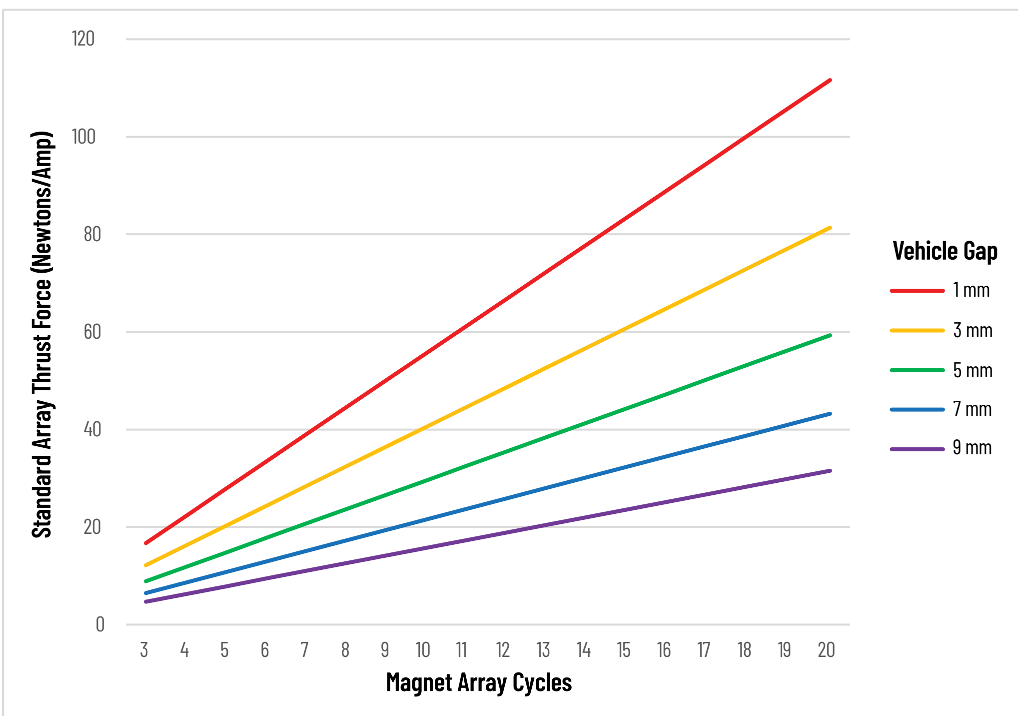


Figure 104 - QuickStick 100 and QuickStick 150 Thrust Force vs. Vehicle Gap, Standard Magnet Array Example

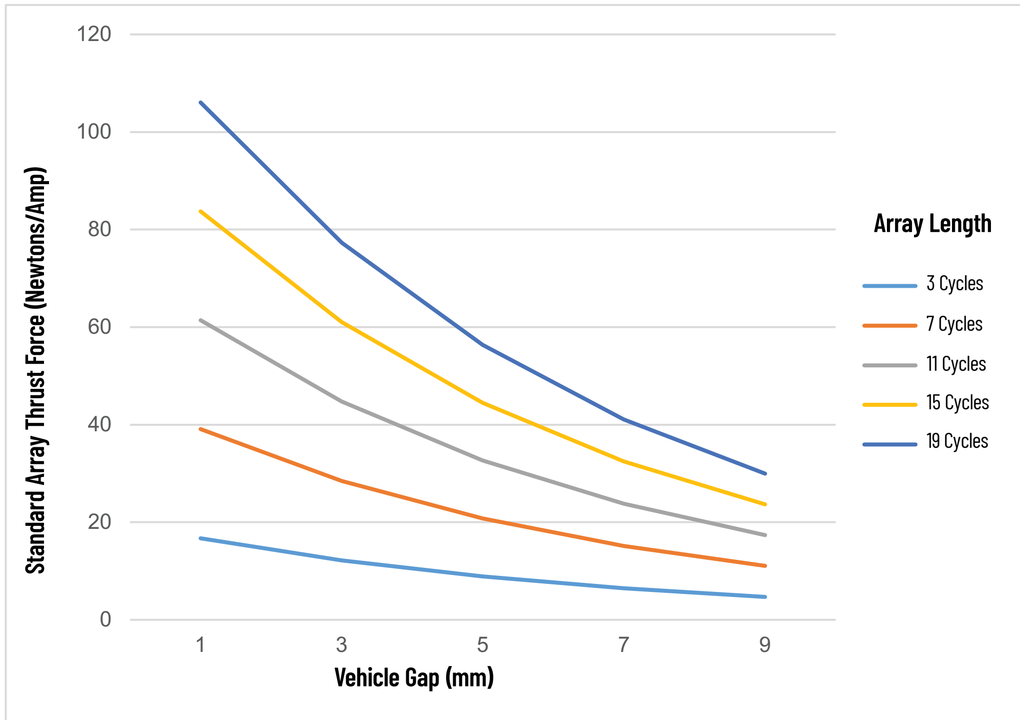


Figure 105 - QuickStick 150 Force vs. Speed Curve (2 mm peak/continuous)

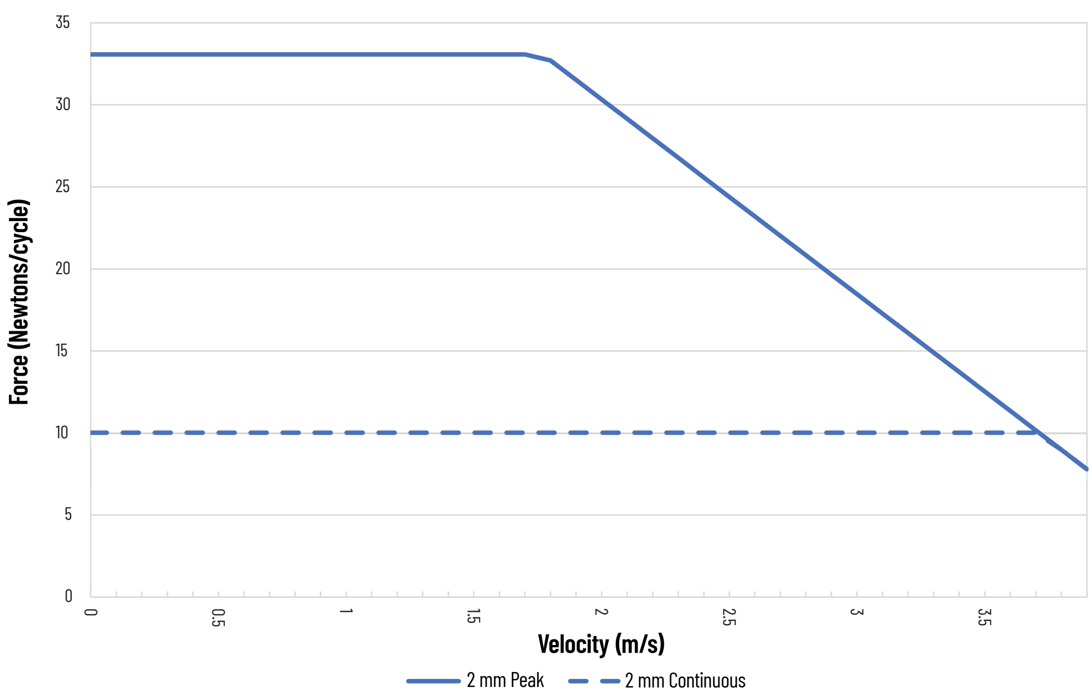


Figure 106 - QuickStick 150 Force vs. Speed Curve (5 mm peak/continuous)

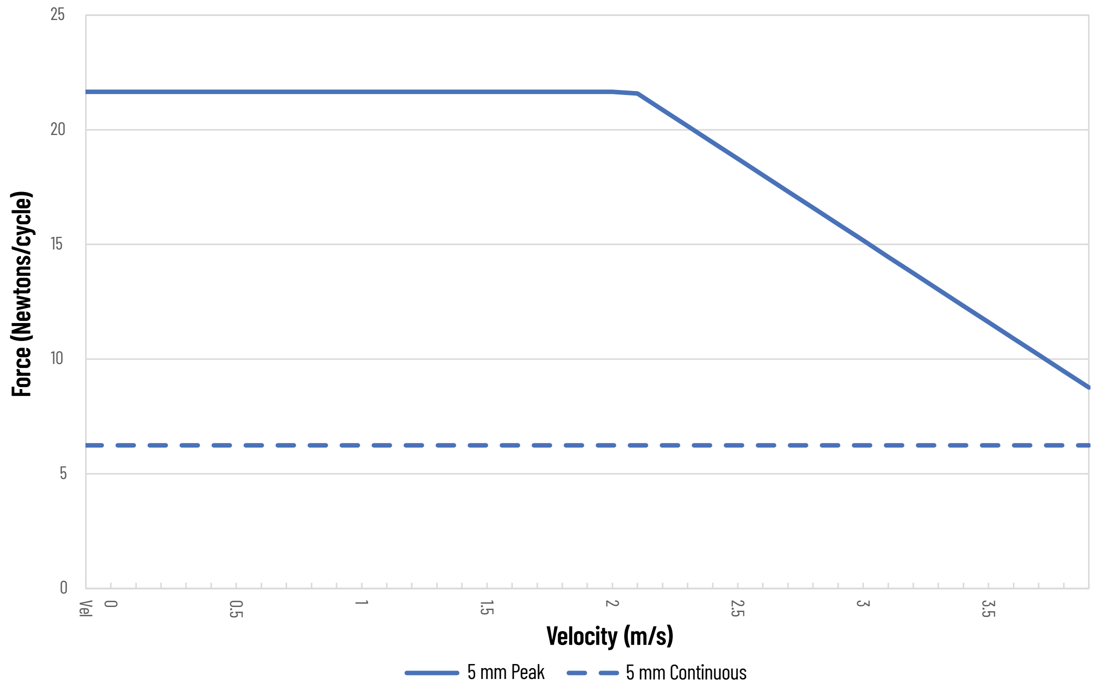
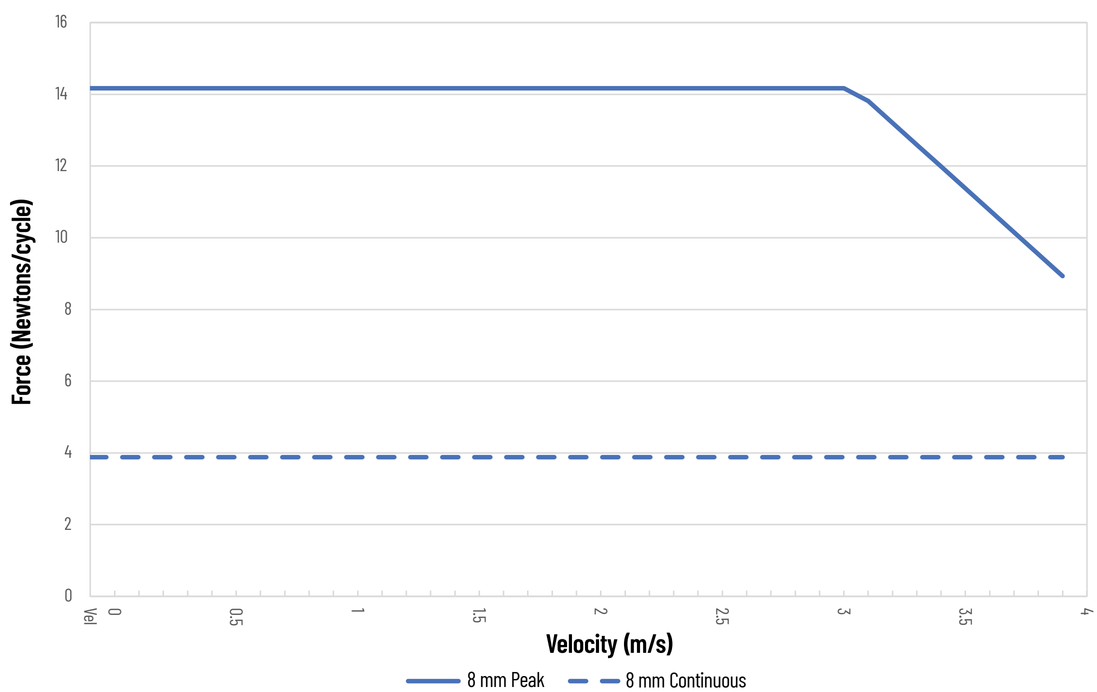


Figure 107 - QuickStick 150 Force vs. Speed Curve (8 mm peak/continuous)



QuickStick HT Typical Static Thrust Calculation

The model equation that describes the thrust that a QuickStick HT (QSHT) motor produces with a standard magnet array is:

$$Thrust\ (\mathrm{N}) = (((-0.209 * I_{stator}^{2}) + (35.04 * I_{stator})) * \mathrm{EXP}^{(-0.056 * PhysGap)}) * NumCycles$$

To convert Newton (N) thrust force to Pound (lb) thrust force, divide the result of this equation by 4.4482.

Where:

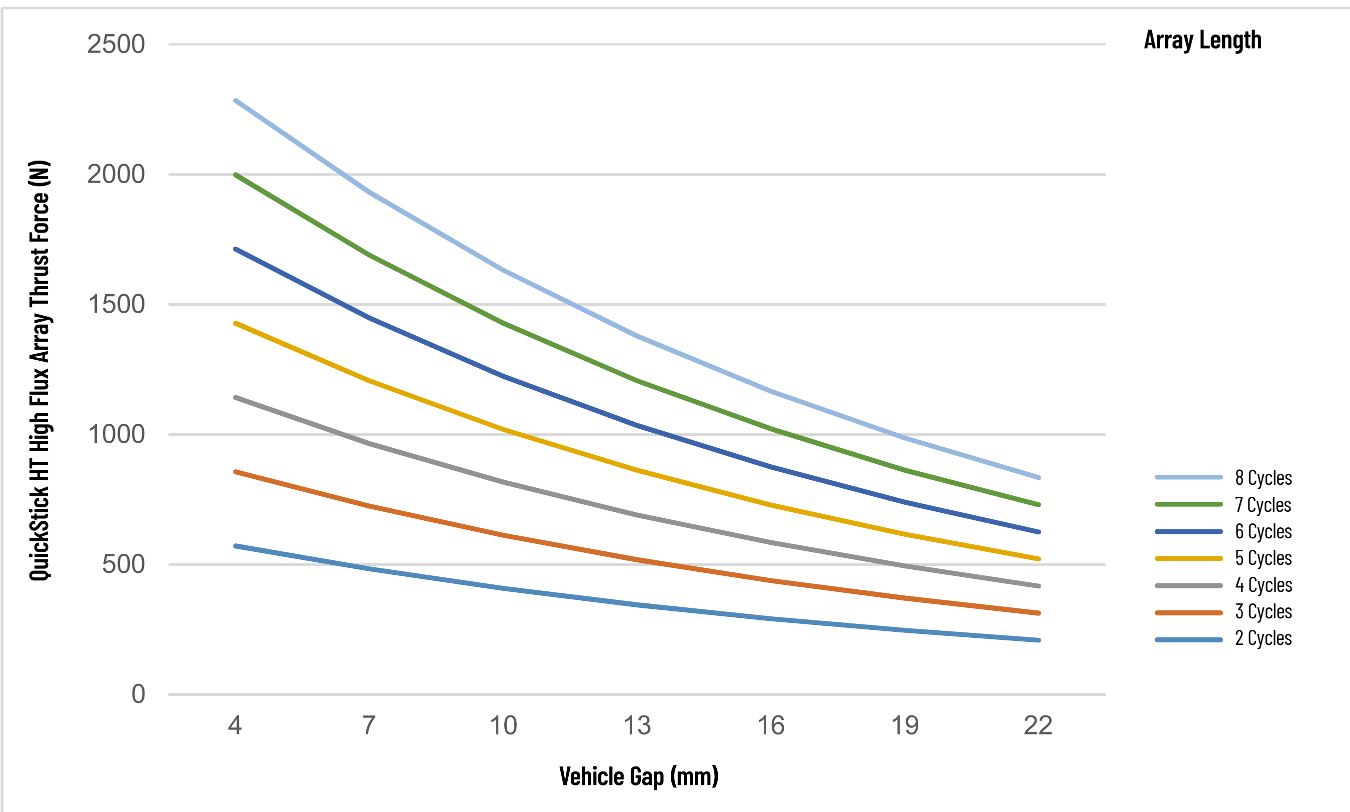
NumCycles – The length of the array that is engaged by the stators, in cycles (from 2…8 cycles - a cycle for the QSHT is 120 mm).

I_{stator} – The stator current, in Amps.

PhysGap – The distance from the top of the stator to the bottom of the magnet array, in mm (from 4…22 mm).

Thrust – The thrust force that is produced.

Figure 108 - QuickStick HT Thrust Force vs. Vehicle Gap, Standard Magnet Array Example



Determine Attractive Force

In addition to the thrust force produced by the QuickStick 150 motor, there is an attractive force between the steel laminations in the stator and the magnet array. This attraction, or hold-down force, is roughly proportional to the length of the magnet array engaged by the stators, and decreases roughly in an exponential fashion as the gap is increased, see Figure 109 on page 146. The hold-down force is nearly independent of stator current, and thus has the same value whether the stator is powered or not powered.

Laboratory measurements of the hold-down force that is obtained with a QuickStick 150 motor at various operational parameter values were used to derive a model that describes the hold-down force produced.

QuickStick 100 and QuickStick 150 Typical Attractive Force Calculation:

The model equation that describes the hold-down force that a standard magnet array experiences when located over a QS 100 and QS 150 motor is:

$$HDForce\ (N) = (144.7 * EXP^{(-0.3 * PhysGap)}) * NumCycles$$

To convert Newton (N) thrust force to Pound (lb) thrust force, divide the result of this equation by 4.4482.

Where:

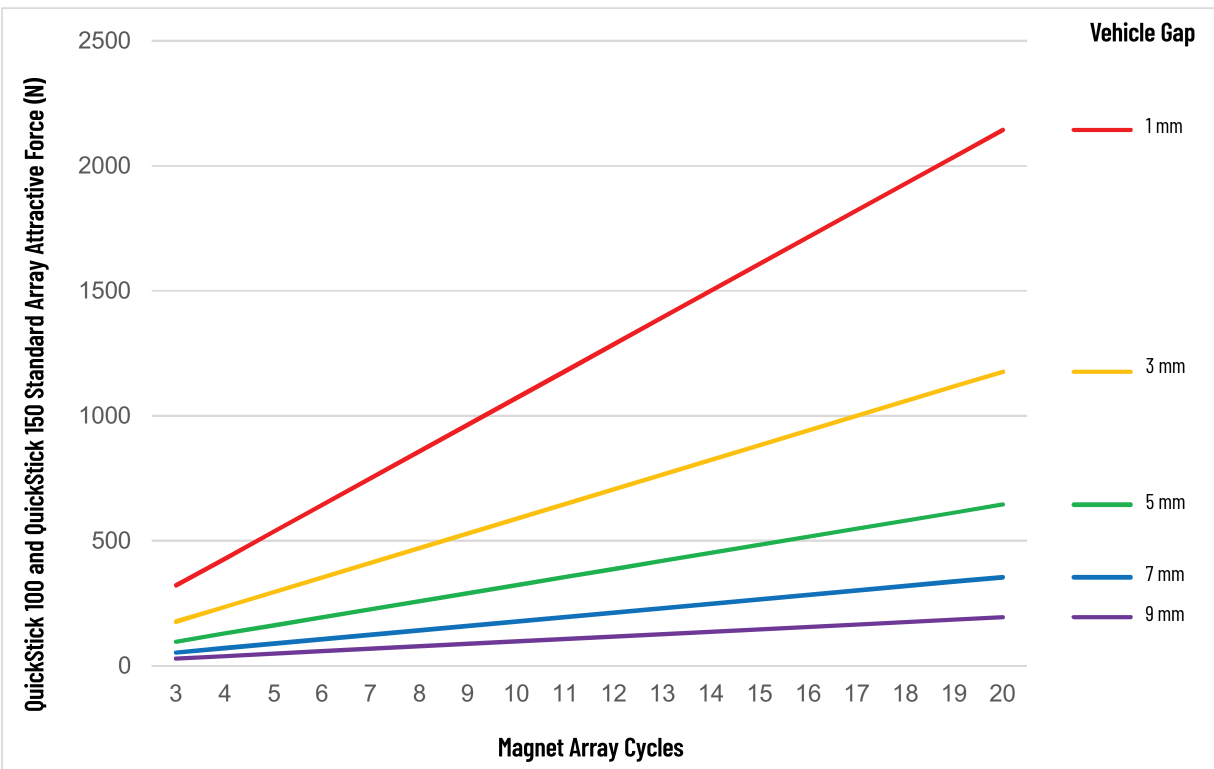
NumCycles – The length of the array that is engaged by the stators, in cycles (a cycle for the QuickStick 100 is 48 mm and the QS 150 is 96 mm).

PhysGap – The distance from the top of the stator to the bottom of the magnet array, in mm (from 1…9 mm).

The attractive force equations were developed with a small tolerance in the physical gap to compensate for minor differences in magnet array spacing.

HDForce – The hold-down force that is produced. The hold-down force is independent of stator current.

Figure 109 - QuickStick 100 and QuickStick 150 Attractive Force Data Curves, Standard Magnet Array, Example



QuickStick HT Typical Attractive Force Calculation:

The model equation that describes the hold-down force that a standard magnet array experiences when located over a QSHT motor is:

$$HDForce\ (\mathrm{N}) = (1850 * \mathrm{EXP}^{(-0.122 * PhysGap)}) * NumCycles$$

To convert Newton (N) thrust force to Pound (lb) thrust force, divide the result of this equation by 4.4482.

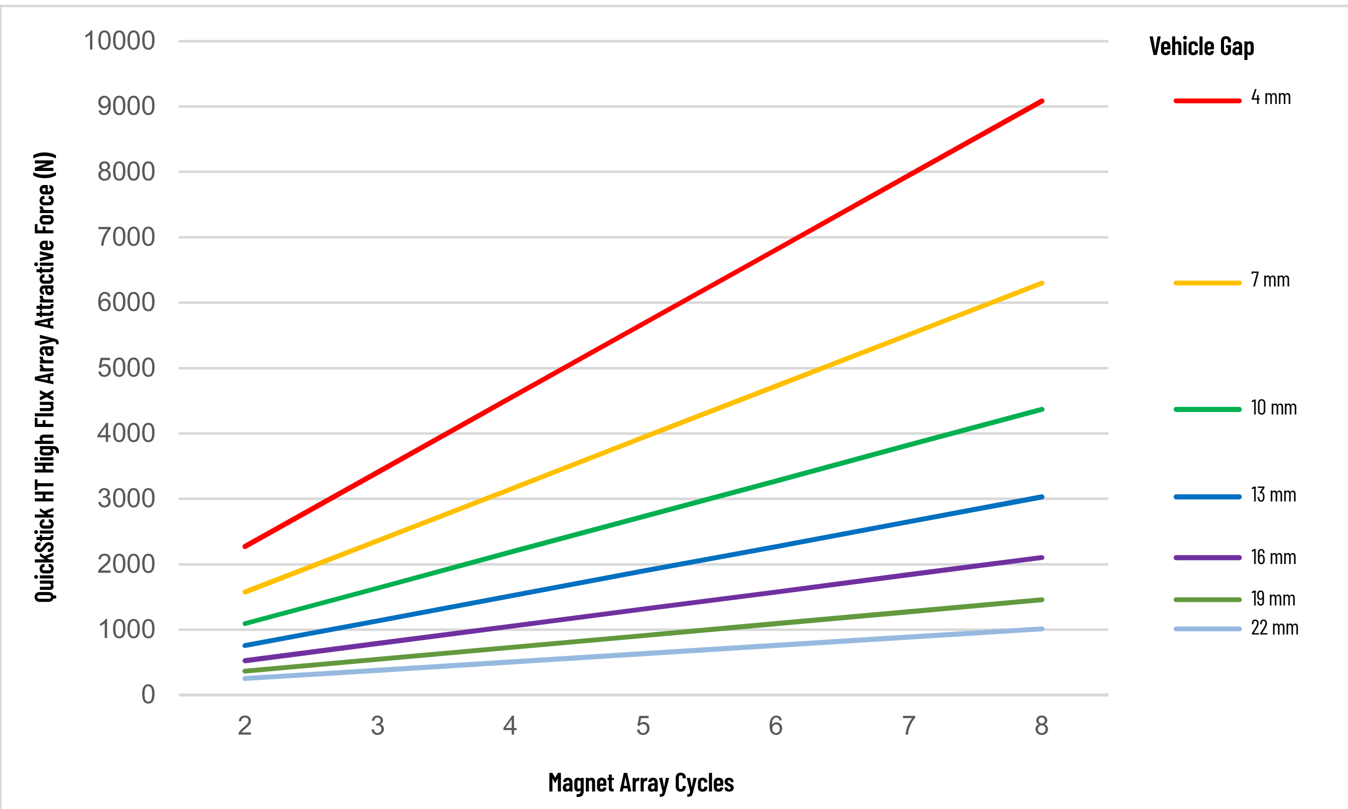
Where:

NumCycles – The length of the array that is engaged by the stators, in cycles (a cycle for the QSHT is 120 mm).

PhysGap – The distance from the top of the stator to the bottom of the magnet array, in mm (from 4…120 mm).

HDForce – The hold-down force that is produced. The hold-down force is independent of stator current.

Figure 110 - QuickStick HT Attractive Force Data Curves, High Flux Magnet Array, Example



Notes:

QuickStick Motors Curve Design and Validation

This appendix provides information on the design and application of curve topologies in a QuickStick® transport system.

Introduction

Several criteria are used to validate a QuickStick (QS) curve application: required thrust, the radius of curvature, and customer necessity for the curved track due to its intricate nature. The amount of available thrust produced by a copper winding (stator coil) is a function of the motor-to-vehicle gap, engaged cycles, and skew angle between the magnet array attached to the vehicle and the magnetic field produced by the LSM coils.

Depending on the firmware release, curve applications can require either a special firmware (for QS 100 only) or an independent correction table file (for QS 150 only) for the system to optimize the thrust of a vehicle in a curve. The independent correction table or special firmware can be generated for a customer, when required. However, it is the responsibility of the customer to determine whether they require a correction table and collect the data for its creation. Contact Rockwell Automation Support.

Motor Sensor Engagement

Motor sensor engagement helps ensure the proper transfer of ownership between motors and is fundamental in the operation of the system. Figure 111 on page 150 shows a vehicle moving across a motor while always maintaining coverage above the sensor array and LSM coils during the move.

- The front edge of the motor must sense the front edge of a magnet array.
- The HES along the motor must contiguously sense the magnet array. The signal cannot be dropped and must be continuously present until the back edge of the magnet exits across the front edge of the motor.
- The leading edge of the magnet should always be aligned with the linear array of sensors.

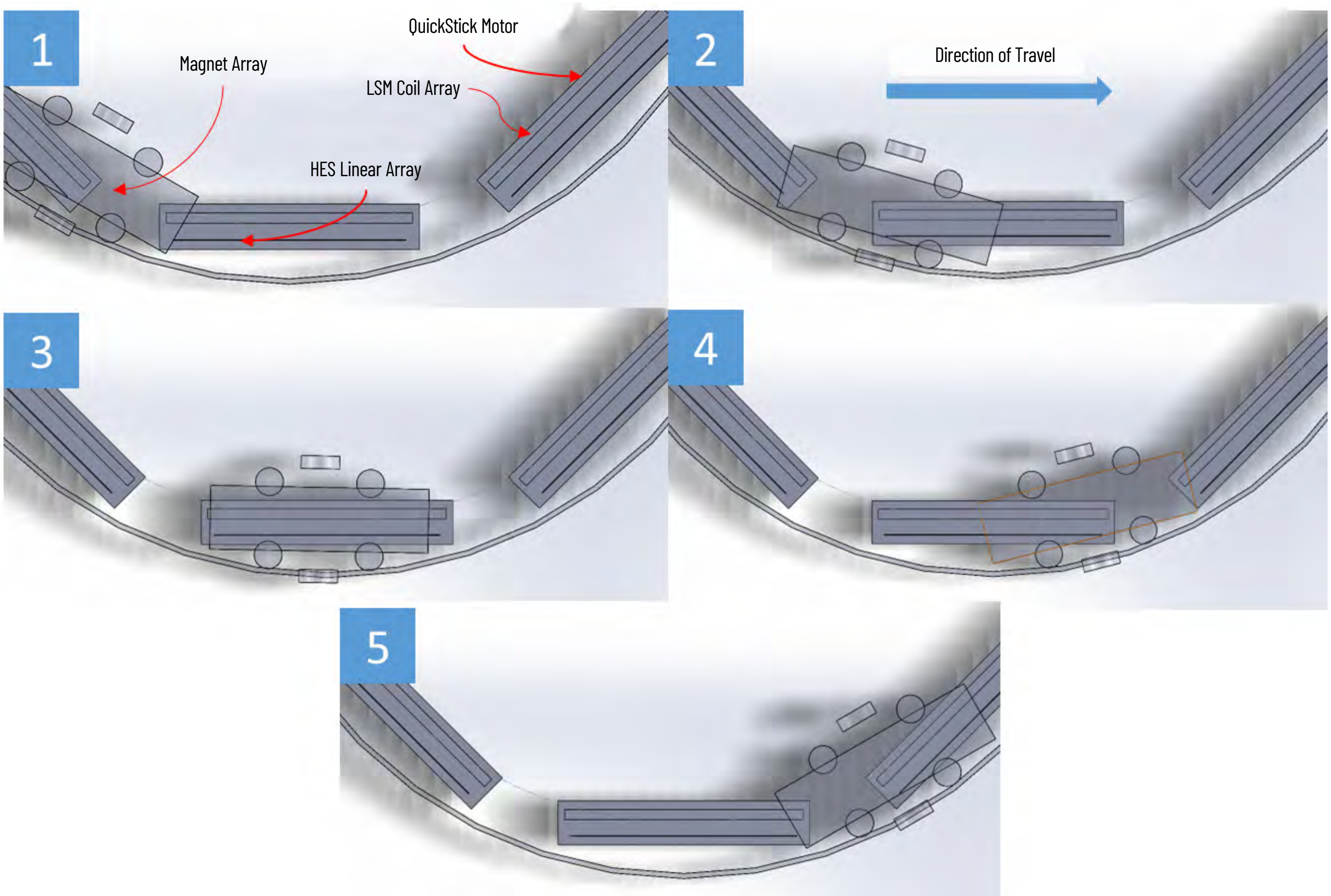


Figure 111 - Magnet Array to QuickStick Motor Sensor Engagement

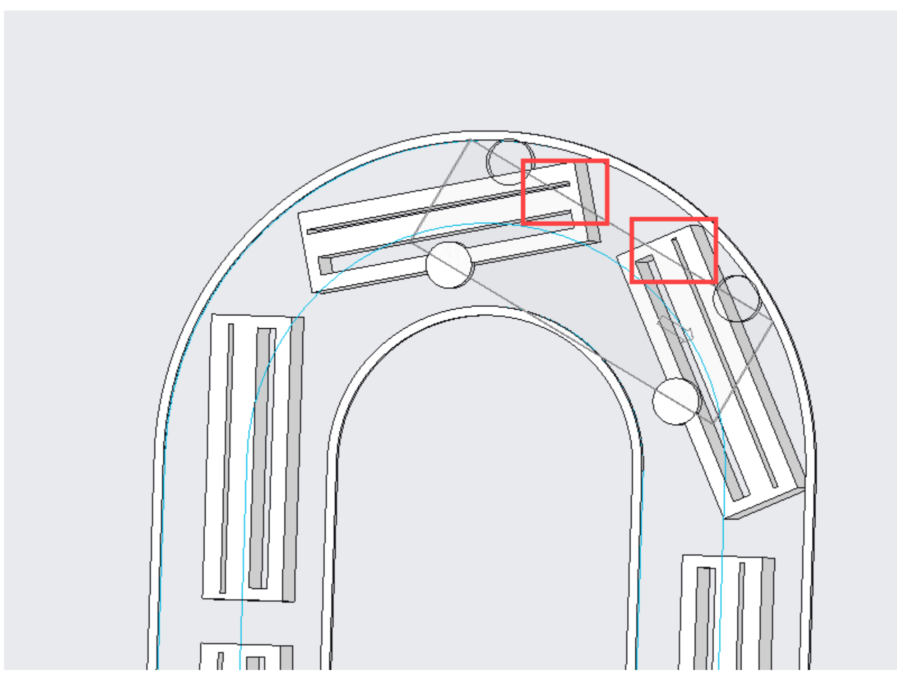


Figure 112 - Magnet Array to QuickStick Motor Sensor Engagement Failure

Minimum Radius of Curvature

The magnetic coverage must be maintained above the sensor array for each motor on a vehicle path. Depending on the vehicle design, vehicle contact points with the track, and the length and width of the magnet, it is possible to lose magnetic coverage above the sensor linear array. When magnetic coverage above the sensor linear array is lost, a PLC reports a signal loss fault on the vehicle status. Partial loss of signal can result in erratic motion. It is possible that the system loses vehicle position information, and it can also experience startup and motor-to-motor hand-off issues since the motors could disagree with the location of a magnet.

Data Assumptions

There is a minimum radius of either 0.5 m for QS 100 motors or 0.3 m for QS 150 motors. Use Computer Aided Design (CAD) tools to verify the track design on a case-by-case basis to achieve sensor coverage across the entire system. For these examples, the vehicle base was assumed to be 96 mm (two cycles) smaller than the magnet length. The data represents a left turn, which allows for a tighter curve radius due to the bias of the sensor array. A right turn would require a larger curve radius.

Figure 113 - QuickStick 100 Minimum Curve Radius - Single Wide Magnet Array

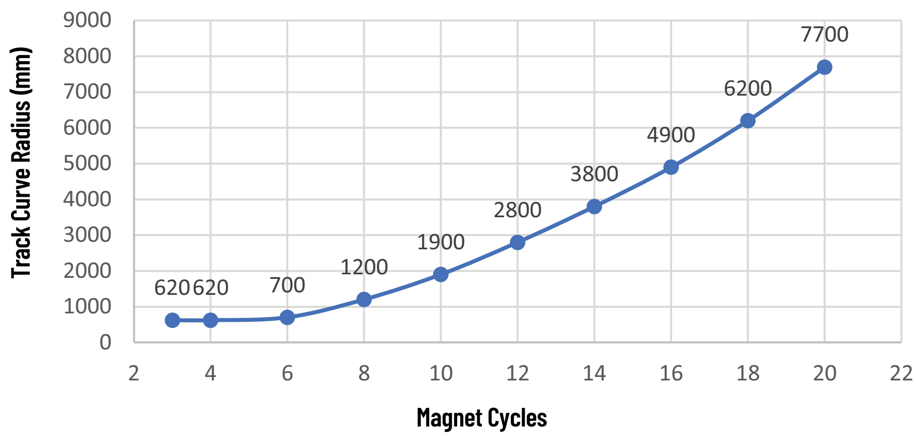


Figure 114 - QuickStick 100 Minimum Curve Radius - Double Wide Magnet Array

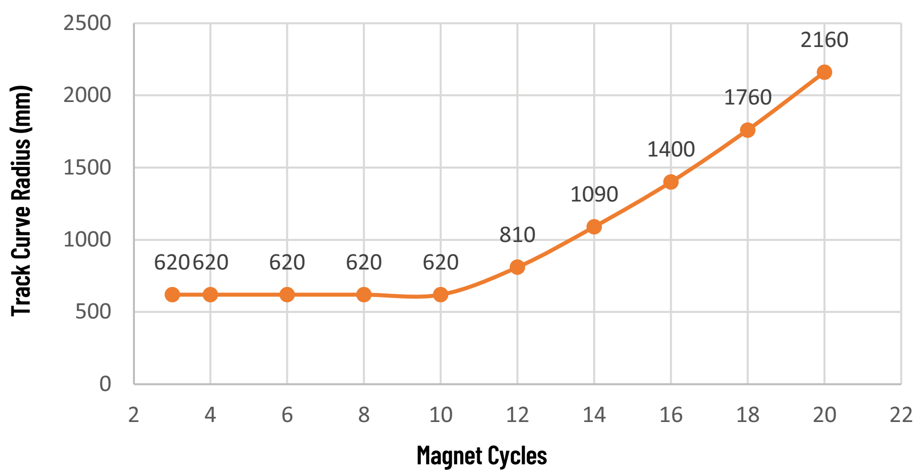


Figure 115 - QuickStick 150 Minimum Curve Radius - Single Wide Magnet Array

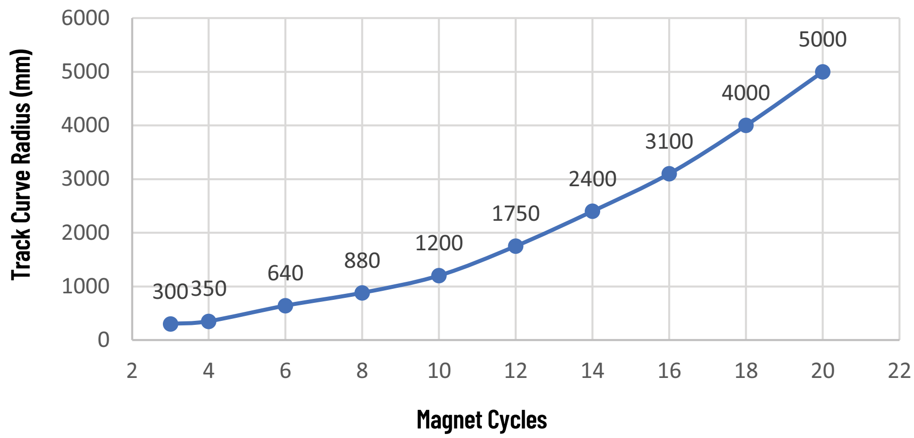
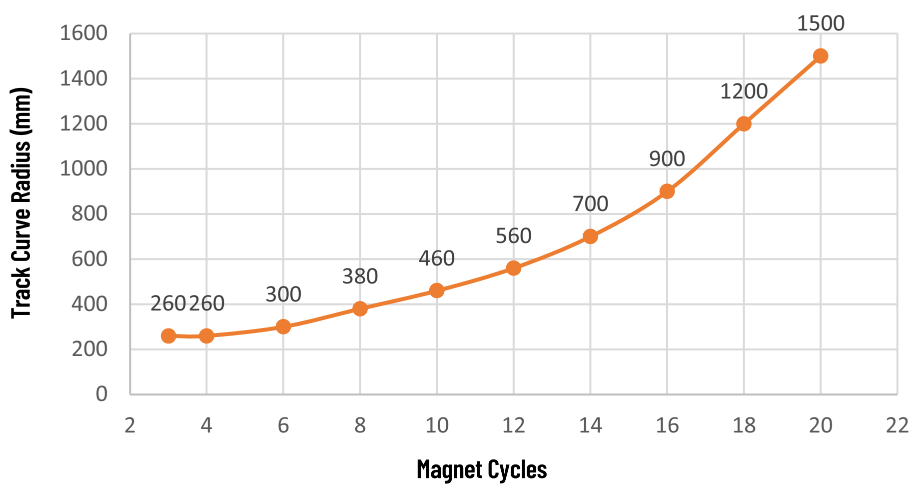


Figure 116 - QuickStick 150 Minimum Curve Radius - Double Wide Magnet Array

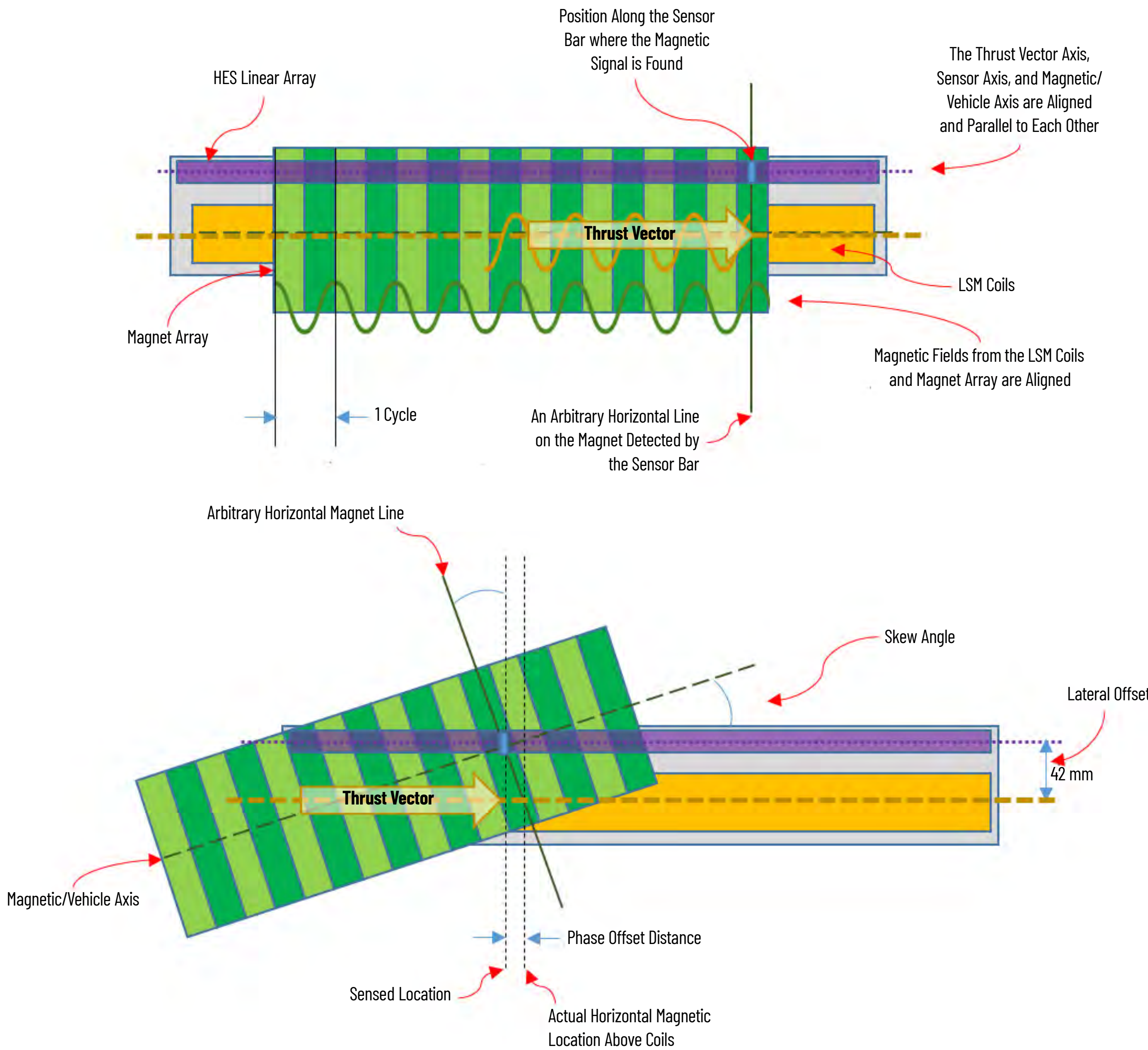


Skew Angle, Lateral Offset, and Phase Offset Distance

The angle between the vehicle/magnet and the motor is called the skew angle. The track-curve radius determines the skew angle. The smaller the curve radius the larger the skew angle, which increases the possibility of lost vehicles. Regardless of adequate sensor coverage, there can still be enough LSM coil disengagement that the motor is unable to produce enough thrust to move the vehicle. Plan the curve to maintain as much engagement from the coils as possible, while maintaining uninterrupted sensor coverage.

The lateral offset is the distance between the magnet sensors and the motor drive coils acting on the vehicle. Installed on a curved track, the lateral offset creates a discrepancy between where the vehicle is sensed and where it is being actuated. Phase offset distance refers to the misalignment between the magnetic fields that are produced by the LSM coils and the magnet array.

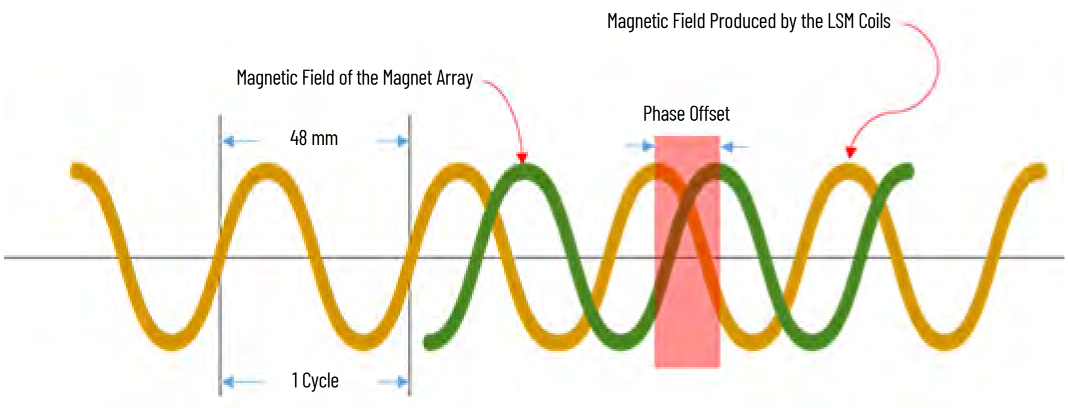
Figure 117 - QuickStick 150 Skew Angle, Lateral Offset, and Phase Offset Distance



Thrust Requirements

Available thrust on QS curves is a function of the motor spacing, vehicle gap, magnetic coverage over the LSM coils, and the skew angle between the magnet array and motor. Since the magnetic field produced by the AC phase on the motor coils and the magnet array is misaligned, a derating factor is considered based on the worst-case skew angle. The phase offset angle or the polar discrepancy between the magnetic phases produced by the magnet array and the LSM coils determines the available thrust. There is a loss of thrust directly proportional to the cosine of the phase offset angle.

Figure 118 - Phase Offset Angle



To calculate the available curve thrust, the phase offset angle and the derated thrust must be determined. The derated thrust is the force that acts upon the vehicle by the magnetic field that the LSM coils produce.

Determine the Available Thrust in a Curve

*Phase Offset Angle = (tan (Skew Angle) * Lateral Offset distance / Magnet Array cycle length) * 360°*

*Derated Thrust = Static Thrust * cos (Phase Offset Angle)*

For static thrust calculations, see Determine Thrust Force on page 141.

Coils that have lost coverage do not count towards engagement length.

The effects of the vehicle gap and worst-case motor-to-magnet array cycle engagement reduces the available thrust. A vehicle that is centered and spans a motor-to-motor gap yields the lowest number of engaged magnet array cycles.

It is recommended to apply a safety factor to accommodate for design variations in gaps, motor spacing, and vehicles.

*Available Thrust = Derated Thrust * SF * cos (Skew Angle)*

Where: *SF* = Safety Factor

If it is determined that the available thrust is insufficient for your specific application, it can be possible to optimize it by increasing the efficiency of the derated thrust by using a curve correction table that is built to your track specifications. See Curve Correction Table on page 155 for details. To request a curve correction table for your specific track geometry, follow the instructions in Commission a Curve on page 155 and contact Rockwell Automation Support.

Curve Correction Table

Linear paths allow vehicles to pass control between motors when the downstream gap is configured correctly. When the downstream gap is not configured correctly, a vehicle could move erratically due to the instantaneous error accumulation. The HES detects the front edge of the magnet array simultaneously to engagement with LSM coils.

Curved paths require additional configuration because the HES feedback is not aligned with LSM coil engagement due on the magnet array position. The magnet array is skewed in relationship to the linear stator. A curve correction table can be required to account for and anticipate this unique signature.

If the predicted thrust loss is less than 20%, a curve correction table or special firmware does not provide substantial benefit and it is not required.

To apply the curve correction table for a motor, select the On Curve option in the Configurator application for the applicable motor. If a curve correction table is required, see MagneMotion® System Configurator User Manual, publication MMI-UM046, for information on how to active the curve corrections for a motor.

A separate correction table is required for each curve geometry. It is beneficial for all curves to have the same radius, if possible. Consistent curve radius minimizes the number of correction tables required.

Commission a Curve

Review these tasks before you commission a curve for your QuickStick transport system.

Install the motors - install and connect cables to the motors as directed in the applicable user manual for your motor. The geometry and the relative position between motors on curves should be as consistent as possible throughout the entire track. A fixture or template of the curves and switches is highly advised to help ensure that the motors are installed as designed. A fixture or template limits the need to reconfigure the curve if a motor must be replaced. See Additional Resources on page 16 for the user manual applicable to your QS motor.

Configure and start up the system - use the nominal distance between motors to determine the downstream gap on curves. For transport system configuration and operation, see Additional Resources on page 16 for the user manual applicable to your QS motor.

Confirm coverage - make sure that your mechanical installation matches the design. To verify that a magnet array is detected, view the SigOKF flags in the NCHost Datastream dialog box. Use the password **custst** to unlock the datastream function in the NCHost TCP/IP Interface Utility. See How to Commission a Curve on page 155. See the MagneMotion NCHost TCP/IP Interface Utility User Manual, publication MMI-UM010, for additional information on how to use the datastream function.

SigOKF is a word of flags (represented in Hexadecimal).

Collect data for a curve correction table (optional) - collect the data that is required for submission to Rockwell Automation to generate a curve correction table. See Collect Data for a Curve Correction Table (Optional) on page 157.

Correct Downstream Gaps - update downstream gaps in the configuration file. See Correct Downstream Gaps on page 158.

How to Commission a Curve

Follow these steps to commission a QuickStick transport system with a curve. For details on how to use the NCHost TCP/IP Interface Utility, see the MagneMotion NCHost TCP/IP Interface Utility User Manual, publication MMI-UM010.

Logic power is required to complete this procedure.

1. In the node controller, complete step a and step b:
   a. Restart services.

b. Send a reset command to all paths.

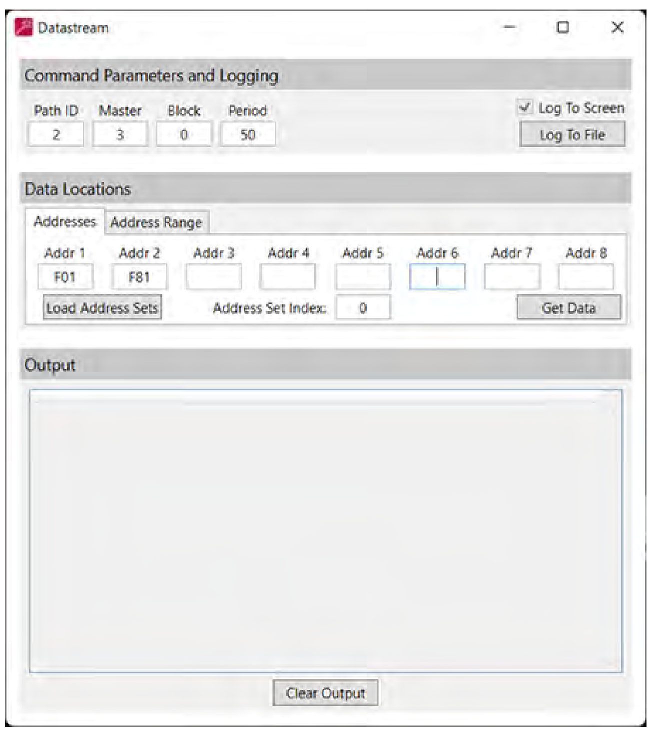
2. Turn off propulsion power, only.
3. To verify the sensors in the NCHost TCP/IP Interface Utility, configure the datastream function by using these values:
   - For blocks 0, 2, and 4, SigOKF is at address F01 (QS 100)
   - For blocks 1 and 3, SigOKF is at address F81 (QS 100)

   These values are not available for QS 150 at the time this document was published. Contact Rockwell Automation Technical Support for SigOKF address values.
4. Position the vehicle upstream of the motor to be verified.
5. To start datastream logging, click Get Data.

   A period of 50 ms or 100 ms intervals is recommended.
6. Push the vehicle by hand at a constant speed until it is completely through the motor and the trailing edge clears the motor's downstream gap.
7. Review the data (see Figure 119 on page 156).
   - For the QS 100, only review the last two bits since there are only two HES sets per block. The values of the words containing the SigOK flags (represented in Hexadecimal) should go from 00 (0000) to 01 (0001) to 03 (0011) to 02 (0010) and back to 00.
   - For the QS 150, only review the last two bits since there are only two HES sets per block. The values of the words containing the SigOK flags (represented in Hexadecimal). For details, see the QS 150 motor firmware revision release notes available on the Product Compatibility and Download Center (PCDC) at rok.auto/pcdc.
8. Repeat step 3...step 7 for the other motor blocks.

   Generally, the sensors in blocks 0 and 4 are most likely to have a loss of coverage when evaluating a curve.

Figure 119 - NCHost Datastream Dialog Box Example



Collect Data for a Curve Correction Table (Optional)

If the predicted thrust loss is less than 20%, a curve correction table or special firmware does not provide substantial benefit and it is not required.

Use these instructions to gather the data required to generate the curve correction tables. If all motors are placed at an equal radius in a curve, this data is required for one motor only in the curve. For details on how to use the NCHost TCP/IP Interface Utility, see the MagneMotion NCHost TCP/IP Interface Utility User Manual, publication MMI-UM010.

This data can then be sent to Rockwell Automation so that ICT Engineering can generate the curve correction table.

Logic power is required to complete this procedure.

1. In the node controller, complete step a and step b:
   a. Restart services.
   b. Send a reset command to all paths.
2. Turn off propulsion power only.
3. Position the vehicle upstream of the motor that you want to check.
4. To configure the datastream function in the NCHostTCP/IP Interface Utility for block 0 (run 1), complete step a…step c:
   a. Set the Block 0 (run 1), datastream addresses (Addr 1…Addr 6) to: F61, F62, F63, F10, F11, and F12.
   b. Set the motor and path number accordingly.
   c. Set the update rate to 5 ms.
5. To start datastream logging, click Get Data.
6. Push the vehicle through the motor at a rate of 0.25…0.5 m/s. The vehicle speed must be fairly consistent, but it is not a requirement.
7. To stop logging, click Log to File.

   Each log file must have a unique name that at a minimum contains the block number (for example: 'P2M1B0.txt').
8. To configure the datastream function in the NCHost TCP/IP Interface Utility for blocks 1…4 (runs 2…5), repeat step 3…step 7 by using the datastream addresses in this table:

Block	Datastream Addresses					
	Addr 1	Addr 2	Addr 3	Addr 4	Addr 5	Addr 6
1	FE1	FE2	FE3	F90	F91	F92
2	F61	F62	F63	F10	F11	F12
3(1)	FE1	FE2	FE3	F90	F91	F92
4(1)	F61	F62	F63	F10	F11	F12

(1) For QuickStick 0.5 m motors only.

Correct Downstream Gaps

Use the Node Controller Web Interface to detect the downstream gaps in your system. For details on how to use the Node Controller Web Interface, see the MagneMotion Node Controller Interface User Manual, publication MMI-UM001.

A text editor (such as WordPad) is required to edit the XML configuration file.

Complete these steps to correct downstream gaps.

1. Apply the correction table firmware, if needed.
2. Apply logic power.
3. Apply propulsion power.
4. Run the Node Controller Web Interface.
5. Drive the vehicle around the system several times.
6. View the detected gaps on the Motor Gap Information page.

IMPORTANT	Use a text editor to update the downstream gap values directly in the XML configuration file. The Configurator application adds 18 mm automatically to the downstream gaps. The gaps that are displayed on the Motor Gap Information page in the Node Controller web interface and contained in the XML represent the magnetic downstream gap.

7. Use a text editor application to open the XML configuration file.
8. Update the applicable downstream gaps.
9. To reboot the system, Complete step a and step b:
   a. Select Restart Services. The restart status is temporarily displayed, then the General Status page is displayed once the node controller has restarted.
   b. Send a reset command to all paths.
10. Repeat step 5...step 8 as needed, until the variance between the detected and configured gaps is minimized.

    This process can take several repetitions if the original gaps were inaccurately measured.

When gaps are correctly set, the motion should be smooth around the system.

QuickStick 150 Site Requirements

This appendix provides detailed information on electrical wiring and communication configuration that is required for QuickStick® 150 applications.

For site requirements and installation information see the applicable user manual for your motor:
- For the QuickStick 100, see the QuickStick 100 User Manual, publication MMI-UM006
- For the QuickStick HT™ see the QuickStick HT User Manual, publication MMI-UM007

Electrical Wiring

This section provides the maximum power requirements and electrical connections for QuickStick (QS) 150 motors.

IMPORTANT Typical power depends on load demand from vehicles.

IMPORTANT The motors draw additional power when the vehicle is moving or accelerating, see Table 4 on page 23. The amount of additional power that is drawn depends on the velocity and acceleration of the vehicle, the number of vehicles accelerating at once, and the magnet array length. All power wiring must be sized to carry the full load.

Providing a separate power source for the logic power allows the motors to be programmed and configured without enabling the propulsion power. If only propulsion power is supplied to the motors, connection to logic power is automatically made within the motor. If one power source is used to provide propulsion and logic power, the QS 150 motor can only operate at 48V DC.

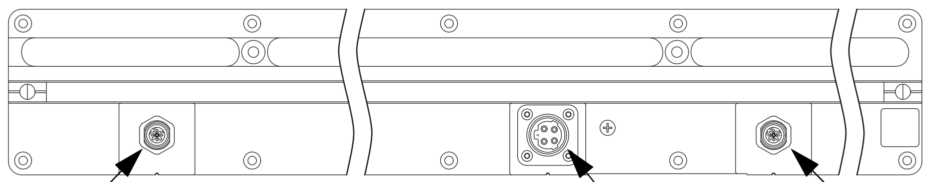
When using separate power sources for logic and propulsion power, the propulsion power return must be tied to ground while the logic return can be left floating.

ATTENTION: Never disable propulsion power by switching the propulsion input pin of the motor from the DC power source directly to ground. Switching the input to ground produces large current spikes that can damage the electronics.

IMPORTANT Any user-supplied power supply must meet local regulations and requirements.

ATTENTION: A hazard of equipment damage exists. Do not plug a power cable into a QS motor or unplug a power cable from a QS motor while the power supply is on.

Figure 120 - QuickStick 150 Motor Electrical Connections



Motor Power Requirements

The QS 150 motors are designed to operate at a nominal DC voltage. However, voltage drops in the power distribution system when delivering power to the motors and voltage increases during regeneration events cause fluctuations in the voltage that is present at the motor power terminals. The power supplies and wiring for the system must be designed to minimize these fluctuations. A block diagram of a QS 150 system schematic is provided in Figure 121 on page 162. Any part numbers that are shown are for reference only and are subject to change.

For additional information about the electrical system and electrical specifications, see Table 5 on page 24 and the QuickStick 150 User Manual, publication MMI-UM047.

Table 16 - Acceptable Voltage Range for QS 150 Motors

Motor Type	Nominal Voltage (V DC)	Max Voltage (V DC)	Min Voltage (V DC)
QS 150	48…72	79	43

See Table 16 for the acceptable voltage ranges. Operation below or above this range can result in the motor turning off or being damaged. While the motor has protections in place to help prevent damage, the power supply system must be designed so that the voltage limits are not exceeded during normal operating conditions and provide protection to the power supply if these limits are exceeded. To supplement any external power management schemes for the QS 150 transport system, a means of internally consuming regenerated power within a QS 150 motor is incorporated as a product feature.

The QS 150 motors are enabled when the internal propulsion bus rises above the minimum voltage that is listed in Table 16. Until this voltage is reached, the motor reports an undervoltage fault and the motor does not allow vehicle motion to occur. Once this internal voltage is reached, the motor can support vehicle motion and operate as intended. If the internal bus voltage drops below the minimum voltage during operation, the motor reports an undervoltage fault and all inverters within the motor are disabled. Normal operation resumes once the internal propulsion bus rises back up to the minimum voltage level. If the internal bus voltage rises above the maximum operating voltage during operation, the motor reports an overvoltage fault and all inverters within the motor are disabled. Normal operation resumes once the internal propulsion bus falls below the maximum operating voltage. Once the inverters are disabled, any vehicles in motion over the motor are no longer be under active control and as such their motion is undefined.

Power Wiring

All power wiring must be constructed such that there is minimal loss between the power supplies and the motors. Additionally, the power wiring must be able to support power regeneration due to the active braking or deceleration of vehicles. The preferred architecture for the power bus in a QS system is a number of junction boxes (shown in Figure 121 on page 162) connected in series to form one low-resistance power bus with a tap to each motor.

The current to each motor in a system at a given time depends on system behavior and vehicle size. When determining the size of cable, the worst case power draw, current, and vehicle motion must always be used. Designing the electrical system to keep voltage drops below 5% of the nominal voltage is recommended.

Vehicle motion consumes power when the vehicle accelerates, and regenerates power when it decelerates. While the vehicle is accelerating, the motor is drawing power from the motor power supply system, including any excess power being generated from regeneration in other parts of the transport system connected to the same power supply system. In the worst case, a motor can draw up to the value for peak power per vehicle while the vehicle is finishing its acceleration. Along with providing the power used to accelerate a vehicle, the wiring must also be designed to manage regenerated power as a vehicle slows and stops. In general, if a system is designed to support supplying full power during acceleration, it also supports the excess power that regeneration creates during deceleration.

Methods to Reduce Voltage Drop

There are two methods that can be used to reduce the drop of voltage in the system during acceleration.

- The first method is to decrease the cable resistance between the power supply and the motors by either shortening the length of the cables or by increasing the conductor gauge of the cables. This method reduces the voltage difference between the power supply and the motor.
- The second method is to limit the number of motors that are connected to one power supply.

Methods to Reduce Voltage Increase

There are two methods that can be used to reduce the voltage increase in the system during deceleration.

- The first method is to decrease the cable resistance between motors by either shortening the length of the cables or by increasing the conductor gauge of the cables. This method reduces the voltage difference between the motor that is regenerating power and the motors that are consuming or dissipating the power and allows the voltage at the regenerating motor to be lower.
- The second method is to install a voltage clamp in the power supply circuit to dissipate power if the voltage on the bus goes above a certain level.

Signal Wiring

Logic power of 48V DC can be provided separately or though the propulsion power pins. Logic power is a constant power per motor, see Table 5 on page 24.

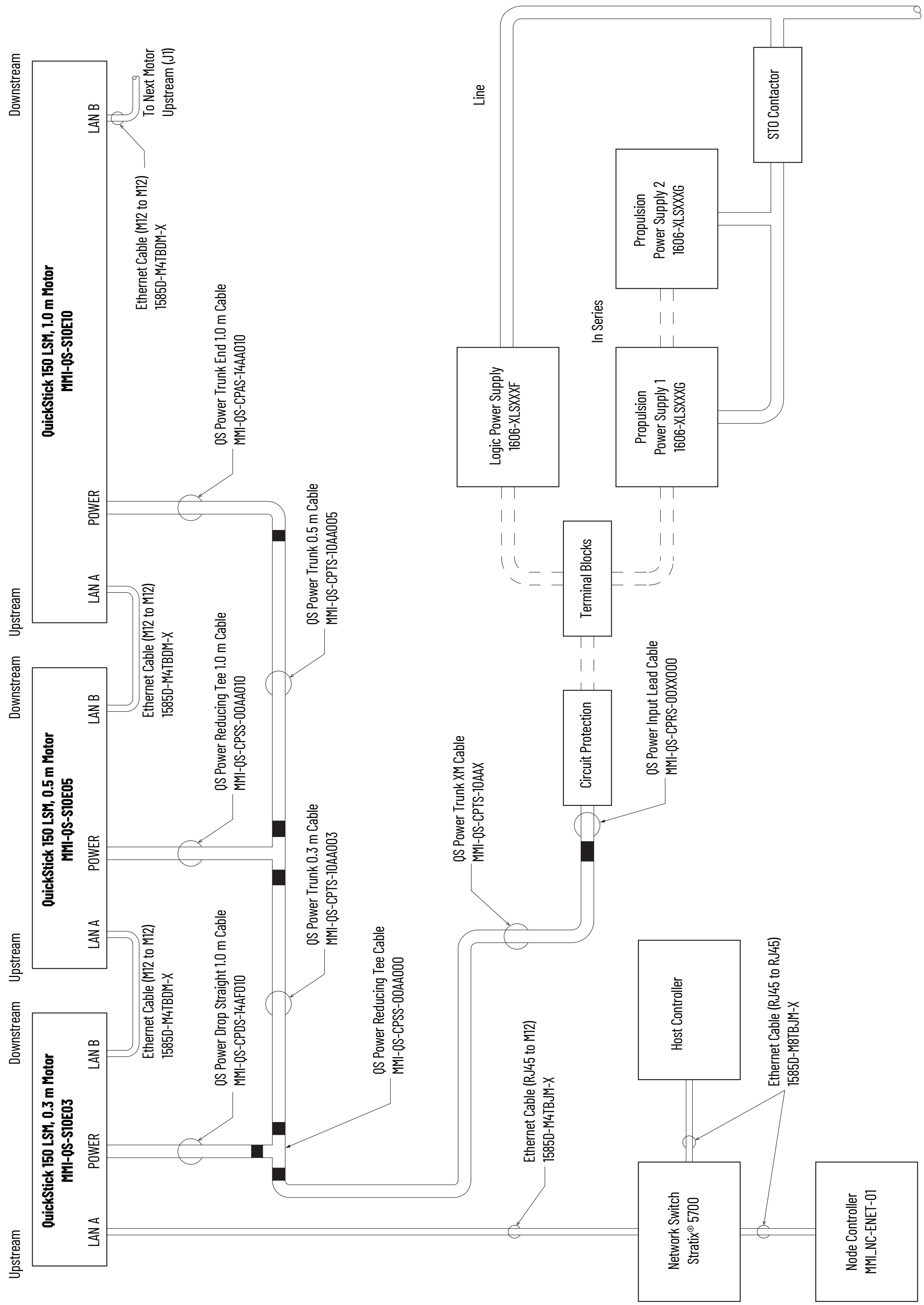
Separating the logic and propulsion power buses allows propulsion power to be removed (for example, during an EMO event) without losing the motor logic functions (for example, configuration data, vehicle data, fault information). Having separate power buses also allows the motors to be programmed and configured without enabling the propulsion power.

Ground

Proper grounding of the QS transport system is required for proper operation and to minimize electrical safety issues.

- The bodies of the motors are grounded through the PE connection on the power connector.
- The Node Controller is grounded through the chassis ground connection on the power connector. See the MagneMotion Node Controller Hardware User Manual, publication MMI-UM013, for more information.
- All power supplies must be grounded to an electrical safety ground (PE) via the safety ground in the AC input connector.
- All junction boxes must be grounded to an electrical safety ground (PE).
- All other components of the system (for example, Ethernet switches) must be grounded per the manufacturer's instructions.

Figure 121 - QuickStick 150 System Wiring Block Diagram



MagneMotion Information and Configuration Service (MICS) File Generation

Overview

The MagneMotion Information and Configuration Service (MICS) file is used to define the Ethernet track topology for the motors in a transport system. The file also describes the interfaces and physical hardware connections within a QuickStick transport system.

The MICS file works with the Node Controller Configuration File, which specifies the configuration of components within the transport system, such as; node controllers, paths, nodes, and motors. Each path that is defined in the Node Controller Configuration File defines the specific motors and their relationships to the motors on a path. The MICS file then defines the MAC address and IP address for each of those motors.

The MICS file contains the following:

- MAC address for each motor
- IP address for each motor
- Transport system location for each motor

The MICS files are written in XML format. XML allows the format to be backward and forward compatible and easily extended. A newer version of software can easily ignore older unused XML tags. An older version of software can ignore newer, unknown XML tags. The XML file format is human readable, which allows manual editing. XML files can be viewed with browsers or code editors in tree fashion (with the ability to expand or contract elements that contain other elements).

An overview of the XML format can be found in the XML Pocket Reference. Basically, an XML file contains a hierarchical set of elements. Each element consists of an opening tag, <Tag_name>, and a closing tag, </Tag_name>, with either data or other elements in between. In general, each tag starts with <Tag_name>, and ends with </Tag_name>. In this implementation, an element contains configuration data or other elements, but not both.

When a motor powers up, its network and topology information (from the MICS file) is provided to it dynamically by the node controller that is responsible for its path. The topology information that the motor receives includes its IP address, subnet mask, default gateway, and information about its neighboring motor connections.

The transport system accepts any valid IPv4 address scheme to operate. The address must be on the same subnet as its node controller. It is important to keep unnecessary broadcast traffic off the transport system network as it can impact overall system performance.

For a large transport system, it is typically useful to organize the IP structure that includes the path/motor information that is included in the Ethernet Motor Communication Recommendations section in the MagneMover LITE Ethernet Motor Configuration and Communication, publication MMI-UM031.

MICS File Format

The MICS file consists of XML elements (identified by their tag names) and comments. The file format consists of a declaration and a root element. The root element contains other elements. Other elements include either data or more elements. Comments can be interspersed with elements or data (but must not be within the tag).

File Naming Convention

The file can have any name for convenient reference, but must have the .xml extension. Once the file is uploaded to the node controller, it is automatically renamed to 'MICS_motor_data.xml'.

As an example:

- MICS_Development_System.xml

Declaration

The XML declaration is placed on the first line of the file. It specifies the XML version and the character encoding of the document. In this case, the declaration line is:

<?xml version="1.0" encoding="US-ASCII"?>

File Identification

MICS files are identified in comment lines following the XML declaration. The revision and last change data reflect the file revision and the data and time of the last change of the file.

For example:

<!-- MICS Motor Data file for a MagneMotion Node Controller -->

<!-- $Rev: 242 $ $LastChangedDate: 2018-02-15 20:06:34 (Thu, 15 Feb 2018) $ -->

Element

There is only one root element in a MICS file. In this case, the root element tag is *MICS_motor_data*. Elements can contain other elements or configuration data. Elements must be properly nested.

Tag Names

Tag names identify the function of the tag. The convention for tag names is only the first letter is capitalized and underscores ('_') are used in place of spaces.

Comments

Comments can be included where desired, including inside elements. Comments are identified by enclosing them in angle brackets with the first characters after the opening bracket an exclamation point and two dashes, and two dashes before the closing bracket. As an example:

<!-- comment -->

MICS File Protocol

The MICS file protocol defines the XML elements and structure that is used to identify the motors, their MAC address, IP address, and location on a path. These elements are only used in the MICS file.

MICS File XML Reference

The XML tags that are shown in Table 17 are used to define and configure the MICS file.

Table 17 - MICS File XML Elements

Element	Description	Page
XML Declaration	Start of the document.	165
MICS_motor_data	Root tag for MICS motor configuration data.	166
Motor	Container tag that defines the MICS data for a motor.	167
Mac_addr	The MAC address of the server high-level controller for the motor.	168
IP_addr	The static IPv4 address of the server high-level controller for the motor.	169
Track_location	The motor position in the specified path.	170

XML Declaration

The XML declaration is the first line in the document. It contains the XML version number and the character encoding for the file.

This element is a declaration, there is no closing tag.

Syntax

<?xml version="1.0" encoding="US-ASCII"?>

Attributes

None

Parent Tag

None

Contents

None

Example

The following example defines the version of XML used as 1.0 and the document encoding as US ASCII (Figure 123 on page 172).

<?xml version="1.0" encoding="US-ASCII"?>

MICS_motor_data

The root tag for MICS XML files, it contains all of the topology parameters for an Ethernet motor-based transport system. This tag contains no data; it only contains other tags.

Syntax

<MICS_motor_data>
.
.
.
</MICS_motor_data>

Attributes

None

Parent Tag

None (root tag)

Contents

<Motor>

Validation

Node controller requirements to accept XML upload:

- Must be the root tag of the XML file

Example

The following example defines the enclosed tags as MICS motor data (see Figure 123 on page 172).

<MICS_motor_data>
.
.
.
</MICS_motor_data>

Motor

Tags for MICS data for a motor. This tag contains no data; it delineates information for one motor. It contains only other tags.

Syntax

<Motor>
.
.
.
</Motor>

Attributes

None

Parent Tag

<MICS_motor_data>

Contents

All children tags:

- <Mac_addr>
- <IP_addr>
- <Track_location>
- <Orientation>

Validation

Node controller requirements for startup and initialization:

- Must contain at least one child tag

Example

The following example defines the enclosed tags as the definition for a motor (see Figure 123 on page 172).

```
<MICS_motor_data>
<!-- PATH 1 -->
   <Motor> <!-- P1M1 -->
   .
   .
   .
   </Motor>
</MICS_motor_data>
```

Mac_addr

Identifies the unique MAC address of the server high-level controller for the motor, its network, and topology configuration, which includes the elements within this tag.

Syntax

<Mac_addr>MACaddr</Mac_addr>

Attributes

None

Parent Tag

<Motor>

Contents

MACaddr – Unique MAC address in standard IEEE-802 format (that is, six groups of two hex digits), a colon ':' must be used to separate the digits (ex. hh:hh:hh:hh:hh:hh). The first three hexadecimal groups are the Organizationally Unique Identifier (OUI). The OUI for MagneMotion is c0:6c:6d. The MAC address values are set when the motor is built and the value within this tag must match the specific motor that this tag is referring to.

Validation

Node controller requirements for startup and initialization:

- Must not contain any child tags
- Must contain a string in the hh:hh:hh:hh:hh:hh format
- Must not be the value 00:00:00:00:00:00
- Must not contain a value that is equal to another <Mac_addr> tag

Example

The following example defines the MAC ID for the first motor on path 1 (see Figure 123 on page 172).

```
<MICS_motor_data>
<!-- PATH 1 -->
  <Motor> <!-- P1M1 -->
    <Mac_addr>C0:6C:6D:E0:00:20</Mac_addr>
    .
    .
    .
  </Motor>
</MICS_motor_data>
```

IP_addr

Identifies the static IPv4 address of the server high-level controller for the motor.

Syntax

<IP_addr>IPaddress</IP_addr>

Attributes

None

Parent Tag

<Motor>

Contents

IPaddress – A 32-bit IP address in IPv4 dotted-decimal format, "ddd.ddd.ddd.ddd", where ddd is a decimal number of up to three digits in the range 0 to and 255. See the “Ethernet Motor Communication Recommendations” section in the MagneMover LITE Ethernet Motor Configuration and Communication, publication MMI-UM031, for details.

Validation

Node controller requirements for startup and initialization:

- Must not contain any child tags
- Must contain a string in IPv4 dotted-decimal notation
- Must not be values of 0.0.0.0, 127.0.0.1, 255.255.255.255, or the node controller Subnet broadcast address
- Must not contain a value that is equal to another <IP_addr> tag

Example

The following example defines the IP address for the first motor on path 1 (see Figure 123 on page 172).

```
<MICS_motor_data>
<!-- PATH 1 -->
  <Motor> <!-- P1M1 -->
    <Mac_addr>C0:6C:6D:E0:00:20</Mac_addr>
    <IP_addr>192.168.1.1</IP_addr>
    .
    .
    .
  </Motor>
</MICS_motor_data>
```

Track_location

Identifies the motor position in the specified path. The Node Controller Configuration File defines the paths where the motors are located.

Straight and curve motors are represented as one <Motor> tag with one <Track_location> tag.

Switches are represented as one <Motor> tag with two <Track_location> tags.

Syntax

<Track_location>Location</Track_location>

Attributes

None

Parent Tag

<Motor>

Contents

Location – The location is identified as PnMn. Where Pn is the path number and Mn is the location of the motor in the path.

Validation

Node controller requirements for startup and initialization:

- Must not contain any child tags
- Must not contain a value that is equal to another <Track_location> tag

Examples

The following example defines a motor that is on path 3 (see Figure 123 on page 172).

```
<MICS_motor_data>
<!-- PATH 3 -->
  <Motor> <!-- P3M2 -->
    <Track_location>P3M2</Track_location>
    .
    .
    .
  </Motor>
</MICS_motor_data>
```

The following example defines a switch that is at the beginning of path 2 and path 3 (see Figure 123 on page 172). The Node Controller Configuration File defines the type of switch (diverge) and the paths where the switch is located.

```
<MICS_motor_data>
<!-- PATH 2 -->
  <Motor> <!—P2M1 P3M1)->
    <Track_location>P2M1</Track_location>
    <Track_location>P3M1</Track_location>
    .
    .
    .
  </Motor>
</MICS_motor_data>
```

The following example defines a switch that is at the end path 2 and path 3 (see Figure 123 on page 172). The Node Controller Configuration File defines the type of switch (merge) and the paths where the switch is located.

```
<MICS_motor_data>
<!-- PATH 2 -->
  <Motor> <!—P2M3 P3M5)->
    <Track_location>P2M3</Track_location>
    <Track_location>P3M5</Track_location>
    .
    .
    .
  </Motor>
</MICS_motor_data>
```

MICS File Example

Figure 122 is an example of a QuickStick system with Ethernet motors. Figure 123 is the MICS file for the system that is shown in Figure 122.

Figure 122 - System Layout for MICS File Example

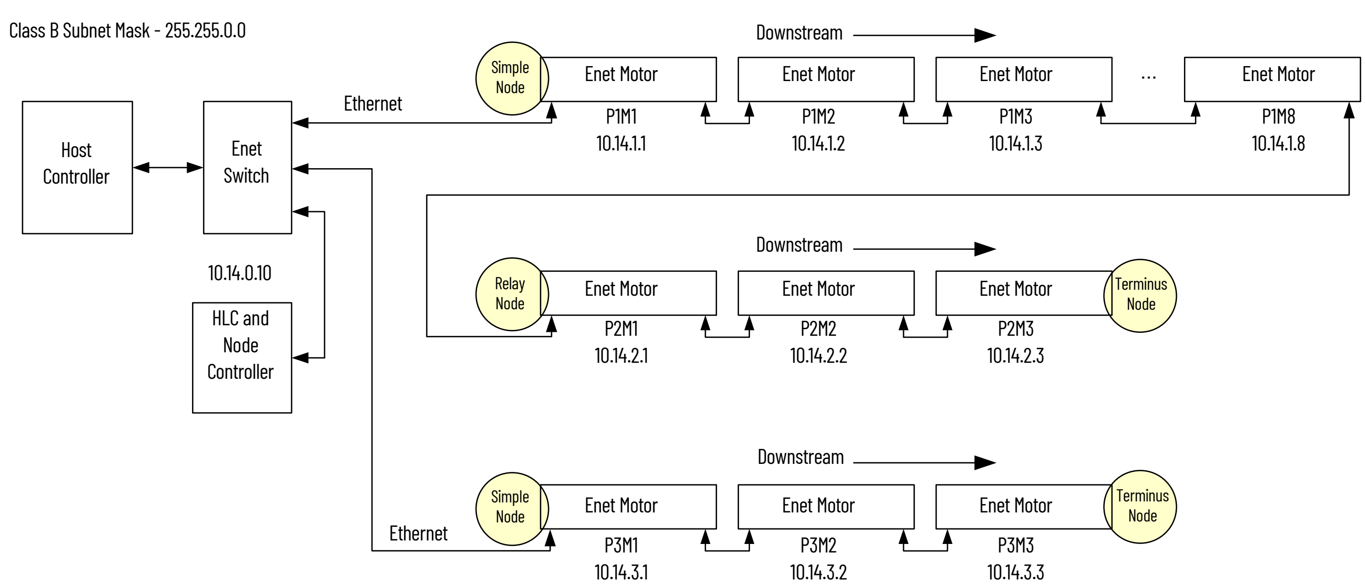


Figure 123 - MICS File Example

```
<?xml version="1.0" encoding="US-ASCII"?>

<!-- MICS Motor Data file for a MagneMotion Transport System -->
<!-- $Rev: 242 $ $LastChangedDate: 2018-02-15 20:06:34 (Thu, 15 Feb 2018) $ -->

<MICS_motor_data>
<!-- PATH 1 -->
  <Motor> <!-- P1M1 -->
    <Mac_addr>C0:6C:6D:E0:00:20</Mac_addr> <!-- Motor's MAC for MICS -->
    <IP_addr>10.14.1.1</IP_addr> <!-- Motor's IP to use for MICS -->
    <Track_location>P1M1</Track_location> <!-- Track NC Path,Motor # -->
    <Orientation>Standard</Orientation> <!-- Motor's orientation to downstream -->
  </Motor>

  <Motor> <!-- P1M2 -->
    <Mac_addr>C0:6C:6D:E0:00:21</Mac_addr> <!-- Motor's MAC for MICS -->
    <IP_addr>10.14.1.2</IP_addr> <!-- Motor's IP to use for MICS -->
    <Track_location>P1M2</Track_location> <!-- Track NC Path,Motor # -->
    <Orientation>Standard</Orientation> <!-- Motor's orientation to downstream -->
  </Motor>

  <Motor> <!-- P1M3 -->
    <Mac_addr>C0:6C:6D:E0:00:28</Mac_addr> <!-- Motor's MAC for MICS -->
    <IP_addr>10.14.1.3</IP_addr> <!-- Motor's IP to use for MICS -->
    <Track_location>P1M3</Track_location> <!-- Track NC Path,Motor # -->
    <Orientation>Standard</Orientation> <!-- Motor's orientation to downstream -->
  </Motor>

  <Motor> <!-- P1M4 -->
    <Mac_addr>C0:6C:6D:E0:00:23</Mac_addr> <!-- Motor's MAC for MICS -->
    <IP_addr>10.14.1.4</IP_addr> <!-- Motor's IP to use for MICS -->
    <Track_location>P1M4</Track_location> <!-- Track NC Path,Motor # -->
    <Orientation>Standard</Orientation> <!-- Motor's orientation to downstream -->
  </Motor>
```

Figure 2 - MICS File Example (Continued)


```
<Motor> <!-- P1M5 -->
    <Mac_addr>C0:6C:6D:E0:00:24</Mac_addr> <!-- Motor's MAC for MICS -->
    <IP_addr>10.14.1.5</IP_addr> <!-- Motor's IP to use for MICS -->
    <Track_location>P1M5</Track_location> <!-- Track NC Path,Motor # -->
    <Orientation>Standard</Orientation> <!-- Motor's orientation to downstream -->
</Motor>

<Motor> <!-- P1M6 -->
    <Mac_addr>C0:6C:6D:E0:00:4E</Mac_addr> <!-- Motor's MAC for MICS -->
    <IP_addr>10.14.1.6</IP_addr> <!-- Motor's IP to use for MICS -->
    <Track_location>P1M6</Track_location> <!-- Track NC Path,Motor # -->
    <Orientation>Standard</Orientation> <!-- Motor's orientation to downstream -->
</Motor>

<Motor> <!-- P1M7 -->
    <Mac_addr>C0:6C:6D:E0:00:4F</Mac_addr> <!-- Motor's MAC for MICS -->
    <IP_addr>10.14.1.7</IP_addr> <!-- Motor's IP to use for MICS -->
    <Track_location>P1M7</Track_location> <!-- Track NC Path,Motor # -->
    <Orientation>Standard</Orientation> <!-- Motor's orientation to downstream -->
</Motor>

<Motor> <!-- P1M8 -->
    <Mac_addr>C0:6C:6D:E0:00:26</Mac_addr> <!-- Motor's MAC for MICS -->
    <IP_addr>10.14.1.8</IP_addr> <!-- Motor's IP to use for MICS -->
    <Track_location>P1M8</Track_location> <!-- Track NC Path,Motor # -->
    <Orientation>Standard</Orientation> <!-- Motor's orientation to downstream -->
</Motor>
```

Figure 2 - MICS File Example (Continued)

```
<!-- PATH 2 -->
  <Motor> <!-- P2M1 -->
    <Mac_addr>C0:6C:6D:E0:00:2B</Mac_addr> <!-- Motor's MAC for MICS -->
    <IP_addr>10.14.2.1</IP_addr> <!-- Motor's IP to use for MICS -->
    <Track_location>P2M1</Track_location> <!-- Track NC Path,Motor # -->
  </Motor>

  <Motor> <!-- P2M2 -->
    <Mac_addr>C0:6C:6D:E0:00:2A</Mac_addr> <!-- Motor's MAC for MICS -->
    <IP_addr>10.14.2.2</IP_addr> <!-- Motor's IP to use for MICS -->
    <Track_location>P2M2</Track_location> <!-- Track NC Path,Motor # -->
    <Orientation>Standard</Orientation> <!-- Motor's orientation to downstream -->
  </Motor>

  <Motor> <!-- P2M3 -->
    <Mac_addr>C0:6C:6D:E0:00:2C</Mac_addr> <!-- Motor's MAC for MICS -->
    <IP_addr>10.14.2.3</IP_addr> <!-- Motor's IP to use for MICS -->
    <Track_location>P2M3</Track_location> <!-- Track NC Path,Motor # -->
  </Motor>
```

Figure 2 - MICS File Example (Continued)

```
<!-- PATH 3 -->
    <Motor> <!-- P3M1 -->
        <Mac_addr>C0:6C:6D:E0:00:76</Mac_addr> <!-- Motor's MAC for MICS -->
        <IP_addr>10.14.3.1</IP_addr> <!-- Motor's IP to use for MICS -->
        <Track_location>P3M1</Track_location> <!-- Track NC Path,Motor # -->
        <Orientation>Standard</Orientation> <!-- Motor's orientation to downstream -->
    </Motor>

    <Motor> <!-- P3M2 -->
        <Mac_addr>C0:6C:6D:E0:00:50</Mac_addr> <!-- Motor's MAC for MICS -->
        <IP_addr>10.14.3.2</IP_addr> <!-- Motor's IP to use for MICS -->
        <Track_location>P3M2</Track_location> <!-- Track NC Path,Motor # -->
        <Orientation>Standard</Orientation> <!-- Motor's orientation to downstream -->
    </Motor>

    <Motor> <!-- P3M3 -->
        <Mac_addr>C0:6C:6D:E0:00:29</Mac_addr> <!-- Motor's MAC for MICS -->
        <IP_addr>10.14.3.3</IP_addr> <!-- Motor's IP to use for MICS -->
        <Track_location>P3M3</Track_location> <!-- Track NC Path,Motor # -->
        <Orientation>Standard</Orientation> <!-- Motor's orientation to downstream -->
    </Motor>

</MICS_motor_data>
```

Notes:

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Rockwell Automation Support

Use these resources to access support information.

Technical Support Center	Find help with how-to videos, FAQs, chat, user forums, Knowledgebase, and product notification updates.	rok.auto/support
Local Technical Support Phone Numbers	Locate the telephone number for your country.	rok.auto/phonesupport
Technical Documentation Center	Quickly access and download technical specifications, installation instructions, and user manuals.	rok.auto/techdocs
Literature Library	Find installation instructions, manuals, brochures, and technical data publications.	rok.auto/literature
Product Compatibility and Download Center (PCDC)	Download firmware, associated files (such as AOP, EDS, and DTM), and access product release notes.	rok.auto/pcdc

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Rockwell Automation maintains current product environmental compliance information on its website at rok.auto/pec.

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